COLLINS

51J-3
COMMUNICATIONS RECEIVER

URR/388

INSTRUCTION BOOK

INSTRUCTION BOOK

for

51 J-3 COMMUNICATIONS RECEIVER

Manufactured By

COLLINS RADIO COMPANY
Cedar Rapids, Iowa

520 9523 00

August 16, 1951

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GUARANTEE

The equipment described herein is sold under the following guarantee:

Collins agrees to repair or replace, without charge, any equipment, parts or accessories which are defective as to design, workmanship or material, and which are returned to Collins at its factory in Cedar Rapids, Iowa, transportation prepaid, provided that the foregoing shall not be applicable to.

(a) Equipment or accessories as to which notice of the claimed defect is not given Collins within one year from date of delivery;

(b) Equipment and accessories manufactured by others than Collins, tubes and batteries, all of which are subject only to such adjustment as Collins may obtain from supplier thereof;

(c) Equipment or accessories which shall fail to operate in a normal or proper manner due to exposure to excessive moisture in the atmosphere or otherwise after delivery, any such failure not being deemed a defect within the meaning of the foregoing provisions.

Collins further guarantees that any radio transmitter described herein will deliver full radio frequency power output at the antenna lead when connected to a suitable load, but such guarantee shall not be construed as a guarantee of any definite coverage or range of said apparatus.

The guarantee of these paragraphs is void if equipment is altered or repaired by others than Collins.

Notice of any claimed defect must be given to Collins prior to return of any item. Such notice must give full information as to nature of defect and identification (including part number if possible) of part considered defective. Upon receipt of such notice, Collins will promptly advise respecting return of equipment. Failure to secure our advice prior to the forwarding of goods for return may cause unnecessary delay in the handling of such merchandise.

No other warranties, expressed or implied, shall be applicable to said equipment, and the foregoing shall constitute the Buyer's sole right and remedy under the agreements in this paragraph contained. In no event shall Collins have any liability for consequential damages, or for loss, damage or expense directly or indirectly arising from the use of the products, or any inability to use them either separately or in combination with other equipment or materials, or from any cause.

HOW TO ORDER REPLACEMENT PARTS

When ordering replacement parts, you should direct your order as indicated below and furnish the following information insofar as applicable:

Address: Collins Radio Company
Sales Service Department
Cedar Rapids, Iowa

Information Needed:

(A) Quantity required
(B) Part number of item
(C) Item number (obtain from Parts List or Schematic Diagram)
(D) Type number of unit
(E) Serial number of unit
(F) Serial number of equipment

HOW TO RETURN MATERIAL OR EQUIPMENT

If, for any reason, you should wish to return material or equipment, whether under the guarantee or otherwise, you should notify us, giving full particulars including the details listed below, insofar as applicable. Upon receipt of such notice, Collins will promptly advise you respecting the return. Failure to secure our advice prior to the forwarding of the goods or failure to provide full particulars may cause unnecessary delay in handling of your returned merchandise.

Address: Collins Radio Company
Sales Service Department
Cedar Rapids, Iowa

Information Needed:

(A) Date of delivery of equipment
(B) Date placed in service
(C) Number of hours in service
(D) Part number of item
(E) Item number (obtain from Parts List or Schematic Diagram)
(F) Type number of unit from which part is removed
(G) Serial number of unit
(H) Serial number of the complete equipment
(I) Nature of failure
(J) Cause of failure
(K) Remarks

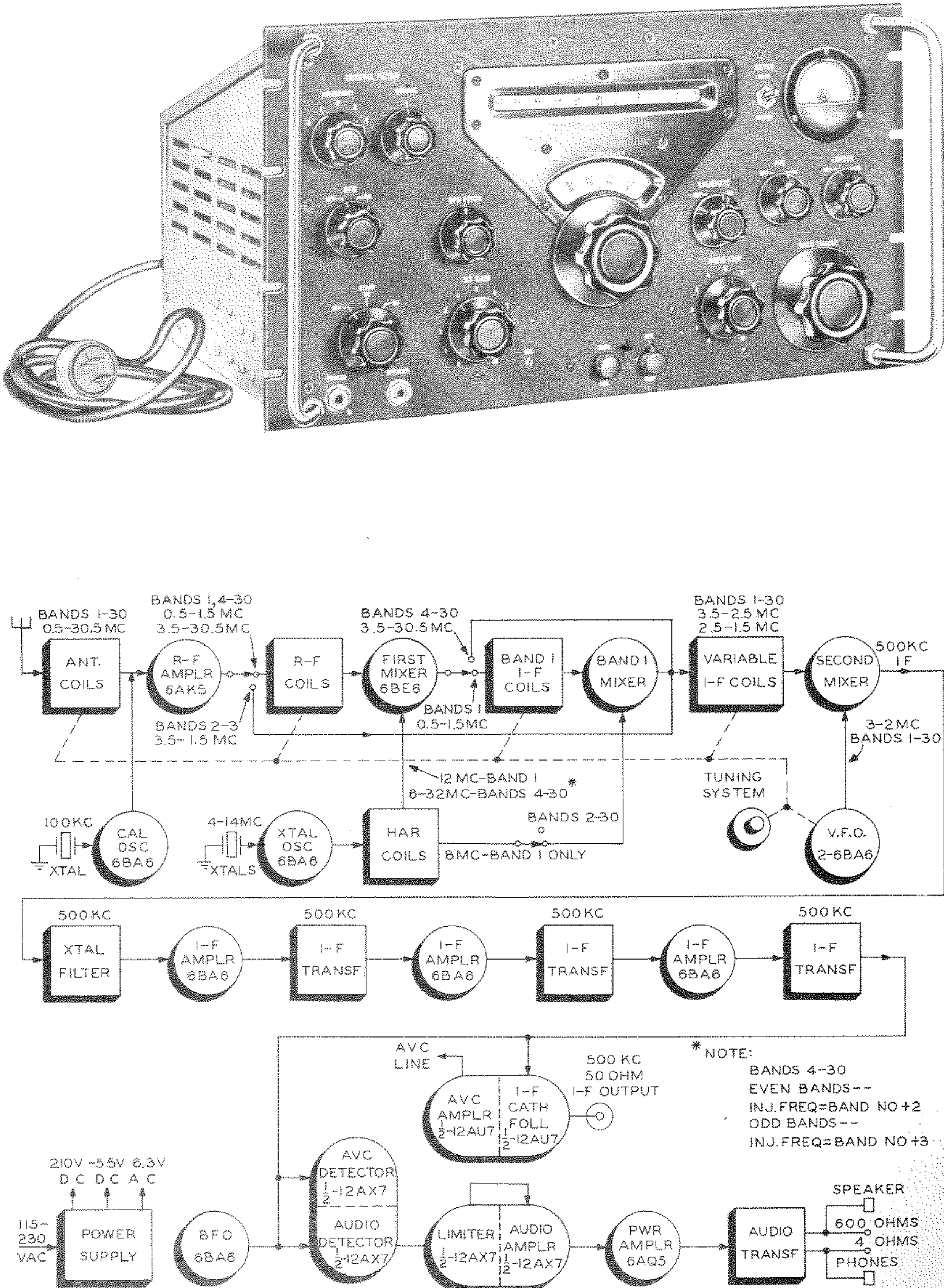

Figure 1-1. Collins 51J-3 Receiver, Front View and Block Diagram

SECTION 1

GENERAL DESCRIPTION

1.1. GENERAL.

1.1.1. PURPOSE OF BOOK. - This instruction book has been prepared to assist in the installation, operation, and maintenance of the Collins 51J-3 Radio Communications Receiver.

