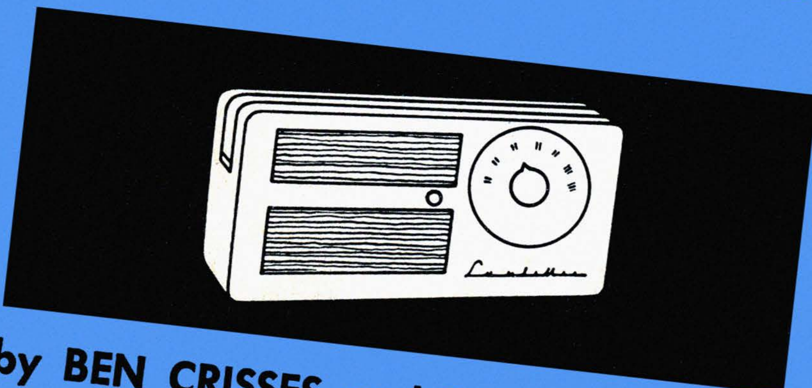
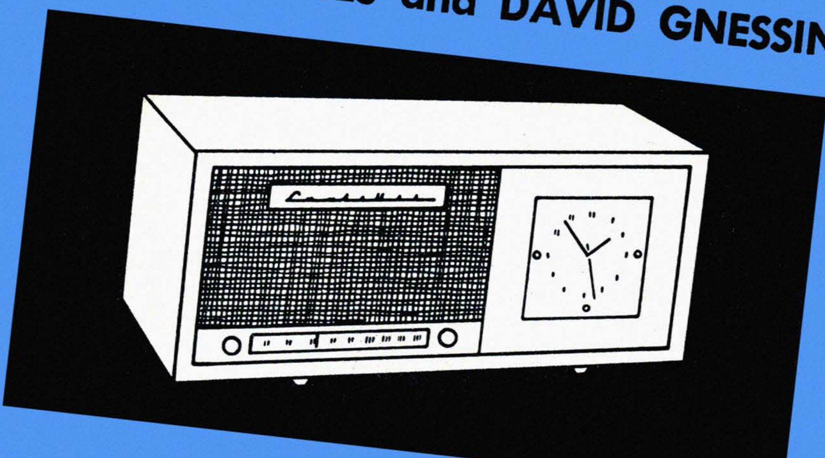
No. 224

REPAIRING

PORTABLE AND CLOCK RADIOS



by BEN CRISSES and DAVID GNESSIN



a RIDER publication

$2.75

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John F. Rider Publisher, Inc., 116 West 14th Street
New York 11, N. Y.

Library of Congress Catalog Card Number 58-12136

Printed in the United States of America

preface

Because of requirements of mobility, compactness, etc., the design of portable and clock radios presents special repair problems to the technicians, many of them different from the usual radio repairs. The authors have emphasized these problems in this book. No attempt is made or intended to create the impression that portable and clock radios are separate and distinct from conventional ac-dc types. Instead, the authors have assumed that the reader has a knowledge of basic radio repair and theory, and, for this reason, have concentrated their information for use in the servicing of portable and clock radios.

Theory and other basic information have been kept to a minimum so that practical information be emphasized. The organization of this book is such that it enables the user to find all his required information on a subject in one section, with cross-referencing not required. Finally, the examples given are of equipment or circuits that enjoy wide popularity. It should be emphasized that the units discussed are chosen because their high reliability has made them so very popular, and not because they are unusually susceptible to breakdown.

The book begins with an introduction to typical portable radio circuits. Emphasis is placed on the filament circuitry and how the major problem of current drain is handled. It then deals with transistor connections and circuits. The portable radio power supply is examined at length, with observations on battery testing and storage.

Three chapters are devoted to repair, replacement, and alignment, including a detailed discussion of probable sites of mechanical troubles, a full list of all repair equipment needed, notes on new parts and substitution of old, and step-by-step analysis of replacement procedures and short-cuts. The text also presents an ample discussion of design improvement – adjustments that go beyond mere repairing of minor troubles that result in long-term improvement of performance or extension of life of the set.

A final unique chapter is devoted to clock radios. It discusses the circuitry and switching of these receivers, the varieties of clock movements and steps in their disassembly and adjustment, clues to probable defects in clock mechanisms, and tips on cleaning and lubricating.

The authors wish to extend their appreciation to the following organizations for making available much of the data and material required for the book: Admiral Corp.; Crosley Div., Avco Mfg. Co.; Electronic Industries Association (EIA); *Electronic Technician*; National Electronic Distributors Association (NEDA); Motorola, Inc.; RCA Service Co., Inc.; Raytheon Mfg. Co.; Sessions Clock Co.; Telechron Div. of G.E.; Zenith Radio and Television Corp. The authors also express their appreciation to Mr. I. Remer, for his many suggestions; and last but not least to their families, who showed such wonderful patience and understanding while this book was being written.

New York, N. Y.
June 1958

Ben Crisses
David Gnessin

contents

1. introduction to portable and clock radios

In recent years there has been a steadily increasing demand for radios that are not only light enough and compact enough to carry anywhere, but also capable of playing wherever they may be taken. There has been, at the same time, a growing market for radios that indicate the time, wake one in the morning, and lull one to sleep at night. This has resulted in radios that are more complicated, both electronically and mechanically, than those of former years. They pose unusual problems to the men who repair and maintain them.

No longer can a service technician look at the underside of a chassis and make routine repairs. He must trace, or at least examine more closely, a complex circuit before he takes action.

Manufacturers of portable and clock radios have taken conventional superhet circuits and modified them to satisfy the demands of the public. For portable radios, the circuits have been changed so that sets may play on battery only, or on battery, on a-c and on d-c lines. These sets are commonly referred to as *three-way portables.* In addition, 1-volt miniature tubes, subminiature tubes, transistors, printed components, and printed wiring are used more and more as manufacturers strive for smaller, more portable radios. Furthermore, there are three-way portable radios that can operate from 117-volt or 230-volt ac-dc power sources and cover a frequency range greater than the broadcast band (535-1605 kc).

Clock radios use conventional 117-volt a-c radio circuits, to which a clock mechanism has been added. The clock includes a mechanical switch that can turn the radio on or off at preset times. Clock-portables are also available, in which a conventional electrical control clock can be plugged into the portable radio when using house current, and unplugged when the portable is operated on batteries.

To clarify the portable radio picture, the differences between ac-dc radios and portable radio receivers will be shown in this chapter and in Chap. 2. These differences lie largely in the filament and power supply circuits.

TYPICAL TUBE-TYPE PORTABLE RADIO CIRCUITS

The great problem in portables is current drain. A special set of tubes has been designed to overcome this difficulty. Table 1-1 lists the tube lineup (in typical sets A, B, C, and D) in the majority of portables (except transistor types) being manufactured today.

Table 1-1

Stage	*Set A*	*Set B*	*Set C*	*Set D*
R-F or I-F	1U4	1AH4	1N5	1AH4
Converter	1R5 or 1L6	1V6	1A7	1V6
Det-Ampl	1U5	1AJ5	1H5	1AJ5
Output	3V4 or 3S4	1AG4	3Q5	none used (a transistor is used)
Rectifier	117Z3 or selenium	none used (battery only)	117Z6	none used (battery only)

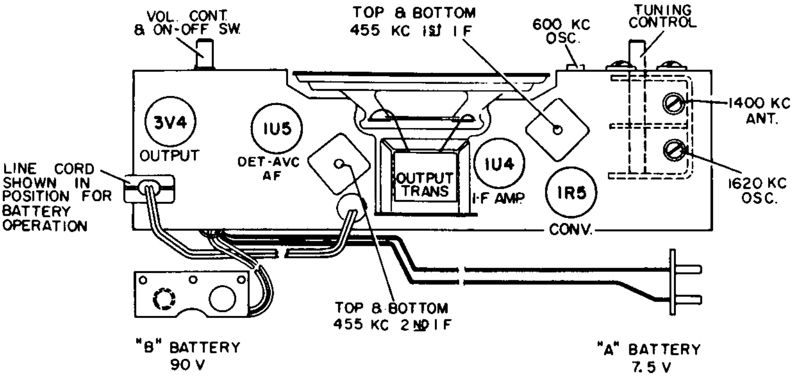


Fig. 1-1. Typical tube layout of miniature-tube set.

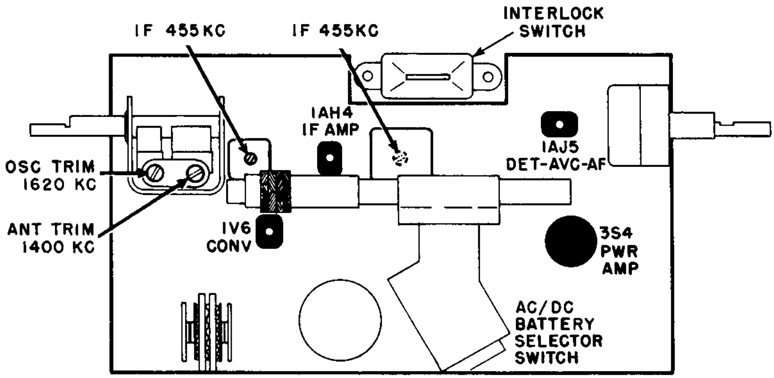


Fig. 1-2. Typical tube layout of miniature/subminiature-tube set.

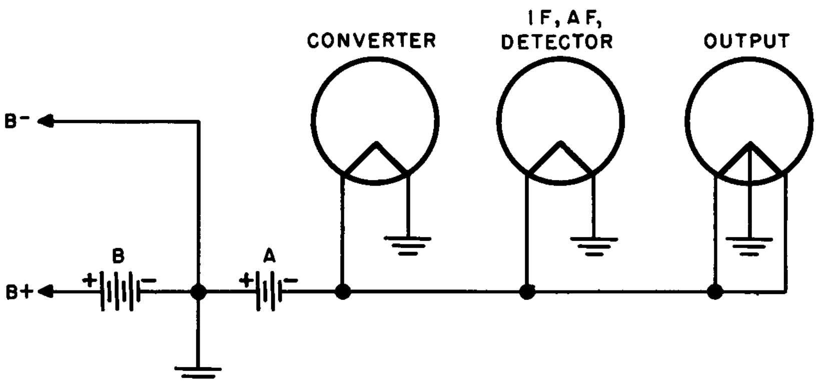


Fig. 1-3. Battery supply circuits; note the filaments in parallel.

Typical tube layouts. Figures 1-1 and 1-2 show the tube layout and tube-type combinations used in many portable radios. Figure 1-1 shows a typical set using miniature tubes, and Fig. 1-2 a typical set using subminiature tubes with a miniature power amplifier tube.

D-c filament supplies. For battery economy, tubes used in portable radio receivers are of the filament type, and require direct current for filament operation. Figure 1-3 shows the supply circuits of a set operating on battery power. The required direct voltages for B+ and filaments are supplied in parallel because the total drain is small.

Figure 1-4 shows the filament circuit popular in three-way sets. This set uses a 9-volt battery for the filament circuits, for portable

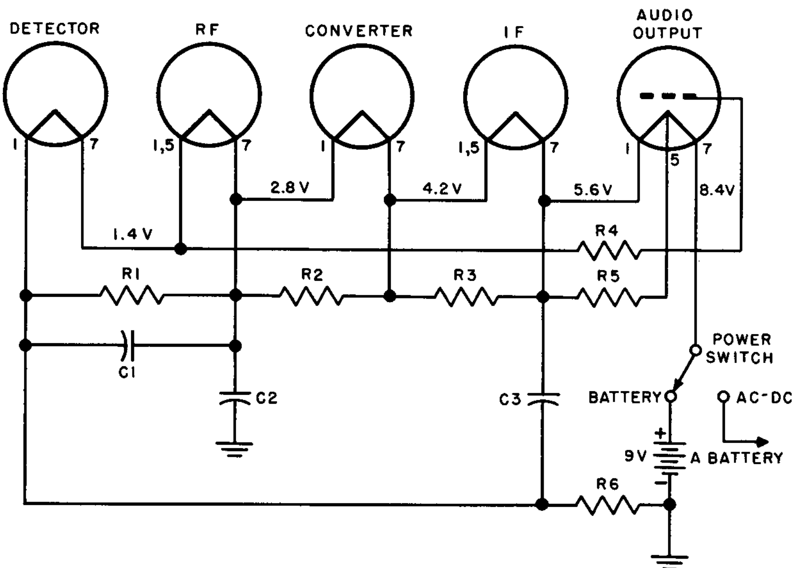


Fig. 1-4. The filament circuits in a typical three-way portable radio.

operation. Note that the series connection of filaments places the audio output stage near the positive end of the d-c source. (The diagram shows the power switch in BATTERY position.) Placing the output tube at the positive end of the d-c source provides a means of securing the required d-c bias voltage for the output stage in the following manner:

The audio output control grid is returned through *R4* to pins 1 and 5 of the r-f stage. This point is 1.4 volts positive with respect to B–. It would seem that the audio output control grid has a positive d-c bias, but of course this is not so. The filament voltage across the audio output tube is 2.8 volts, with the center tap (considered the cathode point) at 7 volts positive with respect to B–. Since grid bias is the value of grid voltage with reference to the cathode, a bias of –5.6 volts is placed on the grid of the output stage.

The other tubes are biased in a similar manner (see typical portable radio schematics in Chap. 2) by returning the control grids to different points in a network formed by the tube filaments. Note also the shunting resistors (*R1, R2, R3,* and *R5*) across the filaments. These resistors shunt plate and screen currents around the filament circuits; otherwise, the relatively heavy plate current for the output stage would probably damage the other filaments. Thus, *R5* is the filament shunt resistor for the audio output stage, *R3* performs the same function for the i-f stage, *R2* does similar work for the converter stage, while *R1* serves as filament shunt resistor for both detector and r-f tubes in series. The three capacitors shown in Fig. 1-4 (*C1, C2,* and *C3*) serve as bypass capacitors, preventing the signal variations (intermediate-frequency and/or audio-frequency) in the filament return lines from upsetting the filament bias. Because the bypass capacitors have a lower reactance to ground (or B–) than the filament path, the signal bypasses the filaments and returns through the capacitors, leaving the filament voltages (and consequently the filament bias values) stable.

Figure 1-5 shows another type of popular filament arrangement. To use a 3-volt battery, and thereby reduce size, the filaments are switched into a series-parallel arrangement during battery operation. In ac-dc operation, the filament string is switched into a series arrangement as follows:

Ganged switches *SW1* and *SW2,* operating together, are placed in the ac-dc position, as shown in the diagram. The 8.6-volt ac-dc line feeds the voltage through *SW1,* through the two series filaments of the 3S4 tube, through the 1U4, through *R5,* through the 1U5, through the 1R5 (and *R6* in parallel), and out through *SW2* to the ac-dc return. The filaments themselves require about 7 volts which, together with the 1.6-volt drop across *R5,* makes up the 8.6-volt supply.

When the ganged switch is placed in the BATTERY position, the 8.6-volt ac-dc line is opened and a series-parallel battery filament arrangement is employed. Note that the 2.8-volt filament of the 3S4 with the 0.2-volt drop across *R4* in series takes up the whole 3 volts from the battery. The 1U4 filament (1.4 volts) and the 1.6-volt

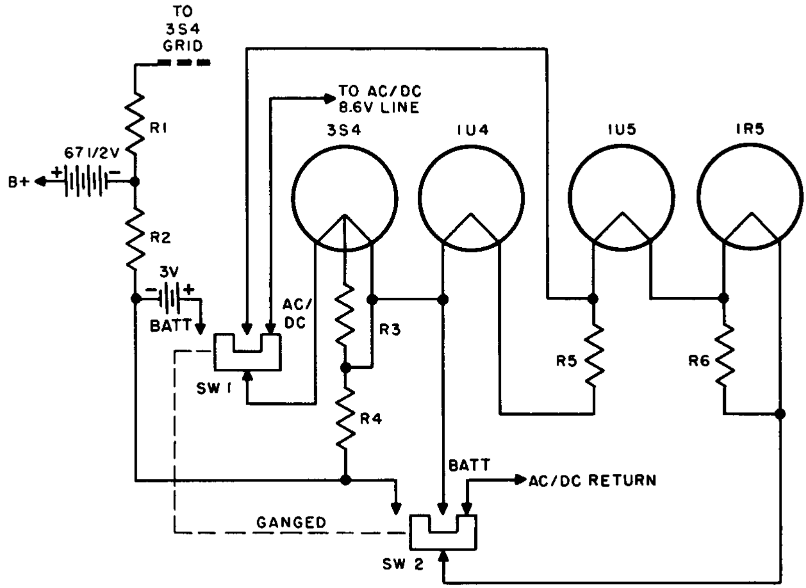


Fig. 1-5. Series-parallel switching for filament circuits.

drop across *R5* make up a second parallel 3 volts from the battery. The 2.8-volt filament requirement of the 1U5 and 1R5 tubes in series is met by the 3 volts from the battery. Resistors *R3* and *R6* are filament shunt resistors to protect the filaments from heavy plate current surges. Resistors *R1* and *R2* provide d-c grid bias, as covered in the description of Fig. 1-4.

Figure 1-6 shows a standard ac-dc filament circuit with limiting resistors. The series and parallel resistors in the filament circuits provide the different voltages and current drains. When necessary, they must be replaced with identical units. The resistors can be briefly described as follows: *R1* is a current-limiting resistor to protect the rectifier diode; *R2* drops the filament voltage to the low voltage required (the point between *R1* and *R2* is the normal take-off for the higher positive voltage for the plate circuits); *R5* is a series current-limiting resistor to protect the filament circuit from current surges; *R3* is a filament shunt resistor that protects the 3S4 filament from plate current surges; *R4* is really in shunt with the other three tube filaments, acting as a filament shunt resistor to protect those filaments from plate current surges.

B+ voltages. B+ voltages for portables present no special problems and therefore are not discussed in this chapter. Where the plate voltages are supplied by batteries, there is only the matter of switching the battery in or out. Where the plate voltage is supplied by rectification (as in three-way portables), the problem resolves into the familiar ac-dc B+ supply.

It was stated that the differences between ac-dc radios and portable radio receivers lie largely in the filament and power-supply

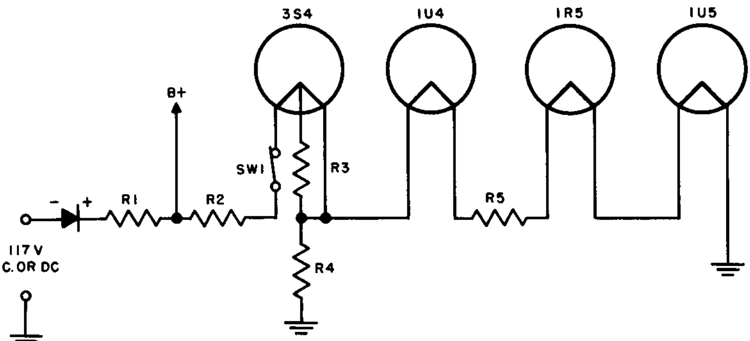


Fig. 1-6. A standard ac-dc filament circuit.

circuits. The circuits described here illustrate this. There is another type of portable radio receiver that differs in much more than filament circuitry (it has no filaments at all). This is the transistor portable radio.

TRANSISTOR CIRCUITS

If a service technician is to repair a defective transistor set, he must understand that it presents problems different from those encountered in tube sets. (As yet, there is little standardization of transistor portable radio circuits.)

Cautions in initial testing. Probably all technicians have at one time or another checked a vacuum-tube audio amplifier by touching finger or screw driver to the center contact of an audio potentiometer to get a buzz in the familiar "circuit disturbance" test. The high input impedance of the audio tube picks up hum and noise from the capacitance of a finger or screwdriver and amplifies it to create the buzz showing normal operation. Touch the center-contact of an audio potentiometer of the transistor audio amplifier and you'll get nothing — even from a good stage. (The low input impedance of the transistor amplifier ignores the familiar circuit disturbance.)

Testing transistors involves the use of special transistor testers. Because the transistor's active life is considerably greater than equivalent tubes, they are usually the last components to be suspected in troubleshooting.

Transistor circuitry is generally much smaller and more fragile than equivalent tube circuitry, and the trend is toward more printed or packaged circuits. In such sets, entire circuits are replaced, rather than individual elements.

P-N-P and N-P-N recognition. In many cases, the technician will not be advised whether he is dealing with *p-n-p* or *n-p-n* type transistor in the circuit. However, it is important to know what type of transistor is being used, so that proper biasing voltages will be applied during testing. By noting the direction of the arrowhead in the symbol (Figs. 1-7, 1-8, and 1-9) on the schematic, the transistor type can be determined. The arrow points *away* from the center in the *n-p-n,* and *toward* the center in the *p-n-p* type.

Typical transistor connections. Depending upon which terminals are used for input circuits and which for output circuits, a transistor can be connected in any one of three ways:

1. Grounded-base connections.
2. Grounded-emitter connections.
3. Grounded-collector connections.

Figures 1-7, 1-8, and 1-9 show these three connections. The grounded-base connection (Fig. 1-7) is roughly equivalent to the grounded-grid amplifier. The grounded-collector connection (Fig. 1-9) is roughly equivalent to the cathode follower. In both of these connections, there is no phase inversion of signal passing through the transistor amplifier. The grounded-emitter connection (Fig. 1-8) is similar to the normal grounded cathode amplifier, with the usual phase inversion of signal. The following are important points to remember:

1. The polarities on all transistor elements are shown in the figures.
2. The grounded-emitter is the only circuit that produces a phase reversal between output and input signals.
3. Compared to tubes, transistor amplifiers have extremely low input impedances and rather low output impedances, the exact values depending on the circuitry used.

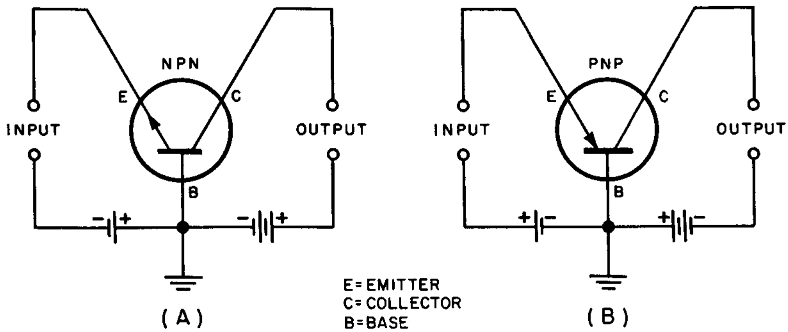


Fig. 1-7. Transistors with grounded base connections: (A) *n-p-n* type; (B) *p-n-p* type.

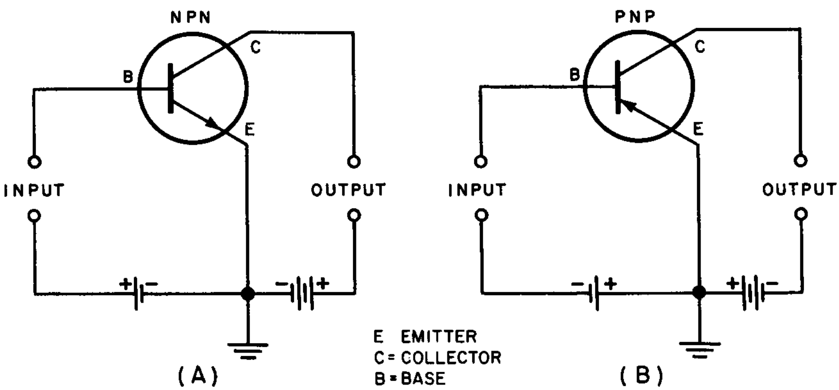


Fig. 1-8. Transistors with grounded emitter connections: (A) *n-p-n* type; (B) *p-n-p* type.

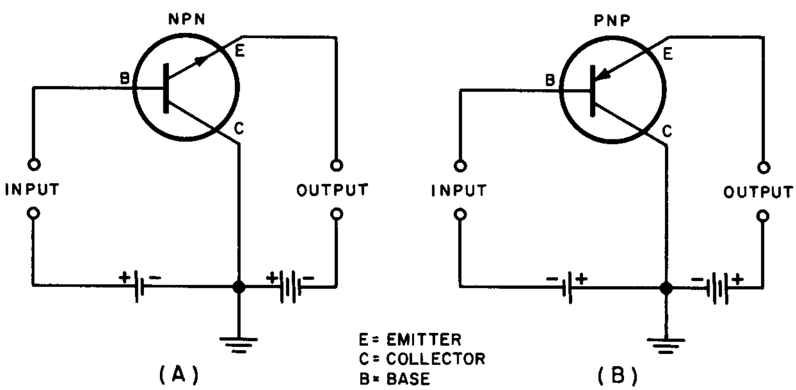


Fig. 1-9. Transistors with grounded collector connections: (A) *n-p-n* type; (B) *p-n-p* type.

Circuit analysis of a typical transistor portable. Figure 1-10 is a schematic diagram of a typical transistor portable. Note that *n-p-n* transistors are used. This means that all collector voltages are positive with respect to the base and emitter. Also note that grounded-emitter-type circuits are used throughout. (A simplified *n-p-n* grounded-emitter circuit was shown in Fig. 1-8A.)

In the oscillator (Fig. 1-10), the collector bias is obtained through the decoupling network composed of *R5* and *C10,* and through *T6.* The base is biased through the voltage divider circuit composed of *R23* and *R24.* Resistor *R25* is the stabilizing resistor, which is bypassed by *C12* to prevent oscillator degeneration. The oscillator tank is tuned by varying *C1D.* The oscillator output is coupled to the mixer base through *C4.* The received signal input is also coupled to the mixer base through the lower winding of *L1,* since both are wound on the ferrite-core antenna.

The mixer collector is biased through the decoupling network of *R3* and *C3.* Resistors *R1* and *R2* are stabilizing resistors for the mixer emitter. Capacitor *C2* is a bypass to prevent signal degeneration. The output is developed across the primary of *T1.* The primaries of the i-f transformers are tuned while the secondaries are not. This is done to match the high collector impedance to the low input impedance of the base of the following stage.

The collector of the first i-f stage is biased through the decoupling network composed of *R9* and *C6.* The base is biased through *R6* and *C9.* Network *R8* and *C5* form the stabilizing network for the emitter. Network *R7* and *C19* form a feedback network to neutralize the internal capacitance of the transistor. It should be noted that it may be necessary to change *R17* and *C19* if a new transistor is installed. The second i-f stage is very similar to the first; hence it does not require separate discussion.

The signal is detected by a 1N295 diode, with the volume control as its load. An avc voltage from the detector stage is applied to the base of the mixer and first i-f stages through a filter network composed of *R10, C9,* and *R4.*

The signal to the driver base is coupled through *C14;* the base is biased through the voltage divider composed of *R17* and *R18.* Network *R16* and *C16* form the emitter stabilizing network. Collector bias is applied through the primary of *T4,* bypassed by *C17.*

The output stage is a common-emitter push-pull amplifier. Resistors *R20* and *R22* form the voltage divider required for biasing

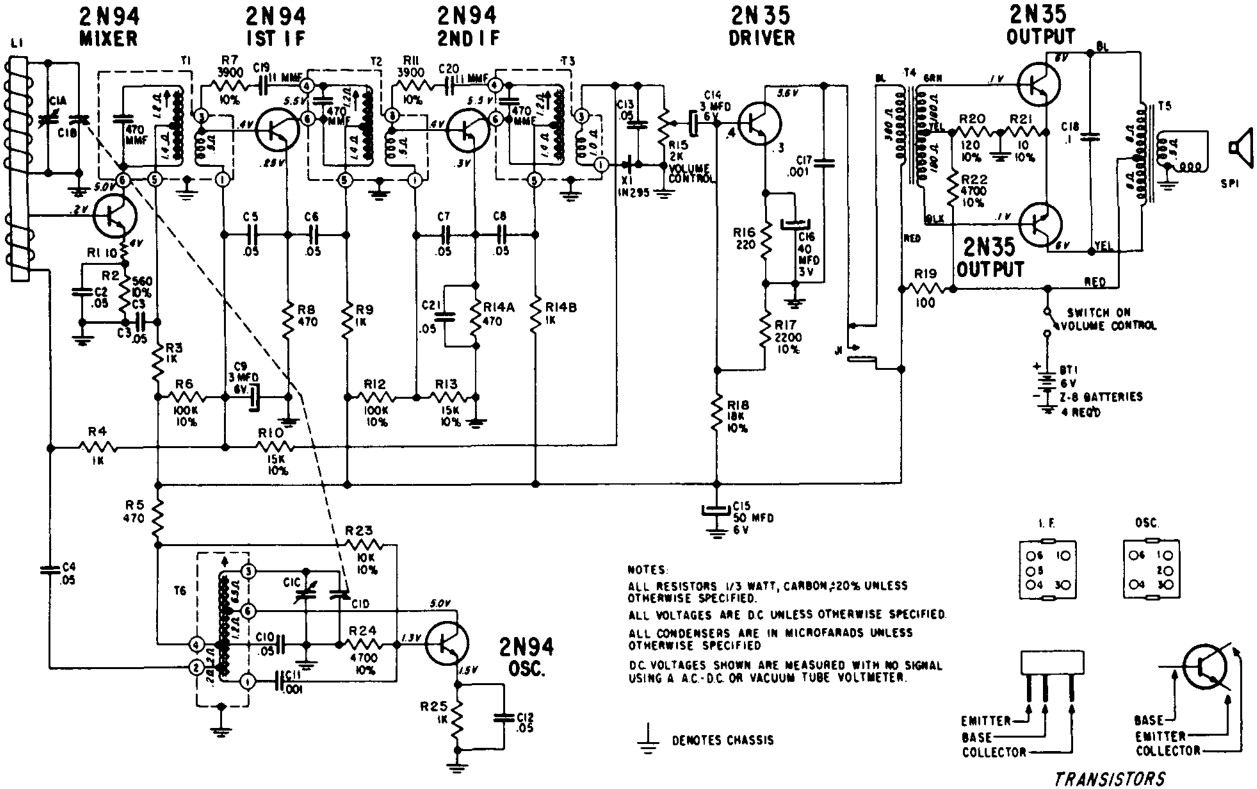


Fig. 1-10. Circuit of a typical transistor portable radio. ***Zenith Radio and Television Corp.***

the bases. Resistor *R21* is a stabilizing resistor, and *C18* cuts out the high frequencies.

Network *C15/R19* provides additional filtering and decoupling action for the battery supply. When the earphone jack is inserted in *J1*, the output stage is eliminated from the circuit.

TRENDS IN PORTABLE AND CLOCK RADIOS

The most consistent trend in portable and clock radios is toward miniaturization. Printed wiring and printed components are being used more and more. Rectifier tubes are being replaced by selenium rectifiers; loop-type antennas are being replaced by ferrite-core antennas. Subminiature tubes are being replaced by transistors, and all miniature tubes may eventually be replaced by transistors, when transistor costs decrease. In short, all portables will be completely transistorized. This trend toward miniaturization and the use of transistors will require special servicing techniques; these will be discussed later.

The technician can also expect to see new types of batteries that are smaller and more efficient than those now in use. Solar and atomic batteries have been developed; only their high cost precludes their use at the present time. Proper servicing and testing techniques will be developed as the frequency of usage of these newer items is incrased.

Clock radio circuits, because of the power requirements of the clock portion, are not changing much. However, the trend toward miniaturization will result in smaller radios, which will increase the complexity of servicing.

In spite of all these changes, servicing techniques will still follow accepted good practice, providing even broader sources of revenue to the practicing service technician.

