511 ALL BAND RADIO

Graymark Educational Projects, Inc.

INTRODUCTION

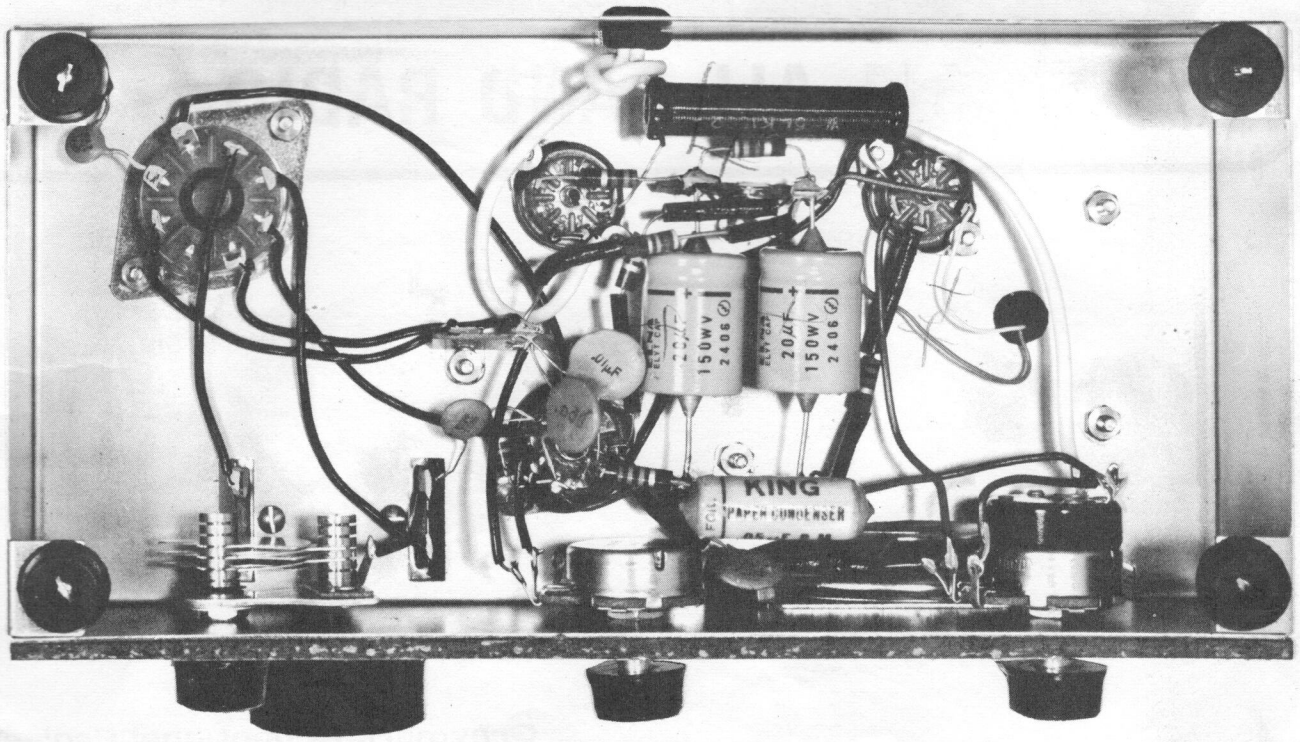
You have chosen an excellent project to help your start in space-age ELECTRONICS. Great opportunities exist in this fast growing field, as a vocation as well as a hobby. You will find the study of electronics interesting and the construction of this project a fascinating experience.

The assembly of the 511 radio has been arranged in a logical, sequential series of stages. You will first draw each stage of the 511 radio on a pictorial layout of the chassis so that the best arrangement of leads and components can be achieved. This drawing is then approved by the classroom instructor. The stage is then wired and tested by you and graded by your instructor. In this way each stage operates and service problems are reduced to a minimum.

In constructing the 511 radio, the builder gains experience in the theory and operation of a series filament circuit, half wave power supply, audio output stage and a voltage amplifier or pre-amplifier stage. Additional information concerning each of these stages of the 511 radio may be obtained from radio text books, available in the local library.

After the 511 radio is completed, you will be ready to proceed to more advanced projects. The basic theory gained in constructing this project will be of tremendous value to you while constructing or servicing more complex projects.

BOTTOM VIEW 511 RADIO

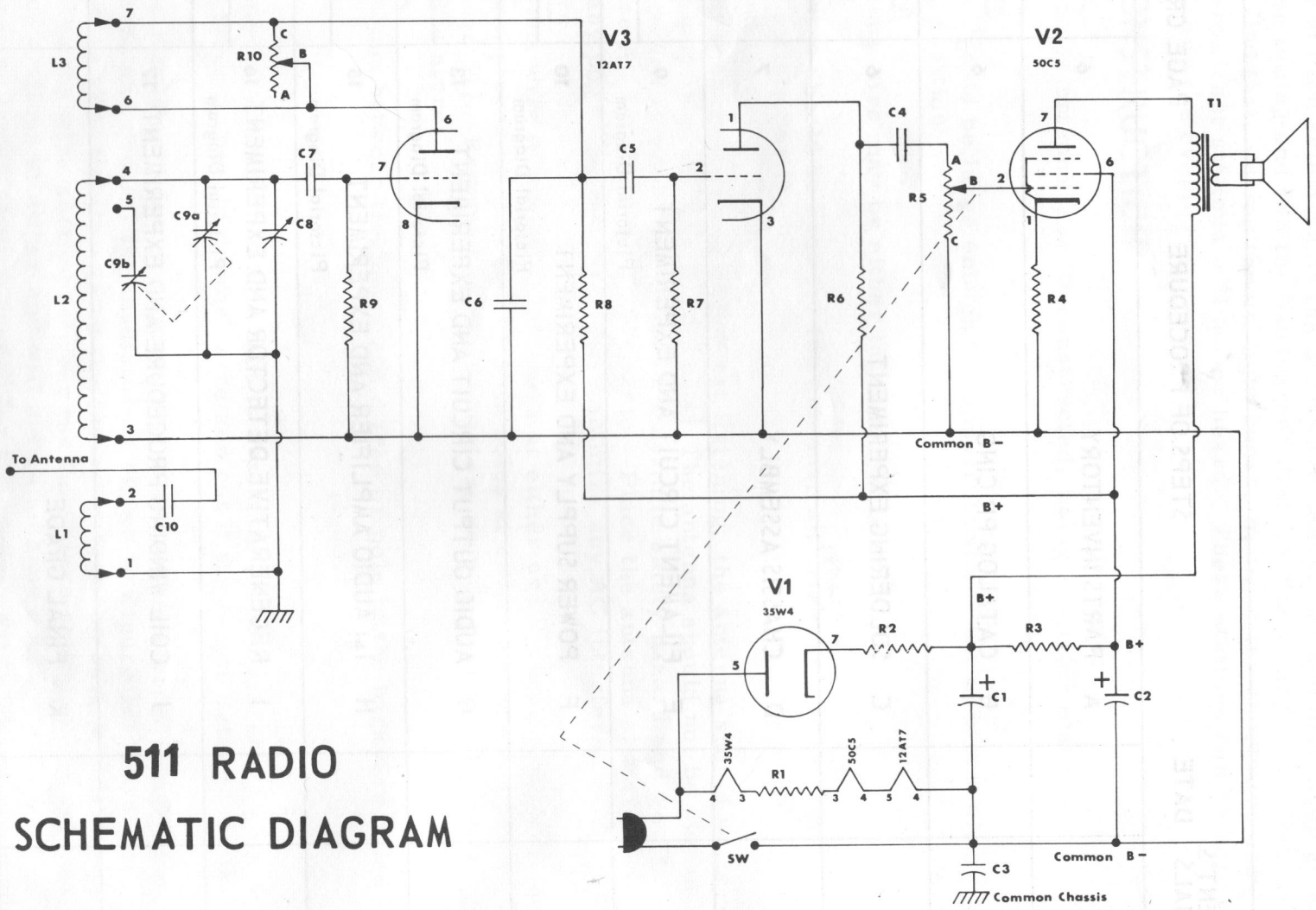


PROGRESS CHART

The progress chart allows you to keep your own record of progress on this project. DO NOT proceed to the next experiment until the previous one has been graded and initialed by your instructor.

STUDENT'S INITIALS	DATE	STEPS OF PROCEDURE	PAGE	GRADE	TEACHER'S INITIALS
		A PARTS INVENTORY	6		
		B CATALOG PRICING	6		
		C SOLDERING EXPERIMENT	6		
		D CHASSIS ASSEMBLY	7		
		E FILAMENT CIRCUIT AND EXPERIMENT	9		
		Pictorial Diagram			
		F POWER SUPPLY AND EXPERIMENT	10		
		Pictorial Diagram			
		G AUDIO OUTPUT CIRCUIT AND EXPERIMENT	13		
		Pictorial Diagram			
		H 1st AUDIO AMPLIFIER AND EXPERIMENT	15		
		Pictorial Diagram			
		I REGENERATIVE DETECTOR AND EXPERIMENT	16		
		Pictorial Diagram			
		J COIL WINDING PROCEDURE AND EXPERIMENT	17		
		K FINAL GRADE			

511 ALL BAND RADIO



511 RADIO
SCHEMATIC DIAGRAM

511 RADIO PARTS LIST

- R-1 Resistor, 150 ohm 5 watt
- R-2 Resistor, 270 ohm 1/2 watt
- R-3 Resistor, 4700 ohm 1/2 watt
- R-4 Resistor, 150 ohm 1/2 watt
- R-5 Potentiometer W/SW 500K ohms
- R-6 Resistor, 100K 1/2 watt
- R-7 Resistor, 1.5Meg. ohm 1/2 watt
- R-8 Resistor, 47K ohm 1/2 watt
- R-9 Resistor, 2.2Meg. ohm 1/2 watt
- R-10 Potentiometer 300 ohm
- C-1 Capacitor, 20 mfd. 150 volt
- C-2 Capacitor, 20 mfd. 150 volt
- C-3 Capacitor, .05 mfd. tubular
- C-4 Capacitor, .01 mfd. disc
- C-5 Capacitor, .01 mfd. disc
- C-6 Capacitor, .005 mfd. disc
- C-7 Capacitor, 100 mmfd. (PF) disc
- C-8 Capacitor, 0-25 PF trimmer
- C-9 Capacitor, 10-110, 10-240PF tuning
- C-10 Capacitor, 470 mmfd. (PF) disc
- T-1 Transformer, output, 2500 ohm to 8 ohm
- Speaker, 3 inch, 8 ohm
- Plate, bottom metal
- Screws, sheet metal (4)
- Tube socket, 7 pin molded (2)
- Tube socket, 8 pin molded (1)
- Tube socket, 9 pin molded (1)
- Knob, Indicator
- Knobs, Black round (3)
- Chassis, Metal
- Front Panel
- Terminal lug, 3 pin (2)
- Terminal lug, 2 pin (1)
- Plug, AC
- Line Cord, AC
- Wire, Hook-up
- Wire, Enameled coil
- Coil form, 8 pin (3)
- Terminal, Colored (1)
- Washer, Flat fiber (1)
- Washer, Shoulder (1)
- Grommets, Rubber (2)
- Spaghetti
- Tube Set (35W4, 50C5, 12AT7)
- Feet, Rubber (4)
- Screws, Machine, (15)
- Nuts, Machine screw (15)

INSTRUCTION GUIDE

In this booklet you will find directions and circuit explanations for construction of your 511 radio. For the best results in achieving both performance and a technical understanding of this project, follow each step in order and be sure that you thoroughly understand a step before proceeding to the next step.

