CHAPTER FOUR
R-278B/GR RECEIVER

1.0 GENERAL

The type R-278B/GR receiver is a multi-channel superheterodyne receiver. Triple conversion is used, utilizing three crystal controlled oscillators. Several views of the receiver are shown in Figures 4-15 through 4-18.

NOTE: The R-278B/GR receiver described in this chapter is manufactured by Collins Radio Co. The R-278B/GR supercedes the R-278A/GR. The R-278A/GR superceded the R-278/GR. These three receivers are all the same basic receiver. A guard channel section was incorporated in the R-278/GR and in the early models of the R-278A/GR, but the R-278B/GR does not incorporate a guard channel section.

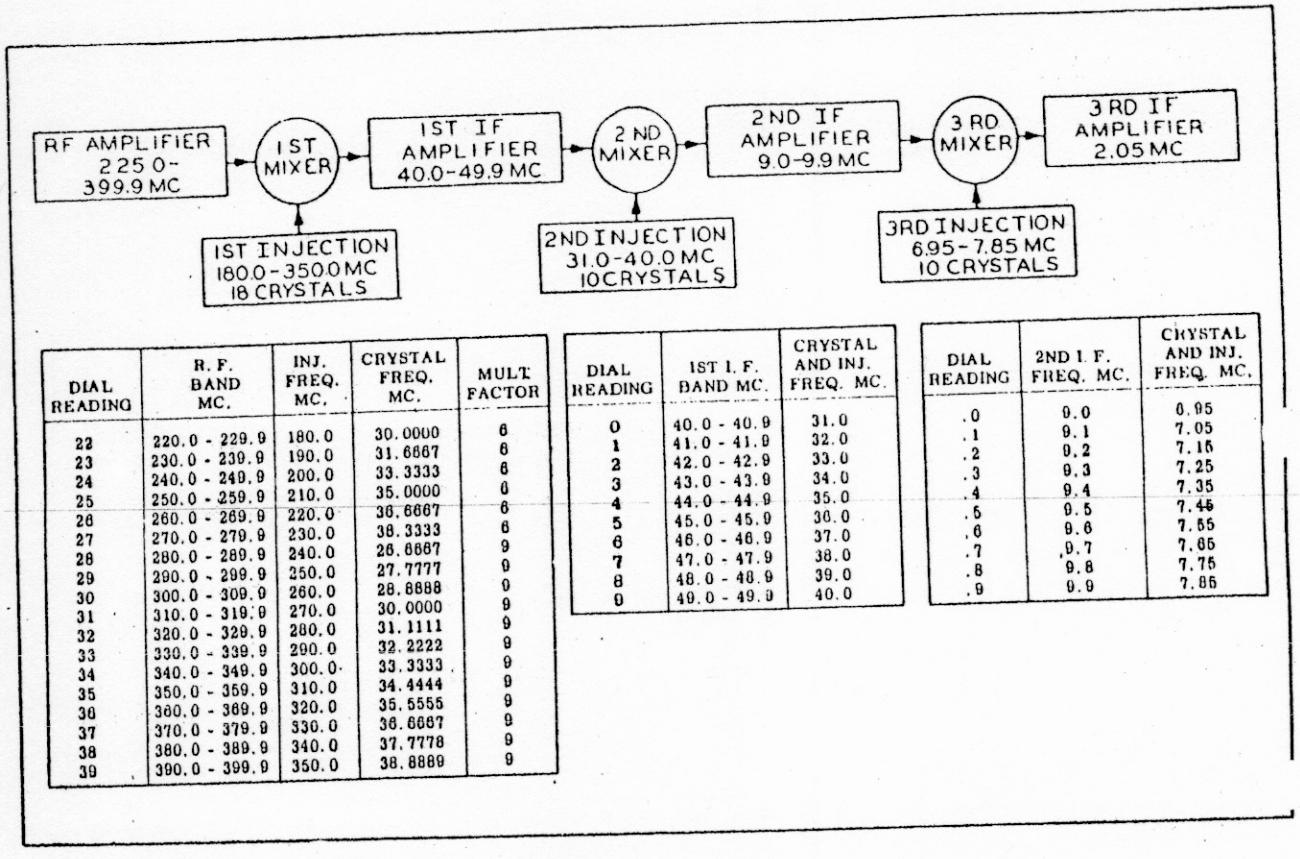
The R-278B/GR receiver manufactured by Delco Radio is identical to the Collins R-278B/GR, except for a few minor differences. One difference is that in the Delco R-278B, avc is applied to the 1st r-f amplifier, whereas in the Collins R-278B, avc is not applied to the 1st r-f amplifier.

1.1 Frequency System

The receiver will operate on any one of 1800 frequencies spaced at 0.1 mc intervals. There are 1750 frequencies spaced at 0.1 mc intervals in the UHF band extending from 225.0 to 399.9 mc. However, the frequency system employed is capable of providing 50 additional frequencies spaced at 0.1 mc intervals from 220.0 to 224.9 mc. Therefore, the receiver will tune to 1800 crystal controlled frequencies spaced at 0.1 mc intervals from 220.0 to 399.9 mc. The receiver is tuned by a motor-driven frequency selector unit. The frequency diagram is shown in Figure 4-1.

The r-f section tunes from 220.0 to 399.9 mc in 1 mc steps, a total of 180 steps. There are three i-f sections. The first i-f section tunes from 40.0 to 49.9 mc in 0.1 mc steps, a total of 100 steps. The second i-f section tunes from 9.0 to 9.9 mc in 0.1 mc steps, a total of 10 steps. The third i-f section operates at a fixed frequency of 2.05 mc.

There are 18 crystals in the main oscillator, 10 crystals in the second oscillator and 10 crystals in the third oscillator, a total of 38 crystals to obtain 1800 crystal controlled channels.



DIAL READING	R. F. BAND MC.	INJ. FREQ. MC.	CRYSTAL FREQ. MC.	MULT FACTOR
22	220.0 - 229.9	180.0	30.0000	6
23	230.0 - 239.9	190.0	31.6667	6
24	240.0 - 249.9	200.0	33.3333	6
25	250.0 - 259.9	210.0	35.0000	6
26	260.0 - 269.9	220.0	36.6667	6
27	270.0 - 279.9	230.0	38.3333	6
28	280.0 - 289.9	240.0	26.6667	9
29	290.0 - 299.9	250.0	27.7777	9
30	300.0 - 309.9	260.0	28.8888	9
31	310.0 - 319.9	270.0	30.0000	9
32	320.0 - 329.9	280.0	31.1111	9
33	330.0 - 339.9	290.0	32.2222	9
34	340.0 - 349.9	300.0	33.3333	9
35	350.0 - 359.9	310.0	34.4444	9
36	360.0 - 369.9	320.0	35.5555	9
37	370.0 - 379.9	330.0	36.6667	9
38	380.0 - 389.9	340.0	37.7778	9
39	390.0 - 399.9	350.0	38.8889	9

DIAL READING	1ST I. F. BAND MC.	CRYSTAL AND INJ. FREQ. MC.
0	40.0 - 40.9	31.0
1	41.0 - 41.9	32.0
2	42.0 - 42.9	33.0
3	43.0 - 43.9	34.0
4	44.0 - 44.9	35.0
5	45.0 - 45.9	36.0
6	46.0 - 46.9	37.0
7	47.0 - 47.9	38.0
8	48.0 - 48.9	39.0
9	49.0 - 49.9	40.0

DIAL READING	2ND I. F. FREQ. MC.	CRYSTAL AND INJ. FREQ. MC.
.0	9.0	6.95
.1	9.1	7.05
.2	9.2	7.15
.3	9.3	7.25
.4	9.4	7.35
.5	9.5	7.45
.6	9.6	7.55
.7	9.7	7.65
.8	9.8	7.75
.9	9.9	7.85

Figure 4-1. Frequency Diagram

The main oscillator crystals are type CR-32/U, operated in a thermostatically controlled crystal oven. The crystal frequency is multiplied 6 times when the receiver is tuned to any frequency from 220.0 to 279.9 mc and the crystal frequency is multiplied 9 times when the receiver is tuned from 280.0 to 399.9 mc. The 18 output frequencies from the frequency multiplier-amplifier are in 10 mc steps from 180.0 to 350.0 mc.

The second oscillator crystals are type CR-23/U. The 10 output frequencies of the second oscillator are in 1 mc steps from 31.0 to 40.0 mc.

The third oscillator crystals are type CR-18U. The 10 output frequencies of the third oscillator are in 0.1 mc steps from 6.95 to 7.85 mc.

1.2 Tuning System

A motor-driven frequency selector is used to permit rapid change of the operating frequency. The frequency selector unit has three rotary output shafts that selects the proper crystal units and tunes various circuits to establish a particular operating frequency. These output shafts are called the 10 mc, the 1 mc and the 0.1 mc shafts. The 10 mc shaft rotates in 18 incremental steps, each step representing 10 mc. The 1 mc shaft rotates in 10 incremental steps, each step representing 1 mc. The 0.1 mc shaft rotates in 10 incremental steps, each step representing 0.1 mc. By combining the outputs of these shafts and applying the mechanical sum to the tuning of the r-f and i-f circuits, any one of 1800 frequencies in the range of 220.0 to 399.9 mc may be selected as explained below.

The r-f amplifier is tuned in 180 one mc steps by the 10 mc shaft (18 positions) and the 1 mc shaft (10 positions) whose rotary motions are combined in a differential mechanism to produce 180 rotational positions.

The 1st injection system (main oscillator and frequency multiplier-amplifer sections) is tuned in 18 ten mc steps by the 10 mc shaft, which also operates the main oscillator crystal selector switch to select one of 18 crystal units.

The 1st i-f section is tuned by the 1 mc and 0.1 mc shafts, the rotations of which are combined in a differential mechanism to produce 100 tenth mc steps. The crystal selector switch and tuned circuits of the 2nd injection oscillator are controlled by the 1 mc shaft (10 positions).

The 2nd i-f section is tuned in 10 tenth mc steps by the 0.1 mc shaft, which also operates the crystal switch of the 3rd injection oscillator (10 positions).

The frequency selector unit is controlled by a switch panel on the front of the receiver, which permits the operating frequencies of 10 channels to be pre-set. Any one of the 10 pre-set channels can be selected by operation of the channel selector switch on the front panel of the receiver or by a remote channel selector switch. Pre-set switches for setting the frequency of a manual channel are also provided. The manual channel can be selected only by the channel selector switch on the front panel of the receiver.

1.3 Frequency Example

As an example case of frequency selection in each of the r-f and i-f units, assume that one wishes to tune the receiver to a signal frequency of 395.5 mc. One of the 10 pre-set channels (assume channel 10) is set to 395.5 mc by turning the knurled disks to 395.5 as indicated on the dials. The CHANNEL SELECTOR switch is turned to channel 10. The frequency selector motor starts and produces a mechanical output that tunes the receiver properly in the following manner:

R-F amplifier	395.5 mc
1st injection system	350.0 mc
1st i-f section	45.5 mc
2nd injection system	36.0 mc
2nd i-f section	9.5 mc
3rd injection system	7.45 mc
3rd i-f section	2.05 mc

1.4 Audio Output

The main output of the receiver is 3 watts into a 600 ohm balanced load. This output is available at the PHONE jack on the front panel of the receiver or at the AUXILIARY CONTROL connector. A low level output of +10 dbm into a 600 ohm load is available at the AUXILIARY CONTROL connector or at the LOCAL CONTROL connector. A cathode follower output (low impedance) is available at the AUXILIARY CONTROL connector for operation of direction finder equipment.

The FREQUENCY RESPONSE switch on the front panel of the receiver permits the selection of a BROAD or NARROW audio frequency response. In the BROAD position the audio frequency response is flat within 4 db from 200 to 20,000 cps. In the NARROW POSITION the audio frequency response is as follows:

200 cps	-	greater than 10 db attenuation
400 cps	-	less than 5 db attenuation
1000 cps	-	0 db attenuation
3000 cps	-	less than 5 db attenuation
5000 cps	-	greater than 10 db attenuation

The audio frequency distortion is less than 5 percent at 30% modulation and 3 watts output.

1.5 Selectivity

The selectivity of the receiver, with reference to 2.05 mc (the 3rd i-f section), is such that the bandwidth is not less than 65 kc at 6 db attenuation and not more than 185 kc at 60 db attenuation.

1.6 Sensitivity

The sensitivity of the receiver is such that at maximum setting of the R-F GAIN control, a 3 microvolt signal modulated 30% at 1,000 cps will produce not less than 1 watt output at not less than 10 db signal to noise ratio.

1.7 Antenna Circuit

The antenna input impedance is 52 ohms. A low-pass filter is used between the antenna terminal on the front panel and the input circuit of the 1st r-f amplifier. The receiver is designed for use with a directional antenna or omni-directional antenna. The directional antenna is used when the direction finder output of the receiver is used. The antenna input connector is a coaxial type connector.

The image frequency rejection is more than 60 db below the signal input level. The intermediate frequency rejection is more than 80 db below the signal input level.

1.8 AVC Characteristics

The audio output is constant within ± 2 db for signal input from 10 microvolts to 0.1 volt and is constant within ± 6 db for signal input from 0.1 volt to 2 volts.

The AVC TIME CONSTANT switch on the front panel of the receiver permits the selection of a short time constant of 1/10 second for communications or a long time constant of less than 3 seconds for direction finding operation.

1.9 Noise Limiters

The receiver uses a series noise limiter, a shunt noise limiter and a noise cancellation detector. A carrier operated relay and squelch circuit is also used.

1.10 Power Requirements

The receiver operates from either 115 or 230 volts, single phase, 50 to 60 cycles power source. The power consumption for normal operation is 385 watts during the first ten minutes and 265 watts thereafter. When a channel selection is being made during the first ten minutes the consumption is 470 watts and 350 watts thereafter. There are two fuses located on the front panel of the receiver. The filament fuse is 5 amps for 115 volt operation and is 3 amps for 230 volt operation. The plate fuse is 3 amps for 115 volt operation and is 1.5 amps for 230 volt operation.

1.11 Construction

The receiver contains 10 sub-chassis which may be removed individually from the basic frame by loosening the retaining screws, releasing mechanical couplings, where used, and lifting out the unit. Each sub-chassis is electrically connected to the system by a cable that plugs into a receptacle on the basic frame. In this way a sub-chassis may be removed from the basic frame, but still be electrically connected for the purpose of maintenance and bench checks. The sub-chassis are as follows:

Unit	Location
R-F amplifier	Upper, right, rear
Main oscillator	Lower, left, rear
Frequency mult-amp	Upper, left, rear
1st i-f amplifier	Top, center
2nd i-f amplifier	Top, right of center
3rd i-f amplifier	Bottom, right
Audio amplifier	Rear, right, lower
Power supply rectifier	Top, left
Power supply filter	Top, extreme right
Frequency selector unit	Front

2.0 THEORY OF OPERATION

With reference to Figure 4-20, the individual circuits of the receiver will now be considered in detail.

2.1 R-F Amplifier

The radio frequency amplifier consists of two grounded grid amplifiers, V-101 and V-102, type 6J4 tubes, operating in conjunction with three special r-f tuner circuits Z-101, Z-102 and Z-103. This type of r-f tuner, shown in Figure 4-2, consists of a variable capacitor and a variable inductor, which are rotated simultaneously so that in 180 degrees of rotation the resonant frequency changes linearly 180 mc or 1 mc per degree. The variable capacitor consists of two stator plates and three rotor plates. The front and rear rotor plates are radially slotted for the purpose of alignment adjustments. The inductive loop consists of the inductance stator rod, the inductance ring and the inductance rotor rod. The three r-f tuners are geared together and driven through a mechanical differential from the 10 mc and 1 mc autopositioner output shafts.

The r-f signal received at the antenna terminal is conducted over type RG-58/U coaxial line through r-f low-pass filter Z-1202 to the r-f amplifier input circuit, where it is link coupled into the first r-f tuned circuit. The signal is amplified in the two grounded-grid, shunt-fed amplifiers V-101 and V-102. The gain of both stages are controlled by the avc circuit. Bifilar chokes in the filament leads and the inductive impedances Z-104 and Z-105 in the plate shunt-fed circuits isolate the power circuits from

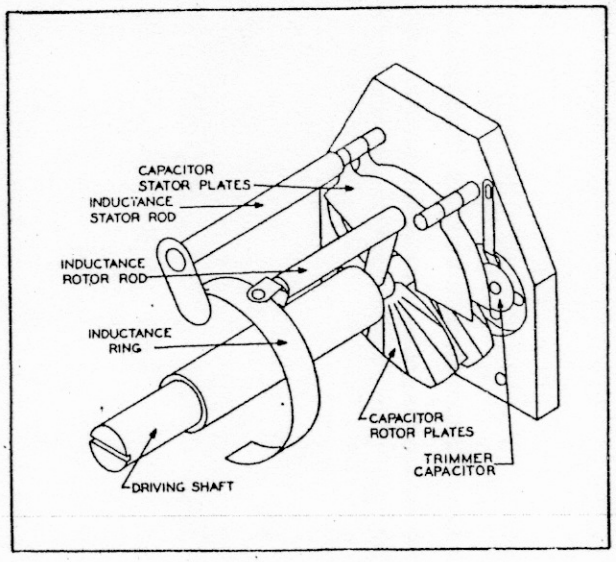


Figure 4-2. Construction of R-F Tuner

radio frequency voltages. The r-f signal is then fed to the first mixer through a soldered connection, which connects the r-f amplifier unit to the first i-f amplifier unit.

2.2 First Injection System

The first injection system is contained in two units designated as the "main oscillator" unit and the "frequency multiplier-amplifier" unit.

2.2.1 Main Oscillator

The main oscillator employs a Butler circuit and consists of: V-201, type 12AT7 tube, a high mu duo-triode; a bank of 18 type CR-32/U crystal units with a crystal switch, all inside a temperature-controlled crystal oven; a bank of 18 coils with associated switch; and other circuit elements. The oscillator consists of a grounded grid amplifier followed by a cathode follower which in turn couples back into the grounded grid stage through a crystal.

To understand the operation of this oscillator imagine a random positive pulse appearing at the cathode, pin 3, of the grounded grid amplifier, V-201A. Since the grid is grounded through a 22 ohm resistor, a rise in cathode voltage will cause a decrease in plate current and therefore an increase in plate voltage. This positive pulse is coupled to the grid of the cathode follower, V-201B. The cathode voltage follows the grid voltage so that the positive pulse is coupled back to the cathode of the grounded grid amplifier through the crystal. The crystal presents a low impedance path only at series resonance. Thus oscillations are generated by the stage and sustained by the feedback loop. The plate load of the grounded grid amplifier is the tuned circuit C-203 in parallel with one of 18 inductances selected by the 10 mc Autopositioner output shaft. The frequency of oscillation can be adjusted over a small range by adjusting the tuning of the plate circuit. This circuit is normally adjusted so that the frequency of oscillation is precisely as desired, thereby eliminating any inaccuracy in the frequency of the crystal unit. A 1.5 microhenry inductance, L-201, is used to resonante with the stray circuit capacities at approximately 30 mc. The oscillator signal is fed to V-301 through a capacitor and a soldered connection connecting the oscillator unit with the frequency-multiplier amplifier unit.

The crystal is maintained at a constant temperature by the thermostatically controlled crystal oven. The crystal oven operates on 115 volts a-c and includes two heater elements and two thermostats. One heater element has a rating of approximately 100 watts and is employed to bring the oven to operating temperature rapidly when the equipment is first turned on. The second heater element has a rating of approximately 20 watts and operates intermittently to maintain the oven at the proper temperature (75° C $\pm$ 5° C).

2.2.2 Frequency Multiplier-Amplifier

The frequency multiplier consists of V-301 and V-302, type 6AK5W tubes, a tapered toroidal coil assembly in the plate circuit of the first stage and

an r-f tuner, similar to that described in section 2.1 (R-F Amplifier), in the plate circuit of the second stage. The tapered toroidal coil is a variable inductor made up of 18 turns of wire. A rotary contact progressively adds an additional turn of wire (from a shorted condition) as the receiver frequency is changed in 10 mc steps from the highest to the lowest frequency.

The oscillator signal (26.6667 to 38.8889 mc) is received on the grid of V-301. The tapered toroidal coil in the plate circuit is tuned to twice the oscillator frequency for the six lowest injection frequencies and to three times the oscillator frequency for the twelve highest injection frequencies. The signal is then fed to the grid of V-302. The signal frequency is tripled in this stage, as the r-f tuner in the plate circuit is tuned to three times the frequency applied to its grid.

The amplifier section of the frequency multiplier-amplifier is a three stage grounded-grid, shunt-fed amplifier employing V-303, V-304 and V-305, type 6J4 tubes, and three special r-f tuners, Z-305, Z-307 and Z-309. The four r-f tuners in the frequency multiplier-amplifier differ from those used in the r-f amplifier as they have differently shaped capacitor rotor plates and are tuned to a lower frequency. The injection signal (180 to 350 mc) is amplified in this three stage amplifier and fed to the cathode of the first mixer. Bifilar chokes in the filament leads and inductive impedances Z-304, Z-306 and Z-308 in the plate shunt-fed circuits isolate the power circuits from radio frequency voltages. All stages in the frequency multiplier-amplifier unit are tuned from the output shaft of the 10 mc Autopositioner through a series of gears. Likewise, the switching in the main oscillator unit is done from the output shaft of the 10 mc Autopositioner.