2. power supplies

PORTABLE POWER SUPPLIES

The portability of its power supply distinguishes the portable radio from the other types. Therefore, an understanding of the power supply is a must for the technician. Among power supply considerations, the filament and bias circuit characteristics were discussed in Chap. 1.

As previously noted, there are two types of portables: the three-way ac-dc-battery type and the battery-only variety. The three-way portables can be divided into those using a vacuum-tube rectifier and those using a selenium rectifier. The three-way usually has filaments in series or series-parallel to facilitate switching. Battery sets can be found that have filaments in either series or parallel.

Figure 2-1 shows a typical three-way power supply, with a selenium rectifier (*D1*) supplying the power when batteries are not in use. Note that two ganged switches are used. Switch *SW1* selects ac-dc or battery operation. The switch is ganged to connect the three basic supply lines – filament, B+, and ground – to either the battery supply or the plug-in primary power.

When *SW1* is placed in BATT position it connects the A and B battery and ground to the lines. When placed in AC-DC position, the line power is applied as follows: The lower plug conductor serves as common ground for the power supply through the lowest switch terminals on *SW1.* The upper plug conductor feeds rectifier line current through selenium rectifier *D1,* current-limiting resistor *R1*

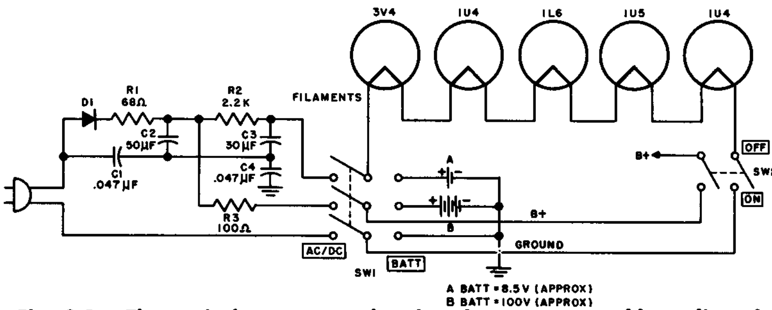


Fig. 2-1. The typical power supply of a three-way portable radio using a selenium rectifier.

(which protects *D1* from line surge currents, to a point between *R1* and *R2.* Here the rectifier line current divides the higher voltage (100 volts) going through B+ filter resistor *R3,* through the middle switch terminals of *SW1* to the B+ lines of the set; while the other line at the junction of *R1* and *R2* goes through the large voltage-dropping resistor *R2* (where the potential drops to about 8.5 volts) and passes through the top terminals of *SW1* to supply the filaments of the set.

The filter capacitors are meant to remove hum from the lines. Capacitor *C1* is a small .047-µf unit meant to bypass line noise from the "hot" lead of the power plug. As a safety measure, the low end of *C1* is returned through another capacitor in series to ground. Thus, even if *C1* should possibly short-circuit, the worst that might happen would be a loud hum. (If *C1* were returned directly to ground, sparks would fly when it shorted.)

Capacitor *C2* is an electrolytic filter from the 100-volt point to ground (also using another capacitor in series to ground as a safety measure). Capacitor *C3* is the second electrolytic filter that keeps hum out of the filament lines. Capacitor *C4* is the safety series capacitor to ground.

Switch *SW2* is the ON-OFF switch. When turned off, it opens the filament circuit, thus opening the primary ac-dc line or filament battery (whichever is in use). It also opens the B+ circuits. When switched on, it completes both A and B circuits providing continuity for all types of power.

Figure 2-2 shows a typical three-way power supply, with a vacuum-tube rectifier supplying the power when batteries are not in use. Switch *SW1* selects ac-dc or battery operation. This opens or

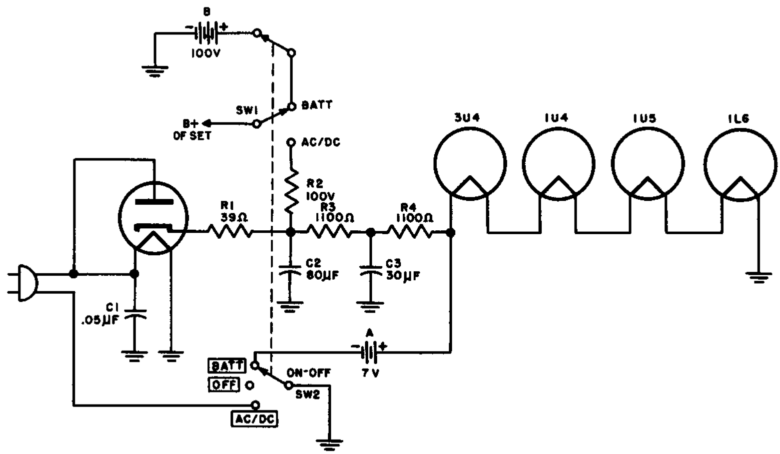


Fig. 2-2. The typical power supply of a three-way portable radio using a vacuum-tube rectifier.

closes the B-battery supply, also selecting either battery power or rectifier power for B+ circuits in the set. Since *SW1* is ganged to *SW2*, a single control takes care of all switching. Switch *SW2* completes the A-battery circuit or the primary ac-dc line. There is also an OFF position, in which all lines are open.

When the switch is in the BATT position, the B-battery supplies power through switch *SW1* to the B+ bus of the set, while the A battery supplies 7 volts to the series filament circuit.

When the switch is placed in AC-DC position, the power line supplies the set as follows: The vacuum tube half-wave rectifier supplies about 100 volts dc from its cathode. The rectified current passes through current-limiting resistor *R1*, where the lines divide. The main B+ line is connected across filter resistor *R2* to the B+ bus of the set. Another branch of the rectified current passes through the double filter-voltage-dropping network of *R3* and *R4*, dropping the output to seven volts for the series filament circuits.

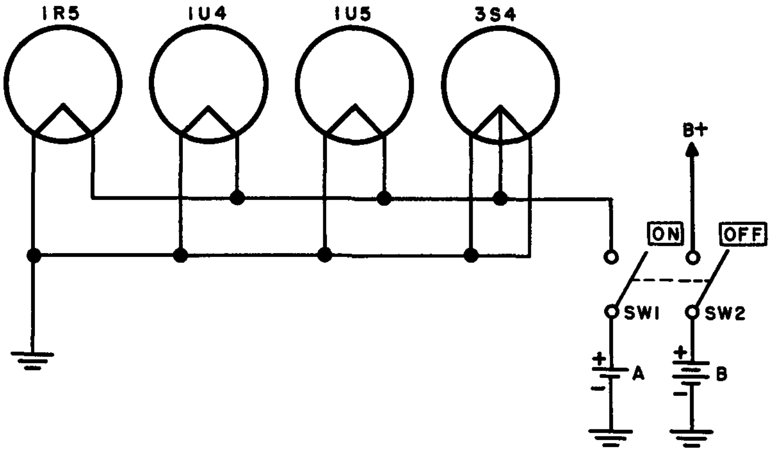


Fig. 2-3. The power-supply circuit of a battery-operated portable radio.

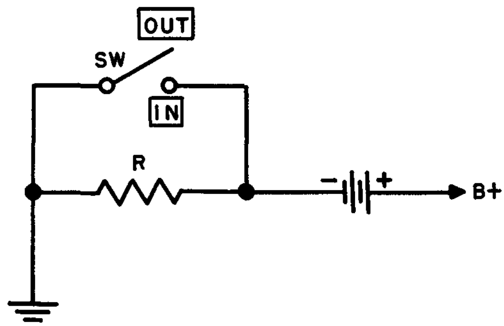


Fig. 2-4. Circuit used to reduce battery drain.

The filter capacitors are straightforward. Capacitor *C1* is a small noise-filtering capacitor for the "hot" line of the power cord. Since *C1* is returned directly to ground (rather than through a second safety capacitor), it is rated at 600 volts. Capacitors *C2* and *C3* are typical 200-volt electrolytics for filtering.

Figure 2-3 represents a battery-set power supply. Switches *SW1* and *SW2* are ganged on a single shaft, so that one knob controls both at once. When switched off, both switches open, breaking continuity for both the A and B batteries, shutting everything off. When switched on, both switches close, permitting current from the A battery to supply the filament circuit and the B battery to supply the plate circuitry.

Many portables now contain some sort of simple circuit and switch to prolong battery life (see Fig. 2-4). In areas of great signal strength, the B+ voltage is reduced slightly, without affecting reception, by inserting the resistor in series with the B+ battery circuits. This reduces battery drain. In areas of average or weak signal strength, the switch is closed. This shorts out the resistor, and applies full B+ voltage, which, although it increases battery drain, increases the gain of the set.

CLOCK POWER SUPPLIES

The clock power supply is the familiar a-c power supply with an ON-OFF switch, controlled manually or by a clock mechanism. A typical clock-radio power supply is shown in Fig. 2-5. The motor field is directly across the a-c input source and therefore is not con-

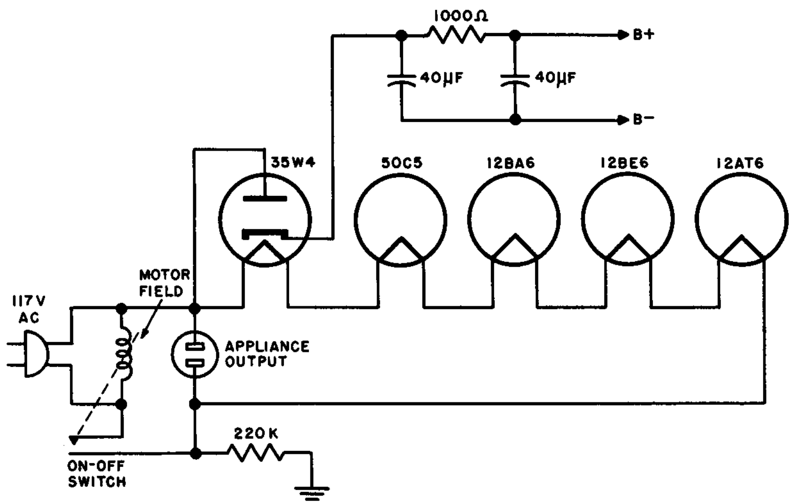


Fig. 2-5. The power supply of a clock radio.

trolled by an ON-OFF switch. An appliance outlet may also be placed across the a-c line, but will be controlled by the ON-OFF switch. A typical clock movement will consume 2 watts of power, but (since it is connected directly to the line) does not affect the operation of the radio.

TRANSISTOR POWER SUPPLIES

The transistor radio does not require the elaborate power supply used in the vacuum-tube radio. The big difference is that there are no heater or filament circuits to consume power. This makes the problem of transistor power supplies relatively simple. All power requirements can be fulfilled from small size batteries.

Transistors usually require a different arrangement of potentials than do vacuum tubes. The base-emitter circuit is usually quite low in impedance. Power is consumed in this circuit. The power supply must therefore be capable of supplying a bias current, rather than a bias potential as in the grid-cathode circuit of a vacuum tube.

Since transistors may be of the *p-n-p* and *n-p-n* types, negative and positive collector potentials must be available. Polarity is important in transistor radios, since transistor damage may result from improper polarity. *Observance of proper polarity cannot be stressed too strongly.*

In presently used transistor circuits, input voltages range up to 25 volts and current drains up to 100 ma. Because of the collector sensitivity to changes in emitter current, it is frequently necessary to provide the emitter bias from a high resistance in series with a constant-voltage source.

Figures 2-6, 2-7, and 2-8 are typical supply circuits using *p-n-p, n-p-n,* or both types of transistors. In Fig. 2-6, since *n-p-n* transistors are used throughout, the emitters are negatively polarized. There is a simple technique for remembering this polarity: The first letter of the transistor type indicates the polarity of the emitter. Thus, a *p-n-p* must have *positive* polarity connected to the emitter; an *n-p-n* must have *negative* polarity. The emitter is represented by the arrow in the transistor symbol. When this arrow *points* into the symbol (note that "point" begins with a *p*), the transistor is a *p-n-p*. When the arrow does *not* point into the symbol (it points *away* from the symbol), it is the *n-p-n* type (refer back to Figs. 1-7, 1-8, and 1-9).

Since the set having the circuit in Fig. 2-6 uses *n-p-n* transistors, the emitters would be connected to the negative terminal of the battery. This is confirmed by inspection of the diagram. (Note that *R1* is a series current-limiting resistor for the emitters of all stages.)

Another simple rule of transistor polarity is: the polarity of the collector is *opposite* to that represented by the final letter of the type. Since this set uses *n-p-n* transistors, the collector polarity will be *positive*. You can easily trace the positive battery potential through the ON-OFF switch to the output collector. This might be the final stage. As in all good design practice with a common supply,

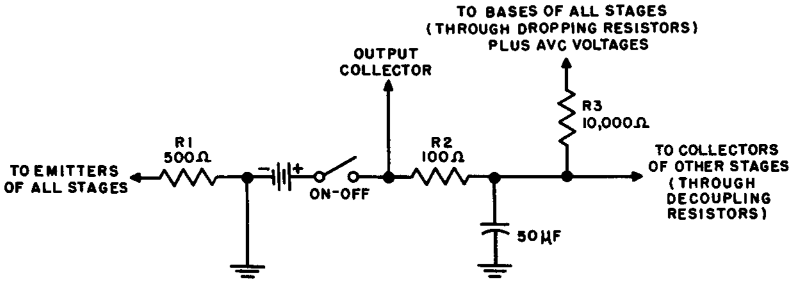


Fig. 2-6. Supply circuits of portable radios using *n-p-n* transistors.

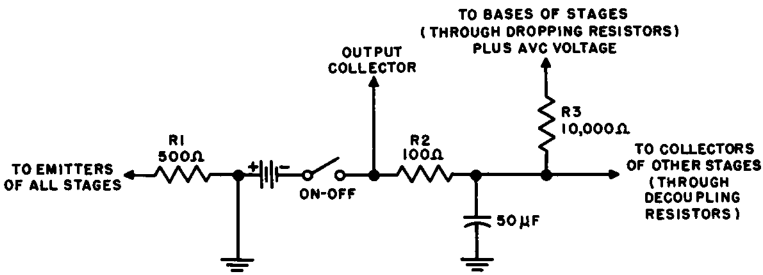


Fig. 2-7. Supply circuits of portable radios using *p-n-p* transistors.

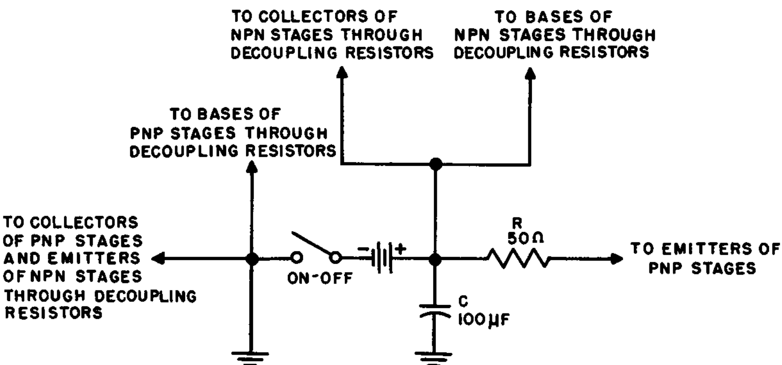


Fig. 2-8. Supply circuits of portable radios using both *n-p-n* and *p-n-p* transistors.

decoupling network resistors (such as *R2*) and a decoupling capacitor (such as the 50-μf low-voltage unit) keep undesired feedback to a minimum.

In general, the polarity of the base is the middle letter of the transistor type (positive in an *n-p-n* type; negative in a *p-n-p* type).

Caution should be exercised here, since the base supply in many sets is made up of resistors in a network in which polarity is not readily apparent. In Fig. 2-6, the base receives its positive polarity (*n-p-n* transistor) through voltage-dropping resistor *R3* in series with *R2*. All transistor bases receive their potential from the same point. They generally have additional dropping resistors to set up the exact voltage required for specific stages.

In Fig. 2-7, *p-n-p* transistors are used. Comparison of Fig. 2-7 with 2-6 shows that only one change has been made in the circuit — the polarity of the battery has been reversed. Note that all conditions are met by this slight change, despite the fact that a different type of transistor is used.

In Fig. 2-8, a combination of *p-n-p* and *n-p-n* transistors is used. By the transistor polarity rule, the negative battery terminal is applied (through the ON-OFF switch) to all negative points in the transistors, including *n-p-n* emitters, *p-n-p* collectors, and *p-n-p* bases (through appropriate decoupling and voltage-dropping resistors as required). The positive battery terminal is applied to all positive points on the transistors, including *p-n-p* emitters, *n-p-n* collectors, and *n-p-n* bases (through appropriate decoupling and voltage-dropping resistors as required).

THREE-WAY POWER SUPPLY

Figure 2-9 is a schematic diagram of the power supply circuit of a modern three-way portable radio. To operate the radio on batteries, the line plug (polarized so that it can be inserted only one way) is inserted in the receptacle *within the set.* This activates *S1* with the "X" pin of the plug only. The "X" pin connects pin 7 of *S1* to pin 4 of *S2,* at the same time pushing a switch to connect pin 2 to pin 3 and pin 5 to pin 6 of *S1,* making the battery connections. However, the ON-OFF switch, *S2,* must be placed in the ON position prior to operation. As the plug is removed from *S1* within the set, movable pin terminals 3 and 6 return to their normal position as shown in the drawing for ac-dc operation. For ac-dc use, the plug is inserted in the wall receptacle, where the slight difference between plug pins has no effect.

The simplified filament circuit shows that the power output tube, 3V4, has its filament nearest the A+ terminal. This places the cathode point (centertap of filament) at a relatively high positive potential, so the 3V4 control grid return to a relatively low positive terminal (pin 1 of V2) places the grid at the proper negative bias with respect to the cathode. Resistors *R1, R2, R3,* and *R4* in the

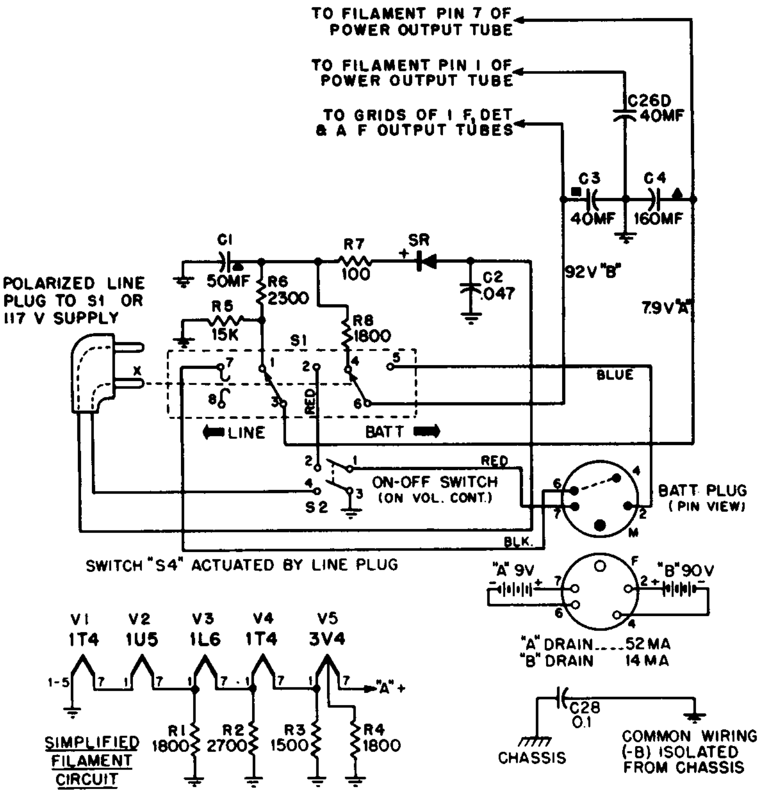


Fig. 2-9. Schematic diagram of power supply of three-way portable. RCA.

simplified filament circuit act as filament shunt resistors, protecting the sensitive filaments from surges of plate current.

In ac-dc operation the line plug delivers 117 volts to the selenium rectifier *SR*. Bypass capacitor *C2* prevents line noises in the audio range from disturbing radio reception. Rectified voltage output of *SR* is filtered by *R7* and *C1,* making 92 volts of B supply available after passing through additional filter *R8,* through switch *S1* contacts 4 and 6. The same rectified voltage at the output of *R7* is dropped by voltage divider *R5-R6* down to 7.9 volts, passing through switch *S1* contacts 1 and 3 to supply the ac-dc filaments of the set.

ARRANGEMENT FOR 230-VOLT OR 117-VOLT OPERATION

Three-way portables that can operate from either 117-volt or 230-volt house power lines are becoming increasingly popular. The basic operation of the power supply is not affected because, in either case, the set itself sees only 117 volts coming in.

Figure 2-10 shows the switching arrangement in a typical receiver of this type. When *SW* is in the 117-VOLT AC-DC position (the condition actually shown in the diagram), the power line is connected directly to the receiver. (Note that the upper power-plug line goes through *SW,* bypassing the network of resistors and diode, and continues as the "hot" 117-volt line to the set.)

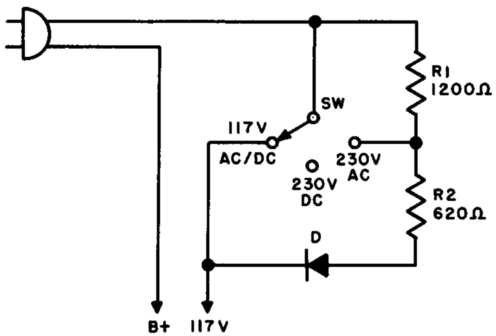


Fig. 2-10. Power-supply arrangement for 117/220-volt operation.

When switch *SW* is in the 230-VOLT DC position, the upper power-plug line goes through *R1* and *R2* in series (the two resistors lower the 230 volts to 117 volts), while *R2* also acts as current-limiting resistor for rectifier-diode *D*. The rectifier-diode converts whatever comes through that line to dc. Because direct current is already coming in that line, the rectifier-diode acts as a low impedance, allowing it through without attenuation. (Diode *D* really serves no useful function in this case.)

In the 230-VOLT AC position, *SW* shorts out *R1* (the 1,200-ohm voltage-dropping resistor), leaving *R2* as the combined voltage-dropping current limiting resistor. The rectification causes a significant voltage drop (which did not occur when the 230-volt d-c power was delivered through the circuit), thus allowing *R2* to serve adequately for alternating-voltage-dropping. It must be remembered that the output arrow marked 117 volts is just the *input* to the set; the power must still be filtered within the set by a filter capacitor that draws appreciable ripple current on a-c operation. Shorting out *R1* during 230-volt a-c operation compensates for the additional drop across the filters, confirming the fact that *R2* alone is adequate for a-c use.

SWITCHING METHODS

A majority of the servicing problems with portables is caused by the only mechanical part involved — the switch. This is to be expected, since any switch that is subjected to moving, dirt, moisture,

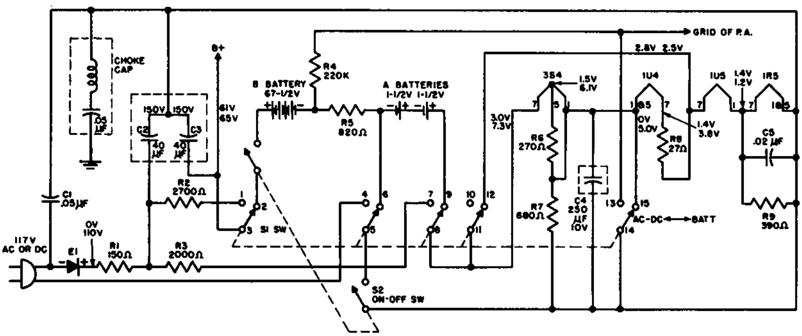


Fig. 2-11. AC-DC-BATTERY switching, with S1 for choice of power and S2 as ON-OFF switch. *Motorola, Inc.*

and other abuses, is bound to break down. On multiband sets, the switching problem is a frequent cause of equipment failure.

On straight portables, the switching arrangement is rather simple, since it is limited to on-off switching. On three-way sets, however, problems exist because of the complexity of the switching arrangements. The three-way sets use different types of switches to achieve the same thing. Some are extremely simple (e.g., the use of a prong of the a-c plug to complete the battery circuit); others use ganged wafer switches. The service technician must become familiar with some of the common switching arrangements. Figures 2-11, 2-12, and 2-13 illustrate various methods of switching used by manufacturers of three-way receivers.

In Fig. 2-11, switch *S1* (shown in BATTERY position) prepares the set for B+ continuity. When *S2* (shown in OFF position) is switched on, the B+ from the 67.5-volt B battery is applied through the closed contacts of *S2* and through terminals 2 and 3 of *S1* to supply B+ to the set proper. B− is connected through terminals 6 and 5 of *S1* to ground (heavy line on drawing). This is also the A− line. The A+ line is connected from the A battery through terminals 9 and 8 of *S1,* and the full 3 volts is placed across the 3S4 filament. At the same time, a parallel path for the A+ is made available through terminal 15 of *S1,* so that 3 volts is placed across the 1U4 filament, with dropping resistor *R8* in series. The same 3 volts is also placed across the 1U5 and 1R5 in series to complete the filament circuit.

For ac-dc application, the rectified 117 volts is fed through *R1* and through terminals 1 and 3 of *S1* to supply B+ to the set proper. The same rectified 117 volts is applied through *R3* (which reduces it to 7.3 volts); the lowered voltage is connected through terminals 7 and 8 of *S1,* to supply all the filaments in series.

Figure 2-12 shows the power switch (*S2*) in AC position with all connections made for such operation. If *S2* is switched to BAT-

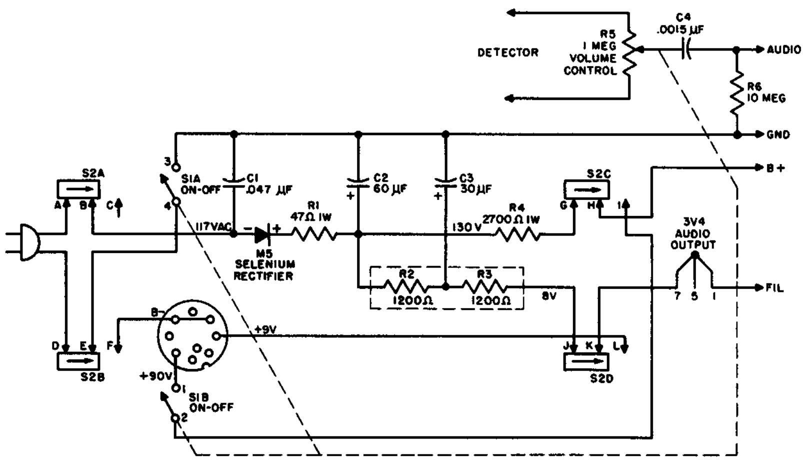


Fig. 2-12. AC-DC-BATTERY switching, with slide switch for power, plus ON-OFF switch. ***Motorola, Inc.***

TERY, *S2A* immediately opens the high side of the line cord connection. Switch *S2B* also opens the other side of line cord connection, connecting B− from the battery to the ground line. Switch *S2C* switches B+ from rectifier to battery. Switch *S2D* connects the filament line to the 9-volt battery or rectified line voltage as required. Switch *S1B* is the set's ON-OFF switch.

Figure 2-13 shows a portable switched for ac-dc use. Although it is not apparent in the schematic, switch *S* is a spring-loaded switch actuated by unplugging the line plug from a receptacle in the set.

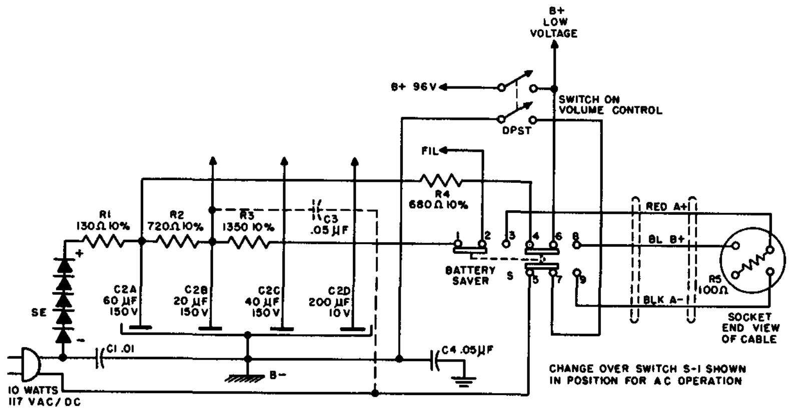


Fig. 2-13. AC-DC-BATTERY switching. ***Zenith Radio and Television Corp.***

Thus there is no visible switch on the set. When the line cord is unplugged from the "battery saver" outlet in the set, continuity is provided for normal ac-dc operation. The volume control (not shown) has the customary ON-OFF *switch.*

When the line cord is plugged into the "battery saver" in the set, the danger of a-c plug-in while the battery is in the circuit is eliminated. In BATTERY operation, switch *S* moves the slider one position to the right, completing the battery circuits. The four sections of capacitor *C2* provide filtering for different B+ voltages when the set is operating on AC-DC.

BATTERIES

At present, no less than 80 different types of batteries are used in portables. No one is expected to keep all of them in stock, especially since they become outdated rather quickly. Therefore, the first problem is to narrow the types on hand to a reasonable number. Table 2-1 shows the types that will take care of more than 75% of battery requirements.

Table 2-1

Type	*NEDA Number*
A - B	400, 401, 404, 405, 415
A	3, 7, 13, 19, 20
B	200, 201, 202, 203, 204, 211

Since different battery manufacturers arbitrarily select different coding systems for their batteries, it is difficult for the technician to replace a radio's batteries if he doesn't have the exact manufacturer's replacement battery.

To simplify this, some manufacturers provide substitution charts to show which of their batteries are available for different sets. While this is of value, the service technician may still be in difficulty if a set requires a battery whose replacement substitute is not made by the manufacturers whose batteries he stocks. Of course, the technician can store replacements from *all manufacturers,* but this is cumbersome. Recognizing this problem, NEDA (National Electronic Dealers Association) has taken steps to help.

NEDA has assigned standard code numbers to all types of batteries (regardless of source of manufacture). Such interchangeability lists plotted against the master NEDA listing are available. In the future it is expected that battery manufacturers will include the NEDA type number directly on the face of the battery in addition to their own type number, for ready replacement by competitive battery types. Figure 2-14 (on the foldout at the back of the book) is the master NEDA Battery List.

No list can be absolutely comprehensive; however, Fig. 2-14 shows the most complete list now available. A few additional facts may help in the use of this list: *Olin* and *Winchester* are brand names of batteries manufactured by the same firm; *Winchester* numbers are the same as *Olin. Bond* batteries (not shown in the list) also generally follow *Olin* numbers. Where they differ, the third digit of a 4-digit *Olin* number of "1" is "2" for the same *Bond* battery. A few examples of this are given in Table 2-2.

Where there is a doubt as to the battery type used, inspection of the battery-connector plugs in the portable radio may aid in determining the proper replacement model. The NEDA Socket Terminal Guide (Fig. 2-15) will assist in identification. For example, suppose a portable is brought in with the original battery so corroded

Table 2-2

NEDA Number	*Voltage*	*Olin Number*	*Winchester Number*	*Bond Number*
6	6	4914	4914	4914
7	4½	4918	4918	4928
8	7½	5219	5219	5229

that identification is impossible. Suppose even worse: the customer has thrown out the old battery and brought in the set without battery for battery replacement. There is no identification anywhere: no make, no model, no hint of battery type.