Remember, this is only a guide to understanding electronics. The biggest challenge is up to you. You must ask questions about circuit theory and develop the curiosity to seek the answers from the many reference books available to you in school and public libraries. Do you accept the challenge?

A PARTS INVENTORY

On page 5 you will find a complete PARTS LIST for the 511 radio. Be sure you can correctly name and identify each component as you check it against the parts list. Write the resistance and capacitance value for each resistor and capacitor on the schematic diagram on page 4. When the parts inventory is complete and the schematic diagram correctly labeled, have your classroom instructor grade your progress chart for this section.

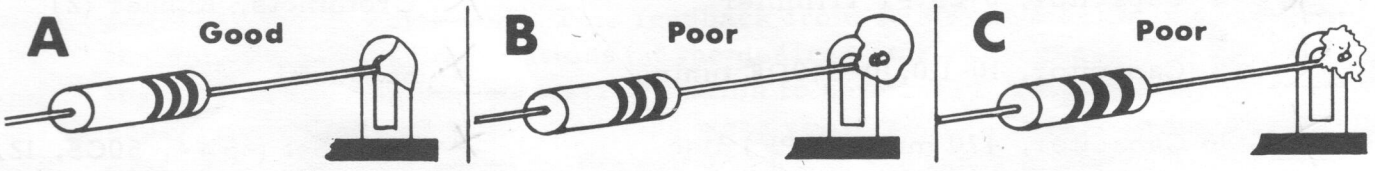
B CATALOG PRICING

Now that the inventory is complete, the next step is to become familiar with the location and price of components in a national electronics parts catalog. On a separate sheet of paper, list the price of each individual component. Add these prices to find the total cost. When you complete your catalog pricing, give your cost sheet to the classroom instructor for grading on this step.

C SOLDERING EXPERIMENT

Before you actually start construction on the 511 radio, you must pass a soldering test. Almost 70% of all problems on the 511 radio are directly related to poor soldering. All soldering joints must be clean and shiny. Rough, volcanic-appearing joints will cause trouble and almost always mean service problems. REMEMBER:

- Soldering iron between 40 - 60 watts
- Well tinned soldering tip
- Use only ROSIN CORE SOLDER
- Use NO separate flux or paste
- Keep the soldering iron tip clean
- Tin all leads



Above are three examples of solder joints. Study them and see if you can make your joints look like Example A. Example B is a poor solder joint caused by too much solder and a dirty terminal and lead. Example C is also a poor solder joint caused by the lack of sufficient heat, or by moving the lead before the solder solidified.

Ask your instructor for several used components and wire to use for soldering practice. When you have completed four perfect solder connections, have your instructor grade your progress chart for this section.

D CHASSIS ASSEMBLY

PROCEDURE

_____ 1 Drill all holes of the front panel with an 1/8 inch drill. Re-drill the control shaft holes as indicated in Figure 1. Use a high RPM drill speed to ensure neat, clean holes.

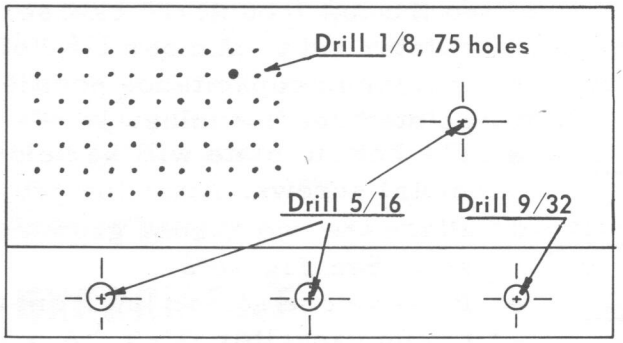


Figure 1

_____ 2 Attach the front panel to the metal chassis as shown in Figure 2. Make sure that the potentiometer with switch, R-5, and the potentiometer, R-10, are mounted correctly as shown. When mounting the trimmer capacitor, C-8, care must be taken to prevent damage to this component.

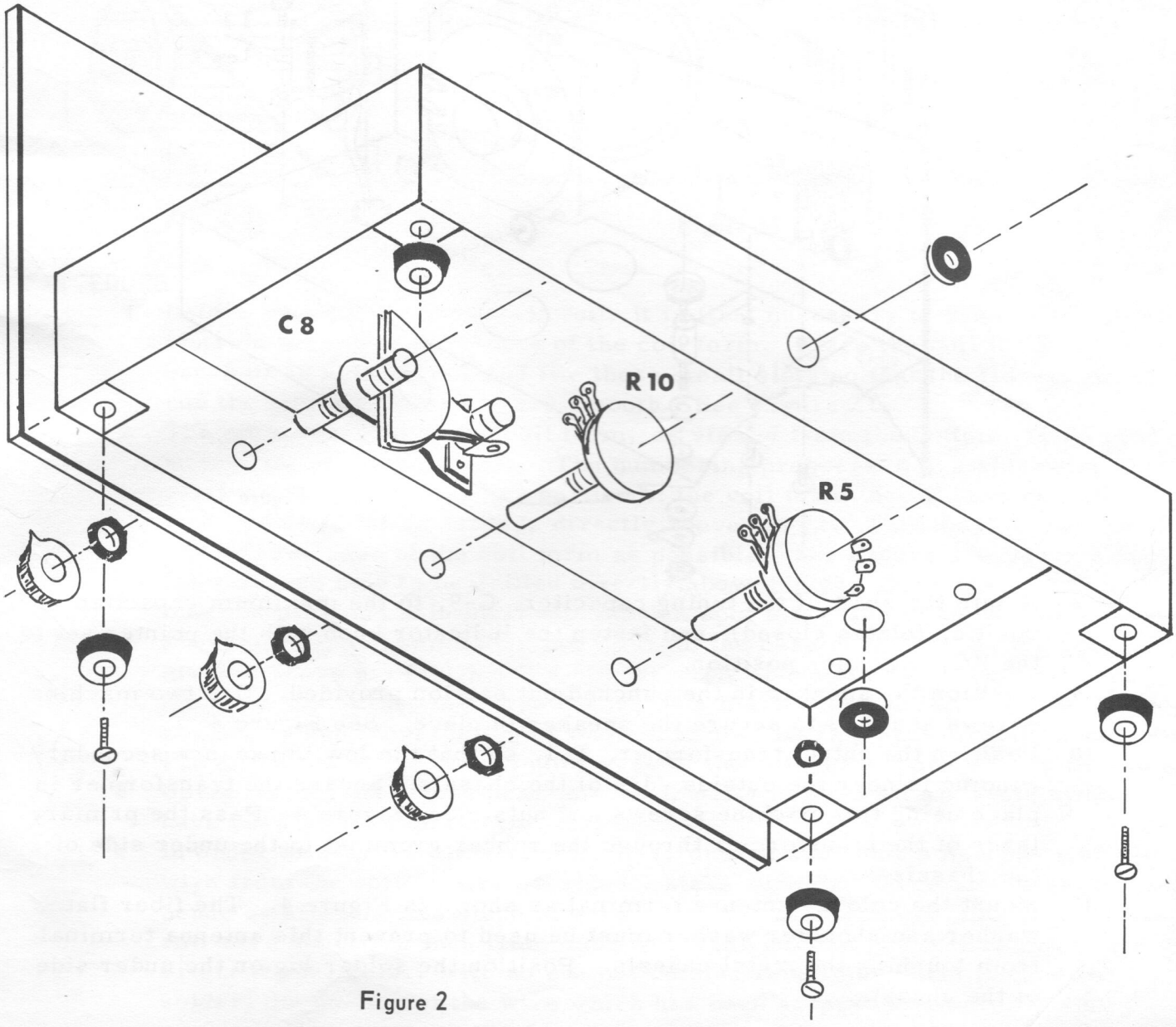


Figure 2

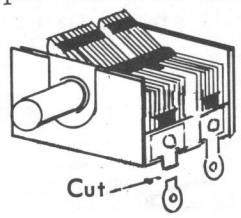
3 Rotate the shaft of potentiometer, R-5, and potentiometer, R-10, all the way to the left (counterclockwise). Fasten the round knobs to the shafts with the pointer set to number 1. Rotate the shaft of trimmer capacitor, C-8, to the maximum capacitance position (plates closed), and fasten the knob with the pointer set to number 1.

4 The bottom plate will be held in place by the four (4) rubber feet and sheet metal screws. After the project is completed, attach these in place.

5 Place the two rubber grommets through the holes provided in the metal chassis. See Figure 2.

6 Remove one solder lug from the tuning capacitor, C-9. A pair of diagonal cutters may be used for this purpose. See Figure 3.

Figure 3



7 Mount the tuning capacitor, C-9, as shown in Figure 4. Secure in place, using ONLY the two machine screws packaged within the tuning capacitor box. Extreme care must be taken when mounting this capacitor to avoid damage to it.

