SECTION IV
THEORY OF OPERATION

1. GENERAL

Refer to the block diagram of figure 1-1. The 75A-4 amateur band receiver is a dual conversion receiver on all bands except 160 meters where single conversion is employed. The dual conversion scheme employs a fixed high frequency oscillator, crystal controlled, and a variable first intermediate frequency. The signal from a type 70E-24 VFO is beat against the variable IF to produce a fixed 455 KC second intermediate frequency. One stage of RF amplification is employed in the receiver. The passband of the fixed IF (455 KC) is shaped by a mechanical filter stage. A "Q" multiplier stage provides a tunable notch to minimize heterodyne interference. Two more 455 KC IF stages follow the "Q" multiplier. These feed separate detectors for AM or CW-SSB reception. The output of the detectors feed a combination AM and CW type adjustable noise limiter. Three stages of audio amplification follow. The output stage feeds a headset jack and a 500-ohm load or a 4-ohm speaker. A separate AVC amplifier and rectifier are used. Bias for the audio output tube and the RF gain control system is obtained from a separate rectifier. A built-in 100-KC calibration oscillator is included in the set. The passband tuning feature is accomplished by gang tuning the BFO and variable frequency oscillator by means of a metal belt.

2. TUNING.

All variable tuned stages including the RF stage, the first mixer, the variable IF system and the variable frequency oscillator are operated by the KILOCYCLES dial. This dial is coupled directly to the shaft of the variable frequency oscillator. All other variable tuned circuits just mentioned are tuned by a common platform to which powdered iron slugs are attached. The platform is moved up and down at a linear rate by means of a mechanism which is coupled to the VFO shaft by a system of split gears and metal belts. The receiver uses a unique method of band switching in the RF stage in which only the 80-meter (T-2) and the 160-meter (T-1) coils are tuned by the main tuning mechanism, and coils for 40-10 meters are selected and connected across the 80-meter coil. Varying the inductance of the 80-meter coil varies the total inductance, and therefore the resonant frequency of the tuned circuit in use.

3. RF CIRCUITS.

A simplified block diagram of the 75A-4 RF system is shown in figure 4-1. The RF stage V-2 feeds the mixer at the carrier frequency of the incoming signal. The coverage of each band is as follows:

160 meters	-	1.5	-	2.5 MC
80 meters	-	3.2	-	4.2 MC
40 meters	-	6.8	-	7.8 MC
20 meters	-	14.0	-	15.0 MC
15 meters	-	20.8	-	21.8 MC
11 meters	-	26.5	-	27.5 MC
10 meters	-	28.0	-	29.0 MC
		29.0	-	30.0 MC

The first conversion circuit, consisting of a crystal controlled oscillator, V-4 and a mixer tube, V-3, converts the incoming signal to the variable IF frequency of 2.5 to 1.5 MC for all bands from 80 meters thru 10 meters. The variable IF is mixed with a signal from the VFO, V-14 and V-15, in the second mixer V-5 where it is converted to a fixed IF of 455 KC. See figure 5-7. A discussion of the individual circuits in the RF portion of the receiver follows:

a. RF STAGE. The RF stage uses a 6DC6 pentode. This tube was chosen because of its low-noise, remote-cutoff characteristics. This tube allows greater grid voltage swing without cross-modulation distortion. Individual variable slug-tuned coils are switched into the grid circuit on 160 and 80 meters. On 40-10 meters the coil in use is switched across the 80-meter coil, and varying the inductance of the 80-meter coil tunes the coil for the band in use. The 80-meter trimmer capacitors are not in the circuit on 40-10 meters.

One coil, T-7, is used for the 11 and 10-meter bands. Manual tracking is used here employing the ANT TRIM capacitor, C-18. Separate antenna coils are employed on the 10-11-meter coil, the 80-meter coil, and the 160-meter coil.

