OPERATING ALIGNMENT & SERVICING INSTRUCTIONS FOR SKY CHAMPION MODEL S-20R

the hallicrafters co.

CHICAGO U.S.A.

June 15, 1945

94X016

GUARANTEE

This receiver is guaranteed to be free from any defect in workmanship and material that may develop within a period of ninety (90) days. from the date of purchase, under the terms of the standard guarantee, as designated by the Radio Manufacturers Association. Any parts that prove defective within this period will be replaced without charge when subjected to examination at our factory, providing such defect, in our opinion, is due to faulty material or workmanship, and not caused by tampering, abuse or normal wear. All such adjustments to be made F.O.B. the factory.

Should this receiver require any adjustments, your dealer or distributor has complete technical service information, or the factory will be glad to assist you in any problem direct.

Should it be necessary to return any part or parts to the factory, a "Return Material Permit" must be obtained in advance by first writing the Adjustment Department, who will issue due authorization under the terms of the guarantee.

The Hallicrafters Co. reserves the right to make changes in design or add improvements to instruments manufactured by them, without incurring any obligation to install the same in any instrument previously purchased.

All Hallicrafters receivers are built under patents of Radio Corporation of America and Hazeltine Corporation.

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SKY CHAMPION MODEL S-20R

OPERATING INSTRUCTIONS

The Hallicrafters Co. believes that, without exception, the model S-20R receiver represents the best value in the communications field. This instruction booklet, when studied and carefully followed will help you to better understand and appreciate your Sky Champion so that you then will be able to obtain all of the characteristics of excellent performance for which this model is noted.

It is recommended that, upon receipt, the owner of the S-20R receiver carefully inspect the carton and then the receiver for any damage which might have occurred in transit. Should any signs of damage be apparent immediately file claim with the carrier accurately stating the extent of the damage.

ANTENNA

The Sky Champion has an antenna input circuit which will allow the use of either a doublet or Marconi (inverted "L") antenna. The approximate antenna input impedance of the S-20R is 400 ohms.

A very serviceable antenna will be the inverted "L", or Marconi type. This antenna should be approximately 75 feet long overall, including the lead-in to the set. Satisfactory operation of the Sky Champion is obtained throughout its tuning range with this type of antenna and because of that fact as well as its ease of construction it is highly recommended.

With the inverted "L" type of antenna terminal A2 must remain connected to terminal G for best operation. While a ground connection is usually not necessary it might prove to be helpful in reducing noise. A cold water pipe or 6' foot rod driven in moist soil will be a very satisfactory ground when connected to the G terminal on the receiver. Connections to a radiator or gas piping are not recommended.

Should a doublet antenna be used it is suggested that a 400 ohm transmission line be constructed so that a most efficient transfer of energy is obtained. The commercially available all wave doublet antennas are usually provided with a coupling transformer which matches the transmission line to the receiver. This transformer connects to the AI and A2 terminals on the antenna terminal strip. The half-wave length-doublet antenna cut for a particular frequency can be computed by the following formula.

$$\text{Length} = \frac{463}{\text{Frequency in MHz}}$$

For example, a half wave 20 meter or 14 megacycle antenna would be 463/14 = 33.7 feet long overall.

This type of antenna is broken in the center with an insulator and has the transmission line connected to each resulting quarter wave section at that point. This antenna is a very good performer, in a direction broadside to its length, only on the relatively narrow group of frequencies for which it was cut. It does not function well on harmonic frequencies.

When using either type of doublet antennas the transmission line should be connected to binding posts A1 and A2. The wire connecting the terminal A2 to ground or G can be left connected if the performance of the receiver is improved.

FREQUENCY RANGE

The Sky Champion tunes from 550 kilohertz to 44 megahertz in four bands. The frequencies covered per band are as follows:

BAND	COVERAGE
1	550 KHz - 1.780 KHz
2	1.74 MHz - 5.4 MHz
3	5.3 MHz - 15.8 MHz
4	15.5 MHz - 44 MHz

The main tuning dial, which appears behind the large escutcheon, is accurately calibrated in kilohertz on band #1 and in megahertz on the remaining three bands.

Note: The accuracy of the main dial calibration will hold only if the BAND SPREAD condenser is set at minimum capacity, or the position indicated by "0" on the Band Spread dial.

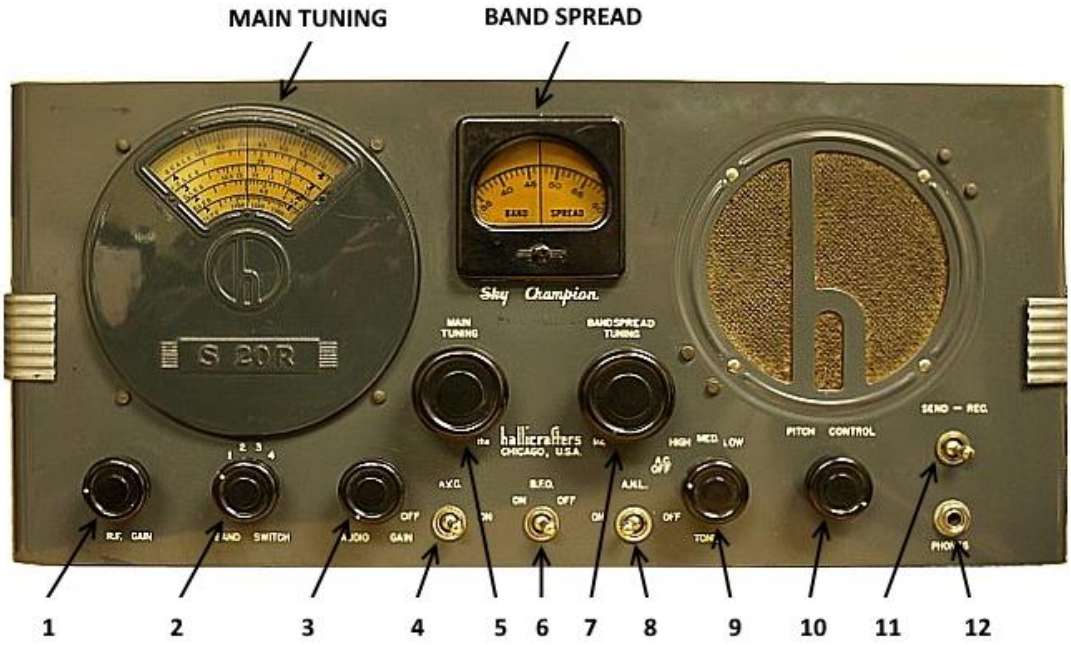
When first using the receiver, become familiar with its operation on the standard broadcast band, or Band #1, before tuning the short wave bands. You then will be able to fully appreciate the capabilities of the Sky Champion.

TUBE LINE-UP

Tube	Tube Number	Function
V1	6SK7	R.F. Amplifier.
V2	6K8	Converter and Oscillator.
V3	6SK7	1st I.F. Amplifier.
V4	6SK7	2nd I.F. Amplifier.
V5	6SQ7	2nd Detector, A.V.C. and 1st stage of audio amplification.
V6	6F6	Audio Frequency Power Amplifier.
V7	6H6	Automatic Noise Limiter.
V8	6J5GT	Beat Frequency Oscillator.
V9	80	Full wave rectifier.

CONTROLS AND OPERATION

Reading from left to right the functions of the various controls will be described.



1 - R.F. GAIN

The R.F. GAIN control adjusts the sensitivity of the receiver by varying the cathode bias on the R.F. and I.F. amplifiers. Maximum sensitivity will be obtained when this control is rotated to the right as far as it will go. When this has been done a switch will operate which turns on the calibrated "S" meter which may be obtained as a separate unit.

2 - BAND SWITCH

The BAND SWITCH selects the frequency range through which the receiver tunes.

3 - AUDIO GAIN

Use this control to adjust the Audio output level.

4 - A.V.C.

For code or C.W. reception, the Automatic Volume Control circuit should be disconnected by setting the A.V.C. switch at OFF. When this has been done the R.F. GAIN control should be manually adjusted so that the set will not overload or block on extremely strong signals. When using the receiver for the reception of modulated, or telephone, signals it is advisable to have the AVC switch set at ON.

5 - MAIN TUNING

The MAIN TUNING control adjusts the main dial of the receiver for reception on the desired frequency.

6 - B.F.O

The B.F.O. control switch turns the Beat Frequency Oscillator ON or OFF. Place it in the ON position when receiving CW or SSB transmissions.

7 - BAND SPREAD TUNING

The BAND SPREAD TUNING control allows smooth back-lash free operation of the separate band spread condenser and dial. Turning the dial in a clockwise direction from 0 to 95 lowers the frequency of the MAIN TUNING dial by approximately 20 KHz. The accuracy of the MAIN TUNING dial calibration will hold only if the BAND SPREAD condenser is set at the position indicated by "0" on the BAND SPREAD dial.