1.1.2. PURPOSE OF EQUIPMENT. - Collins 51J-3 Receiver is designed for communication applications which require the highest order of stability and dial accuracy. Under normal operating conditions, the receiver tunes the range of 0.5 to 30.5 mc with a normal setting error and drift of less than 1 kc at any frequency within its range. Designed primarily for amplitude-modulated and continuous-wave reception, the accuracy and stability of the receiver also make it suitable for applications where it is desired to receive or set definite frequencies without searching or frequent adjusting.

1.1.3. DESCRIPTION.

(a) MECHANICAL. - The 51J-3 receiver is constructed in a panel and shelf assembly designed for mounting in a standard rack cabinet. Overall dimensions are 19 inches width, 10-1/2 inches panel height and 13-1/2 inches depth behind the panel. Damage from dust and other foreign matter is prevented by a dust cover which fits over the top of the chassis.

The following controls are located on the front panel:

R-F GAIN	CRYSTAL FILTER SELECTIVITY
AUDIO GAIN	CRYSTAL FILTER PHASING
BFO ON-OFF	OFF-STANDBY-ON
CALIBRATE ON-OFF	MEGACYCLE TUNING (BAND CHANGE)
BFO PITCH	KILOCYCLE TUNING
AVC ON-OFF	ZERO ADJ.
LIMITER ON-OFF	METER OUTPUT-INPUT
ANT. TRIM	CAL. (100 KC ADJUSTMENTS)

The tuning range of .5 to 30.5 mc is divided into 30 bands, each one megacycle wide. Bands are selected by the BAND CHANGE knob and indicated by a slide-rule type dial calibrated at one-tenth megacycle (100 kc) intervals. The kilocycle tuning control covers each of these megacycle intervals with ten turns of a 100-division circular dial calibrated at one kilocycle intervals. The stability of the receiver is consistent with this finely divided calibration even at the highest frequencies.

A four-ohm headphone jack and a 600-ohm speaker jack are provided on the front panel. The antenna connector , 50-ohm i-f output connector, break-in relay terminals and four-ohm and 600-ohm audio output terminals are provided on the rear. Also, a heavy duty a-c power cord extends from the rear of the chassis.

(b) ELECTRICAL. - Where advantageous, the 51J-3 Receiver uses single, double or triple conversion in tuning the entire frequency spectrum of .5 to 30.5 mc. Eighteen tubes, three of which are dual tubes, are employed in the receiver. With the exception of the rectifier tube, all are of the miniature type. The tuning range is divided into 30 one-megacycle bands by a system of switches and coils that are parts of the r-f amplifier and first mixer circuits. Bands are changed by moving powdered iron slugs into the coils in one megacycle steps until the coils' inductance limits are reached, then changing coils and repeating. Tuning involves positioning these slugs within the one-megacycle intervals. Injection voltage for the first mixer is obtained from either the fundamental or the harmonic output of an oscillator, the frequency of which is controlled by one of ten quartz crystals selected by the BAND CHANGE control. The kilocycle tuning control drives a vernier dial calibrated in 100 one-kilocycle divisions. This control operates through a differential mechanism to move the slugs in the coils until they cover the range between the one megacycle band change steps. Thus the BAND CHANGE control selects coils and crystals and roughly positions the tuning slugs. It also selects one of two ranges of the variable i-f channel and tunes the selected i-f coils along with the r-f coils.

Crystal frequencies for first mixer injection are so chosen that the frequency produced by the first mixer always falls in either the 1.5 to 2.5 mc or the 2.5 to 3.5 mc range of the variable i-f channel.

Exceptions to the operation just described are bands 1, 2 and 3. Band 1 (.5 to 1.5 mc) uses an intermediate mixer between the first mixer and the variable i-f coils. This mixer accepts frequencies in the range of 10.5 to 11.5 mc from the first mixer. These frequencies are produced by applying to the first mixer a 12 mc signal from the crystal oscillator. This oscillator also applies an 8 mc voltage to the band 1 mixer to produce a signal within the range of the i-f channel that tunes from 2.5 to 3.5 mc. Bands 2 and 3, which cover 1.5 to 2.5 mc and 2.5 to 3.5 mc respectively, are identical in span to each channel of the variable frequency i-f coils; thus they feed through to the second mixer without utilizing the first mixer.

Following the variable i.f. and the second mixer are the crystal filter and a three-stage fixed intermediate-frequency amplifier. Conversion to the fixed i.f. of 500 kc is accomplished by injecting into the second mixer a 2 to 3 mc signal from a Collins 70E-15 oscillator. This oscillator signal combines with either of the two variable intermediate frequencies 1.5 to 2.5 and 2.5 to 3.5 mc, to produce the difference frequency of 500 kc. The 70E-15 oscillator is tuned by the kilocycle tuning control in step with all other circuits.

Stability of the 70E-15 oscillator is assured by temperature-compensated components operating in a sealed and moisture-proof housing.

Separate rectifiers are used to produce automatic volume control and audio voltages. D-C amplification of the automatic volume control voltage is provided to obtain essentially uniform input to the detector. Audio power output is held within 3.5 db over signal input voltage ranges of five to 125,000 microvolts at the antenna terminals. A series type noise limiter clips modulation at 30 percent. This allows good reception in the presence of strong noise pulses.

1.2. VACUUM TUBE TABLE.

The following table lists the tubes employed in the circuits just described.

SYMBOL DESIGNATION	TUBE TYPE	FUNCTION
V101	6AK5	Radio-frequency amplifier
V102	6BE6	First mixer
V103	6BE6	Band 1 mixer
V104	6BA6	Calibration oscillator
V105	6AK5	High-frequency crystal oscillator
V106	6BE6	Second mixer
V107	6BA6	First 500 kc i-f amplifier
V108	6BA6	Second 500 kc i-f amplifier
V109	6BA6	Third 500 kc i-f amplifier
V110	12AX7	Detector and A.V.C. rectifier
V111	12AU7	A.V.C. amplifier and i-f output cathode follower
V112	12AX7	Noise limiter and first audio amplifier
V113	6AQ5	Audio power amplifier
V114	6BA6	Beat frequency oscillator
V115	5V4	Power rectifier
V116	OA2	Voltage regulator
V001	6BA6	Variable frequency oscillator
V002	6BA6	Oscillator isolation amplifier

1.3. REFERENCE DATA

FREQUENCY RANGE: 500 kc to 30.5 mc
TYPE OF RECEPTION: AM, CW or MCW
CALIBRATION: Direct reading in megacycles and kilocycles
TUNING: Linear tuning with uniform bandspread
FREQUENCY STABILITY: Dial calibration at room temperature is within 300 cps if the nearest 100 kc calibration point is used to adjust the fiducial.

TEMPERATURE RANGE: -20°C to +60°C

SENSITIVITY: Band 1 - Less than 15 µv gives 1 watt with 10 db s/n
Bands 2 to 30 - Less than 5 µv gives 1 watt with 10 db s/n

SELECTIVITY: Total bandwidth is 5.5 to 6.5 at 6 db down and 17 to 20 kc at 60 db down. With crystal filter in, total bandwidth is 0.2 kc at 6 db down and 12 kc at 60 db down.