Compare the battery plug with the battery socket drawings shown in Fig. 2-15. Note that no two socket drawings are absolutely

SOCKET TERMINAL GUIDE

NUMBERS TO RIGHT OF SOCKETS ARE NEDA BATTERY TYPES. CHART ADAPTED FROM OLIN GUIDE

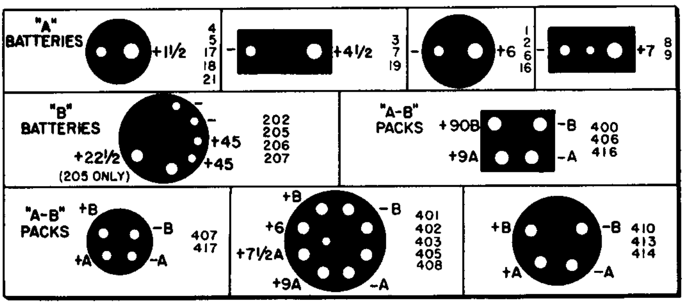


Fig. 2-15. NEDA Socket Terminal Guide. ***Electronic Technician.***

identical. Two sets of sockets are *similar* (the 1½-volt and 6-volt "A" series and the four-hole circular "A-B" packs); in these special cases, check doubly for possible voltage differences and hole spacing as well as socket size (since there are in every single case, small size differences in the terminals and their sockets). When you have identified the battery socket, note that beside it (Fig. 2-15) is a list of NEDA battery types that will satisfy these voltages.

RETMA (the Radio-Electronic-Television Manufacturers Association) has prepared the RETMA Terminal Guide (Fig. 2-16), which is different from the NEDA Socket Terminal Guide. The RETMA (now EIA – Electronic Industries Association) Guide lists

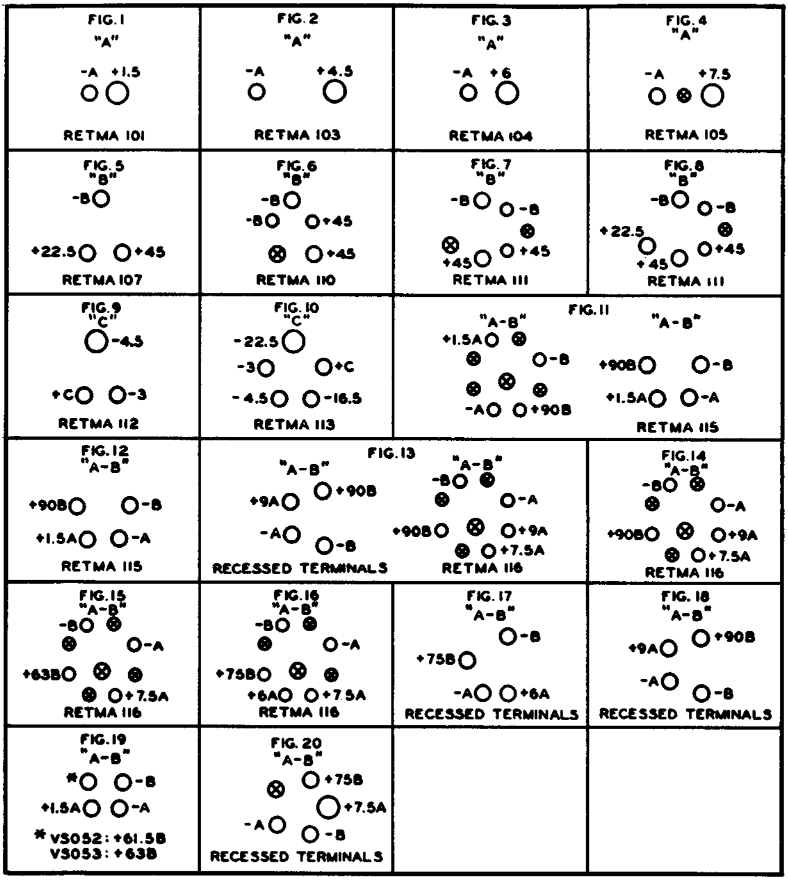


Fig. 2-16. RETMA Terminal Guide. RCA.

more types (special purpose, industrial, etc.) to make a more comprehensive listing, with specific RETMA terminal numbers in almost all cases. In the RETMA chart shown in Fig. 2-16, RCA batteries are listed as a guide for each case. By cross-referencing the RCA batteries with the master NEDA Battery List (Fig. 2-14), it is possible to identify any battery having any of the terminals shown. Of course, several batteries may have the same terminals, so discretion must be exercised; it should not be assumed that a battery will fit the application just because one plug mates with the terminals.

Both the NEDA and RETMA tables are given so that you may use the NEDA Socket Terminal Guide (Fig. 2-15) as a quick guide to most home portables, and the more detailed RETMA Terminal

Guide (Fig. 2-16) for those difficult cases not covered in the condensed guide.

TESTING

Naturally, the best way to test batteries is by trying them in a set. A voltage reading across the battery (without load) will not show the true charge remaining in the battery. A load, approximately simulating the radio set load, can be placed across the battery by means of a resistor, reading the voltage across the battery at the same time. An approximate value of load resistance for an A battery is 180 ohms; for a B battery the value is 2,500 to 5,000 ohms, depending upon plate current, with the lower value used for higher values of plate current. For more complete testing use Table 2-3.

Table 2-3

New Battery Voltage (volts)	*Test Load (ohms)*	*Minimum Voltage Test Load (volts)*	*Minimum Voltage No Load (volts)*
1½	5	0.8	1
3	10	1.6	2
4½	45	2.4	3
6	120	3.2	4
7½	150	4.0	5
9	180	4.8	6
45	4500	24	30
67½	6700	36	45
90	9000	48	60

Note: 1. All resistors should be at least ½ watt.
2. Allow battery to "operate" 5 minutes before making any measurements.

INSTALLATION PRECAUTIONS

Each manufacturer has designed his set electrically and physically to use a specific set of batteries. Therefore, the first and most obvious precaution to follow is to use the specified batteries. Secondly, replace all batteries in the set simultaneously. This measure saves inconvenience and future embarrassment. Before installing the new batteries, remove (with fine sandpaper) any corrosion caused by battery leakage. It is also important to check the battery cable.

Repair or replace any frayed wire or poorly soldered pin connections. In short, do more than merely replace a battery – do a service job.

As an aid to the service technician, many battery manufacturers have prepared complete listings of portable radios, by manufacturer and model number, showing the battery manufacturer's replacement for the receiver's batteries. It is a good idea to collect as many of such lists as possible in order to simplify the battery replacement problem. Also, many portables have labels pasted inside them showing recommended battery replacements. Frequently several alternative batteries of different manufacturers are listed. Also, service literature usually recommends a battery replacement.

STORAGE OF BATTERIES

High temperature and humidity greatly reduce the shelf-life of batteries. (Shelf-life is the time that an unused item, as on a dealer's shelf, can retain its original specifications, so that it is equivalent to a new unit just delivered by the manufacturer.) If a battery remains on your shelf longer than its recommended shelf-life, deterioration will begin. Therefore, batteries should be stored so that their deterioration is slowed down and their shelf-life increased. In certain batteries, deterioration is slowed chemically, by withholding water (in storage batteries) or by sealing in a chemical ampoule that must be smashed internally by striking the battery against a solid object before any battery action can begin. In the main, however, these are unusual innovations, rather than common practices.

The first step in caring for batteries in storage is to seal them in moisture-proof material. Make sure the package is well sealed. Then try to store the package in an area in which the temperature remains around 45°F (lower temperatures are better, if available). Avoid extreme temperatures (zero or below). To use a stored battery (when kept in sealed storage for a length of time), remove the wrapping and allow the battery to warm up to room temperature. Do not attempt to use the battery until it has had time to warm up, otherwise low outputs will be obtained and permanent damage may result.

SUGGESTIONS ON BATTERY USE

Since the rate of battery deterioration varies with temperature, it is suggested that the battery compartment in the radio be well ventilated. Using discretion, in some cases it may be possible to drill ventilating holes in the chassis and/or cabinet to increase ventilation. Batteries, like capacitors and similar components, suffer at high temperatures. Arrange for ventilation of batteries as you would for filter capacitors or rectifier diodes.

EXHAUSTED BATTERIES

During discharge, the zinc (negative terminal) container of individual cells may corrode, developing small holes in the zinc cover. Battery fluid may leak through these holes and attack the metal parts of the radio. Also, an exhausted battery often swells, causing further equipment damage. Therefore, watch for signs of an exhausted battery, and replace any such battery immediately.

RECHARGEABLE WET CELLS

Although the lead-acid cell battery is probably the most popular secondary (rechargeable) cell type – if for no other reason than that every automobile uses one – in portable radios (though some small glass-cased units have been used), the lead-acid cell generally yields to the nickel-cadmium cell in popularity. The relatively new silver-zinc cell is just coming into its own.

Among the reasons for the popularity of nickel-cadmium wet cells in portables is that the alkaline electrolyte (compared to the acid electrolyte in lead-acid cells) permits use of strong, easily machined, relatively lightweight steel for grids and cases; the electrolyte has a relatively constant resistance during storage, charge, and discharge (permitting long storage in any state of charge, including complete discharge); the cell has excellent voltage-regulation during discharge.

As for charging, the nickel-cadmium cell generally uses an ac-dc portable radio power supply through a simple series resistance. Optimum charging, generally performed only by the manufacturer, is based on a charge of 140% of rated cell capacity within a maximum of 3 hours. In the field, the rate is considerably reduced, with a much greater period of time involved.

Figure 2-17 shows a nickel-cadmium cell charging circuit based on a 14-hour charging rate. The simplified drawing does not show the switching circuitry that switches the ac-dc power supply from the tube-filament circuits through the cell-charging resistor, *R1*, to the cell. Similarly, other switches place the nickel-cadmium cell across the tube-filaments in battery operation. *In no case does the cell receive a charge while the radio is operating.*

Although the charging circuit has been shown for the nickel-cadmium cell, the same circuitry could be used in other sets to

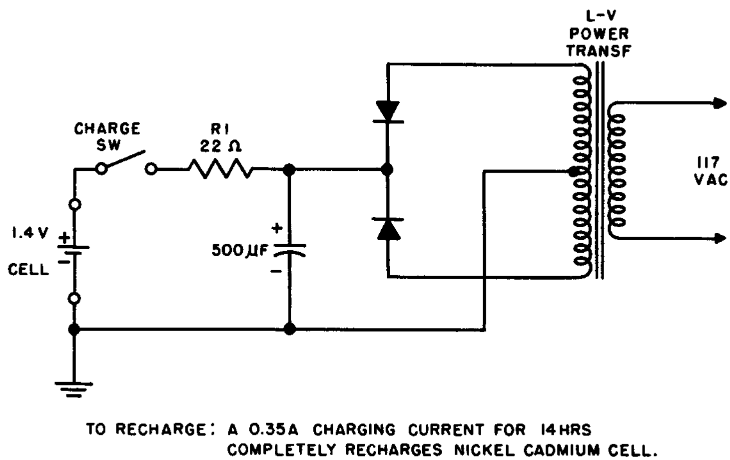


Fig. 2-17. A nickel-cadmium cell charging circuit.

charge lead-acid and silver-zinc cells, with some variation in series resistance for charging rate. The chemical composition of the cell does not affect the charging method involved.

BATTERY REJUVENATOR

In conjunction with rechargeable wet cells, mention should be made of the battery-rejuvenation technique with dry cells (B batteries, exclusively). Although such primary cells are not strictly speaking rechargeable, it is possible to prolong their life by this rejuvenation technique. Figure 2-18 shows a simplified battery-rejuvenator circuit. (All switching that uses the radio's ac-dc power supply to switch in CHARGE position and places the rectified primary power across the battery has been omitted.) *R2* is the series limiting resistor used to set the charging rate for the set's dry batteries (totaling 90 volts). Resistor *R3* is used for bias purposes. The primary supply delivers something over 90 volts to the dry batteries when switched to CHARGE. The manufacturer claims a doubling or quadrupling of battery life is possible when the battery is charged in this

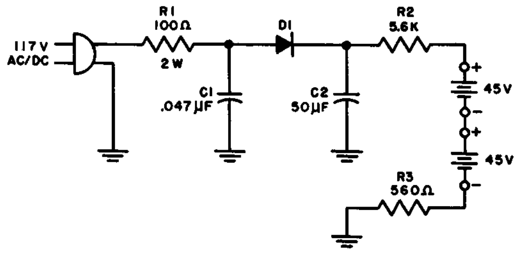


Fig. 2-18. Simplified battery rejuvenator circuit.

manner. A further recommendation is to charge for a time equal to the time the batteries are used; thus, after using the set on batteries for 4 hours, charge the batteries for 4 hours.

MERCURY CELLS FOR USE IN TRANSISTOR SETS

Transistor sets require no filament cells. Their B-battery voltages are very low, rarely more than 30 volts. Because of their economy, battery life is quite long — often several months or more. Thus, mercury cells are frequently used.

Current production of mercury cells is based almost exclusively upon the "RM" system developed by Samuel Ruben about 15 years ago. (The letters *RM* signify Ruben-Mallory, the cells being manufactured by Mallory.) The single cell develops approximately 1.35 volts, and series units are in multiples of 1.35 volts. The mercury cell is a *primary* cell and cannot, by ordinary means, be recharged.

The special characteristics of mercury batteries are:

1. High ratio of energy to volume and weight.
2. Long shelf and operating life.
3. Uniform discharge characteristics.
4. Constant potential.
5. Ability to operate over wide temperature range.

The main disadvantage of these cells is their initial cost, which is several times higher than carbon-zinc batteries of comparable voltage and size.

Popular values of mercury batteries are 1.35, 2.7, 4.0, 5.4, and 6.7 volts. They usually come in cylindrical shapes, with different diameters and heights. Although, like penlite cells, they generally use the button and case for terminals, they are also available in "power-pak" sizes with snap connectors, plug connectors, and tab and pigtail connectors.

GERMANIUM AND SILICON RECTIFIERS

Germanium and silicon rectifiers may be used in place of vacuum-tube or selenium rectifiers in radios. A major saving in size and space results along with a promise of long, trouble-free life. A novel substitution is offered by Hoffman in its type HFWR-1 rectifier, which looks like a metal 6H6 tube, but is actually a full-wave silicon rectifier, in a tube casing used to replace the 5R4-GY.

Germanium and silicon rectifiers (solid-state rectifiers) come in a variety of shapes and sizes, as shown in Fig. 2-19. The selenium stack rectifier has been with the industry for many years. Although

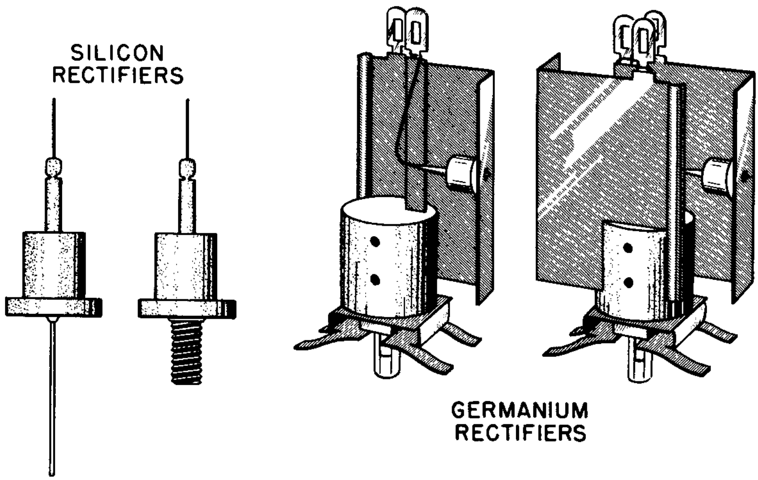


Fig. 2-19. Typical appearance of some germanium and silicon rectifiers.

it does not use a filament supply, it is not markedly smaller than the vacuum tube rectifier. Germanium and silicon rectifiers are much more efficient than vacuum tubes and much smaller, looking more like r-f detectors (in many cases) than power rectifiers.

While high-vacuum rectifiers have large voltage drops with full load, the new efficient solid-state rectifiers operate with as little as 2 volts drop at maximum current rating. The circuitry used with these rectifiers is the same basically at that employed for tube or selenium unit, except that different values of series limiting resistors are required.

SELENIUM RECTIFIERS

Selenium rectifiers are being used in an ever increasing percentage of radio sets. Because of the numerous advantages they offer, such as elimination of filament supply, reduction of space requirements, and elimination of tube socket, selenium rectifiers may someday completely replace vacuum-tube rectifiers in radio sets.

Like tubes, selenium diode rectifiers also decrease in efficiency with use. However, their most common failure is due to accidental overload from a faulty component in the B+ circuit. Therefore, when replacing such a component, the same value and rating must be used.

The troubles resulting from defective selenium rectifiers will usually be among the following:

1. Low B+ voltage, resulting from high forward resistance.
2. Low B+ voltage and hum, resulting from low reverse resistance.
3. No B+ voltage, resulting from open rectifier.
4. No B+ output, resulting from shorted rectifier.
5. No (or low) B+ output, resulting from overheated rectifier.

The most obvious symptom of a defective rectifier is the rotten cabbage (or rotten egg) odor that is characteristic of an overheated rectifier. To confirm the diagnosis that the rectifier is defective, it may be necessary to conduct a few simple tests, as given in Chap. 5.

3. mechanical troubles and repairs

Beside the necessary skill and knowledge for adequate repairs of portable and clock radios, the technician must also have proper tools. Trying to repair without adequate tools is always difficult, and often impossible. Listed below are the tools that should be part of every technician's kit. Although all of the tools may not be used frequently, an attempt should be made to acquire them, so that 99% of all repairs jobs can be undertaken.

Most, if not all, of the tools are familiar to the reader. A few may be considered unusual in their application to radio repair. (The pipe cleaners, for example, do a good job of removing dust and iron particles, when gently inserted into an area where you've just drilled a hole into a chassis.)

All tools should be kept clean and in good working order. (Directions on care and use of some tools and materials will be discussed where appropriate.)

Although not included in the list of tools, it is always advisable to carry such spare parts as may be needed in making repairs. These include small scrap sheets of aluminum; small drilled angle brackets; an assortment of nuts and bolts; knobs; dials; felt feet; cement; tiny screws for mounting dials, nameplates, and clock hands; dial springs; and spare clock hands.

TOOLS AND MATERIALS REQUIRED

1. Soldering gun
2. Soldering iron (not exceeding 35 watts)
3. Diagonal cutters
4. Needle-nose pliers
5. Combination pliers
6. Screwdriver, $\frac{1}{4} \times 4$ inch
7. Screwdriver, $\frac{1}{8} \times 4$ inch
8. Phillips screwdriver No. 2
9. Spin-type ("Spintite") wrenches
10. Pocket knife
11. Soldering tool
12. Electrical socket wrench set
13. Optometrist's tools (for small parts)
14. Triangular file
15. Rat-tail file
16. Flat file
17. Flashlight
18. Hacksaw
19. Hand Drill (Nos. 4, 10, 18, 28, and 33 bits)
20. Portable electrical drill ($\frac{1}{4}$ inch, with high-speed bits)
21. Hammer, centerpunch, and punch
22. Cold chisel
23. Vise
24. Tube pullers
25. Dial cord
26. Furniture polish
27. Scratch stick
28. Scratch removal polish
29. Spirit stain (several shades)
30. Touch-up enamels and lacquers
31. Alcohol
32. Polishing pad
33. Garnet paper
34. Fine steel wool
35. Several small brushes
36. Stick shellac
37. Shellac rubbing fluid
38. Alcohol
39. Spatula
40. Wood glue
41. Plastic glue
42. Pipe cleaners

DIAL CORDS

The great majority of portable and clock radios use dial-cord drive systems. While it is impossible to cover all types of arrangements, the basic systems discussed here will provide sufficient basic knowledge of all systems.

There are two main types of dial-cord tuning systems: the pointer rotating on a round tuning dial (Fig. 3-1), and the pointer moving along a horizontal or vertical straight dial (Figs. 3-2 and

3-3). Both systems present the same servicing problems; if the servicing of the rotating-pointer is understood, the sliding-pointer can also be serviced.

DIAL-CORD SLIPPAGE

The greatest source of trouble in dial-cord drives is slippage. Slippage may be due to insufficient tension, a smooth cord surface, or the binding of a moving part.

A loose cord can be tightened in several ways. The easiest way is to replace the stretched spring, thus increasing spring tension. Another way is to untie the dial cord and retie it with greater tension

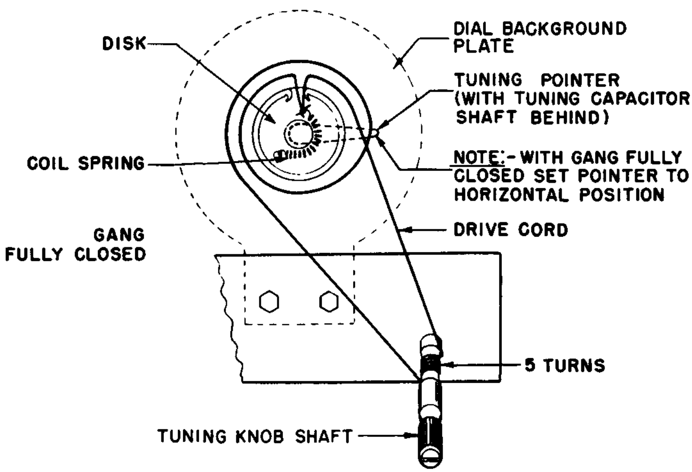


Fig. 3-1. Rotary dial stringing. ***Motorola, Inc.***

(taking up as much slack as the cord will allow). This will change the cord length, and may require resetting the dial pointer: tune to a known station, adjust the dial pointer to this station, retie the dial cord tightly, and test by listening to the station.

When retying a dial cord, the old knot sometimes cannot be untied. If this is the case, cut the knot off and retie with a square knot. For emergency cord-tightening operation, untie the cord and spring and twist the cord a few times. The twist tends to shorten the cord. A popular emergency operation is to cut the spring to a shorter length and replace it and the old cord, providing greater

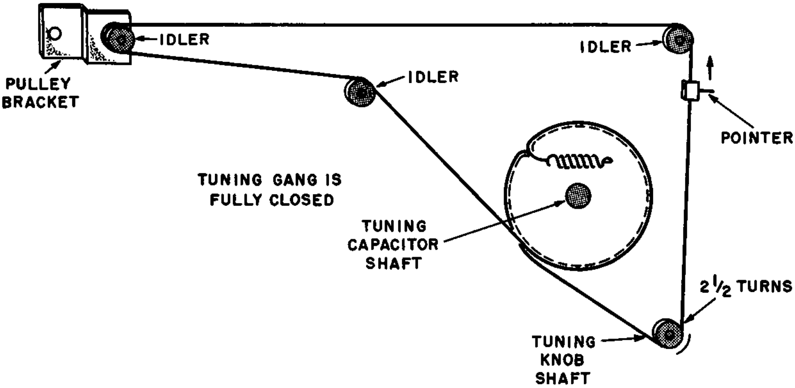


Fig. 3-2. Vertical slide-rule stringing, for a vertical dial indicator.

tension. Generally, cutting the spring is less desirable than replacing it, since a shorter spring is stiffer and "gives" less.

When a dial cord slips, but has no slack, a friction compound can be applied. This is available in stick, powder, or liquid form. (When you find a favorite variety, add it to your list of tools. Follow the manufacturer's directions in applying the friction compound. A home-made variety can be formulated by dissolving some rosin in alcohol or gasoline. Treated cords, however, rarely work well for a long time; hence, replacement is always best.

DIAL-CORD THREADING

Once the fundamental dial-cord threading systems are understood, replacement of dial cords can easily be mastered. The simplest arrangement is the *rotary dial,* shown in Fig. 3-1. The dial cord is looped several times (five turns in the drawing) around the tuning knob shaft with both ends of the cord passing around a disk which is attached directly to the tuning capacitor shaft. The cord ends are drawn into a slot in the disk, and tied to a coil spring drawn tight and hooked to a catch on the disk. The tuning pointer is attached directly to the tuning capacitor shaft (here the pointer is horizontal, with tuning capacitor gang fully closed). Such a rotary dial system uses the fewest parts, with only two shafts connected in line by the dial cord. The pointer describes an arc as the tuning shaft is rotated.

Figure 3-2 shows the slide-rule arrangement (with a vertical dial in this case, the frequencies on the dial face numbered from

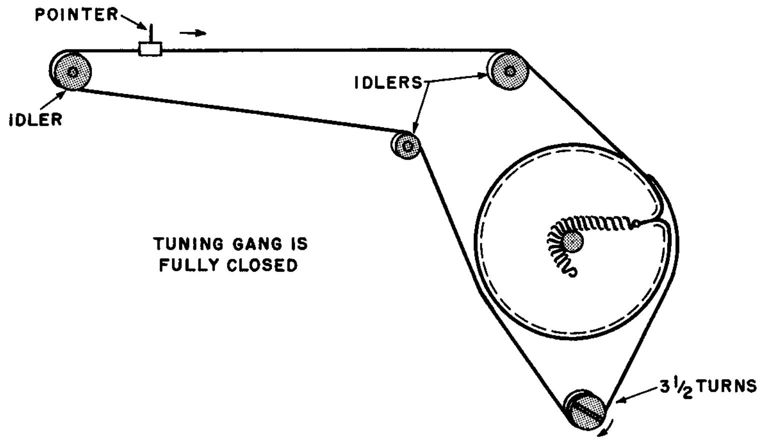


Fig. 3-3. Horizontal slide-rule stringing.

top to bottom). Besides the main tuning knob and tuning capacitor rotating shafts, three additional *idler pulleys* are used. These idler pulleys do not turn anything, and serve only to change the direction of the dial cord, to get around obstructions, and to place the dial and pointer in the desired position. The dial cord is looped a few turns (two and one-half in the case shown) around the tuning knob shaft and looped around the tuning capacitor shaft disk with spring tension, as before – but additional dial cord now goes around the idler pulleys so that the pointer moves vertically along the dial.

BINDING OF PULLEYS

Occasionally slipping of the dial cord may be due to binding of pulleys or shafts. In this case, straightening or bending the pulley bracket (the device that holds the pulley in place) may help. In other cases, a few drops of oil may "loosen up" the tight idler pulleys. However, never use oil where wooden pulleys are used, since this may cause the wood to swell. For lubricating wooden pulleys, use powered graphite.

HORIZONTAL SLIDE-RULE TUNING

Another slide-rule dial arrangement is shown in Fig. 3-3 (the pointer moves in a horizontal direction, dial numbers going from left to right.) The dial cord is looped a few turns (three and one-half turns in the case shown) around the tuning knob shaft and again looped around a spring-loaded tuning-capacitor disk. The dial cord is also passed around idlers to complete the arrangement, with the pointer so arranged as to travel to the right when the tuning knob is rotated clockwise.

DIAL THREADING IN CHANGING PLANES

In some unusual cabinet designs (sloping panels, for example) the tuning knob is in a different plane than the pointer dial. Here idlers are indispensable, as shown in Fig. 3-4. As with other dial

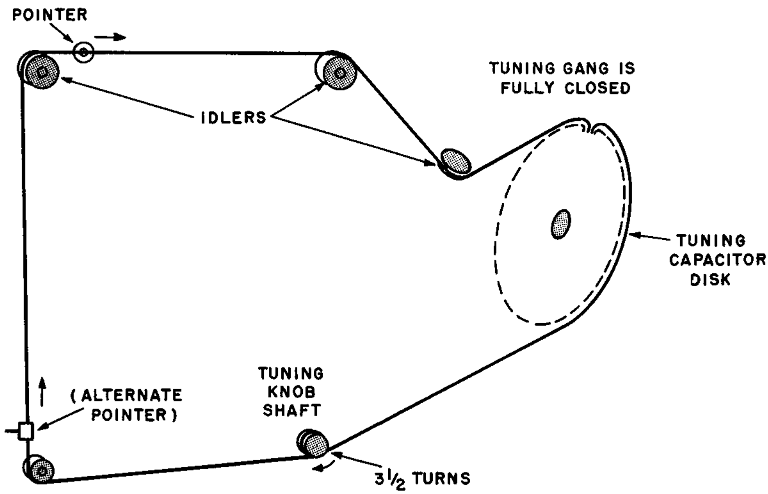


Fig. 3-4. Dial stringing in more than one plane.

cord arrangements, a few turns are placed around the tuning knob shaft, with the dial cord continuing around the spring-loaded tuning-capacitor disk. Note how the various idlers bring the dial cord back into the desired plane. The pointer is shown at the upper left, ready to move horizontally as the tuning knob is turned clockwise. An alternate vertical pointer is also shown, ready to move upward as the tuning knob is turned clockwise, showing how the dial arrangement could handle either a vertical or a horizontal dial.

Figure 3-5 gives another example in which the elements in the dial cord system are in different planes – a 90-degree change of plane.

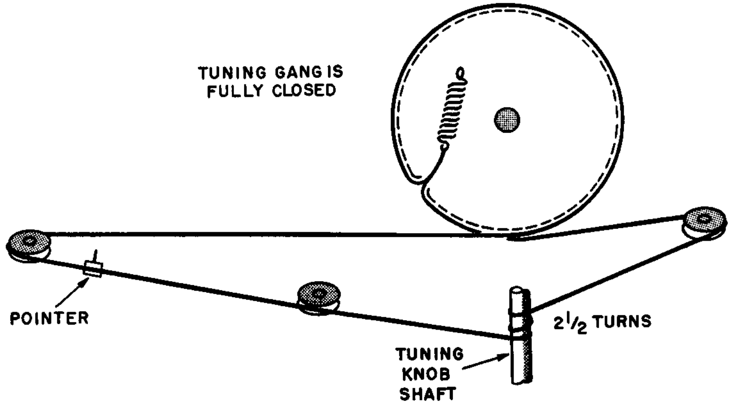


Fig. 3-5. Right-angle dial drive stringing.

Figure 3-5 is a top view, looking into the top of a set in which the line of the tuning gang shaft is vertical, and the tuning knob shaft protrudes from its usual position in the front of the set. A few turns of dial cord are taken around the tuning knob shaft, passed around an idler (at the right), then passed around the tuning capacitor shaft disk. The disk is slotted, so the cord does not slip out. When the dial cord leaves the disk, it again changes plane back to idlers to complete the cord path. The pointer travels horizontally, and the dial cord cord goes through a vertical-horizontal-vertical path.

CROSSED STRINGING

Figure 3-6 shows what at first appears to be a simple rotary dial stringing arrangement. Actually, it is a special case in which it is desired to change direction of rotation from clockwise to counter-clockwise. Thus, after looping a few turns around the tuning knob shaft, the cord *crosses* and loops around the spring-loaded tuning capacitor disk, crossing again as it goes back to the tuning knob shaft. When replacing this cord be especially careful to note that the cord is crossed, otherwise the rotation of the restrung dial will be reversed.

GENERAL AIDS

When restringing dial cords, always use the proper cord. Do not use fish line, twine, or similar materials. There are special linen and nylon dial-cords that are available at all radio supply houses. To be able to restring any model radio, have spools of extra-thin, standard, and medium-thickness dial cord available. Select from these the cord that best matches the old cord of the set being serviced.

Before beginning dial-cord replacement, make a sketch of the stringing arrangement (or obtain a dial stringing diagram, if available in service notes). Then remove the old cord entirely. Before

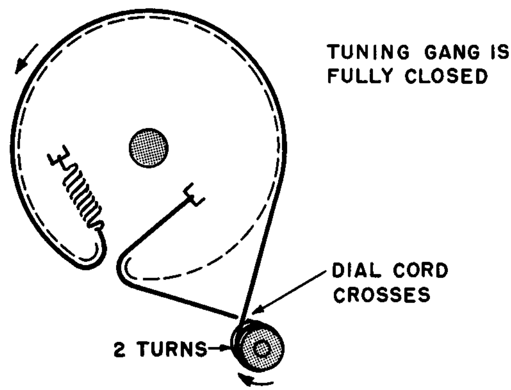


Fig. 3-6. Cross stringing, rotary dial.

starting the restringing, check all knobs, pulleys, and other items in the cording arrangement. Oil or clean where necessary. Note the condition of the spring. Replace it if it is stretched too much.