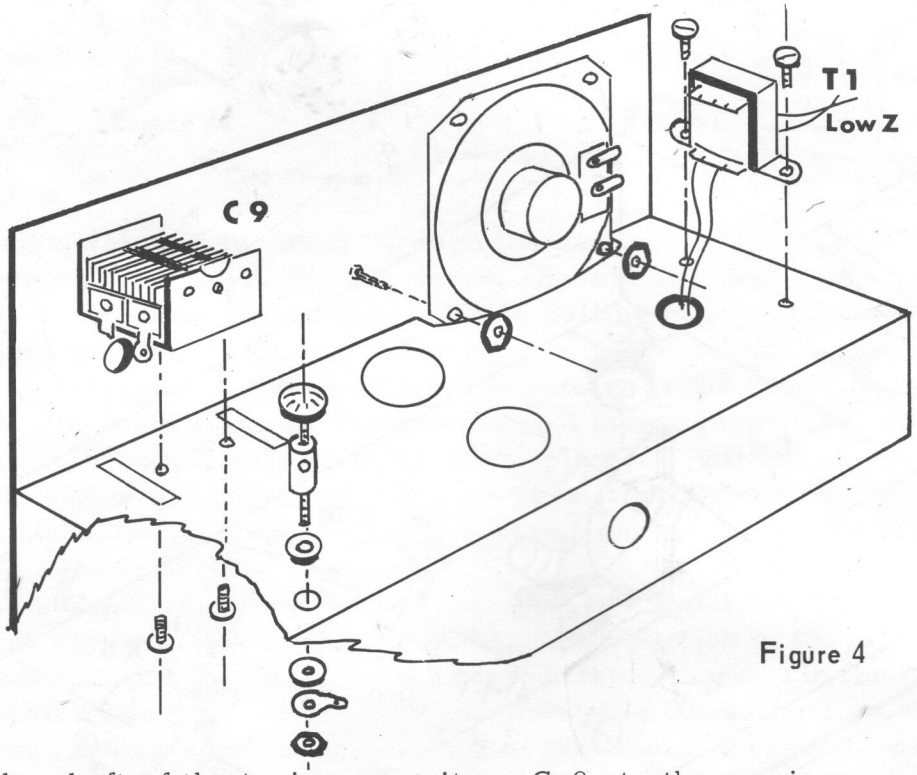


Figure 4

8 Rotate the shaft of the tuning capacitor, C-9, to the maximum capacitance position (plates closed), and fasten the indicator knob with the pointer set to the KC, mc. mc. position.

9 Position the speaker in the punched out section provided. Use two machine screws and nuts to secure the speaker in place. See Figure 4.

10 Position the output transformer, T-1, so that the low impedance secondary winding is near the outside edge of the chassis. Secure the transformer in place using two machine screws and nuts. See Figure 4. Pass the primary leads of the transformer through the rubber grommet to the under side of the chassis.

11 Mount the colored antenna terminal as shown in Figure 4. The fiber flat washer and shoulder washer must be used to prevent this antenna terminal from touching the metal chassis. Position the solder lug on the under side of the chassis.

_____ 12 Position and mount the tube sockets in the holes provided. It is important that pins 3, 4 and 5 of each socket be positioned as indicated in Figure 5. Use machine screws and nuts provided for securing the sockets to the chassis.

_____ 13 Secure the three terminal lugs in place, using the machine screws and nuts provided. See Figure 5, for correct placement.

_____ 14 Have your classroom instructor grade your progress chart for this section.

E FILAMENT CIRCUIT AND EXPERIMENT

PURPOSE

The purpose of the filament circuit is to provide current to the filament in each of the tubes. The filament, in turn, heats the cathode and causes it to emit electrons.

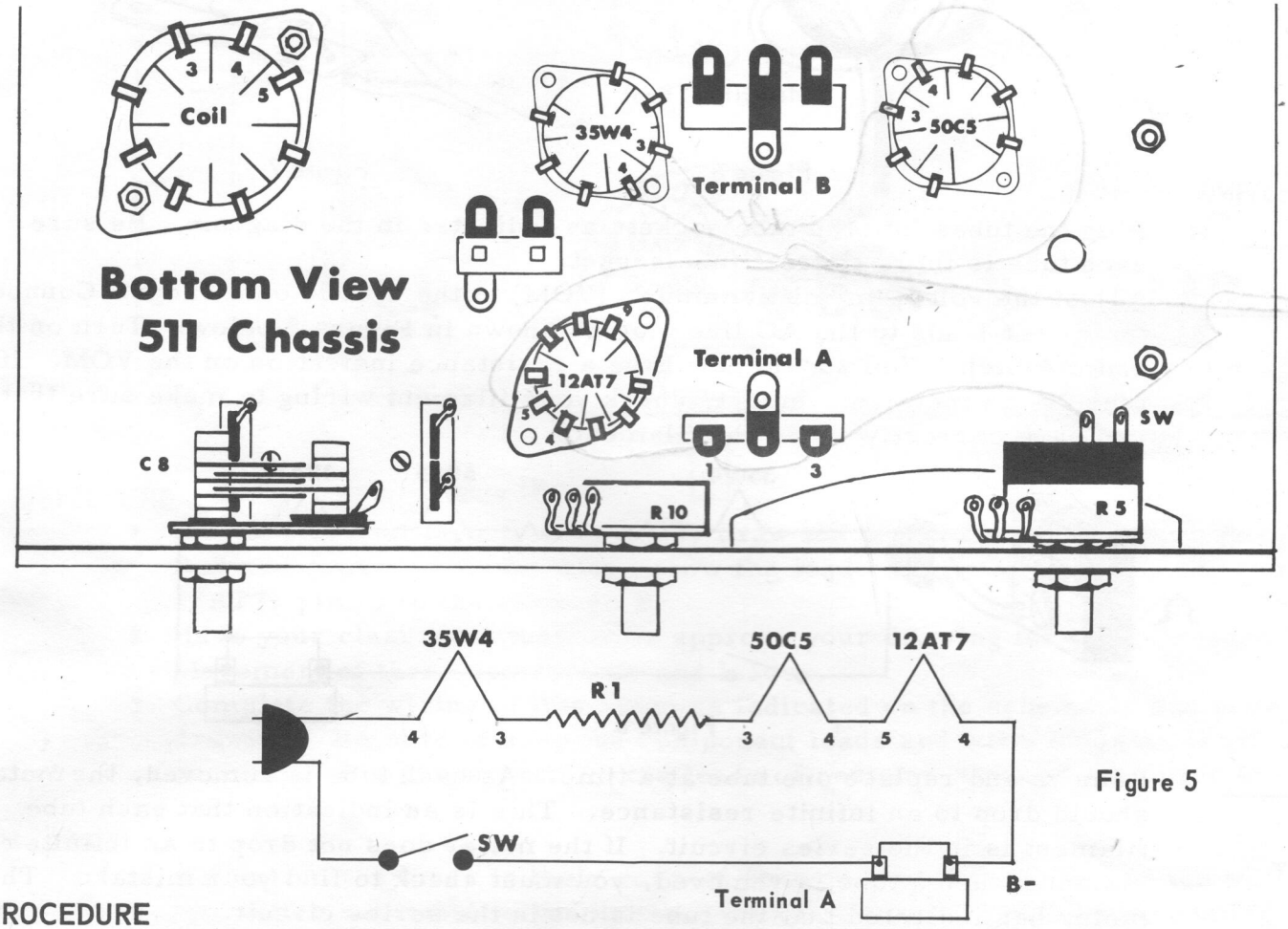


Figure 5

PROCEDURE

_____ 1 The filament circuit of the 511 radio is wired in SERIES and will be referred to as a series circuit. On the bottom view of the 511 chassis, Figure 5, trace the path that the filament wires should take according to the schematic diagram of the filament circuit. Be sure that your drawing shows the filaments connected in the correct order. A jumper lead must be connected between pins 1 and 3 of terminal A. A lead must connect pin 4 of the 12AT7 tube to pin 1 of the terminal A. Connect a lead from pin 3 of terminal A, to the on-off switch at the rear of R-5. The filament of the 12AT7 must be at the end of the filament string. This places the maximum filament potential of this tube at 12 volts to the common B- ground, thus reducing excessive hum in the radio.

_____ 2 Have your classroom instructor approve your drawing of the intended filament wiring.

3 Pass the AC line-cord through the rubber grommet at the rear of the chassis. To prevent the cord from pulling out, tie an underwriters' knot in the cord on the inside of the chassis. See Figure 6. Tin the wire ends with solder, and attach one end to the switch at the back of the potentiometer R-5. Attach the other end to the filament and plate (pins 4 and 5) of the 35W4 tube.

4 Tin the other wire ends of the AC line-cord and attach them to the AC line-cord plug, as shown in Figure 7.

5 Complete the wiring of the filaments as indicated on the schematic and your drawing. Use green wire for this step.

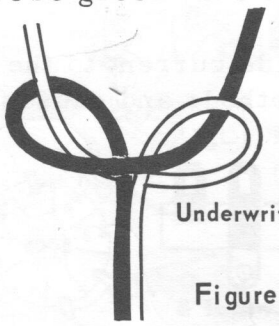


Figure 6

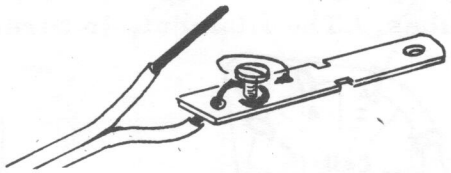


Figure 7

TESTING

1 Plug the tubes into the tube sockets as indicated in the diagram. Be sure each tube is in its correct tube socket.

2 Adjust the volt-ohm-milliammeter (VOM) to the 0-1000 ohm range. Connect the meter leads to the AC line plug as shown in Figure 8 below. Turn on the radio switch. You should now have a resistance indication on the VOM. If there is no meter movement, check your filament wiring to make sure that you have correctly wired the filaments.

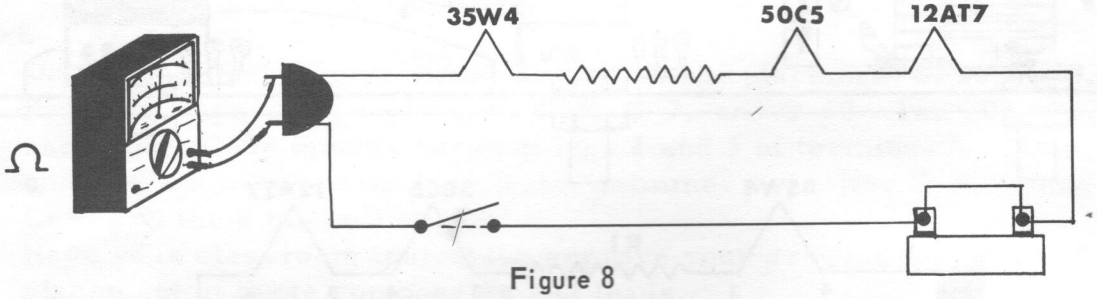


Figure 8

3 Remove and replace one tube at a time. As each tube is removed, the meter should drop to an infinite resistance. This is an indication that each tube filament is in the series circuit. If the meter does not drop to an infinite resistance when a tube is removed, you must check to find your mistake. The meter has indicated that the tube is not in the series circuit.