SPURIOUS FREQUENCY RESPONSE: Down at least 40 db

AUTOMATIC VOLUME CONTROL: Less than 3.5 db increase in audio power output with an increase in r-f signal from 5 to 125,000 µv

S METER: Meter calibrated in 20, 40, 60, 80, 100 db above AVC threshold and -10 to +6 db audio level with 6 mw as reference

NOISE LIMITER: Series type ahead of the first audio stage

AUDIO POWER OUTPUT: 1-1/2 watts at 1000 cps with less than 15% distortion

AUDIO FREQUENCY RESPONSE (overall): Not more than 3 db at 200 cps and not more than 7 db at 2500 cps

AUDIO OUTPUT IMPEDANCE: 4 and 600 ohms

I-F OUTPUT IMPEDANCE: 50 ohms

R-F INPUT IMPEDANCE: Designed to operate into a high impedance whip or single-ended antenna

POWER REQUIREMENTS: 85 watts at 115 volts 45/70 cps. Same power required when reconnected for 230 volt 45/70 cps operation

DIMENSIONS: Panel - 10-1/2 inches high, 19 inches wide, notches for standard rack mounting

WEIGHT: 43 pounds

SECTION 2

INSTALLATION

2.1. UNPACKING.

2.1.1. PROCEDURE. - Collins 51J-3 receiving equipment is packed in a number of heavy cartons. Refer to the packing slip for a list of all equipment supplied on the order. Open cartons carefully to avoid damaging the contents. Remove the packing material, and carefully lift the units out of the cartons. Search all packing material for small parcels. Extra pilot light bulbs and fuses are supplied with each equipment. Inspect each unit for loose screws and bolts. Make sure that all controls such as switches and dials work properly. All claims for damage should be filed promptly with the transportation company. If a claim is to be filed, the original packing case and material must be preserved.

2.2. INSTALLATION.

2.2.1. GENERAL. - The receiver should be mounted in a standard rack. Outline and mounting dimensions are given in figure 2-1. The front panel is slotted for mounting at 1-1/2, 3-3/4, 6-3/4 and 9 inches from the bottom. Panel height is 10-1/2 inches and panel width is 19 inches.

When choosing a position for the receiver, give consideration to convenience of power, antenna and ground connections, to placement of cables and to convenience in servicing the equipment. Rear panel connections are shown in figure 2-2.

2.2.2. ANTENNA CONNECTION. - Connect a cable from a high impedance whip or a single-ended antenna to antenna jack J101 on rear panel. If the receiver is to be operated near a powerful transmitter, the r-f input circuit should be protected by connecting break-in relay K101 to operate when the transmitter is radiating. Break-in relay connections are described in paragraph 2.2.5. below.

2.2.3. AUDIO OUTPUT CONNECTIONS. - Two 1/4 inch diameter audio output jacks are located on the front panel. One is designated PHONES and the other SPEAKER, their output impedances being 4 and 600 ohms respectively. An audio output terminal strip is provided on the rear panel. Terminal G is a ground connection and terminals 4 and 600 are audio outputs of 4 and 600 ohms impedance respectively. Terminal 4 is connected in parallel with the PHONES jack, and terminal 600 is connected in parallel with the SPEAKER jack. Use these output jacks and terminals as required.

2.2.4. I-F OUTPUT CONNECTION. - A 100-200 millivolt, 50 ohm, 500 kc i-f output is available at coaxial jack J104 on the rear panel.

2.2.5. REMOTE STANDBY CONNECTIONS. - Break-in relay connections are available at terminal strip E101 at the rear of the chassis. Terminals are marked 1, 2 and 3. Terminal 1 is connected to receiver ground. Terminals 2 and 3 are connected to the break-in relay coil, which is rated at 8.5 d-c volts and 135 ohms d-c resistance. During operation, terminals 2 and 3 are usually connected to a set of normally closed contacts on the carrier control relay of a transmitter in order to silence the receiver during transmission. When the break-in relay coil is energized, one pair of contacts shorts the antenna to ground; another pair, connected in series with a section of the OFF-STANDBY-ON switch, removes plate voltage from the three i-f amplifier stages. In STANDBY position, the OFF-STANDBY-ON switch also removes plate voltage from the i-f stages.

2.2.6. POWER CONNECTION. - Make power connection by using the rubber - covered cord that is permanently attached at the rear of the chassis. This cord is six feet long and is equipped with a standard a-c plug. The power source must supply 85 watts at 115 volts, 45/70 cps. If 230 volt operation is desired, reconnect transformer T108 by removing the jumpers between terminals 2 and 4 and between 1 and 3; then connect a jumper between terminals 2 and 3.

2.2.7. TUBES. - Before turning on the equipment for the first time inspect the tubes. Be sure that they are in their correct positions, and that they are firmly seated in their sockets.

2.2.8. FUSE. - The fuse is located on the rear of the chassis. It can be removed for inspection by turning the cap of the fuse post to the left and pulling straight up until the cap and fuse come free. This fuse should be the slow-blow type, with a rating of 1.5 amperes.