2.3 First Mixer

The first mixer consists of V-401, type 6AK5W tube. This mixer combines the r-f signal (220.0 to 399.9 mc), received on the grid, with the first injection signal (180 to 350 mc), received on the cathode, to produce the first intermediate frequency in the range of 40.0 to 49.9 mc. The output transformer is permeability tuned as explained below.

2.4 First I-F Section

The first i-f amplifier consists of V-402, type 6AK5W tube, and two interstage i-f transformers. The 40.0 to 49.9 mc i-f signal is amplified and fed to the grid of the second mixer, V-403. The gain of the first i-f section is controlled by the avc circuit. Because the r-f channels are spaced at 0.1 mc intervals, and the first injection system is tunable at 10 mc intervals, there are 100 possible first intermediate frequencies. The interstage transformers, T-401 and T-402 are therefore made tunable in 100 tenth mc increments by means of a differential tuning mechanism which includes a tuning rack that is cam driven from the 0.1 mc and 1.0 mc Autopositioner output shafts (see figure 4-14). The interstage transformers are permeability tuned by powered iron cores mounted on the rack. Cams on a fixed-bearing shaft driven from the 0.1 mc Autopositioner output shaft raise or lower a floating shaft driven from the 1 mc Autopositioner output shaft. Cams on this floating shaft raise or lower the tuning rack. Since each set of cams adjusts the rack in ten steps, the combination of the action of the two sets gives 100 positions of the tuning cores. Threaded studs on the cores make it possible to adjust each core independently when aligning. Trimmer capacitors across the tuned circuits are provided so that the most linear part of the tuning curve can be selected to give the best tracking.

2.5 Second Oscillator

The second injection system consists of V-404, type 12AT7 tube, in a Butler type oscillator circuit. This circuit employs one of ten type CR-23/U crystal units operating at frequencies from 31 to 40 mc. The theory of operation of a Butler oscillator circuit is explained in the discussion of the main oscillator. Selection of the correct crystal unit and the tuning of the plate circuit is done by the 1 mc Autopositioner output shaft. An injection frequency at each megacycle from 31 to 40 mc is provided. The second injection signal is fed to the cathode of the second mixer, V-403.

2.6 Second Mixer

The second mixer consists of V-403, type 6AK5W tube. This mixer combines the first i-f signal (40.0 to 49.9 mc) received on the grid with the second injection signal (31 to 40 mc) received on the cathode, to produce the second intermediate frequency of 9.0 to 9.9 mc.

2.7 Second I-F Section

The second i-f section consists of V-501, type 6 AU6 tube, and tuned circuits. The second i-f signal (9.0 to 9.9 mc) is conducted from the plate of the second mixer to the primary of T-501 over type RG-58/U coaxial line and thence to the grid of V-501 where it is amplified and fed to the grid of the third mixer. The stage is avc controlled and the interstage transformers are permeability tuned by a cam-driven tuning rack operating from the 0.1 mc Autopositioner output shaft. (See figure 4-14)

2.8 Third Oscillator and Mixer

The third oscillator-mixer consists of V-502, type 12AU7 tube, and one of ten type CR-18/U crystal units. A modified Colpitts type oscillator is used to generate one of ten frequencies in the frequency range of 6.95 to 7.85 mc, which signal is impressed on the cathode of the third mixer. The correct crystal unit is selected by the 0.1 mc Autopositioner output shaft. The second i-f signal is received on the grid of the third mixer. These signals are combined to produce the third intermediate frequency of 2.05 mc, which is carried over type RG-58/U coaxial line to T-601.

2.9 Third I-F Section

The third i-f signal is amplified in the three-stage third i-f section consisting of V-601, V-602 and V-603, type 6BA6 tubes, and four interstage i-f transformers tuned to 2.05 mc. The first i-f transformer is overcoupled and the last three are undercoupled. This is done to give the desired band-pass characteristics. The first two stages, V-601 and V-602,

are avc controlled. The secondary of the fourth interstage transformer, T604, is in the audio and avc detector circuits.

2.10 Audio Detector and Noise Limiters

Referring to Figure 4-3, the audio detector and noise limiters employ the following tubes: audio detector V-604A, 1/2 6AL5W tube; series noise limiter V-605A, 1/2 6AL5W tube; shunt noise limiter V-605B, 1/2 6AL5W tube; and noise cancellation detector V-608B, 1/2 12AX7 tube. The diode detector circuit is a conventional circuit in which V-604A operates as a rectifier; the diode load consists of R-613 and R-614 in series, by-passed by C-629. The output of the detector is a negative voltage (normally about -8 volts with respect to cathode of V-604A) upon which is superimposed the audio modulation signal.

The series diode limiter circuit employs diode element V-605A in a circuit which limits the audio output signal to approximately 40% upward modulation. Since impulse noises of the type encountered at UHF consists of very sharp pulses of several hundred percent modulation, this limiting action greatly reduces the amount of noise energy transmitted to the audio amplifier circuits without adversely affecting the intelligibility of voice signals. In the circuit employed, the plate of the diode is connected to the junction of R-613 and R-614 which act as a voltage divider. R-622 and C-634B act as a filter to establish a reference potential. R-623 and R-624 in series act as a diode load resistor across which the output audio signal is developed.

The operation of this circuit can best be understood by assuming V-605A to be an ideal diode; that is, perfectly conducting in one direction and completely non-conducting in the other direction. With a d-c developed bias of about -2 volts at point A, the output of the detector, the electron flow through the circuit will result in d-c potentials at points B, C and D, as shown in Figure 4-3. Note that point C is by-passed to ground so that its instantaneous potential to ground is not affected by the modulation signal. When the audio modulation is superimposed on the developed bias,

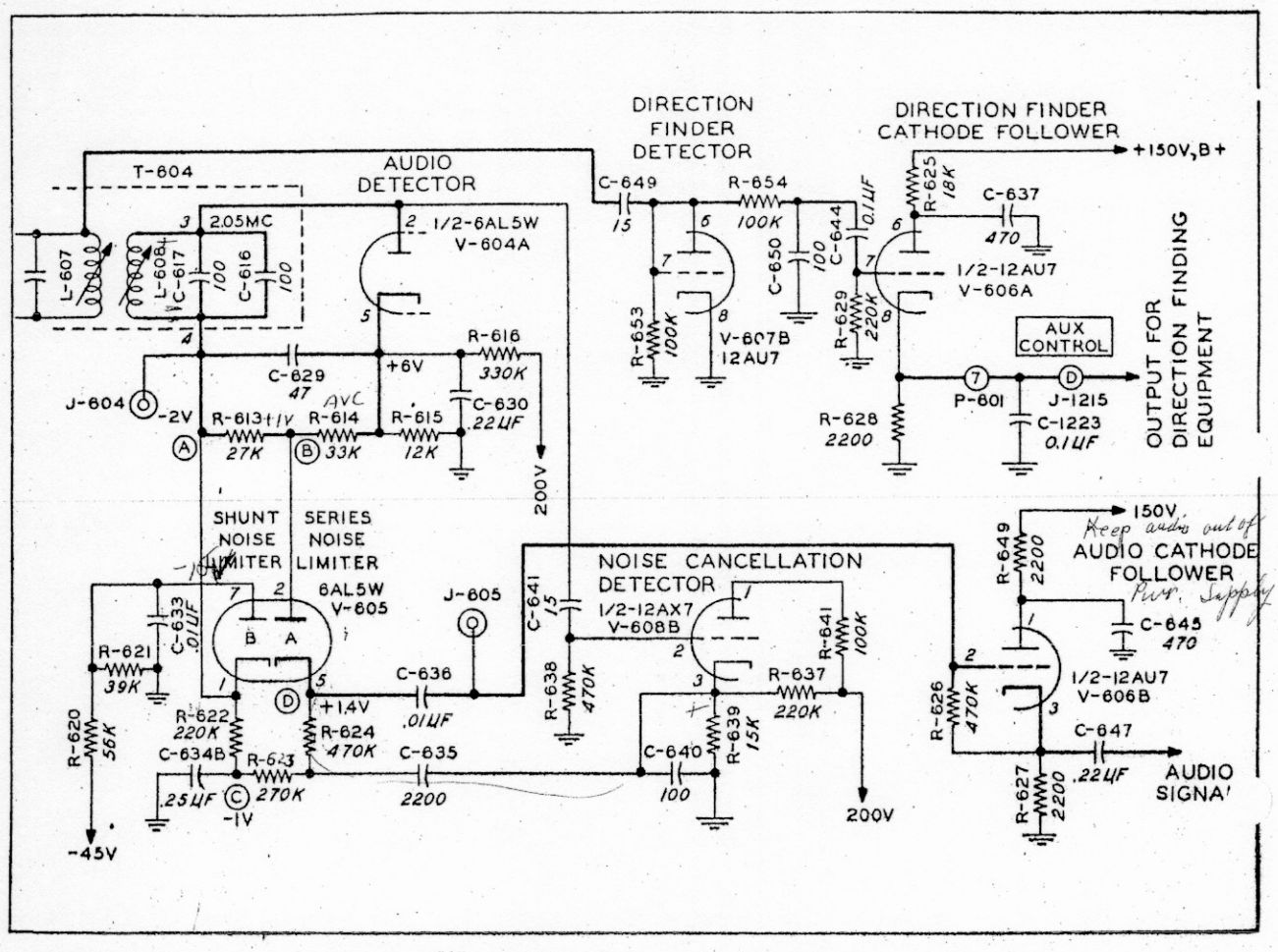


Figure 4-3. Audio Detector and Noise Limiters

the audio signal will be transmitted through the diode from point B to point D as long as the instantaneous potential of point B does not become more negative than that of point C. If this occurs, the electronic conduction of the diode will be cut off and point D will remain at the potential of point C until conduction is re-established. Downward modulation is not affected by this circuit.

The amount of noise energy remaining in the output of the series diode limiter circuit is further reduced by the introduction of noise pulses of about equal amplitude but of opposite polarity to cause noise cancellation. These pulses are generated by the noise cancellation detector V-608B. This tube operates as an "infinite impedance" type detector in which the i-f signal is applied to the grid of the tube and the detected output appears at the cathode. In this application, the tube is cathode biased by means of voltage divider R-637 and R-639 in series to about +15 volts so that only signals exceeding about 100% upward modulation will be detected. Noise pulses which will appear as positive pulses in the cathode circuit are coupled back into the output of the series diode limiter circuit by C-635.

A shunt type limiter has also been included in this receiver for the purpose of protecting the avc and squelch circuits from the effects of noise pulses. In this circuit, diode element V-605B is biased by means of voltage divider R-620 and R-621 to about -15 volts. When an i-f signal of peak amplitude greater than 15 volts is applied to this circuit, the diode conducts and effectively connects a very low impedance across the secondary of T-604 thus limiting the i-f voltage which can appear across it. This reduces the effect of noise impulses which ordinarily would generate appreciable avc voltage, thus reducing the sensitivity of the receiver to desired signals. Since the carrier operated relay control voltage is also developed by the avc detector-amplifier, this limiter also reduces the tendency of the silencer circuit to open in the presence of noise impulses.

2.11 Audio Cathode Follower

Referring to Figure 4-3, the audio cathode follower circuit consists of V-606B, 1/2 type 12AU7 tube. The audio output of the noise limiter circuit is coupled to the grid of V-606B. The output of this stage is developed across the cathode resistor, R-627 and is transmitted through shielded wire to the QUIETING and FREQUENCY RESPONSE controls.

2.12 Direction Finder Cathode Follower

Referring to Figure 4-3, the third i-f signal is detected by direction finder detector, V-607B, and the audio signal developed by this detector is coupled to the grid of V-606A by capacitor C-644. The output of this cathode follower stage is developed across cathode resistor R-628 and is transmitted to pin D of the AUXILIARY CONTROL connector.

2.13 AVC Detector and AVC Gate

Referring to Figure 4-4, the avc circuit consists of the avc detector V-604, type 6AL5W tube, and avc gate V-607A, 1/2 type 12AU7 tube, with associated circuit. Three controls on the front panel are associated with the avc circuit. These controls are AVC TIME CONSTANT switch, MAIN R-F GAIN control R-F GAIN switch (which is labelled LOCAL-AVC OFF-REMOTE). The purpose of the avc detector is to maintain the output of the receiver relatively constant for wide variations of signal input level. The purpose of the avc gate is to provide an avc voltage delay so that the weak signals will be able to come through with maximum amplification.

The two sections of the diode detector, V-604A and V-604B with associated circuit, form a voltage doubling circuit for the avc voltage. The cathode of V-604A is at about +6 volts due to bleeder current from the +200 volt supply through R-616 and R-615. This voltage is sufficient to keep V-607A cut off for low values of carrier signal strength and the gain of the r-f and i-f amplifiers will be determined by the setting of the R-F GAIN control R-1207. As the carrier level is increased the audio detector, V-604A (which is also a part of the avc circuit) develops an increasing negative voltage across its load (R-613 and R-614 paralleled by C-629). Likewise, the avc detector V-604B develops an increasing negative voltage across its load (R-618 paralleled by C-632). Since these two sections of the diode conduct on opposite halves of the cycle, the voltages developed across the two loads are in series and add. The combined voltage will appear at the plate of V-604B and the cathode of the avc gate V-607A. The grid of V-607A

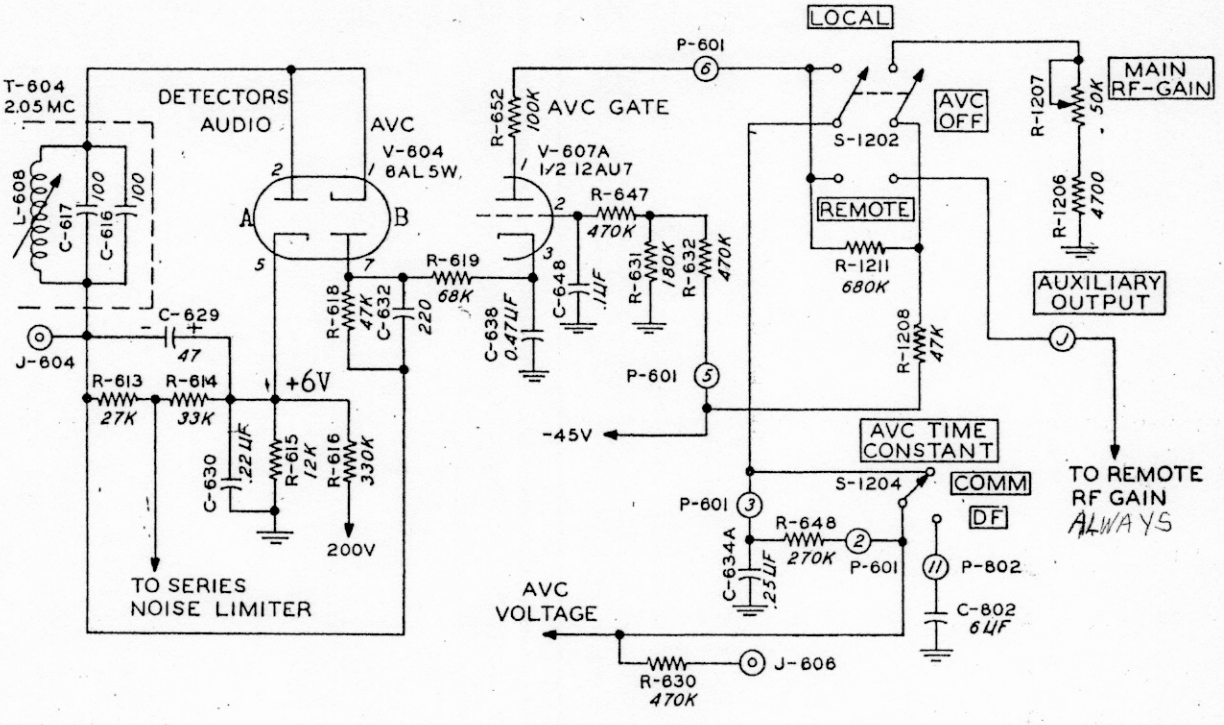


Figure 4-4. Avc Detector and Avc Gate

is at about -12 volts due to -45 volt bleeder current through R-632 and R-631. When sufficient input signal is applied, the cathode of V-607A will become sufficiently negative to cause the tube to conduct. The stronger the carrier signal, the more negative will be the cathode of V-607A, and the more it will conduct. The voltage drop across the plate load will cause the output avc voltage to become more negative, thereby decreasing the gain of the r-f and i-f amplifiers.

2.14 Remote R-F Gain Control

Referring to Figure 4-20, a remote R-F GAIN control may be used by connecting a 25,000 ohm potentiometer from pin J of the LOCAL CONTROL connector to ground.

2.15 AVC Time Constant

Referring to Figure 4-4, two time constants are provided by the AVC TIME CONSTANT switch, namely COMN (communication) position, which has a time constant of 0.1 second and DF (direction finder) position, which has a time constant of 2 seconds. With the MAIN R-F GAIN set to maximum, the avc voltage will vary from about -2 to -8 volts, depending on carrier signal strength.

2.16 Carrier-Operated Relay and Squelch Circuit

Referring to Figure 4-5, the receiver is provided with a carrier-operated relay, which is actuated by a two stage d-c amplifier that receives its control signal from the audio detector circuit. The circuits are designed so that the relay will be actuated whenever a carrier signal of sufficient amplitude (as determined by the setting of the MAIN R-F GAIN control) is received. The carrier-operated relay is provided with three sets of contacts as follows: s.p.s.t. contacts for operation of external equipment, s.p.s.t. contacts for operation of the MAIN CARRIER indicator lamp and s.p.d.t. contacts for operation of the audio squelch (silencing circuit). The carrier-operated relay circuit includes V-608A, 1/2 type 12AX7 tube, V-609, type 6C4 tube, and the carrier-operated relay, K-801. Two controls on the front panel, SQUELCH ON-OFF switch and QUIETING control are associated with the circuit.

A negative d-c voltage having audio frequency voltage superimposed is taken from the audio detector load and impressed on the grid of V-608A. Capacitor C-642 is an audio by-pass capacitor. The two stages of the circuit act as a one-kick multivibrator to assure positive activation of the carrier-operated relay.

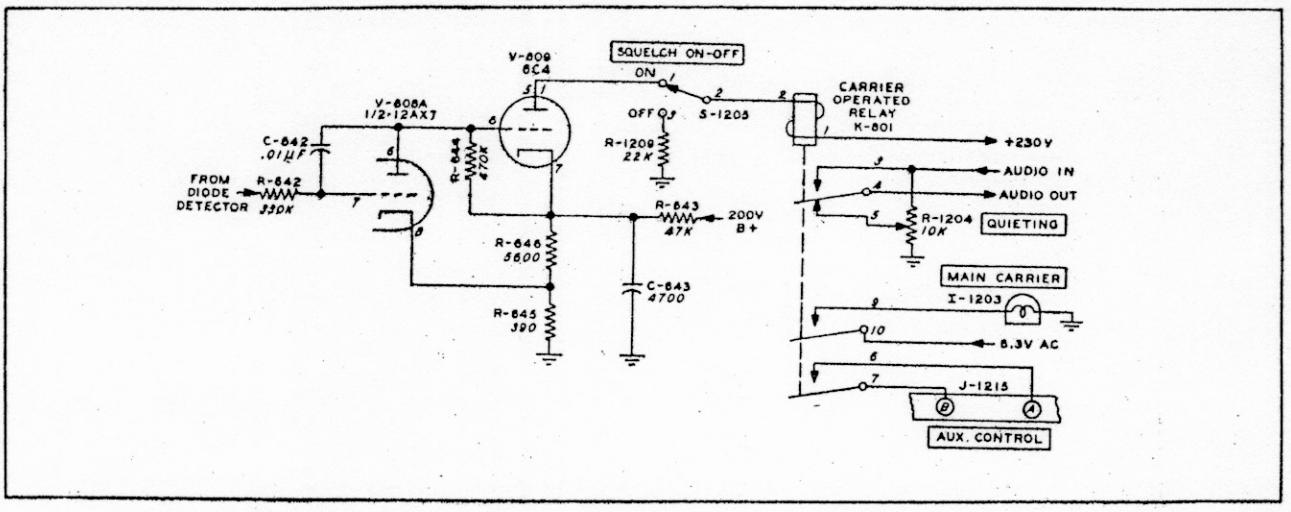


Figure 4-5. Carrier Operated Relay and Squelch Circuit

To understand the operation of the circuit, consider the case of a carrier signal being received after a period of no carrier input. With no carrier input (1) the diode detector tube, V-604, is not conducting, so there is no voltage developed across the diode load, R-613 and R-614 (see figure 4-3), (2) the voltage impressed on the grid of V-608A is about 6 volts as determined by the bleeder, R-616 and R-615, (3) V-608A is conducting, causing a voltage drop across R-644 which makes the grid of V-609 negative, and V-609 is virtually cut-off because of this biasing voltage. Now consider the reception of a carrier signal, (1) the grid of V-608A becomes negative because of the rectified voltage developed across the diode load, (2) current through V-608A decreases, (3) tube V-609 begins conducting because its grid is allowed to go positive, (4) cathode current of V-609 flowing through R-645 biases V-608A even more; this action being regenerative, V-608A is quickly cut off and (5) V-609 conducts to engerize the carrier-operated relay, K-801.

