CHAPTER 7

OPERATING PRINCIPLES OF A REPRESENTATIVE UHF TRANSCEIVER AN/GRC-27A

INTRODUCTION

The Radio Set, AN/GRC-27A (fig. 7-1), is intended for shipboard installation, and is used for u-h-f communications from ship-to-ship, ship-to-shore, or with aircraft. The AN/GRC-27A comprises Radio Transmitter, T-217A/GR; Radio Receiver, R-278B/GR; Modulator-Power Supply, MD-129A/GR; Distribution Panel, J-390/GR; and Mounting Rack, MT-1589/GRC-27A. Because the two major components of the AN/GRC-27A are the transmitter and receiver, the equipment is appropriately called a "transceiver."

The transmitter and modulator-power supply together form a transmitting installation. The receiver is used separately for reception of either u-h-f voice modulated or mcw signals.

GENERAL DESCRIPTION

The transmitter normally generates a radio frequency carrier in a range from 225.0 to

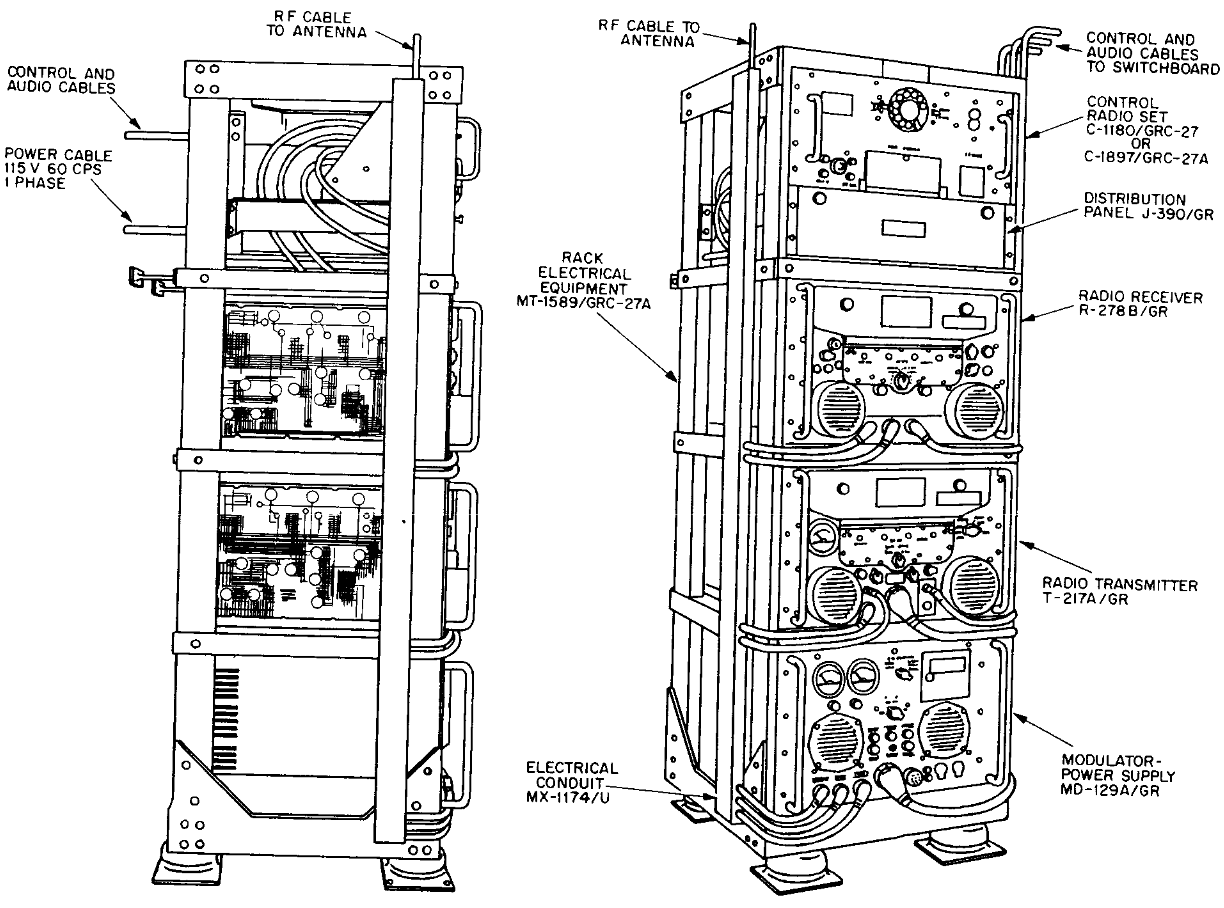


Figure 7-1.—Radio Set AN/GRC-27A. 32.109

399.9 mc with a nominal power output of 100 watts over this range. The transmitter employs 3 crystal-controlled oscillators (frequency generators) which employ a total of 38 crystals. The combination and multiplication (synthesizing) of these 38 crystal frequencies make it possible to produce 1,750 frequencies spaced at 100-kc intervals from 225.0 to 399.9 mc. Any 10 of these 1,750 frequencies can be manually preset by a series of selector switch dials (calibrated in megacycles) in 100-kc increments. Any one of these 10 frequencies (channels) can be selected automatically, either locally or from a remote station. Automatic selection of a preset channel is accomplished in 2 to 7 seconds by a combined autopositioner drive system and a servo system.

The modulator-power supply provides the transmitter with all necessary operating and control voltages, and supplies amplitude modulation power (either voice or mcw tone) for the transmitter. The transmitter output includes both upper and lower sidebands generated when the carrier is amplitude-modulated.

The receiver normally operates on any one of 1,750 frequencies spaced at 100-kc intervals from 225.0 to 399.9 mc. The receiver employs a triple conversion superheterodyne system using crystal-controlled oscillators, and employing a total of 38 crystals in a synthesizer system. Any 10 channels of the 1,750 frequencies can be manually preset, and then, any one of the 10 can be automatically selected either locally or from a remote station.

Automatic channel selection in the receiver is accomplished by a frequency selector and autopositioner system similar to that in the transmitter. A motor-driven system of gear trains operates the various crystal switches and tuning mechanisms to permit rapid change of operating frequency. Here again, automatic shifting of channels can be accomplished in 2 to 7 seconds.

The receiver is designed for use with directional or omnidirectional antennas having a characteristic impedance of 52 ohms. Audio output circuits for operation of loudspeakers and for operation into telephone lines are built into the receiver. A special output circuit for direction-finding applications is also provided. The receiver is equipped with automatic volume control, automatic noise limiter, and carrier operated squelch circuits.

The preset channels for the transmitter or the receiver are selected by operating a channel selector switch on the front panel of the respective units or by telephone-type dials on associated radio set control facilities.

The radio set control facilities (fig. 7-1) include either Radio Set Controls C-1180/GRC-27 or C-1897/GRC-27. These equipments adapt the control circuits of the Radio Set AN/GRC-27A to the standard 12-wire shipboard remote system. Either one or the other of these units is mounted in Rack MT-1589/GRC-27A, together with the receiver, transmitter, and modulator-power supply units. The control units provide for the control of power for Radio Set AN/GRC-27A, starting and stopping the modulator-power supply, automatic channel selection in the transmitter and receiver, local or remote control of the transmitter, and squelch adjustment for the receiver.

RECEIVER BLOCK DIAGRAM

The Receiver R-278B/GR of the Radio Set AN/GRC-27A, and receiver operating controls can be observed in detail in figure 7-2. It will be helpful to the reader to relate the various receiver controls with their associated control circuits as they are discussed in this chapter.

The block diagram (fig. 7-3) reveals that the receiver consists of four major sections: (1) a multichannel receiver section, (2) a frequency selector unit, (3) an audio amplifier section, and (4) a power supply.

The multichannel receiver section normally operates on any one of 1,750 frequencies in the frequency range from 225.0 to 399.9 mc as discussed. The frequency selector unit, which is controlled by switches on the front panel of the receiver, automatically tunes the multichannel receiver to any one of 10 preset channels. The audio amplifier section increases the amplitude of the audio before it is applied to the loudspeaker or telephone line output circuits. The power supply furnishes all voltages required by the various circuits of the receiver.

Although the normal operating range of the receiver is 225.0 to 399.9 mc, as stated earlier, the receiver is capable of operating from 220.0 to 399.9 mc. The feature of the receiver which makes the added coverage possible is considered presently.

The received signal from the antenna is amplified in two stages of r-f amplification, V101 and V102, and applied to the first mixer stage, V401. The local oscillator signal is derived in a main oscillator stage, V201, which contains 18 crystals, and operates in the range from 26.67 to 38.89 mc. The oscillator is followed by

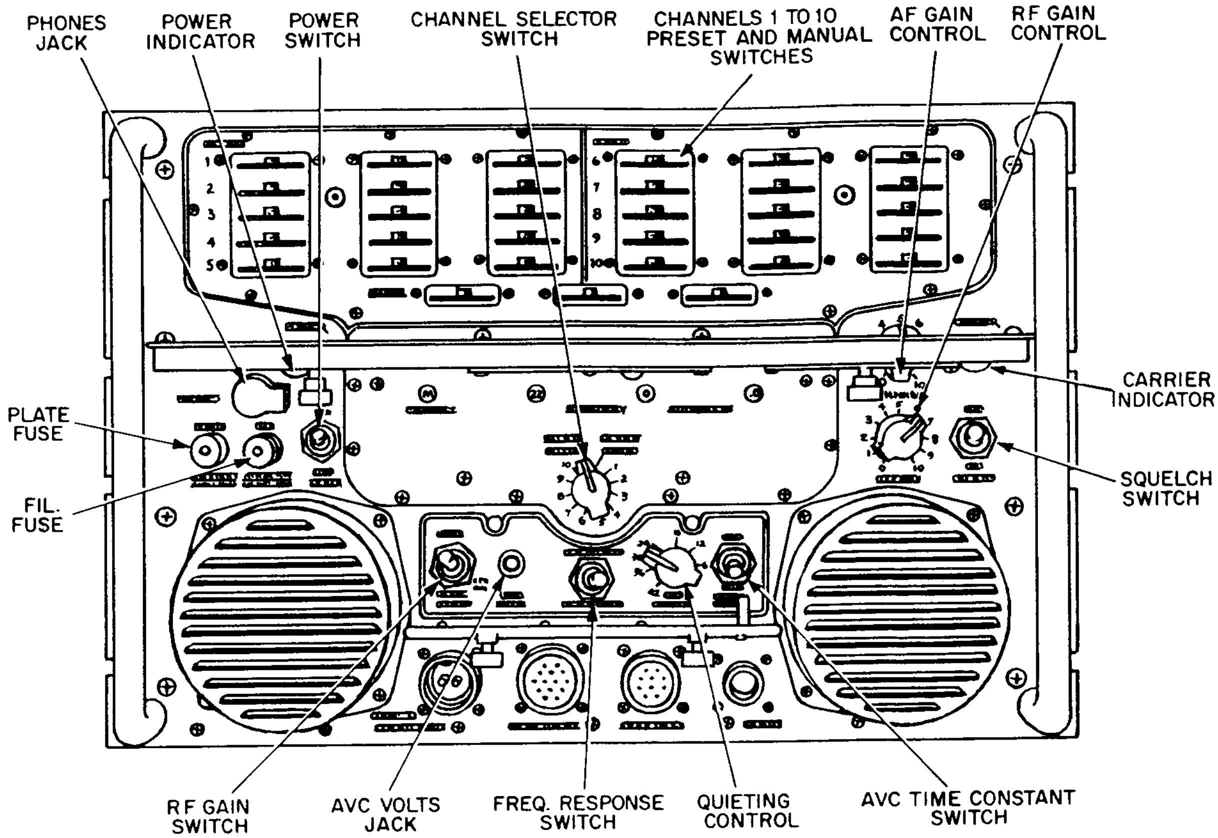


Figure 7-2.—Radio Receiver R-278B/GR, front panel controls.

two frequency multipliers, V301 and V302, and three amplifier stages, V303, V304, and V305. The V305 output is the first local oscillator injection signal, and is in the frequency range from 180 to 350 mc.

The main oscillator, V201, is crystal-controlled by any one of 18 crystals. In order to produce the required intermediate frequencies over the 220.0 to 399.9 mc range, the output of the first injection system is varied from 180.0 to 350.0 mc in 18 steps of 10 mc each, by switching the oscillator crystals.

Unlike most mixer stages, the first mixer, V401, output is not always at the same frequency. Rather, the mixer output may vary from 40.0 to 49.9 mc for each crystal used in the main oscillator. For example, the mixer, V401, output changes from 40.0 mc (when the receiver input frequency is 220.0 mc and the first injection frequency is 180.0 mc) to 49.9 mc when the received signal is 229.9 mc and the injection signal is 180.0 mc.

When the receiver total frequency coverage is considered (220 to 399.9 mc) you will note that a 5-mc increase over the normal operating range is obtained. From this 5-mc increase, the first injection synthesizer system will produce 50 additional intermediate frequencies. Thus, the receiver can accept and reproduce 50 additional frequencies. The following discussion shows how these frequencies are derived.

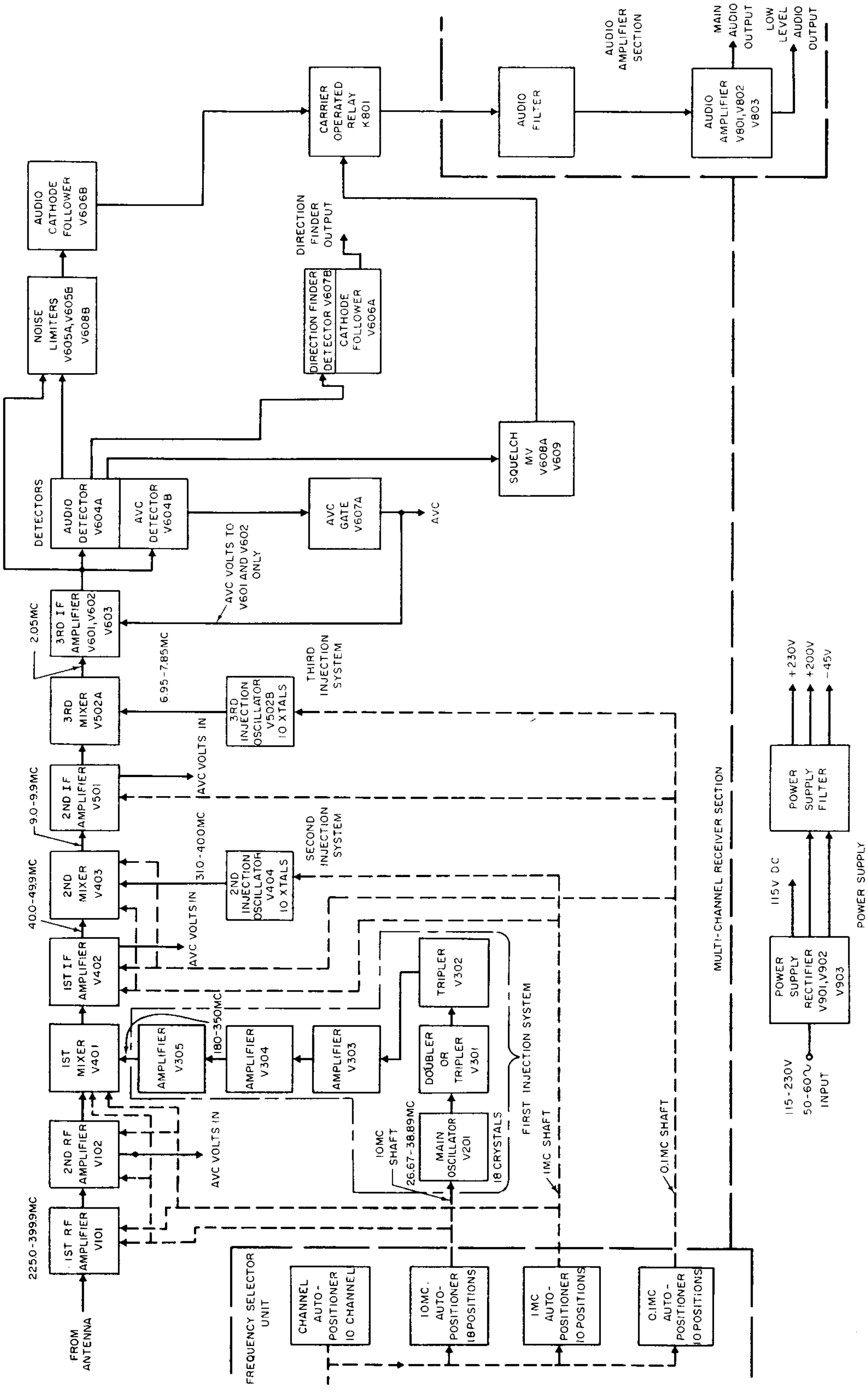
If the receiver input frequency were 225.0 mc, the injection frequency from the first injection system would be 180.0 mc and the mixer, V401, output signal would be 225.0 mc minus 180.0 mc, or 45.0 mc.

If the receiver input frequency were 220 mc, the injection frequency would still be 180.0 mc, and the mixer output signal would be 220.0 mc minus 180.0 mc, or 40.0 mc.

Because the receiver is tuned in 100-kc increments, the 5-mc increase in frequency range at the mixer output provides:

$$\frac{5.0 \text{ mc}}{100.0 \text{ kc}} = \frac{5 \times 10^6}{1 \times 10^5} = 5 \times 10^1 \text{ or } 50$$

additional frequencies which may be selected at the receiver input.



32.111

Figure 7-3.—Block diagram of Radio Receiver R-278B/GR.

The method of tuning the receiver is as follows: The frequency selection unit (fig. 7-3) has three output shafts, which by mechanical drive, select the proper crystals and tune 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, respectively. The 10-mc shaft rotates in 18 incremental steps, each increment 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.

The r-f amplifiers, V101 and V102, may be tuned in 18 incremental steps by the 10-mc shaft and in 10 incremental steps by the 1-mc shaft. For each position of the 10-mc switching shaft, the 1-mc shaft can be rotated through 10 positions, thereby tuning the r-f amplifiers to 10 different frequencies for each position of the 10-mc shaft. In this manner, the r-f amplifiers can be tuned to 180 frequencies in steps of 1 mc.

The antenna input signal is amplified in the first and second r-f amplifiers, V101 and V102, and fed to the first mixer, V401. The r-f signal input to the first mixer is heterodyned with the input signal from the first injection system to produce the first intermediate frequency between 40.0 to 49.9 mc.

The first injection system (comprising the main oscillator and frequency multiplier-amplifier stages) is tuned in eighteen 10-mc steps by the 10-mc output shaft. This shaft also operates the main oscillator crystal selector switch to select one of 18 crystal units (not shown). The first injection system output is fed from amplifier V305 to the first mixer stage, V401. The signal from the first mixer (between 40.0 and 49.9 mc) is amplified in the first i-f amplifier, V402.

