SECTION IV
CIRCUIT DESCRIPTION

4.1. MECHANICAL DESCRIPTION.

4.1.1. BAND CHANGE. - Collins 51J-4 Receiver covers the frequency range of 0.5 to 30.5 mc in 30 bands: 0.5 to 1.5, 1.5 to 2.5, and so on up to 30.5 mc. Each band is one megacycle wide. Circuits affected by band changes are the r-f amplifier grid, first, second, and third mixer grids, crystal selector, and crystal harmonic tuning circuits. The third mixer is switched in only on band 1 (.5 to 1.5 mc). See figure 4-1.

Operations involved in the changing of bands consist of selecting the proper coils in these circuits by means of tap switches and changing the position of the r-f amplifier and first mixer slug tables. All stages are permeability tuned by powdered iron slugs. The r-f amplifier and first mixer slug tables change position a full megacycle in tuning each time a band is changed. This is true of all three slug tables, which tune L104 through L113. However, the tap switches select the proper set of coils for the frequency desired.

Slug tables are driven from two sources: the main tuning knob and the BAND CHANGE knob. These two driving sources are connected to the slug tables through a differential gear mechanism. This is necessary since the coils for bands 4 to 7, 8 to 15, and 16 to 30 cover these tuning ranges with one complete excursion of the tuning slugs. For instance, the band 4 to 7 slug table tunes its associated coils through four megacycles; in one megacycle jumps when operated by the BAND CHANGE knob, and in complete coverage in between when operated by the tuning knob. An interesting feature of the differential gearing is its ability to combine the movements of the two driving sources so that the slug table is moved exactly one megacycle in each band change. The other slug tables operate similarly to the 4 to 7 table, except that the band 8 to 15 table tunes its associated coils through 8 mc, and the band 16 to 30 table tunes its associated coils through 15 mc. These three slug tables are moved simultaneously by means of separate cams.

Switch sections of the band switch are ganged with the BAND CHANGE knob through an over-travel coupler. This over-travel coupler drops the band switch at band 16 while the r-f slug tables continue to operate one position for each band as usual. Refer to figure 4-2. This mechanical diagram shows the gears and connecting shafts associated with band change and tuning. Shafts associated with changing bands are C, D, G, H, I, K, and the over-travel shaft. On band 1 radio frequency coils L101 and L110 are switched by means of the BAND CHANGE knob through the over-travel shaft and shaft G. On bands 2 and 3, the r-f coils are selected by the BAND CHANGE knob through the over-travel shaft and shafts G and K, variable i-f section coils, L116 through L119, being used as additional r-f coils on these bands. On bands 4 to 7, the coils are selected by the BAND CHANGE knob through the over-travel shaft and shaft G, and the position of the slug table is changed through shafts C and D. On these bands the same coils are used for each band. Band change is accomplished by moving the tuning slug in the coil an amount equal to one megacycle in frequency. The slug moves in the coil 0.250 inches for a one megacycle change. On bands 8 to 15, the r-f coils are changed by the over-travel shaft and shaft G, and the position of the slug table is changed one megacycle per band through shafts C and D. The movement of the slug table for a one megacycle change is 0.125 inches. On bands 16 to 30, the r-f coils are switches through the over-travel shaft and shaft G to position 16 where the band switch remains for bands 16 to 30 while the over-travel coupler allows shaft G to rotate through to the thirtieth band. The slugs in the r-f coils are driven through shafts C and D. The slugs travel 0.0625 inches during band change. During operation on any band between 4 and 30 the variable i-f channel is alternated from one variable i-f to the other by shafts G and K. Crystals are selected by operation of the BAND CHANGE knob through the 15-position Geneva system and shafts G, H, and I.