4 If all of your tubes prove to be in series as tested with the VOM, have your instructor grade your progress chart for this section.

5 Plug the AC line into the wall socket. All of the tube filaments should light. Remove the line plug from the socket.

F POWER SUPPLY AND EXPERIMENT

PURPOSE

The purpose of this experiment is to measure the AC and DC voltage of the power supply. The function of the power supply is to change the alternating current (AC) of the wall outlet to direct current (DC). This DC potential is connected to the plate and screen grid of each tube, enabling the tubes to operate efficiently.

PROCEDURE

1. On the pictorial layout, Figure 9, draw the placement of resistors R-2, R-3, and capacitors C-1, C-2. Use lugs 1 and 3 of terminals A and B, for mounting these components.
2. Have your classroom instructor approve your drawing for the intended placement of these components.
3. Complete the wiring of the power supply as indicated on the schematic in Figure 9, and your drawing. To maintain neat appearance and maximum operating efficiency, cut component leads to the minimum length required to join any two specified points. Observe polarity when mounting the filter capacitors, C-1 and C-2.

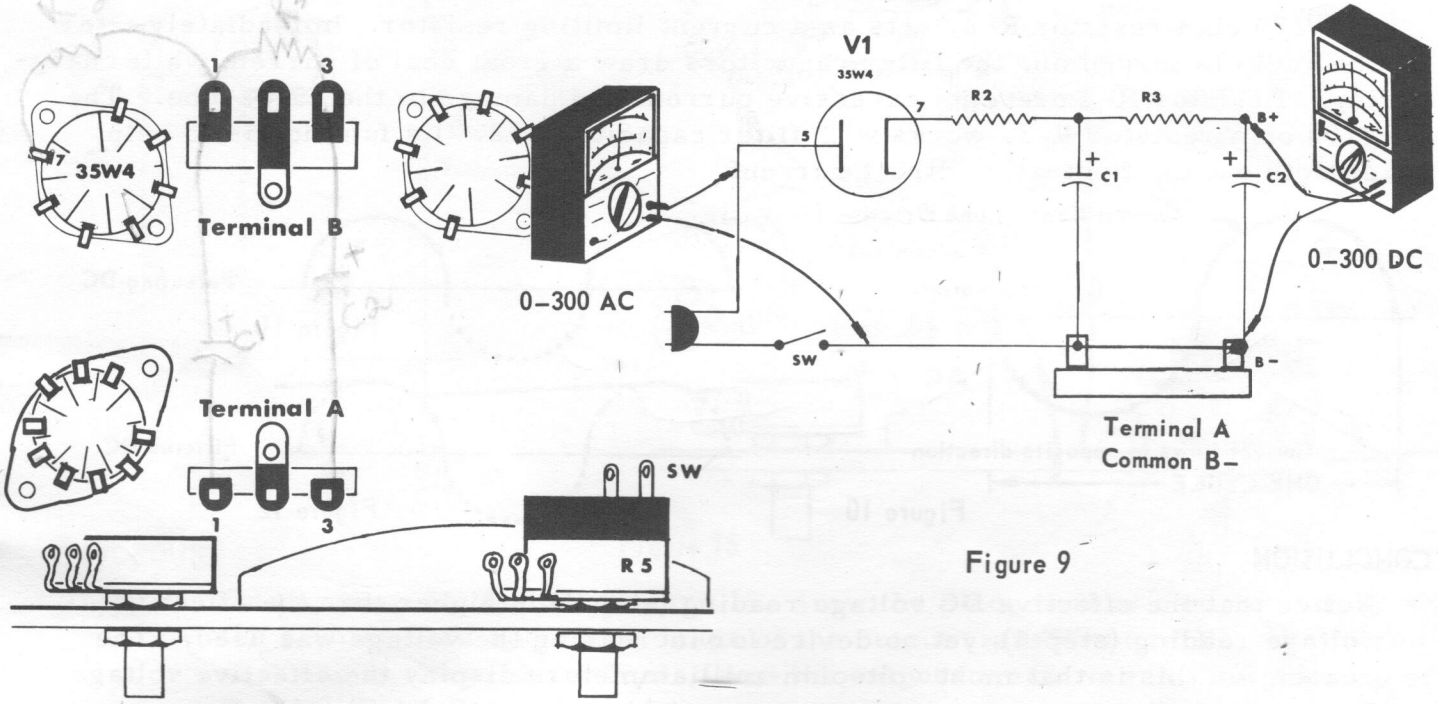


Figure 9

TESTING

1. Adjust a VOM to the 0-300 volt DC range. Connect the negative (-) meter lead to the common ground (B-). Connect the positive (+) meter lead to the positive end of the 20 mfd. filter capacitor, (B+). See Figure 9.
2. With all of the tubes in their correct sockets, plug the radio into the wall socket. After sufficient warm-up, you should observe a reading on the meter. Record this reading. 105 Volts DC. Un-plug the radio from the wall socket.
3. With the radio un-plugged, temporarily discharge the filter capacitor by connecting a piece of wire between the B+ and B- section of the power supply. You will see a small spark and observe the voltage drop to zero on the VOM.
4. Move the meter leads to pin 5 of the 35W4 tube and the common ground (B-). Adjust the VOM to the 0-300 volt AC range. See Figure 9.
5. Plug the radio into the wall outlet. Record the meter reading for the AC line cord. 125 Volts AC.
6. Un-plug the radio and discharge the filter capacitor as in step 3.

The function of the 35W4 tube is to change the alternating current from the wall outlet to pulsating direct current. The current through the filament circuit is alternating current. It changes directions 120 times a second, making 60 complete cycles in one second. See Figure 10. Each time that the plate of the 35W4 tube is positive, it attracts the negative electrons that are being emitted by the heated cathode. Unlike charges attract. Thus, a current is caused to flow through the tube for 1/120 of a second. When the plate of the 35W4 tube is negative, no current will flow through the tube. Like charges repel. The result is a pulsating direct current on the right side of the 35W4 tube. See Figure 11.

The function of the filter capacitor is to charge during the time when current flows through the tube and to discharge through the rest of the circuit when no current flows through the tube. The result is a filtered direct current. See Figure 12.

The 270 ohm resistor R-2, acts as a current limiting resistor. Immediately after the radio is turned on, the filter capacitors draw a great deal of current while charging. Resistor R-2 prevents excessive current and damage to the 35W4 tube. The 4700 ohm resistor R-3, works with filter capacitor C-2. Its function is to help smooth out the fluctuating direct current.

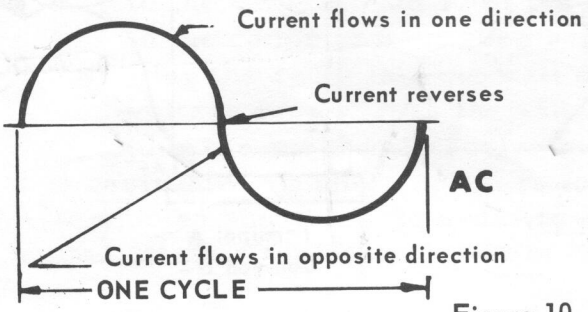


Figure 10

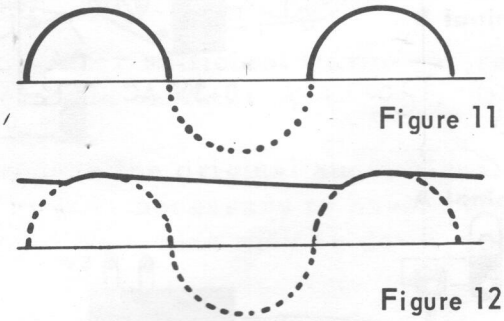


Figure 11 Figure 12

CONCLUSION

Notice that the effective DC voltage reading (step 2) is higher than the effective AC voltage reading (step 5); yet no device for increasing the voltage was used. The reason for this is that most volt-ohm-milliammeters display the effective voltage. It is commonly known as root mean square (abbreviated to RMS) voltage.

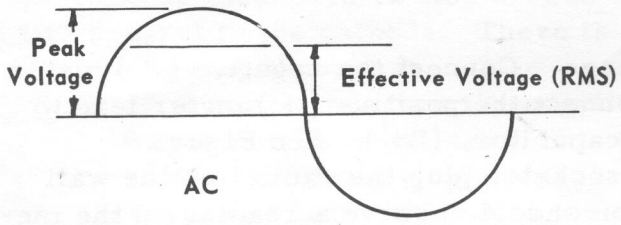


Figure 13

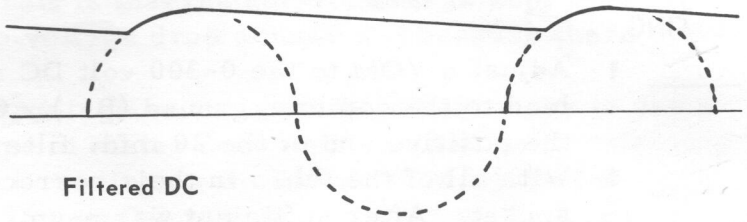


Figure 14

When the AC reading was made, this effective voltage was a little more than half (.707) of the maximum or peak voltage (see Figure 13). The peak voltage is equal to 1.41 times the effective or RMS voltage. When the DC voltage reading was made, it was closer to the maximum AC peak voltage. See Figure 14.

Compare the following:

DC reading in testing Step 2 = 165 DC volts

AC reading in testing Step 5 x 1.41 = 176.25 peak volts

____ 7 Have your classroom instructor grade your progress chart for this section.

G AUDIO OUTPUT CIRCUIT AND EXPERIMENT

PURPOSE

The function of the audio output stage is to further amplify the audio voltage from 1/2 of the 12AT7 1st audio amplifier. The audio voltage, in turn, controls a large flow of electrons in the plate circuit of the audio output tube. This plate current passing through the primary winding of the audio output transformer causes the speaker to reproduce the audio signal exactly as it was transmitted.