8 - AUTOMATIC NOISE LIMITER

The A.N.L. or automatic noise limiter switch will effectively minimize ignition and similar types of interference which are objectionable to short wave reception. Best results are obtained with the AUDIO GAIN control set near the minimum end.

9 - TONE

The TONE switch turns the receiver ON and OFF and in the HIGH position produces natural reproduction. In the MED. and LOW position, the highs are attenuated, a condition that will be helpful in receiving signals during certain types of interference.

10 - PITCH CONTROL

The PITCH CONTROL and its associated BFO switch provide a beat note for the reception of C.W. signals. The PITCH CONTROL, when the B.F.O. switch is set at ON controls the frequency of the beat note which may be set to a pitch most pleasing to the listener.

11 - SEND-REC.

The SEND-REC. switch removes plate voltage from the tubes in the receiver so that the set is inoperative during stand-by periods, but leaves the tube filaments hot for instant use.

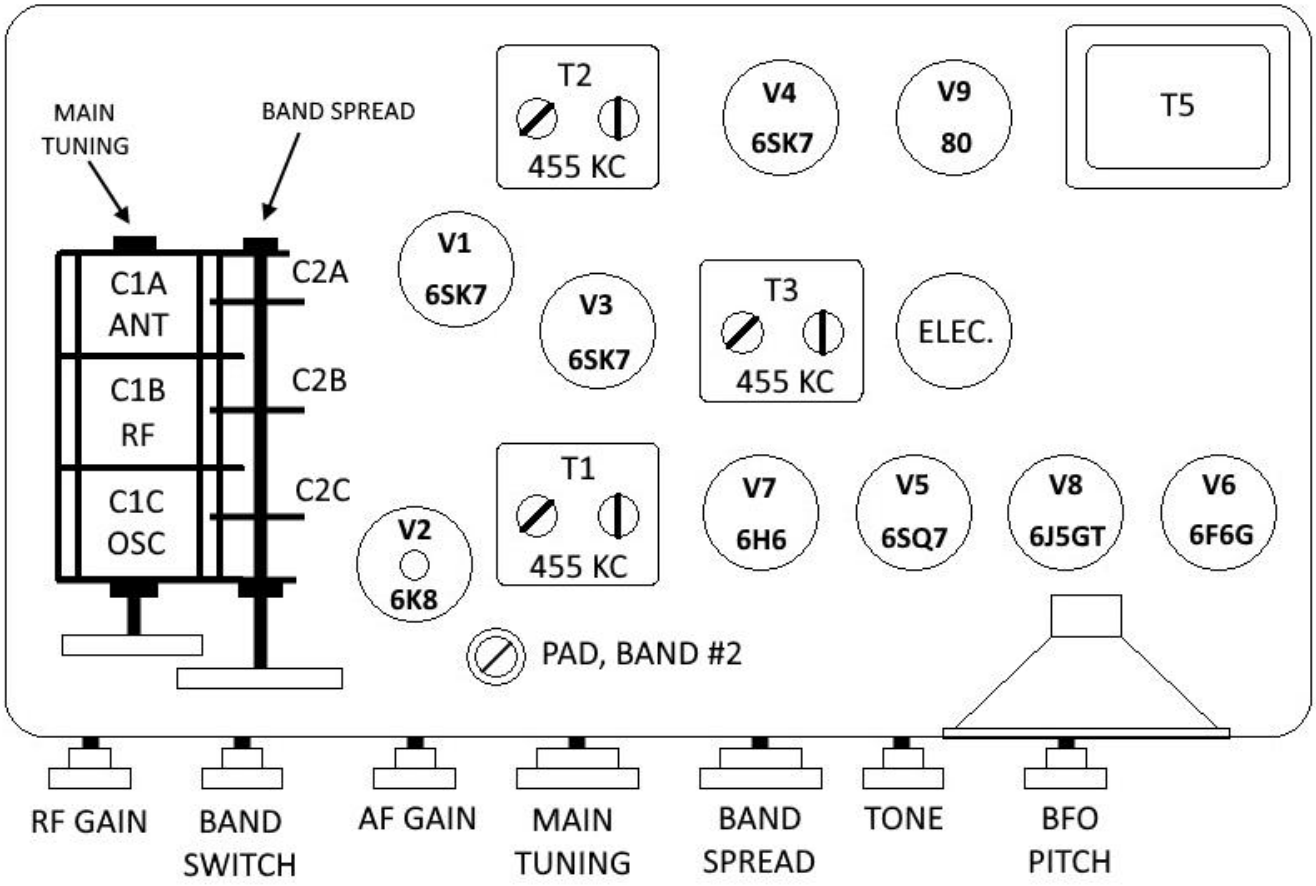
12 - HEAD PHONE JACK

Any type of high impedance headset, crystal or magnetic, may be plugged into the jack marked PHONES.

POWER REQUIRMENTS

Unless otherwise specified the S-20R Receiver operates on 117 volts 50/60 cycle single phase current. A universal model is available on special order for operation on 110 or 250 volts, 25/60 cycle single phase current, at a slight increase in price.

The Model S-20R Receiver draws 65 watts of power from the source. The Hallicrafters Co. reserves the right to make changes in design or to add improvements to instruments of their manufacture without incurring any obligation to install the same in any instrument previously purchased.



TOP OF CHASSIS

Figure 1

ALIGNMENT PROCEDURE

NOTES:

1. For best results, the chassis must be installed within the radio cabinet with all covers installed.

2. Pin 3 of the "S" meter socket at the rear of the chassis is not used. You may want to route the AVC Bus to this pin by connecting it to pin 5 of V7 (6H6). You may then connect a VTVM to this pin to monitor the progress of the receiver alignment. This connection is also used to drive a Magic Eye tuning indicator described at the back of this manual, see " Adding a Magic Eye to the S-20R".

3. Be sure that the dial cords are wound correctly, see "MAIN TUNING DIAL STRING" and "BAND SPREAD DIAL STRING".

4. For all alignment procedures it is very important that the BAND SPREAD dial be set to 0 (zero) at all times. When set to 0, the BAND SPREAD capacitor plates are fully **UN-MESHED**.

EQUIPMENT NEEDED

1. Modulated R.F. signal generator capable of producing signals in the 455 KHz to 50 MHz range.
2. VTVM used to view the negative going DC voltage on the AVC BUS.

I.F. ALIGNMENT

Have the controls set as follows:

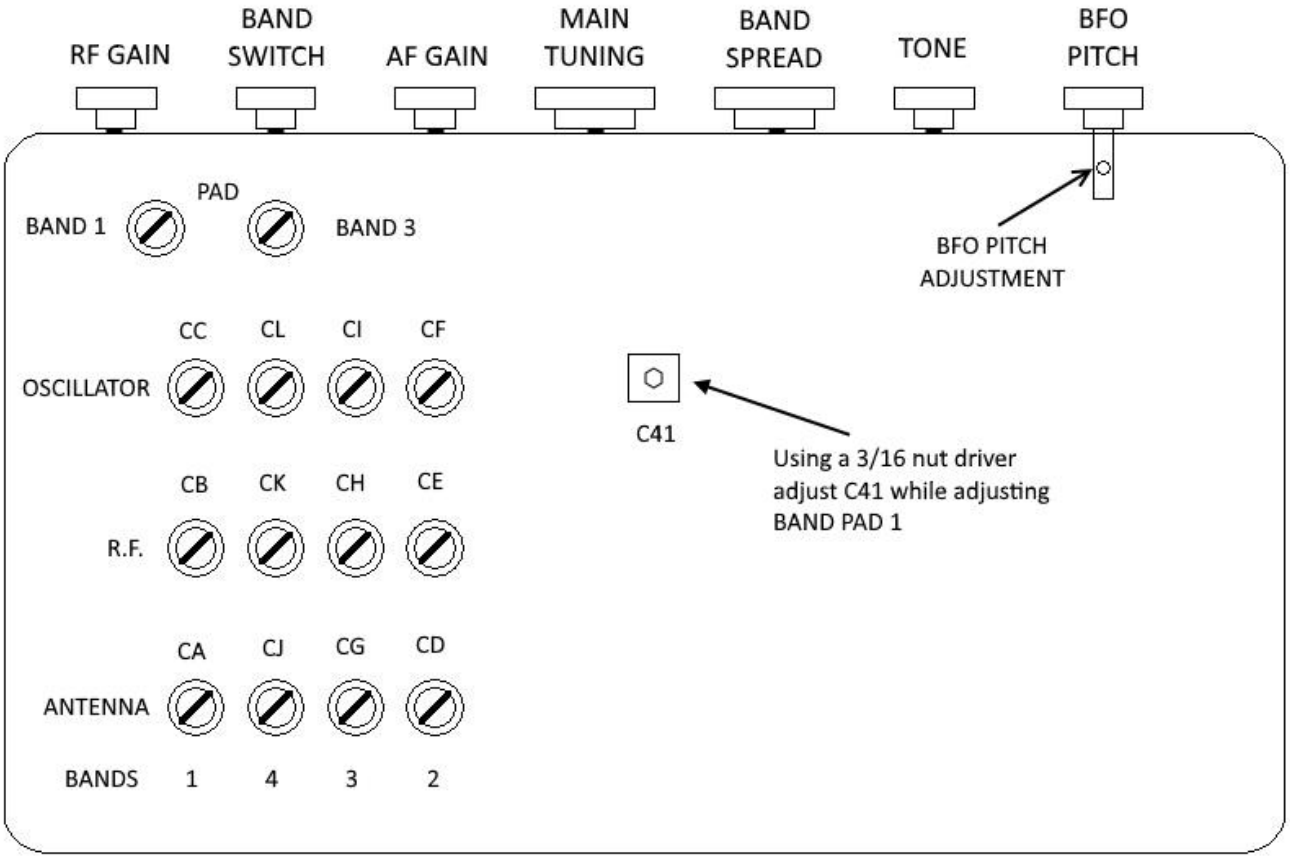
- A.F. GAIN control set to any comfortable level.
- R.F. GAIN control set for maximum level (full clockwise).
- B.F.O. switch set to OFF.
- AVC switch set to ON.
- Set BAND SWITCH to #2 band.
- Set MAIN TUNING dial at 2 megacycles and BAND SPREAD dial at zero.

