SECTION I

DESCRIPTION AND LEADING PARTICULARS

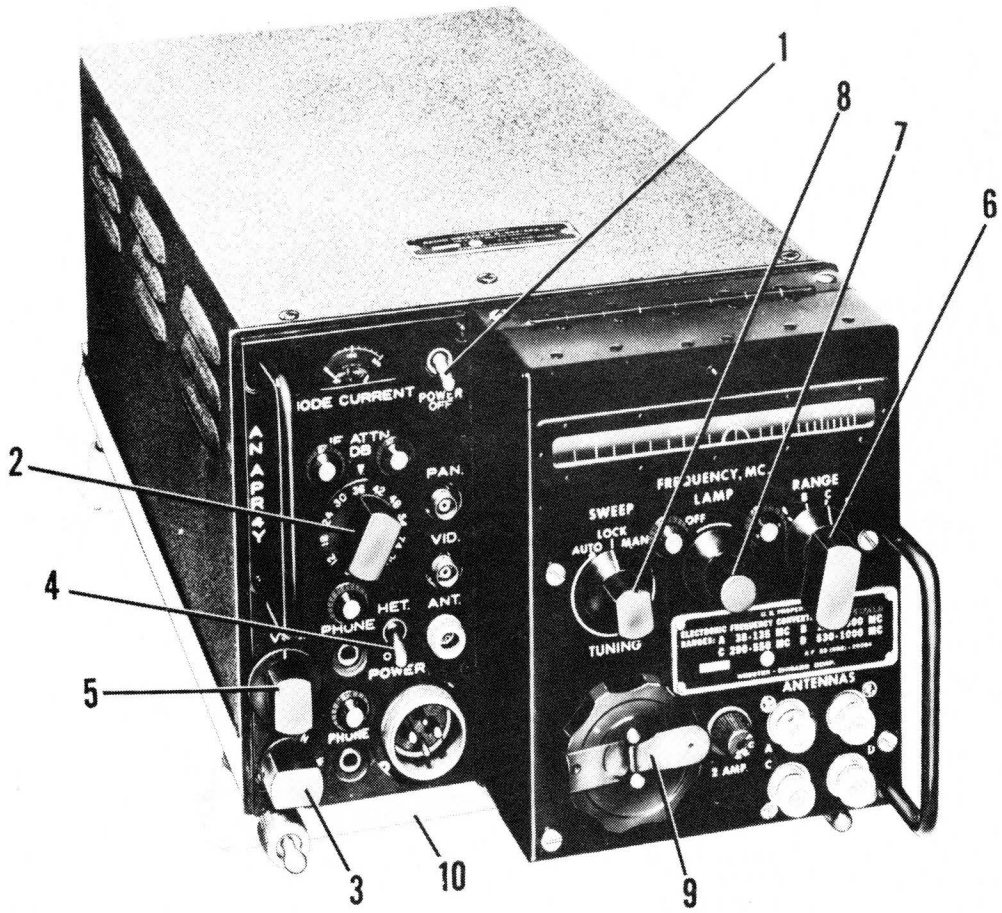
1-1. GENERAL. This handbook consists of Service Instructions at Operational and Organizational, and Field and FASRON maintenance levels for Receiving Equipment AN/ALR-5 manufactured by the Webster-Chicago Corporation, Chicago, Illinois.

1-2. IDENTIFICATION. (See figure 1-1). Receiving Equipment AN/ALR-5 consists of Electronic Frequency Converter CV-253/ALR and Radio Receiver R-444/APR-4Y.

1-3. PURPOSE. Receiving Equipment AN/ALR-5 is a search equipment intended for use in aircraft. This equipment is capable of:

a. detecting any electromagnetic radiation of sufficient strength covering the frequency range between 38 and 1000 megacycles.
b. measuring the frequency of these signals.
c. giving an indication of the relative field strength of these signals.
d. demodulating and obtaining intelligence from these signals.

1-4. LIMITATIONS. Operation of the equipment is limited by:
a. The inability of vhf and uhf signals to travel much beyond the horizon in sufficient strength to be useful.
b. The frequency range of the converter.