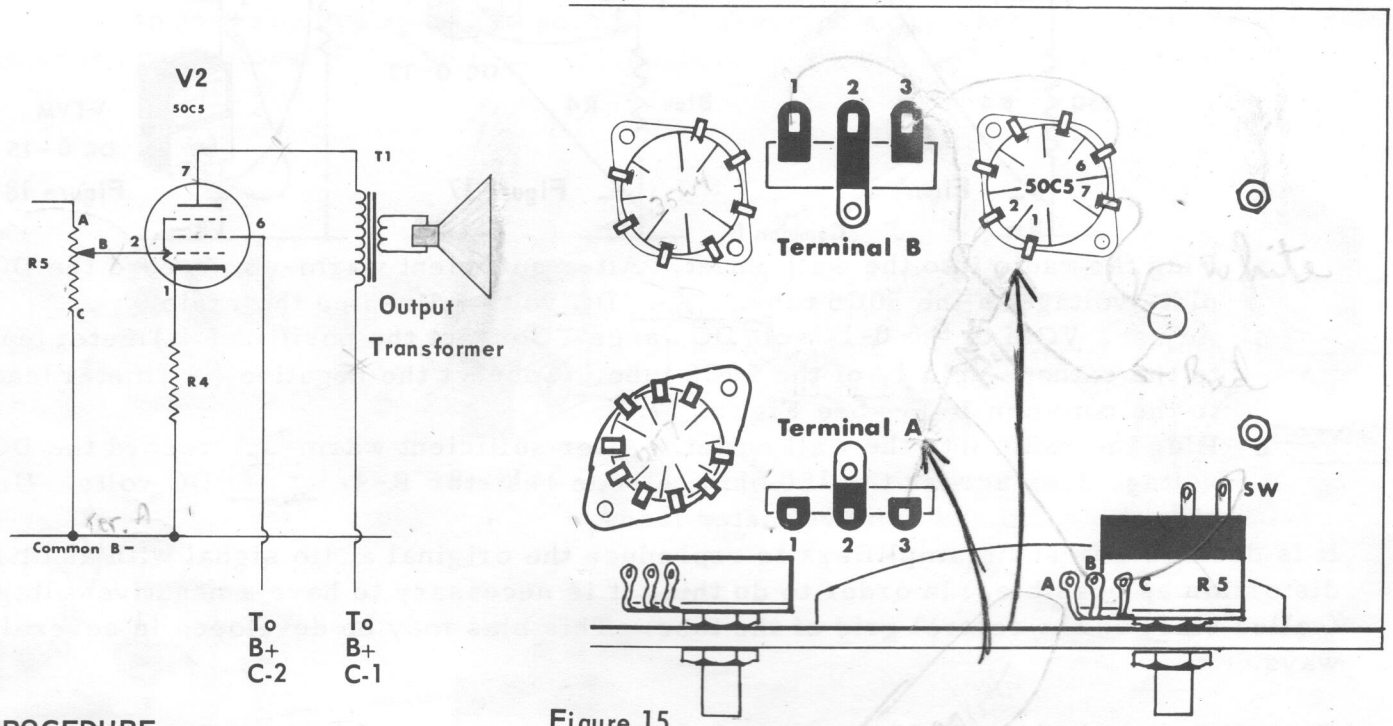


Figure 15

PROCEDURE

_____ 1 On the pictorial layout, Figure 15, draw the placement of resistor, R-4, and the primary and secondary leads of the output transformer. Be sure to connect one of the primary leads from the output transformer to the junction of R-2, C-1 and R-3.

_____ 2 Have your classroom instructor approve your drawing for the intended placement of these components and leads.

_____ 3 Complete the wiring of the audio stage as indicated in the schematic and your drawing. Be sure to keep the component leads and wire leads as short as possible. Place a piece of spaghetti on either end of resistor R-4. Use green wire for this step.

TESTING

_____ 1 With all of the tubes in their correct sockets, plug the radio into the wall outlet. After sufficient warm-up time, you should hear a slight hum coming from the speaker.

_____ 2 While holding a screwdriver by the insulated handle, touch the control grid (pin 2) of the 50C5 tube with the metal tip of the screwdriver. Carefully touch your finger to the metal shaft of the screwdriver. This should cause a definite increase in the hum coming from the speaker. If no hum is heard, adjust the volume control, R-5, until you can hear a hum while touching the screwdriver shaft. If this does not produce a slight hum, check your component placement and lead location. Un-plug the radio from the wall outlet.

____ 3 Adjust a VOM to the 0-300 volt DC range. Connect the positive (+) meter lead to the plate of the 50C5 tube. Connect the negative (-) meter lead to the common B- of the radio. This is lug 1 or 3 of terminal strip A. See Figure 16.

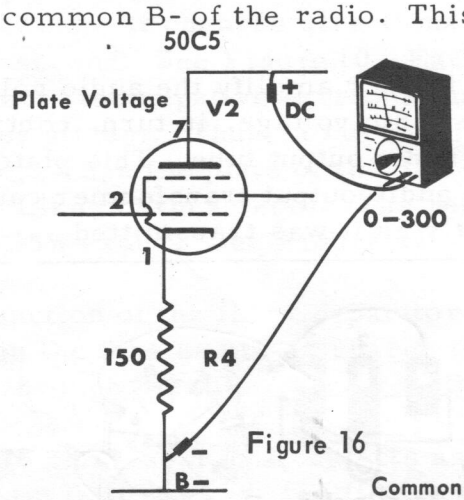


Figure 16

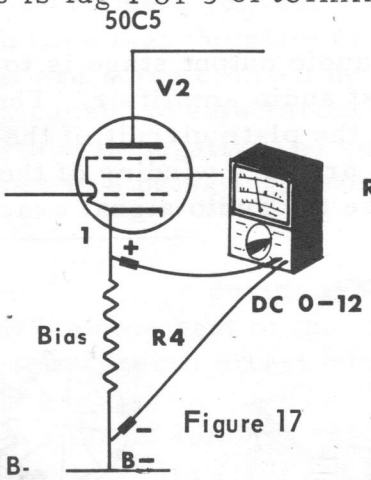


Figure 17

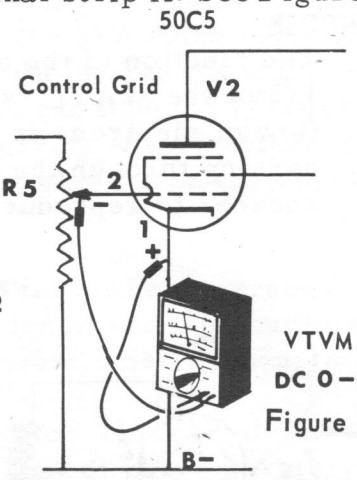


Figure 18

____ 4 Plug the radio into the wall outlet. After sufficient warm-up, record the DC plate voltage of the 50C5 tube. ____ DC volts. Un-plug the radio.

____ 5 Adjust a VOM to the 0-12 volt DC range. Connect the positive (+) meter lead to the cathode, pin 1, of the 50C5 tube. Connect the negative (-) meter lead to the common B- . See Figure 17.

____ 6 Plug the radio into the wall outlet. After sufficient warm-up, record the DC voltage drop across the 150 ohm cathode resistor R-4. ____ DC volts. Un-plug the radio and remove meter leads.

It is desirable in audio amplifiers to reproduce the original audio signal with as little distortion as possible. In order to do this, it is necessary to have a negative voltage (called bias) on the control grid of the tube. This bias may be developed in several ways.

The control grid of the 50C5 power tube is kept negative by what is called self bias. Current from the plate circuit, passing through the 150 ohm resistor, R-4, causes a voltage drop across R-4. This voltage drop causes the cathode to be more positive than the common B- point, by the amount measured in step 6 above. The 500K potentiometer, R-5, acts as a grid return resistor and connects the control grid to the common B- . The common B- point is negative with respect to the cathode, pin 1, of the 50C5 as measured in step 6. The result is that the control grid is kept negative with respect to the cathode. There is no voltage drop across R-5 because there is no current flowing through it.

____ 7 In order to measure the negative voltage on the grid, it is necessary to use a vacuum-tube voltmeter. This type of meter does not add additional resistance to the circuit, giving an incorrect reading as would the VOM. Adjust a vacuum-tube voltmeter to the 0-15 volt DC range.

____ 8 Connect the negative (-) meter lead to the control grid, pin 2, of the 50C5 tube. Connect the positive (+) meter lead to the cathode, pin 1, of the 50C5 tube. See Figure 18. Adjust the volume control to the extreme clockwise position. Plug the radio into the wall outlet. After sufficient warm-up, record the negative (-) bias voltage on the grid. ____ DC volts. Un-plug the radio and remove meter leads.

The function of the output transformer is to match the resistance of the 50C5 tube to the resistance of the speaker voice coil. This matching provides a better transfer of energy from the plate circuit of the 50C5 tube to the speaker.

____ 9 Have your classroom instructor grade your progress chart for this section.

H 1st AUDIO AMPLIFIER AND EXPERIMENT

PURPOSE

The function of one-half of the 12A T7 tube is to amplify the detected voltage (audio) from the other half of the 12AT7 tube. The purpose of this experiment is to show how and why the 12AT7 tube amplifies the detected voltage (audio) from the regenerative detector stage.