4.1.2. TUNING. - All r-f, mixer and variable i-f coils, as well as the variable frequency oscillator

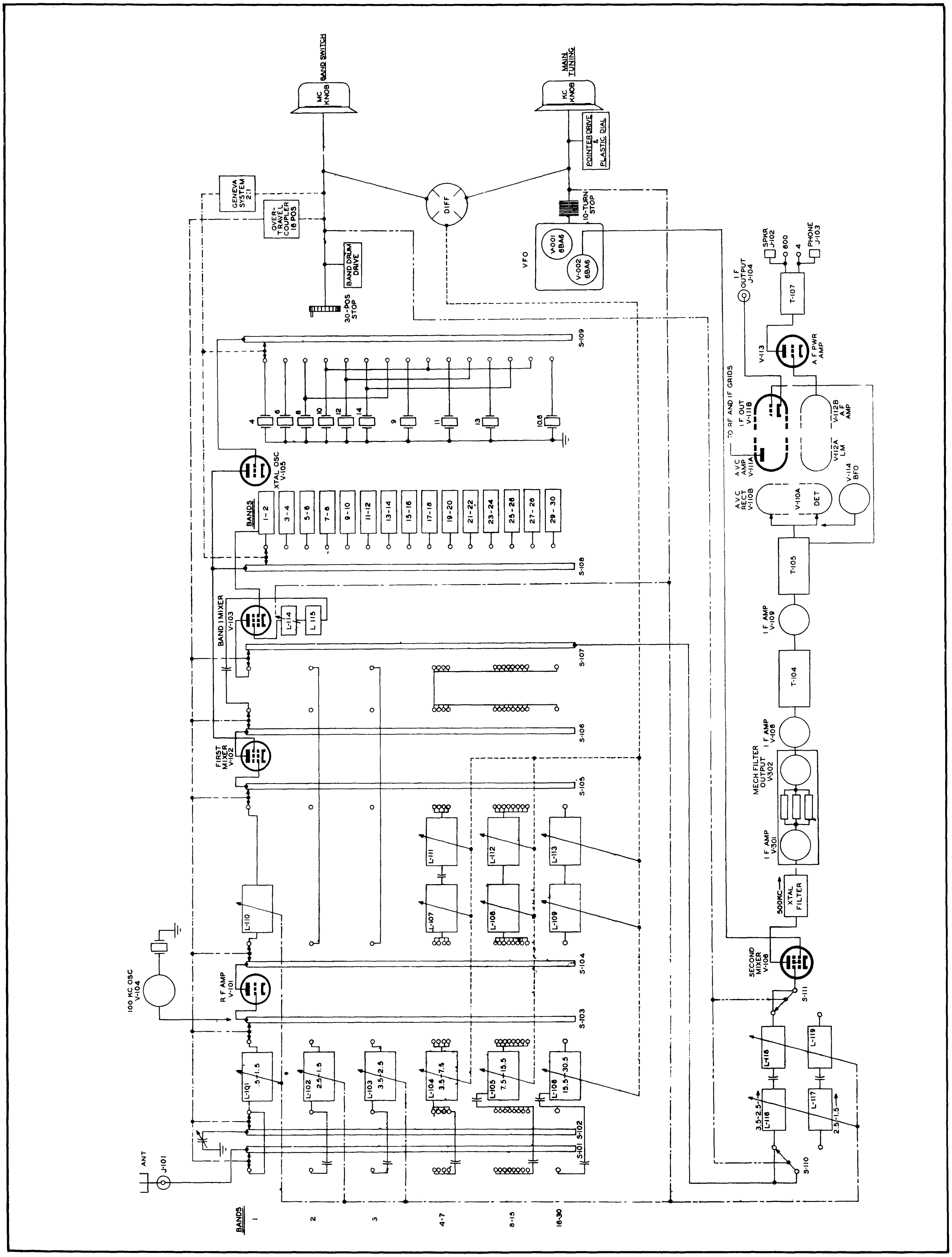

Figure 4-1. 51J-4 Band Change and Tuning System, Block Diagram

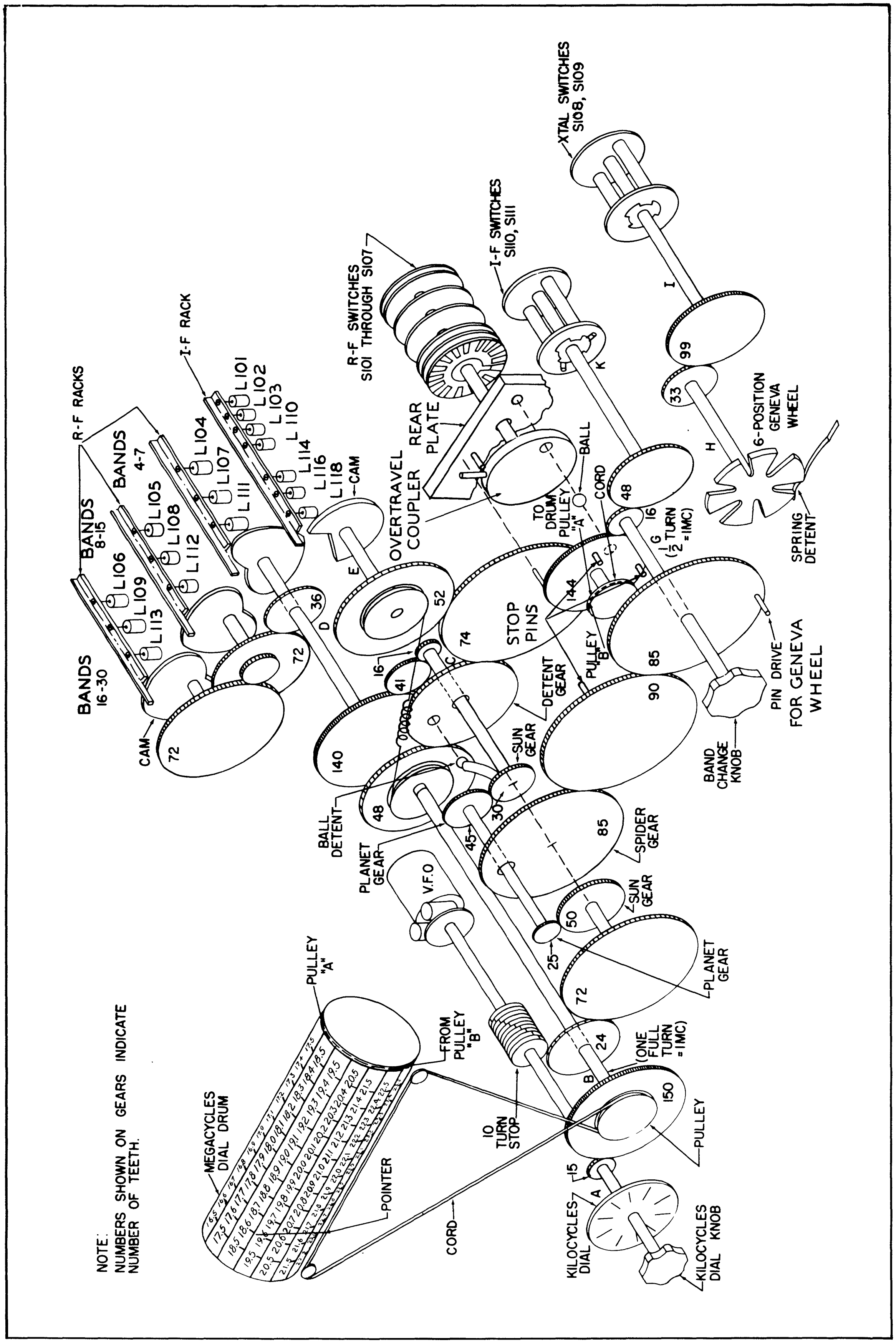

Figure 4-2. 51J-4 Mechanical Block Diagram

coil, are permeability-tuned by powdered iron cores. While tuning, these slugs move in and out of the coils at a rate determined by a cam or by a lead screw. Four slug racks or tables are used in the 51J-3 receiver to perform the function of tuning the r-f, mixer and variable i-f stages. The group of three slug tables in the rear portion of the chassis tunes the r-f and first mixer stages when the receiver is operating in the 3.5 to 30.5 mc frequency range (bands 4 to 30). The fourth slug table, located at the right hand edge of the receiver, tunes the r-f stage, the first mixer grid, the third mixer grid and the variable i-f coils when receiving in the range 0.5 to 1.5 mc. It tunes the r-f stage and variable i-f coils L116 and L118 when receiving in the range 1.5 to 2.5 and 2.5 to 3.5 mc. When receiving in the range 3.5 to 30.5 mc, this slug table tunes only the variable i-f coils L116 and L118. During tuning, positions of the slug tables are varied by a system of gears and cams; see figure 4-2. On band 1 (0.5 to 1.5 mc) coils L101 and L110 are tuned through this frequency range by the main tuning knob through shafts A, B, C and E. On bands 2 and 3 (2.5 to 1.5 and 3.5 to 2.5), tuning is done by the main tuning knob through the same shafts -- A, B, C and E. On band 4 to 7, the main tuning knob tunes coils L104, L107 and L111 over one-fourth of their tuning range through shafts A, B, C and D and the differential shafts. The BAND CHANGE knob moves this same rack through shafts G, C, D, and the differential in four steps. Each step is equal to one-fourth of the coils' tuning range and the shafts are positioned by means of the detent. Thus L104, L107, and L111 are tuned in one megacycle steps by the BAND CHANGE knob, and between these steps are tuned by the main tuning knob. On bands 8 to 15, coils L105, L108, and L112 are tuned through shafts A, B, C, D and the differential. Bands 16 to 30 are also tuned through shafts A, B, C, D and the differential. Each of the two variable frequency i-f channels covers one megacycle range and is tuned by means of the main tuning knob through shafts A, B and E. The proper channel is selected by the BAND CHANGE knob through shafts G and K.

4.1.3. FREQUENCY INDICATION. - The band on which the receiver is operating is indicated on the drum dial that is rotated by the BAND CHANGE knob through shaft G. The 100 kc divisions are indicated by a pointer on the slide rule dial. This pointer is driven from the main tuning knob through shaft A. Kilocycle divisions are indicated by the plastic dial mounted on shaft A. Two scales are necessary on this dial because bands 2 and 3 run in opposite directions. Mechanical stops are mounted on the control shafts to prevent overtravel.