1. Power Switch
2. "IF Attn" Selector
3. "N-W-FM" Selector
4. "Het Switch
5. Volume Control
6. Range Selector
7. Lamp Control
8. Sweep Control
9. Tuning Knob
10. Mounting Base

Figure 1-2. Receiving Equipment Operating Controls

c. Temperatures greater than 71°C (160°F) or less than -55°C (-67°F), altitudes greater than 50,000 feet, and a relative humidity of more than 95 per cent for extended periods of continuous operation.

1-5. LOCATION AND FUNCTION OF OPERATING AND ADJUSTMENT CONTROLS (See figure 1-2).

1-6. RECEIVER CONTROLS.

a. The 'POWER' switch (1) is located in the upper right hand corner of the receiver front panel. This switch applies primary 115 volt a-c power to the receiver.

b. The 'IF ATTN.' selector (2) is located toward the center of the receiver front panel. It decreases the gain of the first two i-f amplifiers by the number of db's (decibels) shown on its skirt at each position. With the selector in the 'AVC' position, an automatic volume control voltage is fed to the grids of the first four i-f amplifier stages.

c. The 'N-W-FM' selector (3) is located in the lower left hand corner of the front panel. In the 'N' position a narrow i-f band pass circuit is selected for AM signals and in the 'W' position a wide i-f band pass circuit is selected for AM signals. A FM detector is utilized for FM signals with the selector placed in the 'FM' position.

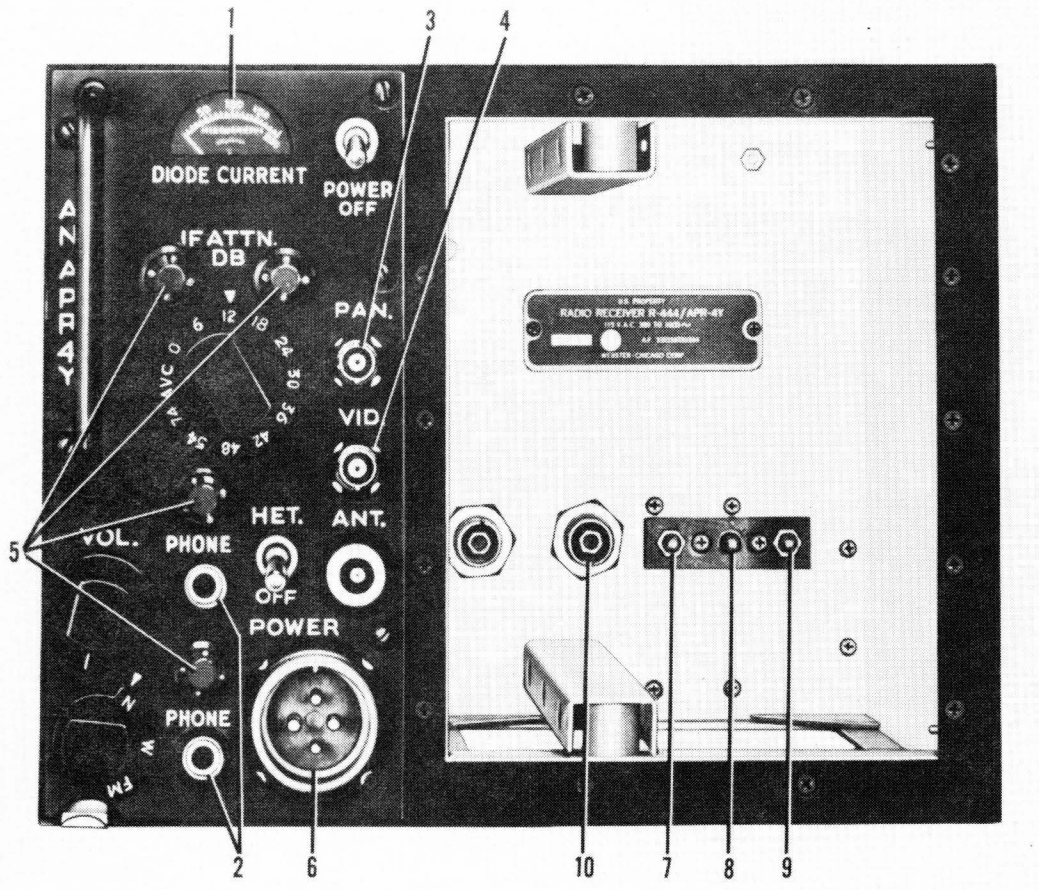
d. The 'HET.' switch (4) is located just above the 'POWER' receptacle (6, figure 1-3) toward the center of the front panel. The switch, when placed in the 'HET.' position, connects the output of a 1000 cycle heterotone oscillator to the grid of the final i-f amplifier stage, for modulation of a CW i-f signal.