Start the restringing by tying one end of the cord to the spring with a square knot. Follow the restringing plan until the spring is reached again. Loop the cord through the same end of the spring that you started the stringing from, and pull tight enough to put the spring under tension. Cut off the excess dial cord, leaving enough to tie a square knot. Check the operation of the dial pointer over the entire scale.

With rotating pointers (circular dials) the position of the capacitor shaft (while stringing) is unimportant, since the pointer is attached to it. On slide-rule dials (horizontal or vertical scales), it is important to watch the position of the capacitor tuning shaft. With both types of dials, however, the pointer can be reset after the dial is restrung.

When restringing a set having a number of pulleys, place cellophane tape or adhesive tape over the cord at each pulley, to prevent the cord from coming off while you complete the restringing. A piece of stiff wire, hooked at one end, can be used to pull the cord around bends and pulleys.

MECHANICAL REPAIRS

Unlike console and table radios, portables may be subjected to severe mechanical wear and tear as they are carried around or moved from place to place. The first problem is cabinet repair. Since virtually all clock and portable cabinets are made of plastic, maintenance and repair of plastic cabinets is emphasized.

Plastic Cabinets. Use special plastic cements (available at all jobbers) on plastic cabinets that are cracked or chipped. Clean the surface thoroughly with special plastic solvents, then work the ce-

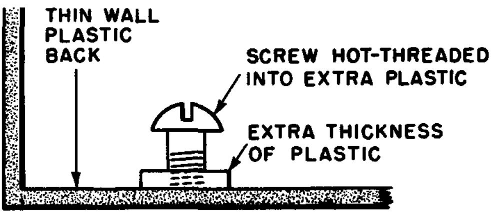


Fig. 3-7. Replacing a stud or machine screw in a thin plastic cabinet.

ment into the crevices. For cracks, clamp the joint together with heavy rubber bands and let the plastic cement set until it is thoroughly dry. (Wipe off the excess cement before it sets.) Use stick shellac (if necessary) to fill into a smooth surface. Remove excess shellac or glue very carefully with a razor blade. Finally, polish the cabinet with a cream-base polish. Badly cracked cabinets should be replaced, since they are difficult to repair and often break again.

If the required materials and time are not available, try the following procedure:

Apply ordinary glue to the edges of the broken sections and place the edges together. Let the glue set for a while and then run a warm soldering iron on the inside of the cabinet along the cracks. Finally, polish the cabinet.

Painted plastic cabinets can be refinished with lacquer enamel. After the enamel has dried, rub lightly with steel wool to blend the old and new surfaces together. The last step, again, is to polish with a cream-base polish.

To create a favorable impression on your customer, before returning any receiver, clean the cabinet with soap and water. Wipe it off with a cloth soaked in clean water. Dry the cabinet thoroughly and then polish it with a cream-base polish or paste wax.

SOLDERING

In connection with mechanical repairs, proper soldering cannot be overemphasized. Since portables are subjected to unusual physical wear, connections often fail if they are not soldered properly. The following rules should be observed:

1. The surfaces to be soldered must be clean. Scrape them with a knife or sandpaper until they are absolutely clean.
2. The joint must be mechanically strong and make perfect electrical contact. Do not rely upon the solder alone to keep the elements together.
3. Enough heat must be applied so that the materials to be joined (not the iron alone) melt the solder. On the other hand, do not use so much heat as to melt insulation or damage other components.
4. Do not use too much solder, and remove any excess. In portables, where components are so closely placed, minute drops of solder touching terminals can short out circuitry, often causing damage.

OTHER REPAIRS

Miscellaneous. If it becomes necessary to insert a screw into a plastic cabinet, an undersized hole should be drilled and a self-tapping screw used, with a few drops of oil.

When a machine screw must be repeatedly screwed in and out of a thin-wall plastic cabinet back, first heat a screw of the desired thread and screw it into a scrap piece of plastic. Do this as many many times as possible, until the scrap plastic and screw work together when cold. When the screw works well in the scrap sheet, cut it to the desired size and cement it in place in the thin-wall plastic back of the set, as shown in Fig. 3-7.

In portables, poor performance is very often caused by dirt in the set. Therefore, it is important that some cleaning and lubrication be performed. A vacuum cleaner is a good source of compressed air for this purpose. Make sure that the blast of air will be strong enough to dislodge dirt without moving components. If lubrication is required, a drop or two of mineral oil will suffice.

Cabling. Fraying and breaking of battery cables constitute another source of trouble. Since the cables are unusually long and subject to twisting and bending, this is understandable. If the battery cable is defective, replace the entire cable, rather than one lead. Standard battery cables with plugs attached are available. These cables are usually color-coded as follows:

Red: A+ and B−
Black: A−
Blue: B+

It is wise, however, to check each wire for proper connections before soldering it, since some manufacturers use whatever colors they may have available. Snap connectors can be adjusted with needle-nose pliers and a small screwdriver.

4. general troubleshooting ■

GENERAL PRECAUTIONS

Portable radios, because of the necessity for saving space, are usually not designed with the serviceman in view. The small size of portables requires using pencil-type soldering irons, needle-nose pliers, and care in working in a small, cramped space. Therefore, when servicing portables, extra precautions should be observed to prevent personal injuries and loss of time and money.

1. In probing around, be careful not to short out any components. Components are generally so close together that it is easy to burn one out by the slightest careless move.
2. Have adequate light available to help you see the small parts and connections.
3. In performing any repair, extreme caution with the soldering iron is mandatory. Components and insulation can be damaged by heat.
4. In the application of solder, use as little as possible removing any excess drops.

5. In testing tubes with an ohmmeter, remember that 1-volt tubes are involved. Use the high-resistance scale. (Using the low-range scale may result in drawing excessive meter current through the filaments.)
6. Use an isolation transformer between the power line and the radio. (Many ac-dc portables have one side of the power line common to the chassis.)
7. Be especially careful when working on the underside of the chassis. Dangerous voltages are exposed, threatening injury to the service technician and to the components.
8. Always disconnect the power cord before making any repairs.
9. When working on top of the chassis, be careful not to bend tuning capacitor plates (this could cause a short, or misalignment).
10. When changing a component held by screws or nuts, replace the lockwashers.
11. Do not overtighten screws inserted through or threaded into plastic materials (plastic threads strip easily, and some plastic cracks more readily than other materials).
12. To avoid new troubles, be very careful when replacing parts.

Note the following items:

1. Before a part is unsoldered, note the position of the leads. If a part has a number of leads, tag each one.
2. Be careful not to damage other leads in pulling or pushing them out of the way.
3. A carelessly soldered connection may cause new faults. Since the poorly soldered connection will be difficult to find later, it is very important to make well-soldered joints at the outset.
4. When a part is replaced in the r-f or i-f circuits, it must be placed in exactly the same position at the original. Give particular attention to proper grounding; use the same ground as in the original wiring (failure to do so may result in decreased gain or possible oscillation in the circuit).

QUICK CHECK FOR THREE-WAY SETS

In repairing portables, much time is lost by having to go through an elaborate procedure in removing a chassis from its case. The following rapid procedures will quickly uncover some common easy-to-repair troubles and determine whether more elaborate troubleshooting is required.

Tube-rectifier type. Remove the batteries and turn the switch to ac-dc. Measure the resistance across the line plug. The normal reading is 100 to 300 ohms. A reading above 300 ohms indicates a defective rectifier, line cord, or switch; a reading of less than 100 ohms usually indicates a bad filter capacitor in the power supply.

To test the filter, remove the rectifier tube and measure the resistance between the cathode hole (pin) in the socket and the line plug (try both prongs). A steady reading of under 20,000 ohms indicates a bad filter. Compare readings between the suspected filter and a filter known to be good before discarding the old one.

The filament circuit can be checked by continuity. A zero (open-circuit) reading indicates an open switch, rectifier, or line cord.

Selenium-rectifier type. The procedure here is similar to that used for the tube-rectifier type. Set the radio for ac-dc operation and, with the ohmmeter on the low- or medium-range scale, measure the resistance across the line plug. A zero (open-circuit) reading should be obtained. Reverse the ohmmeter leads. Again, a zero reading is normal. A reading of up to 1000 ohms or so indicates a bad filter or rectifier. Turn the ohmmeter to the highest scale and take readings in both directions across the line plug. One reading should be 50 times the other. If it is less, the rectifier is suspect.

QUICK CHECK FOR BATTERY SETS

In series-filament sets, the resistance across the A plug will be about 7 ohms per volt of the A battery (about 42 ohms for a 6-volt battery). A reading higher than this indicates a bad tube or bad wiring; a low reading indicates a short in the filament circuit.

The reading from A− to the chassis (or ground) should be zero. The resistance reading from B+ to chassis should be at least 20,000 ohms. A low reading here indicates bad filters or shorts. A reading of more than 2 megohms indicates an open filter or an open resistor between B− and the chassis. The reading from B− to chassis should be zero, or in some circuits, 300 to 1000 ohms.

In parallel-filament sets, the resistance reading across the A-battery plug should be approximately 2½ ohms or less, depending upon the number of tubes. Readings that vary by more than 50% call for further checking and chassis removal.

DETAILED TROUBLESHOOTING PROCEDURES

General. If the procedures given in the quick check do not uncover the cause of faulty operation, the chassis must be removed for detailed examination and complete troubleshooting.

It is a well-known fact that in a great majority of cases more time is spent looking for the trouble in a radio set than in making the actual repair. Therefore, it is most important that troubleshooting time be reduced to a minimum. This can be done only by following a standard procedure in which each step is related to the previous one.

Unfortunately, too few technicians give any thought to planning their procedures, with the result that they try a series of disconnected approaches, which may or may not expose the fault in the quickest time. A generalized, logical procedure is presented below. It can be adapted to any radio equipment, but should always be followed in the order given.

Visual inspection. After the set is removed from its cabinet, make the following visual inspection:

1. Look for any signs of burned resistors or insulation.
2. Look for capacitors that show signs of wax leakage.
3. Look at connections to tube sockets, plugs, and controls.
4. Look for defective solder connections.
5. Look for any bare wires that may be touching the chassis or other wires.
6. Look at the tubes to make sure that they are in their proper sockets. (Surprising as this may seem, many faults are cured by this one step of inspection.) Subminiature tubes are especially difficult to check, since they may fit in each other's sockets easily, and even in their own sockets backwards. Where a paint dot appears next to the first pin (see Fig. 4-1) insert that tube so that its dot corresponds with the paint dot on the chassis, then the first pin of the tube will correspond to the first hole in the socket. Where there is no paint dot, examine the pins to find the two with continuity (the filament) then check with a tube manual to determine the pin relationship.

7. Inspect the power plug and cable. Use an ohmmeter to locate any breaks.

Checking key circuits for shorts. Trouble within the receiver can often be located by checking the resistances of the filament and

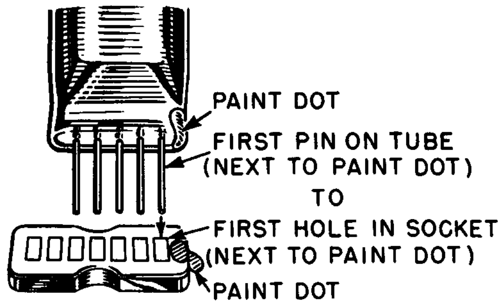


Fig. 4-1. Subminiature tube insertion. *Motorola, Inc.*

B+ circuits. Refer to the manufacturers' resistance tables for the particular set. If the proper readings are obtained, the equipment can be operated without danger of further damage.

Operational Test. The next step is to operate the set while listening for any hissing, sniffing for signs of burning, touching for signs of excess heat, and looking for signs of malfunction. Rotate all controls over their complete range.

Troubleshooting with test equipment. While all the equipment listed below is not absolutely essential, every shop should have these items for efficient operation.

1. An r-f signal generator capable of supplying the r-f and i-f frequencies of the set (approximately from 400 kc to 2 mc).
2. An audio signal generator (any oscillator with a range from 60 cycles to 10 kc).
3. Frequency meter (best quality, to check signal generators).
4. VTVM with a good low-range voltage and reliable resistance scales.
5. Tube tester with facilities for testing miniature and subminiature tubes.

The troubleshooting chart and tables given on the following pages will help to keep testing time to a minimum. They list the more common symptoms, localizing the trouble, and indicating repair procedures. In addition, voltage and resistance measurements should be performed, utilizing the signal-substitution techniques as

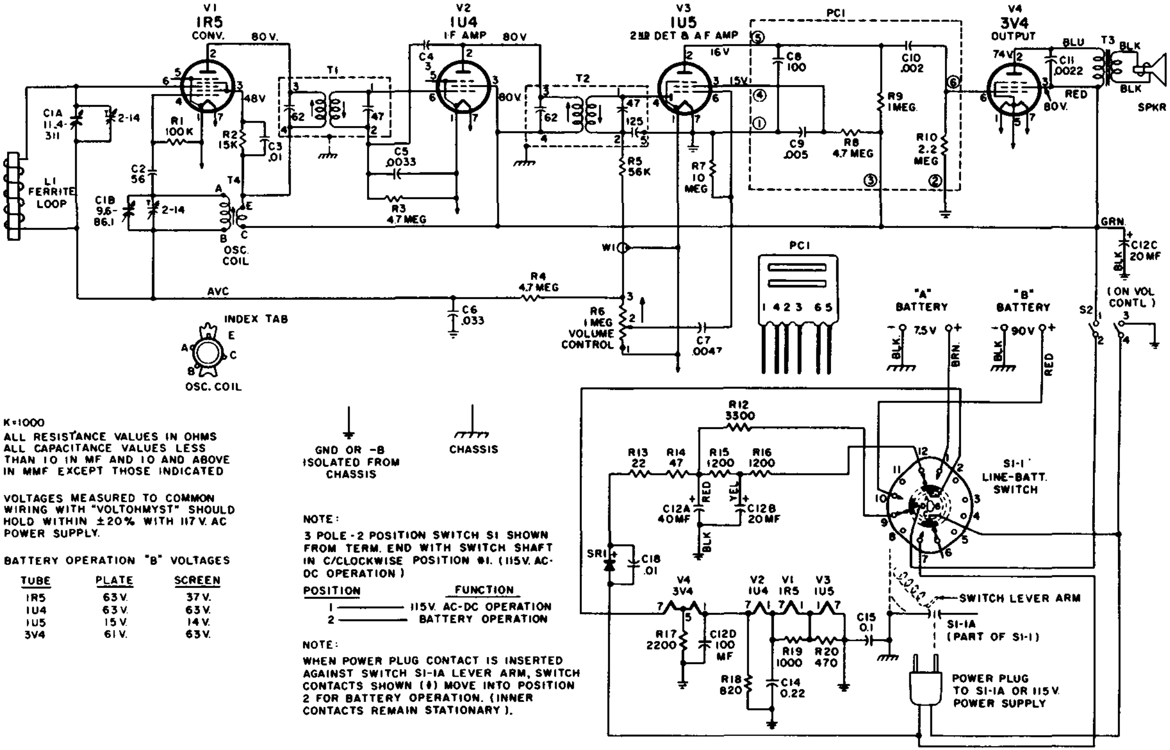


Fig. 4-2. Schematic of ac-dc-battery set showing many conventional circuits. ***RCA.***

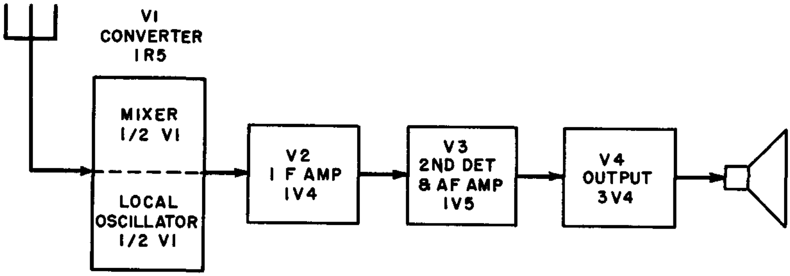


Fig. 4-3. Simplified block diagram of the schematic shown in Fig. 4-2.

indicated. (As an auxiliary technique, stage gain measurements may be performed.)

We will now assume a practical service situation with a typical circuit (Fig. 4-2) shown and discussed. The information can be adapted to any other portables as required. (If your set does not contain the component referred to, skip to the next item.)

As stated previously, this book is not intended as a course in radio fundamentals. However, as a way of summarizing all that has been said throughout, it is felt a rather detailed explanation of a typical receiver on the market today, will enable the technician to overcome unusual servicing problems a bit more efficiently.

For this purpose, we have chosen a three-way portable in which many conventional circuits are found. With a little imagination, the information provided for this set can be used in analyzing other sets.

ANALYZING A TYPICAL CIRCUIT

Figure 4-2 is a schematic diagram of a superheterodyne receiver. Its signal path, as shown in Fig. 4-3, is as follows:

1. The incoming signal from the antenna is applied to the converter, *V1*. This tube is a combination mixer and oscillator that produces the 455-kc i-f signal to *V2*, the i-f amplifier.
2. *V2* is a conventional high-gain amplifier, whose input and output circuits are tuned to 455 kc, the i-f. The output of *V2* is coupled to *V3*, the detector and first a-f amplifier.
3. *V3* is a combination diode detector and pentode amplifier. The i-f signal is demodulated and amplified at this stage. The amplified audio-signal is applied to *V4*, the audio output tube.

4. *V4* is a power amplifier that amplifies the signal sufficiently to drive the speaker.

Converter Stage, V1

1. The converter stage functions as a combination oscillator and mixer. The filament, and grids 1 and 2, form the oscillator. The filament and grids 3, 4, and 5 form the mixer portion of the circuit. The oscillator is the tuned-grid feedback type in which *T4* supplies the required feedback to sustain oscillation. The frequency of the oscillator circuit is determined primarily by *C1B* and *T4*. Grid 2 functions as the plate of the oscillator circuit and grid 3 as the control grid for the mixer section.
2. The r-f signal voltage from the received station is applied to grid 3 (pin 6), which enables it to modulate the electron stream flowing from the oscillator section of the tube. The beating of the oscillator and the received r-f signals results in many different frequencies. However, the primary of *T1* (the *V1* plate load) is tuned to only one of them – 455 kc.
3. *R1* and *C2* provide grid-leak bias for the oscillator grid. *R2* is a voltage-dropping resistor and it is bypassed for r-f by *C3*.

I-F Amplifier, V2

1. The i-f amplifier receives the 455-kc signal from *V1* and amplifies it. The greatest signal gain is provided here. Since the input and output sections for this stage are tuned for 455 kc, only this frequency is amplified.
2. The stage functions as a conventional amplifier, *C4* neutralizes the interelectrode capacitance of the tube by feeding an out-of-phase input to the grid. (Since this is a high-gain stage, it is extremely susceptible to oscillation; the capacitance between the electrodes in the tube could permit enough feedback to start oscillation, and *C4* cancels any of this feedback.) *R3* and *C5* provide the bias for the stage.
3. B+ voltages are applied directly to the screen and grid.

The amplified output is developed across the primary of *T2* and coupled to *V3* by transformer action of *T2*.

Second Detector and A-F Amplifier, V3

1. The i-f signal from *V2* is applied between the diode plate of *V3* and B–. The detected output therefore appears across *R5* and the volume control, *R6*. A portion of the detected output is coupled through *C7* to the control grid of the pentode section, where it is amplified. The amplified output

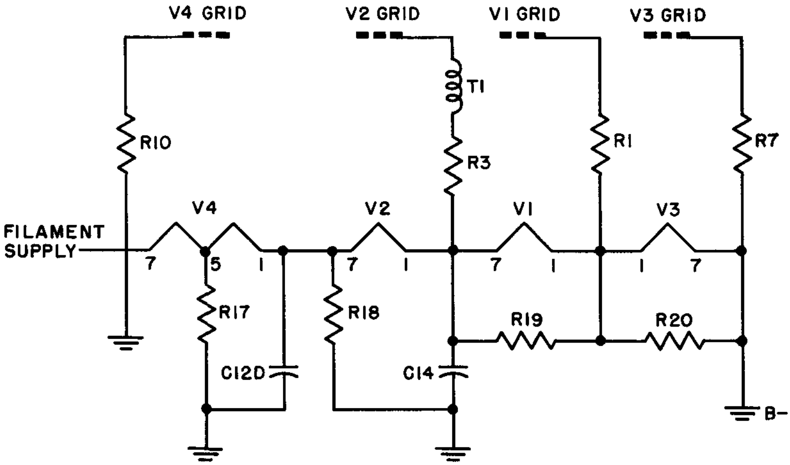


Fig. 4-4. Filament circuit of the schematic shown in Fig. 4-2.

is developed across *R9,* which is bypassed for r-f by *C8. R8* and *C9* form the screen-grid decoupling network. *R7* is the control-grid return for *V3.*

2. The portion of the detected voltage developed across *R6* is used for avc. The avc is applied to the control grid of the mixer section of *V1* through isolating resistor *R4. C6* provides filtering for the avc system.

Output Stage, V4

1. The amplified audio signals are applied to the control grid of *V4* through coupling capacitor *C10. R10* is the grid return for *V4* across which the input signal is applied. B+ is applied through the primary of *T3. C12* filters audio frequencies from the B+ source.
2. The tube operates as a class-A amplifier and by transformer action it drives the speaker.

Bias System. Bias voltages for the various tubes are provided by returning the various control grids to the negative side of each tube filament. As explained in other sections of this book, the filament voltage on direct-heater type tubes varies along the filament string, with the center of the filament used as a reference point when measuring grid bias. In addition, the filament center-to-B— voltage is determined by the position the tube occupies in the filament circuit. The difference between the control grid and the filament-center voltage, is the grid bias for each tube. Figure 4-4 (the filament circuit) indicates how this biasing is accomplished.

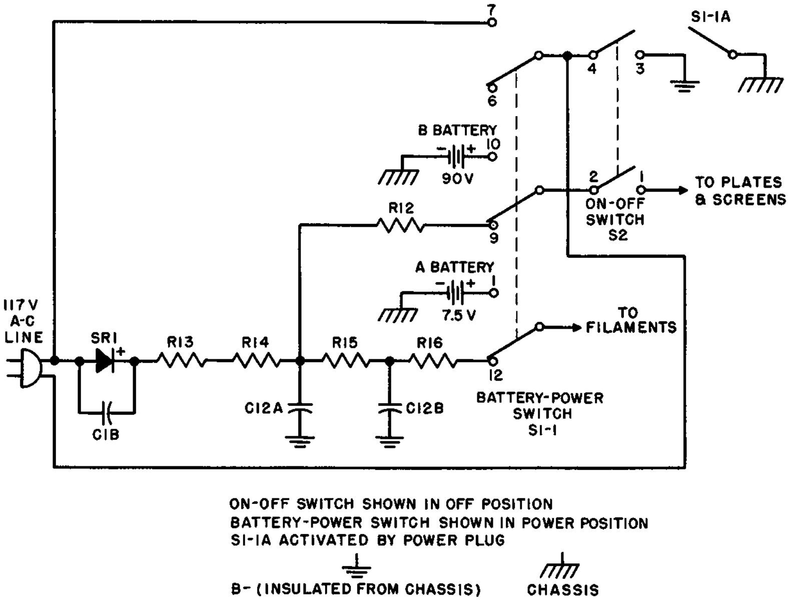


Fig. 4-5. The ON-OFF and BATTERY POWER circuits of the schematic shown in Fig. 4-2.

Filament Circuit

1. The chassis shown uses three 1.4-volt and one 2.8-volt filament-type tubes connected in series as shown in Fig. 4-4. During battery operation, 7.5 volts are supplied directly by the battery. On power-line operation, the *SR1* rectifier output is dropped to 7 volts by resistors *R15* and *R16* (Fig. 4-5).
2. During operation, the plate and screen currents of a filament-type tube pass through the filaments of the tubes preceding it. The closer the tube to the B− end of the line, the more will be the current flowing through its filament. Therefore to prevent this current from burning out the filaments, shunting resistors *R17, R18, R19,* and *R20* are used. Filament radio-frequency bypassing is provided by *C12D* and *C14* (see Fig. 4-4).

Control Circuits. There are three controls in this chassis — VOLUME, ON-OFF, and BATTERY-POWER. The ON-OFF and the BATTERY-POWER (Fig. 4-5) are discussed here.

S2 is the ON-OFF switch which controls battery and power operation. When power is turned on, *S2* applies B+ to the plates and screen, and also completes the plate, screen, and filament circuits by completing the connection to B−.

S1-1 selects the type of operation desired – battery or power. In POWER operation, the rectified direct voltages are applied through the switch. In BATTERY operation, the battery voltages are applied. However, in the BATTERY position, an additional function must be performed. By referring to Fig. 4-5, it will be noticed that the negative battery terminals are connected to the chassis. The negative ends of the plate and filament circuits are connected to the B– bus, which is insulated from the chassis. Therefore, it is required to connect the B– bus with the chassis for battery operation. This is accomplished by inserting the power plug into a receptacle which will actuate *S1-1A*. This completes the required A- and B-battery circuits.

TROUBLESHOOTING

The following chart is drawn up specifically for the chassis we have been describing. It can be made to apply to any three-way or clock radio, applying the given symptoms to the corresponding components in any set under examination. Causes for symptoms given are those mostly likely to occur; no attempt is made to list every conceivable cause for the trouble indicated. Causes for each symptom are given in the order that they are most likely to occur. Finally, many A- and B-circuit causes listed in Table 4-1 can be eliminated by noticing whether the given symptom occurs during battery operation.

Table 4-1

Symptom	*Cause*
1. Set does not operate on line or battery	1. Defective tube Defective ON-OFF switch Defective LINE-BATTERY switch
2. Set operates on battery only	2. Defective rectifier, *SR1* Defective capacitor, *C12* Defective resistors *R12, R13, R14, R15*, or *R16* Defective line cord Defective LINE-BATTERY switch
3. Set operates on line only	3. Defective batteries Defective switch, *S1-1A* Defective LINE-BATTERY switch
4. Excessive current drawn	4. Defective *C12* Defective *C8*

Table 4-1 (continued)

Symptom	*Cause*
5. Tubes light, but no sound	5. Defective *V4* Defective speaker
6. No reception – hum only with volume at maximum	6. Defective *C7* Defective *C10*
7. No reception – hum only with volume control down	7. Defective *C12* Defective tubes Defective antenna
8. Noise only – no signal	8. Defective converter and/or associated components Defective A- and B-supply components (*SR1, C12, R13, R14, R15,* or *R16*) Defective *R20* Defective antenna or antenna connections Misalignment
9. Whistling and/or motorboating	9. Defective tube Defective bypass capacitor (*C5, C8, C9,* or *C12*) Defective *C15*
10. Noisy set	10. Defective tube or tubes
11. Distortion	11. Defective *V4* Defective *V2* Defective *C10, C7,* or *C6* Defective *C12* Defective speaker
12. Weak reception	12. Defective tube Defective A- or B-circuit components Defective *R8* or *R9* Defective *C11* Defective antenna or connections Misalignment

INTERMITTENTS

Intermittents are usually the most difficult troubles to locate. By definition, an intermittent comes and goes, so its activity cannot be forecast. If the intermittent shows up when you're ready for it, the situation is converted into one of routine diagnosis and repair. Consequently, the problem is tracking down the intermittent.

In tracking down the intermittent, gather even the most isolated facts and group them for analysis. It is important to observe the behavior of the set at the time of failure – does it go completely dead, does it become noisy, or does it merely drop off in signal strength? In addition, the frequency of failure should be observed. In many cases, it may be necessary to heat the chassis with a space heater (hair dryer or coil-element heater). If facilities are available for raising input voltages, gently overload the receiver for a few minutes to force the fault to occur. A vibration test (carefully applied by gently tapping the tubes with a rubber mallet, or gently prodding suspected elements with a nonconductor) may jar the element sufficiently to bring on the fault. This may cause the defect to become permanent, making it more easily detected.

If the tubes are suspected, connect a voltmeter across each tube filament. In series filaments, the defective tube will be indicated by a rise in voltage reading. A normal tube will show a zero voltage reading when the set fails. If a poor connection is suspected, gently move wires and components around until the set becomes operative.

NOISY TUBES

If a tube is suspected as the cause of faulty operation, tune the set between stations and turn up the volume. Tap the top and sides of the tube with the eraser on a pencil. (If the noise occurs in *all* tubes tapped, you are tapping too hard, or you may be vibrating microphonic components or poor mechanical connections.) If one tube produces a loud noise or howl when tapped, replace it with a new tube.

EMERGENCY REPAIRS

It's always best to replace defective parts with an identical replacement. However, this is not always possible. The next best thing is to make an emergency repair. This is not a permanent solution, but is a temporary device to keep the customer's set operating while you await a proper replacement part. Since replacement transformers are usually not stored by the service shop, they are the cause of frequent emergency repair.

Figure 4-6 shows a transformer with an open primary winding. Since the secondary of the transformer represents a complete circuit to the input of the next stage, it is possible to cut the entire primary of the transformer (cut as shown in the diagram) and replace the

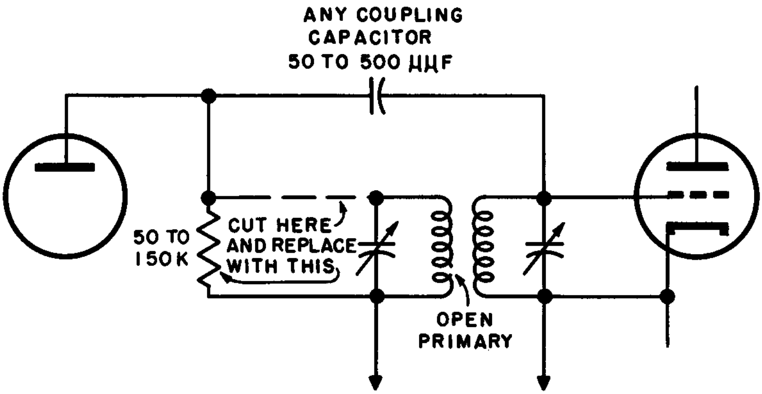


Fig. 4-6. Substituting a resistor and capacitor for an open primary winding.

transformer coupling with resistance-impedance coupling. The primary winding is replaced by a simple carbon resistor (50,000 – 150,000 ohms), with a coupling capacitor of 50 – 500 μμf (for r-f coupling).

Figure 4-7 shows a transformer with an open secondary winding. Since the primary of the transformer represents a complete circuit to the output of the preceding stage, it is possible to open the entire secondary of the transformer (cut as shown) and replace the transformer coupling with impedance-resistance coupling. The secondary winding is replaced by a simple carbon resistor (0.5 – 2 megohms), with a coupling capacitor of 50 – 500 μμf (for r-f coupling).

Figure 4-8 shows how to replace an r-f transformer open primary with resistance-gimmick coupling. The resistor replaces the impedance of the defective transformer primary, while the *gimmick* involves an insulated lead soldered to the primary plate circuit and twisted 5 to 10 times around the grid lead of the secondary circuit. The number of turns and the dress of the gimmick wire control the degree of coupling between the stages.

Figure 4-9 shows the substitution of a resistor and a gimmick for an open secondary winding. The gimmick is now inserted in the primary transformer circuit.