4.2. ELECTRICAL DESCRIPTION.

4.2.1. GENERAL. - Collins 51J-4 Receiver is a complete coverage superheterodyne receiver capable of AM and CW reception in the frequency range of 0.5 to 30.5 megacycles. The set covers the tuning range in 30 bands, each band one megacycle wide. Various portions of the tuning spectrum use single, dual and triple conversion. Three stages of intermediate-frequency amplification and a crystal filter produce the desired degree of selectivity. The receiver also features a low impedance AVC, a good noise limiter, two stages of audio amplification and a 100 kc frequency spotter or calibrator.

The receiver employs dual conversion on most bands and single or triple on others in order to obtain full coverage economically with a minimum of image and other spurious responses on all bands. Band 1, 0.5 to 1.5 mc uses triple conversion, bands 2 and 3, 1.5 to 3.5 mc, use single conversion, and bands 4 to 30, 3.5 to 30.5 mc, use dual conversion. Each band is numbered on the band's center frequency. For instance, band 1 covers 0.5 to 1.5 mc, band 2 covers 1.5 to 2.5 mc, and so on.

On band 1, where triple conversion is necessary, an intermediate mixer is employed between the first and second mixers used in the regular dual conversion scheme. The 0.5 to 1.5 mc carrier on band 1 is fed to the first mixer where it is beat against a 12 mc signal from the h-f crystal oscillator to produce an 11.5 to 10.5 mc signal. This signal is beat against an 8 mc signal in the intermediate mixer to produce the variable i-f or 3.5 to 2.5 mc. The variable i-f is then combined with 3 to 2 mc variable oscillator output to produce the fixed 500-kc if. On bands 2 and 3, the 1.5 to 3.5 mc carrier is fed directly to the second mixer where it is combined with the same variable oscillator output to produce the 500-kc fixed i-f. On bands 4 to 30 the regular dual conversion scheme is employed. On the even numbered bands the signal frequency is beat against the high frequency oscillator output to produce a variable i-f of 2.5 to 1.5 mc. On the odd numbered bands a variable i-f of 3.5 to 2.5 mc is produced. The variable i-f is then combined in the second mixer with the v.f.o. output to produce the 500-kc fixed i-f. The detailed operation of the various receiver circuits is outlined in the following paragraphs.

4.2.2. RADIO FREQUENCY AMPLIFICATION. - One stage of radio frequency amplification is used on all bands. See block diagram, figure 4-1. The circuit is a conventional r-f amplifier circuit employing a type 6AK5 miniature r-f pentode, V101.

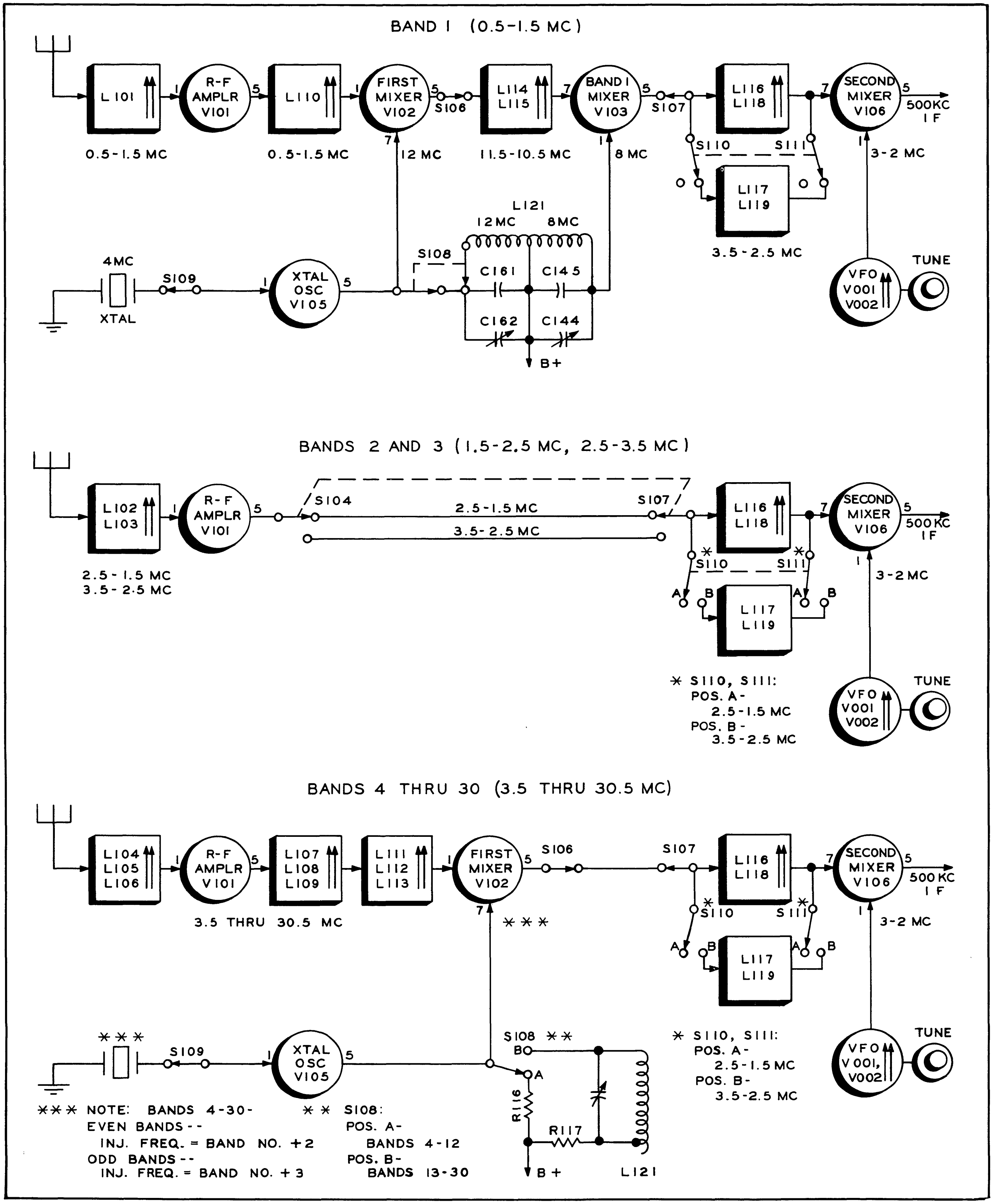

Figure 4-3. 51J-4 Frequency Conversion Circuits

This tube is used because of its low noise and good sensitivity characteristics at high frequencies.

The control grid of this stage is tuned on all bands, the tuned circuit being selected by r-f switch, S103. The antenna is capacitively coupled to the tuned circuits in the control grid through r-f switches, S101, and S102.

When operating in the American broadcast band (band 1), the plate circuit of the r-f amplifier is impedance-coupled to the grid circuit of the first mixer by resistor R105 and capacitor C117. On bands 2 and 3 the plate of the r-f amplifier tube is switched directly to the primary coils of the variable i-f tuner, where additional selectivity is obtained. Single conversion is used on these bands. When operated on bands 4 to 30, the plate circuit is tuned and capacitively coupled to a corresponding tuned circuit in the grid of the first mixer stage.

The r-f coils and associated trimmers in the plate circuit are selected by the BAND CHANGE knob and tuned through the various band ranges via the slug table arrangements. The r-f coils for bands 1, 2, and 3 are mounted on the variable i-f slug table which is at the extreme right hand edge of the receiver as viewed from the front. See figure 5-1. The coils for bands 4 to 30 are clustered at the rear of the chassis and are tuned by slugs mounted on the three r-f and mixer slug tables.