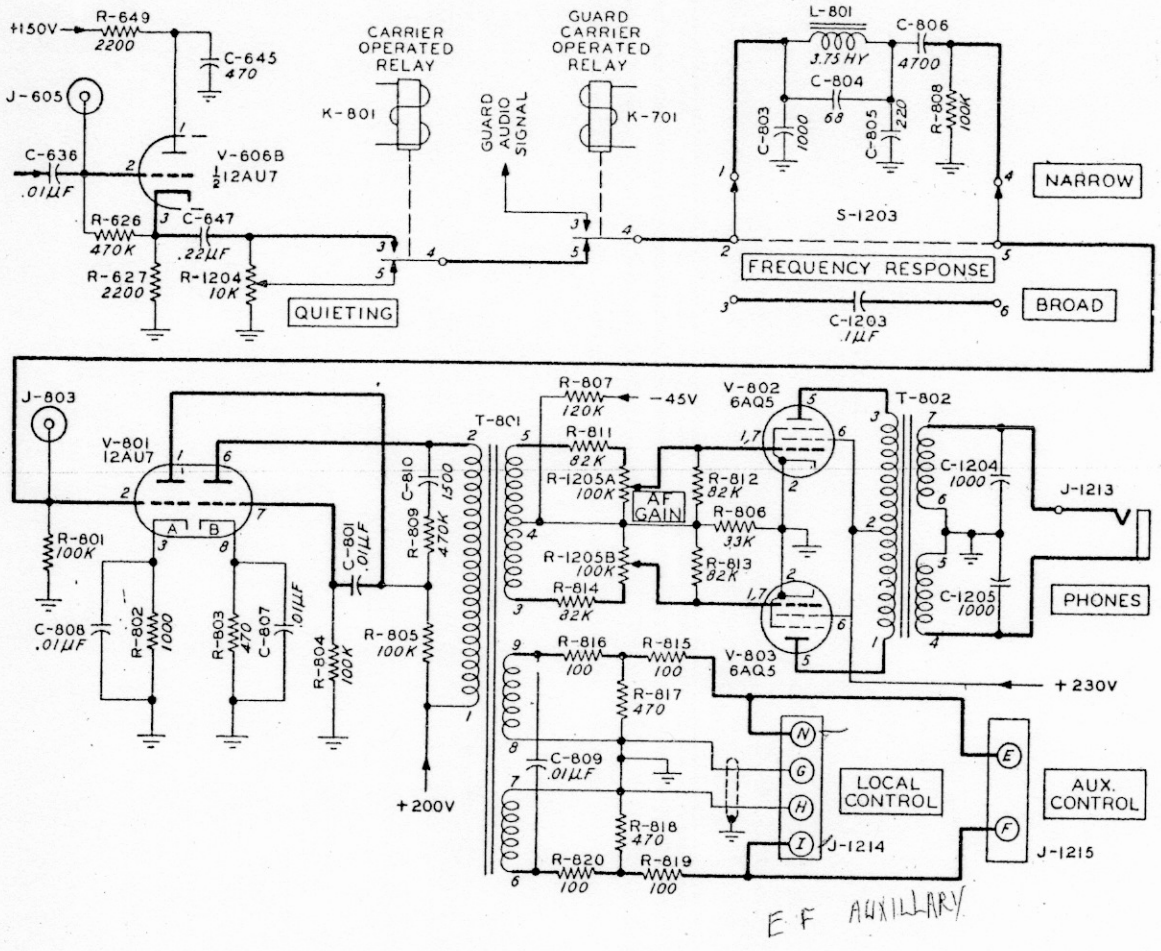


Figure 4-6. Audio Amplifier and Audio Controls

The carrier-operated relay, when activated, causes the MAIN CARRIER indicator lamp to be lighted, removes the QUIETING control from the audio amplifier circuit and provides facilities for operation of external equipment through pins on the AUXILIARY OUTPUT connector. With the SQUELCH switch in the ON position, operation of the carrier-operated relay is described above. In the OFF position, the carrier-operated relay remains actuated all times.

2.17 Audio Amplifier Circuits

Referring to Figure 4-6, the audio amplifier circuits includes a two stage amplifier, V-801, type 12AU7 tube, and push-pull amplifier V-802 and V-803, type 6AQ5 tubes. The audio signal controls consist of the QUIETING control, R-1204, the carrier-operated relay K-801, the audio bandwidth filter and the AUDIO GAIN control R-1205.

The audio signal developed at the cathode of V-606B passes through several audio control circuits before being applied to the grid of V-801. The purpose of the QUIETING control is to attenuate the receiver noise output any desired amount at the time no carrier signal is present. When a carrier signal of sufficient amplitude (as determined by the setting of the MAIN R-F GAIN control) is received the carrier-operated relay operates its contacts so that the audio signal by-passes the QUIETING control, goes through the audio bandwidth filter and to the grid of V-801. The audio FREQUENCY RESPONSE switch has two position, BROAD and NARROW. In the BROAD position capacitor C-1203 is switched into the circuit so that the 200 to 20,000 cps flat response characteristic of the receiver is employed. In the NARROW position the audio frequency response is limited to a narrow audio band as shown on page 4-5 of this chapter.

The audio signal from the bandwith control is amplified in the two-stage amplifier, V-801A and V-801B and impressed across the primary of the transformer T-801. Two of the secondary windings furnish a low level output for operation of external equipment. This level output appears at the LOCAL CONTROL and AUXILIARY CONTROL connectors. These two windings are ordinarily connected in series. The junction point (used as a center tap) may be connected directly to ground or the two leads may be individually by-passed to ground. The latter arrangement is provided for use with the "double simplex technique" in which a d-c control signal is carried over the same lines as are used for the audio signal. The other secondary winding of T-801 applies the signal through the AUDIO GAIN control, R-1205, to the grids of the push-pull amplifier stage consisting

of V-802 and V-803. The output of the push-pull amplifier appears across the output transformer T-802. A maximum of three watts output is available at the PHONES jack, J-1213 and at pins G and H of AUXILIARY CONTROL connector.

2.18 Power Supply Rectifier

Referring to Figure 4-7, the power supply rectifier consists of V-901, V-902 and V-903 working in conjunction with transformer T-901 to provide the plate supply, relay supply and bias supply. Transformer T-902 is used to provide the filament supply.

The receiver is energized by connecting power jack J-1216 to a source of 115 or 230 volt, 50 to 60 cycle power and turning on the POWER switch. The plate and filament transformers T-901 and T-902 employ dual winding primaries which are connected so that either 115 or 230 volt operation may be selected by operating switches S-901 and S-902, located on the power supply rectifier unit, to that position which agrees with the line voltage being used. When the POWER switch is turned on, the filament transformer, T-902, is instantly energized through fuse F-1202. A time delay of approximately 30 seconds provided by the thermal relay K-901 permits the rectifier filaments to reach operating temperature before the plate transformer is energized to apply plate voltage.

The rectifier section employing V-902, type 3B22 gas-filled rectifier, is a full-wave circuit which provides 115 volts d-c for the operation of the muting relay, K-802, and the various relays associated with the frequency selector mechanism. This section is connected in series with the full-wave rectifier section employing V-901, type 3B22 rectifier, to provide the plate supply for the operation of the receiver circuits. A half-wave rectifier, V-903, type 6X4W duo-diode, operates from the same secondary winding as V-902 to provide a negative bias supply voltage. Filament transformer T-902 is provided with a center-tapped-to ground 12.6 volt secondary winding, which provides filament voltage for the receiver, and two 2.5 volt secondary windings, which supply filament voltage for V-901 and V-902. To provide a 115 volt a-c supply

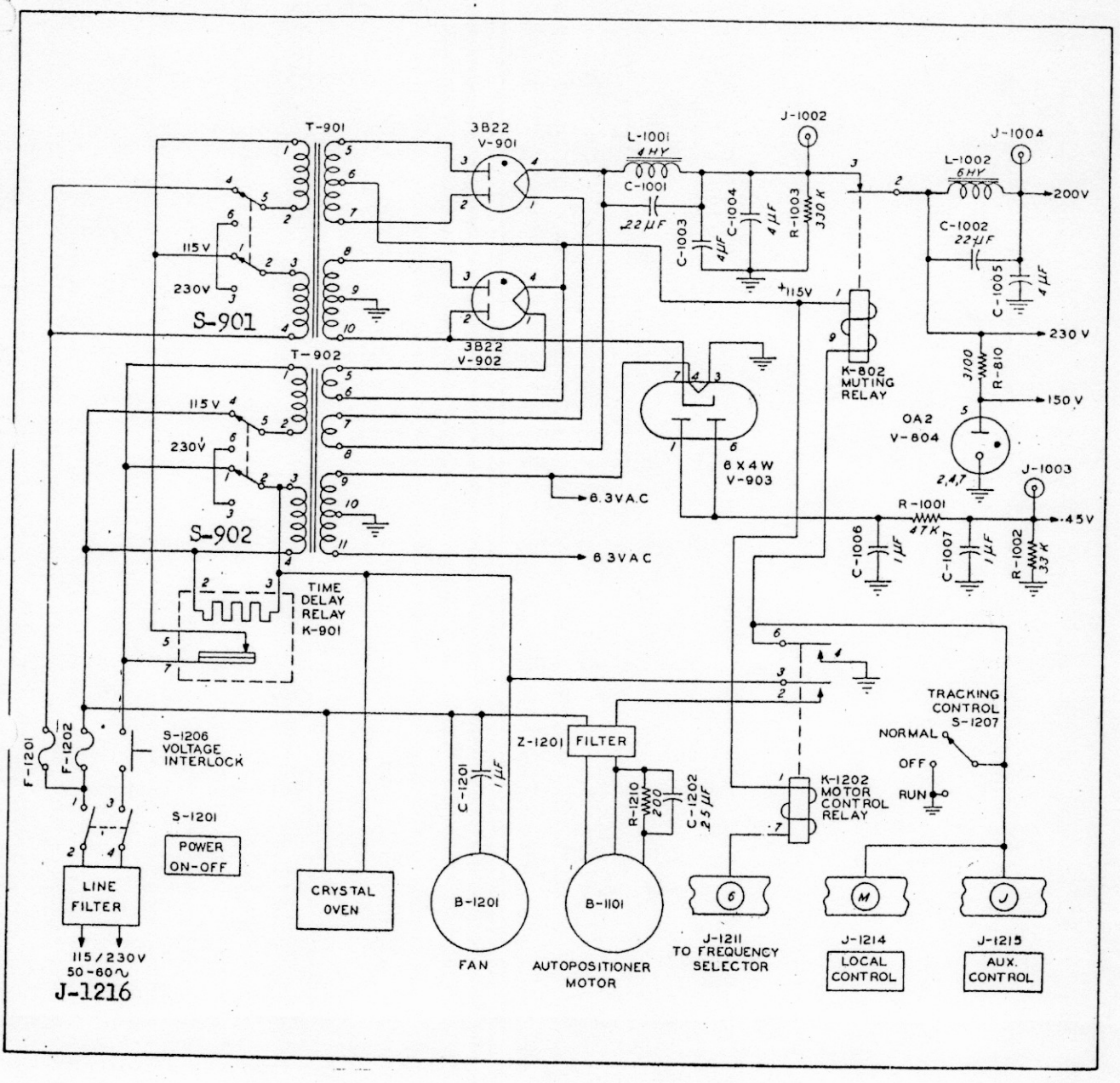


Figure 4-7. Power Supply and Control Circuits

for the operation of the thermal time delay relay, K-901, the blower motor B-1201, the frequency selector motor, B-1101, and the heater elements of the receiver crystal oven, the primary section of T-902 is employed as an autotransformer.

2.19 Power Supply Filter

Referring to Figure 4-7, the power supply filter is built up into three sections, the 230 volt section, the 200 volt section and the bias supply section. The 230 volt section is a choke input L section filter. The input choke, L-1001, is resonated with capacitor C-1001 at the second harmonic of the power frequency to supply additional filtering action. The 230 volt output of this filter section is led through the normally closed contacts of the muting relay, K-802, and back to the 200 volt filter section of the power supply filter where additional filtering occurs and the voltage is reduced to 200 volts. The bias supply filter section is a resistor-capacitor filter, the output of which is approximately -45 volts.

Voltage regulator tube V-804, type 0A2, which is located in the audio amplifier unit, may be considered as part of the power supply. This tube supplies a regulated 150 volt plate supply for the cathode follower circuits.

2.20 Muting Relay

Referring to Figure 4-7, the receiver is provided with a muting relay, K-802, whose principal function is to silence the receiver when used in conjunction with a transmitter. The relay is operated on 115 volts d-c and actuated by providing a ground connection to the relay coil. The muting relay can be actuated from an external source by grounding pin M of J-1214 or pin J of J-1215 and is automatically actuated whenever the frequency selector mechanism operates or whenever the tracking control switch S-1207 is set to off or Run. The muting relay interrupts the 230 volt plate supply.

3.0 FREQUENCY SELECTOR UNIT

The R-278B/GR receiver employs a frequency selector unit that automatically tunes the receiver. Physically, the frequency selector unit consists of two main parts. These two parts are the "pre-set panel"

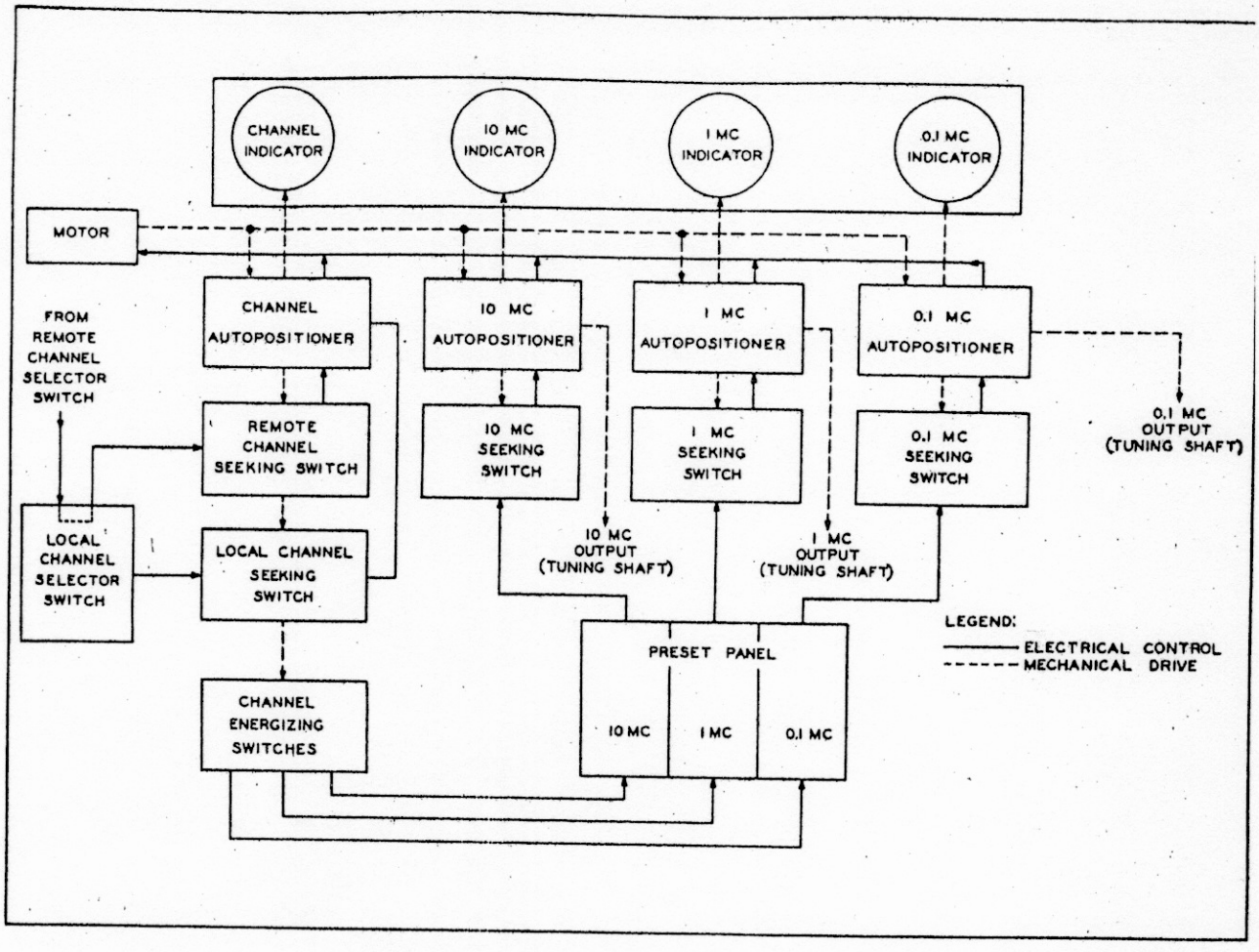


Figure 4-8. Block Diagram, Frequency Selector Unit

and the "autopositioner unit". (The frequency selector in the R-278B/GR receiver is identical to the frequency selector in the T-217A/GR transmitt and they are interchangeable). A block diagram of the frequency selector unit is shown in Figure 4-8 and the mechanical system is shown in Figure 4-13.

3.1 Pre-Set Panel

The receiver has eleven channels. The frequency of each channel is determined by the pre-set panel. The channel selector switch on the front panel of the receiver can be turned to any one of the eleven channels. Ten of the channels are numbered from 1 through 10. The eleventh channel is designated as the "manual" channel. When the channel selector switch is turned to any one of the eleven channels, the auto-positioner unit automatically tunes the receiver to the frequency that has been "set up" on the pre-set panel for that channel. There are three pre-set switches for each channel. The "tens" megacycle frequency is set up on the first switch, the "units" megacycle frequency on the second switch and the "tenths" megacycle frequency on the third switch. Since there are eleven channels there are eleven sets of pre-set switches. Referring to the schematic, Figure 4-19, the corresponding stator contacts of the first switch (10 mc) in each set are connected in parallel and the rotor contact of each switch connect to separate contacts on the 10 mc driven channel selector switch. The corresponding stator contacts of the second switch (1 mc) in each set are connected in parallel and the rotor contact of each switch connect to separate contacts on the 1 mc driven channel selector switch. Likewise, the corresponding stator contacts of the third switch (0.1 mc) in each set are connected in parallel and the rotor contact of each switch connect to separate contacts on the 0.1 mc driven channel selector switch.

In the lower right hand corner of the frequency selector unit schematic, Figure 4-19, the pre-set switches for the manual channel are shown. However, since there are eleven channels, there are 33 of these rotary switches in the pre-set panel. There is a knurled knob on each of the 33 pre-set switches. The frequencies are "set-up" by turning the knurled knobs until they indicate the desired frequency. For example, if 390.0 mc is desired on channel 2, the knurled knobs for channel 2 are turned until they indicate this frequency. The knurled knob on the first (10 mc) pre-set

switch is turned until 39 is indicated on the knob, the knurled knob on the second (1 mc) switch is turned until 0 is indicated on the knob and the knurled knob on the third (0.1 mc) switch is turned until .0 is indicated on the knob. When the channel selector switch is turned to channel 2 the receiver will automatically tune to 390.0 mc.

3.2 Autopositioner Units

The frequency selector unit employs four relay-controlled devices known as autopositioners. An autopositioner is a motor-driven mechanism which will position a shaft to any one of a number of fixed positions. These four autopositioners are called the 10 mc autopositioner, the 1 mc autopositioner, the 0.1 mc autopositioner and the channel selecting autopositioner. The 10 mc autopositioner tunes the receiver in 10 mc steps, the 1 mc autopositioner tunes the receiver in 1 mc steps, the 0.1 mc autopositioner tunes the receiver in 0.1 mc steps and the channel selecting autopositioner turns the driven channel selector switches, which in turn select the proper set of pre-set switches. The shaft of each autopositioner unit is connected through a slip clutch to a common shaft, which in turn is connected through a set of gears to a motor.

Referring to the frequency selector unit schematic, Figure 4-19, the OUTPUT shaft of the 10 mc, 1 mc, and 0.1 mc autopositioners tune the receiver. All four autopositioners turn a SEEKING switch and an INDICATOR dial. On each output shaft there is a notched stop wheel, which is held in position by a pawl. When the autopositioner relay is energized, the pawl releases the stop wheel and contacts on the relay closes the motor control circuit. For a complete tuning cycle, the 10 mc autopositioner output shaft makes 6 revolutions, the 1 mc autopositioner output shaft makes 2 revolutions, and the 0.1 mc autopositioner output shaft makes 1 revolution. Actually, the tuning could be performed by only 1 revolution of the output shaft of each autopositioner, because the shafts in the tuning units make 1 revolution for a complete tuning cycle. However, the torque would be too great on the slip-clutches of the 10 mc and 1 mc autopositioners, due to the fact that the load on these shafts is greater than the load on the shaft of the 0.1 mc

autopositioner. All shafts turn in one direction only, so a complete tuning cycle is when the receiver is tuned, starting at any frequency, and goes through all frequencies returning to the starting frequency.