The first i-f amplifier, V402, employs two permeability tuned transformers, one at the input to the stage and the other at the output. The powdered iron cores of these transformers are driven by the 1-mc and 0.1-mc shaft. The rotation of these shafts are combined in a differential tuning mechanism to produce one hundred 0.1 mc steps. The first i-f amplifier output is applied to the second mixer, V403.

The crystal selector switch and tuned circuits of the second injection oscillator, V404, are controlled by the 1-mc shaft. The 31-40 mc signal from the second injection oscillator, V404, is heterodyned in the second mixer, V403, with the 40.0 to 49.9 mc injection signal from V402. The difference frequency (9.0 to 9.9 mc) is fed to the second amplifier, V501.

The second i-f amplifier, V501, is tuned in ten 0.1 mc steps by the 0.1-mc shaft. The 9.0 to 9.9 mc output from the second i-f amplifier is fed to the third mixer, V502A.

The third injection oscillator, V502B, is also tuned in 0.1 mc steps by the 0.1-mc shaft. The heterodyning frequency from the third injection oscillator, V502B, is between 6.95 and 7.85 mc. The final heterodyning process in the third mixer produces a 2.05-mc intermediate frequency. The third mixer output is amplified in three stages of i-f amplification, comprising V601, V602, and V603.

To summarize the tuning action, assume that a frequency of 395.5 mc is to be selected (see table 1). The frequencies throughout the receiver tuning stages would be as follows:

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

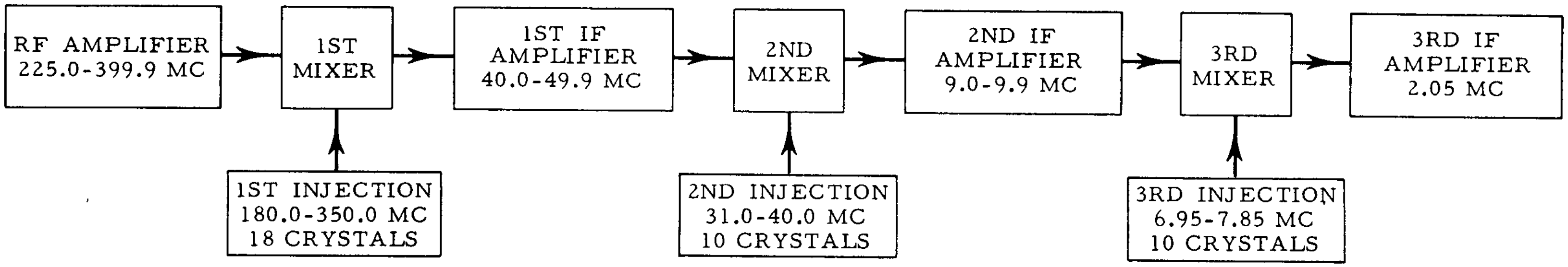
Two detector stages are employed in the receiver. The audio detector, V604A, is used to rectify and filter the audio component of the received signal. The AVC detector, V604B, is used to produce a d-c (AVC) control voltage for various amplifying tubes. The audio signal from V604A is routed through the noise limiter stages, V605A, V605B, and V608B. These stages reduce any spurious noise appearing in the received signal.

The AVC detector, V604B, and the AVC gate, V607A, produce the AVC control signal which is applied to the r-f and i-f stages of the receiver to maintain the audio output level nearly constant for wide variations in the amplitude of the r-f input signal.

The squelch circuit, V608A and V609, produces a d-c voltage to operate the carrier operated relay, K801. The relay functions to increase the audio signal amplitude to the filter (attenuator quieting control) in the audio path whenever a signal is received.

The direction-finder stages of the receiver, V607B and V606A, make possible the use of the receiver with a direction-finder system such as the Radio Direction Finder AN/CRD-6. This feature of the receiver is not required in the normal communications applications of the

Table 7-1.--RF and Injection Frequencies for Various Dial Readings.



READ-ING	RF BAND MC	1ST INJ. FREQ. MC	CRYSTAL FREQ. MC	MULT. FACTOR
22	220.0-229.0	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 READ-ING	1ST IF 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 READ-ING	2ND IF 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

Radio Set AN/GRC-27A, aboard ship. Hence, its operation is not described in detail in this chapter.

When the carrier operated relay is energized, the audio signal from the audio filter is amplified in two stages, V801, V802, and V803. Twin triode, V801, comprises two cascade connected single-ended audio amplifiers, and V802 and V803 are connected in a push-pull amplifier arrangement.

Two output circuits are provided, which are referred to as the main audio and the low level audio outputs, respectively. The main audio output circuit delivers approximately 3 watts into a 600-ohm balanced load. The low level audio output is approximately 10 milliwatts.

FREQUENCY SELECTOR SYSTEM

Radio Receiver R-278B/GR employs a frequency selector system which mechanically tunes the receiver to any one of 1,750 available frequencies. A block diagram of the frequency selector system is shown in figure 7-4. Essentially, the frequency selection system consists of two main parts: the preset panel, and the autopositioners. The preset panel provides switches for presetting 10 automatically tunable channels, and for setting up one manual channel. The autopositioner is an electromechanical device actuated by operating a channel selector switch located on the front panel of the receiver, or by remote control facilities. The autopositioner tunes the receiver to a desired channel selected from the 10 preset channels. The manual channel can be selected only from the panel-mounted channel selector switch (fig. 7-2).

PRESET PANEL

The preset panel (fig. 7-4) employs 33 rotary switches. For purposes of setting up channels, these switches are arranged in 11 horizontal banks of 3 switches each. The "hundreds" and "tens" mc frequencies are set up on the first bank, the "units" are set up on the second bank, and the "tenths" on the third bank.

For example, if a frequency of 245.6 mc is to be selected, the "hundreds" and "tens" mc switch should be set to 24, the "units" switch to 5, and the "tenths" switch to 0.6. By combining

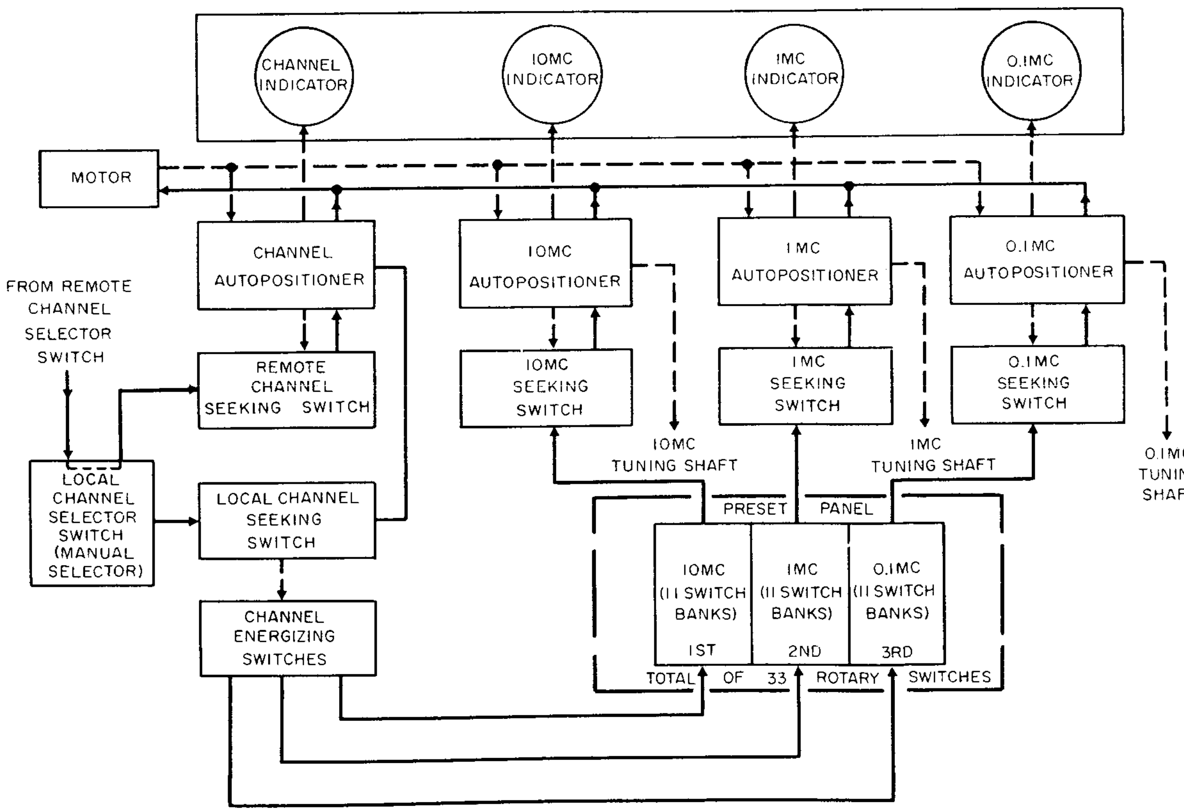


Figure 7-4.—Frequency selector system, block diagram. 32.112

the setting of the 3 switches (horizontal rows), the frequency of each of the 11 channels can be read directly on the front panel of the receiver.

The manual channel is set up the same as the other 10 channels, except that it is not possible to select the manual channel from a remote position. This channel is reserved for the local operator.

AUTOPOSITIONER

In addition to the definition given earlier, the autopositioner can be defined as a motor-driven mechanism which positions a shaft to any one of a number of preset positions. The basic elements of an autopositioner are shown in figure 7-5.

The autopositioner consists of a motor and gear reduction, a slip clutch, a rotary shaft to which is fastened a notched stop wheel, a pawl which engages the notches of the stop wheel, and a relay which actuates the pawl and operates a set of electrical contacts to start and stop the motor.

Associated with each autopositioner is an electrical control system consisting of a control switch and a corresponding symmetrical "seeking" switch which is driven by the autopositioner shaft. This control system is designed so that whenever the control switch and seeking switch are not set to the same electrical position, the autopositioner is energized and operates to drive its shaft (and the driven elements to which it is coupled) to the proper

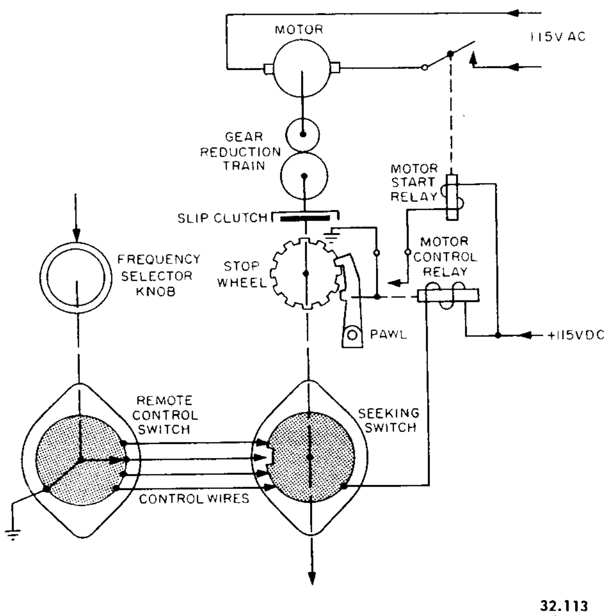


Figure 7-5.—Autopositioner, basic elements.

position to restore the symmetry of the control system.

When the control and seeking switches are in corresponding positions (which represents an open circuit between the two switches) the motor control relay is deenergized as shown, the pawl is engaged in a notch on the stop wheel, and the motor is not energized. In this position, the autopositioner is at rest.

If the operator changes the position of the remote control switch, the symmetry between the remote control and seeking switches will be upset. In this condition, power is applied through the seeking switch to the motor control relay, causing this relay to become energized. The current through the solenoid of the motor control relay exerts a magnetic attraction on the pawl which lifts the pawl out of the notch on the stop wheel. The grounded motor control relay contact arm is mechanically operated by the pawl, so that as the pawl is removed from the notch a ground is simultaneously applied to the solenoid of the motor start relay. The operation of the motor start relay closes another set of contacts which apply power to the motor.

As the motor turns, it drives the autopositioner shaft and the rotor of the seeking switch. When the seeking switch reaches the point corresponding to the new position of the remote switch, the motor control relay circuit is again opened (as shown). The pawl drops back into a notch on the stop wheel to stop the shaft rotation. Simultaneously, the ground is removed from the motor start relay. The contacts which were applying the 115-volt a-c power to the motor are now released (to the position shown) and the motor coasts to a stop, dissipating its energy in the slip clutch.

The seeking switch of the control circuit is adjusted to open the relay shortly before the stop wheel reaches the point where the pawl engages the proper notch. The relay contacts which control the motor are mechanically operated by the pawl arm so that they do not open until the pawl drops into the notch.

Note that the slip clutch between the motor and autopositioner absorbs the energy of the motor as it coasts to a stop. With more than one slip clutch the same motor can drive an equal number of autopositioners, either simultaneously or independently. The frequency selector unit (fig. 7-4) employs four autopositioners: the channel, the 10-mc, the 1-mc, and the 0.1-mc autopositioners. The channel autopositioner energizes the other three through the local channel seeking switch, the channel energizing switches, and the preset panel. When the channel autopositioner control relay is operated by the control circuit, it removes power from the other three autopositioner relays. This action prevents operation of these relays until the channel autopositioner has completed its operation. The 10-mc, 1-mc, and 0.1-mc autopositioners each have output shafts which tune the receiver to the desired operating frequency.

RECEIVER CIRCUIT OPERATION

R-F AMPLIFIERS

The signal input to the receiver is fed via an antenna coupling loop (fig. 7-6) to the input of the first r-f amplifier stage, V101. Triode V101, is connected as a grounded-grid shunt-fed amplifier. Although the gain of the grounded-grid amplifier is somewhat lower than that of a grounded-cathode amplifier, the control grid in the grounded-grid amplifier acts as the common grounded element between the cathode and plate of the tube, and thus reduces the plate-cathode capacitance.

The construction of the input tuning circuit to V101 is shown in figure 7-7. The r-f tuner consists of a variable capacitor, "a", and a variable inductor, "b", which rotate simultaneously so that in 180° of rotation the resonant frequency changes linearly 180 mc at a rate of 1 mc per degree. The variable capacitor consists of two stator plates and three rotor plates, the front and rear of which are radially slotted for aligning adjustments. The inductive loop consists of the inductance stator rod, an inductance ring segment, and the inductance rotor rod. The capacitor rotor plates and inductor rotor rod are mounted on the same driving shaft so that the inductance and capacitance are changed proportionately for each degree of rotation of the drive shaft. The three r-f tuners, Z101, Z102, and Z103 (fig. 7-6) are geared together and driven through a mechanical differential from the 10-mc and 1-mc autopositioner output shafts.

The plate output of V101 is amplified in a second r-f amplifier, V102, which is identical to the first stage. The three r-f tuners, Z101, Z102, and Z103, are used for interstage coupling, and are electrically the same.

Bifilar chokes, L102 and L104, (wound side by side) are used in the filament circuits to isolate the filament power from the r-f signal. Capacitors, C108 and C115, keep the r-f signals out of the B supply. The output signal of the second r-f amplifier is fed to the first mixer stage, V401.

FIRST INJECTION SYSTEM

The first injection system produces the heterodyning frequency for the first mixer stage, V401 (fig. 7-3). The first injection system comprises two major circuits; namely, the main oscillator, and the frequency multipler-amplifier circuits. A simplified schematic of the main oscillator circuit comprising V201 is shown in figure 7-6.

Twin triode, V201, is connected in a Butler oscillator circuit. The oscillator contains 18 CR-32/U crystals, Y201 through Y218, and a crystal switch, S201, within a temperature-controlled oven. Tube, V201, comprises a grounded-grid amplifier, V201A, followed by a cathode follower, V201B.

To understand the operation of this circuit, consider a random positive feedback pulse appearing at the cathode of grounded-grid amplifier, V201A, coming from the cathode of V201B. Since the grid is grounded through a 22-ohm resistor, R205, a rise in the cathode voltage of V201A across R202 causes a decrease in the V201A plate current, and therefore an increase in plate voltage. This positive-going output from V201A is coupled by C202 to the grid of cathode follower, V201B. The V201B cathode voltage follows the grid voltage so that a positive pulse is coupled back to the cathode of the grounded-grid amplifier through the crystal. The crystal presents a low impedance path only to its series resonant frequency. Thus, oscillations are generated by the stage and sustained in the zero-phase-shift (regenerative) feedback loop.

The shunt fed plate tank circuit of the grounded-grid amplifier, V201A, comprises C203 in parallel with one of 18 inductances, L222 through L239, selected by the 10-mc autopositioner output shaft. The frequency of oscillations can be adjusted over a small range by positioning the core in the selected plate tank coil. This circuit is normally adjusted so that the frequency of oscillations is precisely as desired to eliminate any inaccuracy in the final output from the frequency multipliers in the first injection system.

By selection of the oscillator crystals, frequencies from 26.67 to 38.89 mc can be obtained. Inductor, L201, resonates with the crystal holder and stray circuit capacitances at about 30 mc, and thus increases the amplitude of the oscillator output at that frequency.