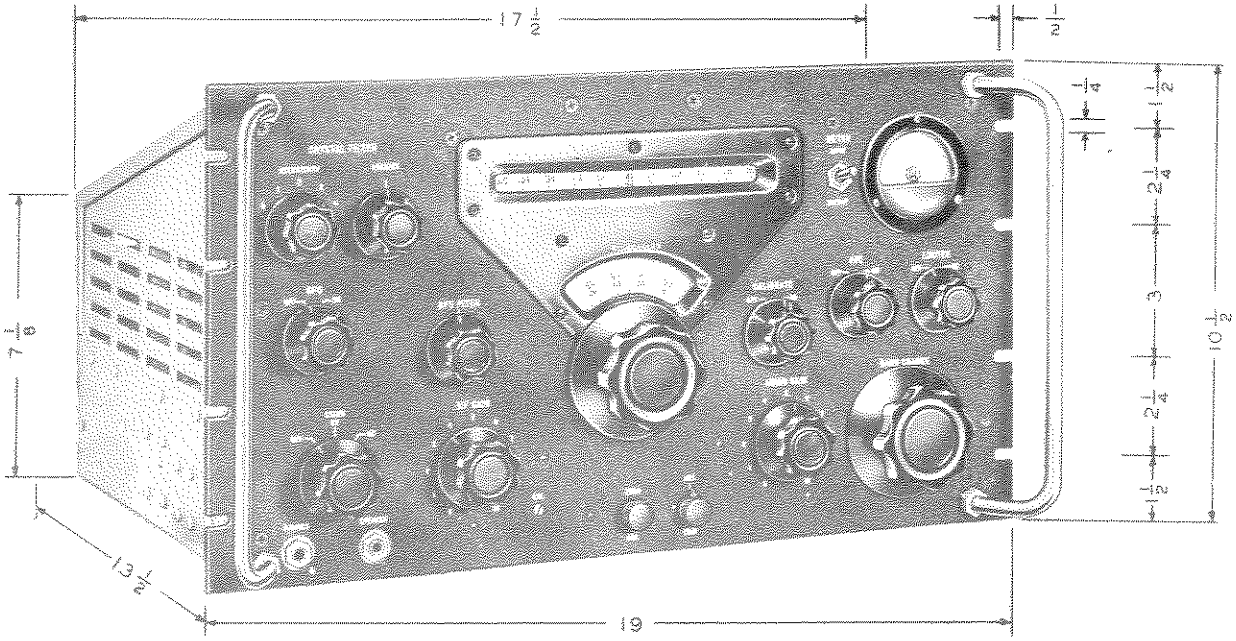

Figure 2-1. 51J-3 Mounting Dimensions

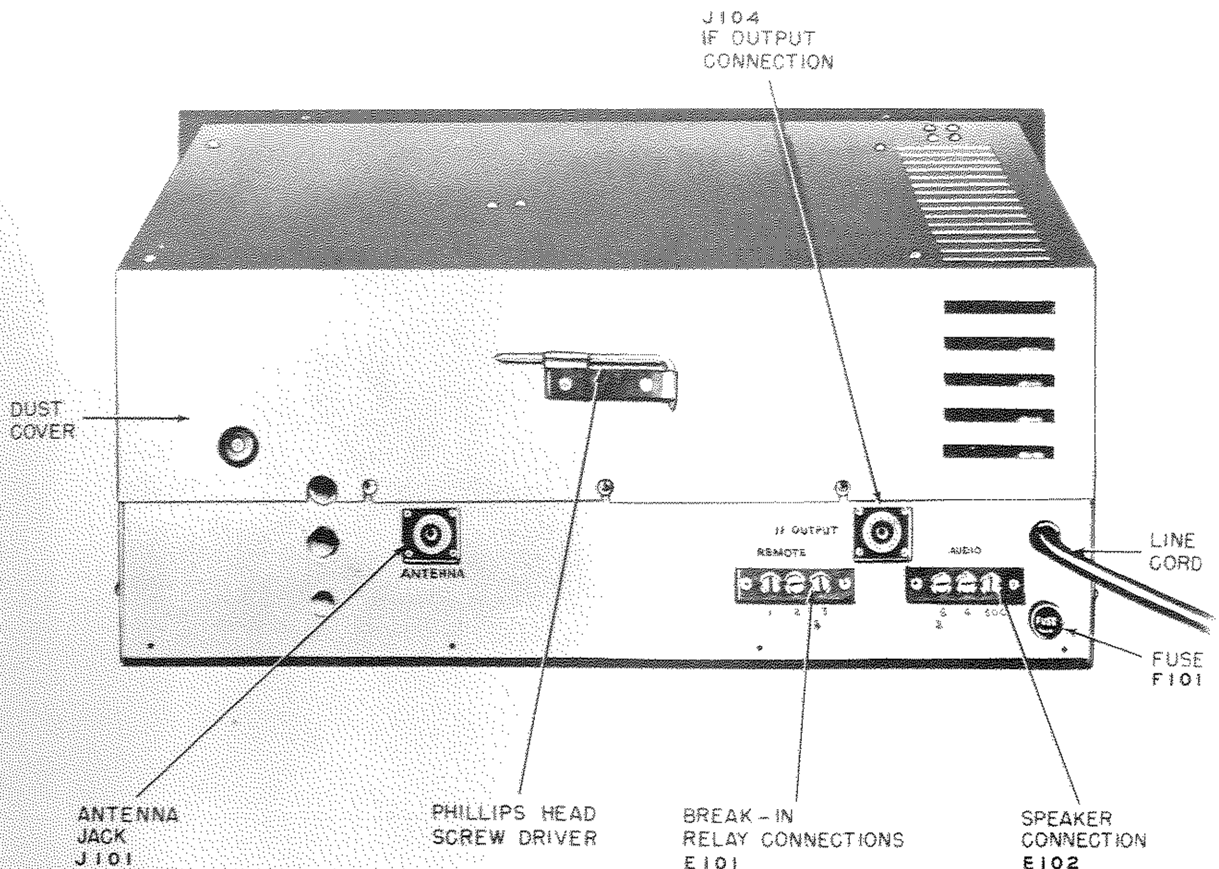

Figure 2-2. 51J-3 Rear Connections

SECTION 3

ADJUSTMENT AND OPERATION

3.1. ADJUSTMENT.

3.1.1. GENERAL. - Other than zeroing the S meter no pre-operational adjustments are necessary. Should the S meter require zeroing, turn the receiver ON, BFO OFF, AVC ON, and the 100 KC CRYSTAL OFF; then turn the RF GAIN fully clockwise. Short the antenna terminals; then turn the meter zeroing control until the S meter reads zero. Refer to figure 5-1 for location of this control.

3.2. OPERATION.

3.2.1. FUNCTION OF CONTROLS. - Operation of the 51J-3 receiver is exceedingly simple if the functioning of the controls is understood. The following paragraphs explain the functions of controls on the receiver's front panel.

(a) OFF-STANDBY-ON. - In the OFF position, this control opens the primary power circuit to turn the equipment completely off. In the STANDBY position the power transformer is excited, thus producing filament voltage for all stages and plate voltage for all except the three i-f amplifier stages. In the ON position the receiver is completely operative.

(b) RF GAIN. - The RF GAIN control is located in the grid return circuit of the avc controlled tubes and is operative at all times. It varies the amount of fixed bias placed upon the grids of these tubes.

(c) AUDIO GAIN. - The AUDIO GAIN control is located in the grid circuit of the first audio amplifier and is operative at all times. It varies the amount of a-f signal applied to the grid of this tube, and thereby controls the amount of audio power produced by the receiver.

(d) BAND CHANGE. - Any one of the 30 bands may be selected by 1/2 revolution intervals by means of this knob. A stiff detent accurately positions the controlled switches on each band.

(e) MEGACYCLE. - The MEGACYCLE scale is on the slide-rule type dial. It is calibrated in ten 100 kc divisions, each of which equals one full turn of the circular KILOCYCLE dial. The 1.5 to 2.5 mc and 2.5 to 3.5 mc bands are printed in red, indicating that the red scale on the KILOCYCLE dial must be used when operating on these bands. Beginning with 3.5 mc band, the amateur bands from 3.5 to 29.7 mc are indicated by green stripes on the MEGACYCLE scale. The pointer on the MEGACYCLE dial is operated by the KILOCYCLE control while the scale is changed by operation of the BAND CHANGE control.

(f) KILOCYCLE. - The KILOCYCLE dial is the main tuning control on the 51J-3 receiver. Each division on its circular face represents one kilocycle. One full turn of the dial tunes the receiver through 100 kilocycles, or one division of the MEGACYCLE scale. To read the tuning dials, merely combine the figures of the MEGACYCLE dial with those of the KILOCYCLE dial, thus arriving at the frequency in kilocycles. For example, a reading of 14.1 on the MEGACYCLE dial and of 78 of the KILOCYCLE dial indicates a frequency of 14178 kc. The KILOCYCLE scale for the 1.5 to 2.5 and 2.5 to 3.5 mc bands is in reverse order to the scale for the rest of the bands, and is printed in red similar to corresponding scales on the MEGACYCLE dial.

(g) ZERO ADJ. - The ZERO ADJ moves the indicator line on the KILOCYCLE control a few divisions in either direction for calibration purposes. The receiver may be calibrated against either any receivable station whose frequency is known or the internal calibration oscillator. This oscillator emits a harmonic every 100 kc in the tuning spectrum. An example of how the receiver may be calibrated using this oscillator follows. If the desired signal is about 14100 kc, turn the 100 KC CRYSTAL ON and the BFO ON. Next, using the KILOCYCLE knob, tune to zero beat with the 100 kc marker at 14100 kc. Then move the ZERO ADJ control until the hair line is exactly on 14100 kc. The dial reading in this region is now very accurate, and the receiver may be set within a few hundred cycles of the desired frequency.