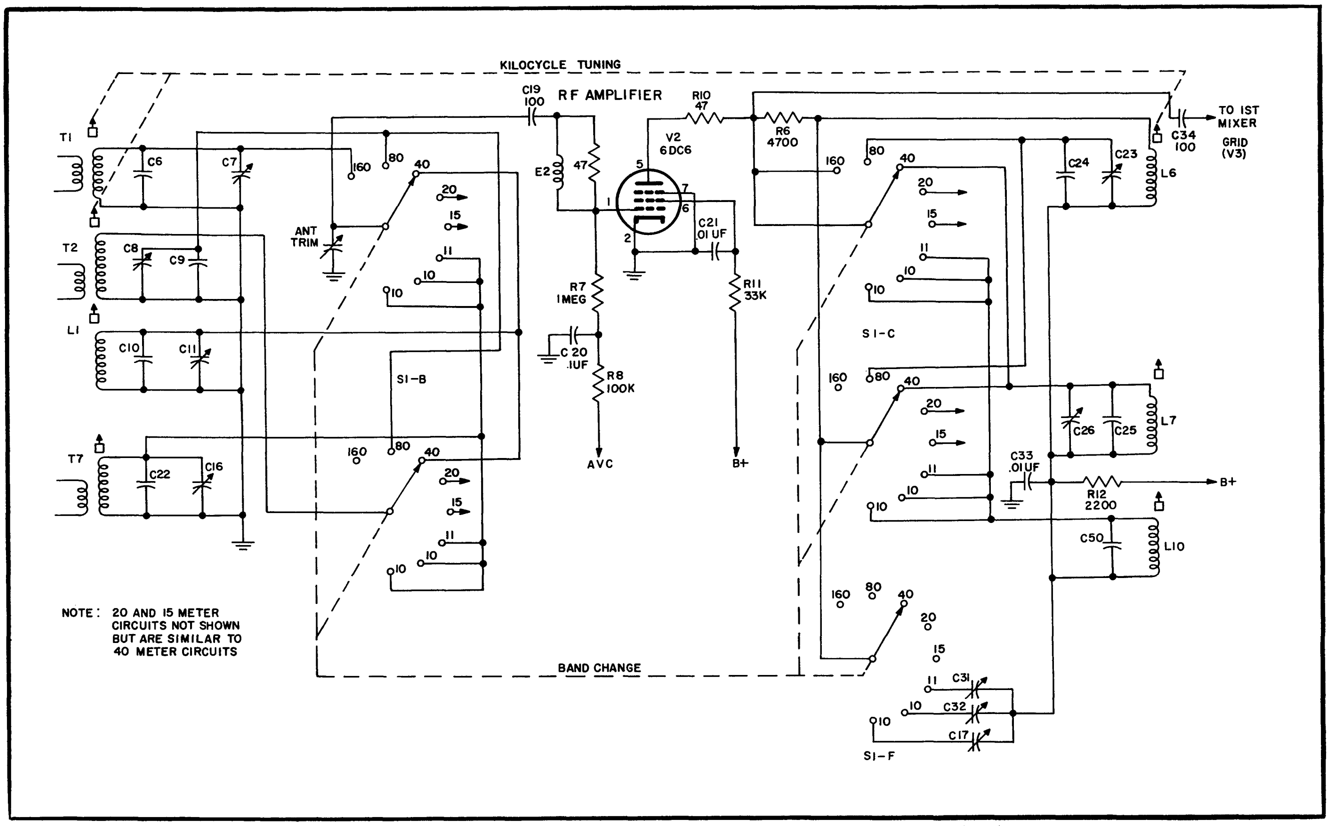


Figure 4-1. Tuning Elements of RF and Mixer Stages, Simplified Diagram

The 160-meter band feeds on thru the first mixer, V-3, into the 2.5 to 1.5 MC variable IF coils, which track with the receiver front end, and on into the second mixer V-5. On 80, 40, 20, 15 and the highest frequency 10-meter band the first mixer grid circuit is similar to the RF stage grid circuit with the higher frequency coils being paralleled with the 80-meter coil to produce the tuning for the band in use. On the low 10-meter band and the 11-meter band, capacitors C-32 and C-31 are individually selected to pad the 10-meter coil to these bands. The following table shows the tuning components used in the various bands for each tube circuit.