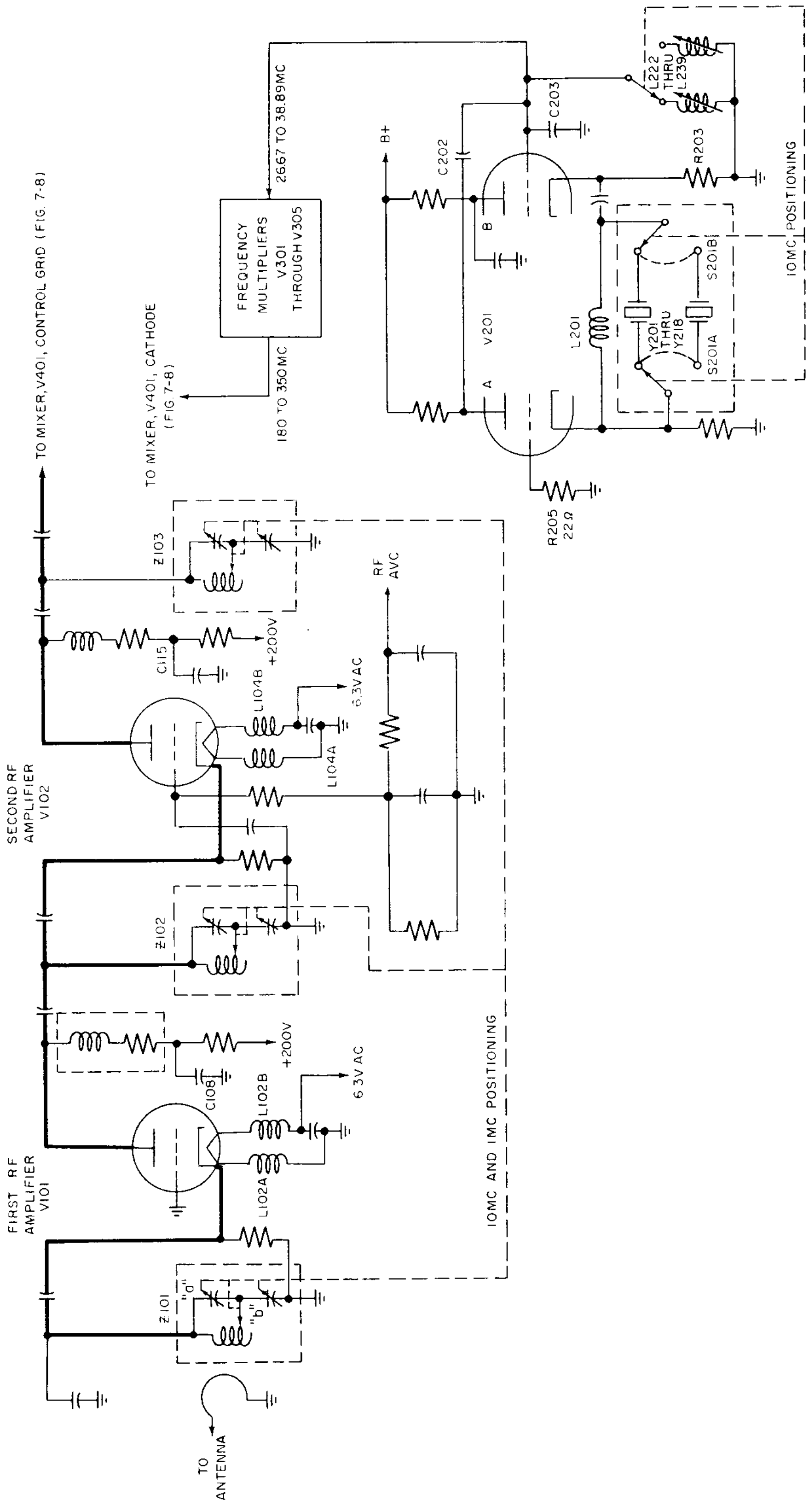


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Figure 7-6.—R-f amplifier and main oscillator.

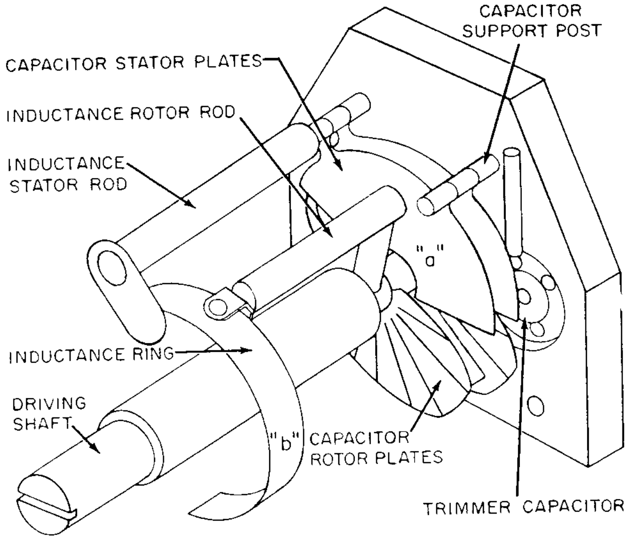

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Figure 7-7.—Radio Receiver r-f amplifier, r-f timer construction.

The oscillator crystal is maintained at a constant temperature in a 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 rapidly to operating temperature, 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 ± 5° C).

The oscillator output (26.67 to 38.89 mc) is fed to frequency multiplier stage V301 (fig. 7-3). Multiplier, V301, contains a tapered toroidal coil assembly in the plate circuit (not shown). The coil consists of 18 turns of wire. A rotary contact (driven by the 10-mc autopositioner output shaft) progressively adds a 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 V301 plate coil is tuned to twice the oscillator frequency for the 6 lowest injection frequencies and to three times the oscillator frequency for the 12 highest injection frequencies. Thus, V301 acts as a doubler or tripler stage as determined by the frequency to which the receiver is tuned.

Pentode, V301, feeds its output to V302. The plate r-f tuned circuits of V302 through V305 are similar in some respects but differ in others from the r-f tuners used in the r-f amplifiers (V101 and V102, fig. 7-6). The former have differently shaped capacitor rotor plates (to produce the desired tuning) and are tuned to a lower frequency. The plate tank of V302 is tuned to three times the input frequency from V301. The signal is therefore tripled in this stage.

The output injection signal frequency from V302 is from 180 to 350 mc. This signal is fed from V305 to the first mixer input, V401, and heterodyned in this stage with the 225-399.9 mc r-f input. All stages in the frequency multiplier-amplifier are tuned from the output of the 10-mc autopositioner shaft. Likewise, the switching in the main oscillator is done from the output shaft of the 10-mc autopositioner.

FIRST MIXER AND FIRST I-F AMPLIFIER STAGES

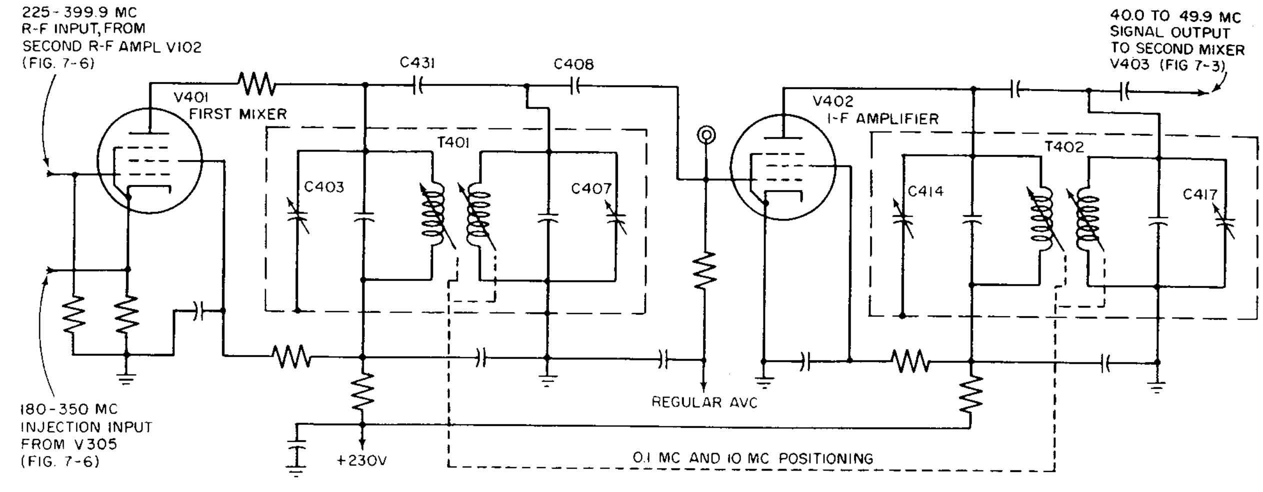
The first mixer, V401 (fig. 7-8), combines the r-f input signal (225.0 to 399.9 mc) received on its grid with the first injection signal (180 to 350 mc) received on its cathode to produce a first intermediate frequency of 40.0 to 49.9 mc. This signal is fed through C431 and C408 to the i-f amplifier stage, V402.

The gain of the i-f amplifier, V402, is controlled by the AVC circuit. The r-f channels are tuned at 0.1-mc intervals (fig. 7-3) by the 0.1-mc autopositioner shaft. The first injection system (main oscillator and multipliers) is tunable at 10-mc intervals by the 10-mc autopositioner shaft. The combined action of the two tuning shafts to control the output frequency of V402 makes possible 100 first intermediate frequencies. The first i-f interstage transformers, T401 and T402, are therefore made tunable in one hundred 0.1-mc increments by a differential tuning mechanism which includes a tuning rack that is cam-driven from the 0.1-mc and 1.0-mc autopositioner outputs.

The interstage transformers, T401 and T402 (fig. 7-8), are permeability tuned by powdered iron cores mounted on the rack. Cams on a fixed bearing shaft (fig. 7-9), driven from the 0.1-mc autopositioner output, raise or lower a floating shaft driven from the 1.0-mc autopositioner output. Cams on this floating shaft raise or lower the tuning rack.

Each set of cams adjusts the rack in 10 steps. The combined action of the two sets of cams yields 100 positions of the tuning cores.

Threaded studs on the cores make it possible to adjust each core independently during the alignment procedure. Trimmer capacitors, C403, C407, C414, and C417 (fig. 7-8), can be adjusted across the tuned circuits so that the



32.116

Figure 7-8.—First mixer and first i-f amplifier.

most linear part of the tuning curve can be selected to give the best tracking. The 40.0 to 49.9 mc output from V402 is fed to the second mixer, V403 (fig. 7-3).

SECOND INJECTION SYSTEM AND SECOND MIXER

The second oscillator or second injection system, V404 (fig. 7-3), employs a Butler oscillator circuit similar to that shown in figure 7-6. The circuit contains 10 CR-23/U crystal units operating at frequencies from 31.00 to 40.00 mc. Selection of the correct crystal unit and tuning of the plate transformer is done by the 1-mc autopositioner output. The 1-mc autopositioner shaft changes in 10 incremental steps. For each change in the shaft the injection frequency changes 1 mc from 31 to 40 mc. The second injection signal is fed to the cathode of the second mixer, V403.

The second mixer, V403, combines the first i-f output signal (40.0 to 49.9 mc) with the second injection signal (31.0 to 40.0 mc) to produce a second intermediate frequency range of 9.0 to 9.9 mc. The circuit of the second mixer (not shown) is similar to first mixer stage, V401, of figure 7-8. The second i-f amplifier, V501, amplifies the 9.0 to 9.9 mc signal and applies its output to the third mixer, V502A.

THIRD MIXER-OSCILLATOR

The third mixer-oscillator, V502 (fig. 7-10), is crystal-controlled by one of 10 CR-18/U crystal units, Y501 through Y510. The crystal oscillator, V502B, is used to generate one of 10 third injection signals in the frequency range of 6.95 to 7.85 mc. The selection of the proper crystal unit is accomplished by the 0.1-mc autopositioner output.

The oscillator output is developed across L505 and R507 and applied to the cathode of V502A as the third mixer injection signal. The second i-f signal (9.0 to 9.9 mc) is received on the grid of V502A. The oscillator and i-f signals are combined in V502A to produce the third intermediate frequency of 2.05 mc.

The third i-f signal (2.05 mc) is conducted over RG-58/U coaxial line to the third i-f amplifier. The third i-f amplifier actually consists of three stages of i-f amplification, V601, V602, and V603. These stages are conventional i-f amplifiers.

AUDIO DETECTOR, SERIES NOISE LIMITER, AND AVC STAGES

The modulated 2.05-mc i-f signal from V603 (fig. 7-3) is fed via the secondary of T604 (fig. 7-11) to the audio detector, V604A. Diode, V604A, is connected as a conventional detector circuit to remove the modulation (audio) component from the i-f signal. The diode load consists of R613 and R614 in series, bypassed by C629.

The rectified output of V604A is taken from the R613-R614 junction and applied to the plate (pin 2) of the series noise limiter, V605A. Note that the series connected components consisting of R622, R623, R624, and V605A are connected in parallel with R613. The plate of V605A is therefore normally positive with respect to its cathode and is normally conducting. The series

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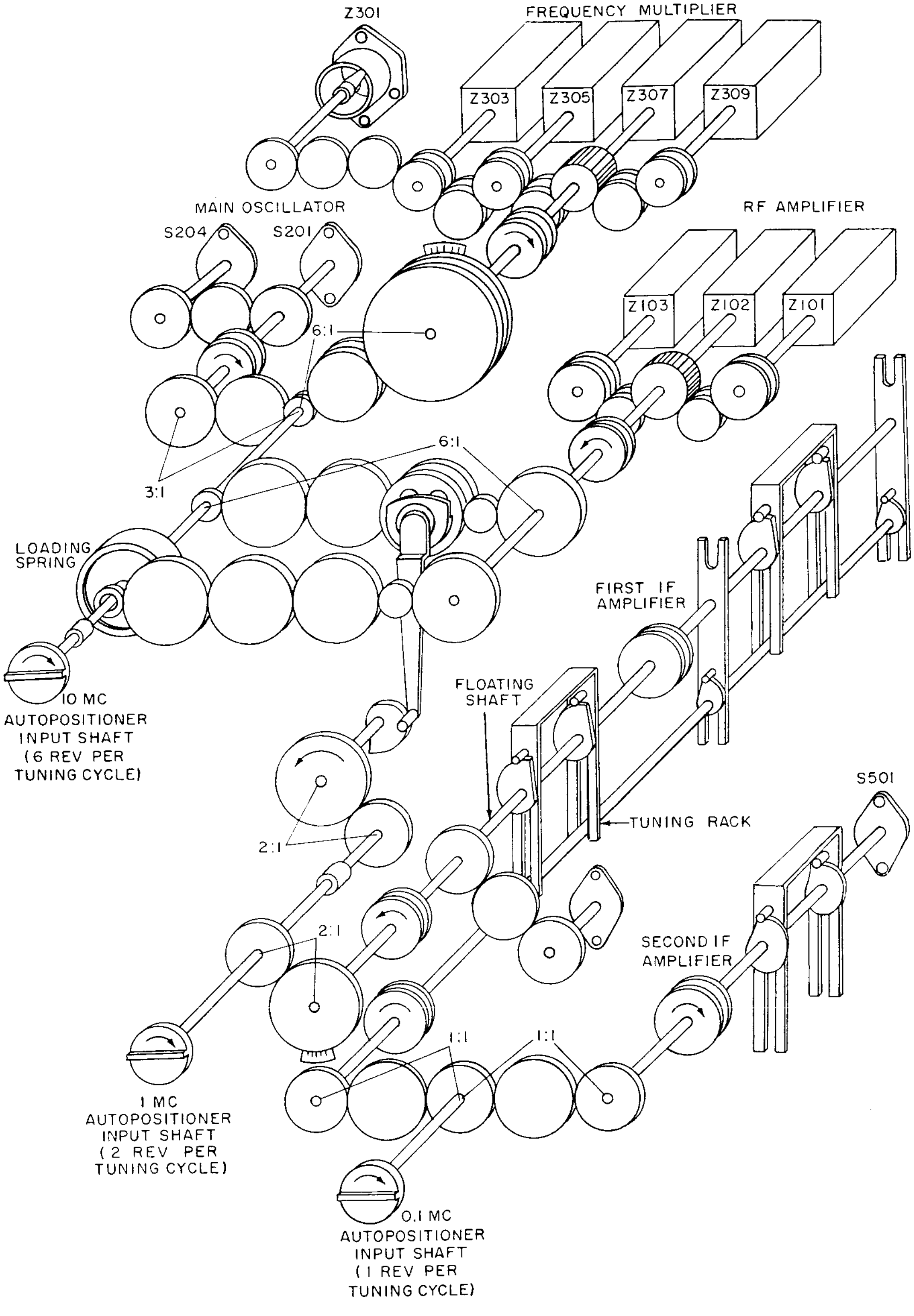

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Figure 7-9.—Receiver tuning mechanical drive system.

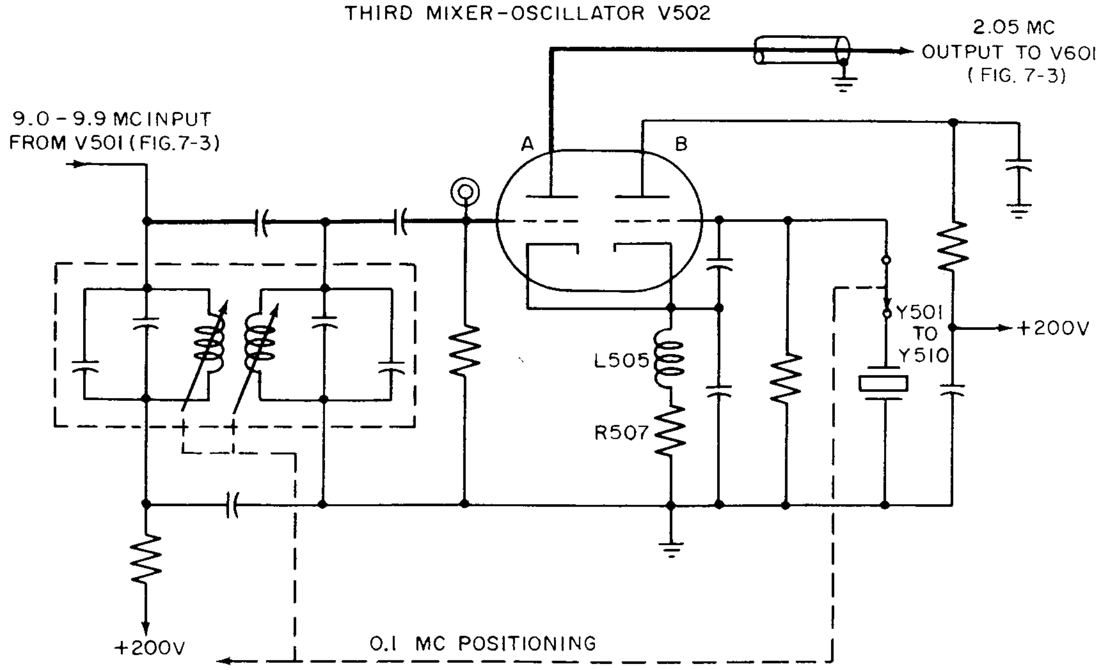

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Figure 7-10.—Third mixer oscillator.