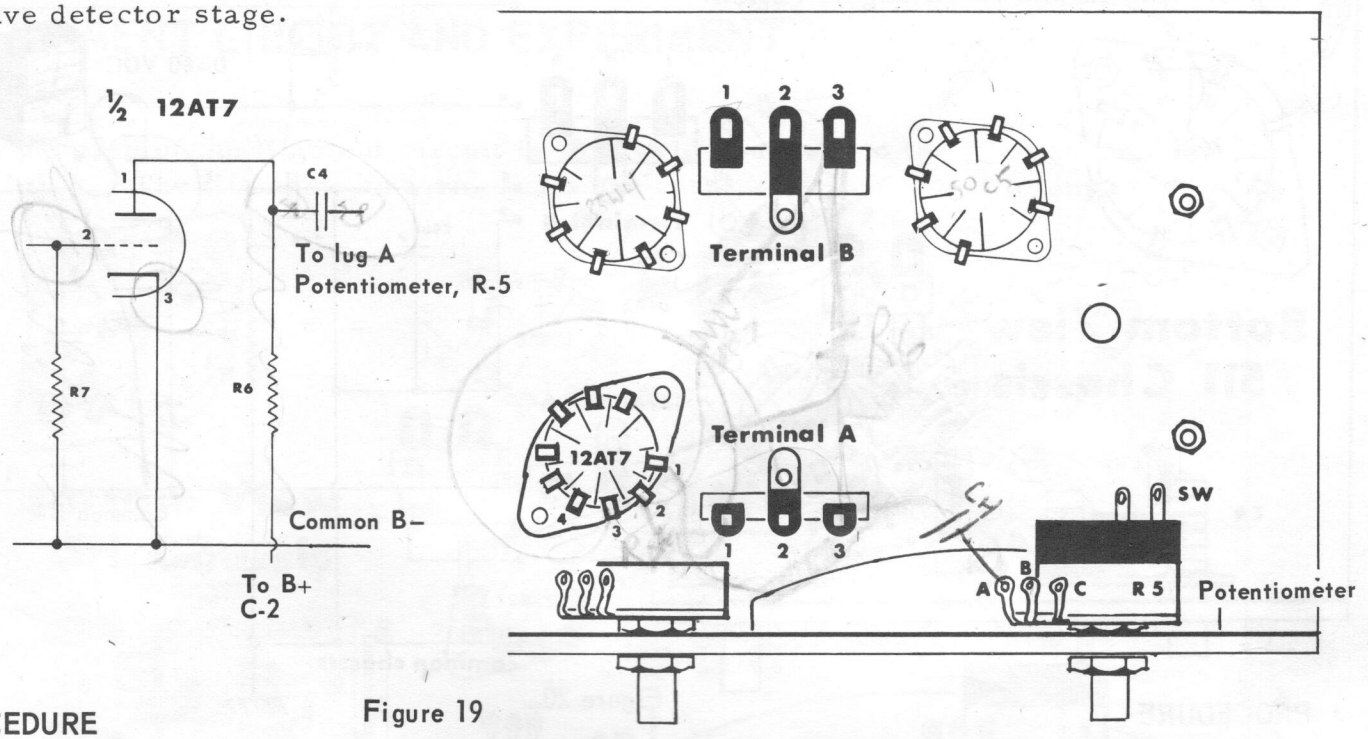


Figure 19

PROCEDURE

1. On the pictorial layout, Figure 19, draw the placement of resistors R-6, R-7 and capacitor C-4. Also, show the lead connecting the cathode of the 12AT7, pin 3, to the common B-
2. Have your classroom instructor approve your drawing for your intended placement of these components and leads.
3. Complete the wiring of this stage as indicated on the schematic and your drawing. Be sure to keep the component leads and wire leads as short as possible. Place spaghetti on the leads of resistor R-6 and capacitor C-4.

TESTING

1. With all of the tubes in their correct sockets, plug the radio into the wall outlet. After sufficient warm-up time, you should hear a slight hum coming from the speaker.
2. While holding a screwdriver by the insulated handle, touch pin 2 of the 12AT7 tube with the metal tip of the screwdriver. Carefully touch your finger to the metal shaft of the screwdriver. You now should hear a loud hum coming from the speaker. Adjust the potentiometer (volume control) back and forth. You will notice that these adjustments will vary the intensity of the hum coming from the speaker. The variation of intensity is an indication that the first audio amplifier section of the radio is operating correctly. If no hum is heard, you should check your component placement and lead location. Unplug the radio from the wall outlet.
3. The now completed audio section of the 511 radio can be used to amplify a microphone, record player or act as a signal tracer. Have your classroom instructor grade your progress chart for this section.

I REGENERATIVE DETECTOR AND EXPERIMENT

PURPOSE

The purpose of this experiment is to show how one-half of the 12AT7 tube acts as a radio frequency detector to the radio station being received, and to show the amplification of this radio station by the use of a feedback or tickler coil. The feedback principle is known as regeneration.

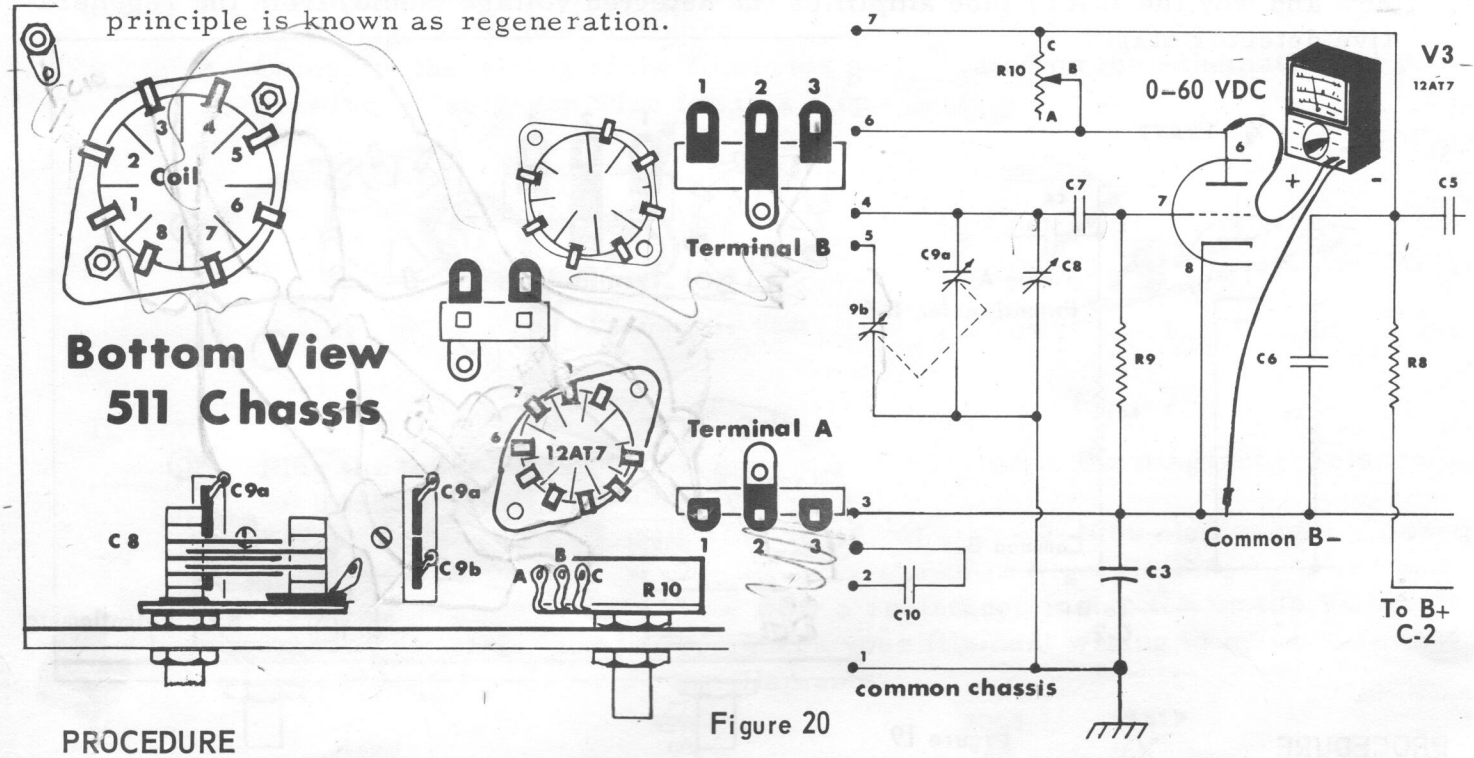


Figure 20

PROCEDURE

_____ 1 On the pictorial layout, Figure 20. draw the placement of resistors, R-8, R-9, and capacitors C-3, C-5, C-6, C-7, and C-10. The .05 mfd. tubular capacitor, C-3, mounts between lugs 2 and 3 of terminal A. Also, show the connections to potentiometer R-10, trimmer capacitor C-8, tuning capacitor C-9, and the 8 pin coil socket.

_____ 2 Have your classroom instructor approve your drawing for your intended placement of these components and leads.

_____ 3 Complete the wiring of this stage as indicated on the schematic and your drawing. Be sure to keep the component leads and wire leads as short as possible. Place a small piece of spaghetti on the leads of resistor R-8. Use black wire for this stage.

TESTING

_____ 1 Adjust a VOM to the 0-60 volt DC range. Connect the positive (+) meter lead to the detector plate, pin 6, of the 12AT7 tube. Connect the negative (-) meter lead to the common B- , lug 3 of terminal A. See Figure 20.

_____ 2 Plug the radio into the wall outlet. After sufficient warm-up, record the voltage on the detector plate. _____ DC volts. Un-plug the radio and disconnect the meter leads. If no voltage was measured, check your connections for possible error. The detector stage will not operate unless there is a DC potential on the detector plate.

_____ 3 Plug the radio into the wall outlet. After sufficient warm-up, touch the junction of the trimmer capacitor, C-8, and the 100 mmfd. capacitor, C-7, with the metal tip of a screwdriver. Carefully touch your finger to the metal shaft of the screwdriver. You now should hear a loud hum coming from the speaker and possibly be receiving several strong local broadcast stations.

It may be necessary to reverse the AC plug in the wall outlet to better receive the radio stations and reduce the AC hum. Un-plug the radio from the wall outlet. The metal shaft of the screwdriver and your body acted as an antenna and the strongest radio stations were detected and amplified in the 511 radio. It is not possible to select separate stations at this time, as the tuning coil is not inserted.

____ 4 Have your classroom instructor grade your progress chart for this section.

J COIL WINDING PROCEDURE AND EXPERIMENT

PURPOSE

The purpose of this experiment is three-fold. First, it shows how the tuning coil, L-2, in conjunction with the tuning capacitor, C-9, is able to select desired stations and reject others. Second, it shows how the tickler coil, L-3, provides a feedback of pulsating DC and regenerates or amplifies the incoming signal. Third, it shows how the antenna-ground coil, L-1, through transformer action, couples the antenna to the tuning circuit.

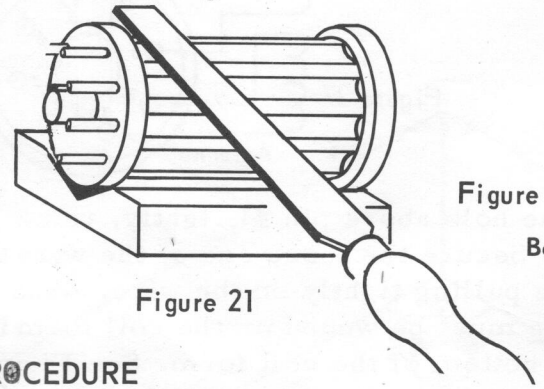


Figure 21

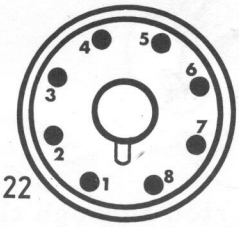


Figure 22

Bottom View of Coil Form

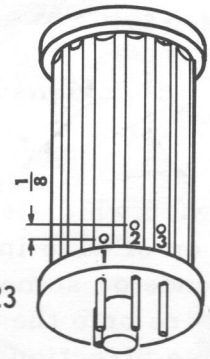


Figure 23

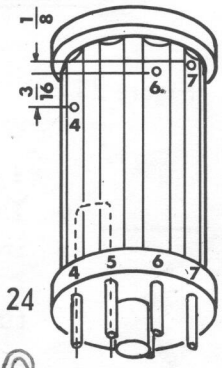


Figure 24

PROCEDURE

____ 1 Before winding the broadcast coil, it is first necessary to remove the small slots on the top of the ridges of the coil form. Place the coil form on a bench or in a "V" block and file these small slots so that the ridges, which run the length of the coil, are smooth. See Figure 21.