BAND (METERS)	ANT L	ANT C PAD	ANT C TRIM	RF L	RF C PAD	RF C TRIM	OSC L	OSC PAD
160	T-1	C-6	C-7 C-18	-	-	-	-	-
80	T-2	C-9	C-8 C-18	L-6	C-24	C-23	L-12	C-40
40	L-1 (T-2)	C-10	C-11 (C-18)	L-7 (L-6)	C-25	C-26	L-13	C-41
20	L-2 (T-2)	C-12	C-13 (C-18)	L-8 (L-6)	C-27	C-28	L-14	C-42
15	L-3 (T-2)	C-14	C-15 (C-18)	L-9 (L-6)	C-29	C-30	L-15	C-43
11	T-7 (T-2)	C-22	C-16 (C-18)	L-10 (L-6)	C-50	C-31	L-16	C-44
10 LO	T-7 (T-2)	C-22	C-16 (C-18)	(L-10) (L-6)	C-50	C-32	L-17	C-45
10 HI	T-7 (T-2)	C-22	C-16 (C-18)	(L-10) (L-6)	C-50	C-17	L-11	C-51

( ) Components used in a previous band

b. CRYSTAL CONTROLLED OSCILLATOR AND FIRST MIXER.

The high frequency mixer stage employs a 12AT7 (V-4) in a crystal controlled oscillator circuit to provide a heterodyning signal. In this oscillator circuit the crystal is connected between the cathodes of a dual triode. One section (V-4 pins 6, 7, 8) is a cathode follower amplifier, the other section, a grounded grid amplifier. Feedback voltage is coupled from the plate of one section, which contains a tank circuit resonant at the crystal frequency, to the grid of the other section. The crystal, inserted between the cathodes, acts as a filter. The phase change through the loop is zero and oscillation takes place at the crystal frequency. Crystal oscillator output voltage is coupled to the injection grid of the 6BA7 first mixer. An individual crystal for each band is switched into the crystal oscillator circuit except for 160 meters, where the high frequency oscillator is not used. The crystal oscillator beats with the incoming carrier to produce the first, or variable, intermediate frequency. In this stage, because the crystal frequency is fixed and the incoming carrier frequency may be anywhere in the range of the band in use, the difference frequency produced in the mixer must be tuned by a variable IF system.

c. VARIABLE IF. The variable IF covers the range 2.5 to 1.5 MC. The system consists of two slug-tuned coils on the same frequency. The first of these coils is capacity coupled to the second which in turn is connected to the grid of the second mixer V-5. L-23, a 5.7 MC trap is connected between the two coils to remove a spurious response that occurs at 3.533 MC.