4.2.3. MIXER STAGES.

(a) FIRST MIXER. - The first mixer stage uses a type 6BE6 miniature pentagrid converter tube, V102. This stage is used on all bands except bands 2 and 3, where only one conversion stage is necessary.

The grid 1 circuit (pin 1) receives the r-f signal from the r-f amplifier stage. On band 1, this grid circuit is tuned by L110, C118, and C119, and impedance coupled to the plate of the r-f amplifier through C117 and R105. On bands 4 through 30, the circuit is tuned by the proper coil and trimmer groups selected by the r-f switch S104, and capacitively coupled to corresponding tuned circuits in the plate of the r-f amplifier stage.

The grid 3 (pin 7) input is obtained from the plate of the hfo (V105). On bands 4 through 30, the frequency of the heterodyning signal applied to this grid is such as to produce an output frequency which falls in one of the two variable i-f ranges, (2.5 to 1.5 mc or 3.5 to 2.5 mc), depending on which of the bands between 4 and 30 is being operated. On band 1, a 12-mc heterodyning signal is applied to this grid, the output of the stage then being in the range of 11.5 to 10.5 mc, which is again heterodyned in the Band 1 Mixer.

The plate output frequency of this stage is then shown to be in the variable i-f spectrum on bands 4 through 30, and the output applied directly to the tuned variable i-f coils. On band 1, the plate circuit is tuned to the range of 11.5 to 10.5 mc by components L114, L115, C139, and C140, and the output applied for further conversion to the Band 1 Mixer, V103.

(b) SECOND MIXER STAGE. - The second mixer stage, V106, also employs a 6BE6 miniature converter tube. Input to this stage is always either 3.5 to 2.5 mc or 2.5 to 1.5 mc from the variable i-f coils L116/L118 and L117/L119. The 3 to 2 mc output of the permeability tuned oscillator is fed into the second mixer tube at grid number one to heterodyne against the input signal to produce a 500 kc intermediate frequency. This mixer stage is always used for all bands.

(c) THIRD MIXER STAGE. - The third, or band 1, mixer stage is used only when receiving on band 1. A type 6BE6 miniature converter tube is used in this application also. Grid number 3 of this tube is excited by a 11.5 to 10.5 mc signal from the plate circuit of first mixer tube V102, and grid number one is excited by a heterodyning 8 mc signal from the crystal oscillator. The output of the third mixer is then 3.5 to 2.5 mc, which is then fed to the grid of the second mixer through the variable i-f coils. This, of course, takes place only when receiving on band 1 as this stage is not used on the other bands.

4.2.4. HIGH FREQUENCY OSCILLATOR. - The high frequency oscillator uses a 6AK5 miniature pentode tube in a piezoelectric oscillator circuit. No tuned coils are needed to make the circuit oscillate because in phase feedback voltage is produced across r-f choke L120. Ten quartz crystals are used to control the frequency of the oscillator output for the various bands. At the minimum, each crystal is used for two adjacent bands, i.e. 1-2, 3-4, 5-6 and so on, since the crystal switch S109 changes position only on odd-numbered bands. For instance, the 8 mc crystal used for bands 5 and 6 is also used for bands 13 and 14 by utilizing its second harmonic at 16 mc. In those instances where harmonic operation is used, a tuned circuit picks off the correct harmonic. This tuned circuit is in the plate circuit of the hfo, V105, and consists of the section of coil L121 in the hfo plate circuit and a number of tuning capacitors. The latter are selected by switch pie S108.

The circuit consisting of the section of L121 in the grid circuit of the Band 1 Mixer and capacitors C144 and C145, is tuned to 8 mc and is used when operating on band 1 to furnish the Band 1 Mixer with an 8 mc heterodyning signal (second harmonic of the 4- mc crystal). At the same time, the other section of L121 and associated trimmers is tuned to 12 mc (third harmonic of the 4-mc crystal) to furnish the first mixer with the required 12-mc heterodyning signal. A list of the crystals and the bands upon whch they function is outlined as follows:

CIRCUIT FREQUENCY

CRYSTAL FREQUENCY	RECEIVER FREQUENCY	BAND	INJECTION FREQUENCY
4	0.5 to 1.5	1	8 and 12
	1.5 to 2.5	2	None
6	2.5 to 3.5	3	None
	3.5 to 4.5	4	6
8	4.5 to 5.5	5	8
	5.5 to 6.6	6	8
	12.5 to 13.5	13	16
	13.5 to 14.5	14	16
10	6.5 to 7.5	7	10
	7.5 to 8.5	8	10
	16.5 to 17.5	17	20
	17.5 to 18.5	18	20
	26.5 to 27.5	27	30
	27.5 to 28.5	28	30
12	8.5 to 9.5	9	12
	9.5 to 10.5	10	12
	20.5 to 21.5	21	24
	21.5 to 22.5	22	24
14	10.5 to 11.5	11	14
	11.5 to 12.5	12	14
	24.5 to 25.5	25	28
	25.5 to 26.5	26	28
9	14.5 to 15.5	15	18
	15.5 to 16.5	16	18
11	18.5 to 19.5	19	22
	19.5 to 20.5	20	22
13	22.5 to 23.5	23	26
	23.5 to 24.5	24	26
10.67	28.5 to 29.5	29	32
	29.5 to 30.5	30	32

4.2.5. VARIABLE INTERMEDIATE FREQUENCY. - The variable intermediate frequency section consists of two channels, one for a frequency 2.5 to 1.5 mc and the other for 3.5 to 2.5 mc. The 2.5 to 1.5 mc i-f is used on the even numbered bands which employ double conversion, and the 3.5 to 2.5 mc i-f is used on the odd numbered bands which employ double conversion. The 2.5 to 1.5 mc i-f is also used on band 2 as an additional tuned r-f circuit. The 3.5 to 2.5 variable i-f is used on band 3 as an additional tuned r-f circuit and on band 1, in the usual application, as a variable i-f for the odd numbered bands. Using two variable i-f channels in this manner cuts in half the number of crystals needed by the high frequency oscillator, since each crystal's fundamental frequency or useful harmonic is used for two bands. Inductors L116 and L118 form the lower frequency i-f coils (2.5 to 1.5) and are the coils in which the tuning slug travels. The 3.5 to 2.5 mc i-f is obtained by shunting L117 across L116, and L119 across L118 to lower the inductances of L116 and L118. Switch sections S110 and S111 alternately switch the shunting coils in and out as the BAND CHANGE knob is rotated. The variable i-f coils are in the grid of the second mixer stage.

4.2.6. VARIABLE FREQUENCY OSCILLATOR. - The receiver circuits described so far have the function of receiving the spectrum in 1 megacycle bands that are presented to the grid of the second mixer. The scheme for obtaining high stability is completed by a method of heterodyning the signals to a lower, fixed intermediate frequency. In this application, a highly stabilized 3 to 2 mc permeability tuned oscillator, Model 70E-15, is employed to heterodyne against the 2.5 to 1.5 and the 3.5 to 2.5 mc output of the variable frequency i-f. The resulting 500 kc signal is amplified by the 500 kc i-f amplifier.