NOTE

WHEN READING THE FREQUENCY OF AN INCOMING SIGNAL, THE BFO PITCH CONTROL MUST BE LEFT IN THE SAME POSITION AS IT WAS WHEN THE RECEIVER WAS CALIBRATED.

A ten division scale (five divisions either side of center) is engraved on the lower edge of the escutcheon opening for the KILOCYCLE dial, and is used to log the calibrated position of the hair line on the various bands in lieu of recalibrating each time the band is used.

(h) METER INPUT-OUTPUT. - The METER switch is a momentary spring-return type toggle switch. In the normal or INPUT position the meter is connected as an S meter. In the OUTPUT position, the meter is connected in the audio output circuit as a db meter.

(i) BFO OFF-ON. - In the ON position this control turns ON the beat frequency oscillator for CW reception. In the OFF position, it grounds the

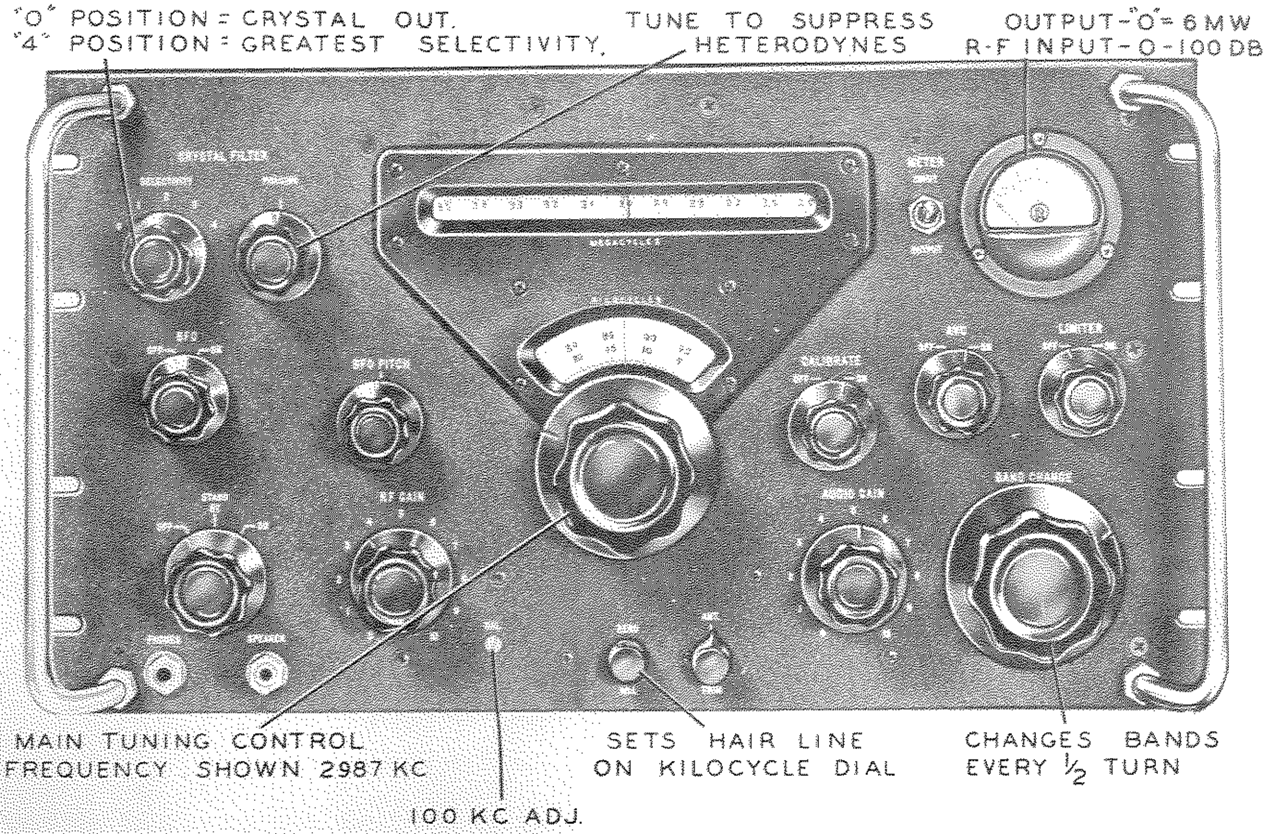

Figure 3-1. 51J-3 Operating Controls

screen grid of the BFO tube.

(j) BFO PITCH. - The BFO pitch control varies the frequency of the beat frequency oscillator to change the pitch of the audio tone which is produced by combining the BFO signal with the incoming signal. A range of about ± 3 kc minimum can be obtained with this control.

(k) CALIBRATE OFF-ON. - This switch is in the cathode circuit of 100 kc crystal oscillator tube V104 and turns the 100 kc oscillator ON or OFF. For an explanation of how to use the oscillator, see paragraph (g) above.

(l) AVC OFF-ON. - This switch turns AVC ON or OFF. In most cases AVC should be ON for both AM and CW reception, but may be turned OFF for CW reception if desired.

(m) LIMITER OFF-ON. - The noise limiter is useful for both AM and CW reception. When noise is not a problem, turn the LIMITER to OFF, as the distortion will be less in this position. When noise of the impulse type is being received, turn the LIMITER to ON. Adjustment of RF and AF gain controls is necessary for best CW noise limiting.

(n) CRYSTAL FILTER.

SELECTIVITY. - In position 0 of this control, the crystal filter is not used and selectivity is determined by the receiver's tuned circuits alone. In positions 1 through 4, the crystal filter is in the circuit, the selectivity being increased as position 4 is approached. Position 4 gives a bandwidth of about 200 cps at 6 db down.

PHASING. - The PHASING control is used to reject unwanted heterodynes. When positioned on the panel mark, the control is properly set for crystal phasing with no rejection notch. If a high frequency heterodyne is interfering with reception, move the control back and forth near the panel mark until the heterodyne is attenuated. If the heterodyne is of lower frequency, move the control farther to left or right of the panel mark. This control will attenuate heterodynes ranging from 1 to 3 kc.

(o) METER. - The tuning meter is calibrated in 20, 40, 60, 80 and 100 db above AVC threshold when reading r-f input. When reading audio output, the meter is calibrated from -10 to +6 db, zero reference being 6 milliwatts into a 500 ohm load.

(p) CAL. - If supreme accuracy is desired, the frequency of the 100 kc oscillator should be checked against WWV or some other station whose frequency is known to be extremely accurate. This oscillator frequency may be varied through small limits by turning the CAL control with a screw driver. Additional range can be obtained by turning C169, located just behind the 100 kc crystal.

SECTION 4

CIRCUIT DESCRIPTION

4.1. MECHANICAL DESCRIPTION

4.1.1. BAND CHANGE. - Collins 51J-3 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 L101 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 three slug tables through an over-travel coupler. This overtravel coupler drops the band switch at band 16 and continues 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 overtravel shaft. On band 1 radio frequency coils L101 and L110 are switched by means of the BAND CHANGE knob through the overtravel shaft and shaft G.