Refer to Figure 1 for locations of the I.F. coil adjustments.

1. Remove the grid cap from the 6K8 (V2) tube and connect the hot lead of the signal generator through a .01 capacitor to the grid of this tube. An alternative method is to loosely couple the hot lead of the signal generator to the grid by simply draping the hot lead over the grid without making and electrical connection. Connect the signal generator's ground lead to the chassis of the receiver.

2. Connect the ground lead of the VTVM to the chassis and the hot lead to pin 5 of V7 (6H6). Select the -DC setting on the VTVM.

3. Now feed a 455 KHz signal into the receiver attenuating the signal to its lowest usable level preventing the AVC from activating . Adjust all I.F. transformer trimmers (T1, T2, T3) for maximum VTVM meter deflection .



BOTTOM OF CHASSIS

Figure 2

R.F. ALIGNMENT

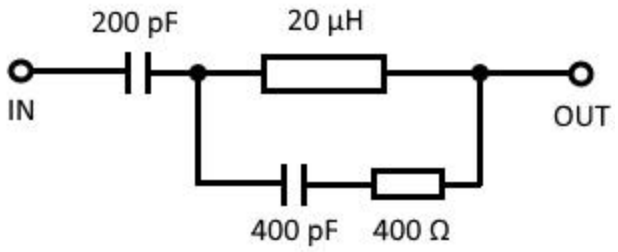
1. Re-connect the grid cap to the 6K8 tube.
2. Connect the hot lead of the generator to antenna terminal A1 on the rear of the chassis through an RMA Dummy Antenna, see Figure 3. Be sure the jumper is connected between terminals A2 and G. Leave signal generator ground connected to the chassis of the receiver.
3. The VTVM remains connected as indicated in step #2 for the I.F. Alignment.

The location of the following trimmers and padders can be determined by referring to the top and bottom chassis views. All pad adjustments are for the low frequency end of each band while the trimmers are for the high frequency ends.

NOTE:

When adjusting C41, see Figure 2, in step 2 below, be sure not to adjust it with too much coupling capacitance causing it to pull the local oscillator as the mixer encounters strong signals.

Step	Band	Signal Generator	Dial Setting	Adjustments
1	1	600 KHz	600 KHz	Adjust Pad Band 1 (also see step 2)
2	1	600 KHz	600 KHz	C41 located under the chassis, is adjusted along with Pad Band 1.
3	1	1400 KHz	1400 KHz	Adjust OSC Trimmer CC
Repeat steps 1 to 3 until the Dial tracks properly.				
4	1	600 KHz	600 KHz	Adjust Antenna Trimmer CA
5	1	600 KHz	600 KHz	Adjust RF Trimmer CB
6	2	2 MHz	2 MHz	Adjust Pad Band 2 (Top of Chassis)
7	2	4 MHz	4 MHz	Adjust OSC Trimmer CF
Repeat steps 6 and 7 until the Dial tracks properly.				
8	2	2 MHz	2 MHz	Adjust Antenna Trimmer CD
9	2	2 MHz	2 MHz	Adjust RF Trimmer CE
10	3	7 MHz	7 MHz	Adjust Pad Band 3
11	3	14 MHz	14 MHz	Adjust OSC Trimmer CI
Repeat steps 10 and 11 until the Dial tracks properly.				
12	3	7 MHz	7 MHz	Adjust Antenna Trimmer CG
13	3	7 MHz	7 MHz	Adjust RF Trimmer CH
14	4	17 MHz	17 MHz	No Pad adjustment for this band.
15	4	34 MHz	34 MHz	Adjust OSC Trimmer CL
16	4	17 MHz	17 MHz	Adjust Antenna Trimmer CJ
17	4	17 MHz	17 MHz	Adjust RF Trimmer CK



RMA Dummy Antenna
Figure 3

BFO Adjustment

The purpose of the C15 gimmick capacitor is to LIGHTLY couple the BFO to the detector. If it's too heavily coupled (i.e. more BFO signal into the detector), the AVC will start to decrease the sensitivity of the radio. Too light a coupling will require you to reduce the RF gain to obtain a decent beat note. One weakness of this design for SSB is completely inadequate BFO signal. If you're not too concerned about loss of sensitivity with the BFO on, replace the gimmick with a coupling cap of 10-20 pF or so. This will make for easier SSB copy. HOWEVER - too much coupling will load the BFO and make it drift according to the signal strength. Moreover, the BFO will try to phase lock to the incoming signal, and this will make for a growling sound on SSB signals. You can check for this by trying to "not quite" zero beat - if the BFO snaps in to zero beat rather than smoothly decreasing in tone, going to zero, then increasing as you tune the BFO thru its range, you have too much coupling capacitance. The same principle applies to the mixer.

1. With the RMA Dummy Antenna connected to the antenna terminals, inject a 455 KHz unmodulated signal with the signal generator.
2. Remove the BFO knob.
3. Turn the BFO switch to the ON position.
4. Turn the receiver on its right side and the bottom facing you.
5. From the bottom of the receiver, insert a 3/16 nut driver into the BFO adjustment hole and loosen the screw.
6. While the nut driver is still holding the screw preventing the BFO shaft from moving, insert a small flat blade screwdriver into the hollow BFO shaft from the front of the receiver.
7. Turn the screwdriver in either direction searching for the point where the BFO zero-beats.
8. Lock down the BFO shaft with the nut driver.
9. Without moving the BFO shaft, install the knob with the knob indicator pointing to the 3 o'clock position (12 o'clock position if the receiver were sitting right side up).

RESISTANCE CHART

Set the controls as follows:

- Volume FULL Clockwise
- BFO ON
- AVC ON
- ANL ON
- RF Gain FULL Clockwise
- Band 1
- SND/RCV RCV

- Resistance readings were taken after replacing all of the resistors.