The coil in the oscillator is cam wound to produce extremely linear frequency change with linear movement of the tuning slug. The circuit is temperature-compensated and the components are sealed against changes in humidity. Ten turns of the oscillator lead screw produce a linear frequency change of one megacycle. The inductance of the oscillator coil is trimmed by an iron core series inductor, the value of which is adjusted at the factory and sealed. A type 6BA6 tube, V002, is used for isolation purposes following the oscillator tube and is an integral part of the oscillator. For stabilization purposes, the supply voltages for the oscillator unit are regulated by V116, a type OA2 tube.

NOTE

A MECHANICAL SQUEAK MAY DEVELOP BETWEEN THE LEADSCREW AND CORE IN THE PERMEABILITY TUNED VFO. MATERIAL SELECTION AND THE LOADING NECESSARY TO INSURE UTMOST STABILITY TEND TO CAUSE THIS SQUEAK. HOWEVER, MATERIALS ARE SELECTED FOR THEIR ABILITY TO WORK WELL TOGETHER WITH SMALL WEAR AND THE SQUEAK IS HARMLESS.

4.2.7. CRYSTAL FILTER. - Selectivity of the 51J-4 Receiver is improved greatly by use of a crystal filter in the 500-kc i-f channel. The crystal filter circuit consists primarily of 500-kc i-f input transformer T101, a 500-kc crystal, and a high impedance tuned circuit T102, connected as shown in figure 4-4. When SELECTIVITY switch S114 is in position 0 the crystal is shorted and T101 is connected directly to T102. Thus there is no crystal filter action when S114 is in position 0; selectivity is determined by the receiver's tuned circuits alone. When S114 is in any other position, crystal filter action takes place--position 4 giving the greatest selectivity.

To analyze the operation of this circuit consider only the loop containing T101 secondary, crystal Y112, and tuned circuits T102. Assume that S114 is in position 1. See figure 4-5. The secondary of T101 is a low impedance coil with a grounded center tap. The primary of T101 is tuned to 500 kc. Consider crystal Y112 in series with T102 as a voltage divider, grid voltage to V301 being taken from the point between Y112 and T102. For an i-f of exactly 500 kc, impedance of the crystal is very low--of the order of 2000 to 4000 ohms, and the impedance of T102 is of the order of 100,000 ohms. Thus, at 500 kc practically all the voltage appearing across T101 secondary is fed to the grid of V301.

For frequencies a few kilocycles further away from 500 the impedance of the crystal increases greatly. When the crystal impedance equals that of T102, only one-half the voltage on T101 secondary appears on the grid of V301. As the crystal impedance becomes still greater, the voltage appearing on V301 grid decreases. This results in a narrower i-f response curve, or in greater selectivity, than that obtained without crystal filtering. Switching S114 to positions 2, 3, or 4 merely shunts T102 with resistance, which effectively lowers the impedance