____ 2 The pin numbering of the coil form, as viewed from the bottom, is like the numbering of a tube socket. The numbering progresses in a clockwise direction from the center key portion of the coil form. See Figure 22. Mark a spot for a hole to be drilled, directly above pin #1. This mark should be as close to the base of the coil form as possible. See Figure 23. Mark a spot for a second hole to be drilled directly above pin #2, about 1/8 inch higher than the previous hole marked. Mark a spot for a hole to be drilled directly above pin #3, the same distance up from the base of the coil as the spot marked above pin #2. Mark a spot directly above pin #4, about 3/16 inch from the top of the coil. See Figure 24. Mark a spot directly above pin #6, about 1/8 inch from the top of the coil form. Mark a spot directly above pin #7, at the top of the coil winding area of the coil form. See Figure 24.

____ 3 Using a #56 drill or one near this size, drill holes in all six spots, which have been marked on the coil form.

____ 4 In order to wind the antenna coil, L-1, unwind and cut a 3 foot piece of #24 wire from the coil of wire provided. Make sure that there are no sharp bends or kinks in this piece of wire. Scrape the enamel coating from the coil wire about 1/2 inch from one end. This portion of the wire must be a bright copper color, with no enamel coating remaining. Tin (coat with solder) the portion of the wire which has been scraped clean.

5 Insert the tinned end of the wire through the hole directly above pin #1. Pull the wire up and out through the top of the coil form and then pass it back down the center of the coil and through pin #1. Pull about 1/4 inch of the tinned wire through the pin and solder it in place. CAUTION: For ease of soldering, place the coil on the bench with the base pointing up. When soldering the wire in the pin, it is important that you heat the pin as well as the wire. The molten solder must run down inside the pin and NOT over the outside of the pin. If the diameter of the pin is increased by placing solder on the outside, it will be impossible to plug the coil form into the socket provided. To prevent overheating of the pin and loosening from the plastic base, it may be necessary to use a pair of pliers as a heat sink. See Figure 25.

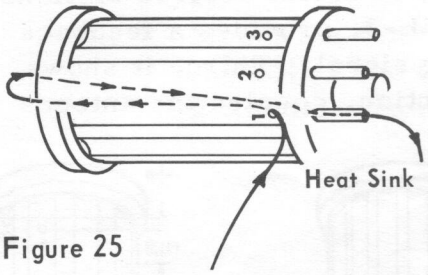


Figure 25

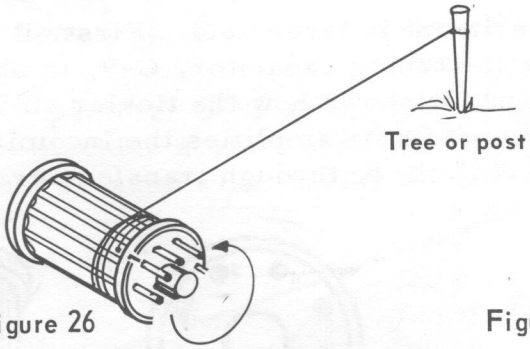


Figure 26

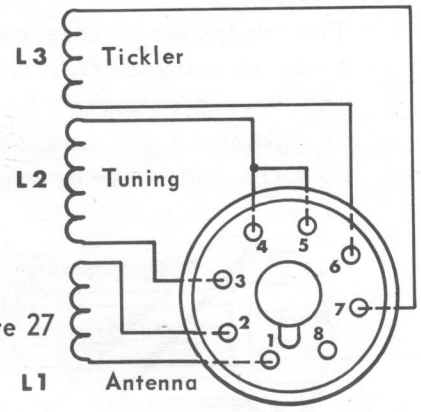


Figure 27

6 Pull the wire, which is inserted through the hole above pin #1, tightly, removing the loop of wire inside the coil form. Secure the loose end of the wire to a vise, fence or some solid object. While pulling tightly on the wire, wind 5 turns of wire onto the coil form. The wire must be wound on the coil form in a clockwise direction as viewed from the bottom of the coil form. See Figure 26. After winding 5 turns of wire on the coil form, insert the end of the wire through the small hole directly above pin #2. Pull the wire up and out through the top of the coil form and then pass it back down the center of the coil form and through pin #2. Pull the wire tightly through pin #2, removing the loop of wire inside the coil form.

7 Scrape the enamel coating from the coil wire for about 1/2 inch, beginning at the point where it comes out of pin #2. This portion of the wire must be a bright copper color, with no enamel coating remaining. Tin the portion of the wire which has been scraped clean. Push the tinned portion of the wire back through pin #2 until about 1/4 inch of the tinned portion is inside the pin. Be careful not to loosen the windings on the coil form. Solder the wire in the pin as in step 4.

8 Snip off the extra wire protruding from pins 1 and 2. This completes the winding of the antenna coil, L-1. See Figure 27 and the coil-winding chart, Figure 30.

9 In order to wind the broadcast band tuning coil, L-2, cut a 24-foot piece of #24 wire from the coil of wire provided. CAUTION: Be careful that the entire coil of wire does not become tangled when taking the 24-foot piece.

10 Tie one end of the 24-foot piece of wire to a fence, or some solid object. Smooth out this piece of wire so that there are no sharp bends or kinks. Insert the free end of the wire through the hole directly above pin #3. Pull the wire up and out through the top of the coil and then pass it back down the center of the coil form and through pin #3. Pull out about 1 inch of wire and bend it over so that the wire will not pull out of the pin.

_____ 11 While holding the coil form, pull the 24-foot piece of wire tightly, removing the loop of wire inside the coil form. Wind 70 turns of wire on the coil form, winding the wire in a clockwise direction (you will be turning the coil form counterclockwise) as viewed from the base of the coil. See Figure 26. Counting turns will be easier if you place a mark on the rim of the coil form. Leave about 1 thickness of wire space between the antenna coil, L-1, and the tuning coil, L-2. Wind each turn of wire close to the previous turn, leaving no space between turns. At the end of the 70th turn of wire, insert the free end of the wire through the hole which is directly above pin #4. Pull the wire up and out the top of the coil form and then pass it back down through the center of the coil and out through pin #4.

_____ 12 Scrape the enamel coating from the coil wire for about 1/2 inch, beginning at the point where it comes out of pins 3 and 4. This portion of the wire must be a bright copper color, with no enamel coating remaining. Tin the portion of the wire which has been scraped clean. Remove the insulation from a 2-inch piece of hook-up wire and form a "U"-shaped wire with which to connect pins 4 and 5. Insert this connecting wire through the pins from the inside of the coil form. See Figure 24. This jumper connects section C-9b of the tuning capacitor into the tuning circuit.

_____ 13 Push the tinned portion of the coil wires back through pins 3 and 4, until about 1/4 inch of the tinned portion is inside the pin. Be careful not to loosen the windings on the coil form. Solder the coil and jumper wires in pins 3, 4 and 5, as in step 4. Snip off the extra wire. This completes the winding of the tuning coil, L-2.

_____ 14 Wind the tickler coil, L-3, in the same manner as the antenna coil, L-1, was wound in steps 3 to 7. Start with the hole which is directly above pin #6. Finish the coil in the hole which is directly above pin #7. The tickler coil consists of 5 turns and should be wound in a clockwise direction on the coil form, as viewed from the base of the coil form. Leave about 1/16 inch between the antenna coil, L-2, and the tickler coil, L-3.

TESTING

_____ 1 The antenna coil and capacitor, C-10, act as a means of coupling or connecting the antenna to the tuning circuit by a transformer action. This allows the tuning circuit to operate freely and increases the selectivity. Connect an antenna which is more than 10 feet long to the antenna post at the rear of the radio. Plug the radio into the wall outlet. Turn the set on and set the regeneration control to 1. Turn the volume up to 8 on the dial. After sufficient warm-up time, tune across the dial with the main tuning capacitor. You should hear many separate stations. Un-plug the radio.

_____ 2 Remove the antenna from the antenna post and attach it to pin 4 of the coil socket. A clip lead may be used for this purpose. The antenna is now connected directly to the tuning circuit. Plug the radio into the wall outlet. After sufficient warm-up, with the controls set as in #1, again tune across the dial with the main tuning capacitor. You will notice that many stations overlap. This is an indication of poor selectivity, produced by the elimination of the antenna coil and capacitor, C-10, functions. The tuning circuit is not operating freely now. Un-plug the radio and disconnect the antenna.

3 The tuning circuit is made up of the tuning coil, L-2, and the capacitors, C-9a, C-9b and C-8. See Figure 28. This circuit can be simplified to resemble that circuit used in a crystal tuner radio. See Figure 29. Different stations may be selected by either changing the number of turns on the coil or by changing the capacitance of the capacitor. On the 511 radio, the number of turns on the tuning coil may be changed by simply using different plug-in coils. Each plug-in coil will have a range of frequencies which may be selected with the tuning capacitor. This range of frequencies or band is determined by the number of turns placed on the tuning coil, L-2. See Figure 30. On the 511 radio, the variable section of the tuning capacitor is connected to the common B- . These two points are joined through the .05 capacitor, C-3, to form a complete tuned circuit. See Figure 28. To show the effect of capacitor, C-3, un-solder and remove one end of the capacitor, C-3, from the terminal strip. Place an antenna on the antenna post and then plug the radio into the wall outlet. After sufficient warm-up, notice that it is not possible to select stations. The stronger stations are received from one end of the tuning dial to the other. With the radio turned on, temporarily connect the .05 capacitor, C-3, back into the circuit. Notice it is now possible to tune in separate stations. Un-plug the radio and solder the capacitor, C-3, in place again.