Tube Pin → ↓	1	2	3	4	5	6	7	8
V1 - 6SK7	0	0	274Ω	4M	274Ω	13K	0.3Ω	23.5K
V2 - 6K8	0	0	33.4K	66K	51.7K	55.7K	0.3Ω	223Ω
V3 - 6SK7	0	0	520Ω	3.9M	520Ω	13K	0.3Ω	23K
V4 - 6SK7	0	0	1.3K	3.9M	1.3K	13K	0.3Ω	24K
V5 - 6SQ7	0	481K	98Ω	770K	770K	320K	0.3Ω	0
V6 - 6F6	0	0	23K	23K	437K	0	0.3Ω	463Ω
V7 - 6H6	0	0	1.7M	617K	3.9M	770K	0.3Ω	0
V8 - 6J5GT	0	0	38.9K	N/C	42.8K	24K	0.3Ω	0
V9 - 80	0	120Ω	129Ω	0	N/A	N/A	N/A	N/A

N/C = Not Connected
N/A = Not Applicable

VOLTAGE CHART

Set the controls as follows:

- Volume FULL Counter Clockwise
- BFO ON
- AVC ON
- ANL ON
- RF Gain FULL Clockwise
- Band 1
- SND/RCV RCV

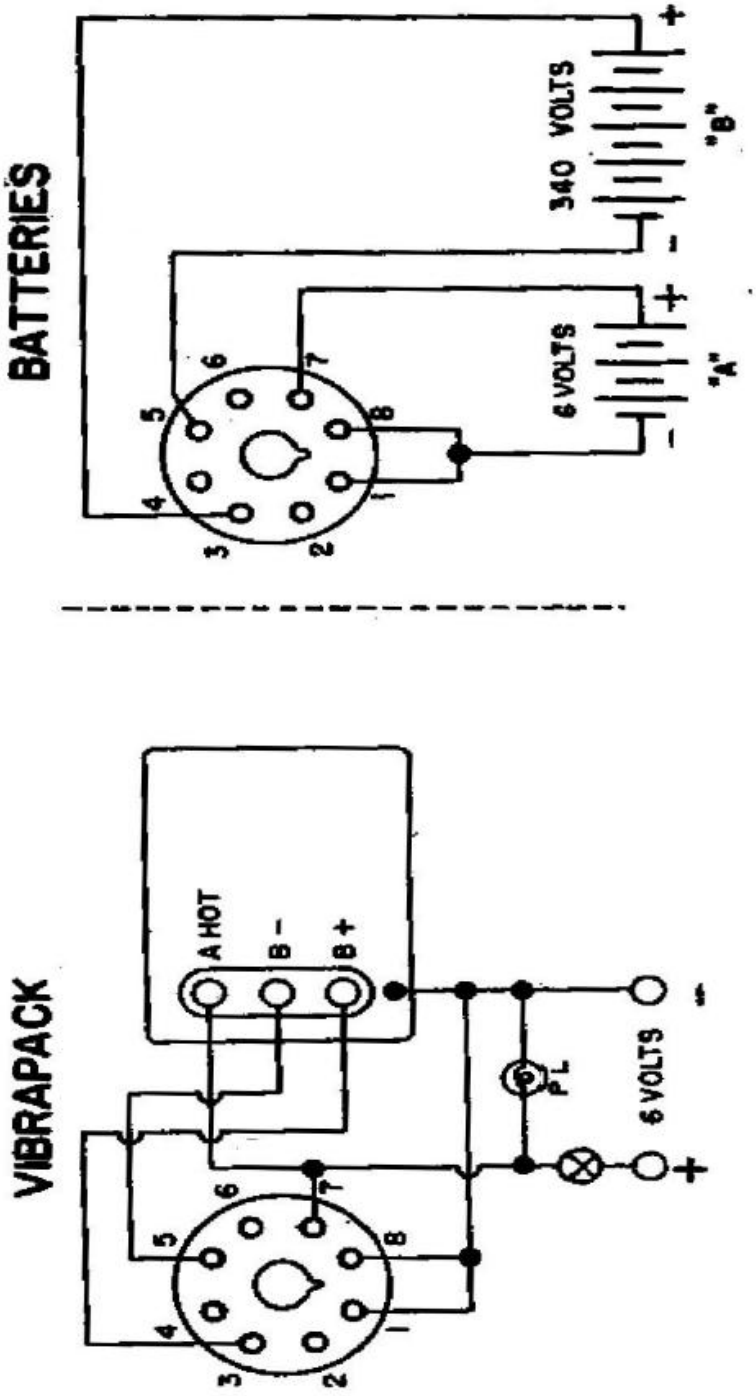
- Voltage readings were taken with 120VAC input voltage.

Tube Pin → ↓	1	2	3	4	5	6	7	8
V1 - 6SK7	0.0	0.0	2.80	-2.80	2.80	123.0	6.5AC	262.0
V2 - 6K8	0.0	0.0	218.0	93.0	-7.30	128.0	6.5AC	1.90
V3 - 6SK7	0.0	0.0	4.34	-5.0	4.34	125.0	6.5AC	268.0
V4 - 6SK7	0.0	0.0	5.90	-1.80	5.90	125.0	6.5AC	261.0
V5 - 6SQ7	0.0	0.0	1.0	-0.030	-0.030	120.0	6.5AC	0.0
V6 - 6F6	0.0	0.0	257.0	270.0	0.02	0.05	6.5AC	17.50
V7 - 6H6	0.0	0.0	-3.62	-2.83	-2.76	-5.10	6.5AC	0.0
V8 - 6J5GT	0.0	0.0	137.0	N/C	-29.20	259.0	6.5AC	0.0
V9 - 80	310.0	333AC	333AC	310.0	N/A	N/A	N/A	N/A

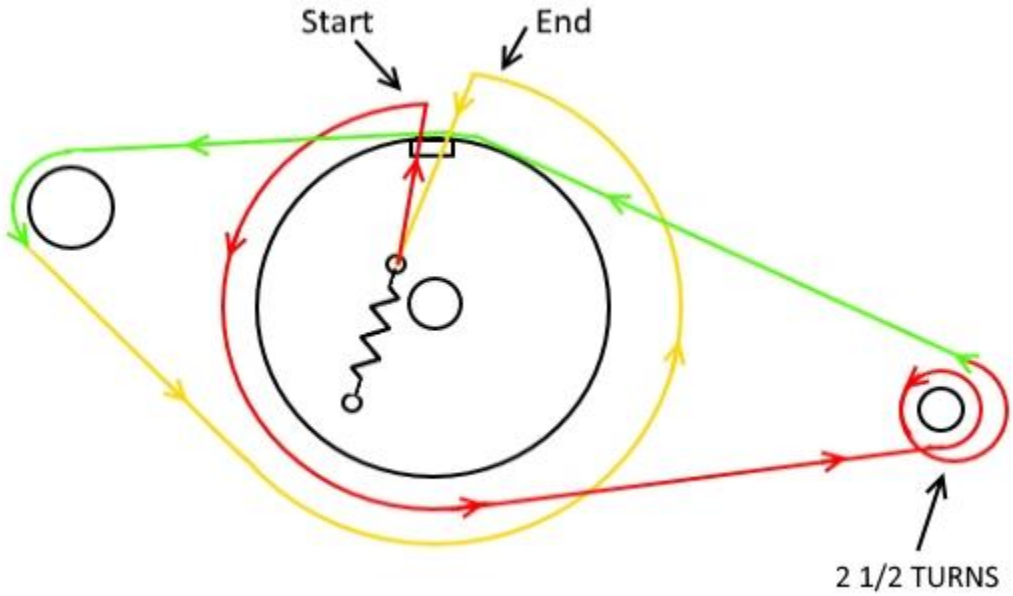
N/C = Not Connected
N/A = Not Applicable

D C OPERATION

CONNECTIONS TO "PWR" SOCKET AFTER REMOVAL OF SHORTING PLUG



MAIN TUNING DIAL STRING

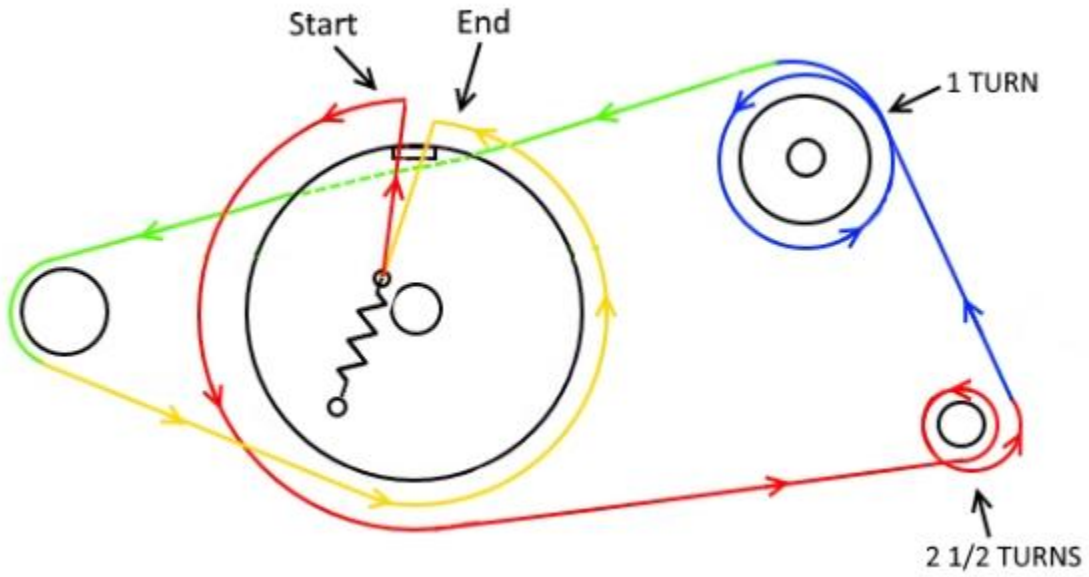


NOTES:

- With the Main Tuning Capacitor fully meshed, adjust the tuning dial to the 0 mark on the logging scale.
- 45 pound test Muskie fishing line is well suited for use as a dial string.