3.3 Operation of the Tenth Megacycle Autopositioner

The output shaft of the 0.1 mc autopositioner tunes the receiver in 0.1 mc steps from XXX.0 to XXX.9 mc. In the tenth magacycle autopositioner, only the tenth mc part of the frequency is changed, therefore the other parts of the frequencies are shown in this discussion as an X. Since the above tuning would be 10 steps, it is necessary to stop the output shaft at 10 different positions, because the output shaft makes 1 revolution for a complete tuning cycle. The seeking switch S-1106 also makes 1 revolution for a complete tuning cycle, so it is driven directly by the output shaft. The notched stop wheel on the output shaft has 12 notches to correspond to the 12 positions of the seeking switch S-1106, however only 10 of these positions are used. The output shaft and the seeking switch turn in steps of 30 degrees when going from XXX.9 to XXX.0 mc, but the step from XXX.0 to XXX.9 mc is 90 degrees. This 90 degree step allows the tuning mechanism to return to the starting point of the tuning range, which is XXX.9 mc for the 0.1 mc part of the frequencies.

The 0.1 mc autopositioner is operated by the autopositioner relay K-1104. The left hand terminal of the relay winding has +115 volts d-c on it, supplied from terminal 12 of P-1101. The negative side of the power supply is grounded. Therefore, to energize the relay, a ground is needed on the right hand terminal. This ground is provided through the seeking switch S-1106, through one of the pre-set switches S-1129 through S-1139, through the DRIVEN CHANNEL selector switch S-1102E, then to terminal 5 of P-1101 which is grounded. When the ground circuit is completed, the relay K-1104 is energized, which pulls the pawl away from the stop wheel. At the same time, contacts on the relay close the motor control circuit and the output shaft starts turning. The other set of contacts places a resistance of 310 ohms in series with the relay winding after the relay is energized. This resistance limits the current through the relay winding. The output shaft will turn until the notch in the seeking switch S-1106 reaches the stator contact through whicl

the ground was provided. The ground is provided through only one of the stator contacts on the seeking switch. The stator contact that provides the ground depends upon the setting of the pre-set switch. When the notch in the seeking switch reaches the stator contact through which the ground was provided, the circuit to the relay winding will be opened, the relay will be de-energized, the pawl will be pulled by a spring and engage a notch in the stop wheel. The contacts for the motor control circuit will open, allowing the motor to stop. The purpose of the slip-clutch is to allow the stop wheel to stop in case the motor control circuit is still closed through the contacts on one of the other autopositioner relays.

Remember, that even though the corresponding stator contacts of the eleven pre-set switches S-1129 through S-1139 are connected in parallel, the rotor contact of each pre-set switch goes to separate contacts on the 0.1 mc driven channel selector switch S-1102E. The rotor of only one of the pre-set switches is grounded through the driven channel selector switch. The rotor that is grounded depends upon the position of the driven channel selector switch, whose position depends upon the channel selected. The rotor of the driven channel selector switch S-1102E is grounded through terminal 5 of P-1101. Therefore, the rotor of switch S-1102E puts a ground on one of the eleven stator contacts of S1102E. The eleven stator contacts on S-1102E are for the eleven channels. The way in which the driven channel selector switch is positioned to the desired channel will be discussed when the operation of the channel selecting autopositioner is described.

3.4 Operation of the Unit Megacycle Autopositioner

The output shaft of the 1 mc autopositioner tunes the receiver in 1 mc steps from XX0.X to XX9.X mc. In the 1 mc autopositioner, only the unit megacycle part of the frequency is changed. The output shaft makes 2 revolutions for a complete tuning cycle. The seeking switch S-1105 makes 1 revolution for a complete tuning cycle, so it is driven by the output shaft through a 2:1 gear ratio. Since the output shaft makes 2 revolutions while

the seeking switch makes 1 revolution, only 6 notches are needed on the stop wheel to correspond to the 12 positions of the seeking switch.

Other than the fact that the output shaft makes two revolutions for a complete cycle of tuning, the operation of the Unit Megacycle Autopositioner is identical to the operation of the Tenth Megacycle Autopositioner. The seeking switch is S-1105, the pre-set switches are S-1118 through S-1128, and the driven channel selector switch is S-1102D. The seeking switch turns in steps of 30 degrees when going from XX9.X to XX0.X mc, but the step from XX0.X to XX9.X mc is 90 degrees. This 90-degree step allows the tuning mechanism to return to the starting point of the tuning range, which is XX9.X mc for the 1 mc part of the frequencies. Since the output shaft makes 2 revolutions while the seeking switch makes 1 revolution, the output shaft turns in steps of 60 degrees, the last step being 180 degrees.

3.5 Operation of the Ten Megacycle Autopositioner

The output shaft of the 10 mc autopositioner tunes the receiver in 10 mc steps from 22X.X to 39X.X mc. In the 10 mc autopositioner, only the 10 mc part of the frequency is changed. Since most of the 10 mc tuning is by means of variable capacitors, only 3 revolutions of the output shaft are used for tuning, while the other 3 revolutions are used to return the capacitors to their starting point. Remember, that all shafts turn in only one direction. Since the above tuning would be 18 steps, it is necessary to stop the output shaft at 6 positions for each of the first 3 revolutions. There are 6 notches on the stop wheel to correspond with the 6 positions for each revolution. The output shaft turns in steps of 60 degrees for the first 3 revolutions, while the last step would be 3 revolutions (1080 degrees).

The seeking switch is not as simple as the seeking switch for the 1 mc and 0.1 mc autopositioners. If an 18 position switch could be used, then the operation would have been similiar to the operation of the 1 mc and 0.1 mc

seeking switches. However, a two-section switch is used, with 12 positions on each switch. Only 9 positions in each section is used to give the required 18 positions. In order to use a two section switch, it is necessary to use a blanking switch. The seeking switch is S-1103, with one section being shown as S-1103A and the other section as S-1103B. The blanking switch is shown as S-1104. Since the output shaft stops at 6 positions for each of the first 3 revolutions of the output shaft, it would stop at 9 positions for the first 1 1/2 revolutions (540 degrees). These 9 positions are controlled by the "A" section of the seeking switch. The blanking switch S-1104 keeps the "B" section shorted during this time. Since the output shaft drives the seeking switch through a 2:1 gear ratio, the seeking switch turns 270 degrees during the first 1 1/2 revolutions of the output shaft. Section "B" of the seeking switch controls the 9 positions for the second 1 1/2 revolutions of the output shaft. The blanking switch S-1104 keeps the "A" section shorted during this time. When the output shaft has turned through all 18 positions (3 revolutions), the seeking switch has turned through 1 1/2 revolutions (540 degrees). During the remaining 3 revolutions of the output shaft, which returns the capacitors to their starting point, the seeking switch turns through 1 1/2 revolutions. The blanking switch shorts both sections of the seeking switch during this time. In other words, when the output shaft makes 6 revolutions, the seeking switch makes 3 revolutions, and during the 3 revolutions of the seeking switch the blanking switch shorts the "B" section during the first 270 degrees, shorts the "A" section during the second 270 degrees and shorts both sections during the remaining 540 degrees. The blanking switch makes 1 revolution during this time.

The "A" section of the seeking switch controls the 9 positions from 39X.X to 31X.X mc. The "B" section controls the 9 positions from 30X.X to 22X.X mc. The driven channel selector switch for the ten megacycle autopositioner is S-1102C. The circuit from the seeking switches to the 10 mc autopositioner relay K-1102 goes through a tracking control switch connected to terminals 13 and 14 of P-1101. Normally, the circuit is closed between these two terminals.

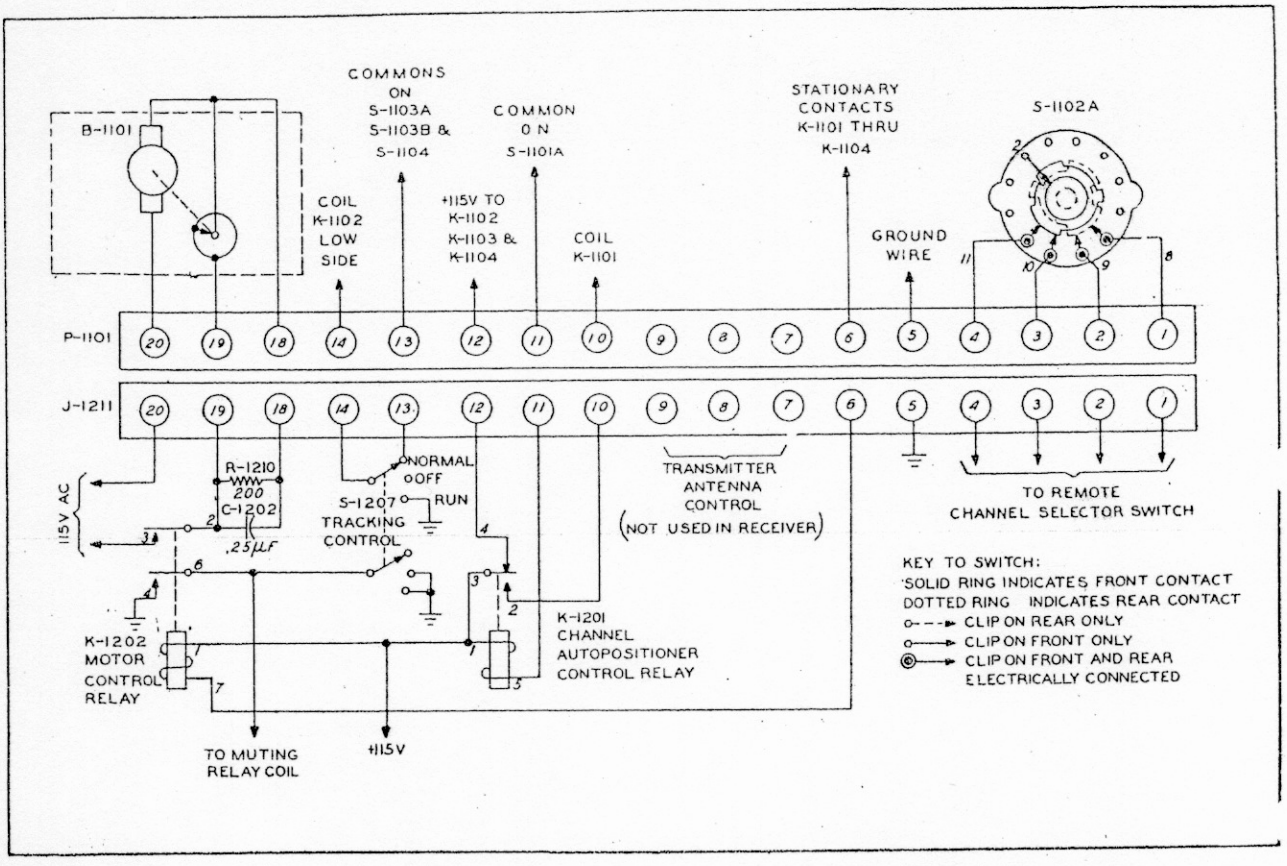


Figure 4-9. External Connections of Frequency Selector Unit.

3.6 Operation of the Channel Selecting Autopositioner

Instead of positioning tuning shafts, as is done in the other three autopositioners, the channel selecting autopositioner positions the shaft of the three driven channel selector switches, S-1102C, S-1102D and S-1102E. These three driven channel selector switches provide a ground on the rotor of the desired set of pre-set switches. In this autopositioner, the relay K-1101 has its right hand terminal grounded and the relay operation is controlled in the +115 volt d-c circuit, which is connected to the left hand terminal of the relay. When the +115 volt d-c circuit is closed to the channel selecting autopositioner, it is opened to the relays of the other three autopositioners. The reason for this is to keep the tuning

autopositioners from operating until the channel selecting autopositioner has positioned the driven channel selector switches. In other words, the channel selecting autopositioner completes its function before the other three autopositioners start their function. The channel selecting autopositioner has two seeking switches, S-1102A and S-1102B. S-1102B is used when the channels are selected by the local channel selector switch on the front panel of the receiver. S-1102A is used when the channels are selected by the remote channel selector switch. When the remote channel selector switch is used, the local channel selector switch must be placed in the remote position.

3.7 Local Channel Selection

Figure 4-9 shows the control circuit which is external to the frequency selector unit but directly associated with it. Referring to Figures 4-9 and 4-19, note that S-1101B has no function in the receiver, but is included to make the receiver frequency selector unit interchangeable with that of the transmitter.

The seeking switch S-1102B controls the operation of the channel autopositioner control relay K-1201, which in turn controls the +115 volts d-c to the autopositioner relays. Relay K-1201, which is shown in Figure 4-9, is normally de-energized and in this position allows +115 volts d-c to be applied to terminal 12 of P-1101, which in turn connects to the three tuning autopositioners. When relay K-1201 is energized, the d-c voltage is removed from terminal 12 of P-1101 and is applied to terminal 10 of P-1101, which in turn connects to the channel selecting autopositioner relay K-1101. The operation of relay K-1201 is controlled by the seeking switch S-1102B. This relay has +115 volts d-c connected to one side of its winding. The other side connects to terminal 11 of P-1101. Then, to energize this relay, a ground is needed on terminal 11 of P-1101. The ground is supplied through the rotor of the local channel selector switch S-1101A, then through one of its stator contacts, then through the corresponding stator contact on the seeking switch S-1102B, then through

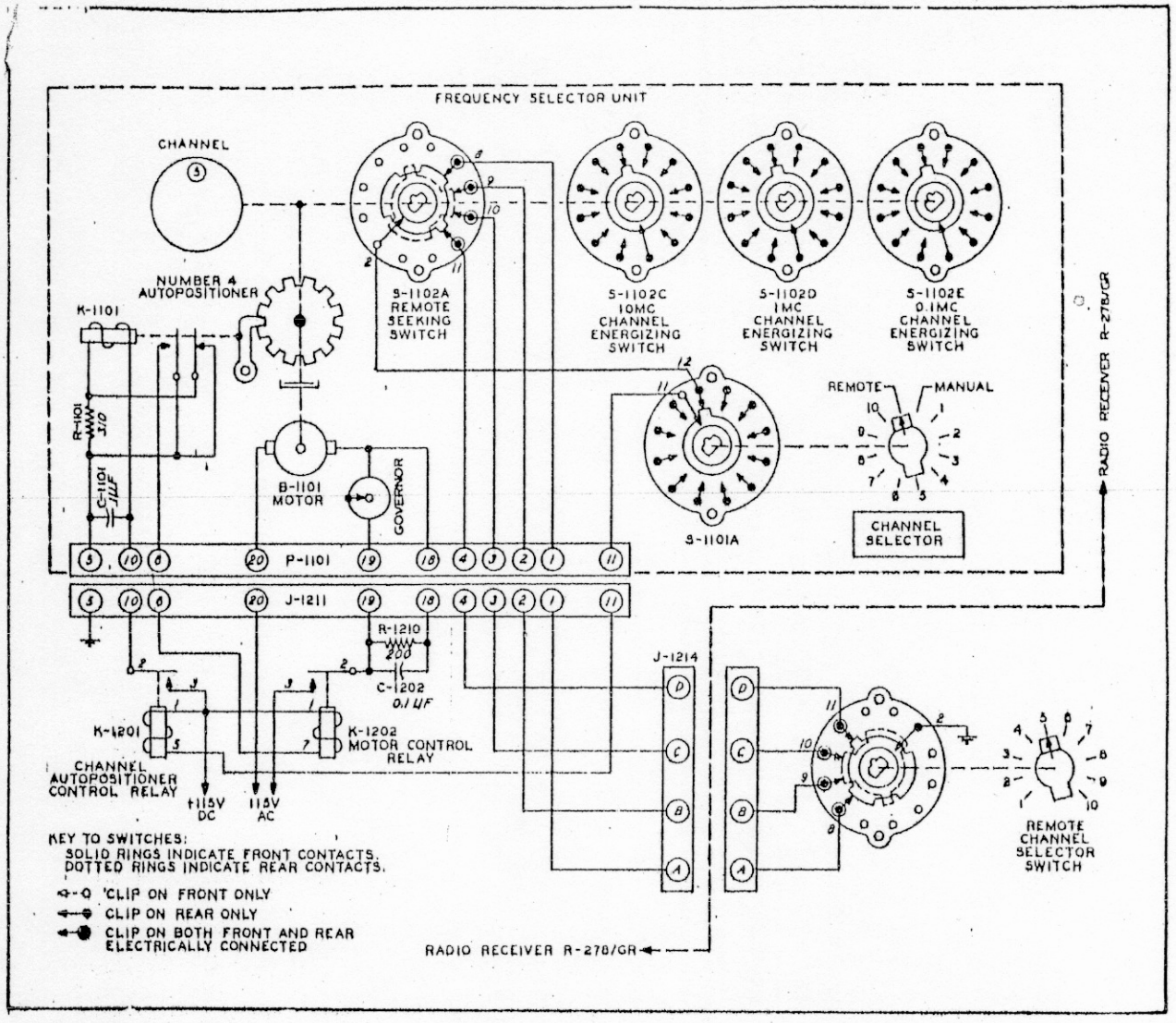


Figure 4-10. Remote Control of Frequency Selector Unit

the rotor contact of the seeking switch to ground. The stator contact of S-1101A through which the ground is supplied depends upon the position of S-1101A. When the notch in the seeking switch S-1102B reaches the stator contact through which the ground is supplied, the ground to K-1201 will be removed. Relay K-1201 will be de-energized and the +115 volts d-c will be removed from the channel selecting autopositioner relay and transferred to the relays of the other autopositioners.

Since the seeking switch and the driven channel selector switches are on the autopositioner shaft, the driven channel selector switches will be positioned for the selected channel.

3.8 Remote Channel Selection

Referring to Figure 4-10, the remote channel selector switch has only 10 positions. The manual channel can not be selected from the remote position. For remote channel selection, the local channel selector is turned to the remote position. The ground for the channel autopositioner control relay K-1201, is now supplied to terminal 11 of P-1101 through the rotor of S-1101A, through the stator contact of S-1101A, through the remote seeking switch S-1102A, through 4 wires that connect to the remote channel selector switch, then through the remote channel selector switch to ground.

In order to use a system of 4 wires and a ground to select 10 channels, special rotary type switches are used. Referring to Figure 4-12, each switch consists of two rotor blades mounted on opposite sides of the switch rotor and insulated from each other. Referring to the table in Figure 4-12, ten combinations of connections for the 4 wires are set up as the remote channel selector switch is rotated. The rotor contact of the remote channel selector switch makes contact with the front rotor blade, while the rotor contact of the remote seeking switch S-1102A makes contact with the rear rotor blade. At each position of the switches, the wires are always making contact with either the front or rear rotor blades, but never make contact to both at the same time. The circuit to the relay is open only when the two switches have the same position, therefore when the remote channel selector switch is turned, the relay will be energized and the remote seeking will turn until it reaches the same position as that to which the remote channel selector switch was turned.