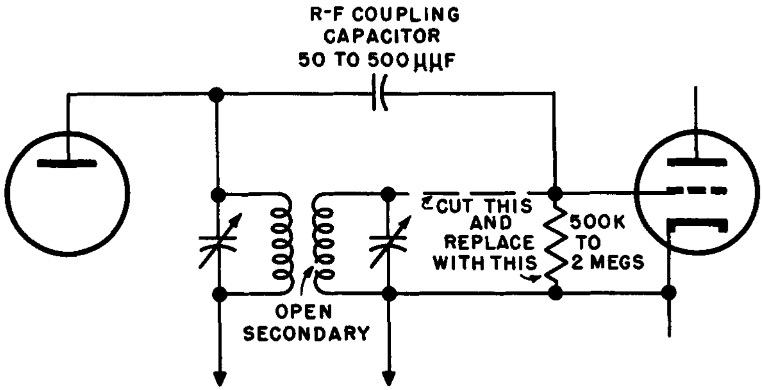


Fig. 4-7. Substituting a resistor and capacitor for an open secondary.

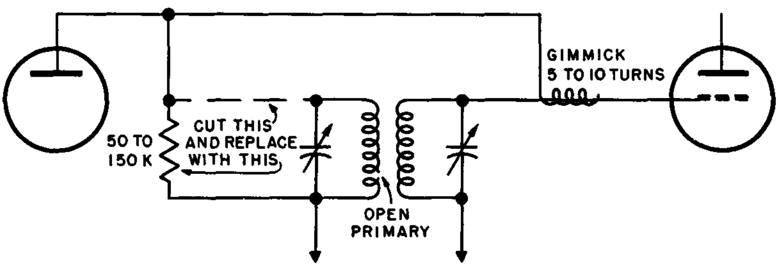


Fig. 4-8. Substituting a resistor and a few turns of wire (a gimmick) for a defective primary.

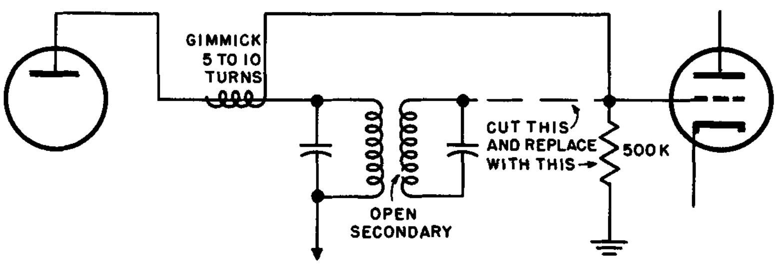


Fig. 4-9. Substituting a resistor and a few turns of wire (a gimmick) for an open secondary winding.

Remember, these are all emergency repairs, pending replacement with manufacturer recommended parts.

TUBE REPLACEMENT

Tube replacement becomes a problem because too many technicians pull all the tubes for testing at once, on the assumption that they know all the tube layouts well enough to replace the tubes properly. In many cases, tubes are then reinserted in the wrong sockets, and burn out or introduce more difficulties. Therefore, the first rule to follow is to remove, test, and replace tubes one at a time.

Actual tube removal can be a problem. Modern clock and portable sets are so compact that it is often impossible to get a firm grip on the tube. Do *not* grasp the tube in any manner possible, and rock and twist it until is comes out. This often causes the socket contacts to spread resulting in additional troubles. Instead, use tube pullers, or other tools specifically designed to aid in tube withdrawal.

If the tube markings are faint, try the following:

1. Hold the tube up to the light in different directions.
2. Rub the tube against your hair.
3. If the above do not permit you to read the markings, chill the tube in a refrigerator for about 15 minutes (condensation will form on the tube, outlining the markings).

Observe the following in replacing subminiature tubes:

1. The red dot on the tube goes nearest the red dot on the socket (see Fig. 4-1).
2. The tube leads of a replacement tube should be cut to the same length as the original.
3. The tube leads should not be bent unnecessarily, since the tubes are fragile.

If it becomes necessary to use a microphonic tube, wrap several turns of solder around the tube, near the top. Use a little speaker-cement to hold the solder in place. (Use this procedure only when a new tube is not available.)

A minimum recommended stock of tubes should include at least those types shown in the Portable Tube Chart of Chap. 1.

TESTING CRYSTAL DIODES

Crystal diodes are being used more every day; their testing should be familiar to the technician. An ohmmeter is the best simple instrument for testing a crystal diode. To test, disconnect one load of the diode, being careful not to use too much heat. Measure the resistance in one direction, and then measure the resistance in the other direction. For a good diode, one reading should be at least 100 times the other.

TRANSISTOR TESTING

In testing transistors, the characteristics to consider are reverse current (leakage) and current gain. Current gain measurements are usually desirable under signal conditions, but reliable results can be obtained by the measuring procedure given below:

Leakage current test. The first test is for leakage current of the diode. Set up the equipment as shown in Fig. 4-10. Note that provisions are made for testing both *n-p-n* and *p-n-p* transistors. An

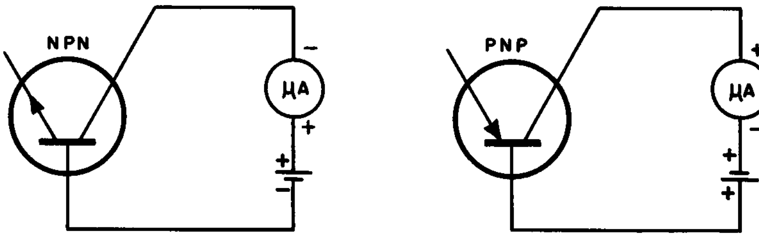


Fig. 4-10. Transistor leakage current test.

ordinary single battery cell will suffice, unless the particular transistor to be tested operates at a significantly higher voltage. Note that the customary current-limiting series resistor is not needed, since measurement is being made for reverse current (back bias). Current will be in the order of microamperes, so the meter should be a microammeter of say 100-μa range (or lower). The polarity of the meter is as shown. The particular biasing voltage and leakage current are given in the data sheet by the manufacturer. Apply the voltage required and read the current. A measured current higher than that given by the manufacturer indicates a faulty transistor. Remember that the manufacturer lists the leakage current (I_{co}) for a particular temperature (usually in centigrade). Try to duplicate the temperature and voltage for most accurate results.

Beta test. The next test is the beta (β) test, shown in Fig. 4-11. The setup for *n-p-n* transistors is shown at the left, with the setup for

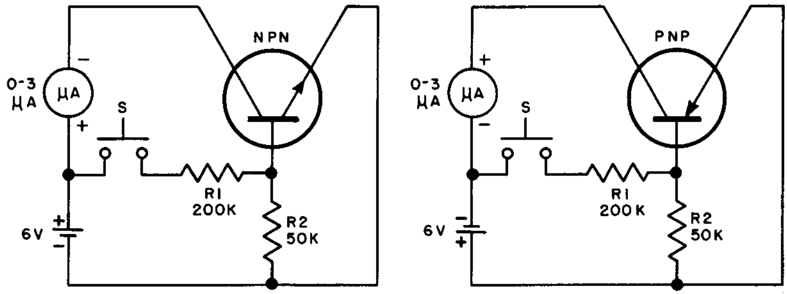


Fig. 4-11. The Beta test for transistors: left for *n-p-n* types, right for *p-n-p* types.

p-n-p transistors at the right. A 6-volt battery supplies the power, while a 0—3-ma meter reads the current. The base is grounded through a 50,000-ohm resistor, with another resistor (200,000 ohms) from base to switch *S*. The emitter is grounded. Note that in both cases the emitter is forward-biased with respect to the base, allowing a small current to flow in the transistor; this current is shown as a small I_c reading in the 0—3-ma meter in the collector circuit. When switch *S* is depressed, the base is forward-biased by the additional base current through *R1*. This additional base current is $I = E/R = 6/200{,}000 = 0.03$ ma. Here is a clear change of base current (ΔI_b) by 0.03 ma. The collector current should change accordingly. The change in collector current may be read from the meter in the collector circuit. Suppose the collector changes to a value 0.3 ma higher than it read before. According to formula.

$$\beta = \frac{\Delta I_c}{\Delta I_b} = \frac{0.3}{.03} = 10$$

Similarly, if the collector changes 3 ma, the beta would be 100. By this means, beta (β) may be checked against the value specified by the manufacturer.

Where a manufacturer specifies alpha (α) rather than beta (β), use this conversion formula:

$$\beta = \frac{\alpha}{1-\alpha}$$

Since beta is a measure of transistor current gain, it is the rough equivalent of an emission test for vacuum tubes. The beta and the leakage current test should provide for rapid checking of most transistors.

As an alternative to the test setups just described, the technician might employ one of the many transistor testers that are now commercially available. These testers are capable of simple leakage and gain measurements.

TRANSISTOR PRECAUTIONS

1. When making resistance measurements in a circuit, remove the transistors to avoid an erroneous reading.
2. Determine the battery voltage and polarity of an ohmmeter, since incorrect lead connections, or too high a battery voltage across a low-voltage electrolytic, may damage the capacitor.
3. "Screwdriver" signal testing is *not* recommended (damage to the transistor may result). Use signal generators for tracing.
4. When soldering near or at a transistor socket, remove the transistor to avoid damaging it.
5. If it is necessary to replace a transistor, use the proper type.
6. Because of the closeness of components, exercise extreme care in making measurements, (to avoid damage to transistors).
7. Be careful to install batteries properly, to avoid incorrect voltages and polarities that may damage the transistors.

PROCEDURE

Unlike tube radios, in which tubes are checked first, in transistor radios the transistors are checked last. The first thing to be checked is the battery. If decreased output with muffled or distorted sound is found, the battery is usually at fault. If replacing the battery does not improve equipment performance, use a signal generator for circuit tracing. Start at the base of the output stage and work toward the antenna, listening constantly for output. When injecting an audio signal at the base of the audio stage, use a high-capacitance electrolytic. A 50-$\mu\mu$f capacitor should be used for injecting i-f and r-f signals. To inject a signal to the antenna coil, couple the antenna loop closely to the antenna coil.

TRANSISTOR INSTRUMENTS

Some service technicians prefer using transistorized service instruments to work on transistor sets. Such service instruments are small, light, and self-powered. Two such instruments the technician can build for himself are shown in Fig. 4-12.

Signal tracing probe. The signal tracing probe (Fig. 4-12A) has a tracing probe that uses a diode *CR* as an r-f detector, with ground clip to complete the circuit. Resistor *R1* is a filter resistor, while *R2* serves as the volume control. Transformer *T1* couples the

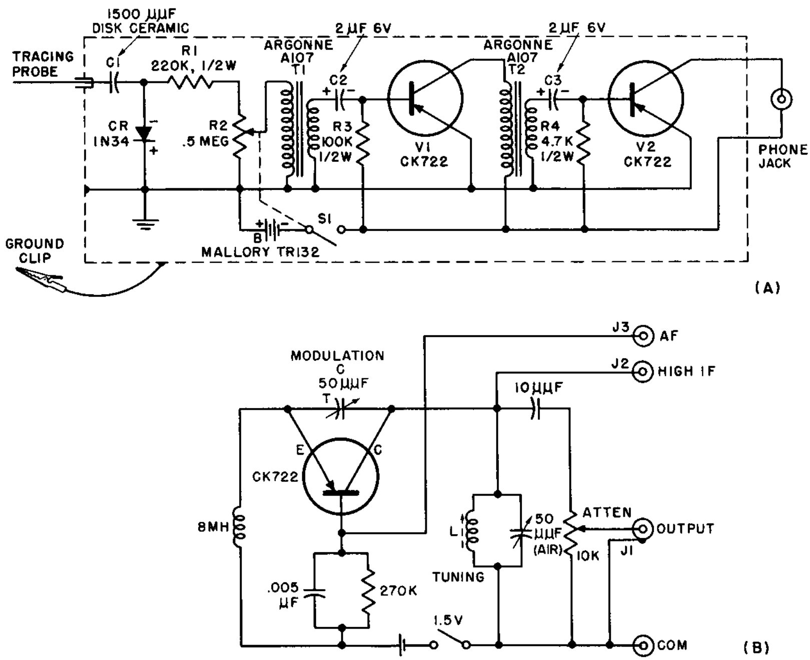


Fig. 4-12. Transistor servicing instruments. (A) signal tracing probe. (B) i-f tester. *Radio and TV News.*

signal (matching the input impedance of *V1*) to the base of the first audio amplifier through blocking capacitor *C2*, while *R3* serves as the base return. The output of V1 is coupled by transistor *T2* to the base of second audio amplifier *V2* through blocking capacitor *C3*, while *R4* serves as base return. The output of *V2* is connected to the phone jack for headphone pickup. The battery and switch complete the circuit.

Radio i-f tester. The radio i-f tester (Fig. 4-12B) uses an 8-millihenry emitter return, and a 50-μμf trimmer for feedback between collector and emitter (modulation control). The R-C network in the base circuit (270,000 ohms and .005 μf) serves as an audio load to the a-f jack. The output of the collector is developed across the tuned tank circuit (L and 50-μμf capacitor), with the 10-μμf isolating capacitor and 10,000 ohm attenuator for controlled i-f output at *J1*. For maximum i-f output, *J2* takes the signal from the high side of the tank circuit. The single CK722 transistor serves as audio oscillator and i-f signal generator. In addition, the audio oscillator serves as a continuity tester.

5. repair and replacements

GENERAL TECHNIQUES

Before starting any actual replacement, read the precautions outlined below. While these precautions are general, they are particularly applicable to small radio sets where components are closely placed.

1. *Tagging leads.* Tagging leads is essential to assure that correct wiring will be made when a part is replaced. Before unsoldering leads from tube sockets, panel connectors, or other parts, tie together the leads that are attached to each of these parts. Using small tags or short pieces of adhesive tape, identify all wires in accordance with their numbered connections. Identify every lead that is to be removed. If tagging is not used, a descriptive wiring diagram should be made, showing the connections to be removed.

2. *Parts and substitution.* When faulty parts must be replaced, identical replacement parts should be used. If identical parts are not available, and the faulty component is beyond repair, a substitution must be made. The part substituted must have identical electrical properties and must be of an equal or higher rating.
3. *Location.* Relocation of substituted parts may produce certain difficulties, such as hum, noise, or crosstalk, and is not recommended.
4. *Mounting.* Mount the new or replaced part in the same mounting position as that formerly occupied by the faulty part. Fasten all mountings securely.
5. *Soldering.* Before soldering any connection, carefully scrape all parts that will be touched by the solder until all traces of rust, corrosion, and paint or varnish are removed. Clean all parts to be soldered. Wrap the wire around the solder lug so that it is mechanically secure. Use very little solder and only sufficient heat to make the solder flow evenly around the connections. In the case of coaxial cables or shielded leads, make sure that the shield is properly soldered to the ground lug. The same applies to bonded connections between metal subassembly frames and the chassis plate. Make sure that the ground lug is securely bonded to the chassis. Be sure to clean away all particles or splashes of solder.

Note: The replacement of components in printed wiring is discussed in a separate section of this chapter.

CAPACITORS

Next to tubes, capacitors are the greatest source of difficulty in radio sets. Therefore, it is important to learn how to locate defective capacitors, how to test, and how to replace capacitors.

Preliminary tests. The best means of locating a defective capacitor is by the senses. Turn on the set and note the condition of all capacitors. If any are unusually warm or are oozing wax, it is wise to replace them. If a hot or burned-out resistor has been located, trace the path of the resistor circuit and replace the capacitor to ground. If there is hum in the set, suspect the electrolytics in the power supply. If tapping or moving a capacitor causes noise, it should be replaced.

Testing capacitors. The next problem is testing. Obviously, the best way is with a capacitor tester. One may not always be available, but other tests will also yield usable results. First, measure the resistance of a capacitor. Any reading below 20 megohms for paper and 300,000 ohms in electrolytics (except for very-high-capacitance values) needs further investigation. Disconnect one lead from the set, and again measure the resistance across the capacitors. If there is still a low reading, with the original part out of the circuit, connect a substitute in the circuit and note the results. There will now be a definite indication of the condition of the original capacitor. (If the original capacitor were shorted or leaky, bridging it in the circuit would do no good.)

Another way of measuring the condition of a capacitor is the so-called "kick test." In this procedure, disconnect one end of the capacitor, and note the meter deflection at the instant when ohmmeter leads are connected to the capacitor. Compare the meter deflection to that of a capacitor, of the same value, known to be in good condition.

Another test, to be used when the capacitor is known not to be shorted, is to measure the alternating current through it. Then compare this with the current through a good capacitor of the same value. In this last test the voltage rating of the capacitor and the power source should be observed.

Replacing a capacitor. If it becomes necessary to replace a capacitor, observe the instructions below.

Use quality components to avoid costly rework later. (Bargain capacitors may be units that have dried up and, therefore, not of the required capacitance of voltage rating. They look new, but very seldom perform satisfactorily.)

In the problem of multisection electrolytics, if one section goes, it is most advisable to replace the whole capacitor rather than the defective section. The experience and headaches of many technicians bear this out.

In replacing a capacitor, observe the capacitance, voltage rating, and polarity. Try to duplicate capacitance as closely as possible. If necessary, use series or parallel combinations to achieve correct capacitance. (See Fig. 5-1 for an example of capacitor combinations.) As for the voltage rating, *never* go below the voltage rating of the replaced capacitor.

Before removing a capacitor, note the polarity color markings of the leads. If necessary, make a sketch. On paper capacitors, note which side has a black band or is marked *ground.* In installing a new capacitor, observe the same method of connection. In mica and ceramic capacitors, polarity is not observed.

Often the mounting strap of the electrolytic can be twisted off with pliers. The rivet can then be removed and the new electrolytics bolted to the chassis through the same hole. It may often be necessary to solder the mounting strap to the chassis.

Several makes of portable radios use can-type electrolytics. When replacing these, it is best to secure an exact replacement. However,

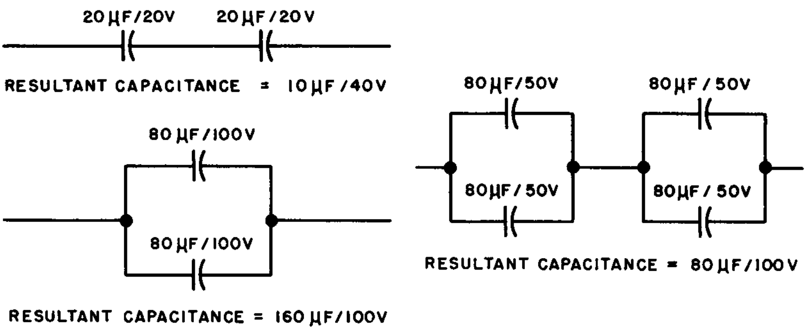


Fig. 5-1. Series, parallel, and series-parallel capacitor combinations.

it is often necessary or convenient to replace them with paper tubular type electrolytics. If this is done, the problem of heat should be considered (the life of an electrolytic is considerably shortened by heat). Tubular electrolytics should be kept away from larger-wattage resistors.

If you desire to replace one section of a multisection capacitor, or to replace the original, refer to Fig. 5-2, which illustrates the replacement of a three-section electrolytic with either two or three capacitors. Note that the original condition (Fig. 5-2A) represents three separate capacitors in the single filter package. In the first replacement (Fig. 5-2B), two separate assemblies (one containing two replacement capacitors and the other containing a single replacement capacitor) replace the original three capacitors in the master filter package. In Fig. 5-2C three single capacitors replace the three capacitors in the original single filter package. Figures 5-2B and C are electrically equivalent to Fig. 5-2A.

Naturally, however, a direct single-unit replacement would probably be the quickest, because identical replacement units could

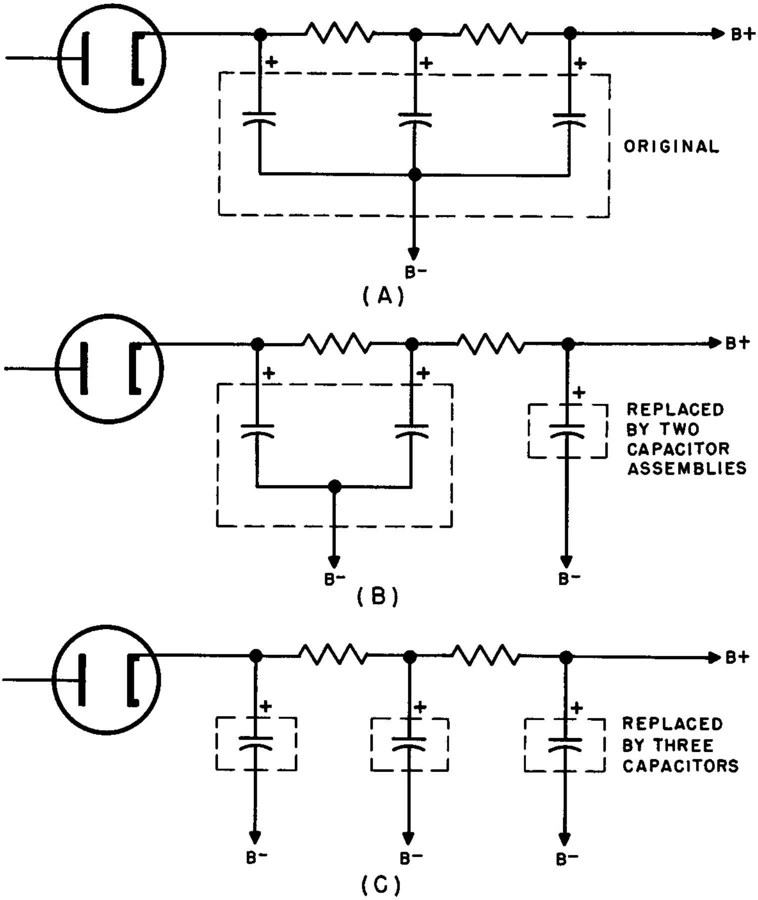


Fig. 5-2. Different ways to replace a three-section electrolytic capacitor. (A) The original three-section electrolytic (in dashed lines); (B) replaced by two-capacitor assemblies; (C) replaced by three capacitors.

be purchased without regard to packaging. Using a two or three capacitor replacement may present a space problem, since packaging (Fig. 5-2A) generally reduces the space required for the units.

SWITCHES

Several types of switches are used in portables. Most radios use the potentiometer-operated switch to control ON-OFF operation, and either a rotary switch or a toggle switch to select power line or battery operation. The volume control and the ON-OFF switch are usually combined on one shaft. Most modern receivers mount the POWER-LINE–BATTERY switch on the back of the set (Fig. 5-3), where it must be activated by the power cord. This prevents equipment damage.

Volume control switch and ON-OFF *switch.* A defective volume control or ON-OFF switch is fairly obvious. Defective volume controls

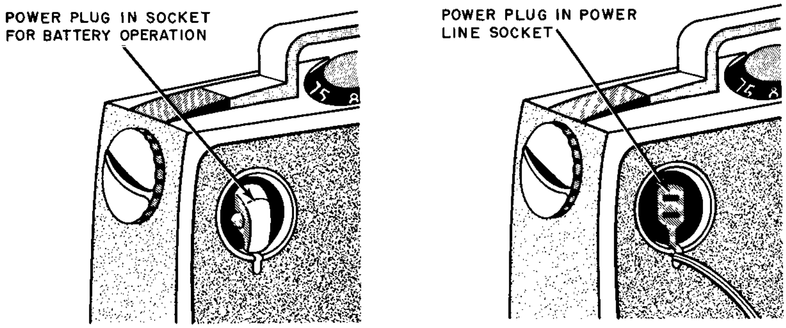


Fig. 5-3. A plug-operated power switch.

stick, scratch, show sudden changes in volume upon adjustment, or do not control volume when varied.

The failure of an ON-OFF switch is evidenced by inability to turn the set on or off.

When the volume control becomes noisy, it is usually wise to replace it. However, a noisy volume control can usually be repaired by the use of any of several commercial fluids made for this specific purpose.

Repair. Try to apply the fluid alongside each terminal so that it flows into the control housing. Sometimes it is necessary to rotate the control to expose the opening along each element and for the fluid to flow downward. Rotate the control a few times while inserting the fluid. If this procedure does not help, it may be necessary to take off the back cover and apply the fluid directly to the resistance element. If the control is still noisy, it must be replaced.

The ON-OFF switch can be repaired, when trouble is caused by the switch operating arm being bent slightly out of position. To fix the switch, remove the back, and (with long-nose pliers) bend the arm until it operates the toggle.

Replacement. Should the control or ON-OFF switch require replacement, it is important to secure an exact replacement. Since these two controls are ganged, it is quite conceivable that the new section might not fit the old one. Therefore, if the exact replacement for the part is not available, order the entire switch-potentiometer unit. To secure replacement data, first determine the manufacturer's part number from his literature. If the supplier has the part, the problem is solved. If not, consult the catalogs put out by such manufacturers as Centralab, Clarostat, and I.R.C.

Remember that carbon and wire-wound controls should not be used interchangeably except as a last resort, and a control should never be replaced with one of a lower power rating than the original. Once the correct replacement is obtained, proceed as follows:

1. Make a sketch of the original connections.
2. Unsolder all leads to the control and remove the control.
3. Following the manufacturer's instructions, assemble the new control. Cut the shaft to the correct length. (In some cases, the old control shaft may be used.)
4. Install the control as directed by the manufacturer, leaving the mounting nut loose.
5. Solder all leads to the control terminal.
6. Adjust the control to the final position and tighten the mounting nut.

One popular replacement unit is sold in the form of separate switches, volume controls, and shafts. The technician selects his own combination and assembles it at the time of installation, matching the original as closely as possible.

BATTERY — POWER-LINE *selector switches.* Typical BATTERY — POWER-LINE selector switches are mechanically and electrically more complicated than the switches previously discussed. Replacements are more difficult to obtain and install. When replacement is required, it is usually necessary to contact the manufacturer. Fortunately, these switches may, in some instances, be serviced.

Repair. In servicing switches, determine whether the switch is at fault, by noting whether the radio operates on batteries and not on power line, or vice versa. If this happens, the BATTERY — POWER-LINE switch is usually at fault. The cause of this trouble is generally dirt, dust, corrosion, or poor physical contact between the stationary and moving portions of the switch.

Contacts that are simply dirty may be cleaned with carbon tetrachloride or other commercial solvents, applied with a small brush. Corroded contacts may require gentle scraping or sanding with fine sandpaper. Extreme care should be exercised in working on contacts. After cleaning, lubricate the contacts lightly with Lubriplate or an equivalent lubricant.

Contacts that lose their tension may have the tension restored by bending the contacts with a special tool, such as shown in Fig. 5-4. This bending procedure is a delicate one and must be done with utmost care. Otherwise, the contact may be broken and a new

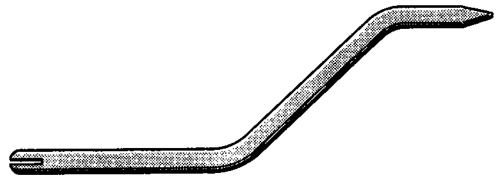


Fig. 5-4. Tool used for restoring contact tension in switches.

switch required. The offset angles in the contact switch bending tool (Fig. 5-4) permit it to be inserted into confined spaces to reach contacts in switches and relays. The slot in the end of the tool is slipped over the edge of the faulty contact and the tool is then twisted as required, causing the contact to turn in the direction desired. While such contact-bending is less desirable than screw adjustment, it is quite acceptable in cases where no screw-adjustment is provided, and where the contact must be bent in order to change angle or tension.

While working on the switch, it is a good idea to check the soldered connections of all leads. Small radios are subjected to a great lead of physical punishment, and soldered connections may work loose.

TUBE SOCKETS

After a trouble has been traced to a definite tube, but that tube is found to be good, the trouble should be considered to be in the tube socket.

In small radios, tube sockets seem to be a particular source of trouble. One of the greatest causes of this trouble is careless wiggling and extraction of the miniature tubes used in small radios.

Repair. Before attempting to replace a tube socket, try these simple servicing procedures:

1. Remove the tube.

2. Unbend a paper clip and insert in into each pin hole in turn, scraping at the contacts to remove dirt and corrosion. (For subminiature tubes, use a pin.)
3. Using long-nose pliers, squeeze the contacts at the back of the sockets.
4. Check the soldered connection to each pin terminal. If it is necessary to resolder, use a small amount of solder, and do not apply excessive heat.

If all the above methods fail, the tube socket must be replaced. Proceed as follows:

Replacement.

1. Make a sketch of all wiring to the tube socket.
2. Disconnect all socket leads, tagging each lead.
3. Drill out the mounting rivets.
4. Remove the socket.
5. Install the new socket with its holes in the same positions as the original.
6. Secure socket with bolts and nuts.
7. Resolder all leads.
8. Insert the tube.

TRANSFORMERS AND COILS

Fortunately, transformers and coils are not as great a source of troubles as tubes, capacitors, or resistors.

When a transformer fails, unless it can be repaired simply, it should be replaced. If an exact replacement is not available, universal replacement types may be used.

The trouble most frequently encountered in coils or transformers is a break or a short between windings. A break can easily be detected with an ohmmeter; a short is a little more difficult to detect. Table 5-1 gives typical values for transformers used in small radios. Any noticeable difference from the reading indicates a defective component.

Table 5-1

Type	*Primary*	*Secondary*
Output transformer (for speaker)	500	1.5
I-f transformer	12	12
R-f transformer	0.5	4

Loudspeaker. If a break is indicated, try to locate it for possible repair. Once it is located, remove the enamel insulation from both ends of the break, and tie and solder them together securely. Anchor the repaired joint with speaker cement.

Replacement. In replacing transformers, it is best to use an exact replacement. This involves less time and effort. However, in many cases, a universal type transformer replacement is adequate.

In replacing an r-f transformer, first make a sketch of all wiring to it. Note that one winding will be smaller than the other. Label the two ends of this winding *A* and *B*. Label the corresponding ends on the new coil *A* and *B*. Label the ends of the larger coil of new and old transformers *C* and *D*. Replace the transformer, and connect all leads.

Try the set. If it doesn't work, it is probable that one set of leads is reversed. Reverse the most convenient set.

I-f transformers can also be easily installed. First, determine exactly what type of i-f transformer is required. An input type is used immediately following the mixer stage, an interstage i-f transformer is used between i-f stages, and an output i-f transformer is used before the detector stage.

Exact replacement is again desirable. However, there is also a universal type that will work well. Before taking out the old trans-

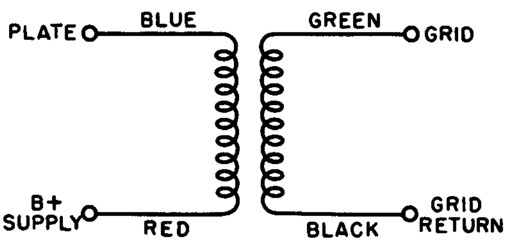


Fig. 5-5. Transformer color coding.

former, sketch all windings. Note the color coding. Most i-f transformers adhere to the RETMA color code given in Fig. 5-5.

Output transformers are also rather easily replaced. In ordering, give the tube type in the output stage and state whether a single-ended or push-pull arrangement is used. This will insure proper replacement.

Complete connecting instructions come with each transformer. If the voice-coil impedance is not available, try the combination that sounds best. However, most sets have a voice-coil impedance of

3.2 ohms. There is also an approximation method of estimating voice-coil impedance that works in the average case. In using this method, measure the ordinary d-c resistance of the voice coil (calling it R). Then multiply R by a factor of 1.4 to find the impedance. The formula is given below:

$$R \times 1.4 = Z \text{ of voice coil}$$

SPEAKERS

The amount of speaker servicing that is feasible is rather limited. It is nearly always cheaper to replace the defective speaker. A few minor repairs, however, are possible. In this section the pm-type speaker is discussed, since it is universally used in the type of small radio discussed in this book.