e. The 'VOL.' control (5) is located on the lower left hand side of the front panel. This control varies the amplitude level of the output signal of the video amplifier. Clockwise rotation increases the output level.

1-7. CONVERTER CONTROLS.

a. The 'RANGE' selector (6) is located in the upper right hand portion of the converter front panel. It selects a separate tuning unit for each of the four frequency ranges. Position 'A' covers the frequency range from 38 to 135 megacycles, position 'B' from 125 to 300 megacycles, position 'C' from 290 to 550 megacycles, position 'D' from 530 to 1000 megacycles.

b. The 'LAMP' control (7) is located in the upper central part of the panel. The control varies the panel illumination. Clockwise rotation of the control increases the intensity of the panel illumination.



1. Diode Current Meter
2. Phone Jacks
3. Panoramic Connector
4. Video Connector
5. Panel Lamps
6. Power Receptacle
7. Tuner Motor Power Connector
8. Tuner Filament Voltage Connector
9. Tuner Plate Voltage Connector
10. Receiver I-F Input Connector

Figure 1-3. Receiver Front Panel and Well

c. The 'SWEEP' control (8) is located in the upper left hand portion of the panel. In 'AUTO' position the tuning drive motor is energized, which results in an automatic sweep of the entire frequency range at maximum speed. Counterclockwise rotation of the control beyond the 'AUTO' position will decrease the motor speed up to a maximum of one half. Any frequency can be secured by placing the control in the 'LOCK' position. The placement of the control in the 'MAN' position disengages the drive motor from the tuning mechanism allowing manual tuning of the frequency range.

d. The manual 'TUNING' control (9) is located directly below the 'SWEEP' control. It allows manual movement of the tuning mechanism. A small crank for rapid manual tuning folds into the knob when not in use.

1-8. INSTRUMENT READINGS AND INDICATOR PRESENTATIONS.

a. The 'FREQUENCY MC' scale (5, figure 1-4) is a cylindrical type of frequency dial with four frequency ranges or scales mounted on it. As the 'RANGE' selector is turned the cylinder rotates, presenting the proper frequency scale. The frequency indicator (6, figure 1-4) is a pointer which slides back and forth across the frequency dial.

b. The panel lamps (2, figure 1-4) indicate that the 28 volt dc power required for the operation of the tuning drive motor is reaching the converter.

c. The 'DIODE CURRENT' meter (1, figure 1-3) shows the amount of current in microamperes flowing through the video detector diode. With the receiver warmed up and the 'IF ATTN.' selector in the 'O' position, the meter will read about 50 microamperes of noise without signal at the 'W' or 'N' positions of the 'N-W-FM' selector. With the 'N-W-FM' selector in the 'FM' position, the meter will read about 25 microamperes of noise without a signal. The introduction of signals will result in readings at or above these noise levels, depending on the strength of these signals. Strong signals will read 100 microamperes or more.

1-9. CHARACTERISTICS.

a. Frequency Range: 38 to 1000 megacycles.