This system of 4 wires and a ground can also be explained by referring to Figure 4-11, in which a system of single-pole double-throw switches are used. As shown, each seeking switch is in the same position as the corresponding remote switch and the circuit to the relay is open. When any one of the remote switches is thrown to a different position, the relay

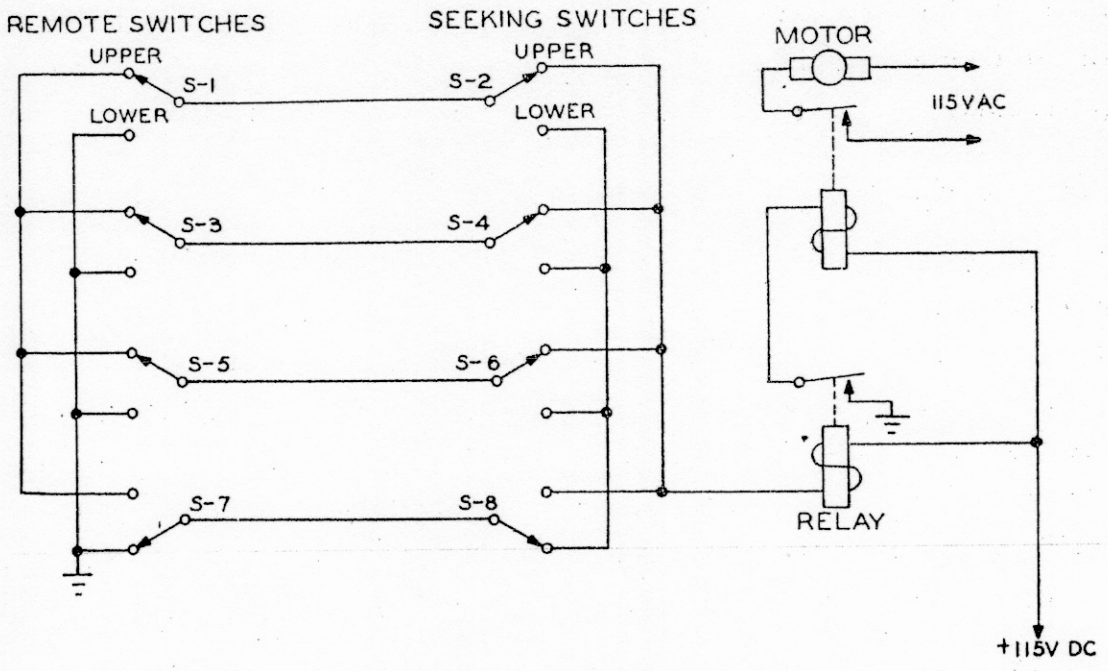
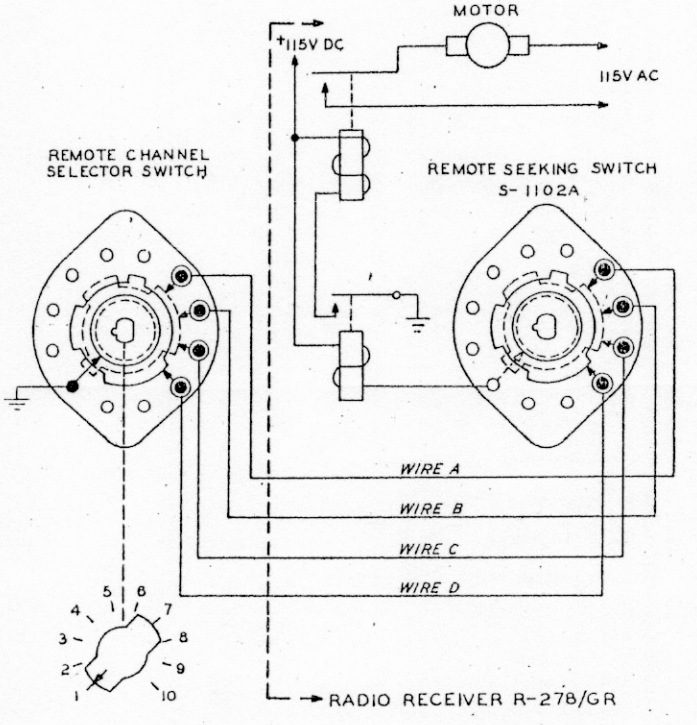


Figure 4-11. Basic Diagram of Binary Control System



CHANNEL	WIRE			
	A	B	C	D
1				X
2	X			
3		X		
4			X	
5	X			X
6	X	X		
7		X	X	
8	X		X	X
9	X	X		X
10	X	X	X	

INDICATES WIRE GROUNDED IN REMOTE CHANNEL SELECTOR SWITCH

NOTE:
SOLID RINGS INDICATE FRONT CONTACTS
DOTTED RINGS INDICATE REAR CONTACTS

KEY TO SYMBOLS:
FRONT CLIP
REAR CLIP
FRONT & REAR CLIPS

Figure 4-12. Channel Coding of Remote Selector Switches

4.0 MECHANICAL DRIVE SYSTEM FOR RECEIVER TUNING

The frequency selector unit mechanically drives the tuning mechanism of the following units: Second I-F Amplifier, First I-F Amplifier, Main Oscillator, Frequency Multiplier-Amplifier, and R-F Amplifier.

4.1 Frequency Selector Unit Mechanical Drive

Referring to Figure 4-13, the motor B-1101 is energized at a time when one or more autopositioner pawls have lifted from their stop-wheels. The following is a typical operation:

The channel autopositioner becomes energized so that its pawl releases the stop wheel and a set of contacts energized the motor; the motor drives the four clutch plates through a series of gears; only the channel autopositioner shaft turns. All other clutches slip, since their pawls lock the stop-wheels; the channel indicator and channel switches set up, which action energizes the other three autopositioners; the channel autopositioner pawl engages its stop-wheel and the other three pawls release their stop-wheels; the motor drives the three frequency determining autopositioners through their clutches; the 0.1 mc autopositioner uses a direct drive output and the indicator dial is geared 1:1 to the output shaft; the 1 mc output uses a gear ratio of 2:1 to drive the 1 mc indicator dial and a gear ratio of 2:1 to drive the 1 mc shafts (see figure 4-14). Therefore, the 1 mc autopositioner must make two complete revolutions to complete a tuning cycle; the 10 mc autopositioner is geared to the tuning mechanism in such a way that six complete revolutions of the 10 mc autopositioner are required to complete a tuning cycle. Seeking switches S-1103A and S-1103B make three revolutions, blanking switch S-1104 one revolution and the 10 mc indicator dial two revolutions.

4.2 Second I-F Amplifier Unit Tuning

Referring to Figure 4-14, the second i-f amplifier has one mechanical input, that from the 0.1 mc autopositioner shaft. The gearing ratio is 1:1, so that one revolution of the 0.1 autopositioner shaft effects a complete tuning cycle

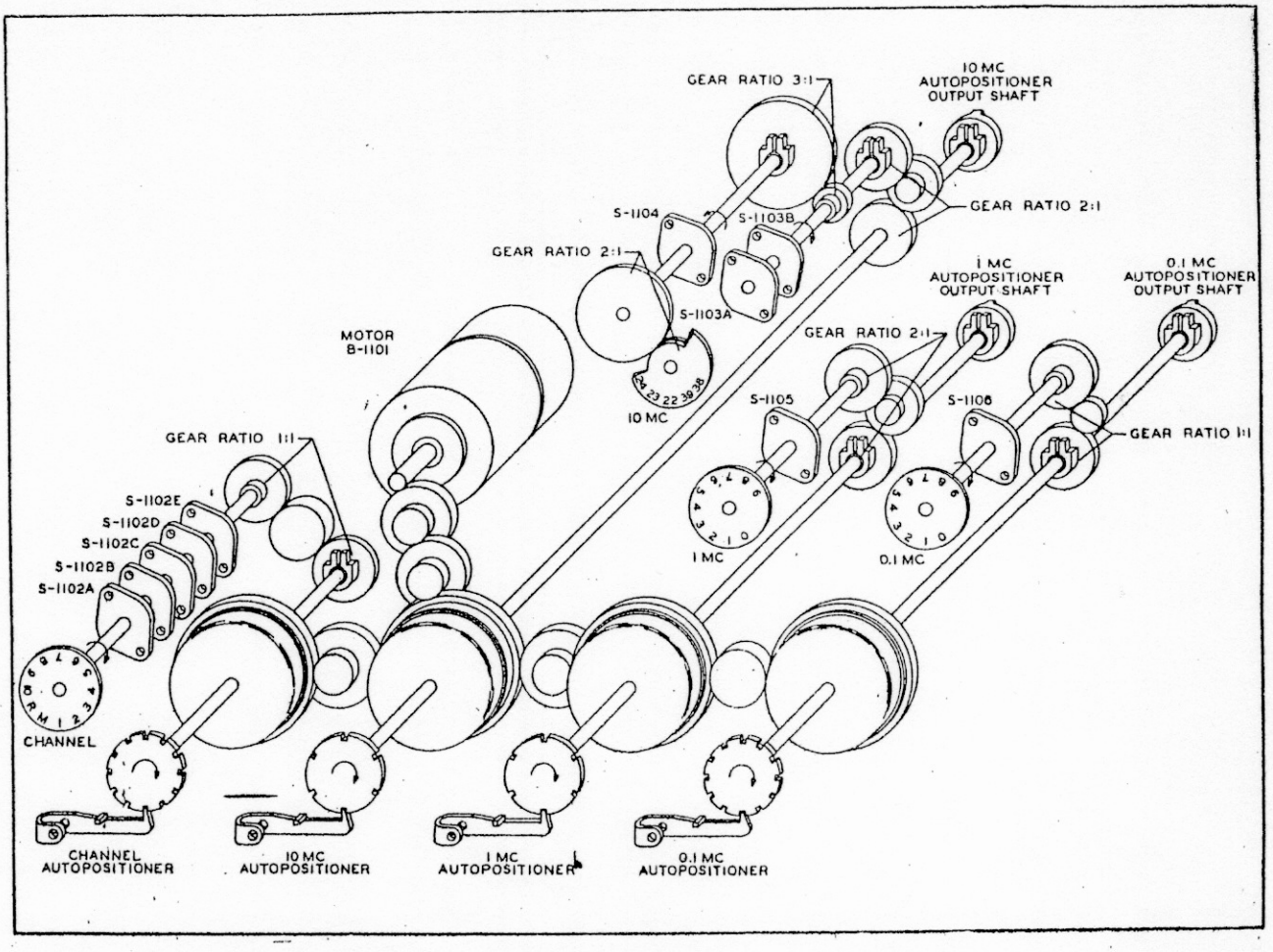


Figure 4-13. Frequency Selector Unit, Mechanical Drive System

of the second i-f amplifier. Two cams mounted on the tuning shaft of the second i-f amplifier turn 270 degrees to raise the tuning-core table from its lowest to its highest position to permeability tune the primaries and secondaries of T-501 and T-502. The remaining 90 degrees of cam travel allows the tuning rack to drop to its lowest position, which represents the highest tuning frequency. A rotary crystal-selector switch, having ten active positions in 270 degrees, is mounted on the end of the tuning shaft to select the proper third oscillator crystal unit for the receiver frequency selected.

4.3 First I-F Amplifier Unit Tuning

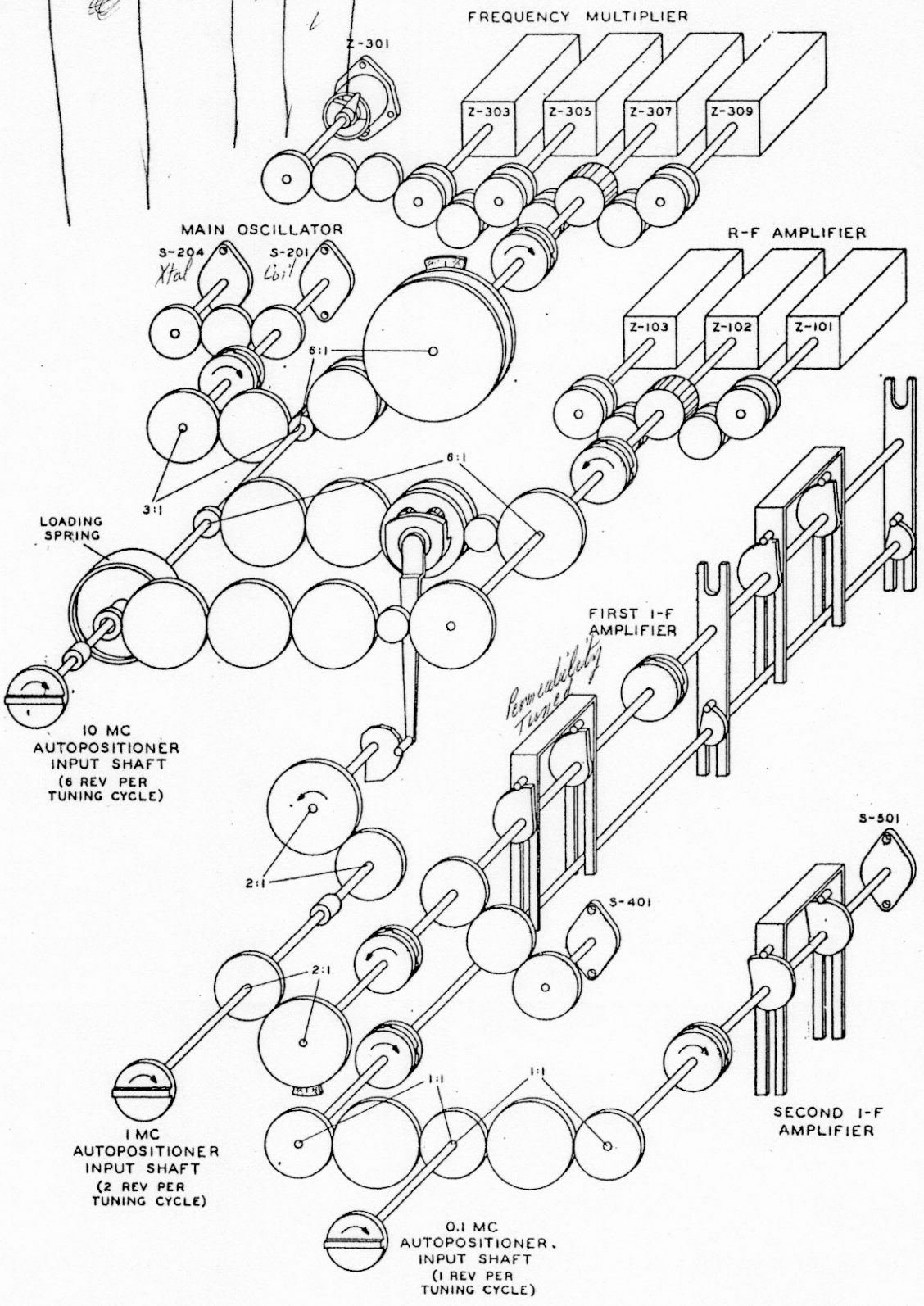
The first i-f amplifier unit receives two mechanical inputs on two parallel tunning shafts. The input from the 0.1 mc autopositioner is geared 1:1 through an idler gear and the input from the 1 mc autopositioner is geared 2:1 since the 1 mc autopositioner makes two revolutions for one tuning cycle.

The i-f transformers, T-401 and T-402, are permeability-tuned by a differential tuning core table which combines the inputs from the 1 mc and the 0.1 mc autopositioners to provide 100 tuning steps. The cams mounted on the floating 1 mc tuning shaft position the tuning core table in ten steps similiar to the tuning of the second i-f amplifier. The cams mounted on the 0.1 mc tuning shaft displace this 1 mc tuning shaft in 10 steps.to provide a vernier adjustment of the tuning core table position. The Oldham-type sliding coupler permits the floating 1 mc tuning shaft to be thus displaced.

The tuned circuits associated with the second oscillator are permeability tuned in 10 steps by a tuning core table positioned by means of two cams mounted on the fixed-bearing 1 mc tuning shaft. The crystal-selector switch of the second oscillator is operated from the fixed-bearing 1 mc tuning shaft through an idler gear.

4.4 Main Oscillator Unit Tuning

The main oscillator unit crystal-selector switch and coil-selector switch are driven from the 10 mc autipositioner shaft through a 3:1 gear reduction. Since the 10 mc autipositioner shaft makes six revolutions per tuning cycle, these selector switches make two complete revolutions per cycle. The first revolution provides 18 rotor positions for the selection of the proper crystal and coil for the selected receiver frequency. The second revolution occurs at the time the tuners of the frequency multiplier-amplifier and the r-f amplifier of the frequency mulitplier-amplifier are in the unused 180 degrees of their tuning cycle.



138/4
2/58

Figure 4-14. Receiver Tuning, Mechanical Drive System

4.5 Frequency Multiplier-Amplifier Unit Tuning

The tuning shaft of the frequency multiplier-amplifier is driven by the 10 mc autopositioner shaft through two stages of gear reduction which provide a speed reduction of 6:1. Thus, the tuners make 1 revolution per tuning cycle. The first 180 degrees of rotation provide the 18 operating positions of the tuners. The second 180 degrees of rotation return the tuners to the beginning point of their cycles. The gears employed in the reduction drive are of the split spring-loaded type to reduce possible inaccuracy due to backlash.

The tuners of the frequency multiplier are driven by the tuning shaft through a system of spur gears which, with the exception of the gears driving the toroidal step tuner, are also of the split spring-loaded type.

4.6 R-F Amplifier Unit Tuning

The r-f amplifier tuning shaft is driven from the 10 mc autopositioner shaft through a gearing system which includes a planetary-type differential in which the tuning information provided by the 10 mc autopositioner shaft is combined with tuning information provided by the 1 mc autopositioner shaft to provide 180 operating positions of the r-f amplifier tuners. The 1 mc input is accomplished by a rocker arm driving a pinion of the planetary gear system. This rocker arm is actuated by a cam driven from the 1 mc autopositioner shaft. This cam has its periphery radius-stepped, so that the rocker arm always rides on circle segments with increasing radius as the frequency increases from the zero position through the nine positions.

The driving gears provide a 3:1 speed reduction from the 10 mc autopositioner shaft and an additional 2:1 reduction is obtained in the differential mechanism. Thus the tuning shaft makes 1 revolution per tuning cycle to provide 18 primary tuning positions each of which is divided into 10 steps as determined by the setting of the 1 mc autopositioner shaft operating through the differential mechanism. Thus 180 positions covering 180 degrees rotation are provided. The tuning shaft is coupled back to the 10 mc autipositioner shaft through a system of loading gears and a helical spring to provide spring-loading of the entire gear train. The r-f amplifier tuners are driven by the tuning shaft through a system of spur-gears employing split spring-loaded gears.