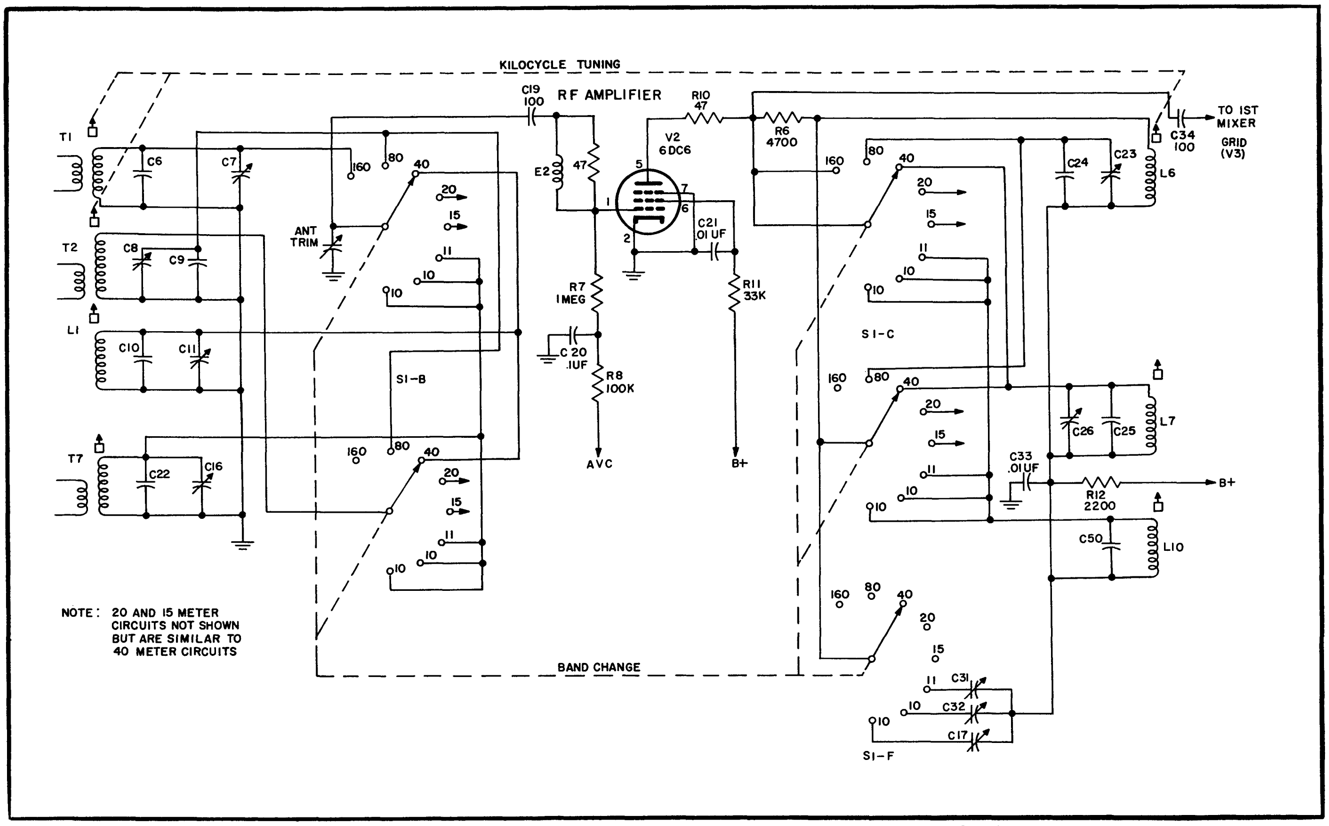
d. VFO AND SECOND MIXER. A Type 70E-24 permeability-tuned precision variable frequency oscillator provides the injection voltage to the second mixer V-5. The frequency range of the VFO is 1955 KC to 2955 KC. This frequency is mixed with the variable IF in V-5 to produce the fixed 455 KC difference frequency which is the frequency of the fixed IF amplifier.

e. MECHANICAL FILTER. The functional diagram of the Collins Mechanical Filter is shown in figure 4-2. The mechanical filter uses the principle of magnetostriction to convert electrical energy to mechanical vibration. The magnetostriction transducer input coil is resonated at 455 KC. A nickel wire within this coil vibrates mechanically and transmits this mechanical energy to the first of a series of nickel alloy discs. The mechanical vibration of this first disc is coupled to succeeding discs by means of nickel-wire coupling elements. Biasing magnets at either end of the mechanical filter polarize the filter elements to prevent frequency doubling, in much the same manner as biasing magnets in a headphone prevent the headphone diaphram from bending in the same direction for both halves of an AC cycle. The mechanical vibration of the last disc is coupled to a magnetostriction transducer element identical to the one used at the input of the filter. By a reverse principle of magnetostriction, the mechanical vibration of the nickel-wire transducer core is converted to electrical energy.

Each of the discs employed in the mechanical filter has a mechanically resonant Q exceeding 2,000. Six of these discs are overcoupled to produce a mechanically-shaped response curve with a flat top and straight, almost vertical sides. Thus, the filter passes a band of frequencies very little wider than the flat top of the selectivity curve. The mechanical filter furnished with the 75A-4 passes a band of frequencies approximately 3 KC wide and centered on 455 KC, providing an IF selectivity curve ideal for the reception of AM and single-sideband signals. The 3-KC filter is supplied as part of the 75A-4; however, a mechanical filter having similar selectivity characteristics but having a band pass of 500 cycles is available for use in CW reception. A 6-KC filter is available for double-sideband reception of AM.