On bands 2 and 3, the r-f coils are selected by the BAND CHANGE knob through the overtravel shaft and shafts G and K, variable i-f 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 overtravel shaft and shaft G, and the position of the slug table is changed through shafts A, B, 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 overtravel shaft and shaft G, and the position of the slug table is changed one megacycle per band through shafts A, B, 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 switched through the overtravel shaft and shaft G to position 16 where the band switch remains for bands 16 to 30 while the overtravel coupler allows shaft G to rotate through to the thirtieth band. The slugs in the r-f coils are driven through shafts A, B, 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 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

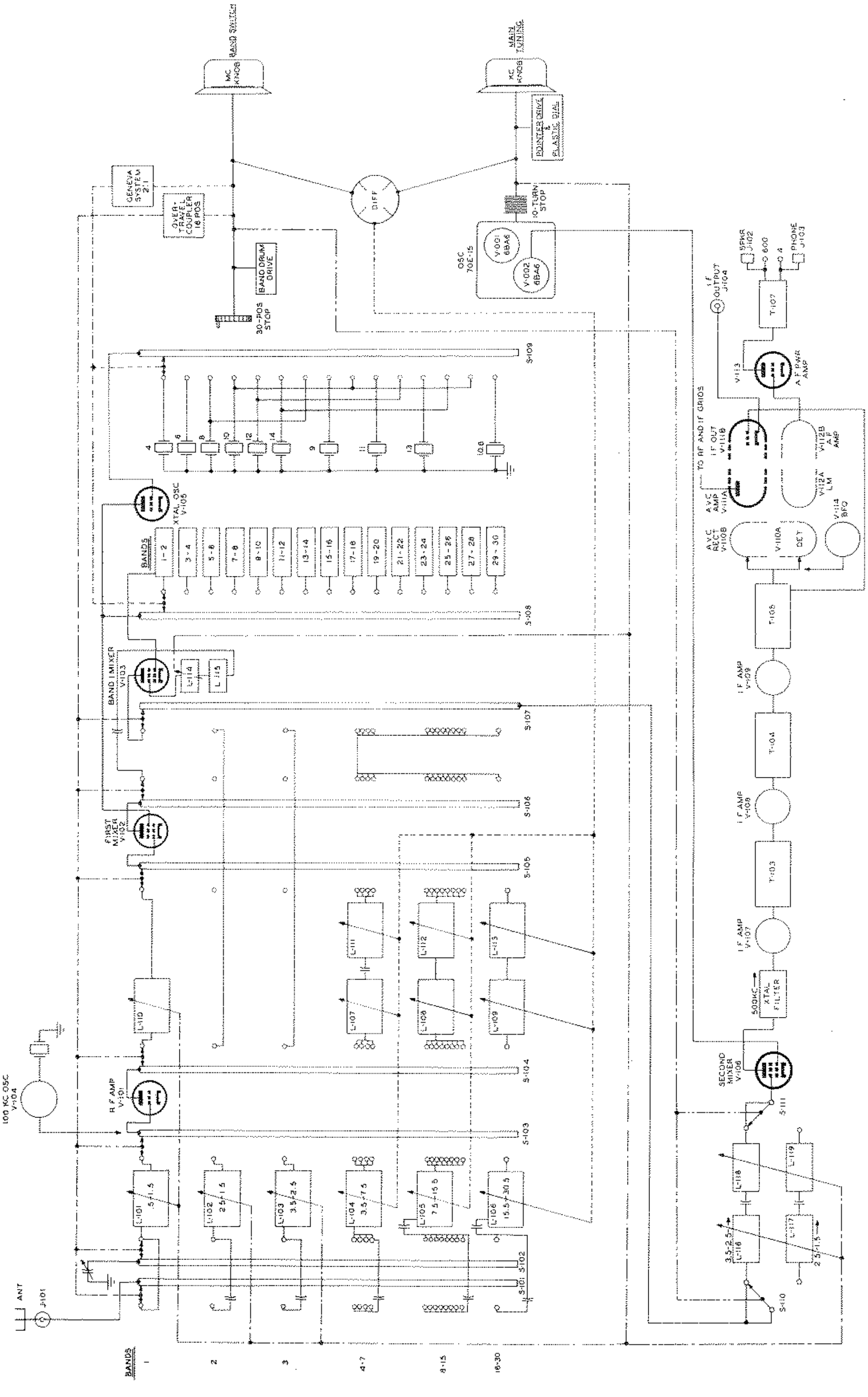

Figure 4-1. 51J-3 Band Change and Tuning System, Block Diagram

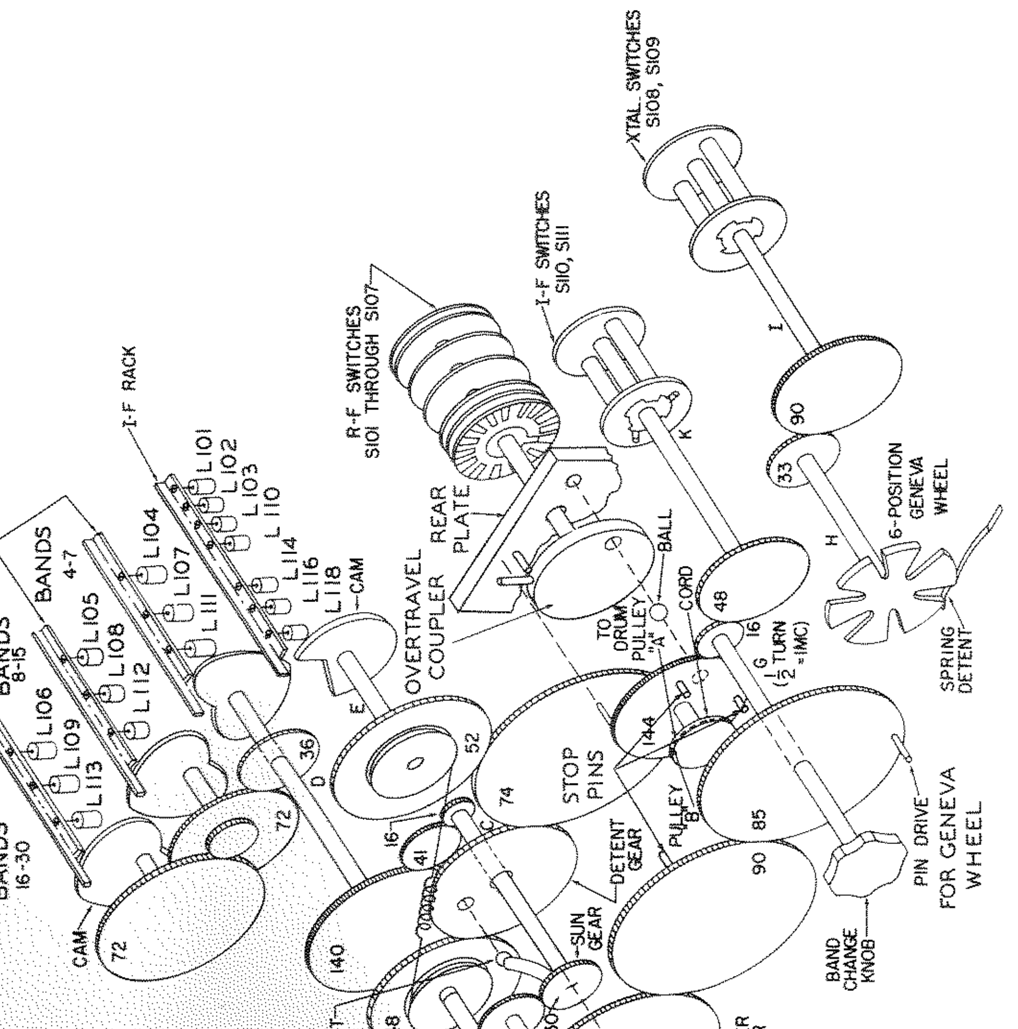

Figure 4-2. 51J-3 Mechanical Block Diagram

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-3 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. of 3.5 to 2.5 mc. The variable i.f. is then combined with the 3 to 2 mc variable oscillator output to produce the fixed 500-kc i.f. 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. - Refer to the block diagram, figure 4-1. One stage of radio frequency amplification is (V101) used on all bands. A type 6AK5 miniature r-f pentode is employed in this stage because of its low noise and good sensitivity characteristics at high frequencies. The antenna is capacitively-coupled to the grid of the r-f stage on all bands. The r-f coils for bands 1, 2, and 3 are mounted in the variable i-f group and are tuned by slugs mounted on the variable i-f slug table which is at the extreme right hand edge of the receiver as viewed from the front. 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.