Speaker troubles that can be easily repaired are those caused by dirt, rips or tears, an open voice coil, or loose joints due to drying out of cement or glue.

Before starting replacement or repair, the technician should make sure the trouble is definitely in the speaker. This procedure involves operating the set to listen for rattling or scratchy or fuzzy sounds, examining the speaker for physical defects, and using an ohmmeter to determine whether the voice coil connections are open.

If a break in the voice-coil connections is easily accessible, clean the insulation, make a good tight solder-joint, and anchor the repaired joint with speaker cement. Sometimes the voice-coil leads that are anchored to the cones work themselves loose. They can be recemented to the cone. If the break is not easily accessible, replace the speaker.

When joints become loose because of dried up cement, they must be recemented. In applying cement, do not use too much; this would cause the cone to become too stiff.

Small rips or tears can also be repaired, though with somewhat uncertain results. First, cut away the ragged edges, then apply cement. On small radios, this patching may cause but little difference in tone. An alternative is to use a piece of tissue paper or onionskin paper as a patch over the hole.

Replacement. Replacement speakers are readily available. In ordering a replacement, check the speaker size and depth, and the location of its mounting holes. Also, note the location of the original output transformer; in many cases it can be used with the new speaker. Bring the speaker to the supply house with you, and try to get the closest thing to the original. It may be necessary to drill new holes in the chassis or the speaker frame. Also, many new speakers have adapters for mounting the transformers and brackets for attaching the speaker to the chassis. One word of caution: handle the speaker carefully to avoid damaging it.

PRINTED ELECTRONIC COMPONENTS

As portable and clock radios become smaller and the demand for lower prices becomes greater, the use of printed components becomes more widespread. (Printed *components* should not be confused with printed *wiring*, which will be discussed later.) Figure 5-6 shows a typical printed electronic circuit — a ceramic-based printed component consisting of a complete resistance-capacitance coupling network. Many sets contain one such unit, and some contain three.

Circuit diagrams *must* be used when testing and replacing a printed electronic circuit. If this circuit goes bad and no diagram is available, the whole unit should be replaced. To obtain the proper replacement, use the manufacturer's part number and catalogue. In replacing any printed electronic circuit, always make a sketch showing where each lead goes.

Testing. If a schematic is available, it may be possible to test and substitute for defective components in the printed electronic circuit. Before attempting to replace or test a component, study the circuit closely. As an example, consider Fig. 5-6: Resistor *R4* can be tested by taking a reading between terminals 6 and 8. Resistor *R1* can be tested by taking a resistance reading between terminals 1 and 3.

Replacement. Replacement also requires some thought. Suppose *R4* must be taken out of the circuit and replaced. Looking at the diagram, it can be seen that the only way to do this would be to open lead 6 and connect the new resistor between the former tie point of lead 6 and lead 8. However, cutting lead 8 would open the circuit from *C5* to the output stage; thus *R4* could not be replaced alone. Similarly, resistor *R1* cannot be replaced individually, since other components would then be taken out of the circuit. Close examination shows that capacitor *C1* is the only component in this printed unit that can be replaced individually.

In replacing a complete unit, use a low-melting-point solder, to avoid damaging other components, and make sure that the old

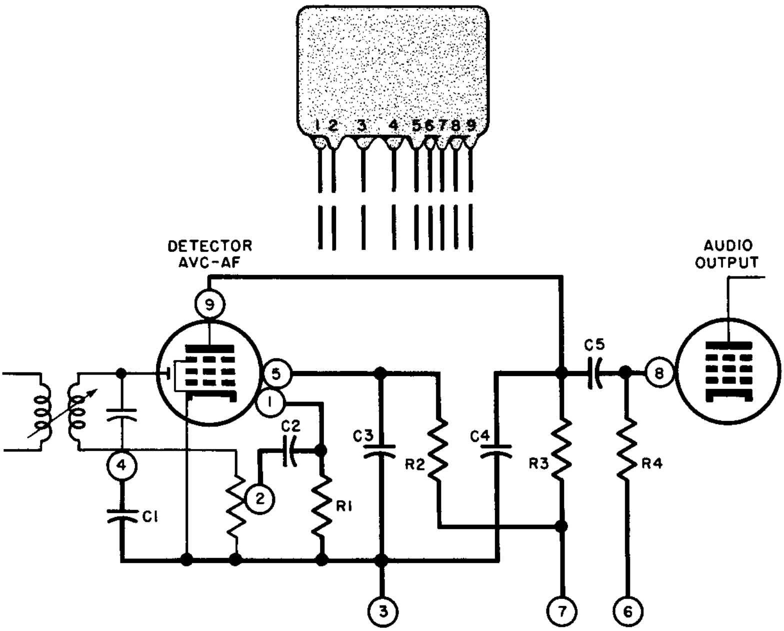


Fig. 5-6. A printed electronic circuit (shown in heavy lines). ***Centralab.***

lead is well insulated, so that it will remain out of the circuit permanently.

ANTENNAS

Each manufacturer of portable and clock radios has his own ways of arranging the antennas for his various sets. Some use a pancake loop on the back of the set, some a carrying-strap loop, and some a ferrite-core type antenna mounted on the chassis. Regardless of the arrangement, antennas on small radios do not present any particular problem. Antennas seldom need replacement, and, when replacement is necessary, there are enough standardized types to fulfill every need.

Antenna loops frequently get loose from their mounting on the cabinet. They can be remounted with plastic or speaker cement. A defective antenna can also be caused by a break in the antenna connecting wire; this can be repaired in the normal manner.

In replacing any type of antenna, original placement and connections should be kept in mind. The replaced antenna must approximate the original as closely as possible. When required, use plastic or speaker cement for mounting the antenna to the cabinet.

SERVICING PRINTED CIRCUITS

The trend toward printed circuits is most pronounced in portable sets, because printed circuits favor small low-voltage units. In printed circuits, point-to-point wiring is replaced with wiring printed (plated or etched) on a nonconducting "card."

Some special materials useful in servicing printed circuits are listed below:

1. 20- to 40-watt pencil type soldering iron.
2. Small wire brush.
3. 60% tin, 40% lead low-temperature rosin-core solder.
4. Thin-bladed knife.
5. Soldering aid or small wire pick.
6. Denatured alcohol.
7. Wood wire cutters.
8. Needle-nosed pliers.

The repair of printed circuit chassis is relatively simple and, in many instances, actually easier than repairing a conventionally wired chassis. Normal troubleshooting procedures should be carefully followed in detecting and isolating the cause of the trouble. Due to the accessibility of all components, the use of short-cut methods, such as shunting components (suspected open capacitors or resistors, etc) or temporary isolation and substitution of shorted parts, can be done very easily in a printed circuit chassis. However, the removal and replacement of the i-f cans, oscillator coil, and volume control in printed circuits are a little more time consuming than in a conventionally wired chassis; hence, make certain a component is defective (ohmmeter check) before replacing it. When servicing a printed circuit load, use exact replacements, because the correct mechanical, as well as electrical, specifications are very important.

Whenever possible, replace resistors and capacitors right on the mounting board or "card" (see Fig. 5-7), soldering the replacement part to the leads of the original component, which has been clipped out. In cases where this is impossible, the following procedure should be used in removing a defective component.

1. Apply heat from a low-wattage soldering iron to the connections, and quickly brush away the melted solder.
2. Cut off the component leads, or lugs, close to the board.

3. Continue to heat the connections just long enough for the solder to melt and the component or lead to be removed. If more than one lead or lug is holding the component, try to disengage one side at a time.
4. Clean the mounting holes, then insert the new component in the holes provided for it.
5. Bend the component leads and solder the connections very carefully, using as little solder as possible. Make certain excess solder does not short to an adjacent strip.

If prolonged excessive heat or forceful removal of parts causes a section of the metal strip to lift up from the chassis board, it can

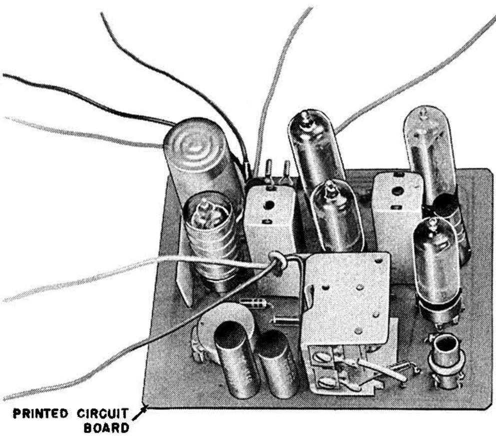


Fig. 5-7. A typical printed circuit board. *Crosley Div., Avco Mfg. Co.*

be repaired simply by cutting away the damaged section and replacing it with a small piece of insulated wire.

Figure 5-8 shows the standard procedure recommended by one receiver manufacturer for printed circuits.

Replacement of capacitors and resistors (Fig. 5-8A and B)

1. Cut the leads where they enter the component. In many cases, it is advisable to cut the defective component in half to get enough lead to solder the new component.
2. Clean off the remaining leads, leaving as much of the lead as possible.
3. Make a small loop in each lead of the replacement component.
4. Slide the loop over the remaining leads of the old component.

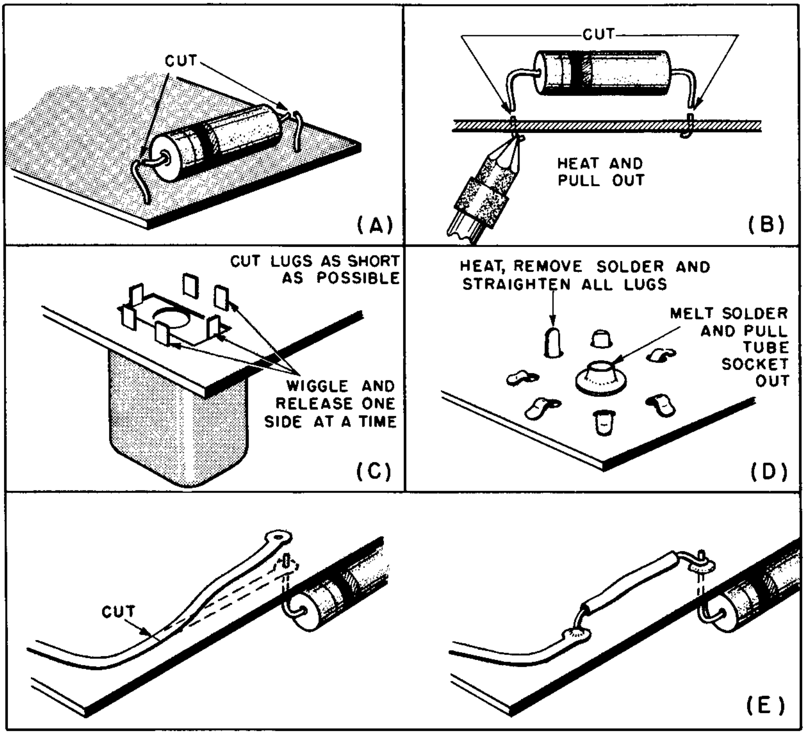


Fig. 5-8. Repair procedures for printed circuits. ***After Emerson Radio and Phonograph Corp.***

5. Tie new and old leads together with new components well anchored on board.
6. Solder the new connections, avoiding excessive heat and brush off any excess solder.

Replacement of coils (Fig. 5-8C)

1. Heat the connection on the wiring side of the board, brushing away the solder with the wire brush as it melts.
2. Insert a knife blade between the bent-over component lead and the wiring.
3. When the lead is perpendicular, withdraw the coil.

Replacement of tube sockets (Fig. 5-8D)

This procedure is exactly the same as above, except that the grounding lug is done last and does not require bending. Just withdraw the socket while heat is applied to the grounding lug.

Repair of wiring (Fig. 5-8E)

1. Cut a piece of insulated wire to span the break.
2. Without using excess heat, solder the wire to the printed wiring.

SELENIUM RECTIFIERS

Selenium rectifiers require ventilation; they are most effectively cooled when the cells are vertical. These rectifiers must be replaced with great care. The soldering iron must avoid contact with the surfaces of cells, since the heat may melt or damage the cell coating. Failures of selenium rectifiers fall in four catagories: open-circuit, short-circuit, high forward resistance, low backward resistance.

The line resistor in series with a selenium rectifier must be carefully replaced. Its resistance is critical as a current-limiting factor during surges, and its wattage rating is important if it is used as a fuse.

The fumes present when a selenium rectifier fails are poisonous. Avoid inhalation.

Indications of failure. Selenium rectifier faults are often indicated by a rotten-egg smell, melting of the alloy coating on the cells, or signs of extreme heat on the rectifier. Where signs of heat are present, temporary overload or overheating, perhaps from insufficient ventilation, may have caused rectifier damage and subsequent self-healing. If more than 15% of the surface of the selenium rectifier shows burning, or when any sparking or smoking is noted, replace the rectifier.

Field tests with an ohmmeter. First read the resistance across the rectifier, then reverse the ohmmeter leads and read the resistance again. One low and one high reading should be obtained from a properly functioning selenium rectifier. If both readings show high resistance, the rectifier is shorted. (If your ohmmeter leads are color-coded for polarity, with red for positive and black for negative, you can readily check whether the low resistance is forward or backward.)

Assume that the red probe of the ohmmeter is connected to the positive battery terminal of the ohmmeter, while the black probe is connected to the negative battery terminal. When the test probes (and therefore the battery) are attached to the rectifier, the rectifier diode is either forward-biased or back-biased, depending on the battery polarity. Forward bias occurs when the arrow side of the rectifier is connected to the positive battery terminal and/or when

Table 5-2*

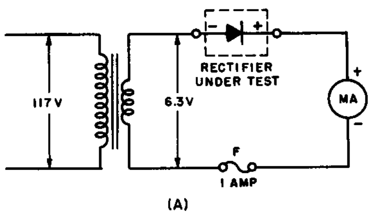
Symptom	*Possible Trouble*	*Procedure*
No B+ voltage	Open line resistor or open rectifier	Test for alternating voltage between switch and B−. If O.K., test for alternating voltage between rectifier B+ and B−. If O.K., check stack for open circuit.
Low B+ voltage	High-forward-resistance rectifier, leaky or low capacitor, or excessive B+ current	Test rectifier for forward resistance. If O.K., test capacitor for capacitance and leakage. Test B+ circuit for excessive tube current or partial short-circuit due to defective components.
Hum in loud-speaker	Leaky or low capacitor, or low-reverse-resistance rectifier	Test capacitor. If O.K., test rectifier.
Sparking or dark spots on plates of rectifier	Deformed rectifier	If sparking occurs after set has been inoperative for a long time, leave it on; rectifier will probably reform. If sparking continues, test rectifier reverse resistance. If reverse current is high or sparking persists, replace rectifier.
Burned-out line resistor	Defective capacitor, defective rectifier or shorted load	Test for shorted rectifier or capacitor. Check load for excessive current or intermittent shorts.

* Courtesy *Electronic Technician.*

the "K" side of the rectifier is connected to the negative battery terminal. In forward-bias condition, the conductance is maximum (least resistance). When the ohmmeter leads are reversed, the diode is back-biased (maximum resistance). See Table 5-2 for a rapid check on selenium rectifiers.

SELENIUM RECTIFIER TESTS

Simple diode rectifier resistance test. With an ordinary ohmmeter, measure the resistance across the diode rectifier. Note the reading. Reverse the ohmmeter leads and again measure the resistance across the diode rectifier. Note the reverse reading. If the resistance is over 1,000 ohms in one direction and below 100 ohms in the other direction, the diode rectifier is probably good (with low forward direction and high reverse direction resistance). Verify this result by taking resistance readings across a diode rectifier of the same capactiy that is known to be good.



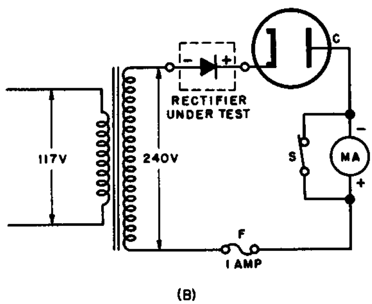


Fig. 5-9. (A) Forward current test and (B) reverse current test for simple diode rectifier.

This resistance test does not indicate quality very well. Therefore, two current tests are indicated. These include a *forward-current test* and a *reverse-current* test, as given below.

Simple diode rectifier forward-current test. Set up the test equipment as shown in Fig. 5-9A. This includes a simple filament transformer (any capacity, with a 6.3-volt winding); a d-c milliammeter with a 50-ma scale, connected with polarity as shown in the diagram; a means for connecting the rectifier under test; the necessary fuse. The required readings for acceptable performance are shown in Table 5-3:

Simple diode rectifier reverse-current test. Set up the test equipment as shown in Fig. 5-9B. This includes a 240-volt plate winding (which might well be another winding of the transformer in Fig. 5-9A used for both tests), the same d-c milliammeter with a 50-ma scale, connected with polarity reversed from the last test, with a

Table 5-3

Rectifier Current Rating	*Minimum Meter Reading Acceptable*
65 ma	20 ma
75 ma	20 ma
100 ma	33 ma
150 ma	33 ma

switch added across the milliammeter, and a *tube rectifier* (whose filament circuit is not shown; it may draw current from the filament winding used in the last tests). In these two rectifier tests do *not* omit the protective lamp fuse. *Do not open the switch S for the first minute, or the meter may be damaged by the high initial surge currents.* After a minute, open *S* and read the milliammeter. The required readings for acceptable performance are shown in Table 5-4.

Table 5-4

Rectifier Current Rating	*Maximum Meter Reading Acceptable*
65 ma	13 ma
75 ma	13 ma
100 ma	19 ma
150 ma	19 ma

Note: For good performance, readings should be *below* the maximums indicated.

REPLACING SELENIUM RECTIFIERS

In replacing a selenium rectifier, the following precautions should be observed:

1. Do not bring the soldering iron in contact with the rectifier cells. (This might damage the protective coating.)
2. Mount the rectifier in its original position. Do not place any components in positions that prevent circulation of air through the rectifier cells.
3. Be sure that the replaced rectifier is mounted firmly, so that it cannot turn and come into contact with the chassis, components, or wiring in the set.

In the matter of stocking a variety of rectifiers, the same problems exists as in stocking batteries except that the problem of an exact mechanical fit usually is not difficult. Wherever possible, use an exact mechanical and electrical replacement. However, a good minimum stock should favor electrical equivalents over mechanical equivalents. General electrical requirements for diode rectifiers include a minimum of one 65-ma, one 75-ma, one 100-ma, and one 150-ma unit, all having a 130-volt rating. Keeping this minimum stock on hand will allow for an emergency replacement. If the volume of business warrants it, of course, increase the stock in the units frequently replaced. Keep the rectifiers packed in their cardboard cartons, both for quick inventory identification and for protection. (A screwdriver scratch on the surface of a diode rectifier plate may damage it.)

TRANSISTOR REPLACEMENT

Figure 5-10, shows transistors in a typical radio. (The seven transistors are the small black oblong-shaped objects.) Note that the transistors are plugged in from the top of the chassis like vacuum

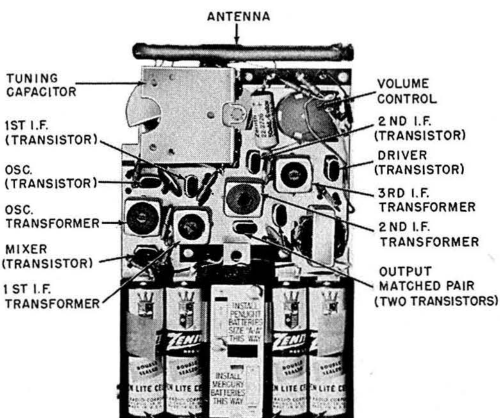


Fig. 5-10. A typical transistor portable radio. *Zenith Radio and Television Corp.*

tubes. Note also how little space the transistors occupy, a factor that makes possible a degree of compactness never achieved with tubes.

In transistor radios, the last component to be suspected is the transistor. Once the defect has been definitely trace to the transistor, replace it.

In servicing, bear in mind that transistors are unusually sensistive to heat and to incorrect voltage polarities. To replace a transistor, you will need a set of jeweler's or optometrist's tools, a 35-watt soldering iron with a pencil point, a long-nose pliers – and the patience. The components in transistor sets are closely spaced, and the wiring fragile. Care is required in all servicing procedures. Use 60/40 rosin-core solder only:

Observe the following rules:

1. When soldering or unsoldering a transistor, grasp the wire being soldered tightly with long-nosed pliers. This is a heat-dissipating measure. Keep the pliers tight for *1 minute* after the iron is removed.
2. Keep the transistor leads as long as possible, consistent with space limitations.
3. Get the soldering done as soon as possible.
4. Observe proper voltage values and polarities in checking the replaced transistor.

6. alignment

Although alignment is not performed as frequently as it should be by shop technicians, its importance cannot be overlooked. Too often a set returned to the user after repair does not perform as well as it should, because of failure to align it properly. The procedures involved are not difficult, and are well worth the time and effort required. The technician should especially be prepared for an alignment job if he has reason to believe the customer has tampered with the alignment adjustments of the receiver. This may be indicated by fresh scratches on the i-f cans, or by an absence of dust on them.

The need for alignment is usually caused by one or more of the following:

1. Component aging.
2. Replacement of components during servicing.
3. Vibration, rough handling, or tampering.
4. Moisture, heat, or exposure to the elements.

EQUIPMENT

The following equipment is adequate for most alignment work:

1. A calibrated signal generator capable of supplying i-f and r-f signals, modulated 30% with a 400-cycle signal.

2. An output meter or a vtvm.
3. An isolation transformer. (If an isolation transformer is not available, connect the low side of the signal generator to B— through a 0.1-μf capacitor.)
4. A small fiber screw driver.
5. A dummy antenna. (Since each manufacturer indicates his particular requirements, it is wise to obtain his servicing literature on the set.)
6. A 3.2-ohm, 5-watt resistor.

PRECAUTIONS

The most elementary precaution in alignment work is do *not* begin alignment unless a calibrated signal generator is available. (While it is possible to align without such an instrument, the technician has no way of knowing that the original intermediate frequency has been used; this upsets calibration.)

In all procedures, observe the following:

1. Use the proper tools and equipment.
2. Isolate the circuit being aligned from the signal source. (Avoid applying the signal directly to the circuit being aligned.)
3. Reduce the signal strength so that at no time is a reading of more than 0.4 volt obtained across the load resistance substituting for the speaker voice coil.
4. Recheck the alignment at both the upper and lower ends of the band.
5. Know the alignment points before turning anything.
6. When the antenna loop is used, hold it in the position that is normally used.
7. Seal trimmers with nail polish after they have been set.
8. Use the isolation transformer.

PROCEDURE FOR TUBE-TYPE RADIOS

The superhet receiver is usually aligned by sections: First the i-f section, then the oscillator, and finally the r-f section. This sequence must be followed, because alignment depends on the proper functioning of previously aligned stages. Detailed procedures for aligning a typical i-f, oscillator, and r-f sections are given below.

(When available, follow the manufacturer's specific alignment instructions, rather than the typical procedure given here.)

I-F ALIGNMENT

The common procedure for i-f alignment is to feed an AM signal into the i-f section and to adjust the trimmers or slugs for maximum output at the speaker circuit. The i-f stages must be aligned first. The procedure given here, although general, contains enough specific information to be adapted to any portable or clock radio.

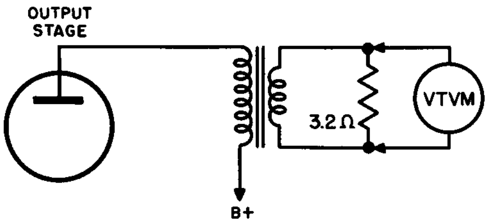


Fig. 6-1. For i-f alignment, connect the vtvm across the output, as shown.

1. Disconnect or short out the loop antenna.
2. Connect the signal generator to the mixer grid through a dummy antenna or capacitor.
3. Disconnect the speaker voice coil, and connect a 3.2-ohm resistor across the output secondary. As shown in Fig. 6-1, connect a VTVM across this resistor (use the low-range a-c scale of the VTVM).
4. Connect the receiver to the power source, using the isolation transformer.
5. Connect the signal generator to the power source.
6. Set the tuning capacitor fully open and the volume control to maximum.
7. Turn on the signal generator and the receiver, and let them warm up for 20 minutes.
8. Adjust the signal generator for the intermediate frequency, modulated 30% at 400 cycles, so that the reading across the load resistor is no more than 0.4 volt. (At no time during any alignment should the output reading exceed 0.4 volt.)
9. Starting at the last i-f stage secondary, and working backward, adjust each trimmer for maximum output. It will probably be necessary to reduce the signal generator output as the i-f stages are aligned.

10. Recheck the alignment by adjusting the trimmers for maximum audio output.

In many cases the avc circuit must be disabled for satisfactory and true peaking of each trimmer. While avc-disabling is good in all cases, it is obviously needed when turning the i-f screws produces

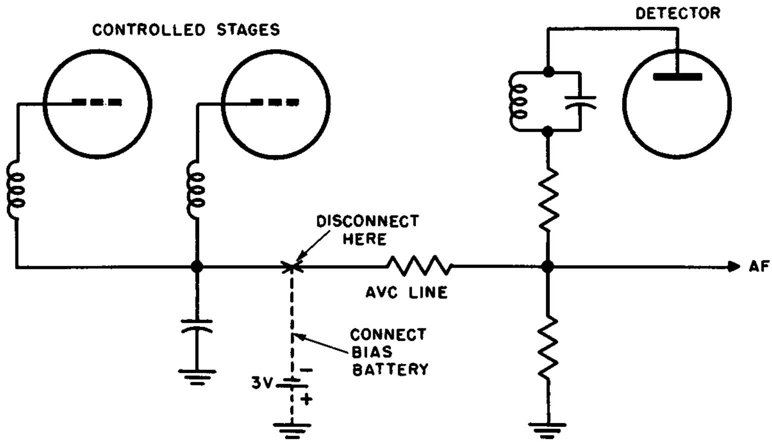


Fig. 6-2. Disabling avc during i-f alignment.

no marked change in volume, or when a change in generator output causes no marked change in volume. To disable the avc, disconnect the avc lead from the detector stage and use a bias source of —3 volts for biasing the controlled tubes (see Fig. 6-2).

OSCILLATOR ALIGNMENT

The next step is oscillator alignment. To align the oscillator stage, set up the equipment as for the i-f alignment, except for the following:

1. Remove the dummy antenna and reconnect the loop antenna, placing it in its ultimate position.
2. Set the signal generator frequency at 1620 kc, making sure that the tuning capacitors are fully open. (This is the highest frequency on the broadcast band.)
3. Connect the signal generator output across a 5-inch diameter 5-turn loop and couple it inductively to the receiver loop. Keep the loops 12 inches apart. (See Fig. 4-3 for general practice.)

4. Adjust the oscillator trimmer for maximum output, as indicated by the meter reading.
5. After the r-f alignment (next step), tune to a station of known frequency. If the dial reading does not correspond to the known frequency, the dial pointer must be readjusted.

R-F ALIGNMENT

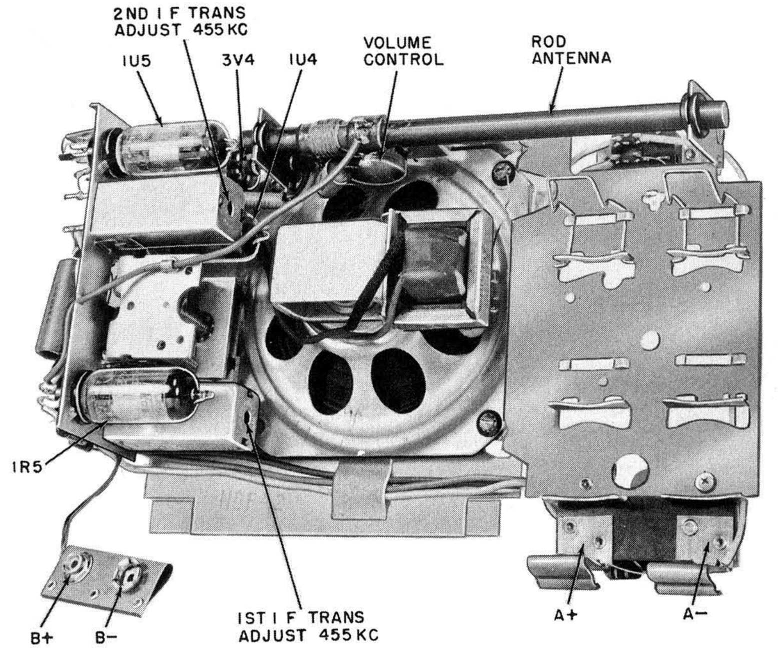
The final step is aligning the r-f stage. Proceed as for the oscillator alignment, except for the following:

1. Set the generator frequency for 1400 kc.
2. Tune the receiver for maximum signal.
3. Adjust the antenna trimmer for maximum output as indicated by the meter reading.
4. Reconnect the speaker.

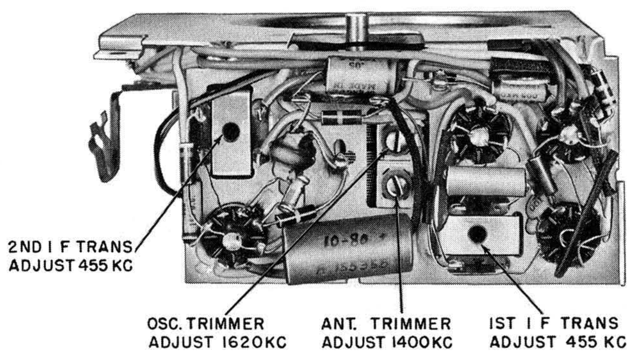
ALIGNMENT IN THE HOME

It is frequently necessary to align a set in the home of the user, where there is not test equipment available. The procedure given below will lead to satisfactory results. The locations of the alignment adjustments on a typical tube-type portable are shown in Fig. 6-3.

1. Set the dial pointer so that it travels the full length of the scale as the set is tuned. (The end points of the scale can usually be determined by the wear and dirt on the slide plate.)
2. Tune to some station between 1500 and 1600 kc. If necessary, attach a length of wire to the stator lug of the tuner to obtain some reception.
3. If a station should appear at 1520, but is picked up at 1570, for example, adjust the oscillator trimmer (Fig. 6-3B) until the station comes in at 1520. Obtain the exact station frequencies from the radio page of a local newspaper.
4. Starting at the output end, adust each i-f trimmer for maximum reception.
5. (This step should be followed only if the intermediate frequency is known.) If the i-f of the set is 455 kc, the image frequency of the 1520-kc station should appear at 610 kc (1520 minus 2 times 455 kc). If the image appears at 580 kc instead of 610 kc, the i-f trimmers are set to 470 kc (1520 − 580/2). Readjust the i-f screws by 1/8 turn.



(A)



(B)

Fig. 6-3. A typical tube-type portable, showing location of alignment adjustments. (A) Rear view. (B) Bottom view. ***Crosley Div., Avco Mfg. Co.***

6. Readjust the oscillator trimmer until the signal is received at 1520 kc.
7. Adjust the i-f trimmers for maximum output.
8. Check the frequency of the image station. If necessary, repeat steps 5, 6, 7, and 8.