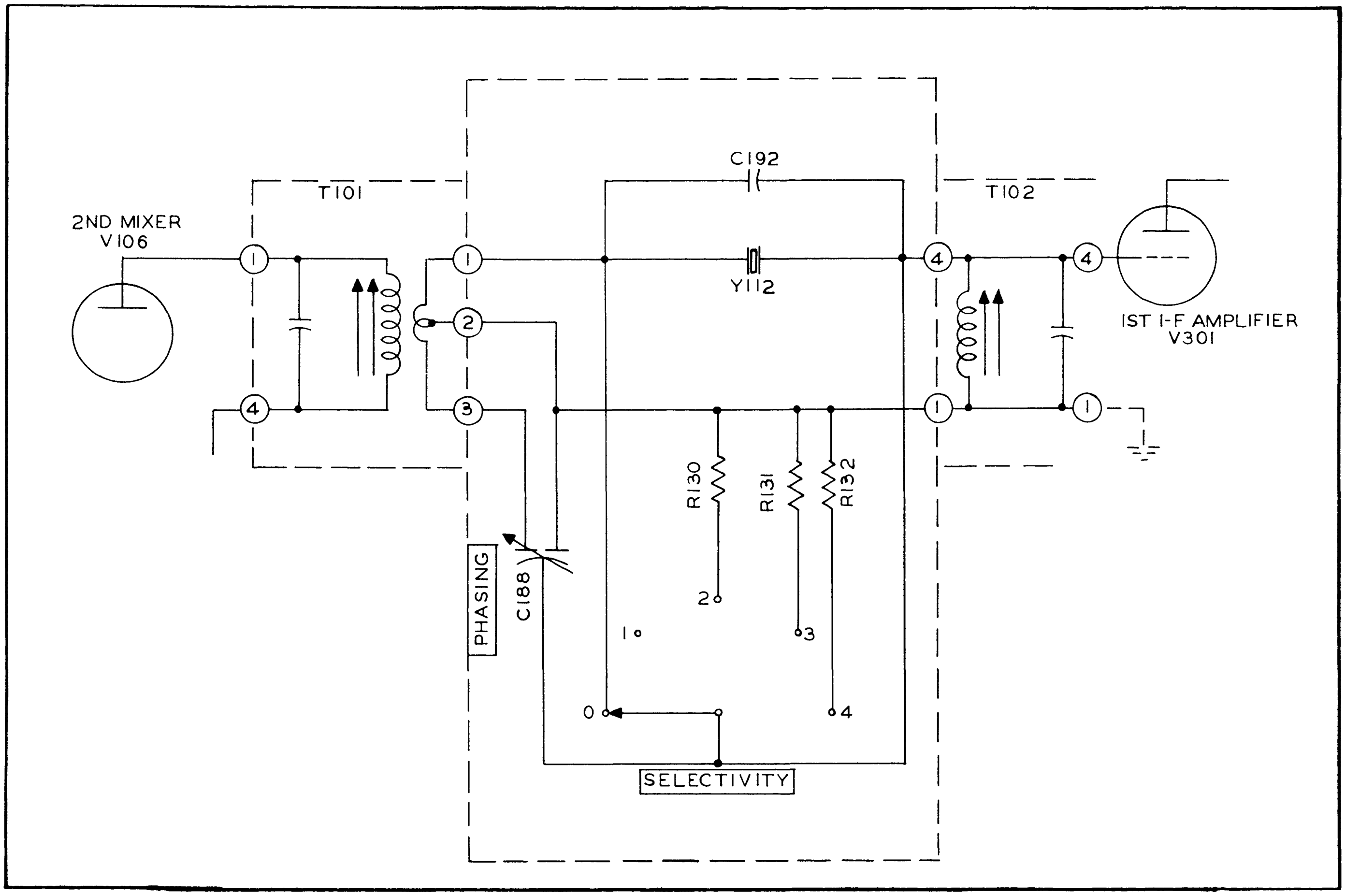

Figure 4-4. 51J-4 Crystal Filter

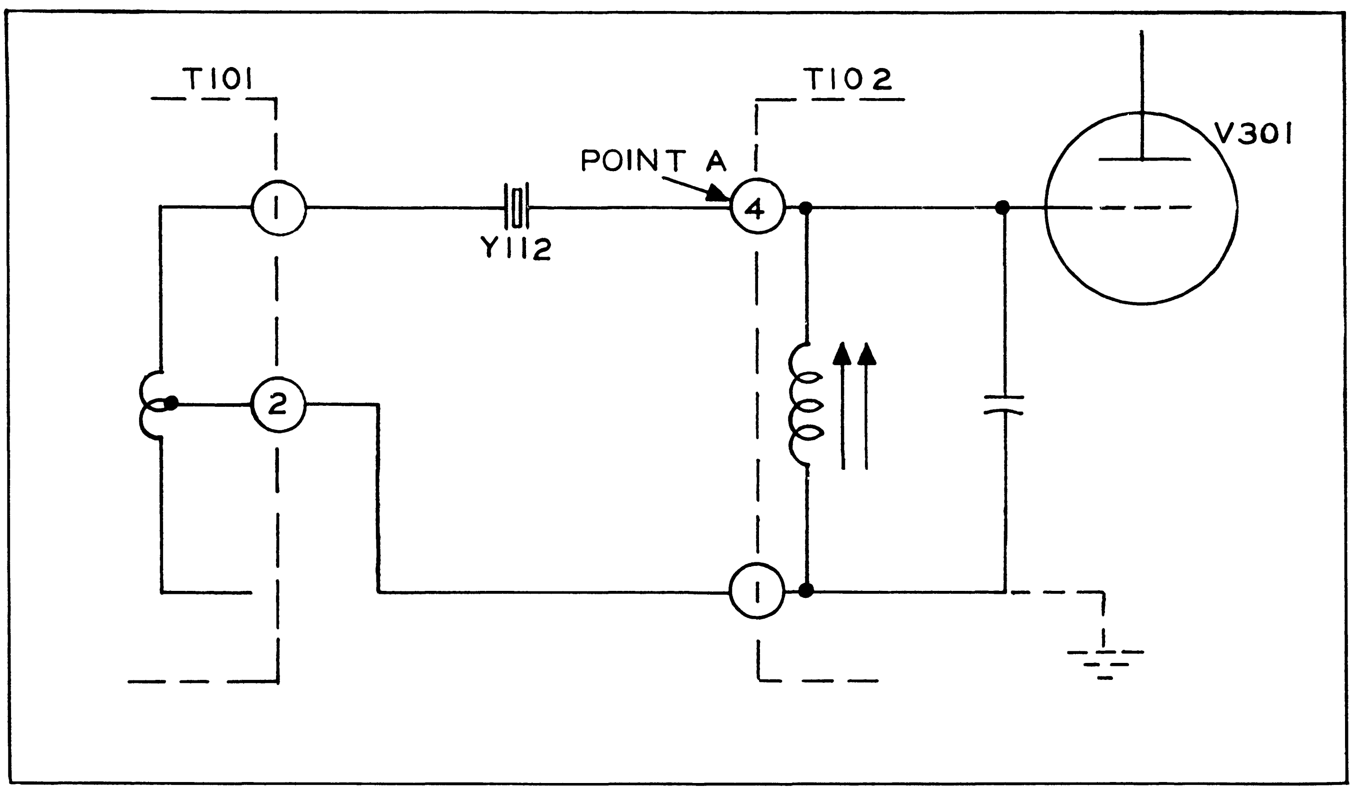

Figure 4-5. 51J-4 Crystal Filter - Simplified, Position "1"

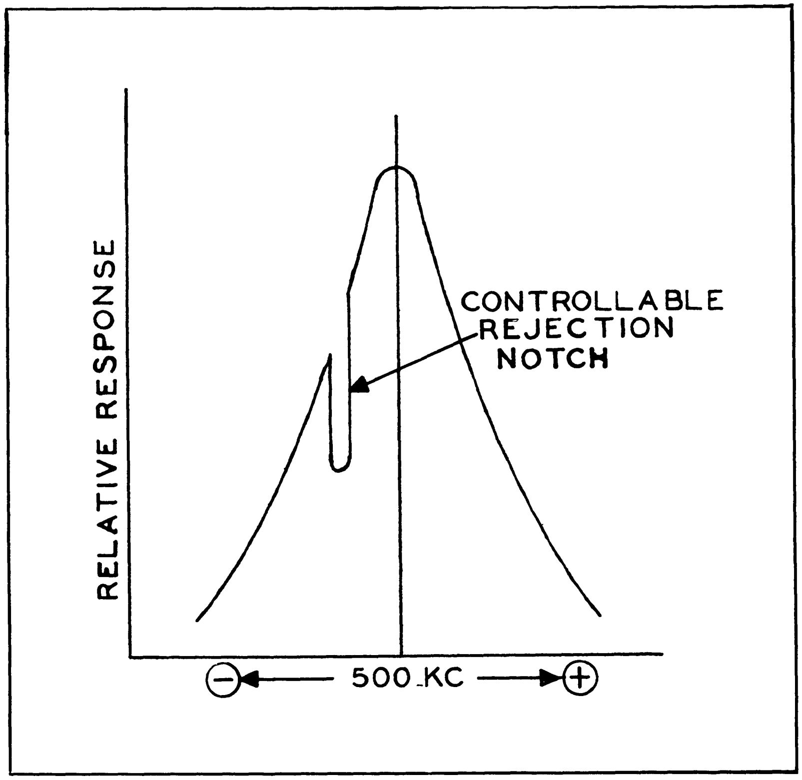

Figure 4-6. 51J-4 Crystal Phasing Rejection Notch

of T102 for those positions. This results in a more rapid decrease in V301 grid voltage as the i-f deviates to either side of 500 kc. Hence, as the effective impedance of T102 lowers, selectivity increases. In the sharpest position the bandwidth at 6 db down is from 200 to 300 cps.

The primary purpose of PHASING capacitor C188 is to produce a controllable rejection notch in the i-f response curve so that unwanted heterodynes may be tuned out. The section of C188 connected to the bottom end of T101 secondary provides a capacitive path around the crystal that balances out the shunt capacitance of the crystal in its holder and external capacitor C187. Varying C188 either side of the balance point varies the antiresonant frequency of the crystal circuit within 3 kc either side of 500. Since the impedance of the crystal circuit at antiresonance is extremely high, the crystal filter rejects signals at the antiresonant frequency. Thus at antiresonant frequency points, the phasing action gives a sharp dip in response and the selectivity curve takes on a notch as illustrated in figure 4-6.

In order to avoid detuning tuned circuit T102 when varying C188, a second section of C188 is shunted across T102. Since C188 has a split stator and a single rotor, the total shunt capacitance across T102 remains practically constant as the setting of C188 is varied.

4.2.8 SECOND INTERMEDIATE FREQUENCY. - The second intermediate frequency channel is fixed-tuned to 500 kc. It consists of the mechanical filter and four amplifier stages and employs 6BA6 tubes in all stages. Input tube V301 is excited by the crystal filter output coil T102. Permeability-tuned transformers, with output taps taken off the secondary coils near the ground end, are used in the amplifier portion. Both i-f amplifiers stages and one tube in the mechanical filter are supplied with AVC voltage. Plate and fixed screen voltages are controlled by the ON-STANDBY-OFF switch and the remote operation relay, K101 on all 500 kc i-f tubes except V302. These voltages are removed to render the receiver inoperative during transmission periods.