When operating in the American broadcast band (band 1), the plate circuit of the r-f tube is impedance-coupled to the grid circuit of the first mixer tube by resistor R105, capacitor C117, and inductor L110. On bands 2 and 3 the plate of r-f amplifier tube V101 is switched directly to primary coils of the variable i-f tuner where additional selectivity is obtained, single conversion being used on these two bands. When operated on bands 4 to 30, the plate circuit of the r-f stage is tuned and capacitively-coupled to the tuned circuit in the grid of the first mixer stage.

4.2.3. MIXER STAGES.

(a) FIRST MIXER. - The first mixer stage consists of a type 6BE6 miniature converter tube. This stage is used on band 1 and bands 4 to 30 (0.5 to 1.5 mc and 3.5 to 30.5 mc) but not on bands 2 and 3 (2.5 to 1.5 and 3.5 to 2.5). In the range .5 to 1.5, the grid circuit of this tube is tuned by L110, C118 and C119. In the range of 3.5 to 30.5, the grid circuit is capacitively-coupled to the tuned plate circuit of r-f stage V101. The plate circuit of first mixer tube V112 is tuned to either 2.5 to 1.5 mc or 3.5 to 2.5 mc, depending on which band between 4 and 30 is being operated. However, this circuit is tuned to the 11.5 to 10.5 mc spectrum when the receiver is tuned to the American broadcast band (band 1). On bands 13 to 30, the heterodyning signal for the first mixer is obtained from crystal oscillator stage V105 through the proper crystal oscillator plate tuning coils. On bands 4 to 12 no plate tuning coils are used. On bands 4 to 30 the output of the first mixer is always between 1.5 to 2.5 mc or 2.5 to 3.5 mc. When used on band 1, the first mixer is fed a 12 mc heterodyning signal from oscillator tube V105. The output of the first mixer is 11.5 to 10.5 mc which, when mixed in the third mixer with an 8 mc signal from the crystal oscillator, produces a 3.5 to 2.5 mc

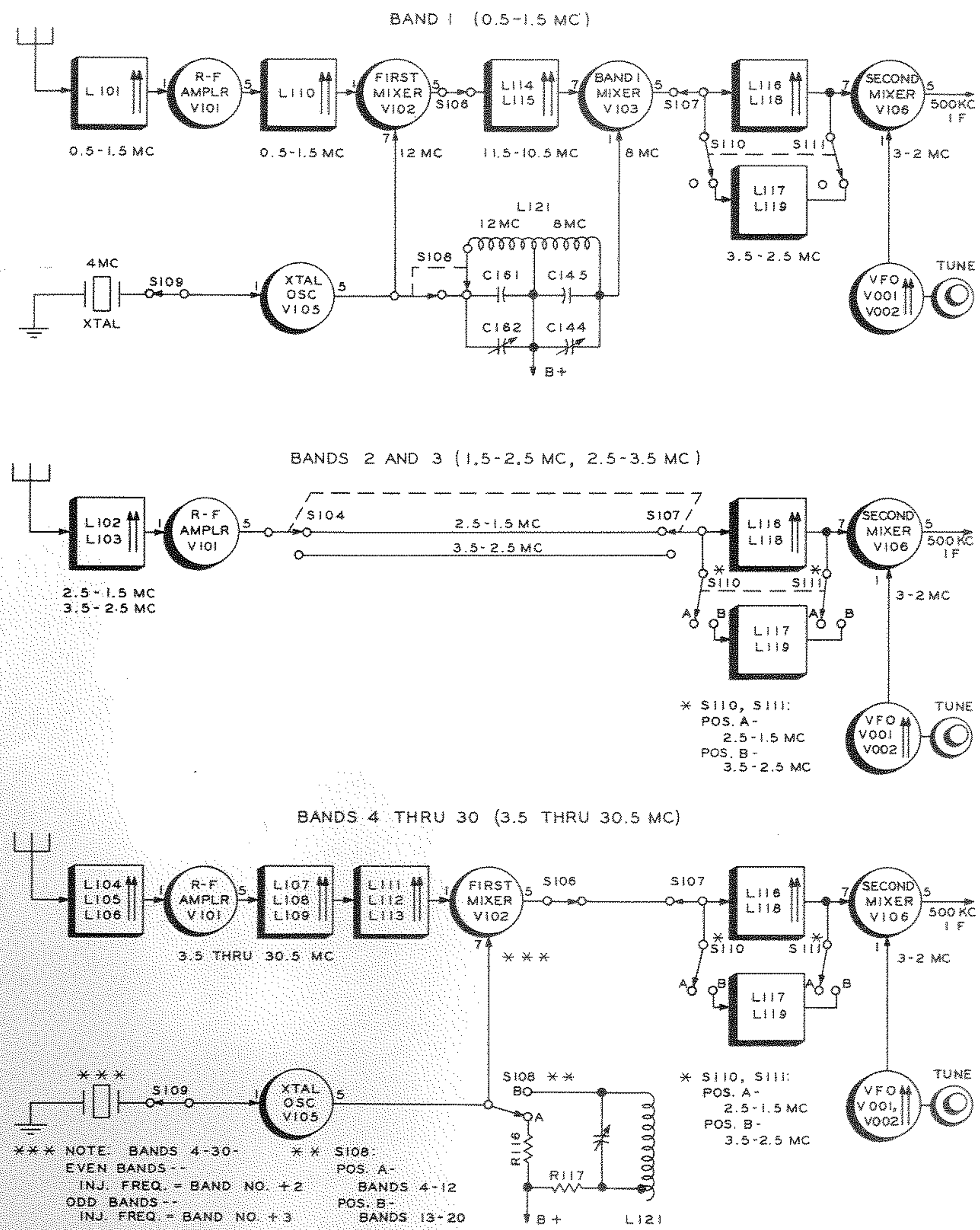

Figure 4-3. 51J-3 Frequency Conversion Circuits

voltage for presentation to the variable i-f coils. Output of the first mixer is switched from the variable i-f coils to the grid of the third mixer by means of switch pies S106 and S107.

(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 V101, 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 modified Colpitts 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. The harmonics of certain crystals are used also for other higher 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 oscillator tube V105 and consists of the primary coil of L121 and a number of tuning capacitors. The latter are selected for the proper band by switch pie S108. The secondary of coil L121 is tuned to 8 mc and is used when operating on band 1 to furnish the third mixer with an eight mc heterodyning signal (second harmonic of the 4 mc crystal). At the same time, the primary of L121 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 which they function is outlined on the following page:

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
	2.5 to 3.5	3	None
6	3.5 to 4.5	4	6
8	4.5 to 5.5	5	8
	5.5 to 6.5	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 L116 across L117, and L118 across L119 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 circuit 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 is used for isolation purposes following the oscillator tube. This isolation tube, V002, is an integral part of the oscillator.