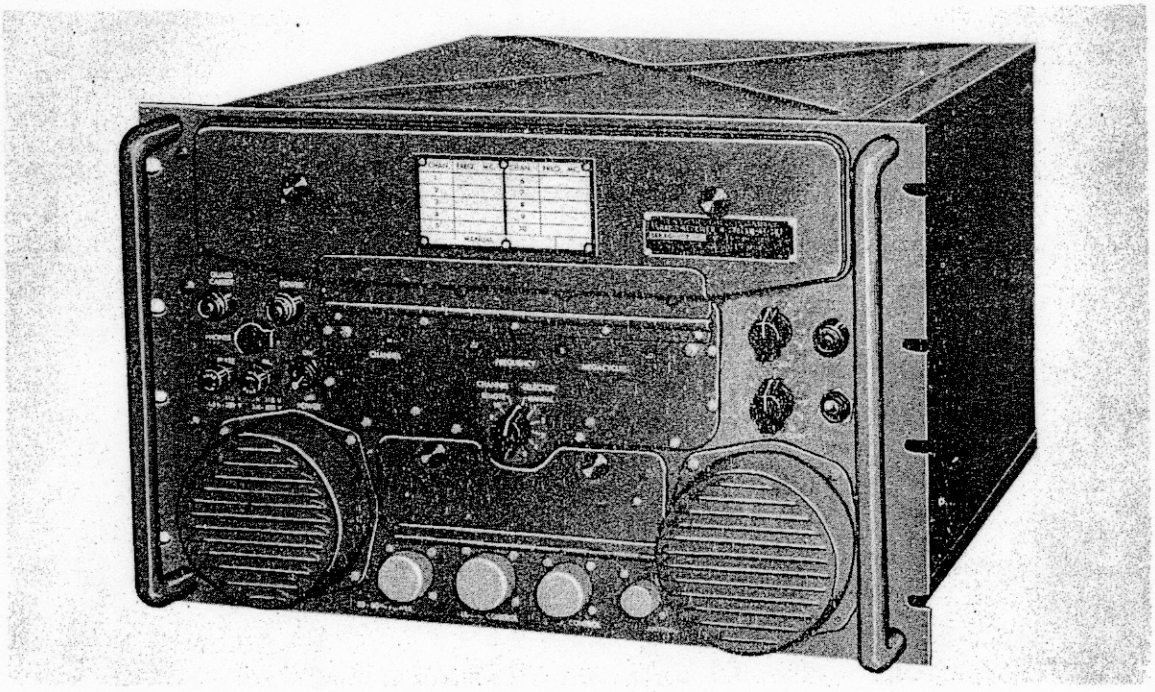


Figure 4-15. Radio Receiver R-278/GR

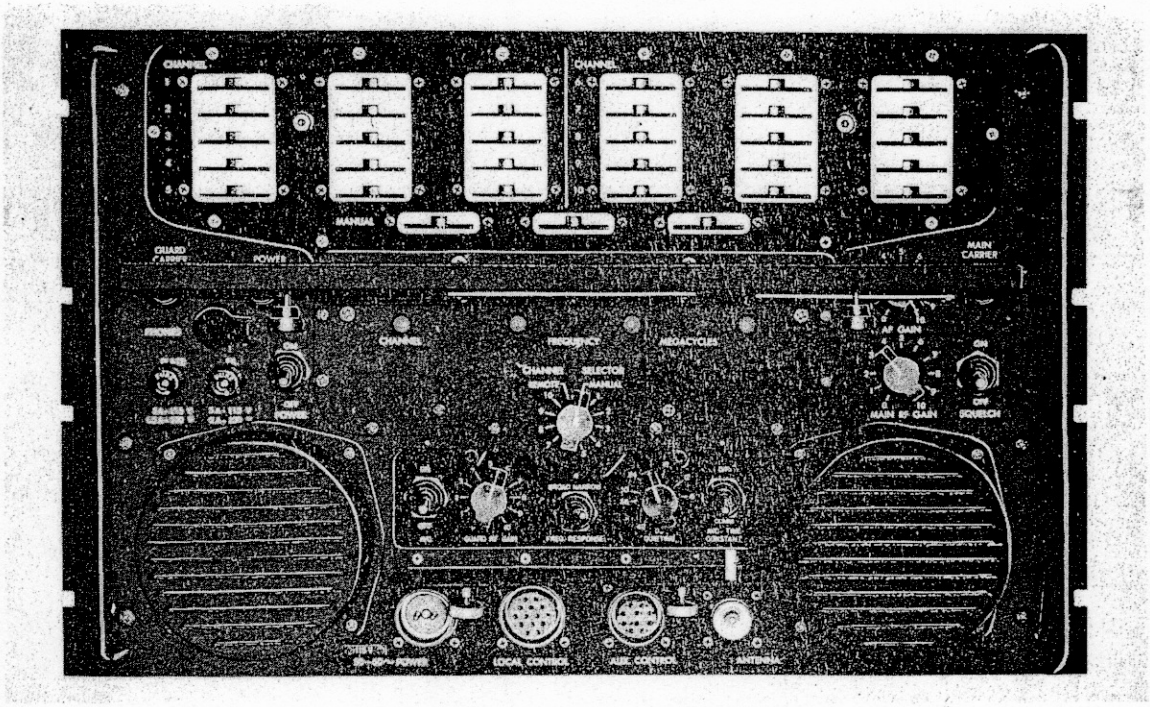


Figure 4-16. Radio Receiver R-278/GR, Controls

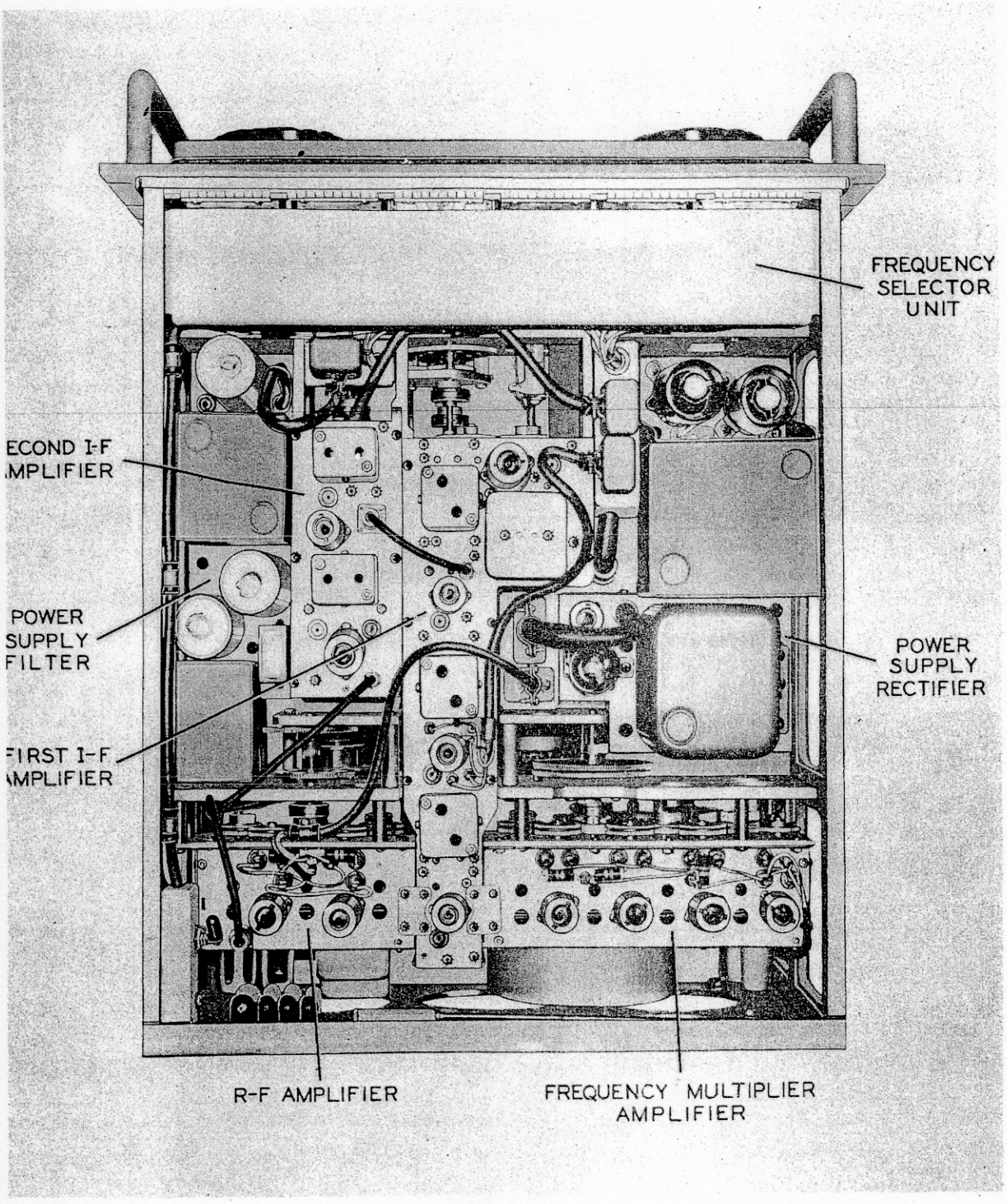


Figure 4-17. Radio Receiver R-278/GR Sub-Unit Arrangement, Top View

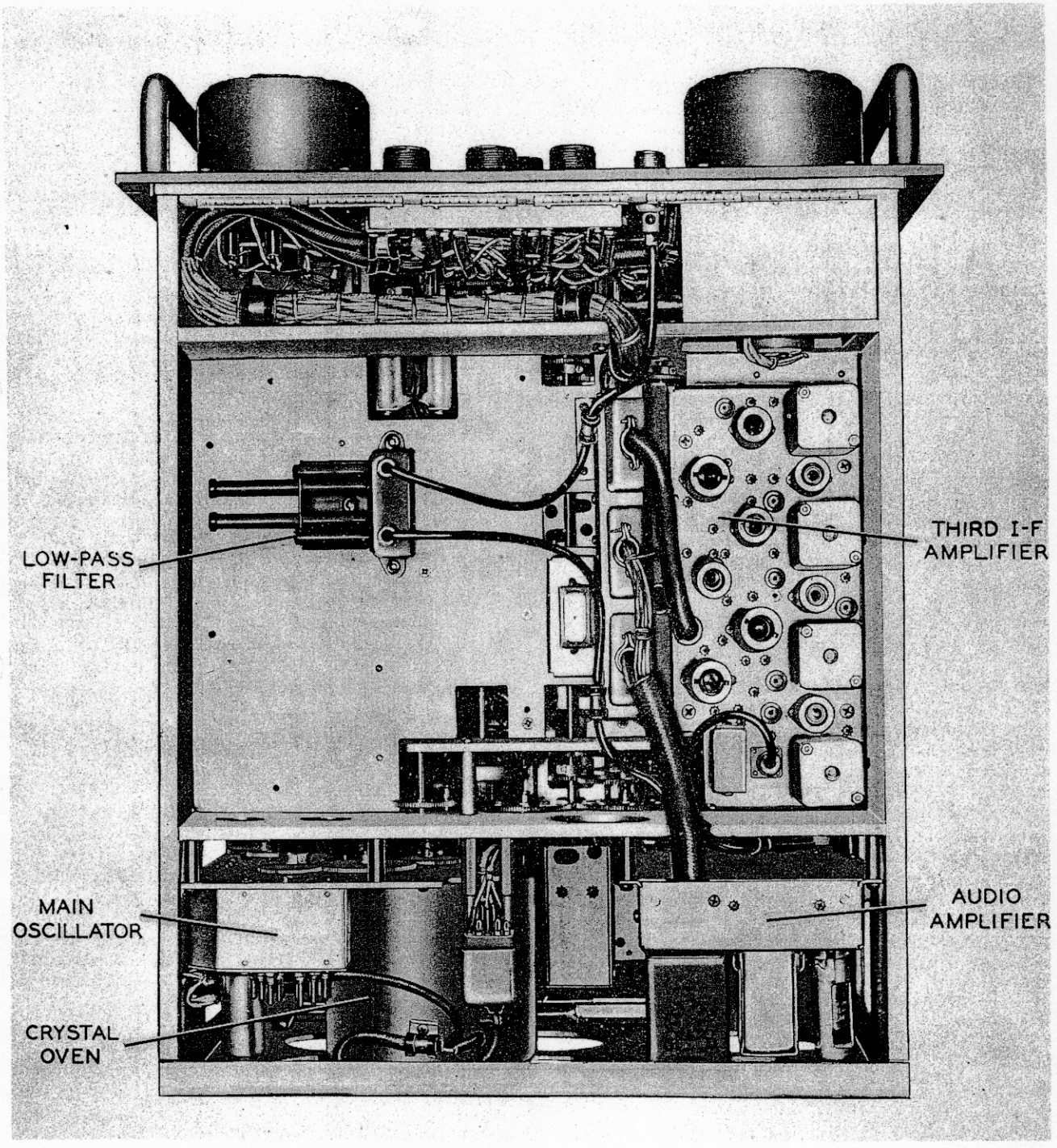
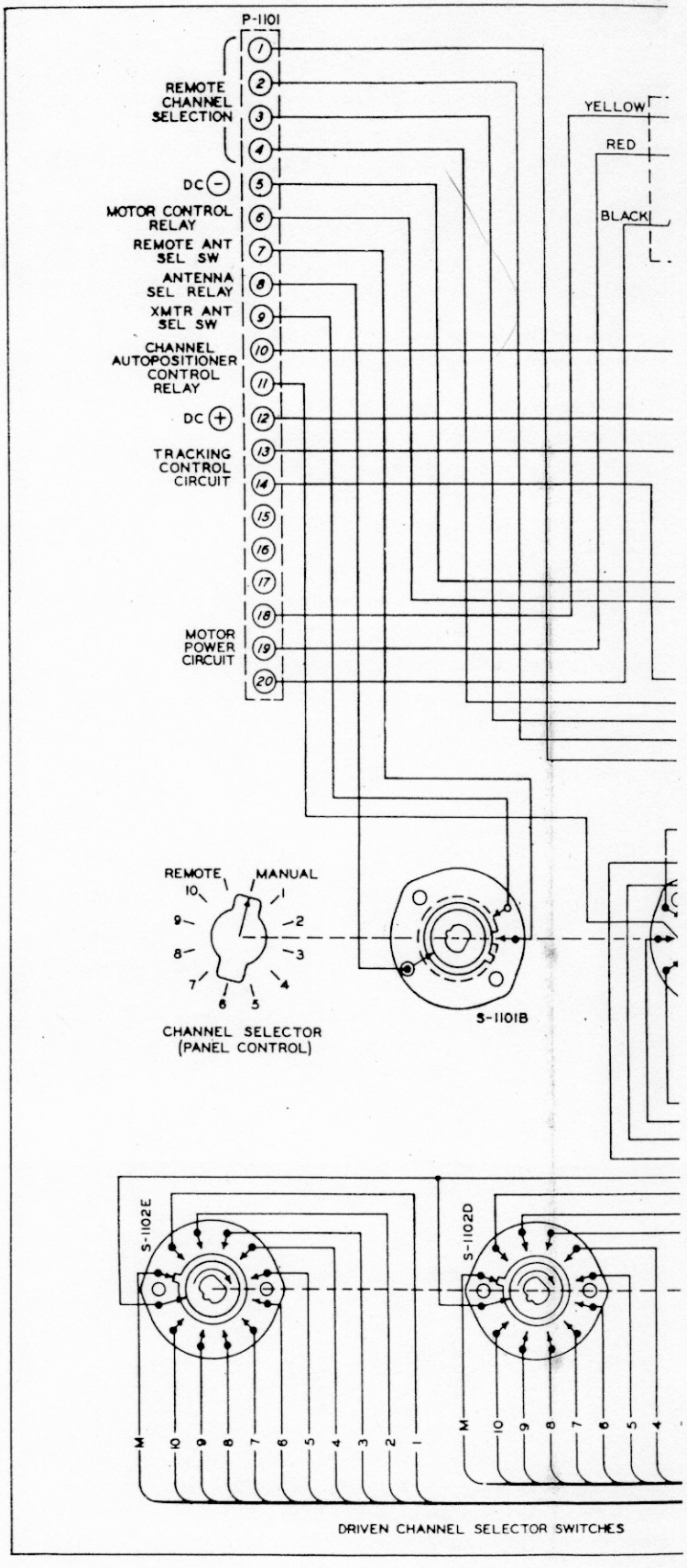
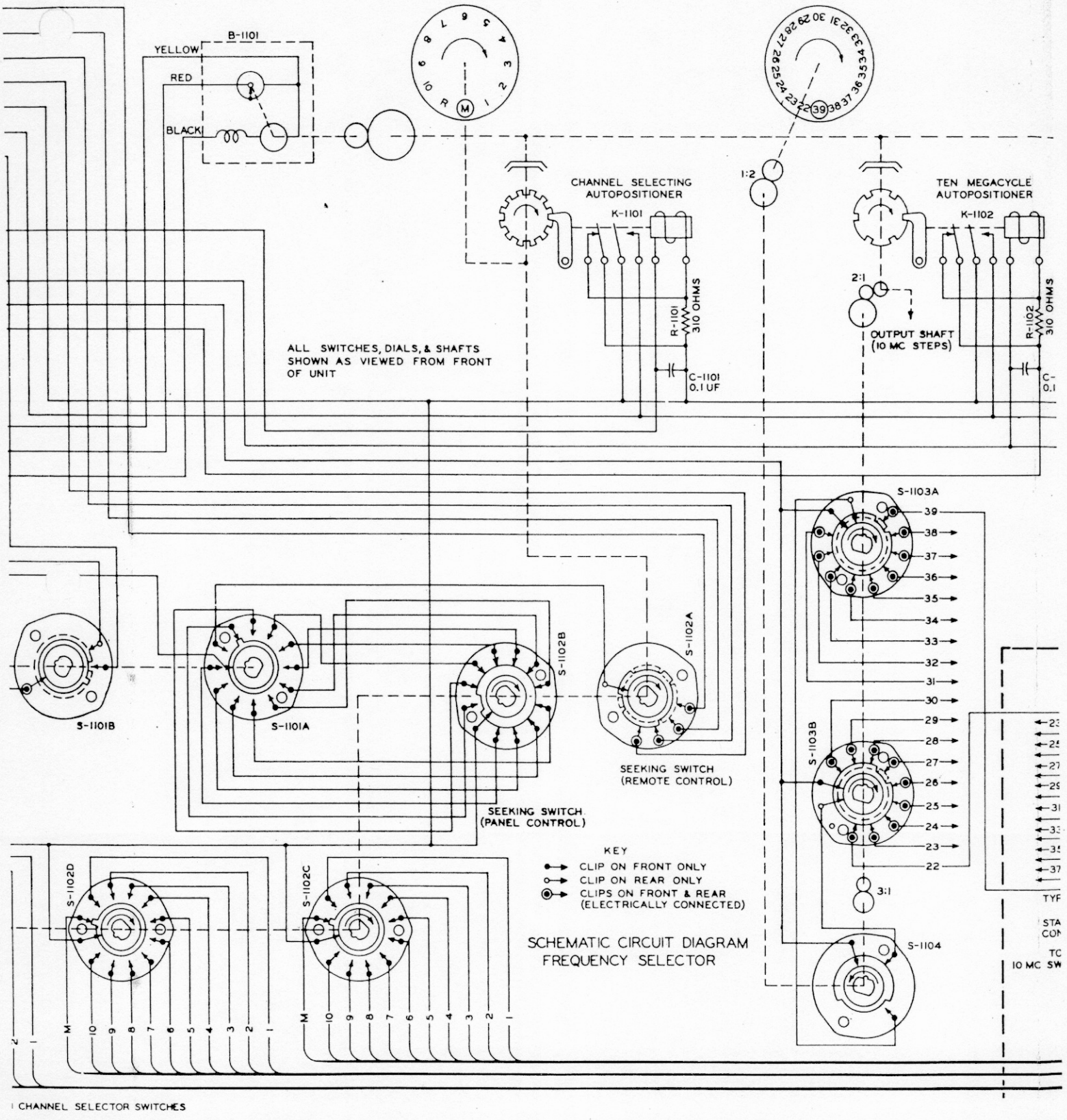


Figure 4-18. Radio Receiver R-278B/GR Sub-Unit Arrangement, Bottom View


P-1101
REMOTE CHANNEL SELECTION
DC (−)
MOTOR CONTROL RELAY
REMOTE ANT SEL SW
ANTENNA SEL RELAY
XMTR ANT SEL SW
CHANNEL AUTOPOSITIONER CONTROL RELAY
DC (+)
TRACKING CONTROL CIRCUIT
MOTOR POWER CIRCUIT
YELLOW
RED
BLACK
REMOTE
MANUAL
S-1101B
CHANNEL SELECTOR (PANEL CONTROL)
S-1102E
S-1102D
M
DRIVEN CHANNEL SELECTOR SWITCHES


B-1101
YELLOW
RED
BLACK
CHANNEL SELECTING AUTOPOSITIONER
K-1101
TEN MEGACYCLE AUTOPOSITIONER
K-1102
1:2
2:1
3:1
OUTPUT SHAFT (10 MC STEPS)
R-1101 310 OHMS
R-1102 310 OHMS
C-1101 0.1 UF
ALL SWITCHES, DIALS, & SHAFTS SHOWN AS VIEWED FROM FRONT OF UNIT
S-1101B
S-1101A
S-1102B
S-1102A
S-1103A
S-1103B
S-1104
S-1102D
S-1102C
SEEKING SWITCH (REMOTE CONTROL)
SEEKING SWITCH (PANEL CONTROL)
KEY
CLIP ON FRONT ONLY
CLIP ON REAR ONLY
CLIPS ON FRONT & REAR (ELECTRICALLY CONNECTED)
SCHEMATIC CIRCUIT DIAGRAM
FREQUENCY SELECTOR
CHANNEL SELECTOR SWITCHES

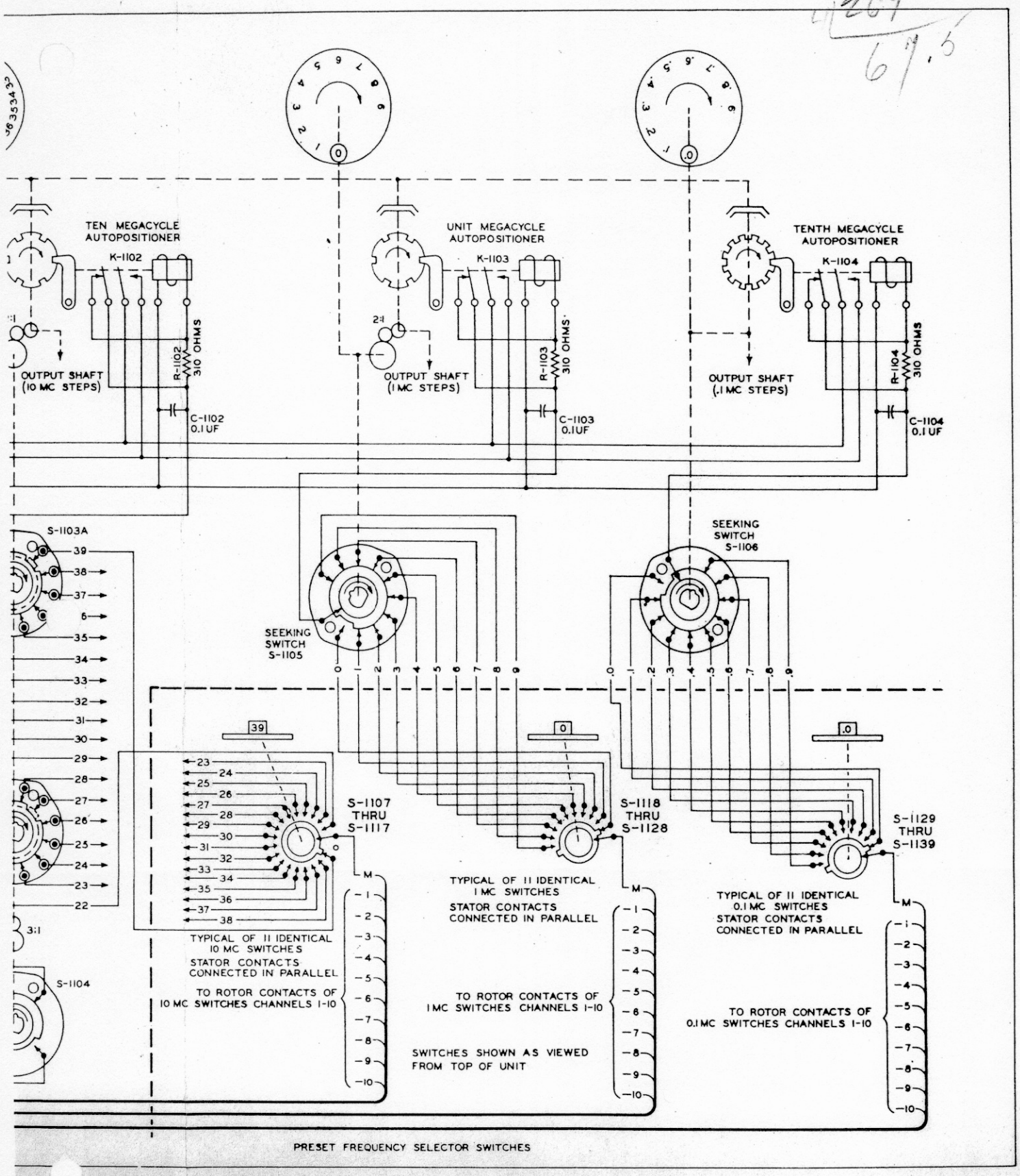
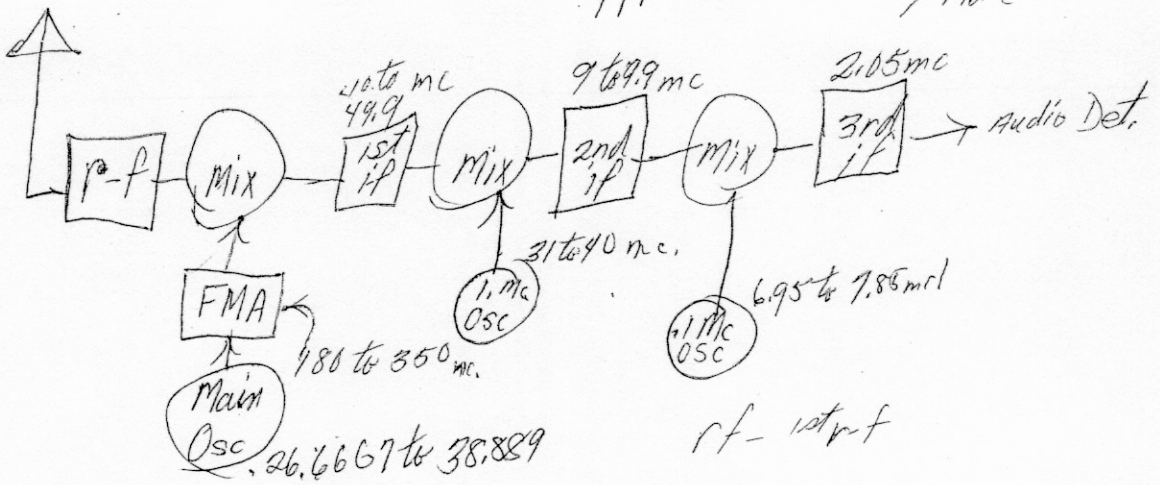


Figure 4-19 Frequency Selector Unit

9 ÷ X

< less
> more



x 9

1st i-f 40 mc last two digits of injection freq.