4.2.9. DETECTOR. - The detector in the 51J-4 Receiver consists of one half of a 12AX7 dual triode tube, V110 (pin numbers 6, 7, and 8). The tube is used as a diode, with rectification taking place between the plate and cathode, the grid being connected to the plate. R150 and R151 serve as load resistors for the detector while C202 provides r-f filtering.

4.2.10. NOISE LIMITER. - A series type noise limiter is used in the 51J-4 Receiver. This limiter

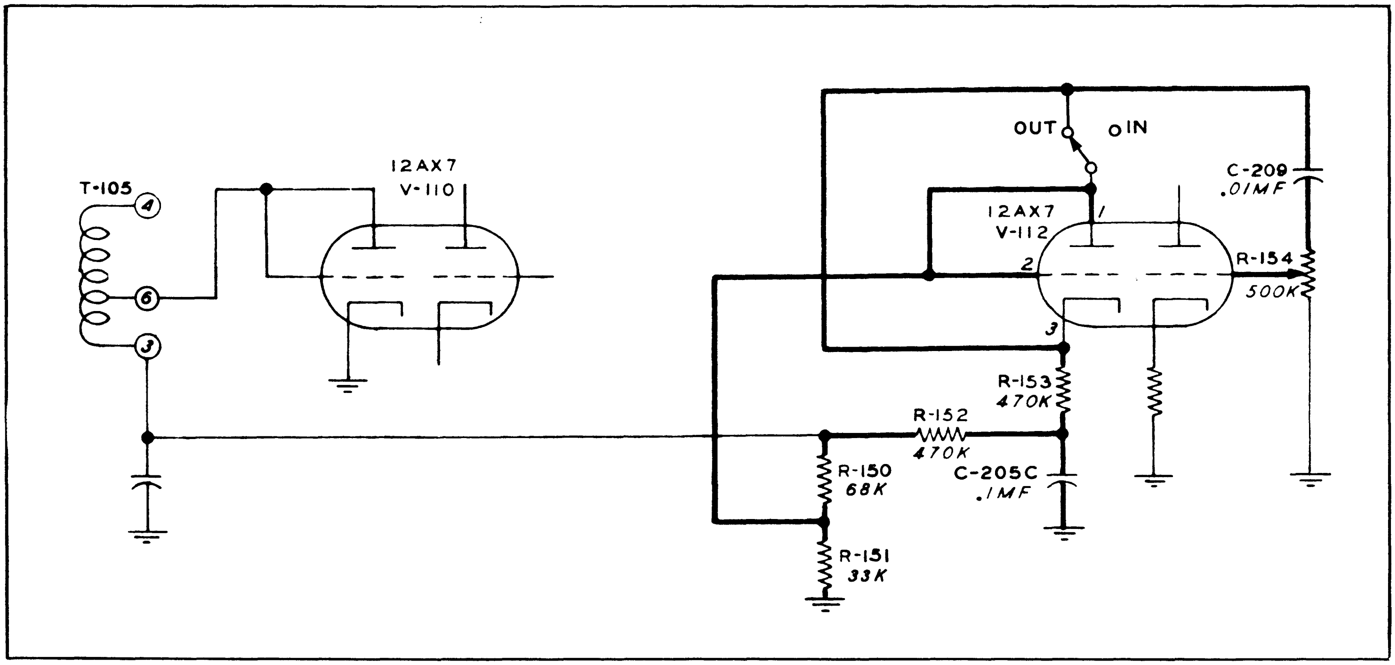

Figure 4-7. 51J-4 Noise Limiter Circuit

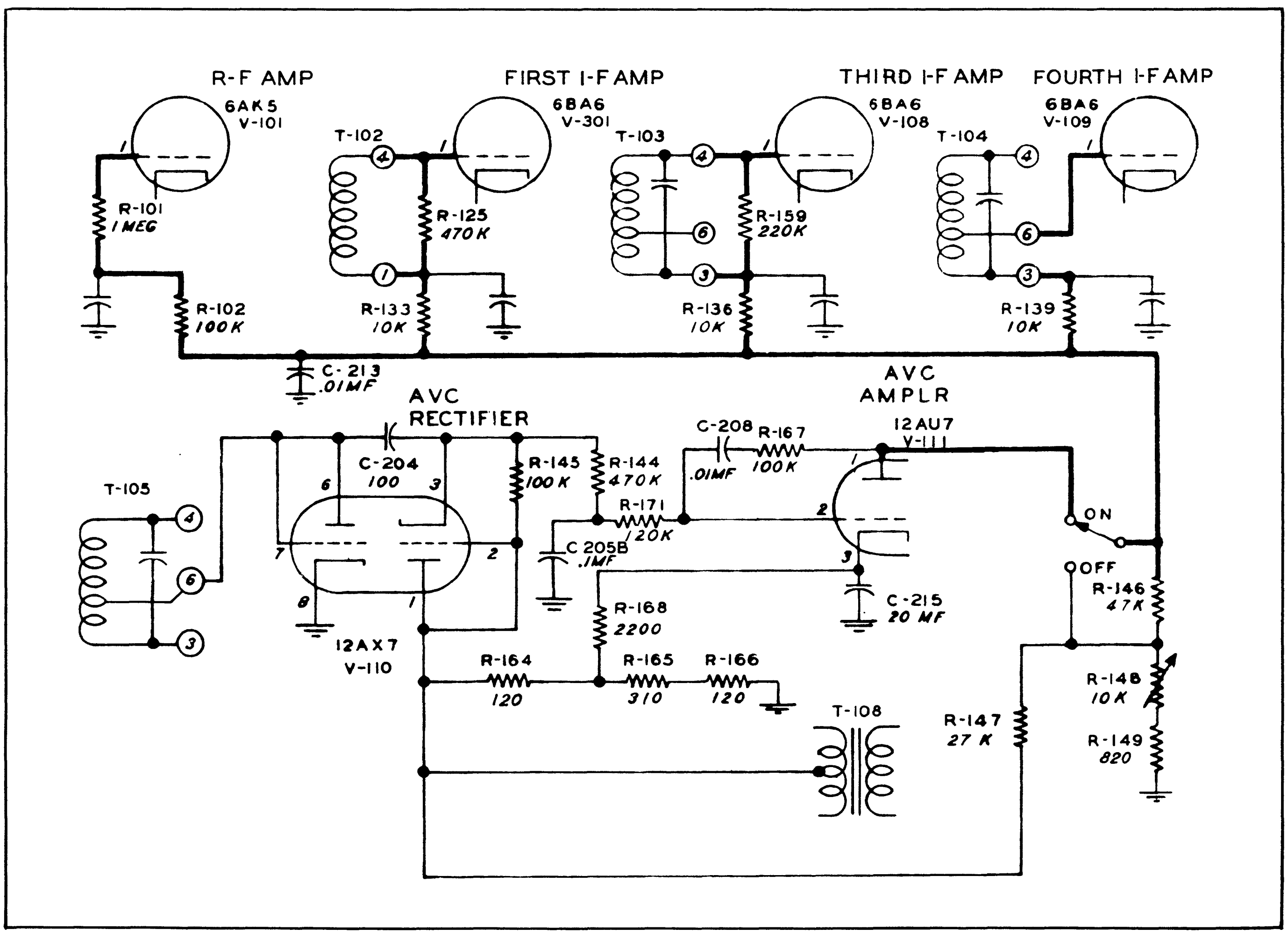

Figure 4-8. 51J-4 A. V. C. Circuit

employs one-half (pins 1, 2, and 3) of a type 12AX7 dual triode tube, V112. Refer to figure 4-7. Due to a-c loading of the second detector, heavy noise impulses are automatically clipped from the positive audio peaks in the detector. The noise appearing on the negative side of the audio cycle is clipped by the noise limiter. In operation, a negative voltage produced by rectification of the carrier is developed across capacitor C205C. This voltage cannot change rapidly due to the value of C205C and R152. This negative potential is placed upon the cathode of the noise limiter tube through R153. The cathode is then negative with respect to the plate of the noise limiter tube, due to voltage divider action of R150 and R151 and current flows. This current is modulated by the audio which then appears on the noise limiter cathode to which the grid of the audio amplifier section of V112 is connected. The noise limiter diode will conduct as long as the cathode is negative in respect to the plate. However, should a heavy noise impulse be received, the plate would be driven negative faster than the cathode could follow due to the time constant of R152 and C205C. If the plate is driven more negative than the cathode, the tube will cease to conduct and no audio will reach the grid of the following audio tube. The audio cannot reach the cathode of the limiter tube directly from the diode load because of the filtering action of R152 and C205C. The value of modulation at which the limiter clips can be adjusted by changing the value of some of the components in the circuit. In this receiver, limiting starts between 50% and 85% modulation. Switch S116 bypasses the signal around the noise limiter when receiving conditions do not require its used.

4.2.11. AUTOMATIC VOLUME CONTROL. - The problem of blocking that is created by strong signals or heavy static is eliminated by use of an amplified AVC system and a low impedance AVC line. Refer to figure 4-8. The second triode section of V110 is used as an AVC rectifier to produce control voltage for the AVC amplifier which uses one half of dual triode V111. The AVC voltage that is applied to grids of the controlled tubes is produced when plate current flowing through one-half of AVC amplifier tube V111 causes a voltage drop across resistor R146. Plate voltage for the amplifier half of V111 is obtained from the voltage drop across resistors R165 and R166, which are in series with the center tap of the power transformer to ground. However, V111 will not draw plate current when there is no signal input to the receiver because of approximately 11 volts of bias that is placed upon its grid by the voltage drop through R164. This bias voltage for V111 is taken from the end of R145 through which the rectified carrier flows in opposition to the bias voltage. Thus, when the rectified carrier becomes strong enough to overcome the bias voltage on V111, V111 will draw plate current and produce a voltage drop across R146, thereby producing AVC voltage in proportion to the strength of the received signal. The bias on the grid of V111 is high enough to produce a delay in the generation of AVC voltage and thus allows the receiver to function at full sensitivity on weak signals. Resistor R144 and capacitor C205B form the time constant in the AVC circuit. R171, C208, and R167 are used in a degenerative circuit to prevent the AVC amplifier tube from responding to low audio frequencies. AVC is turned off by opening the plate circuit of AVC amplifier tube V111. Tubes controlled by AVC bias include the r-f amplifier V101, and the 500 kc i-f amplifier tubes, V301, V108 and V109.