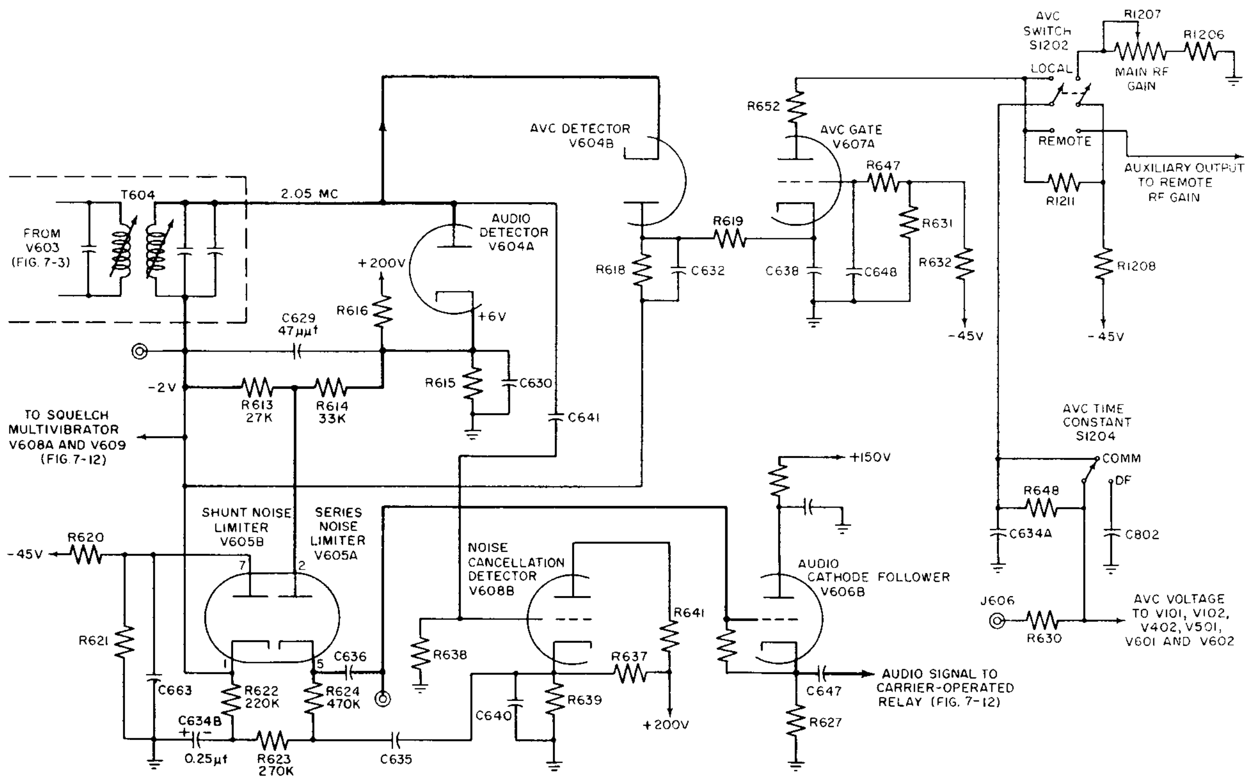

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Figure 7-11.—Audio detector, noise limiters, and AVC stages.

noise limiter, V605A, limits the audio and noise components of the rectified signal.

Since impulse noises of the type encountered at ultrahigh frequencies consist of very sharp pulses several times the amplitude of the audio, this limiting action greatly reduces the amount of noise energy transmitted to the audio amplifier circuits without adversely affecting the intelligibility of voice signals.

Resistor, R622, and capacitor, C634B, act as a filter to establish a reference potential at the cathode of V605A. Since the frequency and capacity is low the reactance of C634B is high. Thus, the filtered negative voltage from the top of C634B to ground represents an appreciable portion of the full rectified audio signal amplitude. During normal (no noise) conditions, the reference voltage across C634B (at the V605A cathode) will be negative with respect to the plate, and the audio signal at the plate will be developed across R623 and R624.

Because C634B will not respond to an instantaneous voltage change, the d-c cathode potential of V605A will not change appreciably with the application of a few negative-going noise spikes. The voltage across R614 will exceed that across C634B and V605A will be reverse biased during the noise spikes. This action momentarily opens the audio signal path at V605A to cut off the output signal via C636. However, if the noise pulses persist over a longer period, C634B will assume an increasingly greater negative charge. The increase in negative potential at the V605A cathode causes V605A to conduct an increased amount of the negative-going spikes until most of the noise signal is no longer eliminated.

NOISE CANCELLATION DETECTOR

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 cancellation. The pulses are generated by noise cancellation detector, V608B.

Triode, V608B, operates as an infinite impedance detector. The 2.05-mc i-f signal is applied to the grid of the tube from the T604 secondary and the detected output appears at the cathode. V608B is biased by voltage dividers R637 and R639 to about +15 volts so that only signals exceeding normal amplitude (noise signals) are detected.

The noise pulses of sufficient amplitude to cause V608B to conduct are developed at the cathode and coupled through C635 back into the output of the series diode limiter circuit. These pulses (positive-going) are of opposite polarity to the negative-going noise pulses which appear across C634B from the audio detector output. The positive output of V608B, therefore, tends to keep the C634B voltage from being driven more negative during the reception of long duration noise pulse groups. The resulting action causes cancellation of the two out-of-phase noise voltages and the quality of the audio output across R624 is improved.

SHUNT NOISE LIMITER

A shunt-type limiter, V605B (fig. 7-11) has also been included in this receiver for the purpose of protecting the AVC and squelch circuits (discussed later) from the effects of noise pulses. Diode V605B is biased in the nonconducting direction by a negative potential at its plate (approximately -17.5 volts). This potential is obtained from the junction of R620 and R621 which is connected from the -45-volt supply to ground.

When an i-f signal of peak amplitude greater than -17.5 volts is applied to the V605B cathode, the diode conducts and prevents the a-v-c voltage from exceeding this value. This action reduces the effect of noise pulses that would ordinarily generate appreciable a-v-c voltage and decrease the sensitivity of the receiver to desired signals. Since the carrier-operated relay control voltage (fig. 7-3) is also developed by the AVC circuit, the limiting of the signal amplitude to control the amount of AVC voltage also reduces the tendency of the squelch circuit to cut off the receiver audio output in the presence of high amplitude noise impulses.

The audio output from the cathode of the series noise limiter, V605A, is coupled through C636 to the grid of the audio cathode follower, V606B. The audio output of this stage is developed across R627 and coupled by C647, through shielded cable to the carrier-operated relay, K801 (fig. 7-12).

DELAYED AUTOMATIC VOLUME CONTROL

The delayed automatic volume control circuit includes the audio detector, V604A (fig. 7-11), the AVC detector, V604B, and the AVC gate, V607A. The purpose of the AVC circuit is to maintain the output of the receiver relatively constant for wide variations of the input signal level. The AVC gate stage, V607A, provides an AVC voltage delay so that weak signals can be

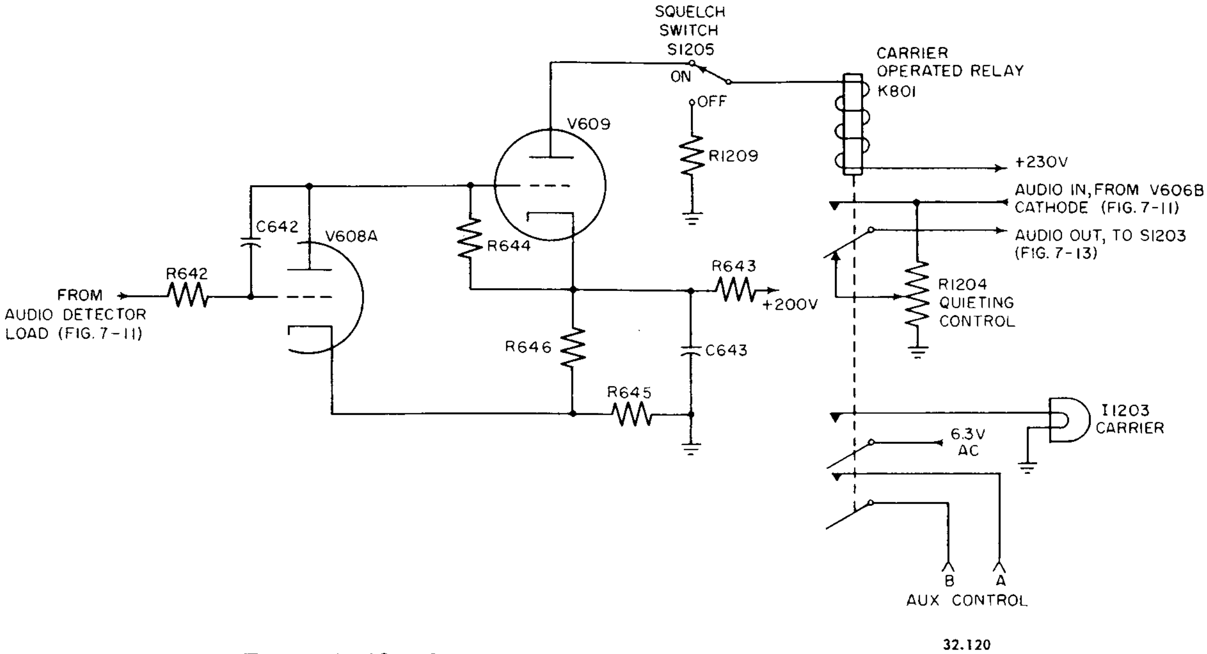


Figure 7-12.—Carrier operated relay and squelch circuit.

passed through the receiver with maximum amplification.

The two sections of the diode detector (V604A and B) with their accompanying circuit form a voltage doubling circuit for the AVC voltage as will be shown presently. Note that the cathode potential of V604A is about +6 volts due to the bleeder current from the +200-volt supply through R615 and R616. During the no-signal-reception condition of the receiver, this potential is fed through R614, R613, R618, and R619 to the cathode of V607A. The grid of V607A is at about -12 volts because of its connection to the junction of R631 and R632 through R647. The action of the two voltages bias V607A beyond cut off.

When a signal is received, the audio detector, V604A (which is a part of the AVC circuit) develops an increasing negative voltage across its load (R613 and R614 paralleled by C629) during one half cycle of the i-f input. Likewise, on the next half cycle, the AVC detector, V604B, develops an increasing negative voltage across its load (R618 paralleled by C632). These voltages appear in series aiding across R618, R613, and R614. Capacitors, C629 and C632, filter the voltage across their respective loads. The combined voltage appears at the plate of V604B and is applied through R619 to the cathode of the AVC gate, V607A. Although the plate of V607A is held negative (about -17.5 volts) the tube will conduct if a sufficiently negative potential is applied to its cathode.

For normal signal amplitudes, the reduction in bias of V607A (by the application of the negative voltage at its cathode) will not be sufficient to cause V607B to conduct. Since the AVC feedback voltage appears in the plate circuit of V607A when the tube conducts, no AVC voltage will be developed while small amplitude signals are being received. When large amplitude signals or signals containing large noise components are received, the cathode of V607A becomes sufficiently negative to cause the tube to conduct. The stronger the signal, the more negative is the cathode of V607A, and the heavier it conducts. The voltage drop across the plate load (R1211) is the output AVC voltage which increases as the V607A cathode potential increases. The AVC potential is filtered by C634A, and fed through the AVC switch, S1202 (in the LOCAL position) to all the r-f and i-f stages except i-f amplifier, V603, in the third i-f amplifier section (fig. 7-3).

The AVC voltage determines the gain of the stages to which the potential is applied. The main r-f gain control, R1207 (fig. 7-11) is also effective in determining the bias on these stages. The r-f gain control also determines the sensitivity of the AVC circuit by setting the V607A plate potential. When the gain control is set to maximum, the AVC voltage varies (according to the incoming signal amplitude) from about -2 to -8 volts.

Two AVC time constants are provided by positioning the AVC time constant switch, S1204. The shorter time constant (0.1 second) is used for communication reception and the longer time constant (2 seconds) is used for direction finder reception.

CARRIER-OPERATED RELAY AND SQUELCH CIRCUIT

To minimize noise in the receiver when it is idle, or when searching for a signal, a carrier-operated squelch circuit reduces the audio output until a carrier is received; then the audio output is increased.

The multichannel receiver is provided with a carrier-operated relay, K801 (fig. 7-12), which is actuated by a two-stage d-c amplifier, V608A and V609. The amplifiers receive the input signal from the V604A audio detector-load (fig. 7-11).

The carrier-operated relay and squelch circuits (fig. 7-12) are designed so that the relay is actuated whenever a carrier signal of sufficient amplitude is received. The signal amplitude required to activate the relay is determined by the setting of the main r-f gain control (fig. 7-11). This control sets the bias level of the r-f and i-f amplifiers and therefore determines the gain of a given signal through the receiver.

The carrier-operated relay, K801 (fig. 7-12), is provided with three sets of contacts. The lower set of SPST contacts are used to control external auxiliary equipments (such as a teletype converter-comparator, facsimile, etc.). The middle contacts, also SPST, control the main carrier indicator lamp, I1203, which is located on the front panel of the receiver (fig. 7-2). The upper contacts on the K801 (fig. 7-12), control the audio signal to the audio amplifier stage (fig. 7-13).

The operation of the squelch circuit is as follows: The voltage across the audio detector, V604A, diode load (fig. 7-11) is applied through R642 (fig. 7-12) to the control grid of V608A. The action of V608A and V609 is similar to that of a "one-shot" multivibrator. With no received signal, the voltage across the V604A diode load resistors (fig. 7-11) is zero. The potential at the cathode of V604A (about +6 volts) is applied through R614, R613, and R642 to the grid of V608A (fig. 7-12). Triode, V608A, is therefore conducting, causing a voltage drop across R644 that makes the grid of V609 negative with respect

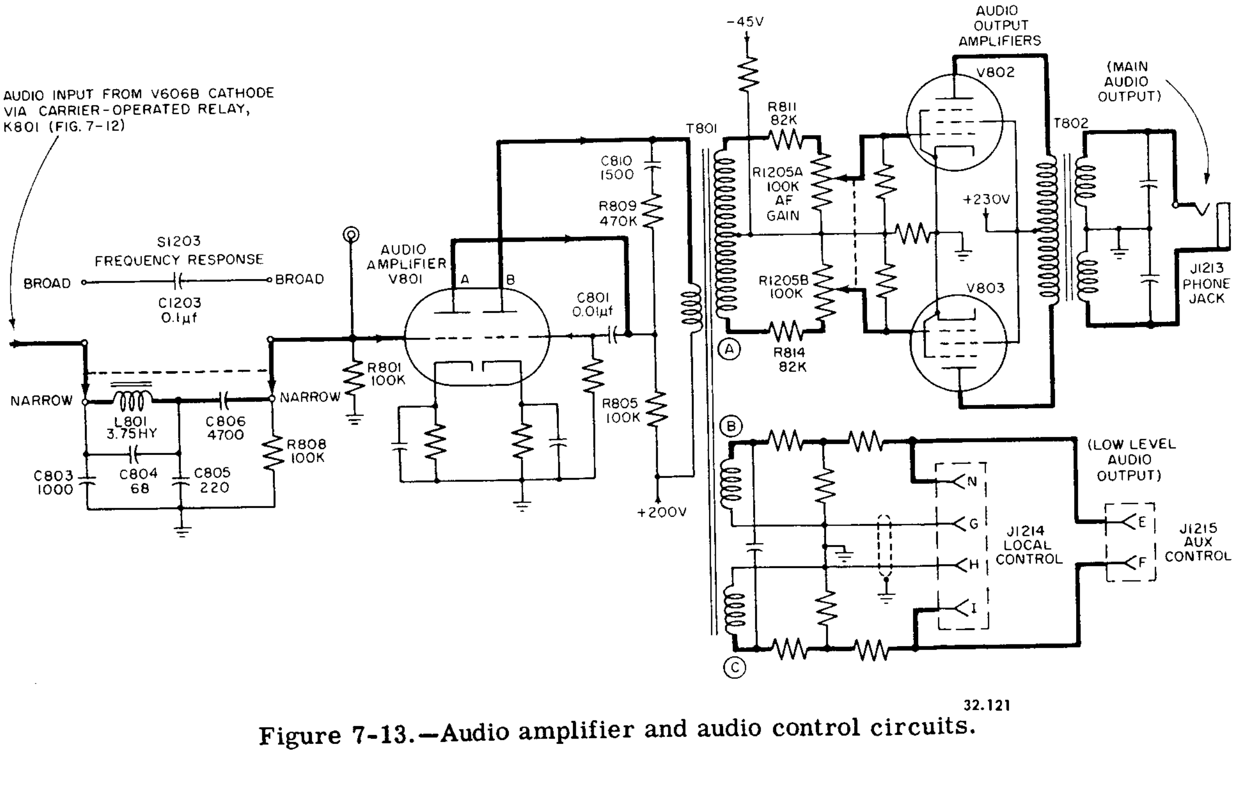


Figure 7-13.—Audio amplifier and audio control circuits.

to its cathode. The grid potential is actually about +5.3 volts positive while the cathode is 28.2 volts positive. Thus, when no signal is received, V608A is conducting and V609 is cut off.

When a carrier signal is received, the voltage across the detector (V604A) load (fig. 7-11) becomes negative to ground. This potential is fed through R642 (fig. 7-12) to the V608A control grid. The negative voltage at the grid of V608A causes the current in this tube section to decrease. The decreased current through R644 allows the grid of V609 to go positive with respect to its cathode, and V609 conducts. The V609 cathode current through R645 increases the bias on V608A, and is regenerative to the input signal. Thus, V608A is quickly driven to cutoff while V609 is driven to saturation.

With V609 conducting (representing a received carrier signal) the current through the K801 solenoid causes the relay to energize. When K801 is activated, the main carrier indicator, I1203, is lighted, the quieting control, R1204, is removed from the audio amplifier circuit, and the circuit to the auxiliary equipment connected to the lower contact of K801 is completed.

Carrier indicator, I1203, located on the receiver front panel (fig. 7-2), is used in conjunction with the main r-f gain control in setting the squelch level of the receiver. With K801 energized, all of the audio output signal developed at the cathode of V606B (fig. 7-11) is fed through the K801 upper contacts to the audio stages of the receiver. The purpose of the quieting control, R1204 (fig. 7-12), is to attenuate the receiver noise any desired amount at the time no carrier signal is present.

The squelch switch, S1205, determines the on-off condition of the squelch circuit. With the squelch switch in the ON position, (as shown) operation of the carrier-operated relay is as described above. In the absence of a carrier the voltage drops across R613 and R614 (fig. 7-11) are reduced to zero and the +6 volts of the V604A cathode is applied to the V608A grid via R642 (fig. 7-12). This action causes V608A to conduct. The resulting drop across R644 biases V609 to cutoff, and K801 opens. In the OFF position of S1205, a continuous current through R1209 and the K801 solenoid keeps the K801 contacts in the energized position (opposite the position shown) and the carrier-operated relay remains actuated at all times. Placing S1205 in the OFF position removes the plate voltage from V609 and the squelch circuit is deactivated.

AUDIO AMPLIFIER CIRCUITS

The audio amplifier circuit (fig. 7-13) includes two-stage amplifier, V801, and push-pull amplifier, V802 and V803. The audio signal from the V606B cathode via K801 (fig. 7-12) is fed to an audio filter (frequency response) network (fig. 7-13).