Main Osc ÷ by 9

2nd i-f — 3rd i-f = .1 mc. osc. freq.
2.05

Main Osc. Butler - 18 CR-32/U xtals Range 26.6667 to 38.8889
1 mc " " 10 CR-23/U " " 31 to 40
mc Pierce modified Colpitts 10 CR-18/U " " 6.95 to 7.85

FM 2 multi.
1st doubling or tripling
2nd always tripling
+3 amp 6.

Range 180 to 350 mc.

1st if 40 to 49.9 mc.
2nd if 9.69.9 mc
3rd if fixed 2.05

1st - image rejection
3rd if selectivity
2nd if to acquire additional freq ranges

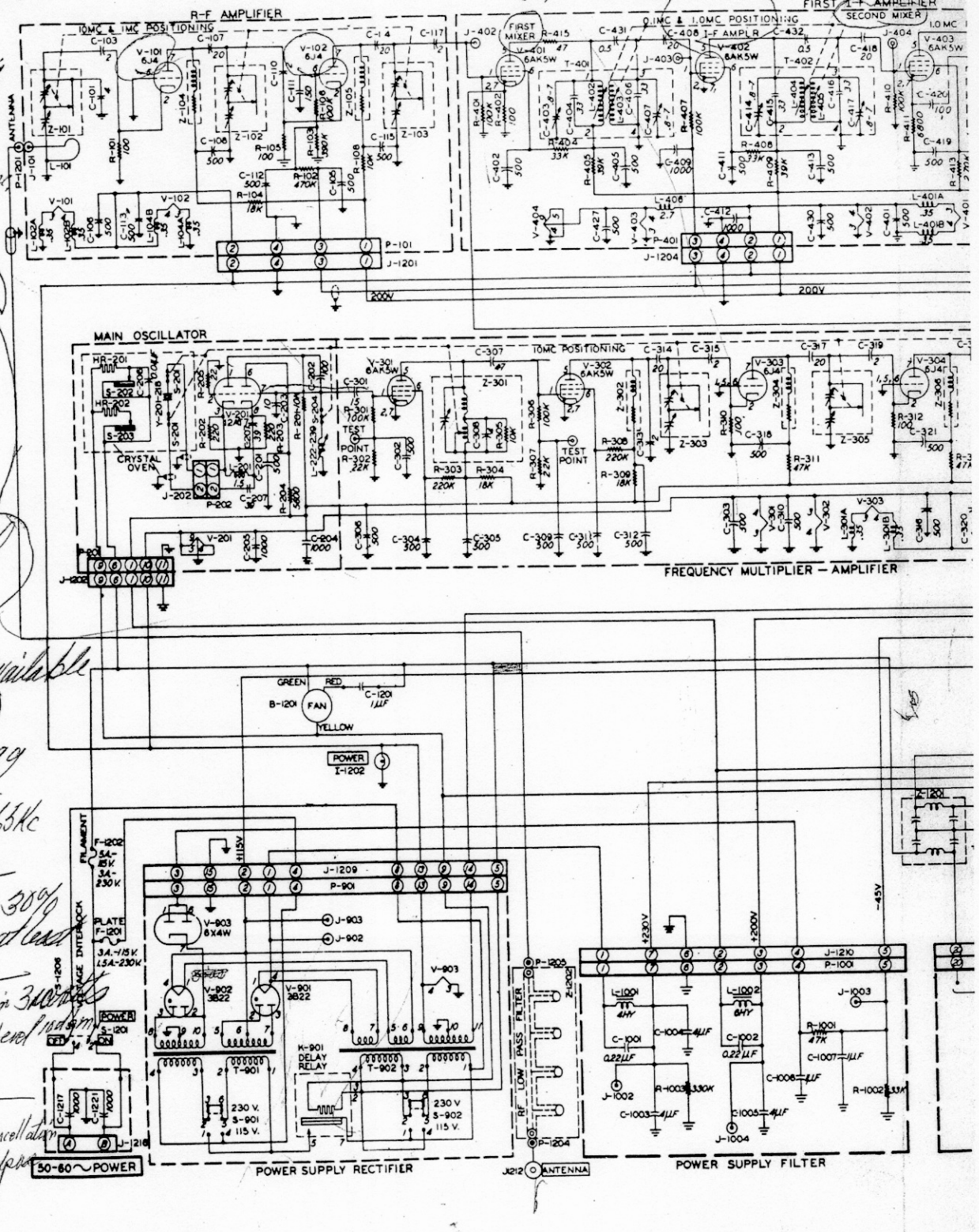
1808 frequencies available
Separated 100Kc (.1 Mc)
from 220.0 to 399.9

Selectivity - 6db 7.65Kc
-60db < 185 Kc

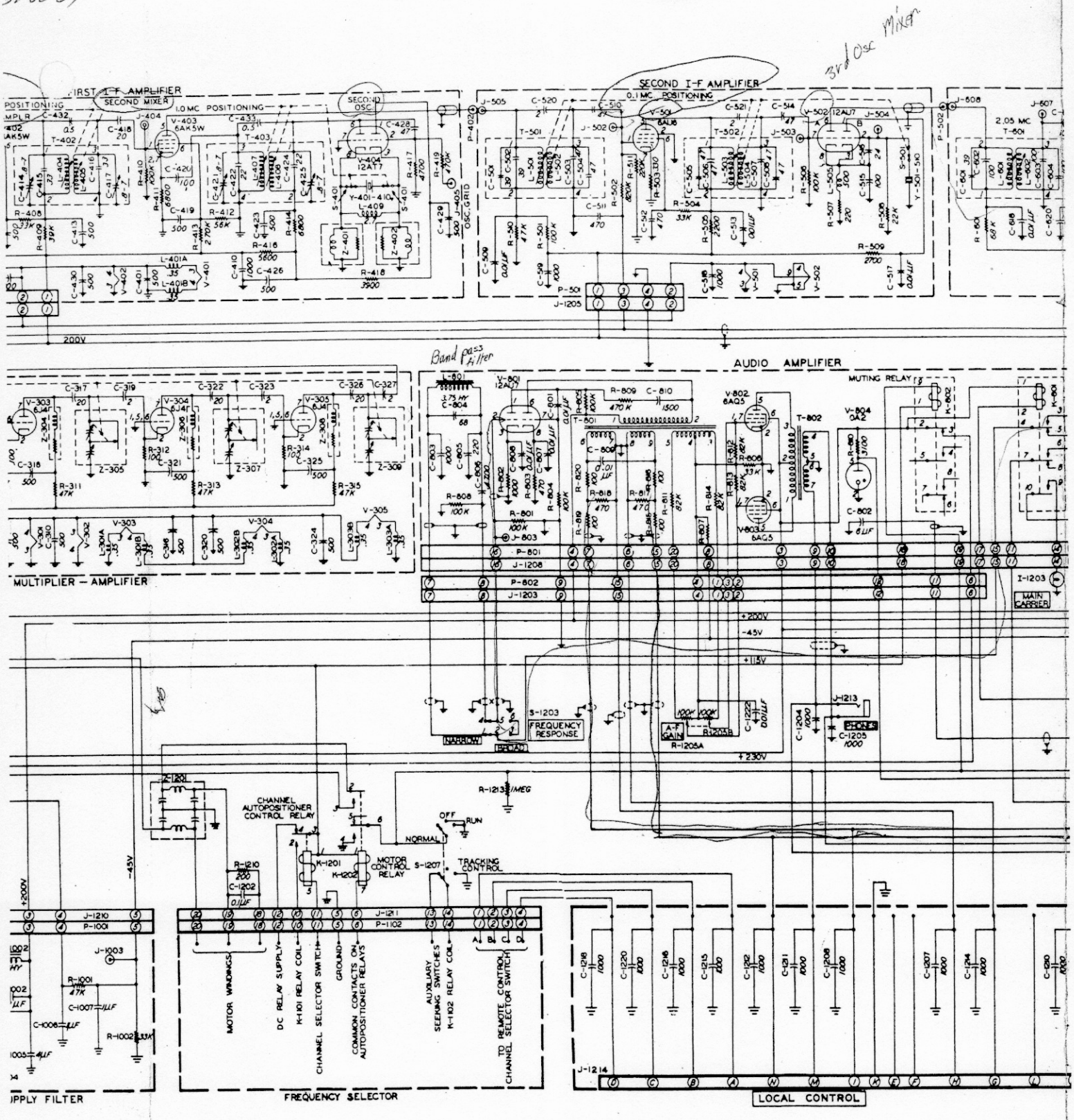
rf Sensitivity 3uv 30%
1Kc should produce at least
1 watt S/N 10db

Audio output Main 3000 ohm
100 uw into 300 ohm ½ Level
600 ohm
3000 ohm

Series NL, Shunt NL, Cancellation
Detector, Squelch, Broad bandpass
filter, + grid grid appp.



8.8889


FIRST I-F AMPLIFIER
SECOND MIXER
1.0 MC POSITIONING
SECOND OSC.
SECOND I-F AMPLIFIER
0.1 MC POSITIONING
2.05 MC
200V
AUDIO AMPLIFIER
MUTING RELAY
Band pass filter
MULTIPLIER – AMPLIFIER
S-1203
FREQUENCY RESPONSE
NARROW
BROAD
A-F GAIN
R-1205A
R-1205B
PHONES
I-1203
MAIN CARRIER
+200V
-45V
+115V
+230V
CHANNEL AUTOPOSITIONER CONTROL RELAY
MOTOR CONTROL RELAY
K-1201
K-1202
NORMAL
OFF
RUN
TRACKING CONTROL
S-1207
R-1213 1MEG
R-1210
C-1202
MOTOR WINDINGS
DC RELAY SUPPLY
K-1101 RELAY COIL
CHANNEL SELECTOR SWITCH
GROUND
COMMON CONTACTS ON AUTOPOSITIONER RELAYS
AUXILIARY SEEKING SWITCHES
K-1102 RELAY COIL
TO REMOTE CONTROL CHANNEL SELECTOR SWITCH
J-1210
P-1001
J-1211
P-1102
J-1214
IPPLY FILTER
FREQUENCY SELECTOR
LOCAL CONTROL

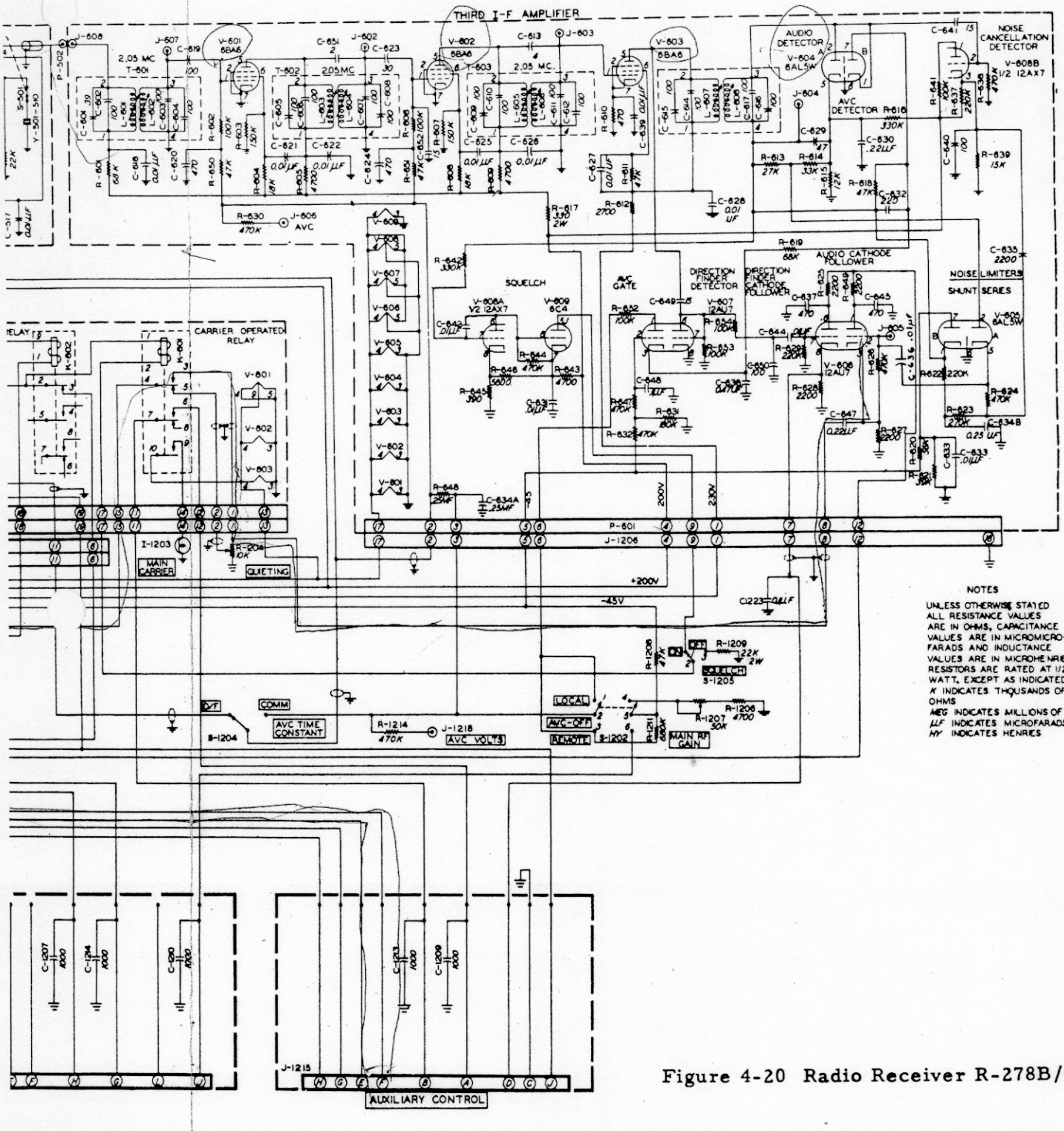
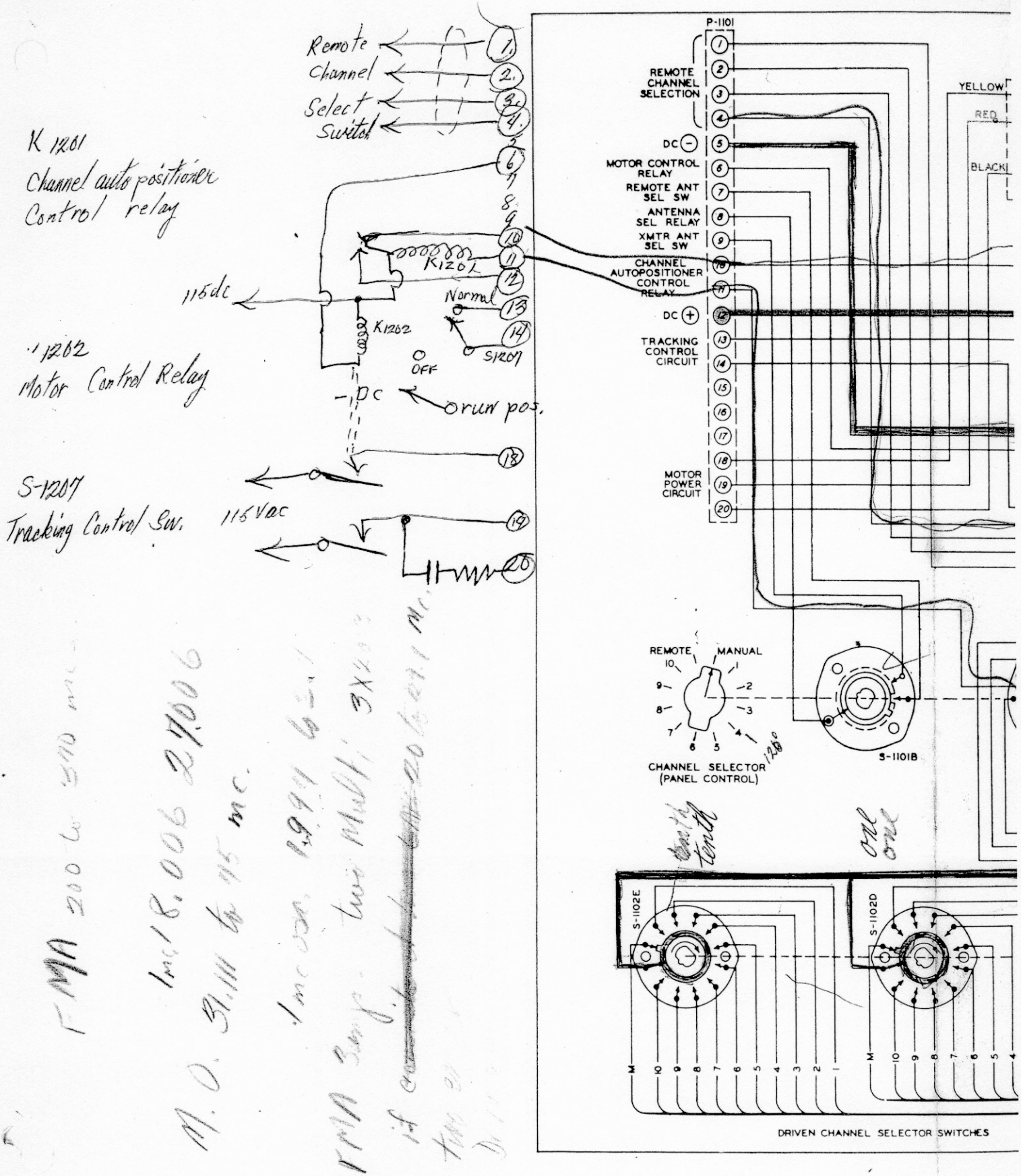
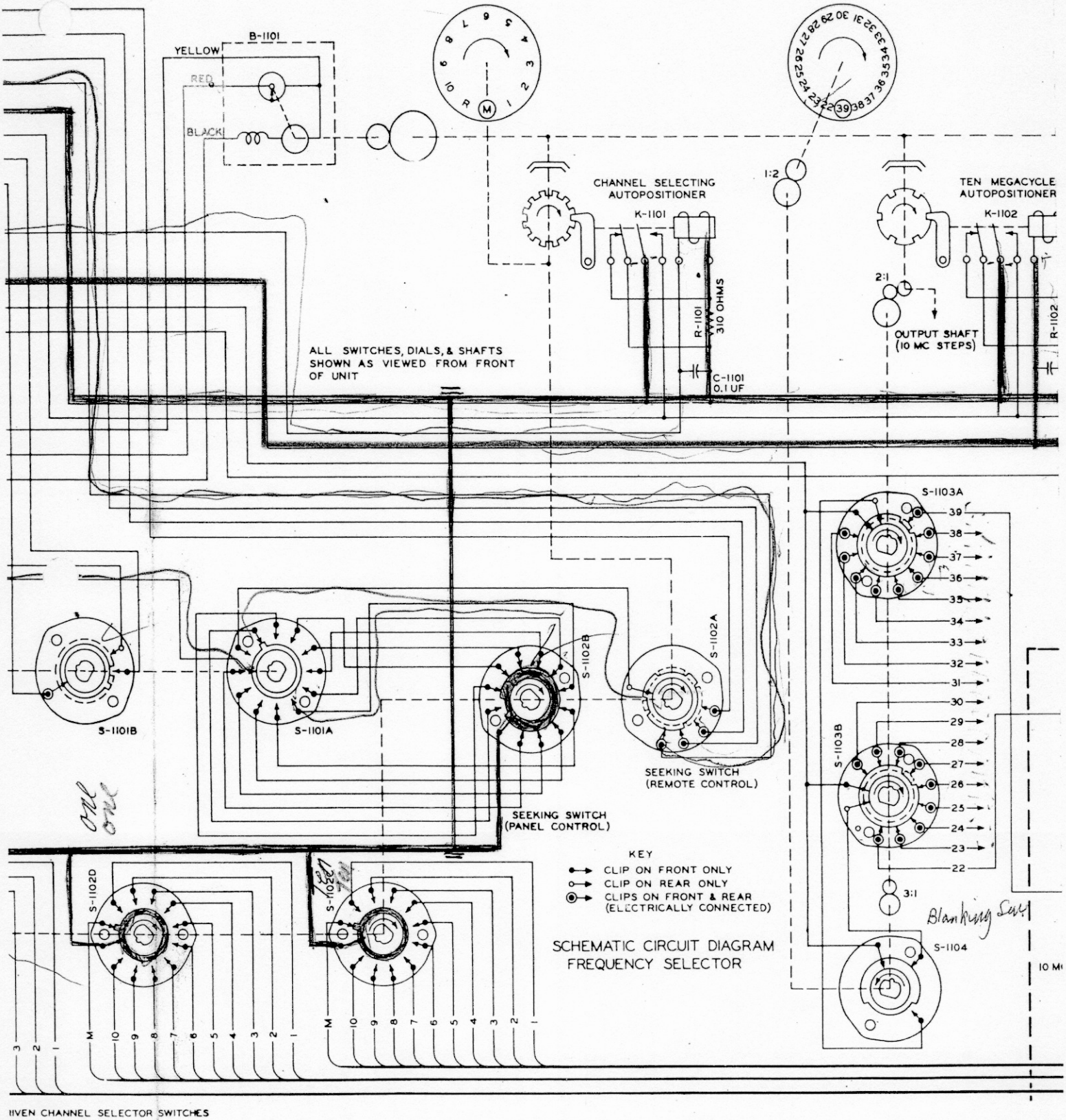