4.2.7. CRYSTAL FILTER. - Selectivity of the 51J-3 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 7-7. 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 circuit T102. Assume that S114 is in position 1. 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 V107 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 V107.

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 V107. As the crystal impedance becomes still greater, the voltage appearing on V107 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 of T102 for those positions. This results in a more rapid decrease in V107 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 anti-resonant frequency of the crystal circuit within 3 kc either side of 500. Since the impedance of the crystal circuit at anti-resonance is extremely high, the crystal filter rejects signals at the anti-resonant frequency.

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 is fixed-tuned to 500 kc. It consists of three stages and employs 6BA6 tubes in all three stages. Input tube V107 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 to produce the desired i-f selectivity. All three stages are supplied with AVC voltage.

4.2.9. DETECTOR. - The detector in the 51J-3 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-3 reciever. This limiter employs one-half (pins 1, 2 and 3) of a type 12AX7 dual triode tube, V112. Refer to figure 4-4. 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 C210 and R152 through which C205C charged. This negative potential is placed upon the cathode of the noise limiter tube through R153. The cathode is then negative in 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 C210. 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 bottom of the detector transformer because of the filtering action of R152 andC205C. 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 use.

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 4-5. 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 R164, 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, the 500 kc i-f amplifier tubes, V107, V108 and V109.

4.2.12. AUDIO AMPLIFIER. - Two stages of audio amplification are employed in the 51J-3 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 of 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 Pierce 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 re-connecting 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. The 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. 6.3 volts a-c are furnished for the tube filaments and dial lights from a winding on the power transformer.

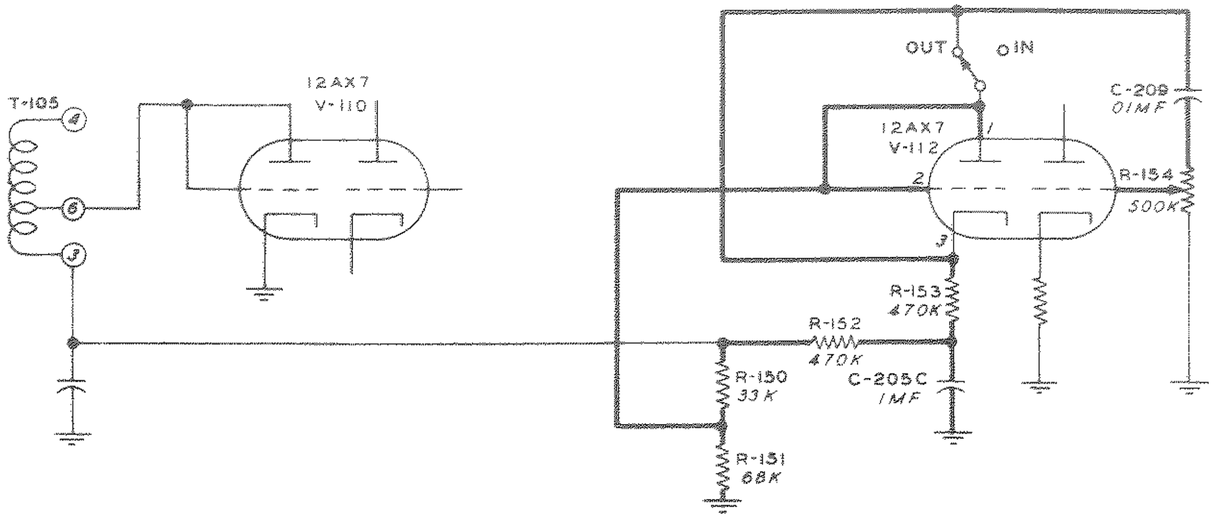

Figure 4-4. 51J-3 Noise Limiter Circuit

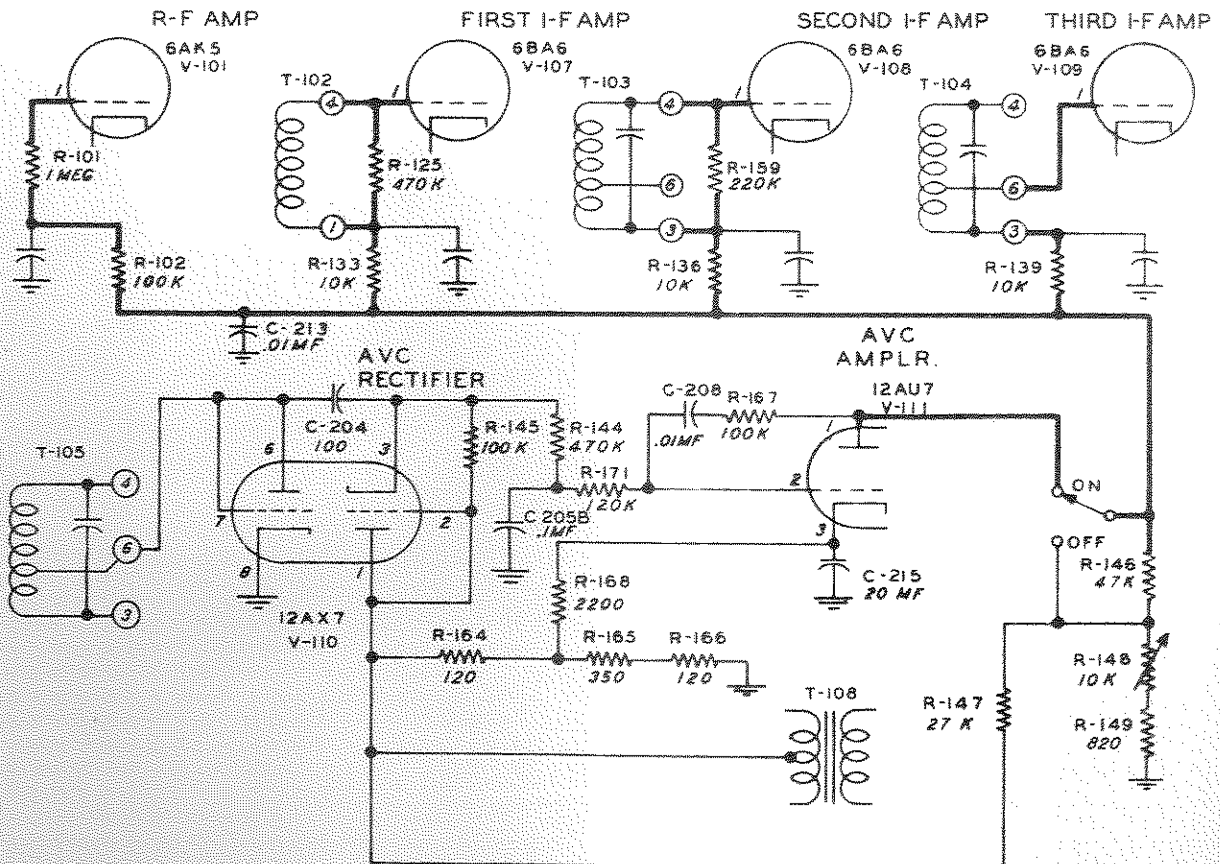

Figure 4-5. 51J-3 A.V.C. Circuit