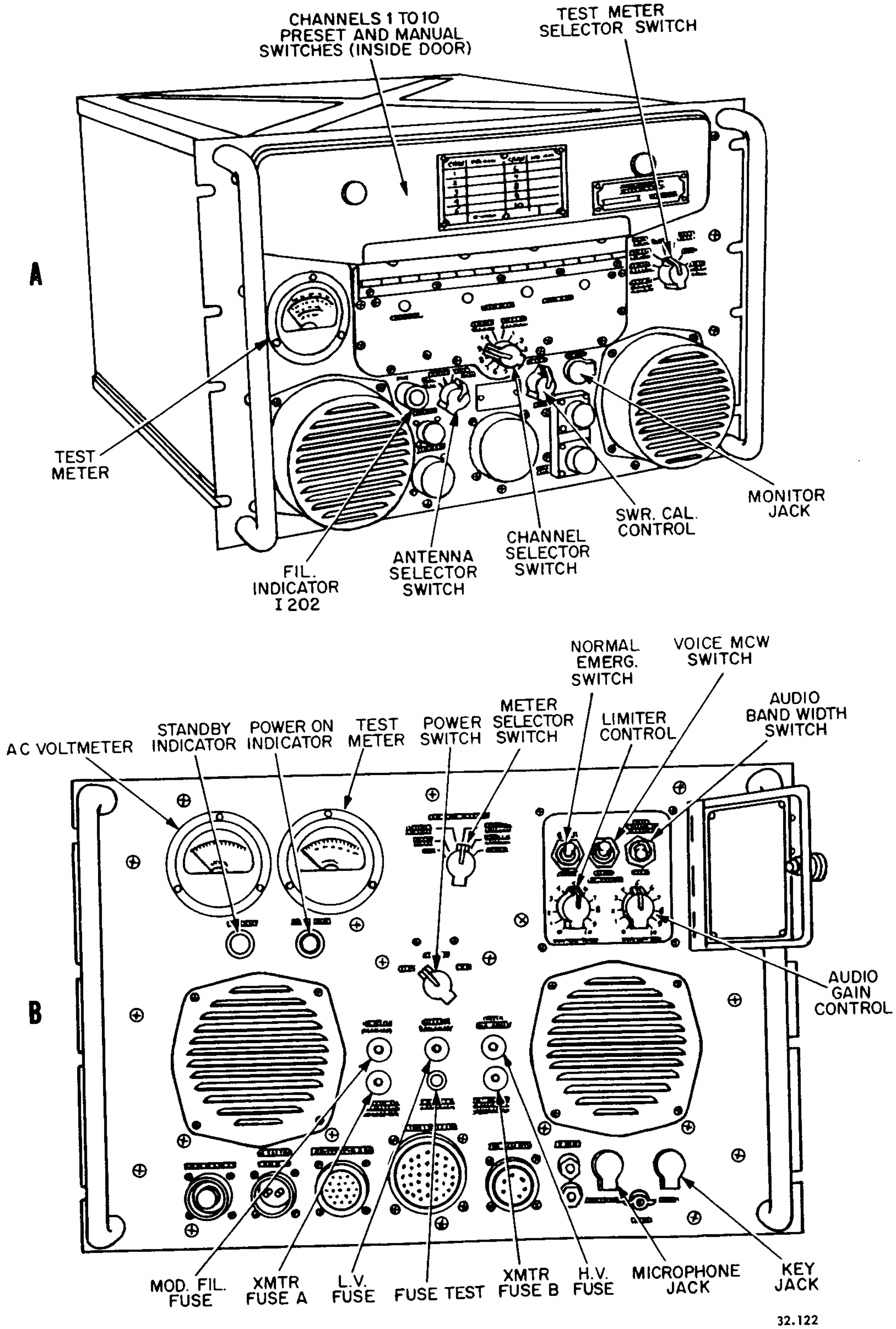
The audio frequency response switch, S1203, is used to select the desired bandpass and has two positions, BROAD and NARROW. In the NARROW position (as shown) a sharp filter circuit comprising L801, R808, and capacitors C803 through C806 is connected in the audio input path so that the audio frequency response is limited to a narrow audio band. In the BROAD position of S1203, C12-3 is placed in the audio input path. This position of the frequency response switch allows almost flat frequency response from about 200 to 20,000 cps.

The audio signal from the frequency response circuit is amplified in V801A which is a conventional class "A" amplifier. Triode, V801A, couples its output through C801 to a second class "A" amplifier, V801B. The audio output of V801B is applied across the primary of audio output transformer, T801.

A frequency compensating network is formed by C801, R809, and R805 across the T801 primary to remove higher-than-audio frequencies. Note that the voltage across R805 (the plate load of V801A) is 180° out-of-phase with the voltage across C810 and R809. Thus, the two voltages oppose each other to degenerate the undesired audio components.

Transformer, T801, employs three secondaries, designated A, B, and C. The lower two secondaries, B and C produce the low-level audio output which is essentially the same voltage as that appearing at the plate of V801B. The low-level output is used for the operation of external equipments.

The audio signal induced in the A secondary of T801 is developed across the voltage divider comprising R811, R1205A, R1205B, and R814. The A and B sections of potentiometer R1205 are ganged together and serve as the a-f gain control. The input audio signal is push-pull amplified in V802 and V803 and coupled across audio output transformer, T802, to the phone jack, J1213. This jack is located on the front panel of the receiver (fig. 7-2). The maximum output at the phone jack is 3 watts into a 600-ohm load.



A. Modulator power supply
B. Transmitter
Figure 7-14.—Radio transmitter and modulator power supply.

RADIO TRANSMITTER T-217A/GR

Radio Transmitter T-217A/GR and its associated Modulator-Power Supply MD-129A/GR (fig. 7-14) constitute the radio transmitting installation of the Radio Set AN/GRC-27A. The transmitter normally delivers a nominal output power of 100 watts, either tone or voice modulated, in the frequency range of 225.0 to 399.9 mc. Like the receiver, the transmitter has a maximum frequency range of 220 to 399.9 mc.

A functional diagram of the transmitter and modulator-power supply is shown in figure 7-15. It can be seen that the transmitter is essentially a frequency generating system, an exciter and driver, and a power amplifier. The modulator-power supply provides the transmitter with power, and voice or tone modulates the output stage of the transmitter.

FREQUENCY SELECTION SYSTEM

The radio transmitter employs a frequency selector system that automatically tunes the multichannel transmitter to any one of 1,750 crystal-controlled frequencies in the range from 225.0 to 399.9 mc. The frequency selector system (fig. 7-16) employed in the transmitter is identical with the system used in the radio receiver. A block diagram of the frequency selector system is shown in figure 7-4.

BLOCK DIAGRAM

The main oscillator, V201 (fig. 7-16), generates the basic frequency for the transmitter. The oscillator employs 18 crystals which are selected by the 10-mc autopositioner to tune the oscillator from 31.111 to 45 mc. This circuit is also referred to as the 10-mc frequency generator since the output frequency of V201 is changed one time for each 10-mc change in the transmitter output frequency.

The 31.111- to 45.0-mc output of the main oscillator is doubled or tripled in frequency multiplier, V301. Pentode, V301, operates as a doubler circuit when the output frequency of the transmitter is 299.9 mc or below. For frequencies above 299.9 mc, V301 triples the oscillator original. The chosen output of V301 is tripled in a second frequency multiplier, V303. Amplifiers V302, V304, and V305 are also a part of the frequency multiplier-amplifier.

The frequency multiplier-amplifier produces one of 18 frequencies spaced at 10-mc intervals. The frequencies are 200 to 370 mc and are delivered to the mixer, V406. The heterodyning frequency for the mixing section in V406 is obtained in the following manner:

The 1-mc frequency generator, V404, contains 10 crystals which are selected by the 1-mc autopositioner. This stage generates any one of 10 frequencies at 1-mc intervals in the 18- to

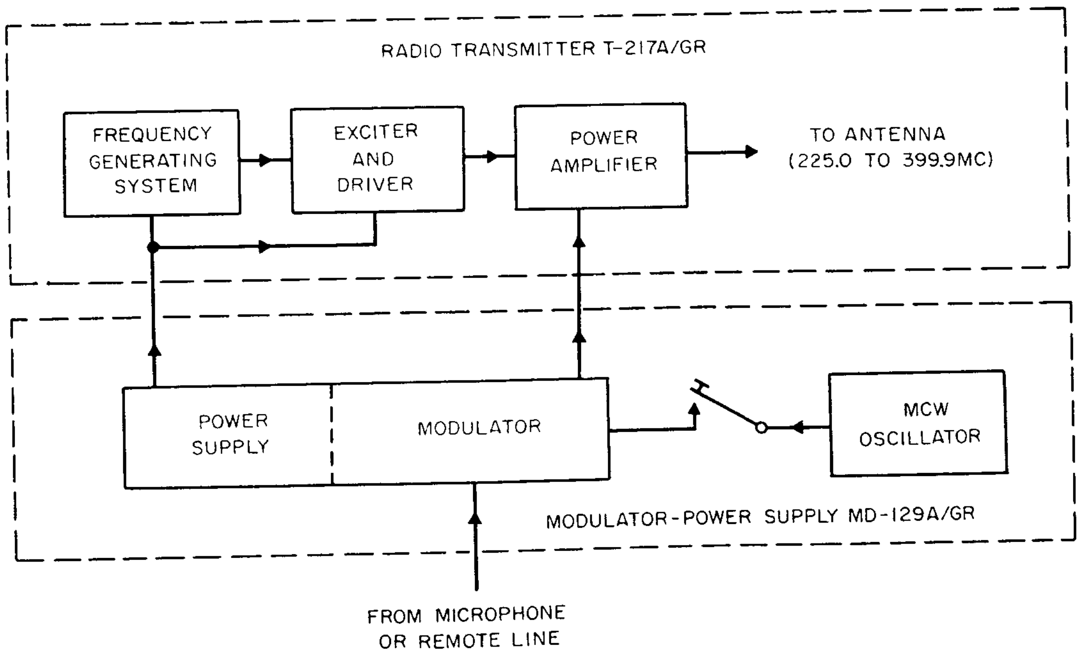


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Figure 7-15.—Radio transmitter and modulator power supply composite direction block diagram.

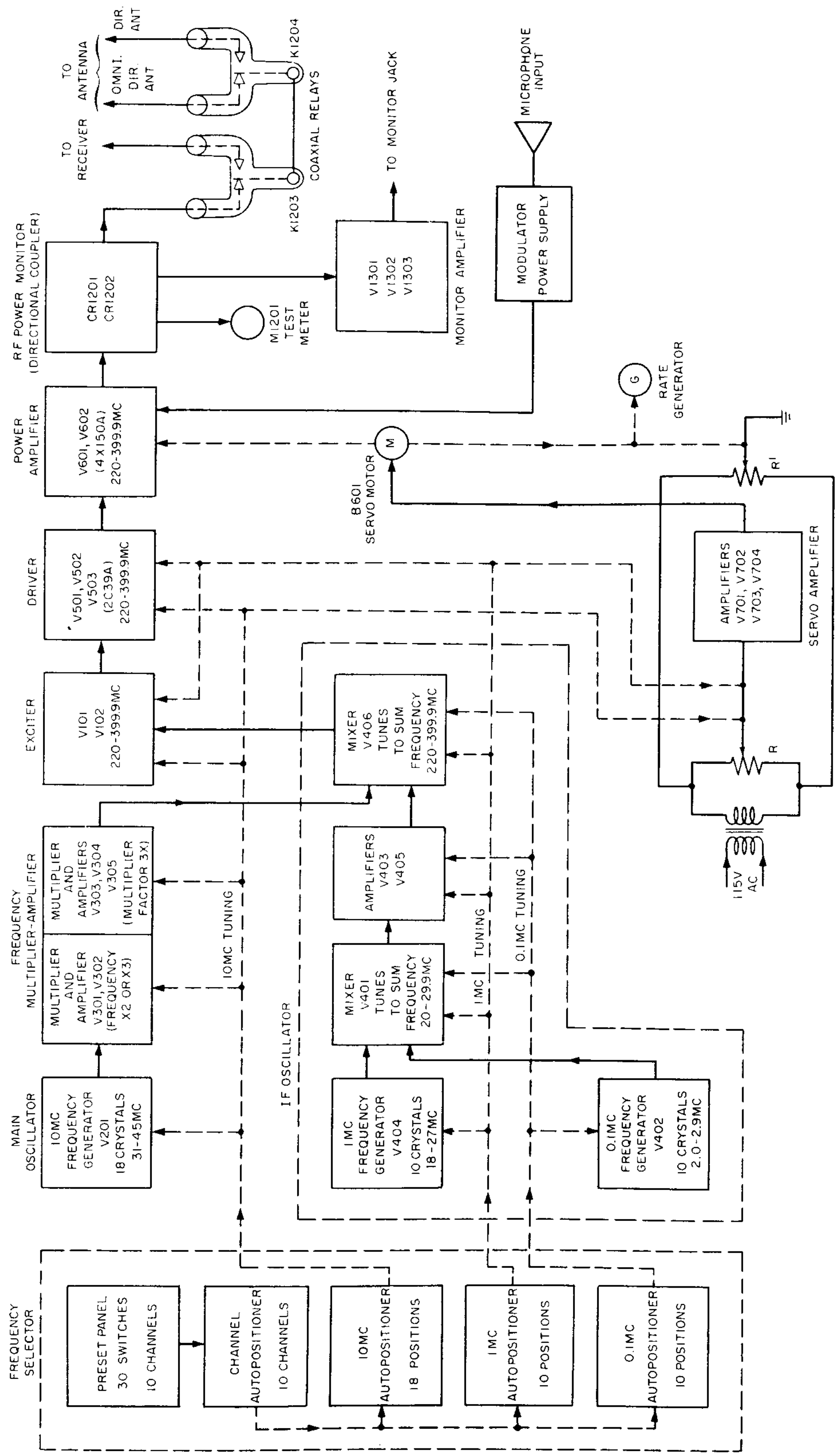

Figure 7-16.—Radio transmitter, block diagram.

27-mc frequency range. The frequency generated is determined by the crystal selected and also by the timing of the V404 output circuit by the 1-mc autopositioner.

A secondary frequency generator referred to as the 0.1-mc frequency generator, V402, contains 10 crystals which are selected at 0.1-mc interval. The frequency range is from 2.0 to 2.9 mc, as determined by the selected crystal.

The output frequencies of the two frequency generators (V404 and V402) are heterodyned in mixer, V401, to produce the sum frequency (20.0 to 29.9 mc). This sum frequency output is amplified in V403 and V405, and fed to mixer, V406.

The incoming frequency from the frequency multiplier-amplifier (200 to 370 mc) and the output from V405 (20.0 to 29.9 mc) is heterodyned in V406 to yield the sum frequency (220.0 to 399.9 mc). Because of the tuning differential between the 1-mc and 0.1-mc frequency generators, the output from the mixer, V401, can be any of 100 frequencies.

The signal from the mixer, V406, is amplified in the exciter, which comprises V101 and V102. The exciter output signal from V102 is amplified in three stages, V501, V502, and V503. The exciter and driver stages are tuned by the 10-mc and 1-mc autopositioners in 1-mc steps from 220.0 to 399.9. The amplifier stages in the exciter and driver are tuned to the center frequency of each 1-mc band. The bandpass of these stages is broad enough to amplify the 0.1-mc variations.

Pentodes, V601 and V602, amplify the driver (V503) output signal to produce a nominal output power of 150 watts. A servo system, employing servo motor, B601, is used to tune the power amplifier throughout the frequency range of the transmitter. The servo amplifier circuit receives its error signal input from a servo bridge.

A basic representation of the tuning bridge includes potentiometers R and R'. Both resistors are connected across the 115-volt a-c line input. Actually, this load across the bridge consists of the input circuit to the grid of the first amplifier, V701 (not shown). Since the input circuit to V701 is grounded, the load across the bridge is connected between the arms of R and R'. Note that the arm of R is positioned by the 10-mc and 1-mc autopositioner shafts, and that the arm of R' is positioned by a mechanical connection to the servo motor.

If the power amplifier is on frequency, the potential at the arm of R will be the same as on the arm of R' and the voltage difference across the load (V701 input) will be zero. The bridge is therefore balanced, the motor is not turning, and the error signal is zero. However, if the balance of the bridge is upset, as will be the case when a new channel is selected, the 10-mc and 1-mc autopositioners move the arm of R in an attempt to select the new frequency. Thus, the bridge becomes unbalanced when the potential at the arm of R differs from that at R'. This potential difference represents the error signal which is applied to the input of V701.

The output of V701 is amplified in V702, V703, and V704. The amplified output drives the servo motor, B601, which mechanically tunes the power amplifier. Simultaneously, the servo motor drives the arm of R' until its position corresponds with the new position of R.

The direction of the error signal is determined by the direction of movement of R from its zero error position. The direction of rotation of the servo motor also is determined by the direction of the error signal.

The output of the power amplifier is fed through coaxial filters (not shown in the block diagram) which employ five tuned stubs to discriminate against frequencies above 450 mc. The output of this filter is connected to the r-f power monitor.

Two directional couplers are used in the r-f power monitor to provide two sampling voltages. The output from one directional coupler is used to indicate power output, to supply an input to the monitor amplifier, and to calibrate a standing wave ratio indicator. The output from the other directional coupler provides standing wave ratio indication in conjunction with test meter, M1201.

The signal from the r-f power monitor is passed to the antenna transfer relay, K1203. This relay works in conjunction with the push-to-talk circuit, transferring the antenna from the receiver to the transmitter when the push-to-talk circuit is energized. The circuitry is arranged so that the antenna is transferred before the high voltage is applied to the transmitter.

A directional or omnidirectional antenna selected by K1204 may be used with the transmitter. The transmitter output is fed from K1203 through K1204 to the selected antenna.

TRANSMITTER CIRCUIT OPERATION

MAIN OSCILLATOR AND FREQUENCY MULTIPLIER-AMPLIFIER

The main oscillator, which generates the basic transmitter frequency, is identical to the oscillator circuit used in the first injection system of the receiver. The circuit operation of the oscillator was explained earlier in this chapter (see fig. 7-6). The main oscillator is crystal-controlled by any of the 18 crystals, to produce 18 frequencies from 31 to 45 mc. The oscillator output is applied to the frequency multiplier-amplifier stages via C301 (fig. 7-17, A).

The frequency multiplier-amplifier (V301 through V305) stages are tuned by the 10-mc autopositioner. These stages function together to amplify and multiply the oscillator signal either six or nine times. The output of the frequency multiplier-amplifier can be any one of 18 frequencies within the 200 to 370 mc range.

The output signals from the main oscillator are coupled through C301 to V301, which is the first stage of the frequency multiplier-amplifier. Here, either the second or third harmonic of the main oscillator frequency is selected by the plate tank, Z301. When the transmitter output frequency is to be 299.9 mc or below, V301 functions as a doubler stage. For output frequencies above 299.9 mc, V301 triples the oscillator signal.

The selected output of V301 is amplified in V302, developed at the plate by plate load impedance, Z302, and coupled by C314 to tripler, V303. The tripled output of V303 appears in the shunt-fed tank impedance, Z304.

Tank circuit impedances, Z301 and Z302, the plate tanks of V301 and V302, respectively, consists of an 18-turn tapered toroidal coil in series with a high frequency trimmer coil, both of which are paralleled with a variable capacitor to provide low frequency adjustment. The 18-turn coil is wound on a form which permits each turn of the coil to be contacted in sequence by a switch arm as the transmitter is tuned to the various frequencies throughout its tuning range. The switch arm is driven in 18 steps by the transmitter selector systems. The tanks may be tuned in increments of 3 1/3 mc each, between 66 2/3 and 123 1/3 mc.