The mechanical filters used in the 75A-4 are the plug-in type that plug into a 9 pin miniature tube socket. These are sealed units and must not be tampered with. No external variable tuning is employed.

f. "Q" MULTIPLIER. (See figure 5-5.) The "Q" multiplier, as used in the 75A-4, is employed only as a rejection filter. In this capacity it performs the same function as the rejection notch of the crystal filter in earlier receivers but does it much better. It is capable of attenuating as much as 40 db, any single audio tone (heterodyne) which may be present within the receiver's passband. The "Q" multiplier consists of a cathode follower amplifier coupled to a regenerative amplifier, the plate load of which is a bridge T-filter. The regenerative amplifier is kept just below the oscillating point by R-36. At this point the plate circuit has a very high Q and provides a very sharp null to frequencies within the receiver passband. REJECTION TUNING capacitor C-72 can shift the null around to any frequency within the passband. The "Q" multiplier is removed from the circuit by turning the



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BAND (METERS)	ANT L	ANT C PAD	ANT C TRIM	RF L	RF C PAD	RF C TRIM	OSC L	OSC PAD
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80	T-2	C-9	C-8 C-18	L-6	C-24	C-23	L-12	C-40
40	L-1 (T-2)	C-10	C-11 (C-18)	L-7 (L-6)	C-25	C-26	L-13	C-41
20	L-2 (T-2)	C-12	C-13 (C-18)	L-8 (L-6)	C-27	C-28	L-14	C-42
15	L-3 (T-2)	C-14	C-15 (C-18)	L-9 (L-6)	C-29	C-30	L-15	C-43
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10 HI	T-7 (T-2)	C-22	C-16 (C-18)	(L-10) (L-6)	C-50	C-17	L-11	C-51

( ) Components used in a previous band

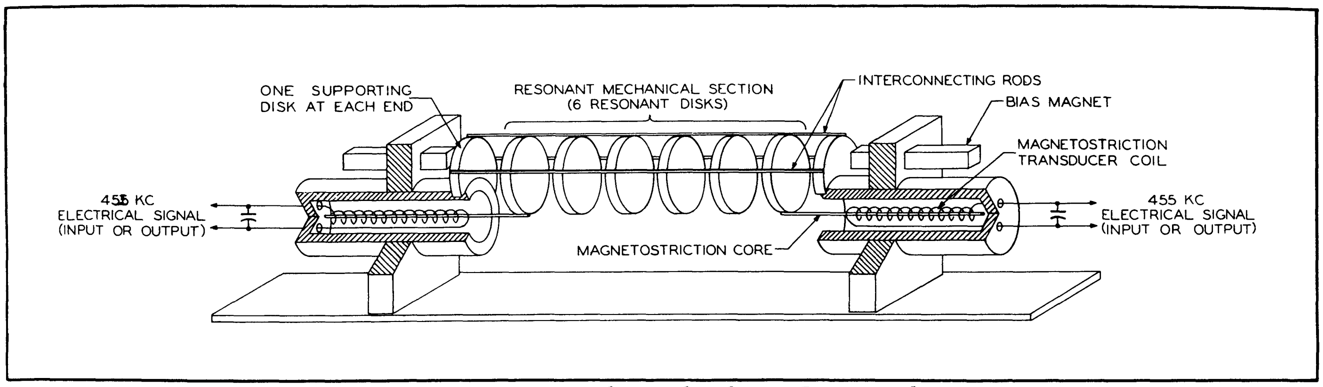

Figure 4-2. A Collins Mechanical Filter, Functional Diagram

REJECTION TUNING Control clockwise to actuate a switch which short circuits inductor L-26.

g. 455 KC IF. AMPLIFIER. The 455 KC IF amplifier consists of V-6 which is associated with the mechanical filter and V-8 and V-9; the latter two are conventional IF amplifiers that contribute nothing to the passband wave shape, which is determined by the mechanical filter. All are 6BA6 tubes. AVC is applied to the grids of all three tubes.

h. AM DETECTOR. The AM detector is a conventional diode rectifier excited from IF transformer T-3 and having R-56 and R-57 as its load. The audio from the detector is applied to the noise limiter, V-12, when AM CW SSB selector switch S-3 is operated to AM position.