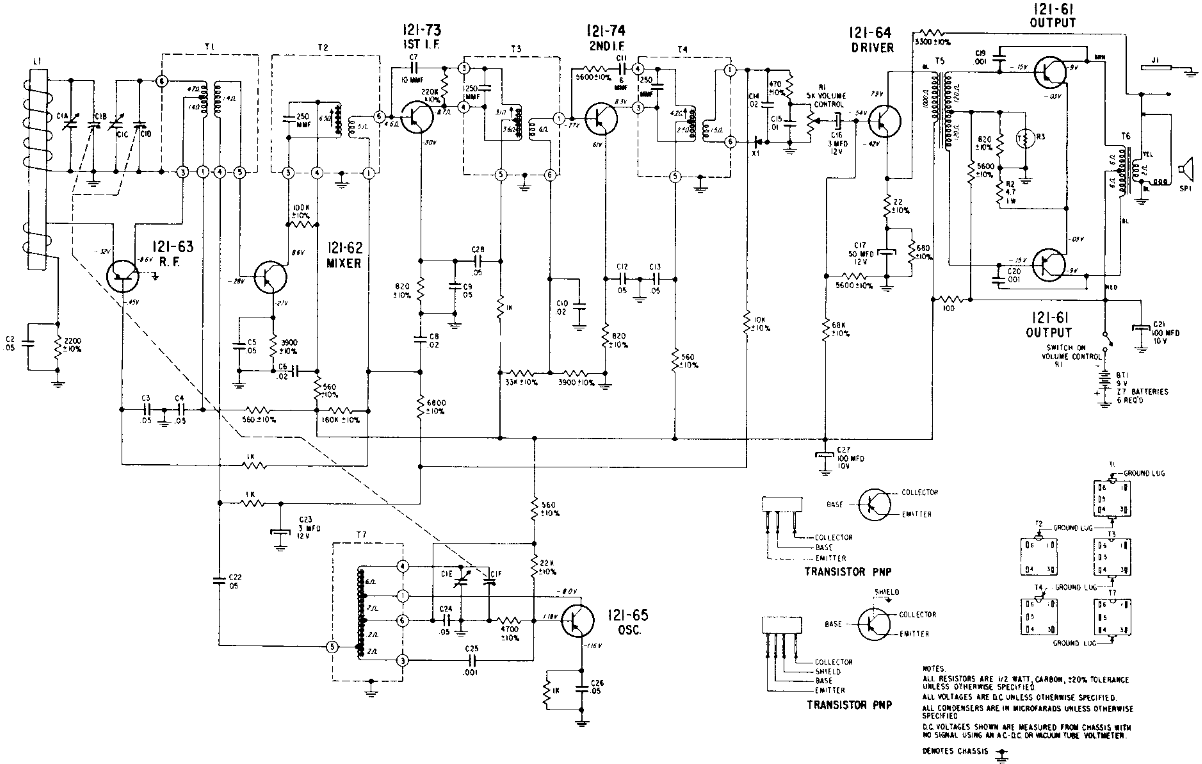


Fig. 6-4. Schematic diagram of a typical all-transistor portable radio. ***Zenith Radio Corp.***

9. Tune between stations and peak all trimmers for maximum noise output. (Tuning between stations makes the avc inoperative, so that small noise changes can be detected.)

TRANSISTOR SET ALIGNMENT

The alignment procedure for transistor sets is very similar to that discussed for tube type sets. The following procedure, adapted from the Zenith 8AT41Z2 chassis (Fig. 6-4), can readily be applied to any set.

1. Connect the signal generator to the set antenna by means of one turn of the generator lead, loosely coupled.
2. Connect an output meter (with a 1-volt scale) across the voice coil.
3. Turn the set on and set the volume to maximum.
4. Turn the signal generator on and set it at 455 kc (the intermediate frequency of this set) with 400-cycle modulation and the output high enough to give a meter reading. Set dial at 600 kc.
5. Adjust *T3*, *T2*, and *T1* for maximum output. This provides i-f alignment.
6. Set the signal generator at 1620 kc, open the tuning gang all the way, and adust *C1C* for maximum output.
7. Set the signal generator at 535 kc, close the tuning gang, and adjust slug in *T6* for maximum output.
8. Repeat steps 6 and 7.
9. Set the signal generator at 1260 kc, move the radio dial at 1260 kc, and tune *C1A* for maximum output. This aligns the loop antenna.

The above procedure can be adapted to all present transistor sets, where the manufacturer's specific instructions are not available. Note that the intermediate frequency must be observed, that the oscillator coil is adjusted for low-frequency tracking, and that the oscillator capacitor is adjusted for high-frequency tracking.

7. design improvement

Although the technician does not normally perform the functions of a design engineer, there are some improvements he can make in small sets that not only may result in improved equipment performance, but will also lead to additional income. The changes discussed in this chapter can readily be performed with a minimum of time and equipment. Caution is, nonetheless, urged; avoid indiscriminate changes in design.

HUM REMOVAL

Depending upon the customer, hum may prove to be a varying source of annoyance. Some customers may object to the slightest hum and demand its removal; others may not complain until hum becomes overpowering.

The most obvious source of hum is the filtering and decoupling circuits. Many technicians simply test the filter circuits, find nothing obviously wrong, and return the set – with hum still unchecked. Therefore, if you do hear hum, replace the capacitors, starting with the filters. New capacitors are bound to be an improvement over the old ones. Also, try to use lower-leakage types (higher voltage-ratings). Don't be afraid to try a capacitor of a little larger capacitance (if it doesn't affect the sensitivity too much).

In many portables, the line cord is not pulled fully out of the case; this permits the power cord to rest on the antenna, with the result that 60-cycle noise is radiated directly into the antenna with the r-f signal.

Another difficulty is the placement of leads and ground connections. These items should be checked, because they are sources of annoyance that are hard to detect.

Finally, there is hum caused by the a-c filament circuits. This can be corrected by using direct current for the filaments, accomplished with the installation of a selenium rectifier. (The actual procedure is presented later in this chapter.)

ADDING A PHONE JACK

Some people prefer the novelty and privacy of a set of earphones. With smaller sets, this can become a problem. However, if the physical placement of components and method of procedure are worked out beforehand, it is not too difficult. Figure 7-1A shows typical installations that can be used on any set.

Locate the audio output transformer. Open the secondary circuit of the transformer at a convenient point and solder the cut wires to a three-point terminal strip, with the third terminal going to the other lead of the output transformer. Wire in the closed-circuit phone jack as shown, so that insertion of the phone plug opens the speaker circuit and permits quiet earphone reception. Low-impedance phones should be employed.

For more sensitive phone operation, higher-impedance phones should be connected through a .01-μf blocking capacitor to the plate circuit of the audio output tube. A switch may then be added to connect a 3-ohm resistor across the secondary of the output transformer in place of the speaker, as shown in Fig. 7-1B.

BATTERY PORTABLE TO AC-DC

This problem may be solved in either of two ways — by building a separate power supply or by rewiring the old set. Both methods

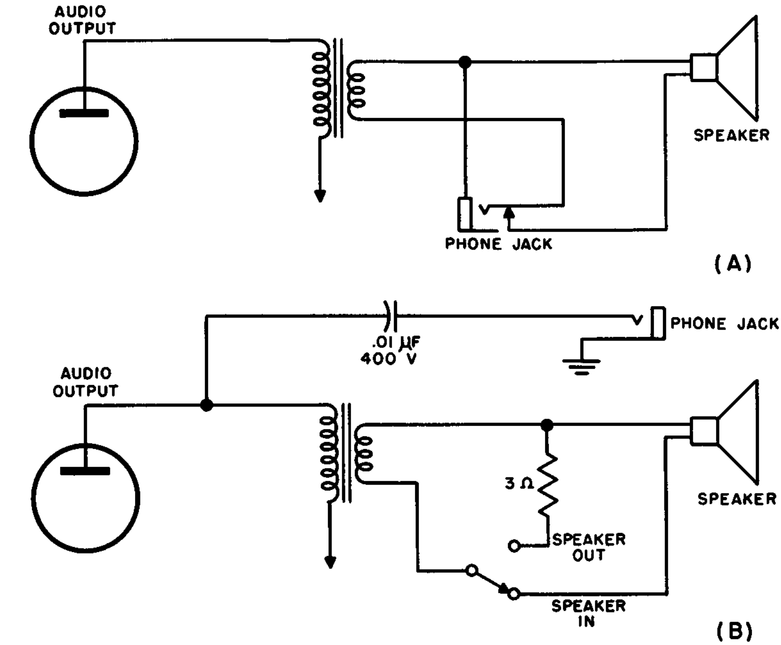
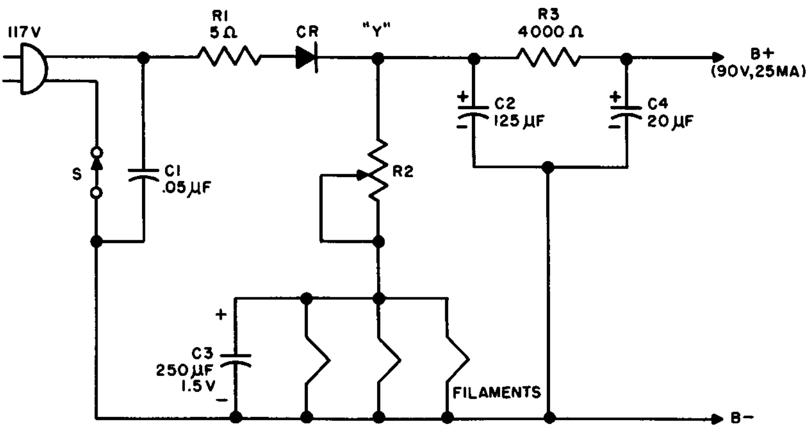


Fig. 7-1. Adding phone-jack installations. (A) A typical installation that can be added to any set. (B) An installation using high-impedance phones.



CURRENT FILAMENT VALUE IN MA	FILAMENT SUPPLY DROPPING RESISTOR (R2) IN OHMS
200	700
250	560
300	470
400	350

Fig. 7-2. A typical separate power supply that can be added to any battery portable radio.

have their advantages and disadvantages. The choice depends on individual conditions.

Adding a separate power supply. Figure 7-2 shows a power supply circuit that can be used, with slight modifications, with almost any portable on the market. The size of the rectifier and the value of *R2* will depend on the individual set. Determine the filament current value for the set and then refer to the chart of Fig. 7-2 for the correct value of *R2*. Of course, provision must also be made to connect the power supply to the radio.

For example, suppose all the 1.5-volt filaments in parallel total 250-ma drain. The value of *R2* will be 560 ohms (according to the table in Fig. 7-2). The power supply is turned on by switch S (with filter capacitor *C1* of .05 μf at 600 volts across the line). The 5-ohm current-limiting resistor *R1* controls current input to the selenium rectifier *CR,* which supplies approximately 100 volts of direct current to the point *Y*.

The filament supply dropping resistor, *R2,* drops the filament voltage to 1.5 volts, which is applied to all the 1.5 volt filaments in parallel. The 250-μf 1.5-volt capacitor *C3* filters the filament d-c supply.

The major d-c supply of 100 volts at *Y* is filtered by a pi-type filter network consisting of a 4000-ohm resistance, *R3,* and two filter capacitors, *C2* and *C4,* delivering 90 volts at 25 ma as plate supply (B+) for the set.

Rewiring. If desired, a battery set can be rewired for permanent ac-dc operation. The filament circuit should be changed, usually from a parallel string to a series string with a rectifier inserted.

Make the change in filament wiring only if all the set filaments have the same current drain. (If tube filaments have different current drains, use the filament arrangement shown in Fig. 7-2.) Where the series filament wiring is used, there is an optimum placement of certain tube functions in series. In rewiring the set, observe the following filament string lineup, starting from the ground end:

1. Converter.
2. R-f amplifier (if used).
3. Diode detector.
4. I-f amplifier.
5. Output stage.

Figure 7-3 shows a typical power supply that may be used with slight modifications in most battery-only sets for conversion to ac-dc operation. E_1 is the plate supply (approximately 90 volts), which

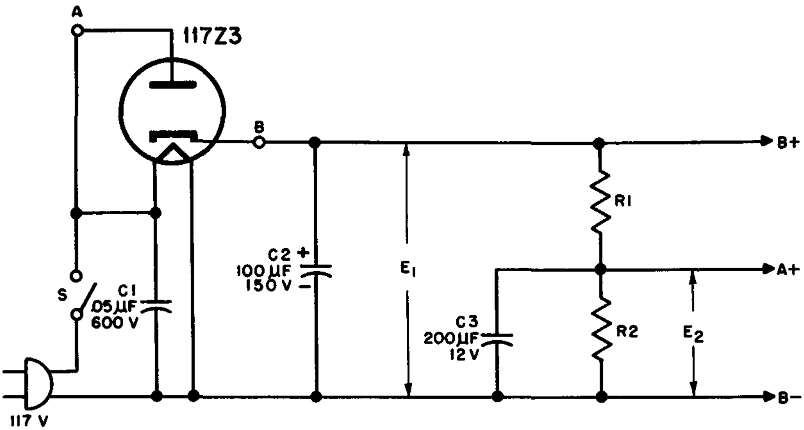


Fig. 7-3. A power supply used for converting a battery portable to permanent ac-dc operation.

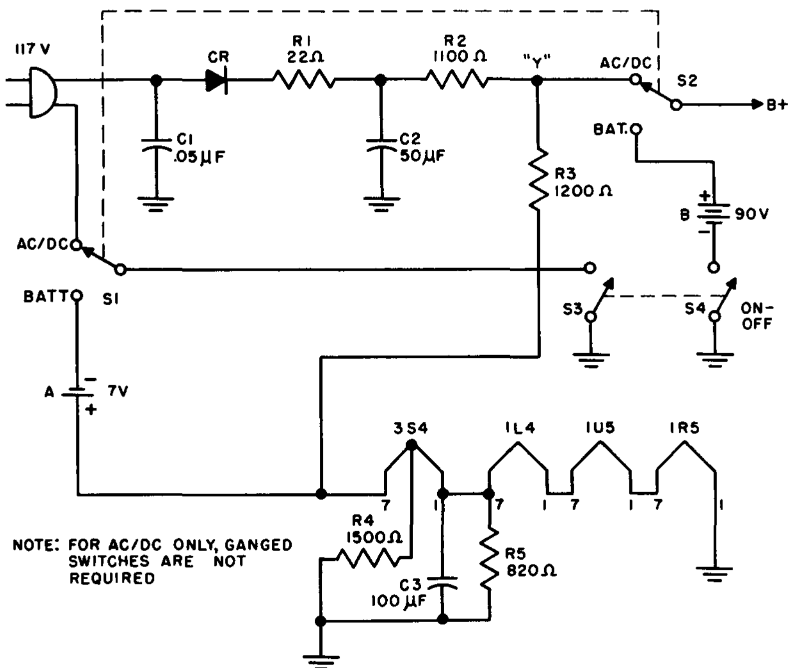


Fig. 7-4. Converting a "battery only" set to an ac-dc or a three-way set.

should be reduced by means of a practical series filter resistance to the specific plate voltage desired for the set. E_2 is the voltage for the filament string. Resistors *R1* and *R2* are a voltage divider to yield the desired A voltage for the filaments.

BATTERY PORTABLE TO A THREE-WAY SET

To make a portable into a three-way set, the set must be rewired, a rectifier circuit added, and a two-position switch inserted. The problem of rewiring has been discussed above. Insertion of a two-position switch may cause placement problems. Each set presents different physical problems, but they are all quite similar electrically.

A typical circuit used to convert a battery-only radio into an ac-dc or three-way set is shown in Fig. 7-4. Ganged switches *S1* and *S2* are shown in ac-dc position. Line power is rectified through *CR*, passing through the current-limiting 22-ohm resistor *R1*, the 50-μf filter *C2* and 1100-ohm series filter *R2* to point *Y*. The 1200-ohm resistance at *R3* drops the rectified voltage at *Y* to the suitable filament value for the filament string. The high voltage at *Y* is available as B supply for the set.

When ganged switches *S1* and *S2* are switched to BATT, the A and B batteries are connected into the power supply instead of the line power. The ON-OFF switch (ganged *S3* and *S4*) shuts *everything* off or turns *everything* on.

REPLACING A RECTIFIER TUBE WITH A SELENIUM RECTIFIER

There are many advantages to replacing a rectifier tube with a selenium rectifier. The job should take only ten minutes and is well worth it. The following is a typical procedure for use in three-way sets:

1. From tube handbooks or manufacturers' data, determine the current rating of the radio set. Do this by adding all plate and screen currents drawn throughout the set and add this current to the highest filament current in the set.
2. Obtain a selenium rectifier that can safely carry this total current.

For the following steps refer to the circuit shown in Fig. 7-3.

3. *a.* For replacing 117-volt tubes, measure the output voltage across the first filter (E_1) and across the entire filament string (E_2).
   b. Remove the rectifier tube and connect the selenium rectifier in series with a 25-ohm, 1-watt resistor, between *A* and *B*.
   c. Measure E_1 and E_2 again. The values should be within 10% of those obtained in the first measurements. If they are not, increase or decrease the value of the added resistor to obtain voltage readings which are within 10% of the original values.

For the following steps refer to Fig. 7-3 (although a 117-volt, rather than a 35-volt tube is shown, the reference points are the same).

4. *a.* For replacing 35-volt rectifier tubes, remove the tube and insert the selenium rectifier as indicated in Fig. 7-5.

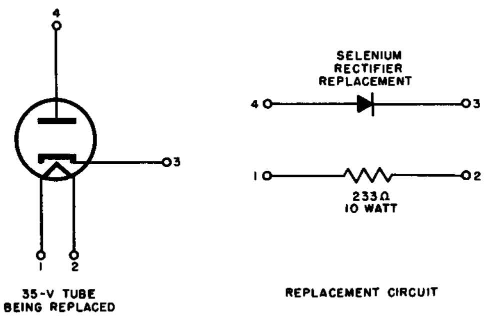


Fig. 7-5. Replacing a 35-volt rectifier tube with a selenium rectifier.

   b. Remove all the other tubes and measure the voltage across the first filter capacitor. Call this voltage E_1. Assume 100 volts for E_1 in the example following.
   c. From the tube handbook, determine the voltage and current required for the filament string E_2. For example, suppose the tubes are: 1R5 converter, 1U4 i-f, 1U5 detector-a-f, and 3V4 output. The total voltage would be 7 volts for the nominal filament string, with a common filament current of .05 amperes. Call this voltage E_2.

d. Using Ohm's law, calculate the value of the required dropping resistor:

$$\frac{E1 - E2}{\text{Tube Current}} = R \text{ (dropping resistor)}$$

In this case:

$$\frac{100 - 7}{I} = \frac{93}{0.05} = 1860 \text{ ohms (dropping resistor)}$$

e. Calculate the wattage of the resistor by using the square of the tube current times R. In this case: $(0.05)^2 \times (1860) = 4.7$ watts. In practice, a 10-watt resistor should be used for safety.

f. Insert the dropping resistor in the filament circuit. In Fig. 7-3 this new dropping resistor would replace *R1*. (In this application, *R2* does not exist as such, but represents the resistance of the series filament string.)

5. Observe the following precautions when installing selenium rectifiers:
   a. Observe proper polarity: a + sign is equivalent to the cathode; a – sign indicates the plate.
   b. Anchor the rectifier securely, so that it can't move around and short out other components.
   c. Mount the rectifier in a cool place in the chassis, near the r-f stage and away from dropping resistors.
   d. Insert a protective covering, if necessary.

REPLACING A LOOP WITH A FERRITE-CORE ANTENNA

To increase the sensitivity of a radio it is often advisable to replace the loop-type antenna with a ferrite-core type. This is mainly a mechanical problem; in fact, in many sets, this antenna replacement may not be possible because of close quarters. However, when the replacement can be made, obtain the proper type from your dealer (universal-replacement types are available.) Anchor it well, and, above all, away from components that may radiate into it.

8. clock radios

Clock radios are now as common as the ordinary ac-dc set. The technician is missing a lucrative source of business if he turns down clock radio trade because he doesn't feel qualified. It should be emphasized that more than 75% of clock radio troubles are in the *radio* itself – and the radio in a clock radio is no different from the ordinary ac-dc set. Since it is assumed that the technician is familiar with the ac-dc set, this chapter will discuss the difficulties peculiar to the clock.

TYPICAL CIRCUITS

Referring to Fig. 8-1, note that there are two time switches: *S1* closes automatically at a preset point in the clock cycle, while *S2* is the usual ON-OFF manual front-panel control. These two time switches (ON-OFF and MANUAL) are in parallel; either one can switch the set on.

In all clock radios, the clock is connected directly across the power line, independent of all switching. *Is is impossible to switch the clock on or off.* This rather fundamental fact may save service

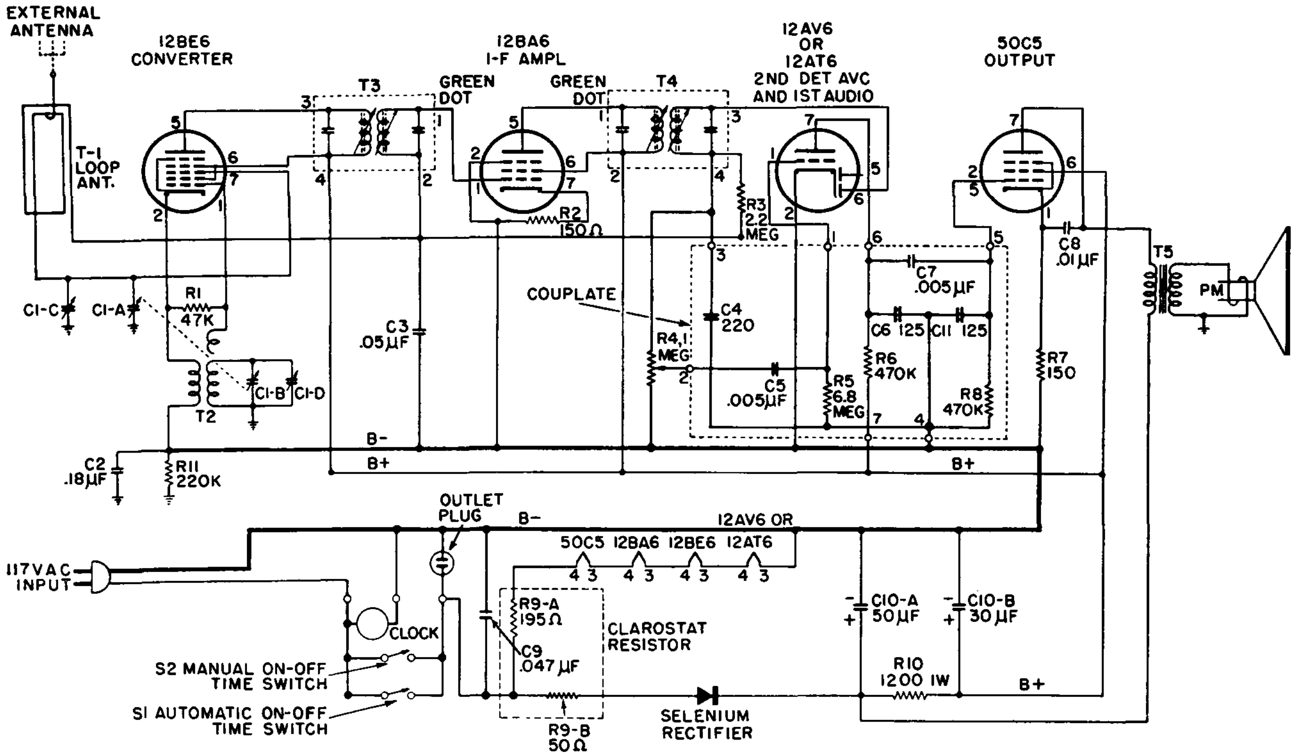


Fig. 8-1. Schematic diagram of a typical clock radio. ***Raytheon Mfg. Co.***

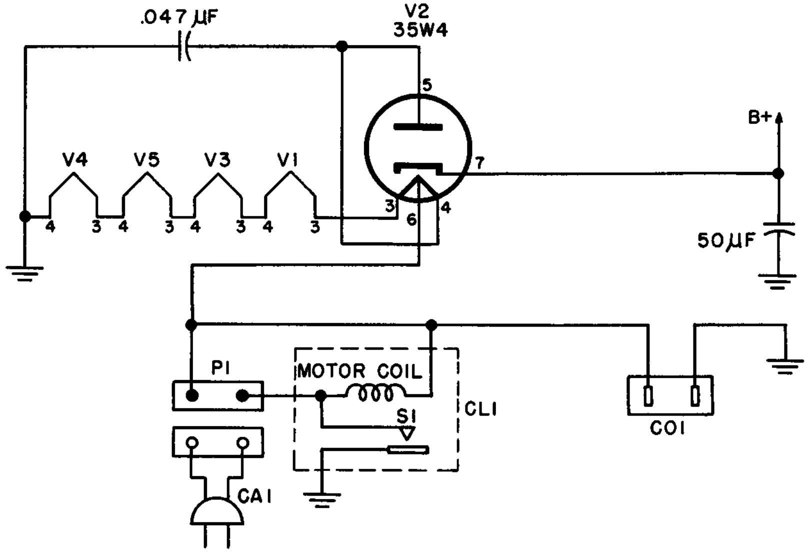


Fig. 8-2. A clock radio power supply.

time with a faulty set. No matter what the complaint, if a clock radio is plugged in, the clock should start instantly, regardless of switch settings or the state of switch circuitry. (The second hand should start spinning immediately; if there is no second hand, listen for the hum of the clock motor or watch the minute hand to observe movement.) The clock is completely independent of the radio.

It should also be noted that the manual ON-OFF switch (*S2* in Fig. 8-1) can be tested from the front panel. Since this manual switch is in parallel with the automatic time switch (*S1*), the manual switch will turn on the set, even if the automatic switch is open. (Of course, if the automatic switch is ON, the manual switch will have no further effect.)

The outlet plug receives current when either of the two switches is turned on. Thus, if an external appliance is plugged into the output plug, it can be automatically activated at a preset time by *S1*.

Figure 8-2 shows a clock radio power supply with the clock (motor coil) connected independently across the line. It is as if the clock and the radio were two separate appliances, using a common plug. Again, if the clock doesn't work, this fact has nothing to do with the radio — check the plug wiring and clock mechanism only, ignoring the radio completely.

Plug *CA1* has an interlock *P1* (something like the *cheater cord* on TV). The entire clock assembly is inside the dashed line marked *CL1* and includes time switch *S1*. When the clock "rings," time switch *S1* closes, completing the circuit to clock outlet *CO1* and general chassis ground, permitting primary power to reach the radio circuit.

Figure 8-3 shows a three-way portable with provision to plug in the clock when operating on alternating current only. Except for built-in switching within the clock assembly (not shown), the circuit is straightforward.

The clock is plugged into the safety interlock switch. As in all clock-radios, this places the clock directly across the a-c line. One caution must be observed — the clock must not be plugged in except when the set is operating on alternating current. (Figure 8-3 shows the set in a-c position.) This a-c position connects the lower conductor of the plug to chassis ground, permitting the upper conductor of the plug to supply the selenium rectifier, resulting in direct current passing through the 150-ohm resistance of the tapped resistor and then through the 2,700-ohm resistor to the set proper. Another path of current is through the 2,000-ohm resistance of the tapped resistor to supply the series filaments.

CLOCK REPAIRS

This book is not intended as a course in clock repair, even though this chapter should encourage the radio technician by showing him how to keep many clock radios going. However, the authors definitely do not wish to encourage unnecessary tinkering with clocks and clock mechanisms.

As is true of all machinery, the clock in a clock radio set will eventually break down under normal wear or with the accumulation of dirt.

The following is a list of clock mechanism repairs that are not difficult and *can be accomplished* in any well-equipped radio repair shop:

1. Replacement of broken crystals.
2. Replacement of damaged bezels and knobs.
3. Replacement of inoperative rotors and open coils.
4. Vibrator and alarm adjustments.
5. Cleaning of clock mechanism.

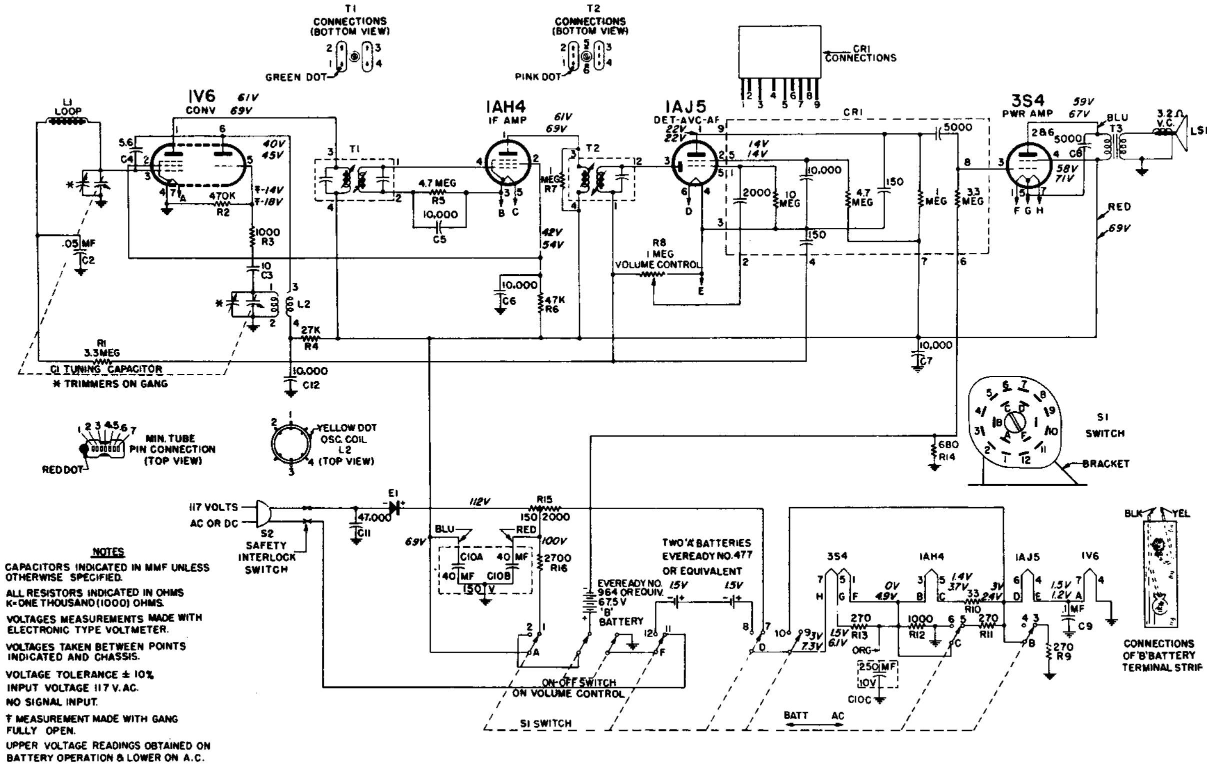
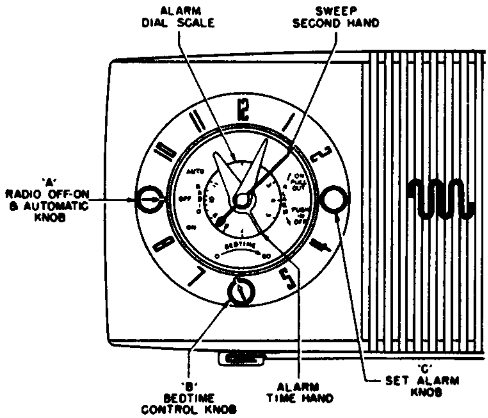


Fig. 8-3. Schematic of a three-way portable clock radio using subminiature components and tubes.