4.2.12. AUDIO AMPLIFIER. - Two stages of audio amplification are employed in the 51J-4 Receiver. The first stage utilizes the second triode section of V112 in a resistance-coupled amplifier arrangement. A type 6AQ5 miniature pentode power amplifier tube is used in the audio output stage. This stage has fixed bias obtained from the voltage drop produced across R166 in the center tap lead of the high voltage transformer secondary. The secondary of the audio output transformer has both 600-ohm and 4-ohm outputs. Both the outputs are terminated on the rear of the chassis at terminal strip E102. Plug-in connections to both outputs are also made on the front panel.

4.2.13. 50 OHM I-F OUTPUT. - One-half of dual triode V111 supplies 50-ohm 500-kc i-f to coaxial connector J104 on the rear of the chassis. This section of V111 is used as a cathode follower. Excitation is obtained from the voltage drop across R178, which is connected in a series circuit across the secondary of i-f transformer T105.

4.2.14. 100 KC CALIBRATOR. - This calibrator is included with the receiver for use when extreme accuracy of calibration in the order of 200 cycles is desired. It is coupled to the grid r-f amplifier tube V101, and is made operable when CALIBRATOR ON-OFF switch S111 is turned on. The calibrator utilizes a 6BA6 tube in a piezoelectric circuit, a low drift 100 kc crystal between the control grid and screen, and a 5-25 uuf capacitor C169 between grid and ground. The capacitor permits the making of small frequency corrections that set the calibrator to zero beat with a primary frequency standard. Variable capacitor C224 on the front panel provides for fine adjustment of frequencies.

4.2.15. POWER SUPPLY. - The receiver is equipped with a power transformer that is connected for a 115-volt source. However, the transformer can be used on a 230 volt source by reconnecting the primary windings in series. The power supply is capable of producing 220 d-c volts at 125 ma. A two section choke input filter is used following a 5V4 high vacuum rectifier, a filter consists of a 3 henry input choke, a 5 henry output choke and two 35 mfd filter capacitors. B+ for the audio output is taken from the junction of the two chokes. The receiver's ON-OFF switch, and a 1.5 ampere, slow blow fuse are located in the primary circuit of the power supply. A 6.3 volts a-c are furnished for the tube filaments and dial lights from a winding on the power transformer.

4.2.16. BEAT FREQUENCY OSCILLATOR. - The bfo is a modified Hartley circuit employing electron coupling in a type 6BA6 pentode tube, V114. The output frequency is 500 ±3 kc, which is beat against the 500-kc intermediate frequency in the detector stage to produce an audio tone. Pitch of the audio tone is varied by changing the frequency of oscillation in the bfo by means of the BFO PITCH control on the front panel. When the BFO-ON-OFF switch is in OFF position, the screen grid of the bfo stage is grounded.

4.2.17. MECHANICAL FILTER. - The mechanical filter uses the principle of magnetostriction to convert oscillating magnetic energy to mechanical vibration. The magnetostriction transducer input coil is resonated at 500 kc. A nickel wire within this coil vibrates mechanically and transmits this mechanical energy to the first of a series of nickel alloy disks. The mechanical vibration of this first disk is coupled to succeeding disks 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 diaphragm from bending in the same direction for both halves of an a-c cycle. This mechanical vibration of the last disk 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 impulses.

Each of the disks employed in the mechanical filter has a mechanically resonant Q exceeding 2,000. Six of these disks 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 3.1 kc mechanical filter used in the 51J-4 passes a band of frequencies approximately 3 kc wide and centered on 500 kc, proving an i-f selectivity curve ideal for the reception of AM and single sideband signals. The 6-kc filter and the 3.1 kc filter are most used for voice reception and a mechanical filter having similar selectivity characteristics but having a bandpass of 1.4 kc is generally used in cw reception or in 'phone reception under conditions of extremely heavy QRM or QRN.