1. Pass the end of the string (red) through the small hole in the rim of the large pulley but do not tie it to the spring. Leave about 4 inches dangling, enough to be able to tie a knot later.
2. Wind the string half a turn counter clockwise around the large pulley.
3. Wind the string around the tuning shaft 2-1/2 turns in a counter clockwise direction.
4. Route the string (green) over the large pulley and wind it around the small pulley.
5. Wind the string (yellow) counter clockwise around the large pulley and insert the end of the string into the small hole in the rim of the pulley.
6. Grasp both loose ends of the string and temporarily windthem a couple turns around the tuning shaft in the center of the pulley.
7. While holding the ends of the string taut, turn the tuning shaft in both directions until the string become tight.
8. Hook one end of the spring into the hole in the large pulley then thread the end of one string through the eye of the other end of the spring. Tie the ends of the string using 2 knots and making sure to stretch the spring.
9. Apply a few drops of cyanoacrylate glue (crazy glue) to the knot.

BAND SPREAD DIAL STRING



NOTES:

When the Band Spread dial is at the 0 mark, the Band Spread capacitor plates are fully un-meshed.

1. Pass the end of the string (red) through the small hole in the rim of the large pulley but do not tie it to the spring. Leave about 4 inches dangling, enough to be able to tie a knot later.
2. Wind the string half a turn counter clockwise around the large pulley.
3. Wind the string around the Band Spread shaft 2-1/2 turns in a counter clockwise direction.
4. Wind the string (blue) around the dial pulley 1 turn in a counter clockwise direction.
5. Route the string (green) behind the large Band Spread pulley the around the small pulley.
6. Wind the string (yellow) counter clockwise around the large Band Spread pulley and insert the end of the string into the small hole in the rim of the pulley.
7. Referring to the MAIN TUNING DIAL STRING instructions, follow steps 6 to 9.

PARTS LIST(Resistors)

Symbol	Name of Part and Description	Function
R1	33Ω ±20%, 1/2 watt, carbon.	Parasitic suppressor.
R2	220Ω ±10%, 1/2 watt, carbon.	Cathode bias for tube V1.
R3	100K ±20%, 1/2 watt, carbon.	AVC Filter.
R4	Potientiometer, 10K, carbon.	RF gain control.
R5	150Ω ±20%, 1/2 watt, carbon.	AVC Filter.
R6	10K ±10%, 2 watt, carbon.	Plate circuit filter of tube V2.
R7	47K ±20%, 1/2 watt, carbon.	Grid bias for tube V2.
R8	220Ω ±10%, 1/2 watt, carbon.	Cathode bias for tube V2.
R9	22K ±10%, 2 watt, carbon.	Plate circuit filter for triode section of tube V2.
R10	33K ±10%, 2 watt, carbon.	Screen supply filter for hexode section of tube V2.
R11	10Ω ±20%, 1/2 watt, carbon.	Parasitic suppressor.
R12	33Ω ±20%, 1/2 watt, carbon.	Parasitic suppressor.
R13	470Ω ±10%, 1/2 watt, carbon.	Parasitic suppressor.
R14	470Ω ±10%, 1/2 watt, carbon.	Cathode bias for tube V3.
R15	330Ω ±10%, 1/2 watt, carbon.	Cathode bias for tube V4.
R16	1K ±20%, 1/2 watt, carbon.	Plate circuit filter for tube V4.
R17	2.2M ±20%, 1/2 watt, carbon.	AVC filter.
R18	1M ±20%, 1/2 watt, carbon.	Plate circuit filter of ANL tube V7.
R19	47K ±20%, 1/2 watt, carbon.	Diode filter for diode section of tube V5.
R20	100Ω ±20%, 1/2 watt, carbon.	Cathode bias for tube V5.

Symbol	Name of Part and Description	Function
R21	100K ±20%, 1/2 watt, carbon.	Diode filter for diode section for V5.
R22	270K ±10%, 1/2 watt, carbon.	Diode filter for diode section for V5.
R23	270K ±10%, 1/2 watt, carbon.	Diode filter for diode section for V5.
R24	270K ±10%, 1/2 watt, carbon.	Diode filter for diode section for V5.
R25	470Ω ±10%, 1/2 watt, carbon.	Cathode bias for tube V6.
R26	470K ±20%, 1/2 watt, carbon.	Grid return for tube V6.
R27	4.7K ±20%, 1/2 watt, carbon.	Tone control network.
R28	Potientiometer, 500K, carbon.	Audio gain.
R29	15K ±10%, 2 watt, carbon.	Plate circuit filter for tube V8.
R30	47K ±20%, 1/2 watt, carbon.	Grid return for tube V8.
R31	12K ±10%, 2 watt, carbon.	Voltage divider.
R32	10K ±20%, 4 watt, carbon.	Voltage divider.
R33	1M ±20%, 1/2 watt, carbon.	AVC decoupling.

PARTS LIST (Capacitors)

Symbol	Name of Part and Description	Function
C1	3 section Main Tuning capacitor, 12.5pF - 410pF.	Main tuning capacitor.
C2	3 section Band Spread capacitor, 20pF effective capacity change.	Band Spread tuning capacitor.
C3A	Adjustable dual capacitor, 600-1050pF ceramic (part of transformer T2).	Primary tuning of transformer T2.
C3B	Adjustable dual capacitor, 150-600pF ceramic (part of transformer T2).	Secondary tuning of transformer T2.
C4	0.05µF, 200VDC, paper.	Cathode by-pass for tube V1.
C5	25µ F, 500VDC, ceramic.	Capacity coupling in transformer T10.
C6	5-6.5pF, 500VDC, ceramic.	Capacity coupling in transformer T11.
C7	2200pF, 500VDC, mica.	Cathode by-pass for tube V2.
C8	0.05µF, 200VDC, paper.	Cathode by-pass for tube V2.
C9	0.02µF, 600VDC, paper.	Screen circuit by-pass.
C10	0.05µF, 400VDC, paper.	Plate circuit filter for tube V2.
C11	0.02µF, 200VDC, paper.	AVC by-pass.
C12	0.05µF, 200VDC, paper.	Cathode by-pass for tube V3.
C13	0.05µF, 200VDC, paper.	Cathode by-pass for tube V4.
C14	0.02µF, 600VDC, paper.	Plate circuit filter for tube V4.
C15	Twisted leads to form small capacity.	BFO coupling to diode section of tube V5.
C16	47pF, 500VDC, mica.	Diode filter for diode section of tube V5.
C17A	Adjustable dual capacitor, 100pF, 500VDC, mica, ceramic base (Part of T3).	Primary tuning of transformer T3.

Symbol	Name of Part and Description	Function
C17B	Same as C17A (Part of T3).	Secondary tuning of transformer T3.
C18	47pF, 500VDC, mica.	Diode filter for diode section of tube V5.
C19	0.02μF, 600VDC, paper.	Coupling between tube V5 and tube V6.
C20	**30**μF, 25VDC, electrolytic.	Cathode by-pass for tube V6.
C21	0.1μF, 400VDC, paper.	Screen circuit filter for tube V6.
C22	0.01μF, 800VDC, paper.	Plate circuit by-pass for tube V6.
C23	0.02μF, 600VDC, paper.	Tone control capacitor.
C24	0.02μF, 600VDC, paper.	Audio coupling between diode and triode section of tube V5.
C25	0.01μF, 400VDC, paper.	DC blocking capacitor in plate circuit of tube V8.
C26	100pF, 500VDC, mica.	Grid circuit coupling of tube V8.
C27	0.01μF, 800VDC, paper.	AC line filter.
C28	Triple unit electolitic, 30-10-10μF, 450VDC	Power supply filter.
C29	Part of C28, 10μF, 450VDC electolitic.	Power supply filter.
C30	0.1μF, 400VDC, paper.	Screen supply filter.
C31	0.05μF, 200VDC, paper.	Plate circuit by-pass of tube V7.
C32	Part of C28, 10μF, 450VDC electolitic.	Plate circuit filter for hecode section of tube V2.
C33	105pF, 500VDC, ceramic.	Plate blocking capacitor for triode section of tube V2.
C34	105pF, 500VDC, ceramic.	Primary tuning of transformer T14.
C35A	One section of adjustable dual unit, 2100pF , 500VDC, mica, ceramic base.	Transformer T15 secondary padding capacitor.