Since the V302 output is tripled in V303, the input tuned circuit to amplifier V304, must be tunable over three times the V303 output or from 200 to 370 mc. The tuned input and output circuits of the amplifier stages (V304 and V305) are special r-f tuners similar to those used in the r-f amplifier stages (V101 and V102) of the receiver (fig. 7-7). These tuners (fig. 7-17, A) are ganged together and driven by the 10-mc autopositioner of the frequency selector system. Each of the circuits is tuned in increments of 10 mc each, between the limits of 200 and 370 mc. The tuners provide linear tuning over the entire range by simultaneously changing both the capacitors and the inductance as they are positioned by the frequency selector system.

Figure 7-17, B illustrates the manner in which the inductance and capacitance change to produce the required resonant frequency as the tuning elements are rotated. Note that the point of minimum capacitance does not correspond to the maximum frequency of the tuning range. However, the change in inductance and capacitance is such that the resonant frequency rises linearly for each degree of coverage over the tuning range from about 18° to 198°, or for 180° of rotation of the tuning shaft. Thus, by the simultaneous changing of the inductance and capacitance through 1°, the resonant frequency of the tank is changed 1 mc.

The capacitor rotor plates (fig. 7-7) are divided into 20° sectors by slots that are cut well down toward the center of the plates. The slots are staggered so that the slots on one plate correspond to the center of the sectors on the other plate. If the capacitor rotor plates are rotated in 10° increments (10-mc), at each position at which the rotor comes to rest, one sector of one or the other of the plates will be just half engaged with the stator. Tracking of these tuners over the frequency range is accomplished by bending (in the proper direction) the sector which is half engaged at each of the tracking frequencies. The point at which the inductance rotor rod is exactly in line with the short capacitor support bar (fig. 7-7), is used as a reference point in the tracking procedure.

The 200- to 370-mc output of V303 (fig. 7-17, A) is amplified in grounded-grid amplifiers, V304 and V305. The output r-f signal is fed through C332 to the mixer, V406, cathode (fig. 7-17).

I-F OSCILLATOR

The i-f oscillator section of the transmitter is shown in figure 7-18. The purpose of the i-f oscillator circuit is to provide an injection signal to the mixer, V406, at any of 100 frequencies spaced 100 kc apart in the range of 20.0 to 29.9 mc. When any one of these frequencies is added to the output of the frequency multiplier-amplifier in the mixer stage, V406, it makes available to the exciter a signal of some particular frequency which is amplified and finally emerges as the output frequency of the transmitter.

The i-f oscillator circuit comprises two crystal oscillators, V402 and V404, respectively.

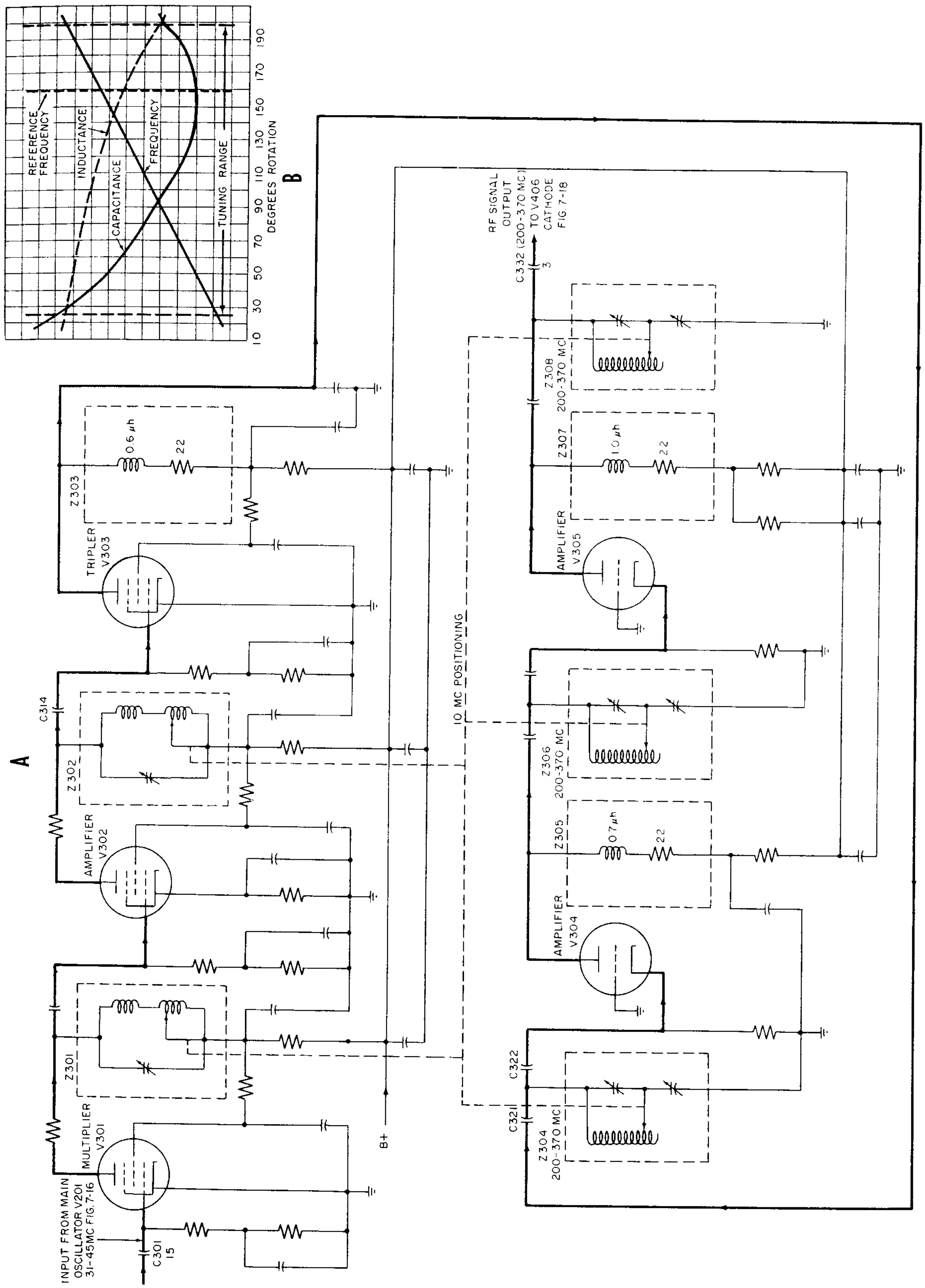

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Figure 7-17.—Radio transmitter frequency multiplier amplifier.

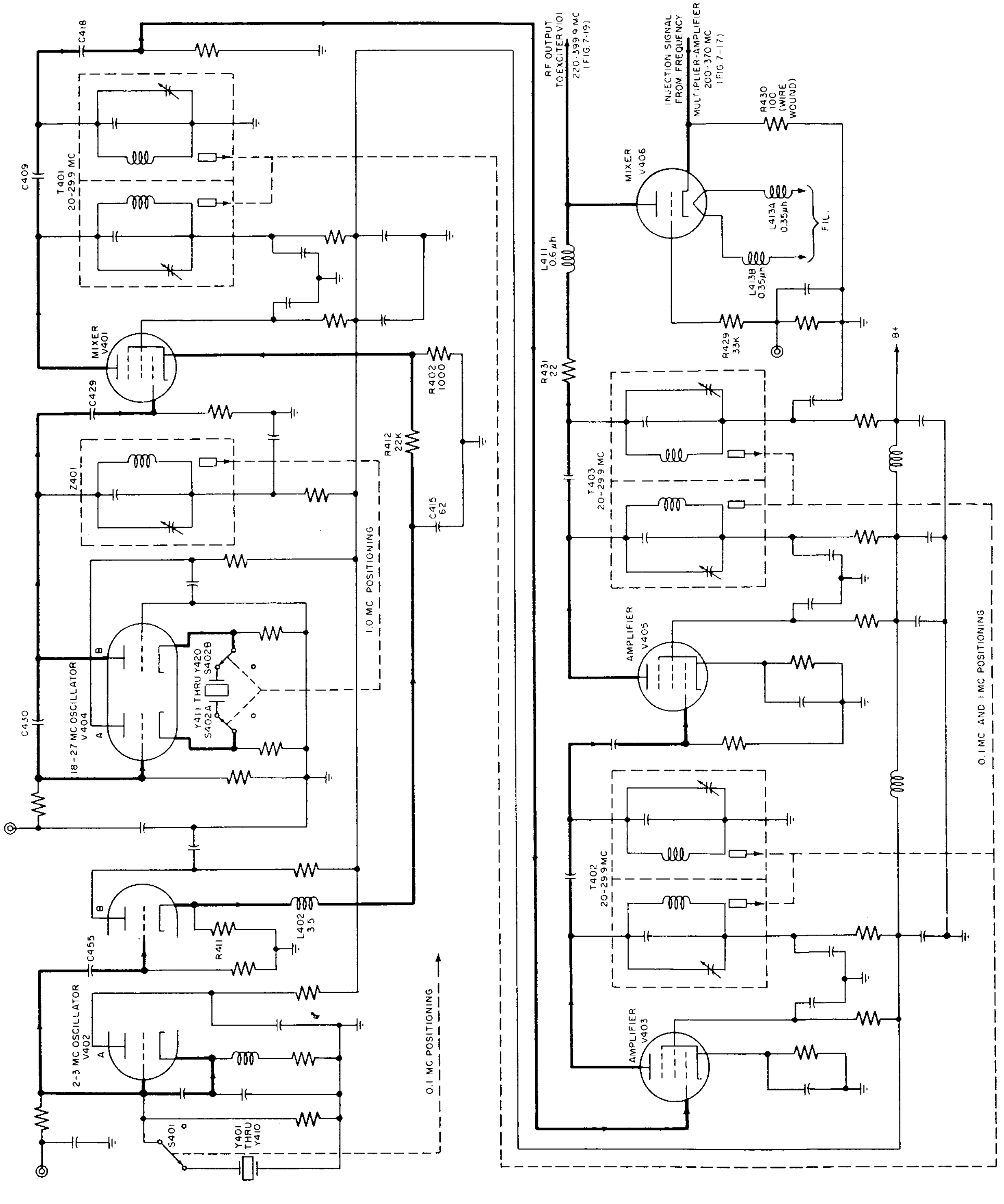

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Figure 7-18.—Radio transmitter, i-f oscillator.

The outputs of these oscillators are added together and amplified before being impressed upon the grid of the mixer.

One of the oscillators (the 2-3 mc oscillator) is composed of one-half of V402 and its associated circuitry. This stage is fundamentally a Pierce oscillator since the crystal is essentially connected between plate and grid of the oscillator by C413. The oscillator employs one of 10 crystals (Y401 through Y410) which is selected by S401. This switch is driven by the 0.1-mc autopositioner shaft. The oscillator can therefore produce any of 10 output frequencies.

The output of oscillator V402A is taken from the grid of the stage to minimize the harmonic content in the output. The output frequency from the oscillator ranges from 1.994 to 2.894 mc in steps of 0.1 mc. The V402A output signal is coupled through C455 to the grid of V402B.

Triode, V402B, functions as a cathode follower and acts as a buffer stage to isolate the oscillator, V402A, from the mixer stage, V401, to which the oscillator signal is applied. The purpose of the mixer, V401, is considered presently.

You will note that the V402B cathode follower output developed at the junction of R412 and R402 is impressed on the V401 mixer cathode. These resistors (R412 and R402) are the cathode follower load resistors. Inductor, L402 and capacitor C415, form a series resonant circuit at about 10 mc to effectively ground the V402B cathode at this frequency. For lower frequencies the reactance of C415 is high and a large portion of the 1.994- to 2.894-mc output of V402B will be developed across R402. However, the reactance of C415 decreases for higher frequency components (harmonics) of the V402B output, and the amount of harmonic content which can appear across R402 at the mixer input is limited. Resistor, R411, is connected in parallel with the cathode follower, V402B, load components to effect impedance matching between the cathode follower, V402B, and the mixer, V401.

The second oscillator stage, the 18- to 27-mc oscillator, V404, is a Butler oscillator composed of both triode sections. Any of the crystals, Y411 through Y420, control the frequency of the oscillator between 18.006 and 27.006 mc. The desired oscillator crystal is selected by S402, which is driven by the 1.0-mc autopositioner output shaft.

This shaft also permeability tunes the plate tank of V404B. Triode, V404B, is the grounded-grid amplifier section of the oscillator, and V404A is the cathode follower. The output from the oscillator (developed in V404B plate load impedance Z401) is coupled to the control grid of mixer, V401.

The purpose of mixer V401 is to combine the outputs of the two oscillators (V402A via V402B and V404) to produce the sums frequency output in the primary tuner circuit of T401. Since one of the input frequencies (from V402B) may vary from 1.994 to 2.894 mc in 10 steps of 100 kc, and the other input (from V404B) may vary from 18.006 to 27.006 mc in 10 steps of 1 mc, the output (sum frequency) may vary from 20.0 to 29.9 mc. The mixer, V401, plate tank is tuned by the 0.1 and 1-mc autopositioners so that the combined tuning yields 100 frequency steps of 100 kc each.

The V401 sum frequency output is coupled from the tuned T401 secondary through C418 to the control grid of amplifier V403. Capacitor, C409, increases the high-frequency coupling across T401. Pentodes, V403 and V405, are r-f amplifiers, with plate load impedances, T402 and T403, respectively, functioning exactly as T401.

Resistors, T401, T402, and T403, are all permeability tuned by a rack (fig. 7-9) that is driven by two cam shafts. The sum of the shaft positions determines the physical position of the tuning rack over 100 incremental tuning steps.

The 20.0- to 29.9-mc output of V405 is coupled from the T403 secondary through R431, and L411 to the plate of mixer V406. You will recall that the 200- to 370-mc output of the frequency multiplier-amplifier, V305 (fig. 7-17), is fed to the mixer, V406, cathode (fig. 7-18). The plate r-f potential of V406 therefore varies in accordance with the combined input signals. One of the output signals appearing at the mixer, V406, plate is the sum of the two input frequencies which ranges from 220 to 399.9 mc. The two original frequencies, as well as the difference frequency, will also be present at the V406 plate. All of the frequencies will be fed to the exciter circuit input (fig. 7-19). However, because of the tuning of the shunt fed input tank, Z101, only the sum frequency is selected and coupled through C102 to the first r-f amplifier, V101, input.

EXCITER

The exciter stages, V101 and V102 (fig. 7-19), serve the purpose of amplifying and filtering the mixer, V406 of figure 7-18, output to a sufficient level to provide adequate input signal power to the subsequent driver stages of the transmitter.

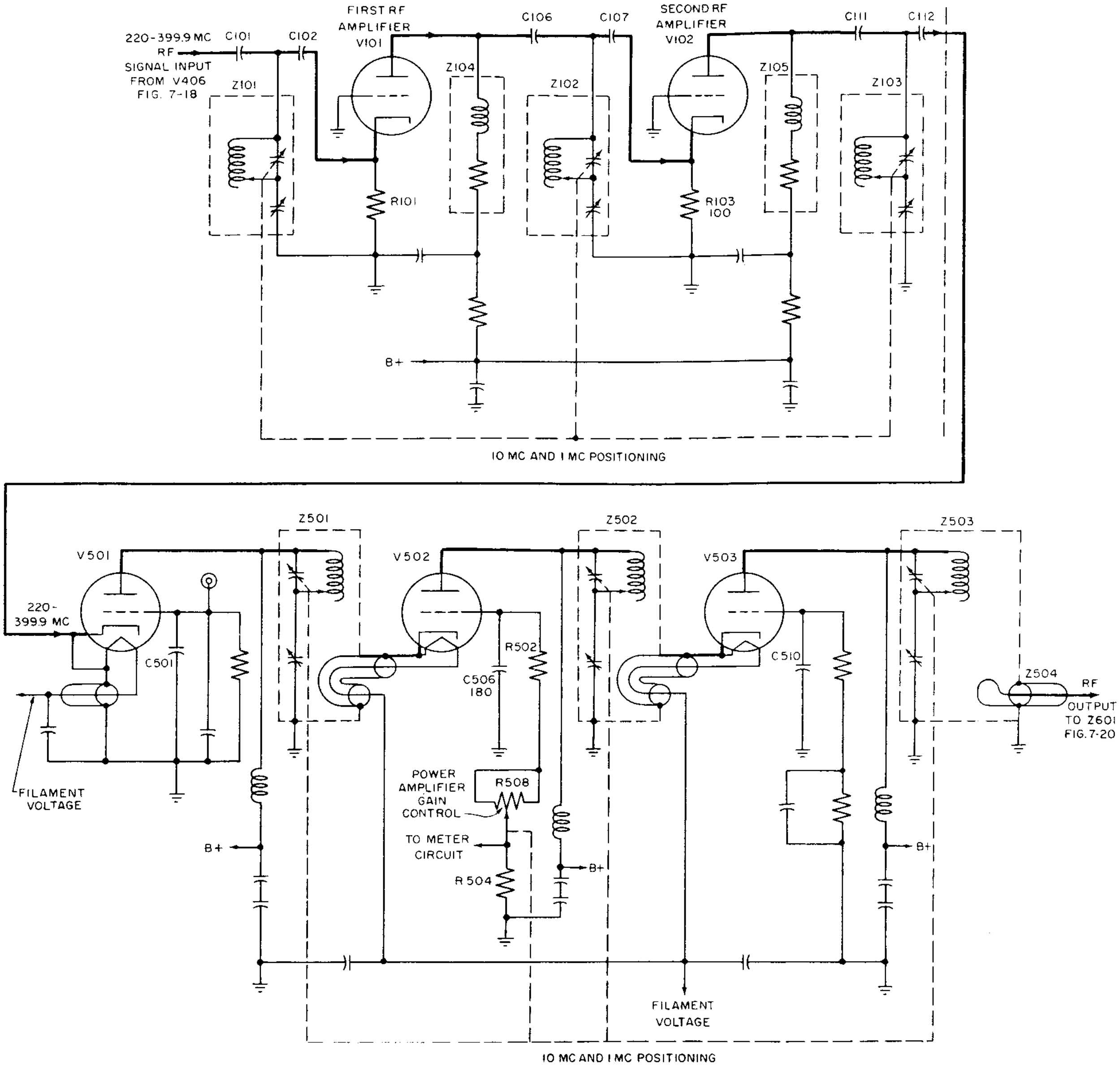

Figure 7-19.—Exciter and driver stages. 32.127

Three tuned circuits, Z101, Z102, and Z103 and two amplifiers, V101 and V102, are included in the exciter. The tuned circuits cover a range from 220.0 to 399.9 mc. Each position of the tuner corresponds to the center frequency in each 1-mc band so that the tuning of Z101, Z102, and Z103 is actually set in 1-mc steps from 220.5 to 399.5 mc.