Fig. 8-4. The front plate of a typical radio clock. *Telechron Div. of GE.*



TYPICAL RADIO TIMERS

In order for any technician to service a timer intelligently, he should understand how one works. A radio timer is any device preset to operate an appliance at any given time. There is no better way to understand timing devices than to go through an actual disassembly procedure and, as each part is removed, study its relationship to the parts with which it mates.

In most cases, however, the most economical course, if mechanical failure is suspected, is simply to replace the entire clock mechanism.

Disassembly of a Telechron C57 movement is discussed below and a Sessions movement is shown later.

Disassembly of Telechron C57 movement. (Figure 8-4 shows the face of the clock movement; the parts numbered in Figs. 8-5 and 8-6 are indicated in parentheses below; and Fig. 8-7 shows a final exploded view.)

1. Take off the clock control knobs.
2. Pull out the clock plug from the receiver receptacle.
3. Remove the hex nuts and cover from the rear of the clock.
4. Remove the clock from the cabinet by taking out the four screws at the corners of the clock front plate.
5. Disconnect the wire connections from the field coil (25).
6. Take out the mounting screw in the laminated iron core at each side of the rotor (24).

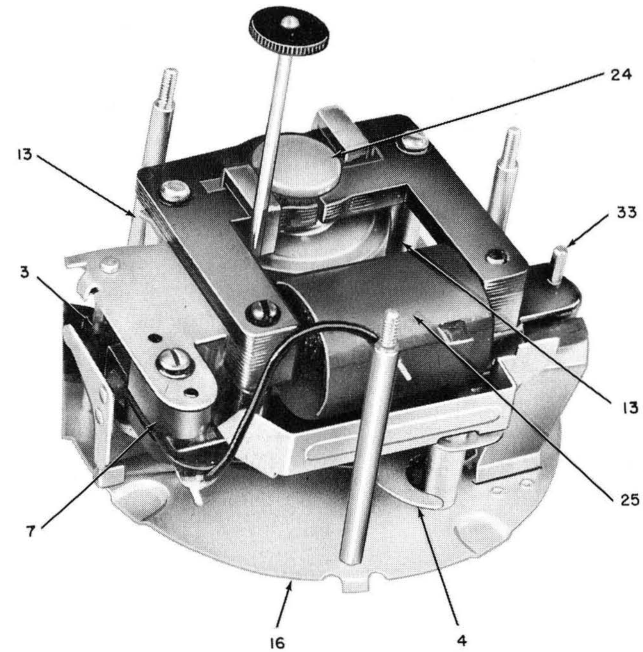


Fig. 8-5. Rear view of Telechron clock. ***Telechron Div. of GE.***

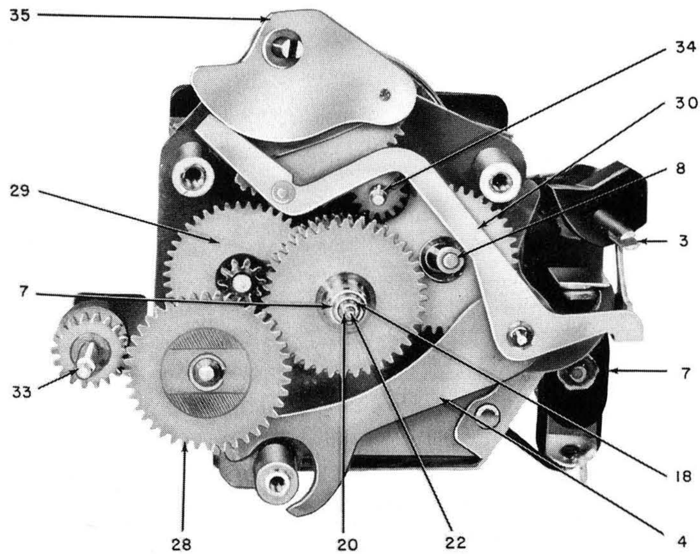


Fig. 8-6. Front view of Telechron clock with front plate removed. ***Telechron Div. of GE.***

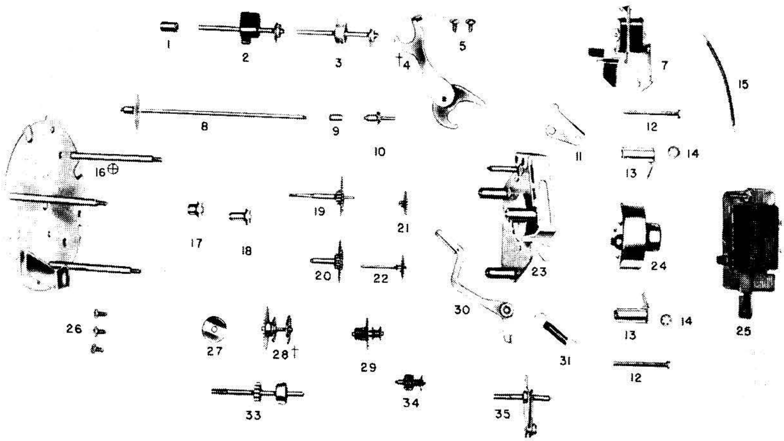


Fig. 8-7. Exploded view of the Telechron clock movement. ***Telechron Div. of GE.***

7. Move the core and the rotor off and over the time-set shaft (8). The rotor unit spacers (13) will then drop off.
8. Push out the rotor from the yoke formed by the core.
9. Remove the screw and nut to separate one of the sections of laminated cores.
10. Push the coil off the cores.
11. Set the selector to WAKE and the sleep control to zero.
13. Remove the switch contact assembly (7) from the bracket mounting.
14. Pull off the second, minute, and hour hands.
15. Pull off the alarm-set dial.
16. Remove the dial face and the paper dial spacer.
17. Remove the front plate assembly (16) by removing the three screws that hold it.
18. Remove the switch shaft and bushing (3).
19. Remove the alarm-set shaft (33).
20. Remove the sleep control shaft assembly (35).
21. Remove the sleep switch lever (30).
22. Remove the alarm-set sleeve (17).
23. Remove the hour hand sleeve (18).
24. Remove the intermediate gear assembly (34).
25. Remove the time-set shaft and bushing (29).
26. Remove the sleep switch friction assembly (29).
27. Remove the minute hand sleeve (20).
28. Remove the cam shaft assembly (28).

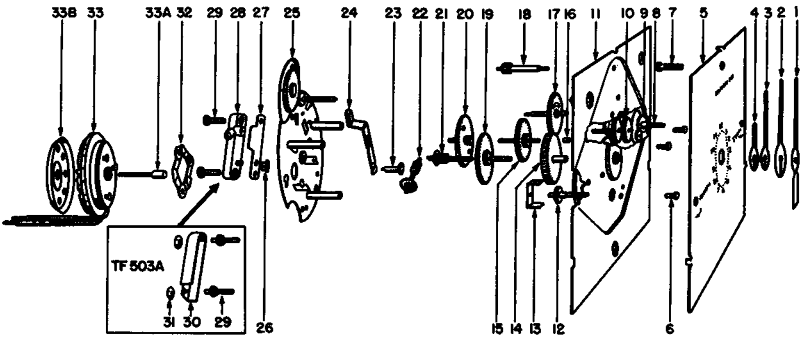


Fig. 8-8. Exploded view of typical Sessions clock movement, with parts description. *Sessions Clock Co.*

29. Remove the switch yoke lever (4).
30. Remove the sweep second hand shaft (22).

Reassembly is in the exact reverse order of disassembly; that is, to reassemble, start at step 30 and work backwards to step 1, *assembling* instead of disassembling.

For comparison of the Telechron clock movement discussed above with another typical timer, refer to the exploded view of the Sessions movement shown in Fig. 8-8.

GENERAL SERVICE INSTRUCTIONS

The general service instructions given below are sufficient in detail to provide the technician with the necessary precautions and to guide him along proper lines when servicing clock timer mechanisms.

Preliminary inspection and test. When a timer is brought in, find out from the customer what is wrong in the behavior of the clock. Visually inspect for any obvious defects, such as bent shafts or hands. If visual inspection reveals nothing, plug the movement into a proper power supply and observe its behavior. See Table 8-1 for possible troubles.

Disassembly of movement. In disassembly of clock movements be sure to observe the following precautions:

1. *Knobs.* Some knobs are push-on types, others are threaded. Remove the push-on knobs by grasping them and pulling them off, unscrew the threaded ones. Remember not to use force; damaged knobs may be a nuisance to replace.

2. *Bezels.* To remove a bezel with tabs, straighten the tab that is bent over the dial back. Bezels that are crimped may, of course, be removed by straightening out the crimp.
3. *Crystals.* If a glass crystal is used, it may be removed after the bezel is lifted off. Some plastic crystals are attached to the dial by tabs that are part of the crystal itself. The suggested procedure for removing these plastic crystals is to use an electric hot plate; to lessen the danger of the crystal overheating and catching fire. Do not overheat; plastic crystals burn very easily. Heat the crystal near the plastic tabs. When heated, straighten the tabs and remove the crystal. Other plastic crystals are simply snapped on the dial by short tabs. This type of crystal is removed by pulling the crystal off gently.
4. *Hands.* Clock hands may be removed with thin-nosed pliers. Remove each hand individually by grasping it as close to the shaft as possible and pulling gently. Avoid scratching the hands and dial with the pliers.
5. *Dials.* A typical dial may be removed by bending the "ears" that are bent over its back and lifting the dial off. Some dials are held by rivets; care must be exercised in the removal of these.
6. *Soldered connections.* Excess heat may cause damage. Therefore, use a small iron and apply only enough heat to loosen the electrical connections.

CLEANING AND LUBRICATION

1. *Cleaning for appearance.* All repaired timers should present their best appearance. Clean plastic crystals with a soft cloth or facial tissue, using only water. Glass crystals should be cleaned with a good glass wax. Bezels should be cleaned with a soft cloth moistened with soapy water; don't rub too hard or you may remove the lacquer finish.
2. *Cleaning movements.* To clean a movement, completely disassemble it and clean all moving parts in carbon tetrachloride or a similar cleaner. Oxidized oil may be removed by rubbing it with a fine grade of steel wool moistened with carbon tetrachloride.

Table 8-1

Defect	*Cause*	*Part No. in Figs. 8-5, 8-6, 8-7*
Clock will not operate	Defective field coil	25
	Defective rotor	24
	Binding of parts	—
	Defective clock switch	7
Clock loses time	Binding parts	—
	Defective rotor	24
	Timing shaft bent	8
	Broken or damaged gear teeth	8, 10, 17, 18, 19, 20, 21, 22, 28, 29, 33, 24
	Too little friction on minute-hand sleeve assembly	20
	(Spring defective)	31
Clock noise	Rotor defective	24
	Alarm armature improperly adjusted	
	Loose parts	
	Binding of moving parts	

3. *Lubrication.* Do not use too much oil. Too much oil collects dust and later oxidizes; in addition, it may stain the crystal and dial. Apply the oil with a small wire. Use only clock oil, such as Hye's Celebrated Oil or its equivalent. Lubricate the two arms, the bearing holes for the operating shafts in the front and back plates, and the end of the sweep second shaft at the back bearing plate. Using graphite, lubricate the levers and cam gears.

ALARM AND SWITCH ADJUSTMENTS

After the clock has been reassembled, the following adjustments should be made:

1. Turn the function switch to the AUTOMATIC WAKE or ALARM position.
2. Set the automatic (alarm or wake) dial hand for any desired time.
3. Turn the time set knob, or clock hands control, clockwise to the preset alarm hour. The radio (or alarm) should turn on automatically. (Make certain that the switch contacts close at the alarm hour.) Continue to rotate the clock hands and note if the alarm (or wake) vibrator arm drops toward the field core 7 to 10 minutes after the set was automatically turned on.
4. If the switch contacts do not close at the correct time, the minute hand should be moved to make the necessary adjustment. The time-set knob should be held firmly while the minute hand is being moved.
5. To adjust the alarm period, set the clock so that it reads 10 minutes after the time set for the alarm. Slowly turn the adjusting screw *in,* until the shut-off lever just slides over the edge of the screw head . (When the alarm shaft is in the OFF position, there must be clearance between the shut-off lever and the vibrator adjusting screw at all times.)
6. To adjust the tone of the vibrator, connect power to the set, have the vibrator operate, and bend the vibrator arm (close to its anchor point) nearer of farther from the field core.

INSTALLATION OF SWITCH TIMERS

Many times there is a call for installation of a switch timer in an ordinary ac-dc set. It is possible to purchase a timer mechanism and mounting bracket that may be installed in some radio cabinets. Every case requires a different installation approach, so make a careful study of the problem before attempting installation. If a timer cannot be installed, due to lack of space, for example, obtain a separate timer mechanism (including the clock and all switches) into which the radio may be plugged. The timer is plugged into the a-c line and, in effect, the radio is converted into a clock radio.

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BATTERY CROSS-REFERENCE AND INTERCHANGEABILITY LIST

VOLTAGE	ACME	BRIGHT STAR	BURGESS	EVER-EADY	GENERAL	MARA-THON	NEDA NUMBER	OLIN	PHILCO	RCA	RAY-O-VAC	USALITE	ZENITH
"A" BATTERIES													
6		866*	2F4	718	7		1	4817		VS010	A1		
6			Z4	724	39		2	4919*		VS068	A2		
4½		360	F3	736	38	3	3	3816	D100	VS067	A3	688	Z736
1½	114	462	4F	742	3	4	4	4816	P94	VS004	A4		Z94
1½			6F	743	5		5	4814*	P96*	VS007*	5		Z96
6		646	F4PI	744	4	496	6	4914	P4F4R	VS009	A6	639	
4½		361	G3	746	8	381	7	4918	P100	VS002	A7	683	Z83A
7½			B5	713			8	5219		VS129	8		
7½		591	C5	717	31	9	9	5316	P31	VS065	9		Z750
7½			T5	W360			10				10		
1½			2F	W353			11			VS141	11		
1½			4FL				12			VS005	12		
1½	111	10M	2-2R	950	920	120	13	1550	P920	VS036	2LP	75LP	Z2NL
1½		11M	1	935	914	110	14	1311	C	VS035	1LP	74	Z7
1½	115	59	Z	915	900	170	15	1711	AA	VS034	7R		Z8
6			2F4L	747			16	4815	8CF4*	VS011	16		Z698L
1½	118		8F	741	46		17	4819	P8F1		17	635	
1½			2D	720			18	2516		VS069	18		
4½	31		D3	726		19	19	4516		VS072	19		Z450
1½			21R	964	77	20	20	2416	P77	VS236	20		Z5
1½			8FL*	745		891	21	4813*		VS008*	21	645	
7½			G5		10		22			VS003*	22		
1½			8R	960P	EF728		23			VS070	23		Z1
1½		58	7	912	901		24	1911	K	VS074	400		
6			F4L*				25				25		
"B" BATTERIES													
67½		45N	XX45	467	108	45NR	200	1710	P67	VS016	200	767	Z67
45			XX30	455	105	201	201	6211	P105	VS055	201		Z455
45		30-33	M30	482	109	202	202	6210	P45	VS013	202	640	Z783
67½			K45	457	172	203	203	1712		VS082	203		Z457
90		60N	N60	490	132	204	204	1713	P132	VS090	204	769	Z490
22½, 45	530	30-59	Z30	738	104		205	6718*	P104	VS015	205	620	
45	430		A30	W359	110	3040	206	6118*	P210	VS014	206		Z530
45	330	30-03	B30	484	111	3050	207	6218	P305	VS012	207	624	
15			U10	411	611		208	1914		VS083	208		
30			U20	413	613		210	1916		VS085	A210		
67½			P45M			211M	211M		P175	VS215 VS216	211M		
67½		675	P45	477	149	211	211P	1709	P149	VS218	211P		Z477
75			XX50	437	144	212	212	1708	P144	VS217	212		Z437
45			U30	415	150	213	213	1909	P150	VS086	213		Z415
90			P60	479	176	214	214	1706	P176	VS219	214		Z90
22½		12P	U15	412	612	215	215	1915	P612	VS084	215		
"A" and "B" BATTERY PACKS													
9, 90		66-03	G6B60	752	343	400	400	616	P60B6F6	VS047	A400		Z985
7½, 9, 90	460	66-50	F6A60	753	271	60A6F	401	614	P841A	VS019	401		Z979
7½, 9, 90			G6M60	754		60BR6G	402	615		VS018*	402	1	
6, 7½, 75		66-52	T5Z50	755	350		403	618	P350	VS050	403		
7½, 9, 90		66-53	T6Z60	756	371		405	619	P371	VS057W	405		
9, 90		66-54	F6A60P	757	273	406	406	620		VS058	406		Z909
1½, 63			4GA42	W366	258		407	624*	P41A4FL	VS053	407		
7½, 63			G5A42	W367	263		408		P87	VS038	408	AB676	
1½, 90			5DA60*				409			VS043	409		
1½, 90			6TA60	W369			410	622*		VS054	410		
6, 75			F4A50	W368			411				411		Z6394
1½, 60			2TXX40	W370	254		412		P89				
1½, 90	782	61-05	17GD60	759		1860	413	518		VS022	413		Z802
1½, 90			4SD60	758	299		414	513*	P60B6L	VS021*	414		
7½, 9, 90			S6D60	776		415	415		P326	VS119	415		Z990
1½, 9, 90							416						Z985X
1½, 90			6FA60*		279		417	611*	P6084L	VS037*	417	AB667	
6, 90			F4B60*			418	418			VS048*	418		
1½ A, 67½ B, 7½ C							419			VS041*	419		
6, 7½, 67½			F5M45*				420			VS020*	420		
6, 90			2F4A60				421			VS044*	421		
6, 75			G4B50*		348	422	422			VS046	422		Z675
1½, 61½							423			VS052	423		
1½, 90						424	424			VS099*	AB82 Metal Can		
1½, 90			4TZ60	729	364		425		P364	VS064	425		
1½, 90			18GD60*		318		426			VS045	426		Z28
6, 67½							427				AB6145N		
9, 90			T6Z60P	727	366	428	428			VS059	428		Z962
1½ A, 67½ B, 7½ C							429			VS051*	429		
9, 90			3G6D60*				430				AB982		
7½, 75			T5Z50P	785		431	431			VS060	431		Z775

NEDA NUMBER	ADVANCE	EMERSON	FIRE-STONE	GAMBLE	GOOD-RICH	GOOD-YEAR	MONTG. WARD	SEARS	WESTERN AUTO	WILLARD	OTHER	MAXIMUM DIMENSIONS IN INCHES: Length	Width	Overall Height
"A" BATTERIES														
1												4	2 15/16	5½
2												1⅜	1⅜	2⅜
3			4D86				26	6441	3B6135	3F3		4	1 7/16	4⅛
4				43-263			21	6430	3B6110*	4F1		2⅝	2⅝	4 3/32
5								6431*	3B6115*	6F1*		4 3/32	2¾	4⅛
6								6451	3B6145*	WA4-2		2 21/32	2 21/32	4¼
7								6440		WA3-1*	Air Castle FM8247	4 1/16	1⅜	4 11/16
8												4 1/16	15/16	3
9		EM717	4D136			21-5626	29		3B6160	5C5	Admiral A47 Crosley CE90	2 5/16	2	3 1/16
10												2 5/16	2 19/32	4 3/32
11												2 19/32	1⅜	4¼
12												3 29/32	1⅜	5⅝
13	2DL		7C1	17-430	32-909		3259 3262 3253 3252 3260	4650	3B-6730 3B-6732	D		1⅜	Diameter	2 13/32
14		EM35	7C44	17-425	39-501			4659	3B6730	C		1½	Diameter	1 31/32
15	1AAL		7C39					4653	3B6710	AA		19/32	Diameter	1 31/32
16				43-268				6452*				3 31/32	1½	10 13/16
17	118						20			8F1*		3 29/32	2 13/16	5½
18												2⅝	1⅜	3 17/32
19	31											3 15/16	1⅜	3
20		EM236	4D71 4D133		39-520	21-5629	27	6442	3B-4112* 3B-6113	77		1⅜	Diameter	4 9/32
21												3 29/32	1 7/16	10 13/16
22									3B6154*	WA5-1*		3⅞	2 11/16	4 9/16
23												1 11/32	Diameter	4 1/16
24	1KL		7C50					4656				7/16	Diameter	1¾
25								6450*				4	1 7/16	5 13/16
"B" BATTERIES														
200		EM467	4D84	43-304	39-522	21-5615	43	6480	3B6258	WBM2	O.T.&S. 54-412	2 13/16	1⅜	3 13/16
201			4D132			21-5619	79		3B6242			2 21/32	1	3¾
202			4D89				42	6461	3B6241	WBM1		3 17/32	1 27/32	5½
203												2 13/16	1⅜	2½
204			4D88			21-5622	46	6465	3B6260	WBM3		3 23/32	1⅜	3¾
205	530									V30AA		3	2 5/16	4⅛
206	430						41	6460*	3B-4228 3B-4229	V30A		3 5/16	2¼	4⅝
207	330		4D85	Z43-301			49	6462*	3B6239*	V30B	Andrea FM8266	4⅛	2⅝	5⅜
208												1 1/32	⅝	1 29/64
210												1 1/32	⅝	2 5/16
211M		EM216	4D72			21-5630		6482	3B6256*			1 15/16	1	5 5/16
211P			4D135	43-310	39-521		40		3B6257	149		1 15/16	1	5 5/16
212					21-5628		47			144		1 15/16	1 15/32	6 13/32
213		EM86	4D134					6485	3B6242			1 3/64	⅝	3¾
214			4D139									1 31/32	1 1/32	7 15/32
215							86					1 1/32	⅝	2
"A" and "B" BATTERY PACKS														
400							37	6401		WZ3		14 1/16	2¾	4 11/16
401	460		4D138	43-323	39-524		33	6407	3B6460	60A6F6/5		9½	2 13/16	4½
402							35	6404	3B6470*	AB14*		10⅝	3 7/16	4⅛
403								6408	3B6464	50AA5CE5/4		8 9/16	3¾	2 7/16
405			4D74					6409	3B6466	AB15		8 15/16	2 7/32	3⅞
406								6410	3B6462	60AF6F6		9½	2¾	4⅜
407				AB669			34		3B6440*	WP1*		9⅜	2⅛	4¾
408							36					9⅛	2 13/16	4 7/16
409										WP2*		5⅝	2 11/16	7⅛
410												10	2⅝	4 29/32
411												9 3/32	2 25/32	3 21/32
412							32			WP4*		7⅞	2 5/16	1 11/32
413			4D1					6312	3B6430	60DL-11L		16	4⅜	6 15/16
414							59	6303*	3B6410*	60B6L*		10 13/16	4 5/16	6 13/16
415												8¼	4½	13⅞
416												14 1/16	2 11/16	4⅛
417				AB667			31			WP3		12	6 7/16	1½
418												10¾	2⅜	5
419												4 5/16	3¾	6⅜
420								6400*				9 9/16	2 11/16	4½
421												12⅛	2¾	4⅜
422				AB670				6403*		WZ2*		12¾	2¾	4¼
423												9⅜	2 11/16	3 7/16
424							51	6308*	3B6432			4 11/16	6¾	15¾
425												3 27/32	2 7/32	7 15/16
426								6305*		WZ1		12 9/16	5⅝	6 13/16
427								6406				7 9/16	1 7/16	2¾
428												9 7/16	2 5/16	3 13/16
429												4¼	3⅞	6⅝
430												8¼	4½	13⅞
431												8 9/16	3 11/16	2 7/16

*Asterisked items are discontinued numbers and shown for reference purposes only.

For the purpose of standardization, lengths and widths shown are dimensions for the area in which the terminal is located.

VOLTAGE	ACME	BRIGHT STAR	BURGESS	EVER-EADY	GENERAL	MARA-THON	NEDA NUMBER	OLIN	PHILCO	RCA	RAY-O-VAC	USALITE	ZENITH
INDUSTRIAL and SPECIAL PURPOSE													
1½		262*	2FBP	W354			700			VS101	700		
3			F2BP	W352			701			VS102	701		
18, 22½, 3			2156				702			VS137*	702		
3			2F2H	W356			703			VS136	703		
3		50-17*	422	750			704			VS134	704	1095	
4½			432	751			705			VS142	705	1090	
4½		03-17	532	752			706			VS133	706	1005	
							707						
3 to 22½			5156SC	778	216*		708	5216-8	P1588*	VS131	708	1090	
22½, 45	330S		5308	W376	113		709	6219		VS112	709		
—22½			4156	763	103		710	5115*		VS110	A710		
22½, 45			Z30NX	W350	122		711			VS114	711		
1½ to 4½			2370ST	761T	214*		712	3516		VS130	712		
1½ to 7½		51-03	5540	773	208		713	5218		VS029	713		
4½		03-17S	5360	781	201		714	3217		VS028	714		
22½, 45			21308SC	W364F			715			VS157	715		
22½, 45			10308SC	W363F			716			VS127	A716		
22½, 45		30-95	2308PI		115	3020	717	6518*	P30D	VS026	717		
3, 4½		71-17	2370PI	771	215	3002	718		P3D	VS030	718		
1½		20-60*	20F	740	15*		719		P816	VS024*	719		
3			20F2		21		720		P8024	VS025*	720		
3 to 22½		15-03	5156PI	768	212*		721	5216	P1585	VS031	721		
300			U200	493	609*		722	922		VS093	722		
22½, 45			2308SC	W365F			723			VS126	723		
22½, 45			1030BSC-Pur				724			VS127W	724		
6			F4X				725				725		
22½, 45		30-60	10308PI	W363P	119	3090	726		P30F	VS027*	726		
22½, 45			2130BPI	W364P	121		727		P30FL		727		
Industrial and Lantern													
1½	114S	464	4FH	735	952	491ST	900	1605		VS108	900	634S	
3			4F2H	W357			901			VS138	901		
6			4F4H	706	991	896	902			VS103	902		
7½		155	4F5H	715			903	5605		VS139	903		
9			4F6H	716			904			VS140	904		
1½		6 Ign.	6 Ign.	6 Ign.	986	66	905	6 Ign.	6	VS006-S	6 Ign. S		
1½		6 Tel	6 Tel	6 GL	978	6-T	906	6 Tel	6 Tel	VS042C*	6-Tel C	6T	
6		146	S461	1461	955	640	907	4615	P64	VS039	641	641	
6	411L	466	F4H	509	916	490	908	4812	P4F	VS040C	941	934	
9			D6BP				909			VS132*	909		
1½			N	W468	913	N	910			VS073	716		
1½		6 Ind.	6 Ind.	6 Ind.	977	66R	911	6 RR			6 RR		
7½		156		1562			912	5615*					
9		166*		1662			913	6615*					
1½			6 Ign. C	6 Ign. C	986-C		914			VS006C	6 Ign. C	634C	
6		466S	F4BP	510S	36		915	6715S		VS040S*	941SC	934S	
6				409	923	490NL	916				941 RR		
6				510F			917				941C		
6				731			918						
Transistor and Other													
4				E233	696		1300		P696	VS400			
4							1301			VS311	1301		
4							1302			VS308	1302		
6			4D4	274			1400						
5½							1401			VS310	1401		
5½							1402			VS307	1402		
9				226			1600			VS300	1600		
9, 6, 3			D6PI		89		1601			VS301	1601		
9			2N6	246	178		1602	1707		VS305	1602		
9			D6	276	88	1603	1603			VS306	1603		
9			2U6	216			1604				1604		
9			M6	266			1605						
9							1606			VS309	1606		
							1607	6316					
13½, 9			XX9	239	177		1900			VS304	1900		
-21, -12				2314			2400						

NEDA NUMBER	ADVANCE	EMERSON	FIRE-STONE	GAMBLE	GOOD-RICH	GOOD-YEAR	MONTG. WARD	SEARS	WESTERN AUTO	WILLARD	OTHER	MAXIMUM DIMENSIONS IN INCHES: Length	Width	Overall Height
INDUSTRIAL and SPECIAL PURPOSE														
700												[illegible]	[illegible]	[illegible]
701												[illegible]	[illegible]	[illegible]
702												[illegible]	[illegible]	[illegible]
703												[illegible]	[illegible]	[illegible]
704												[illegible]	[illegible]	[illegible]
705												[illegible]	[illegible]	[illegible]
706												[illegible]	[illegible]	[illegible]
707												[illegible]	[illegible]	[illegible]
708										H1588		[illegible]	[illegible]	[illegible]
709												[illegible]	[illegible]	[illegible]
710												[illegible]	[illegible]	[illegible]
711												[illegible]	[illegible]	[illegible]
712								5005*				[illegible]	[illegible]	[illegible]
713										V58		[illegible]	[illegible]	[illegible]
714										H38*		[illegible]	[illegible]	[illegible]
715										V30FLSC		[illegible]	[illegible]	[illegible]
716												[illegible]	[illegible]	[illegible]
717				Z43-280			70	6363*		V30-D1		[illegible]	[illegible]	[illegible]
718				43-305			83	6390*	3B-6310*	H3D*		[illegible]	[illegible]	[illegible]
719								6330*		1211L*		[illegible]	[illegible]	[illegible]
720				68			64	6342*	3B-6125*	P24L-2*		[illegible]	[illegible]	[illegible]
721							85	6391*	3B-6320*	H15B		[illegible]	[illegible]	[illegible]
722												[illegible]	[illegible]	[illegible]
723												[illegible]	[illegible]	[illegible]
724												[illegible]	[illegible]	[illegible]
725									3B-6770			[illegible]	[illegible]	[illegible]
726				43-295			73	6361*	3B-6220*	V30F		[illegible]	[illegible]	[illegible]
727				8830			77	6360*		V30FL		[illegible]	[illegible]	[illegible]
Industrial and Lantern														
900				17-410						4F1-S		2 11/16	2 11/16	4 9/16
901												3 29/32	2 11/16	6 1/32
902												8 5/16	2 13/16	6 7/16
903												7¼	4 1/16	6 7/16
904												8 37/64	4 1/16	6 7/16
905				17-410			3250	4701	3B6916	6	O.T.&S. 54-422	2⅝	Diameter	6⅝
906										6T		2⅝	Diameter	6⅝
907			70B174	17-415	39-514		3255	4700	3B6928	641	O.T.&S. 54-423	10½	2 13/16	7 13/32
908	411L		7C16		39-510		3257	4702	3B6760	V4F	O.T.&S. 2-107-7	2 11/16	2 11/16	4⅜
909												4 3/32	2 13/16	3 5/16
910												29/64	Diameter	1 5/16
911										6 Ind.		2⅝	Diameter	6⅝
912												8	5¼	7⅞
913												7⅞	5 5/16	7 13/32
914												2⅝	Diameter	6⅝
915												2 11/16	2 11/16	4¼
916												2⅝	2⅝	4¼
917												2 11/16	2 11/16	4 9/32
918												5 7/16	2⅞	4 15/16
Transistor and Other														
1300		EM233	4D137								Mallory TR233R	1 1/64	Diameter	2
1301												35/64	Diameter	1 1/32
1302												31/32	Diameter	1 1/16
1400												2 9/16	2 1/32	7 29/32
1401												35/64	Diameter	1¼
1402												31/32	Diameter	1 9/32
1600												1	1	1 31/32
1601								6420				8	2¾	1 9/16
1602												1 1/32	1⅜	2¾
1603												2 9/16	2 1/32	3 5/32
1604											Mallory TR146R	1 1/32	11/16	1 31/32
1605												1 13/16	1 13/16	2 7/16
1606												35/64	Diameter	1 29/32
1607												6⅛	1 1/16	2 5/16
1900							95					1 21/64	1 1/32	2 11/16
2400												1 21/64	1 1/32	2⅞

*Asterisked items are discontinued numbers and shown for reference purposes only.

For the purpose of standardization, lengths and widths shown are dimensions for the area in which the terminal is located.

Fig. 2-14. Master *NEDA* battery list.