i. CW-SSB DETECTOR. This detector, V-11 is designed especially for SSB reception. It is a mixer type circuit that takes the output of the BFO and mixes it with the output of the 455 KC IF. Tube elements 1, 2 and 3 perform as a cathode follower amplifier. The remainder of the tube is a plate detector, the cathode of which is common with the cathode follower amplifier. The detector greatly reduces the distortion which is generated when a conventional diode detector is used for detecting SSSC signals. The audio from the detector is applied to the noise limiter V-12 when S-3 is operated to the CW-SSB position.

j. BFO. The BFO V-20, uses a 6BA6 in an electron coupled oscillator whose frequency range is approximately 453-457 KC. The BFO is tuned by means of the knob on the front panel labeled PASSBAND TUNING. The shaft of the PASSBAND TUNING Control is attached by a metal belt to the frame of the variable frequency oscillator which is mounted in a ball and oilite bearing equipped cradle. As the BFO is tuned through its range the VFO is also tuned a like amount. (The shaft of the VFO is prevented from turning by the gearing of the vernier tuning dial.) Because the actual intermediate frequency is changing, the passband is being shifted and an unwanted signal can be dropped off the edge of the passband while retaining the wanted signal in the passband without changing its pitch.

4. AUDIO CIRCUITS.

a. NOISE LIMITER. Noise limiter V-12, a 6AL5 tube, couples the audio from the detectors to the first audio stage. The function of the noise limiter is to minimize interference by removing noise peaks which exceed the amplitude of the modulation. It is effective on AM, CW and SSB.

Both diode sections of the 6AL5 are required in order to limit both the positive and the negative peaks. During AM reception, a negative voltage is derived across diode load resistors R-56 and R-57. NOISE LIMITER Control R-67 is connected to this source of supply. As a result the cathodes of V-12 assume a negative DC potential which is adjustable by means of the NOISE LIMITER Control, and direct current flows through the diodes (the plates being positive with respect to the cathodes). The AF signal voltage from the receiver is applied to the anode (pin 7) of one section of V-12 through coupling capacitor C-93. This AF signal modulates the DC flowing through this diode section and, as a result, the AF signal appears across cathode resistor R-65. This resistor is common to both diode circuits, therefore the AF signal is superimposed on the DC flowing through the second section of V-12 and appears across load resistor R-63. From this point, the signal is coupled through C-96 and AF GAIN Control R-62 to the audio amplifiers.

Any negative impulse that drives the anode of the input diode (pin 7) more negative than the cathode, will cut off the diode, and that impulse will be limited to an amplitude equal to the threshold voltage (as set by the NOISE LIMITER Control). Similarly, any positive impulse that overcomes the threshold potential on the cathode of the second section (pin 5) will cut off that diode, and the positive impulse will be limited. As the NOISE LIMITER Control is turned toward 10 a less negative threshold voltage is applied to the diodes, and more severe limiting results. The threshold voltage at any given setting of the NOISE LIMITER Control varies with the average amplitude of the diode load signal, therefore limiting action automatically adjusts itself. C-97 and R-66 decouple the limiter circuit from the detector circuit.

During CW or SSB reception when the carrier is intermittent or absent, the reference voltage is supplied by connecting the NOISE LIMITER Control R-67 through switch S-3 to a value of bias obtained from the receiver bias rectifier. Because of the flat AVC characteristic of the receiver, frequent adjustment of the NOISE LIMITER Control is unnecessary.

The noise limiter is made inoperative by applying a value of B+ to the diode plates through R-64 and by grounding the cathodes of V-12 thus insuring that the diode currents cannot be cut off on noise or high modulation peaks. This is done by a switch associated with the NOISE LIMITER Control. C-98 provides a ground path for the audio when S-4 is in the OFF position.

b. AUDIO AMPLIFIERS. The audio section consists of two stages of voltage amplification (both halves of the dual triode V-13, a 12AT7) and a 6AQ5 power amplifier. The AF GAIN Control is located in the grid circuit of the first stage. Fixed bias from the bias rectifier is applied to the grid of the power amplifier. The output transformer secondary consists of a 500-ohm winding suitable for driving auxiliary apparatus and a four-ohm winding for use with loudspeaker voice coil and headphones. When a headphone is plugged into the headphone jack J-2, the speaker connection is interrupted and a 10-ohm load resistor is connected in parallel with the headphone to keep the output transformer properly loaded.