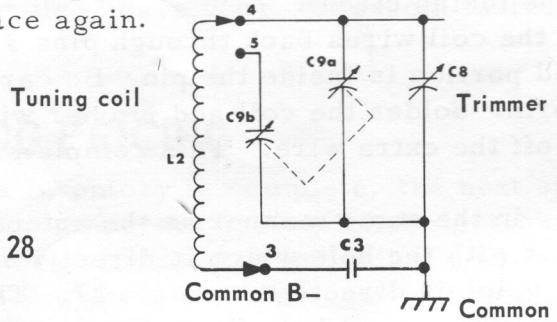


Figure 28

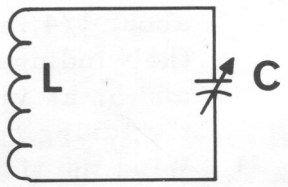


Figure 29

4 The regeneration control regulates the amount of plate current passing through the tickler coil, L-3. Plug the radio into the wall outlet. Set the regeneration control to position #1. After sufficient warm-up, tune in a weak broadcast station. Slowly turn the regeneration control in a clockwise direction until a squeal is heard from the radio, and then turn the control in a counterclockwise direction until the squeal stops. (If your regeneration control operates in reverse of this, you have the control connected backwards.) At this point, the 511 radio is at its maximum sensitivity. The amount of plate current that is allowed to flow through the tickler coil, L-3, by the regeneration control, causes a magnetic field around the tickler coil. This magnetic field is increasing and decreasing in step with the magnetic field about the tuning coil, L-2. This feedback from L-3 to L-2 helps to increase the amplitude of the oscillations (at the desired station frequency) in the tuning circuit and causes the desired station to be louder. This regeneration is especially important when receiving weak short wave stations. If the regeneration or feedback becomes too great and the 511 radio produces a loud squeal, this is an indication that the detector stage has started to oscillate. This can interfere with other radios as the 511 is now acting as a transmitter. To prove this, select a station on the 511 radio and turn the regeneration control until a squeal is heard. Obtain another radio and tune in the same station to which the 511 radio is tuned. At this point on the dial, you will hear a loud squeal on the other radio. This noise is coming from the 511 radio as it is transmitting at that frequency. Un-plug both radios.

5 Have your classroom instructor grade your progress chart for this section.

SHORT WAVE COIL WINDING

PROCEDURE

1. When winding the shortwave band coils, it will not be necessary to remove the small individual grooves on the coil form into which individual turns of wire fit.
2. All coils must be wound in a clockwise direction as viewed from the bottom of the coil form.
3. Each end of the wire on coils L-1, L-2 and L-3 for the shortwave band solder to the same pin numbers as on the broadcast band coil. See Figure 27. Information concerning the number of turns and length of wire for each coil may be obtained from the coil winding chart, Figure 30.
4. Find the location for drilling the lead holes by counting the grooves which correspond to the number of turns to be placed on the coil. On the higher frequency shortwave coils, it will be necessary to double space the turns of wire for the tuning coil, L-2. In this case, locate the lead hole to be drilled by counting twice as many grooves as turns of wire to be wound on this coil. See the coil winding chart, Figure 30. The wire jumper between pins 4 and 5 is not used on the high frequency coils. Space coils L-1, L-2 and L-2, L-3, two grooves apart on the shortwave band coil forms.

COIL WINDING CHART Figure 30

BAND	L-1	space	L-2	space	L-3	Frequency range C-8 & C-9 closed open	NOTES
1 BC*	5T* 3ft.	1/32"	70T 24ft.	1/16"	5T 3ft.	820KC - 1400KC	file groves jumper pins 4 & 5 close space turns
2	5T 3ft.	2G*	21T 8ft.	2G	5T 3ft.	2.3MC - 7.6MC	jumper pins 4 & 5
3	5T 3ft.	2G	14T 51/2	2G	5T 3ft	5.7MC - 14.5MC	no jumper, pins 4, 5 close space L-1, & L-3 1G between turns L-2
4	2T 1 1/2	4G	5T 3ft.	1G	3T 2ft.	11.5MC - 28MC	no jumper, pins 4 & 5 close space L-1 & L-3 2G between turns L-2

* BC= broadcast band, T=turns, G=grove

Note: With an increase in frequency, there is a decrease in turns of wire on L-2. With a decrease in frequency, there is an increase in turns of wire on L-2.

TUNING PROCEDURE

1. Insert the coil required for the desired range of frequencies. Attach an antenna to the antenna post. Plug the AC cord into the wall outlet and turn on the set. Set the volume control to 9 on the scale.
2. Adjust the regeneration control to the point where the radio just starts to oscillate. A squeal from the speaker will be heard at this point.
3. Slowly turn the main tuning capacitor from the closed to the open position. Each individual squeal across the dial will be a station. In order to receive each station properly, adjust the tuning dial until the squeal is at its loudest

point. Then turn the regeneration control toward a smaller number on the dial until the squeal is no longer heard. At this point, you should be able to properly listen to the station.

____ 4 In order to receive Morse code, it will be necessary to leave the regeneration control set at a point of oscillation.

____ 5 For easy station selection on the shortwave bands, use the main tuning dial for coarse tuning and use the bandspread dial for fine tuning.

____ 6 You will find that, during the daylight hours, many of the shortwave and foreign broadcast stations will not be heard. These stations can be best received late in the evening.

ANTENNA CONSTRUCTION

A simple inexpensive antenna may be constructed, using available materials.

Wire size
The wire should be large enough to support itself and not to break when placed in position

Insulation
The antenna wire may be either insulated or bare.

Material
Copper wire should be used for the antenna, although steel wire will perform satisfactorily.

Height and length
For general shortwave and broadcast listening, the antenna should be as high and long as practical. CAUTION: The antenna should not be placed close to power lines. This would be a definite safety hazard and would also cause AC interference in the radio. Place the antenna at a right angle to any power lines. This will minimize any AC interference.

Insulators
The antenna wire must have insulators at either end. These may be made from small pieces of 1/4" plastic with holes at either end of each piece (see Figure 31). Regular antenna insulators may be purchased from a radio parts store.

Construct an antenna between the house and a tree or pole in the backyard. See Figure 32.

PROCEDURE

____ 1 Determine the maximum length that is available for the antenna.

____ 2 Obtain a piece of No. 18 enamel wire and cut it the length determined in Step 1.

____ 3 Attach an insulator 5 feet from each end of the antenna wire. To do this, cut the wire and connect the insulator as shown in Figure 32. Wrap the antenna wire very tightly around the insulator to make sure it will not unwind. With the wire section between the insulators acting as the antenna, the 5-foot sections at either end will act as antenna support wires.

____ 4 Determine the length of wire needed for the lead-in wire. Allow some additional length as it is not necessary for this wire to be very tight. This wire will connect the antenna to the room where the antenna is to be used.

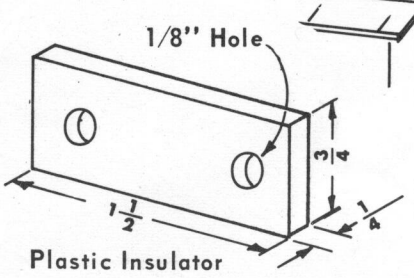


Figure 31

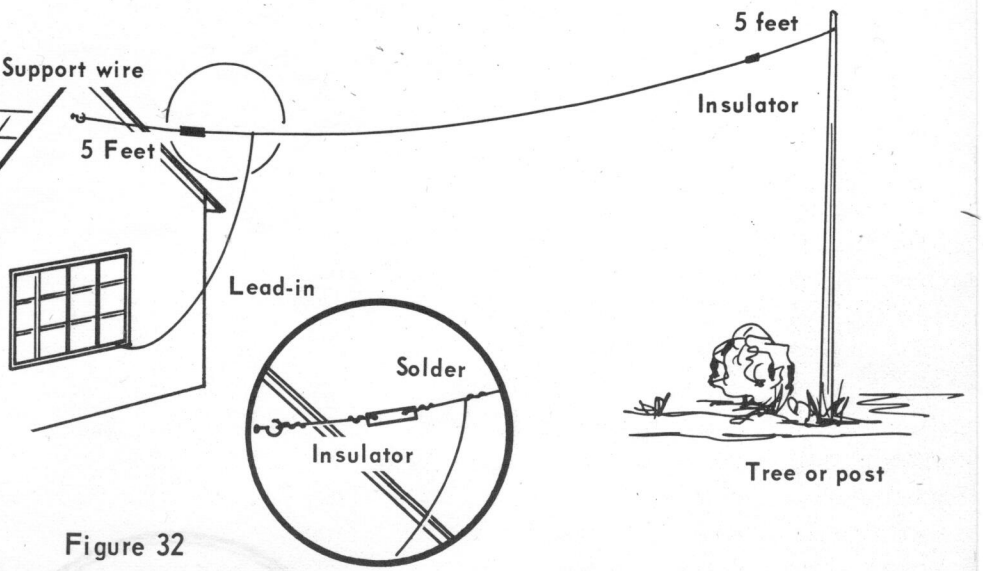


Figure 32

_____ **5** Cut a piece of #18 enamel wire the length necessary for the lead-in wire. Remove the enamel coating from the last 3 inches of the lead-in wire. Remove 3 inches of the enamel coating near the end of the antenna wire, where the lead-in is to be attached. Twist the scraped portions of the lead-in and antenna wire together and solder to make a good connection.

_____ **6** Attach a large screw hook to the highest accessible point on the house and attach one of the antenna support wires to the hook. Twist the support wire very tightly around the hook and back along itself to make sure it will stay in place.

_____ **7** Attach the other antenna support wire to the highest accessible point on a tree or pole. Pull the antenna up into position until there is only a slight sag in the antenna. This will allow some movement of the antenna without the danger of it breaking. Secure the antenna support wire so that the antenna will remain in position. To make the antenna raising easier, secure a pulley at the top of the tree or pole. Thread a rope through the pulley and attach one end to the antenna support wire. Raise the antenna by pulling on the rope, drawing the antenna support wire up and through the pulley. Secure this end of the rope at the base of the tree or pole.

_____ **8** Pass the free end of the lead-in wire through an open window and into the room where the antenna is to be used.

_____ **9** In parts of the country where there is lightning, it will be necessary to attach a lightning arrestor to the lead-in wire. A commercial lightning arrestor may be obtained or an old auto spark plug will serve this purpose. Drive a piece of pipe about 4 feet into the ground. Screw a coupling on top of the pipe and screw the spark plug into the pipe coupling. Attach a wire from the top of the spark plug to the lead-in wire. A 1/100 ampere fuse should be placed in series with the lead-in wire and radio for added protection.

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