Symbol	Name of Part and Description	Function
C35B	One section of adjustable dual unit, 430pF , 500VDC, mica, ceramic base.	Inductor L1 padding capacitor.
C36	Adjustable capacitor, 1300pF, 500VDC, mica, ceramic base.	Transformer T16 padding capacitor.
C37	2200pF, 500VDC, mica.	Grid blocking capacitor for triode section of tube V2.
C38	Pair of twisted leads.	Neutralizing for band 3 to attenuate coupling between HF oscillator and mixer stage.
C39	470pF, 500VDC, mica.	Tuning capacitor across secondary of L2.
C40	0.05μF, 200VDC, paper.	AVC filter.
C41	Temperature compensating capacitor.	Temperature compensating capacitor in HF oscillator circuit.
C42	Adjustable dual capacitor, 600-1050pF ceramic (part of transformer T1).	Primary tuning of transformer T1.
C42B	Adjustable dual capacitor, 150-600pF ceramic (part of transformer T1).	Secondary tuning of transformer T1.
C43	270pF, 500VDC, mica.	Plate by-pass on tube V5.
C44A	One section of a 4 unit, adjustable 4pF, mica, ceramic base.	Transformer T6 secondary trimmer.
C44B	One section of a 4 unit, adjustable 18pF, mica, ceramic base.	Transformer T7 secondary trimmer.
C44C	One section of a 4 unit, adjustable 25pF, mica, ceramic base.	Transformer T8 secondary trimmer.
C44D	One section of a 4 unit, adjustable 2.5-50pF, mica, ceramic base.	Transformer T9 secondary trimmer.

Symbol	Name of Part and Description	Function
C45A	One section of a 4 unit, adjustable 2.5-50pF, mica, ceramic base.	Transformer T10 secondary trimmer.
C45B	One section of a 4 unit, adjustable 2.5-50pF, mica, ceramic base.	Transformer T11 secondary trimmer.
C45C	One section of a 4 unit, adjustable 1.5-30pF, mica, ceramic base.	Transformer T12 secondary trimmer.
C45D	One section of a 4 unit, adjustable 2.5-50pF, mica, ceramic base.	Transformer T13 secondary trimmer.
C46A	One section of a 4 unit, adjustable 2.5-50pF, mica, ceramic base.	Transformer T14 secondary trimmer.
C46B	One section of a 4 unit, adjustable 2.5-50pF, mica, ceramic base.	Transformer T15 secondary trimmer.
C46C	One section of a 4 unit, adjustable 1.5-30pF, mica, ceramic base.	Transformer T16 secondary trimmer.
C46D	One section of a 4 unit, adjustable 2.5-50pF, mica, ceramic base.	Inductor L1 trimmer.
C47	0.02μF, 400VDC, paper.	Transformer T14 secondary padding capacitor.

PARTS LIST (Transformers)

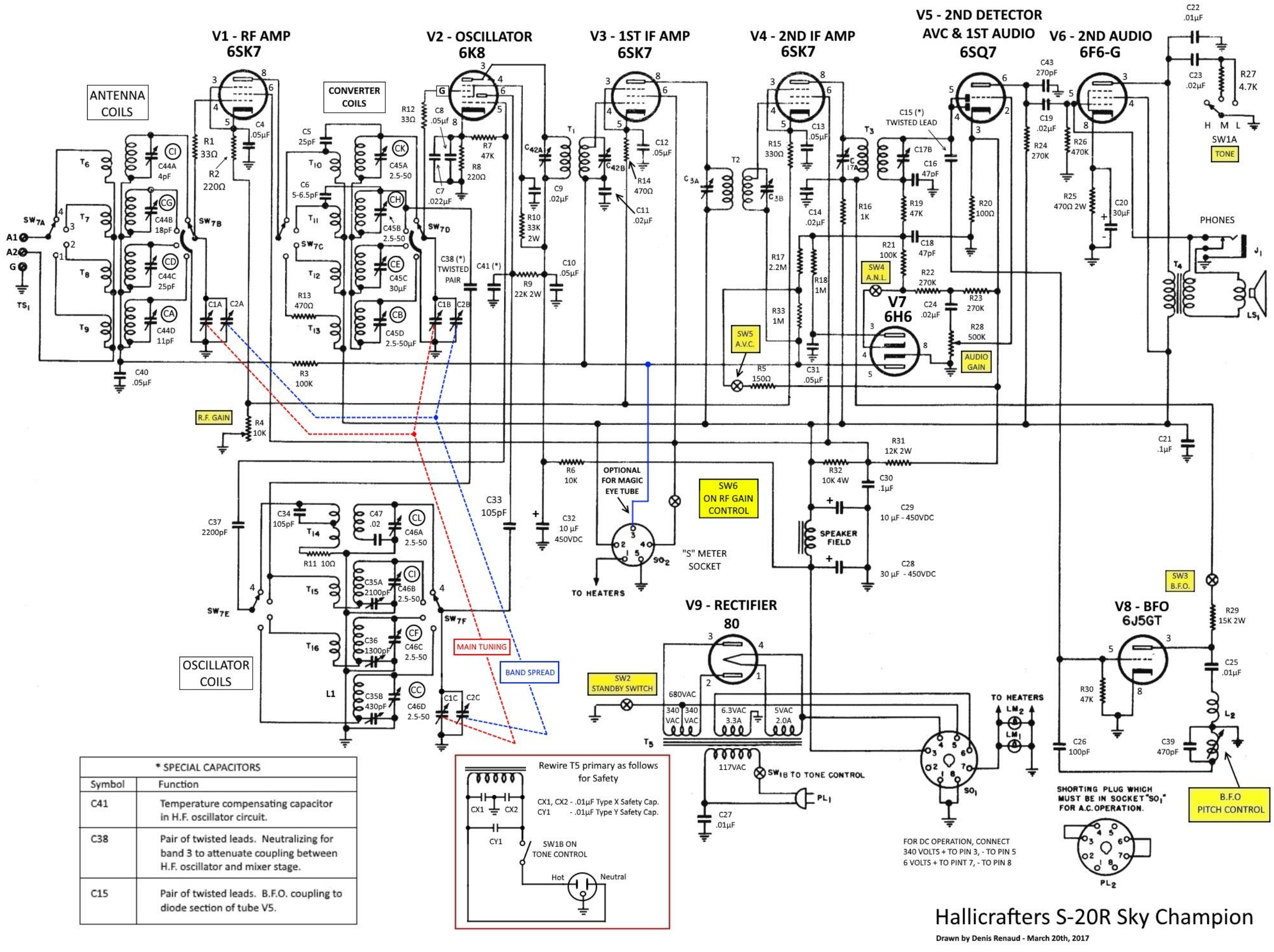
Symbol	Name of Part and Description	Function
T1	Intermediate Frequency, 455 KHz, primary 1040mh, secondary 1040mh tapped, air core, shielded.	First IF transformer.
T2	Intermediate Frequency, 455 KHz, primary 1040mh, secondary 1040mh tapped, air core, shielded.	Second IF transformer.
T3	Intermediate Frequency, 455 KHz, primary 965mh, secondary 965mh, air core, shielded.	Second detector transformer.
T4	Part of speaker assembly, matches single 6V6G to voice coil.	Audio transformer.
T5	Primary 117VAC 50/60Hz Secondary 6.3VAC @ 3.3 amperes, 5.0VAC @ 2.0 amperes 680VAC center tapped.	Power transformer.
T6	15.5-44 MHz range, air core.	Antenna stage transformer, band 4.
T7	5.3-15.8 MHz range, air core.	Antenna stage transformer, band 3.
T8	1.74-5.4 MHz range, air core.	Antenna stage transformer, band 2.
T9	550-1780 KHz range, air core.	Antenna stage transformer, band 1.
T10	15.5-44 MHz range, air core	Band 4, converter stage transformer.
T11	5.3-15.7 MHz range, air core.	Band 3, converter stage transformer.
T12	1.74-5.4 MHz range, air core.	Band 2, converter stage transformer.
T13	550-1780 KHz range, air core.	Band 1, converter stage transformer.
T14	15.5-44 MHz range, air core.	Band 4, oscillator stage transformer.
T15	5.3-15.7 MHz range, air core.	Band 3, oscillator stage transformer.

T16	1.74-5.4 MHz range, air core.	Band 2, oscillator stage transformer.
L1	550-1780 KHz range, air core.	Band 1, oscillator stage inductance.
L2	455 KHz, air core.	Beat Frequency Oscillator inductance.