Figure 4-20 Radio Receiver R-278B/GR


Remote
Channel
Select
Switch
K 1201
Channel auto positioner
Control relay
K1201
115dc
Normal
K1202
S1207
OFF
-DC
orun pos.
K 1202
Motor Control Relay
S-1207
Tracking Control Sw.
115Vac
P-1101
REMOTE CHANNEL SELECTION
DC (-)
MOTOR CONTROL RELAY
REMOTE ANT SEL SW
ANTENNA SEL RELAY
XMTR ANT SEL SW
CHANNEL AUTOPOSITIONER CONTROL RELAY
DC (+)
TRACKING CONTROL CIRCUIT
MOTOR POWER CIRCUIT
YELLOW
RED
BLACK
REMOTE
MANUAL
CHANNEL SELECTOR (PANEL CONTROL)
S-1101B
S-1102E
S-1102D
DRIVEN CHANNEL SELECTOR SWITCHES


B-1101
YELLOW
RED
BLACK
CHANNEL SELECTING AUTOPOSITIONER
K-1101
TEN MEGACYCLE AUTOPOSITIONER
K-1102
1:2
2:1
3:1
R-1101
310 OHMS
C-1101
0.1 UF
R-1102
OUTPUT SHAFT (10 MC STEPS)
ALL SWITCHES, DIALS, & SHAFTS SHOWN AS VIEWED FROM FRONT OF UNIT
S-1101B
S-1101A
S-1102B
S-1102A
S-1103A
S-1103B
S-1104
SEEKING SWITCH (REMOTE CONTROL)
SEEKING SWITCH (PANEL CONTROL)
S-1102D
S-1102C
KEY
CLIP ON FRONT ONLY
CLIP ON REAR ONLY
CLIPS ON FRONT & REAR (ELECTRICALLY CONNECTED)
SCHEMATIC CIRCUIT DIAGRAM
FREQUENCY SELECTOR
Blanking Sect
10 M
IIVEN CHANNEL SELECTOR SWITCHES

C D E

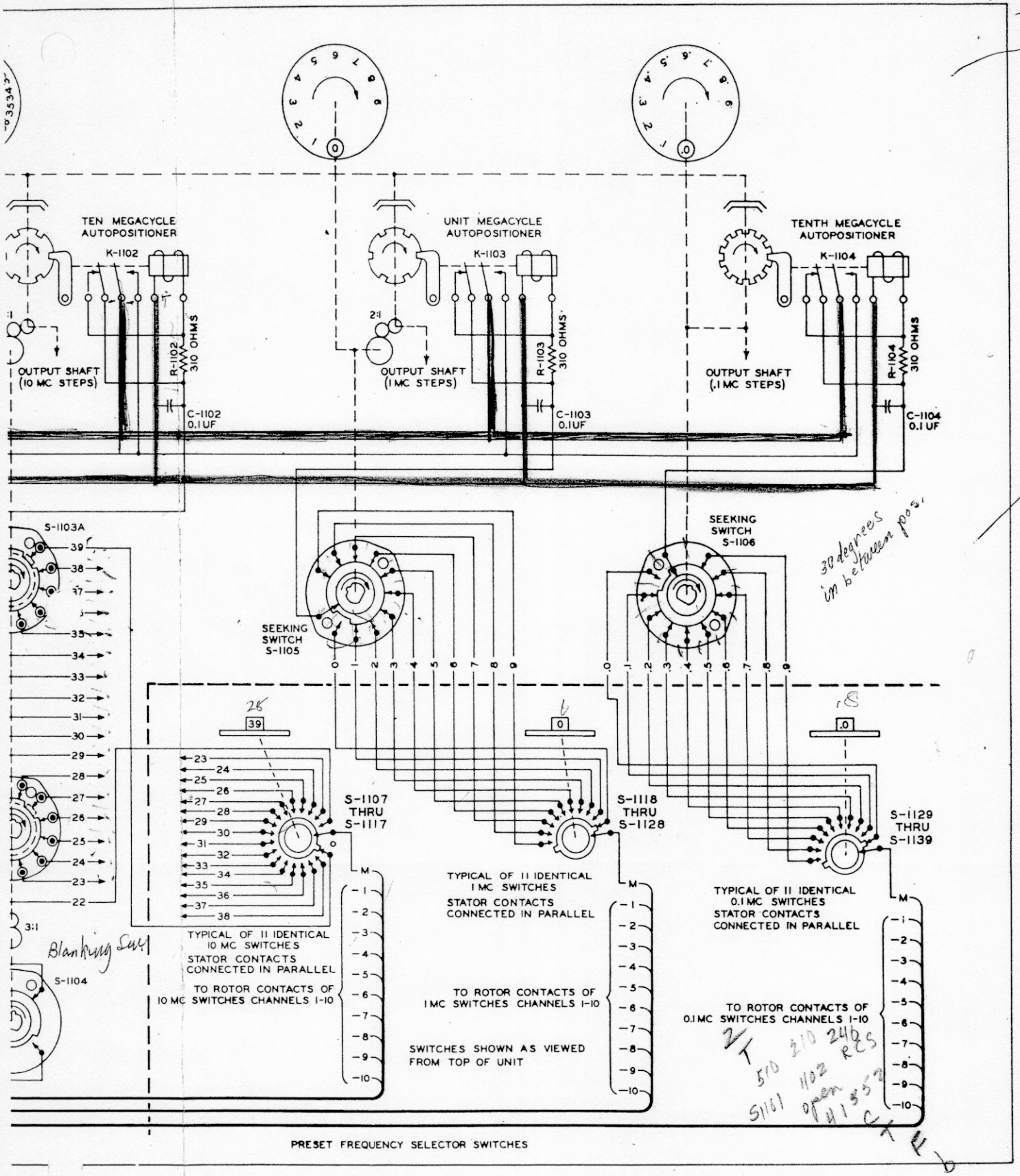
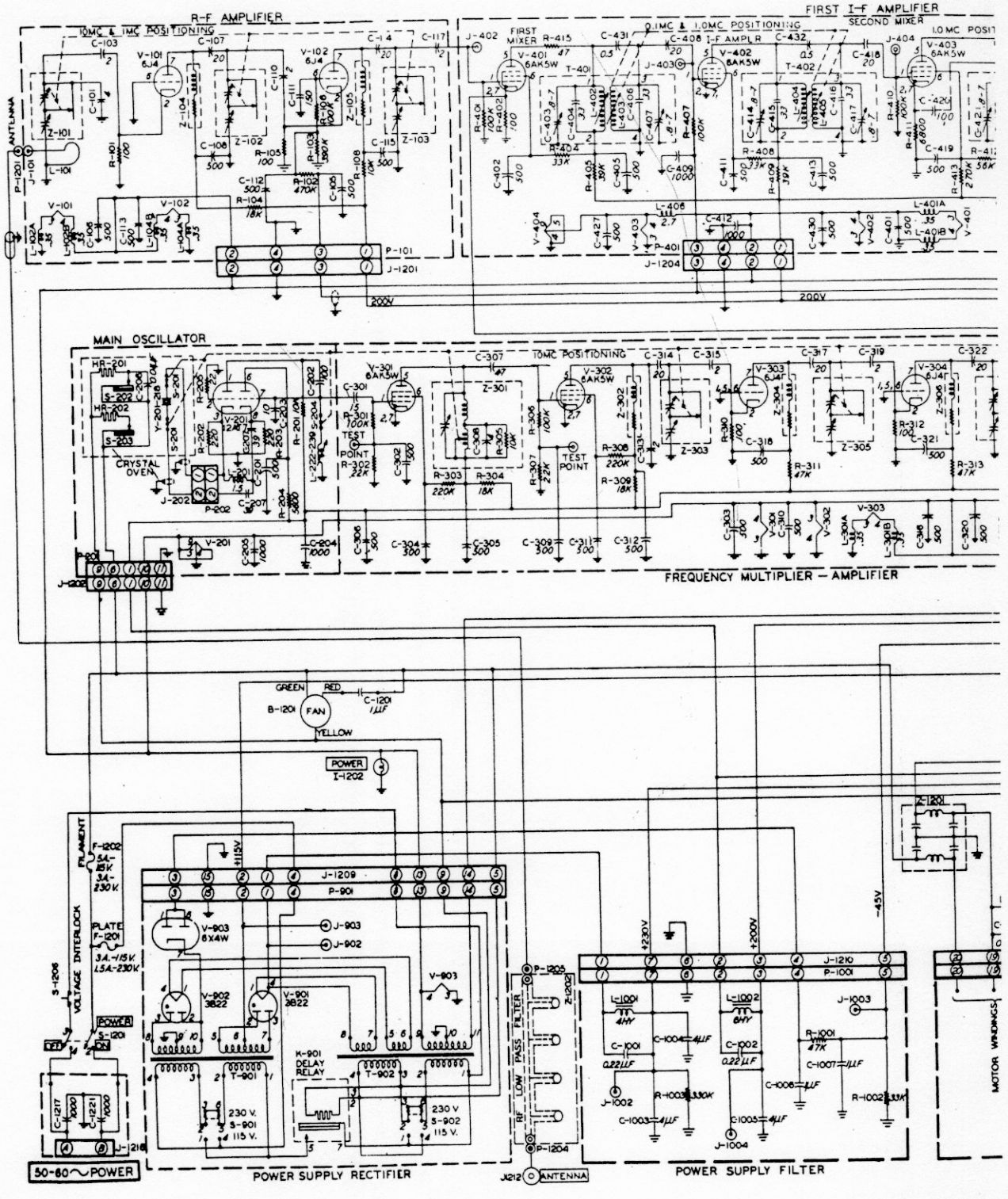
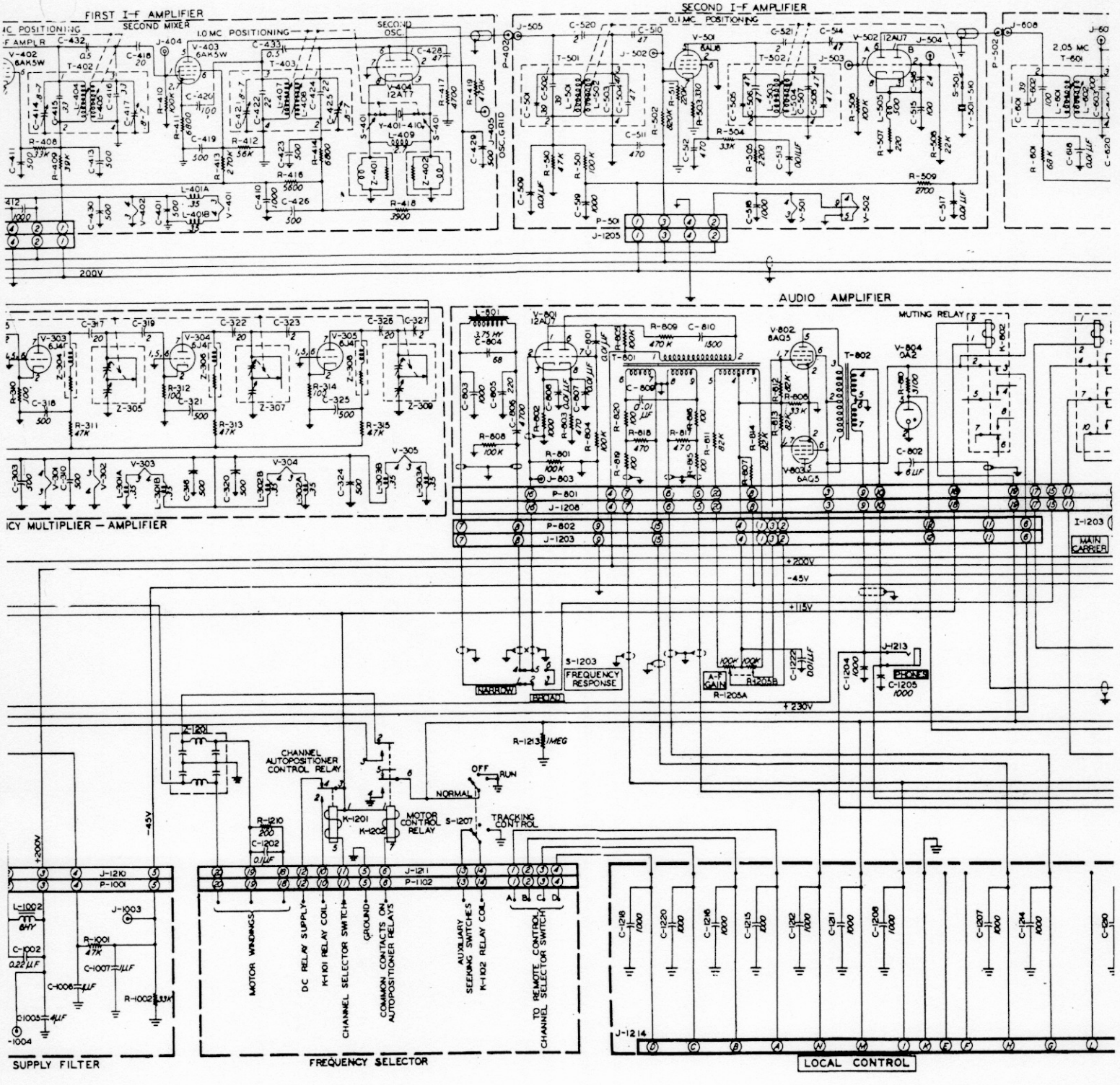


Figure 4-19 Frequency Selector Unit


R-F AMPLIFIER
10MC & 1MC POSITIONING
FIRST I-F AMPLIFIER
SECOND MIXER
FIRST MIXER
I-F AMPLR
0.1MC & 1.0MC POSITIONING
1.0MC POSIT
MAIN OSCILLATOR
CRYSTAL OVEN
1MC POSITIONING
TEST POINT
FREQUENCY MULTIPLIER — AMPLIFIER
FAN
POWER
I-1202
FILAMENT
PLATE
VOLTAGE INTERLOCK
K-901 DELAY RELAY
230 V.
115 V.
RF LOW PASS FILTER
ANTENNA
50-60~POWER
POWER SUPPLY RECTIFIER
POWER SUPPLY FILTER
MOTOR WINDINGS
+230V
+200V
-45V
200V


FIRST I-F AMPLIFIER
SECOND MIXER
1.0 MC POSITIONING
SECOND OSC.
SECOND I-F AMPLIFIER
0.1 MC POSITIONING
2.05 MC
AUDIO AMPLIFIER
MUTING RELAY
200V
-45V
+115V
+230V
MAIN CARRIER
FREQUENCY RESPONSE
NARROW
BROAD
A-F GAIN
PHONES
CHANNEL AUTOPOSITIONER CONTROL RELAY
MOTOR CONTROL RELAY
TRACKING CONTROL
OFF
RUN
NORMAL
MOTOR WINDINGS
DC RELAY SUPPLY
K-1101 RELAY COIL
CHANNEL SELECTOR SWITCH
GROUND
COMMON CONTACTS ON AUTOPOSITIONER RELAYS
AUXILIARY SEEKING SWITCHES
K-1102 RELAY COIL
TO REMOTE CONTROL CHANNEL SELECTOR SWITCH
SUPPLY FILTER
FREQUENCY SELECTOR
LOCAL CONTROL

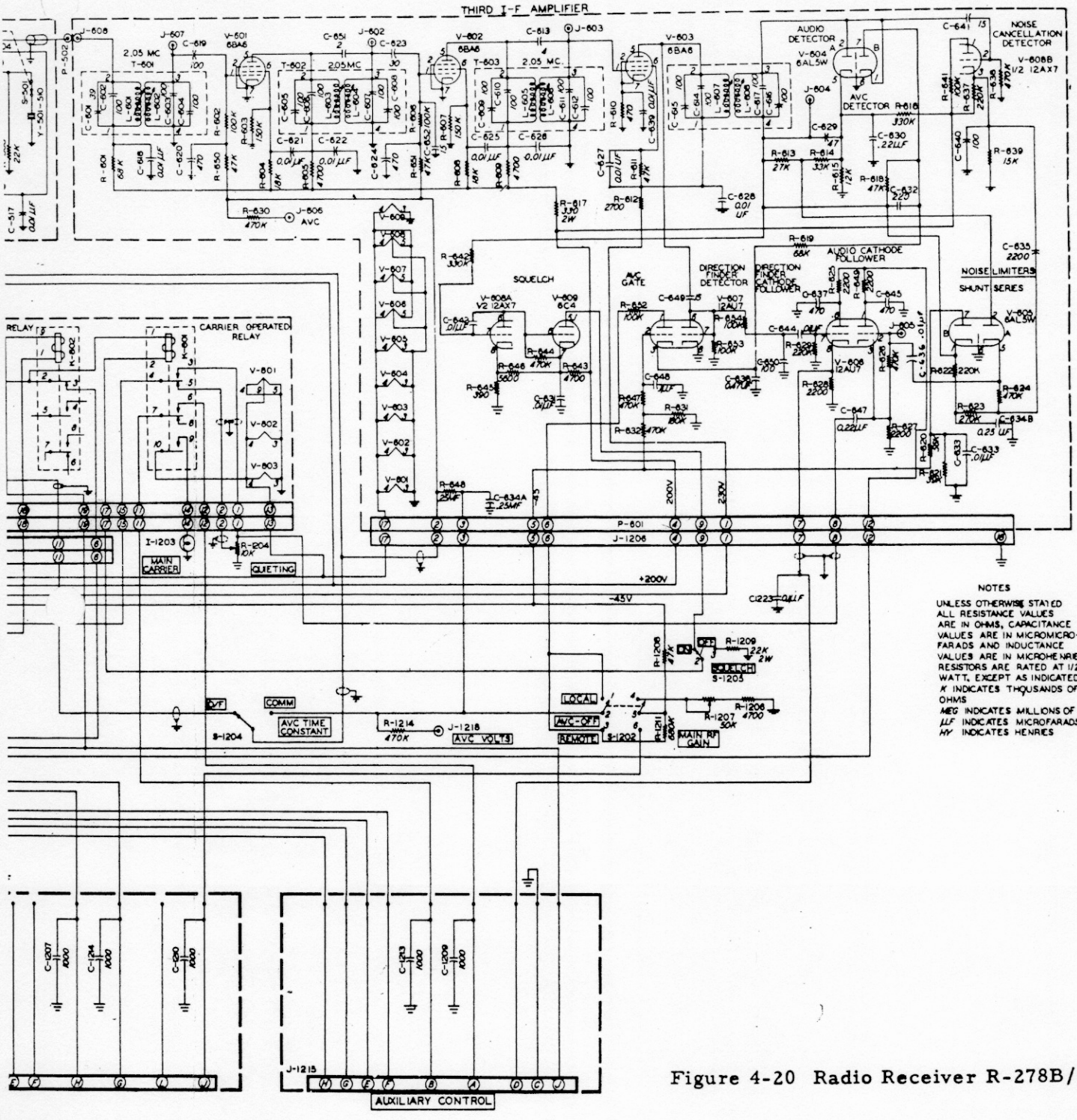


Figure 4-20 Radio Receiver R-278B/GR