The r-f tuners of the exciter are the type used in the receiver r-f amplifiers (fig. 7-7). The main advantages of these tuners are linear tuning and the ability to discriminate against undesired signals.

Triodes, V101 and V102, are grounded-grid amplifiers. The input signal is applied to the cathode of the amplifiers. The grounded-grid amplifier circuit arrangement has the advantage of removing the feedback coupling between the grid and plate of the tube and places the grid-plate interelectrode capacitance effectively in parallel with the load.

Cathode resistors, R101 and R103, are each 100-ohm wire-wound inductive-type resistors. The fact that they are inductive causes them to look like a high impedance to the ultra-high frequency signal; therefore, holding the loading of Z101 and Z102 to a minimum.

DRIVER

The driver stages, V501, V502, and V503 (fig. 7-19), function to amplify and filter the output from the exciter stages and provides approximately 15 watts of u-h-f power to drive the final power amplifier. The input signal to each of the amplifier stages (V501 through V503) is applied to the cathode while the grid of each stage is held essentially at r-f ground potential by capacitors, C501, C506, and C510, respectively. Each of the stages operates as a grounded-grid amplifier.

The plate tank of each of the amplifiers (Z501, Z502, and Z503, respectively) are r-f tuners similar to that of figure 7-7 (described earlier). As stated earlier, these circuits select the desired signals and discriminate against unwanted signals. Each tank is tuned over the range of 225.0 to 399.9 mc in 1-mc increments by the 10-mc and 1-mc autopositioner.

Interstage coupling in the driver is accomplished by bringing the concentric filament supply leads, and consequently the cathode loop, into close proximity with the inductance stator rods in the r-f tuners. Output coupling from the driver is provided by loop Z504 which is placed in close proximity to the final driver-amplifier plate tank, Z503.

It is desirable to maintain a constant amplitude r-f output from the driver stage over the entire 225.0- and 399.9-mc tuning range. However, because of shunt capacities and other unwanted effects, the r-f output amplitude may vary with frequency. To eliminate or reduce this variation in amplitude with transmitter operating frequency the bias on the second drive amplifier, V502, can be adjusted to keep the gain in the driver stages relatively constant for all operating frequencies.

Because of rectifier action between the grid and cathode of V502, a charge (upper plate negative to ground) is accumulated across C506 at the V502 grid. The discharge path for C506 is through R502, R508, and R504, back to ground. The V502 grid resistance to ground (therefore the average V502 grid to ground voltage) is adjusted by R508. The charge and discharge action is similar to grid-leak bias in normal class "C" grid input-cathode grounded amplifiers. The magnitude of the V502 bias, and consequently the amplifier gain is automatically adjusted as the transmitter is tuned throughout its range.

POWER AMPLIFIER

The r-f output from the final driver-amplifier, V503, is link coupled from Z504 through connectors to Z601 (fig. 7-20). The function of the power amplifier (V601 and V602) is to amplify the 225.0- to 399.9-mc output of the driver stages to the required 100-watt transmitter output power level. The power amplifier input and output circuits are automatically tuned by a servo system, as previously described in the block diagram analysis (fig. 7-16).

The power amplifier employs V601 and V602 in a tuned-grid tuned-plate push-pull class "C" operated amplifier. The tubes used are type 4 × 150A beam tetrodes because of their low grid-plate capacitance and their relatively low driving power requirements.

The grid and plate tuned circuits of the power amplifier each contain a shorted quarter-wave stub which is formed into about 300° of a circle. The ends of the grid stub are connected through C603 and C602 to the control grids of V602 and V601, respectively.

The grid input signal (unmodulated 225.0 to 399.9 mc) is developed at the V601 and V602 control grids across L601 and L602, respectively. A fixed bias of approximately -47 volts is applied to the control grids of these tubes. Some grid-leak bias is also developed in the grids by the discharge of C602 and C603 through R602 and R603, respectively. The sum of the two grid currents may be read on a panel-mounted test meter (fig. 7-14), when the test meter selector switch is in the "PA GRID" position.

A positive screen grid potential for the push-pull power amplifier tubes is obtained from the junction of R605 and R606. These resistors are connected in series with L604 and shorted resistor R609 from the high voltage supply to ground. Control over the screen voltage is provided by R608. This potentiometer should be adjusted only after circuit changes have been made, such as the changing of the power amplifier tubes or after the power amplifier has been re-aligned.

To increase the power output, the screen voltage should be increased to a maximum of 300 volts, or until there is a maximum of 450 milliamperes plate current read on the front panel meter. These two readings should not be exceeded as the transmitter is tuned across its frequency range. If the adjustment of R608

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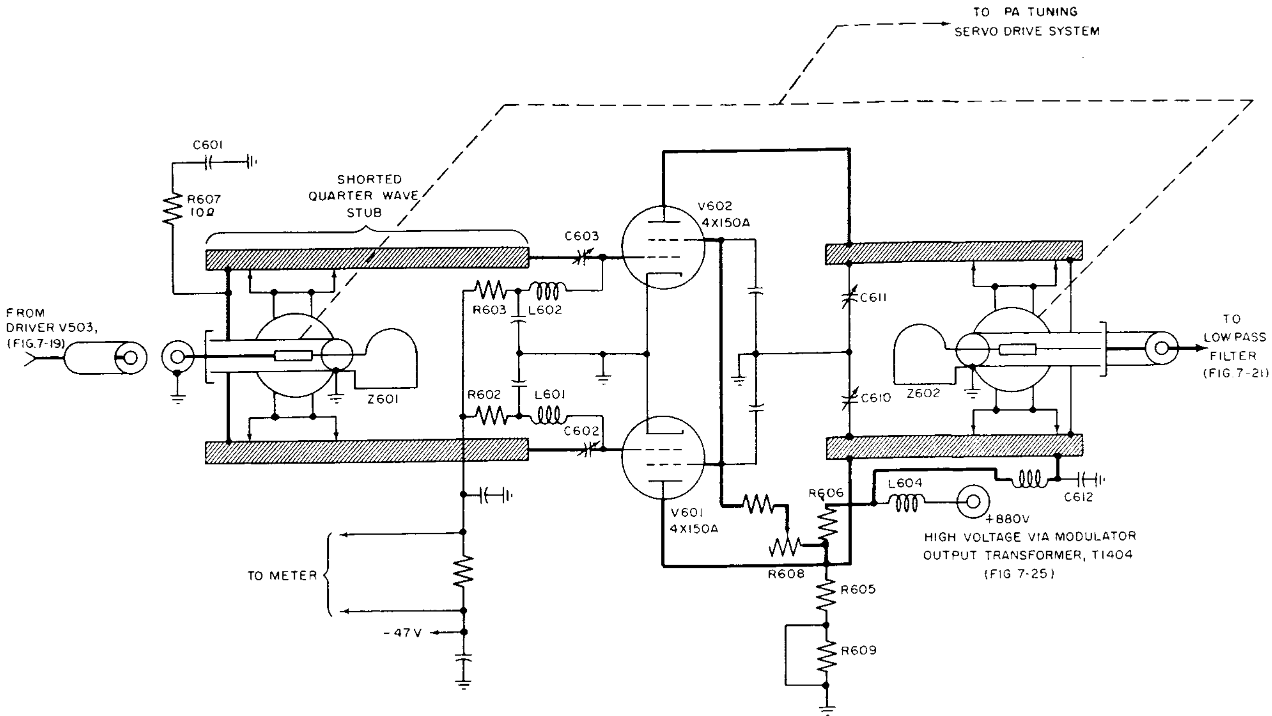

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Figure 7-20.—Transmitter power amplifier.

cannot provide sufficiently high screen voltage or plate current, the bus wire that shorts-out R609 may be clipped. This action increases the screen potential to ground.

Plate voltage for V601 and V602 (+880 d-c) is applied through the center tap of the low inductance plate tuning stub. Capacitors, C610 and C611, are trimmer capacitors used for tracking and to compensate for the slight capacity variations when the PA tubes are changed.

Capacitor, C601, holds the center tap of the grid tank at r-f ground potential, while C612 bypasses r-f energy around the power amplifier plate supply. Resistor, R607, in the grid circuit is a parasitic suppressor.

The input signal from the driver stage is push-pull amplified and developed across the plate tuned circuit. The power amplifier is tuned by a servo system.

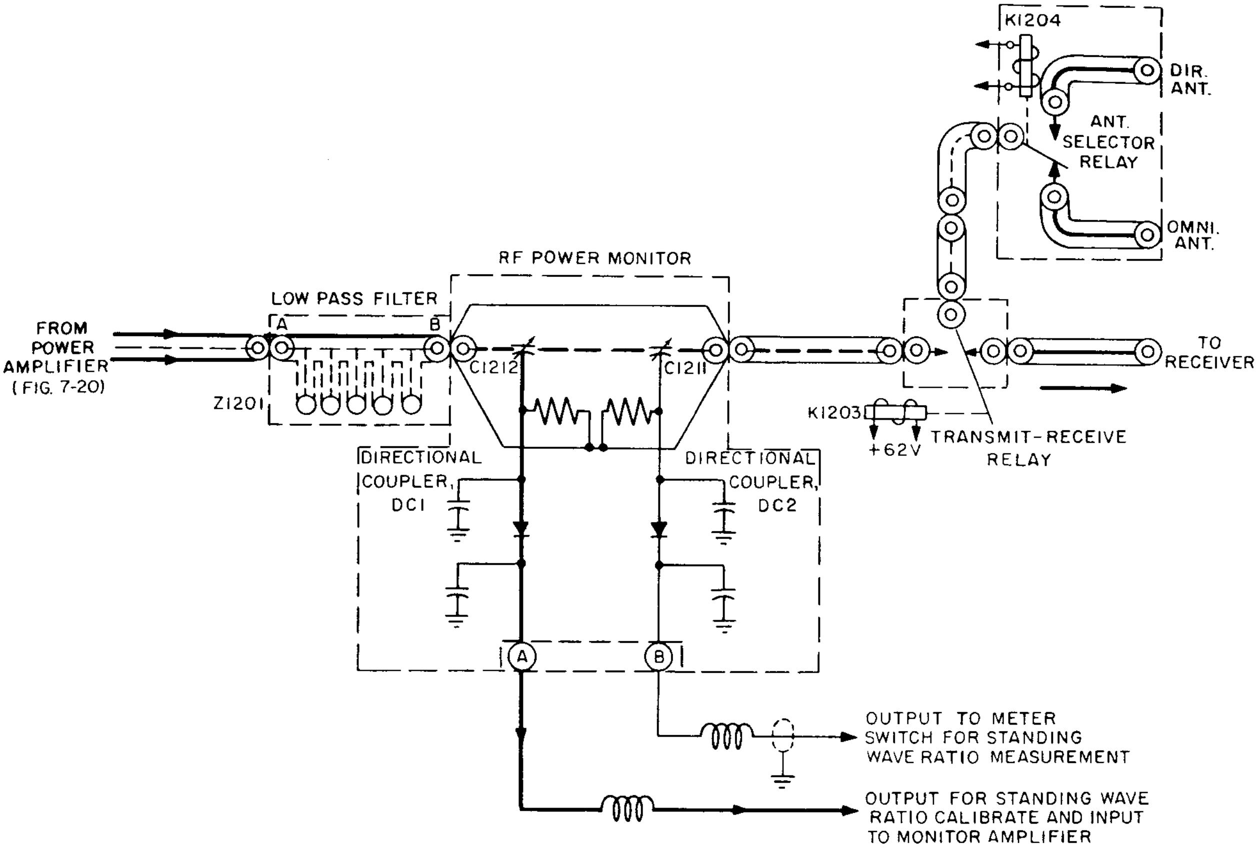
The output signal from the PA is coupled to output loop Z602 and fed along a coaxial cable to a low pass filter, Z1201 (fig. 7-21). Filter, Z1201, is a coaxial-type filter which employs five quarter-wave shorted stubs. The stubs are of the proper length to discriminate against frequencies above 450 mc.

OUTPUT NETWORK

The output of filter Z1201 is connected through coaxial cable to the r-f power monitor. This circuit contains two directional couplers, DC1 and DC2, to provide two sampling voltages. DC1 receives a small amount of the r-f power through C1212 and produces a rectified output voltage proportional to the transmitter r-f output. This output is fed to the meter switch on the front panel of the transmitter. The meter will indicate the transmitter output power in watts when the meter switch is placed in the POWER OUTPUT WATTS position.

Directional coupler, DC1 (fig. 7-21), also provides an output which is used to calibrate a standing wave ratio indicator. This voltage in conjunction with a separate input from DC2 will permit the standing wave ratio to be read on the front panel meter (fig. 7-14) when the meter switch is in the SWR position.

Directional coupler, DC1 (fig. 7-21), also furnishes a rectified input signal to a monitor amplifier (not shown). The monitor amplifier consists of a single-ended amplifier, a phase inverter and a push-pull (output) amplifier. The



32.129
Figure 7-21.—Transmitter output circuit.

amplified audio output from the monitor amplifier is made available at the monitor output jack on the transmitter front panel (fig. 7-14).

The transmitter output is fed through coaxial cable, through the transmit-receive relay, K1203 (in the TRANSMIT position) to the directional or omnidirectional antenna as selected by K1204.

TRANSMITTER POWER AND CONTROL CIRCUITS

Switches and relays in the transmitter section of the AN/GRC-27 permit the application of power to the various circuits and prevent damage to the stage of the transmitter by controlling the B supplies and blower motors. A schematic diagram of the power and control circuits is shown in figure 7-22.

When power switch, S1401, is moved to the ON position (opposite to position shown), power is applied to T1405, B1401, and K1403, in the modulator-power supply. In the transmitter the components which will receive power are T1201, T1202, B602, B501, B1201, and B1202. Thus the filaments of the stages in the modulator-power supply immediately begin heating to operating temperature, the blowers begin operation, and the time delay relay, K1403, begins to count-down 30 seconds. The purpose of this count-down will be considered presently. Note also that the filaments in the transmitter begin heating, power is applied to the servo drive system of the power amplifier, and the blowers begin operation.

If the internal temperature of the transmitter is below -12° C (10° F) when transmitter power is applied, S1210, which permits the application of a-c power to the cabinet blowers, B1201 and B1202, will be open. Thus the blowers do not operate. Thermal switch, S1210, remains open until the temperature rises to 4.5° C (40° F).

The operating temperature of the main oscillator crystal oven is 75° C. Thermal switches, S202 and S203, connect heating elements HR201 and HR202 across the line until this temperature is reached. When the oven temperature is 75° C, switches S202 and S203 will open. Thus, HR201 and HR202 are deenergized. Heating element, HR202, is then periodically energized through the action of S203 to maintain the oven operating temperature.

After S1401 has been in the ON position approximately 30 seconds, thermal time delay relay, K1403, becomes energized (contacts in position shown). Thus, the primary of low voltage transformer, T1407, receives a-c power. The secondary of T1407 provides plate voltage to the power supply rectifier tubes. The voltage output from the rectifier tubes is filtered and available to auxiliary push-to-talk relay, K1401, and to the servo amplifier in the transmitter through terminal B of J1407.

If the push-to-talk relay, K1404, is deenergized the servo amplifiers will draw approximately 100 milliamperes. This current flows through series resistors, R1467, R1466, R1465, and R1464, from the center tap of the secondary of T1407, which makes the center tap have a negative potential of slightly less than 20 volts.

The coil of bias interlock relay, K1405, is in parallel with R1464 which has a resistance of 20 ohms. The resistance of the solenoid of K1405 is approximately 27 ohms. Relay, K1405, requires about 200 milliamperes to actuate. Therefore, since this 27-ohm coil is paralleled by R1464, the total output current from the low voltage supply must be about 470 milliamperes before K1405 will become energized. The bias interlock relay, K1405, prevents the application of plate and screen voltage to the modulator tubes and plate voltage to the power amplifier tubes in the transmitter until sufficient bias is available to these tubes to prevent them from drawing excessive plate current.

Relay, K1405, is energized in the following manner: When the push-to-talk switch of the microphone connected to J1401 is pressed, K1401 is energized. If the tracking control switch, S1208, is in the NORMAL position (as shown) a current flows from the -47-volt terminal of the low voltage supply through the upper closed contacts of K1401, through terminal H of J1210 on the transmitter, through S1208 in the position shown, through the normally closed contacts of K1201, back to the antenna selector switch, S1209. With the antenna selector switch, S1209, in either the DIRECTION or OMNIDIRECTIONAL position, the current path from the low voltage supply is completed through K1203 and K1205 in parallel, back to the +62-volt terminal of the supply. Thus, both relays are energized. Relay, K1201, is energized (opposite to the position shown) during the selection of a channel to prevent the operation of the transmitter.

Closing the lower contacts of K1205 connects terminal D of J1407 in the modulator and in the transmitter, to the negative side of the low voltage supply and since one side of relay K1404 is normally connected to the positive side of the supply the relay is energized.

This action closes the K1404 contacts to permit the application of voltage to all of the low voltage circuits in the transmitter and modulator-power supply, except to the screens of the final push-pull modulator tubes, V1407 and V1408.

Because of the current drawn by the tubes now being supplied from the low voltage supply, the total current is now in excess of the 470 milliamperes required to close K1405. As K1405 closes, the low voltage supply is connected to the screens of V1407 and V1408, and the high voltage transformer, T1406, is connected across the a-c line voltage through the contacts of K1404 and K1405.

The voltage supplied by the high voltage rectifier is applied to the plates of modulator tubes, V1407 and V1408, to the final power amplifier tubes, V601 and V602, in the transmitter, and through R1452, R1471, and R1474, to the plates of the other stages in the transmitter.

With all the low voltage circuits connected to the low voltage supply, the total current through R1464, R1465, R1466, and R1467 is increased to approximately 550 milliampers. This places the center tap of T1407 at a negative potential of about -47 volts. The -47-volt potential is used as a bias for modulator tubes, V1407 and V1408, and for the final power amplifier tubes, V601 and V602, in the transmitter. This sequence completes all the necessary functions of the equipment to allow all voltages to be applied to the stages of the transmitter and modulator-power supply for operation.

MODULATOR-POWER SUPPLY

The modulator-power supply has two main functions. It provides all necessary power to Transmitter T-217A/GR, and the modulator audio output modulates the transmitter r-f carrier.

The power supplies of the modulator-power supply are conventional a-c rectifier circuits and are not explained in this chapter. The discussion of the transmitter power and control circuits brings out the important features of the power supplies and how the various transmitter circuits are activated.

A block diagram of the modulator section of the modulator-power supply is shown in figure 7-23. This section consists of the audio input circuit, several stages of audio amplification, a limiter compressor circuit, and an mcw oscillator.