MECHANICAL PARTS LIST

Symbol	Name of Part and Description	Function
SW1A	One unit of a dual unit rotory switch, single pole, three position.	Tone control circuit switch.
SW1B	Second unit of a dual unit rotory switch, SPST, toggle action, 10 amps @ 10 volts / 3 amps @ 125 volts.	AC line switch.
SW2	SPST, toggle, 3 amps @ 250 volts.	Standby switch.
SW3	SPST, toggle, 3 amps @ 250 volts.	BFO switch.
SW4	SPST, toggle, 3 amps @ 250 volts.	ANL switch.
SW5	SPST, toggle, 3 amps @ 250 volts.	AVC switch.
SW6	SPST, toggle, located on back plate of RF gain control, R4.	External "S" meter switch.
SW7A SW7B SW7C SW7D SW7E SW7F	3 section, 4 position, wafer rotory switch.	Antenna XFMR primary winding selector. Antenna XFMR secondary winding selector. Converter XFMR primary winding selector. Converter XFMR secondary winding selector. Oscillator XFMR primary winding selector. Oscillator XFMR secondary winding selector.
PL1	2 prong utility type line cord.	AC line connection.
PL2	Bakelite male octal plug.	Shorting plug for AC operation.
SO1	Bakelite female Octal socket.	Power connection for DC operation.
SO2	Bakelite 5 prong female socket.	Connection for external "S" meter.
J1	Single circuit with switch contact jack.	Headphone jack.

Symbol	Name of Part and Description	Function
LM1 LM2	6.3V @ 250 mA lamp, bayonet base, type 44.	Main tuning dial illumination. Band Spread dial illumination.
LS1	5 inch speaker. XFMR matches single 6F6G to output coil. 1.4K field coil.	Loudspeaker.
V1	6SK7 - Pentode.	RF amplifier.
V2	6K8 - Triode/Hexode.	Converter and HF oscillator.
V3	6SK7 - Pentode.	1st IF amplifier.
V4	6SK7 - Pentode.	2ns IF amplifier.
V5	6SQ7 - Duo-diode/Triode.	2nd detector AVC, 1st AF amplifier.
V6	6F6-G - Pentode.	AF amplifier.
V7	6H6 - Twin diode.	ANL
V8	6J5GT - Triode.	BFO
V9	80 - Duo-diode.	Rectifier.



* SPECIAL CAPACITORS	
Symbol	Function
C41	Temperature compensating capacitor in H.F. oscillator circuit.
C38	Pair of twisted leads. Neutralizing for band 3 to attenuate coupling between H.F. oscillator and mixer stage.
C15	Pair of twisted leads. B.F.O. coupling to diode section of tube V5.

Hallicrafters S-20R Sky Champion

Drawn by Denis Renaud - March 20th, 2017

Adding a Magic Eye to the S-20R

This article was written by Philip I. Nelson -- https://www.antiqueradio.org/magiceye.htm
Reprinted here with Philip's kind permission.

The Hallicrafters S-20R is a fine old shortwave receiver, but it lacks a tuning indicator. Hallicrafters did offer an external S-meter that plugged into a socket in the back, but the external meter was an extra-cost option (model SM-20) and probably quite scarce nowadays. The alternative is to roll your own, and that's what I did, choosing a magic eye over the more pedestrian S-meter. This page gives complete plans for building your own S-20R magic eye. The eye tube is contained in a small box that connects to the receiver with a cable. With a little creativity, this project could be adapted to many different radios.

Caution! Although the magic eye circuit is simple, this project requires connecting to a high-voltage current source within the chassis of an antique tube radio. For that reason, I consider it suitable only for advanced builders and radio restorers. The project also requires the ability to read your receiver's schematic and determine the appropriate place to connect to its AVC bus. If you are not able to build this project safely, please find a technical helper who can do so.

Parts for the Magic Eye

The parts for this project are readily available. Here is what I used.

Part	Description	Part No.	Quantity
V1	**1629 eye tube**	**AES**	**1**
C1, C2	**470uf 16v electrolytic capacitor**	**Radio Shack 272-957**	**2**
SR1, SR2	**1N4001 rectifier diode**	**Radio Shack 276-1101**	**2**
R1	**1 megohm 1/2 watt resistor**	**Radio Shack 271-1134**	**1**
R2, R3	**10 megohm 1/2 watt resistor**	*****	**2**
Misc	**Plastic project box, 5" x 2.5" x 2"**	**Radio Shack 270-1803**	**1**
Misc	**Octal tube socket**	**AES P-ST8-209MIP**	**1**
Misc	**Hookup wire**	**Radio Shack**	**1**
Misc	**Flexible cable sheath**		**1**
Misc	**Aluminum coax clamps**		**2**
Misc	**Strain relief clamps**		**2**

Building the Magic Eye

Here are the steps that I followed in building this project.

1. Wire small components and cable wires to octal tube socket.
2. Connect jumper from receiver's AVC bus to pin 3 of S-meter accessory socket.
3. Test magic eye for correct operation.
4. Install magic eye in project box.
5. Attach cable sheath and plug.

Step 1. Wire small components and cable wires to octal tube socket.

I found it simplest to mount the small components directly on the eye tube socket. I wired the components onto the tube socket in two stages. First, I connected the three resistors, R1, R2, and R3. Then I soldered together the capacitors and rectifiers (C1, C2, SR1, SR2) as a little subassembly and connected that to the socket. Start by soldering resistor R1, a 1-megohm unit, directly between pins 3 and 4 of the socket.

At pin 4, where R1 is attached, you will also connect the cable wire that will run to the B+ voltage pin of the accessory socket. The cable length is not critical; I made mine about two feet long, allowing the magic eye to be placed either atop the receiver or on the side. I recommend using different colored wires to minimize confusion when you later wire a plug the cable's end. For instance, you could use red for the high-voltage B+ wire, black for the Ground cable, green for the 6.3-volt filament wire, and yellow for the AVC bus wire.

After attaching resistor R1 and the first cable wire, solder together resistors R2 and R3. These resistors form a voltage divider to reduce the S-20R's AVC bus voltage to the right level for this tube. The junction of the R2/R3 resistor pair is wired to pin 5 of the socket. The "far" end of R2 is connected to pin 8, which also connects to Ground. The far end of R3 is connected to the cable wire that will run to the AVC bus pin on the receiver's accessory socket.

At this point, you have connected three resistors and two of the four cable wires, forming the innermost "layer" of components attached to the socket. Next, lay out the four voltage doubler components (C1, C2, SR1, SR2) in a square arrangement on your workbench. The width of the square formed by these four components should be roughly the same as the diameter of the tube base. The idea is to make a little subassembly that can be neatly attached right behind the socket.

The voltage doubler components are polarity-sensitive, so make *sure* that their positive and negative ends are arranged as shown in the schematic. Solder together these four components, keeping in mind that each corner of the resulting square will be an attachment point for some other part of the magic eye circuit.

Hold the completed voltage doubler subassembly up to the socket and determine which way it should be mounted to form the shortest and tightest connections to the tube base. Then connect the voltage doubler to the magic eye as follows:

The junction of C1 and SR1 connects to pin 2 of the magic eye socket.
The junction of C2 and SR1 connects to pin 7 of the magic eye socket.

1. The junction of C1 and C2 connects to pin 8. Also connect the cable wire that will run to the Ground connection at the receiver's accessory socket.
2. The junction of SR1 and SR2 connects to the cable wire that will run to the 6.3-volt filament connection at the receiver's accessory socket.

The magic eye circuit is complete! Before going any further, double check all of your connections against the schematic and examine your solder joints to make sure that they are clean and solid.

Step 2. Connect jumper from receiver's AVC bus to pin 3 of S-meter accessory socket.

At this point, your magic eye should be operational, given the right connections to the receiver. Although you could wire its cable permanently to the chassis, I chose to use a plug that fits the radio's S-meter accessory socket. This lets you disconnect the magic eye when moving or servicing the receiver. Whether or not you use a plug, the S-20R's accessory socket provides three of the four connection points that you need. Like the factory S-meter, our magic eye needs connections to Ground, the B+ voltage supply, and the 6.3-volt filament supply. It also requires a fourth connection to the receiver's AVC bus.

Pin 3 of the S-meter accessory socket is not normally used, so you will need to connect a short jumper wire from this pin to the receiver's AVC bus. Again, I am going to assume that you are an advanced builder who can refer to the S-20R schematic and determine the right connection point on your own. If you don't have a schematic, one can be ordered from the sources listed on our Parts page. You will need to remove the radio's bottom access panel for Steps 2 and 3. It is not necessary to remove the S-20R's chassis from its cabinet.

Step 3. Test magic eye for correct operation.

With AVC voltage available at pin 3, you can connect the cable wires to the receiver and test your magic eye. I temporarily soldered the cable wires to the accessory socket terminals inside the receiver. Needless to say, this should be done with the receiver unplugged! (Please don't succumb to the temptation to connect the cable wires with alligator clips. The risk of short circuits or shocks is not worth the negligible time saving over making temporary solder joints.) Before turning on the receiver, double check your connections and secure the cables and magic eye on your workbench so that nothing can slip around or make a short circuit while the receiver is powered.