5. RF GAIN CONTROL SYSTEM.

The RF gain control system in the 75A-4 works in conjunction with the AVC system. To control the sensitivity of the set, a source of fixed bias is added to the AVC voltage which is then applied to the AVC controlled tubes. This system maintains the gain distribution constant throughout all settings of the gain control. In order to prevent the RF GAIN Control from affecting the characteristics of the line due to loading, an RF gain gate is employed to decouple the RF GAIN Control from the AVC line. This gate is in the form of 1/2 of a type 6AL5 twin diode, V19. The other half of the tube is employed as a bias rectifier.

Bias from this rectifier is connected to one end of the RF GAIN Control. The arm of the control is connected to the AVC line through the RF gain gate, V19 (pins 1 and 7). Advancing the control adds negative bias to the AVC bias and reduces the gain of the tubes connected to the AVC line, namely, V-2, V-6, V-8, and V-9. The value of R104 is selected in final test and ranges from 270 ohms to 560 ohms. R104 in this set will be one of the following values and part numbers:

270 ohms	745 1328 00
330 ohms	745 1331 00
390 ohms	745 1335 00
470 ohms	745 1338 00
560 ohms	745 1342 00

6. "S" METER.

The "S" meter is connected in a bridge circuit between the cathode of V-8 and the screen grids of V-6 and V-8. These are the I-F amplifier tubes that are furnished with AVC voltage. A reference voltage is developed at the positive terminal of the "S" meter by the screen current flow of V-6 and V-8. This reference voltage is adjusted by R-43 under no-signal conditions to a value equal to that developed at the negative terminal of the "S" meter by the cathode current of V-8. The presence of a signal in the IF strip causes an AVC voltage to be developed which reduces the current through V-8 causing its cathode voltage to decrease and at the same time causing the screen voltage on the two IF tubes to slightly increase. These changes of voltages at the cathode of V-8 and at the screen circuits of the two IF tubes, being in opposite directions, unbalance the bridge and cause the meter to read in proportion to the strength of the received signal. R41 adjusts the sensitivity of the "S" meter.

7. AVC SYSTEM.

A low impedance AVC line is employed to minimize blocking on strong signals. The RF amplifier V-2 and the 455 KC IF amplifiers V-6, V-8, and V-9 are all AVC controlled. A stage of IF amplification V-21, separate from the signal IF amplifier, is employed to amplify the IF signal for rectification for AVC voltage. The IF amplified IF voltage is rectified by 1/2 of V-16, a twin diode. The other half of V-16 is used as an AVC noise clipper. This tube clips sharp noise impulses from the AVC voltage and thus prevents the noise from desensitizing the AVC Circuit. A small positive DC voltage is applied to the AVC rectifier through R-86 to produce an AVC delay so that the AVC is ineffective on weak signals. A network of load resistors is switched by switch S-5 to select either fast or slow AVC characteristics. C-110 provides RF filtering for the AVC detector output, R-89, R-91 and R-92 are the detector loads. R-90 and C-112 provide the AVC time constant with R-92 and R-91 modifying the time constant for slow and fast AVC operation. AVC test point J-4 is provided for use in aligning the AVC IF amplifier transformer T-4. Each controlled stage is decoupled from the AVC line by suitable capacitors and resistors to prevent instability because of RF feedback.

8. CALIBRATOR CIRCUIT.

The calibrator employs a 6BA6 tube in a crystal controlled oscillator circuit. The fundamental frequency of the oscillator is 100 KC, therefore, a harmonic appears at each 100 KC point over the entire range of the receiver when the calibrator is turned on. C-1 is used to zero beat a calibrator harmonic with a 1500 KC or 1600 KC broadcast station or with WWV at 2.5, 15 or 30 MC. The calibrator output is coupled to the receiver input by C-5. The calibrator is turned on wherever S-6 is in the CAL position.