AUDIO INPUT CIRCUIT

The audio input circuit provides a method of introducing the voice signal from a local or remote microphone to the input audio amplifier stage, V1401A. Transformer, T1401 (fig. 7-24), is the audio input transformer. This transformer has three separate primary windings. Winding 1-2 is used for a microphone input from J1401. When the push-to-talk button on the microphone is depressed, auxiliary push-to-talk relay, K1401, is energized.

It will be recalled from the discussion of the transmitter control circuits (fig. 7-22) that when K1401 is energized and the tracking control

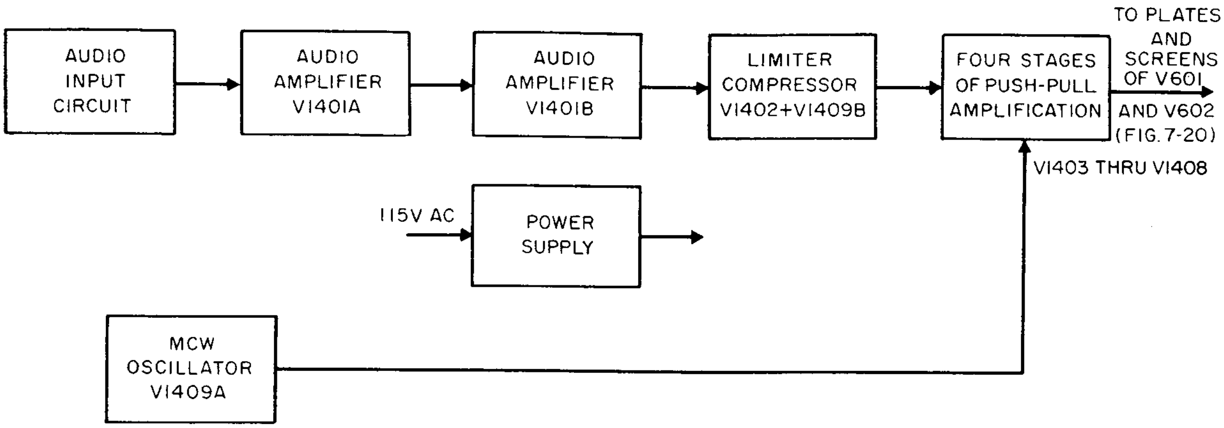


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Figure 7-23.—Modulator section, block diagram.

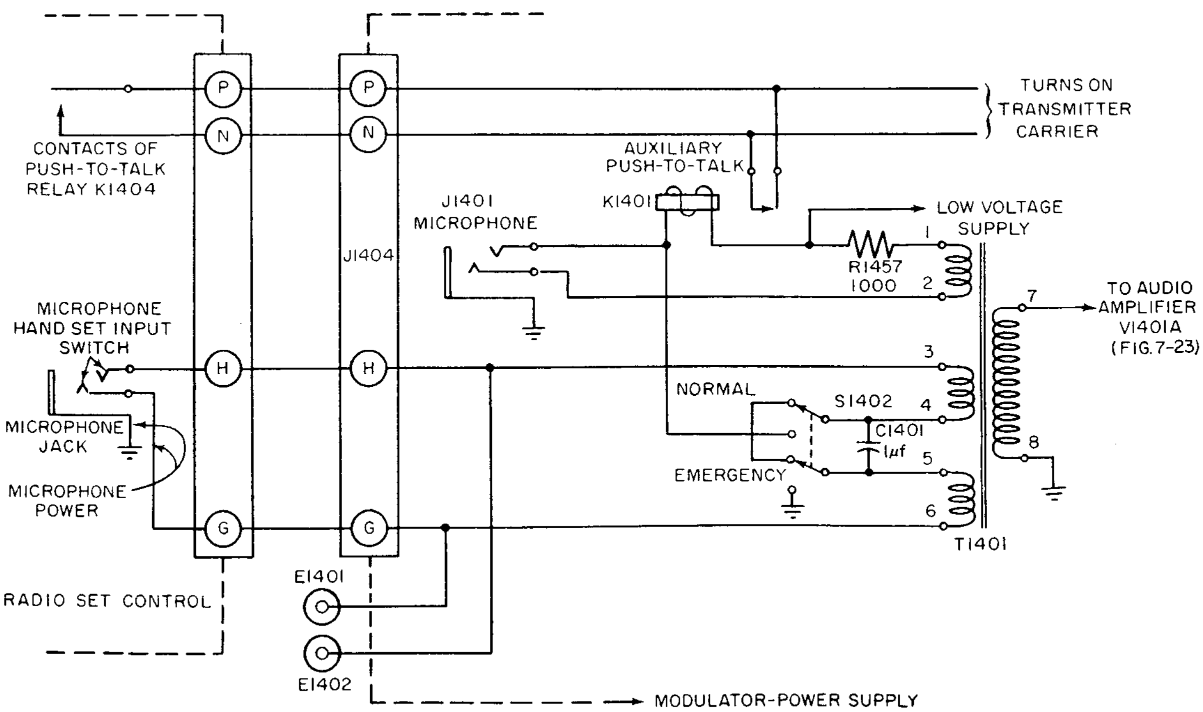

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Figure 7-24.—Audio input circuit.

switch, S1208, is in the NORMAL position, the circuit path through the solenoids of K1203 and K1205 is completed. The closing of the contacts of K1205 completes the circuit path of the push-to-talk relay, K1404. This action permits the application of B voltage to all of the low voltage circuits in the transmitter and modulator-power supply (except to the screens of the final push-pull modulator stage) and the transmitter carrier is turned on.

The second and third winding terminals 3-4 and 5-6 of T1401 (fig. 7-24) are used for remote control operation and provide 600 ohms termination for the remote microphone connected from terminal H of J1404 to ground. When S1402 is in the NORMAL position (as shown) windings 3-4 and 4-5 of T1401 are used only for audio frequency voltage fed from the terminals G and H of J1404. When the jack is used, a circuit in the local control unit (not shown) closes contacts P and N of J1404, which is essentially the same as closing the contacts of K1401. The resulting action turns on the transmitter carrier in the same manner as described above.

When normal-emergency switch, S1402, is placed in the EMERGENCY position a ground on the bottom contact of S1402 permits the circuit path to K1401 to be completed through the 5-6 terminal of T1401, through the push-to-talk switch (when depressed), through the 3-4 terminals of T1401, through the upper contact of S1402, and the solenoid of K1401, to the low voltage supply. Relay, K1401, in turn, initiates the action to turn on the transmitter carrier.

AUDIO STAGES

The audio stages of the transmitter (fig. 7-23) include two single-ended class "A" amplifiers, V1401A and V1401B, and four stages of push-pull amplification comprising V1403 through V1408. The audio output signal from the final push-pull modulator stage, V1407 and V1408, is applied to the transmitter final power amplifier through an audio transformer, T1404, (fig. 7-25A). One of three T1404 secondaries, through which the B voltage is applied to the transmitter power amplifier, is connected in series with the PA plate path. Thus, audio voltage from the modulator output amplitude modulates the r-f plate voltage of the transmitter final power amplifier (fig. 7-20).

Audio compression involves the narrowing of the volume range of an audio frequency signal input so that weak signals will not be lost in background noise, and that loud signals will not overload any part of the audio system. One method of audio compression is illustrated in figure 7-25, A.

The bridge circuit of the audio compressor comprises R1409 and R1410 in the upper and lower left side, and R1411 and V1402 in the upper and lower right side of the bridge. The input from V1401B is applied between diagonally opposite corners, E and F. The output is taken from the other pair of diagonally opposite corners, C and D via transformer, T1402.

Figure 7-25, B illustrates the signal voltage distribution for no compression. Triode, V1402, acts like an open circuit (the triode is biased to cutoff) and the bridge has a maximum unbalance, with an output voltage about one-half of that of the input.

Bias for V1402 controls the effective resistance which this triode presents to its associated arm of the bridge. The audio output voltage induced in the lower secondary of T1404 is rectified by V1409B and filtered by C1421 and C1407 to produce an opposing component of bias voltage injected in the V1402 grid circuit proportional to the audio output. Increasing input signal voltage to the bridge results in reduced bias on V1402 and a decrease in effective resistance in that arm of the bridge.

Figure 7-25, C illustrates the signal voltage distribution for maximum compression. Triode, V1402, presents an effective resistance of approximately 40 k-ohms and the bridge approaches (but does not equal) a balanced condition. This action restricts any further increase in bridge output with rising input.

Circuit constants in the bridge and in the rectifier circuit of V1409B are such that a 20-db increase in input level results in only a 2-db increase in output level when R1440 is adjusted for the threshold of compression at low input levels. Variable resistor, R1412, adjusts the compression to the specified limit and compensates for tube variations in V1402.

MCW OSCILLATOR CIRCUIT

The mcw oscillator, V1409A (fig. 7-26) produces a 1,020 cps tone which may be keyed to produce mcw coded signals. The audio tone signal is amplified in one section of push-pull amplifier V1403 (fig. 7-23) and in three subsequent stages of push-pull amplification.

When mcw signals are to be transmitted, voice-mcw carrier on switch S1404 (fig. 7-22) is placed in the MCW CARRIER ON position. This action completes the circuit path for push-to-talk relay, K1404, from the -47-volt tap on the low voltage supply to the +62-volt tap if the

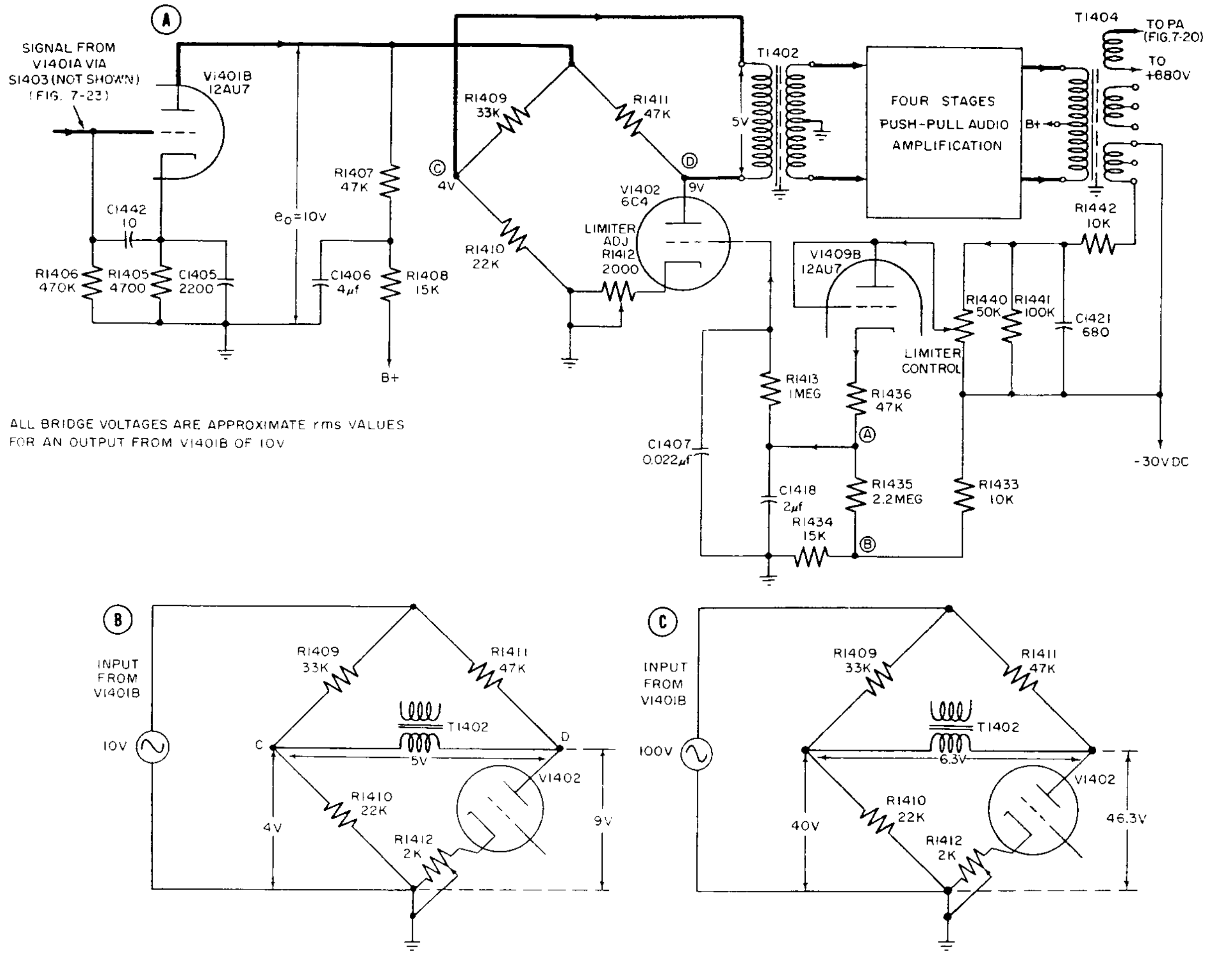

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Figure 7-25.—Limiter compressor circuit.

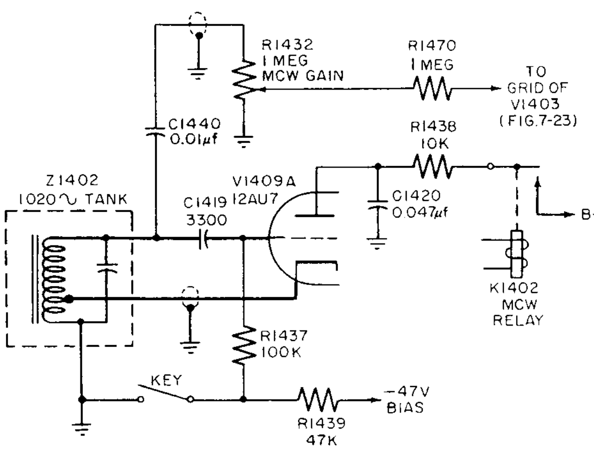

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Figure 7-26.—Mcw oscillator.

tracking control switch, S1208, is in the NORMAL position as shown. This, in turn, causes the transmitter carrier to be turned on through the same process as described earlier. Simultaneously, the closing of S1404 to the MCW CARRIER ON position connects the solenoid of K1402 from the -47- to the +62-volt taps on the low voltage supply. Thus, K1402 energizes, and the +285-volt potential from the low voltage supply is applied through R1438 to the plate of mcw oscillator, V1409A.

In the unkeyed condition of the mcw oscillator, V1409A (fig. 7-26), -47 volts is applied to the grid of the tube through R1439 and R1437. This potential cuts off or blocks the grid of V1409A and no oscillations can occur. However, when the key is closed, the biasing circuit is shorted and oscillations begin. This simulates the tone-on condition of the oscillator. This method of keying is called blocked-grid keying.

The oscillator is connected as a series fed Hartley circuit. The 1,020-cps oscillations developed by the grid tank, Z1402, also appears across C1440 and R1432. The signal voltage from the arm of R1470 is fed to the grid of audio amplified, V1403 (fig. 7-23), where it is amplified and subsequently modulates the r-f transmitter carrier.

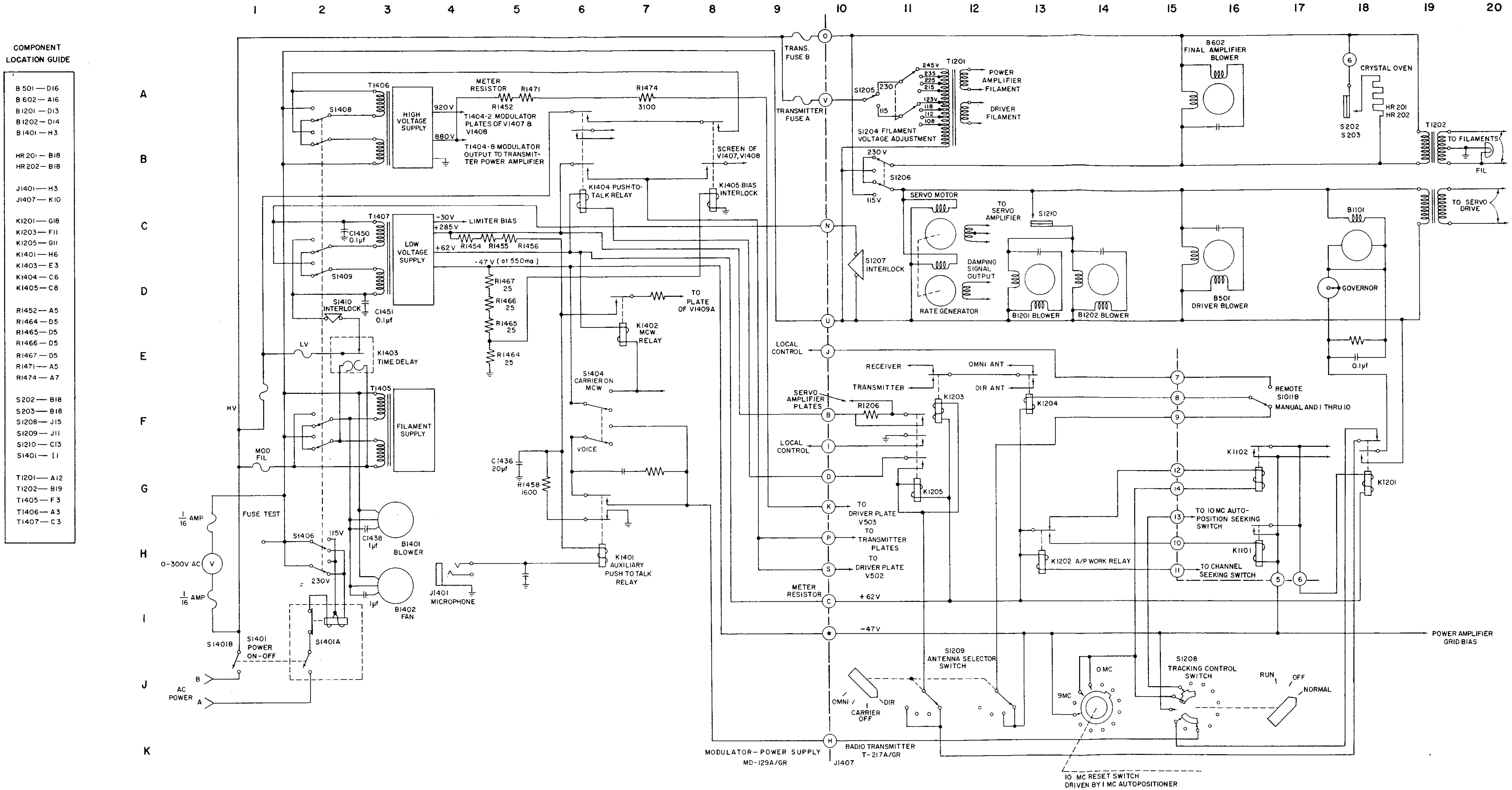

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Figure 7-22.—Transmitter power and control circuits.