How the Magic Eye Works

A magic eye is typically used on a radio that has AVC, or automatic volume control (an alternate term is AGC, or automatic gain control). Here is a brief description of AVC from a well-known text, *Elements of Radio Servicing* by Marcus and Levy:

AGC action can be described as follows: A strong local station delivers a strong signal to the receiver. A station at some distance away will deliver a much weaker signal to it. Yet it is desirable for each of these stations to produce approximately the same volume from the speaker. This effect could be performed manually by means of a volume control, but it is far superior if this effect is performed automatically. That is the function of the AGC system. It is also sometimes called automatic volume control (AVC). In plain English, AVC automatically "turns down" the strength of the signal for stronger stations. This is done through a negative (minus) voltage. The stronger the signal, the larger the negative voltage created by the AVC circuit. This voltage is applied to amplifying tubes in the radio's RF and IF stages. A larger negative voltage turns down their gain (amplification) a lot. A smaller negative voltage reduces their gain to a lesser degree. The upshot is that strong and weak stations play at approximately the same volume.

Use of electron-ray tuning indicator.

Unless the superheterodyne receiver is tuned exactly to a station, serious distortion due to side-band cutting may result. Many receivers use some form of tuning indicator as an aid in tuning correctly, so as to avoid this distortion. The tuning indicator in most general use in modern receivers is an electron-ray (often called a "magic eye") like the 6U5/6G5. This is a cathode-ray tube which shows a wide deflection when a low voltage is applied to its grid. The deflection narrows as the applied grid voltage is increased. The magic-eye grid is connected to the AGC bus as shown in Figure 1.

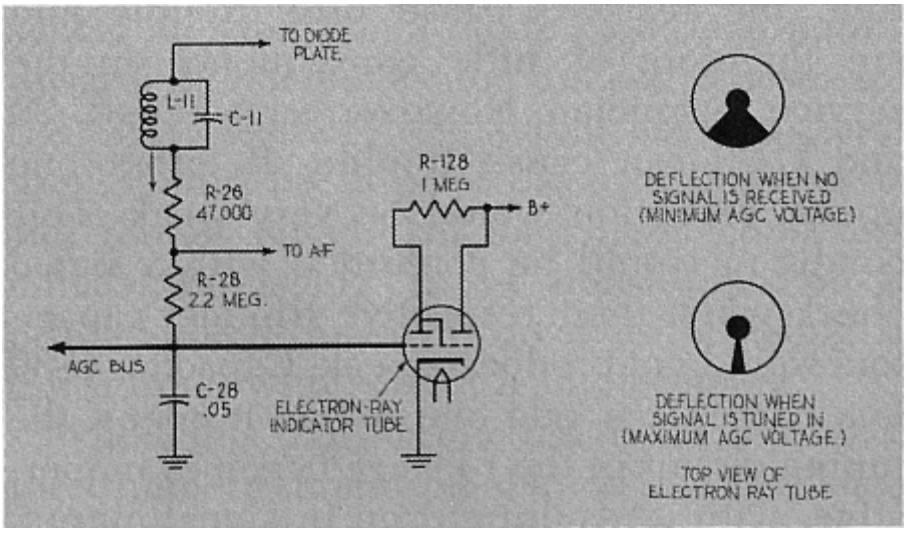


Figure 1. Electron-ray tube connected to the AGC bus as a tuning indicator.

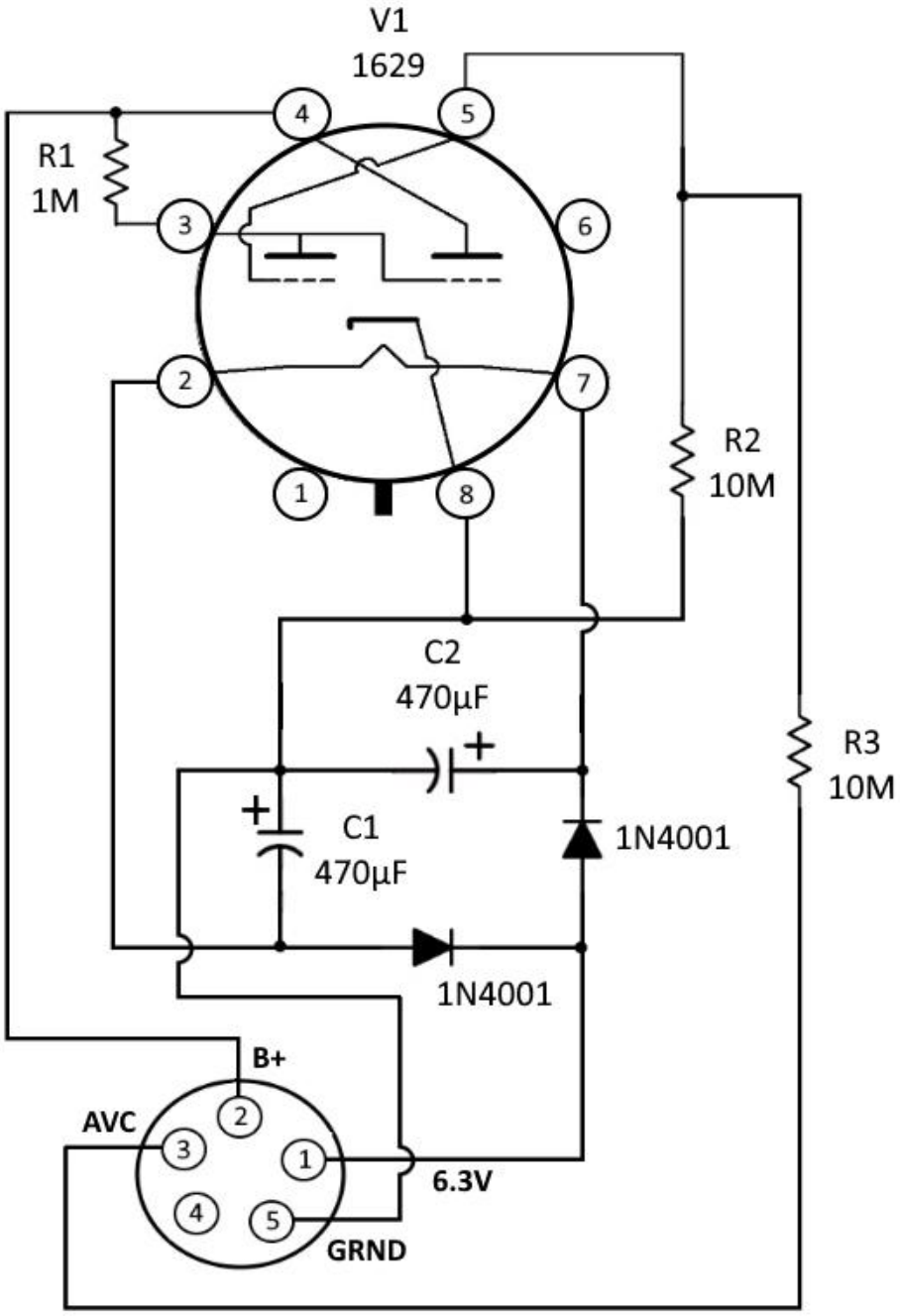
At no signal, the AGC voltage is zero and the deflection is wide; as a signal is tuned in, the AGC voltage increases and the deflection narrows. When the signal is tuned accurately, the AGC voltage is at a maximum and the deflection is at its narrowest. To tune any station correctly, simply tune the receiver for the narrowest deflection of the magic-eye tube. Since this tube must be located on the front panel of the receiver, its socket is not on the chassis. The tube is usually supported in position by a clamp, with a cable of connecting leads running down to the chassis.

This description and diagram gave me basic information about connecting a 6E5/6U5 type eye tube to my radio. To complete the project, I needed to account for differences between those tubes and my 1629 tube.

The 1629 also needs a higher filament voltage than older eye tubes, requiring about twelve volts rather than six.

To sum up, our magic eye works by tapping into the AVC circuit, making visible the radio's automatic compensation for stronger signals. A little extra circuitry is required to accommodate the 1629 tube. The voltage doubler increases the radio's 6.3-volt filament current to about 12 volts for the 1629 tube. A voltage divider reduces the radio's native AVC voltage to a level that makes the tube respond correctly.

Magic Eye Schematic



Notes:

Notes:

Battle Flags!

All of us at the Hallicrafters are both proud and humble to have important assignments in defeating America's enemies.

That our efforts have justified the award of the famous Army-Navy "E" flag is a great honor. We shall keep it proudly flying.

all of the hallicrafters