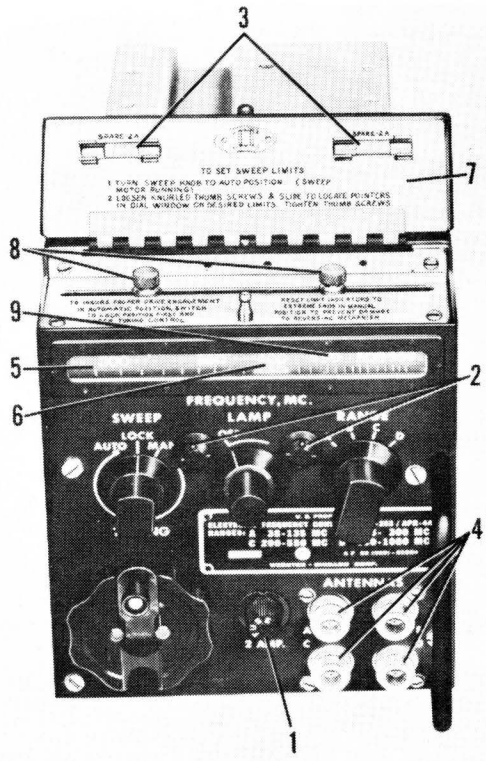
b. Tuning Ranges in Megacycles: 38 to 135, 125 to 300, 290 to 550 and 530 to 1000.

c. Frequency Stability: ± 1% of the frequency tuned.

d. Type of Output: video, panoramic adapter and audio outputs.

e. Sensitivity: Input required for 100 microamperes rise on the 'DIODE CURRENT' meter.

1-10. POWER GENERATING EQUIPMENT. Power generating equipment is already installed in the aircraft.



1. Fuse
2. Panel Lamps
3. Spare Fuse
4. Antenna Connectors
5. Dial Scale
6. Dial Pointer
7. Locking Lid Adjustment
8. Sweep Stop Lock Nut
9. Sweep Stop Indicator

Figure 1-4. Converter Front Panel

TABLE I. SENSITIVITY OF THE RECEIVING EQUIPMENT

A BAND			B BAND			C BAND			D BAND		
Freq. in mc	Sensitivity in uv	Calibration Accuracy	Freq. in mc	Sensitivity in uv	Calibration Accuracy	Freq. in mc	Sensitivity in uv	Calibration Accuracy	Freq. in mc	Sensitivity in uv	Calibration Accuracy
38	6.5	±0.76 mc	127.5	13	±2.55 mc	292	13	±5.8 mc	540	13	±10.8mc
85	6.5	±1.7 mc	215	13	±4.3 mc	350	13	±7 mc	780	13	±15.6mc
132	6.5	±2.64 mc	297	13	±5.9 mc	530	45.5	±10.6 mc	950	45.5	±19 mc
Note: "IF ATTN." Set at '6' at all frequencies.						545	45.5	±10.9 mc	1000	45.5	±20 mc

TABLE II. VOLTAGE AND POWER REQUIREMENTS

Supply Voltage Required for Operation of Converter	Power Required for Operation of Converter	Supply Voltage Required for Operation of Receiver	Power Required for Operation of Receiver
28 ± 2 volts dc	10 watts	115 ± 2 volts ac	90 volt-amperes

TABLE III. TUBE COMPLEMENT

Quantity	JAN Type Number	Function
Frequency Converter		
4	5654	R-F Amplifiers, Mixers
4	6AF4	Oscillators
Radio Receiver		
8	5654	I-F Amplifiers, FM Limiter, Video Amplifier, Heterotone Oscillator
2	5726	AVC, AM Detector, FM Detector
1	5686	Video Amplifier
2	5Y3WGTA	Rectifiers
1	OA2	Voltage Regulator

NOTE

In the event of tube failure, replace the defective tube with the improved type authorized for replacement by T.O. 12-1-12.

TABLE IV. FUSE COMPLEMENT

Quantity	Type Number	Ampere Rating
Frequency Converter		
2	4AG	2 amperes
Radio Receiver		
1	4AG	2 amperes

TABLE V. CRYSTAL COMPLEMENT

Quantity	JAN Type Number	Function
2	1N21 B	Mixers

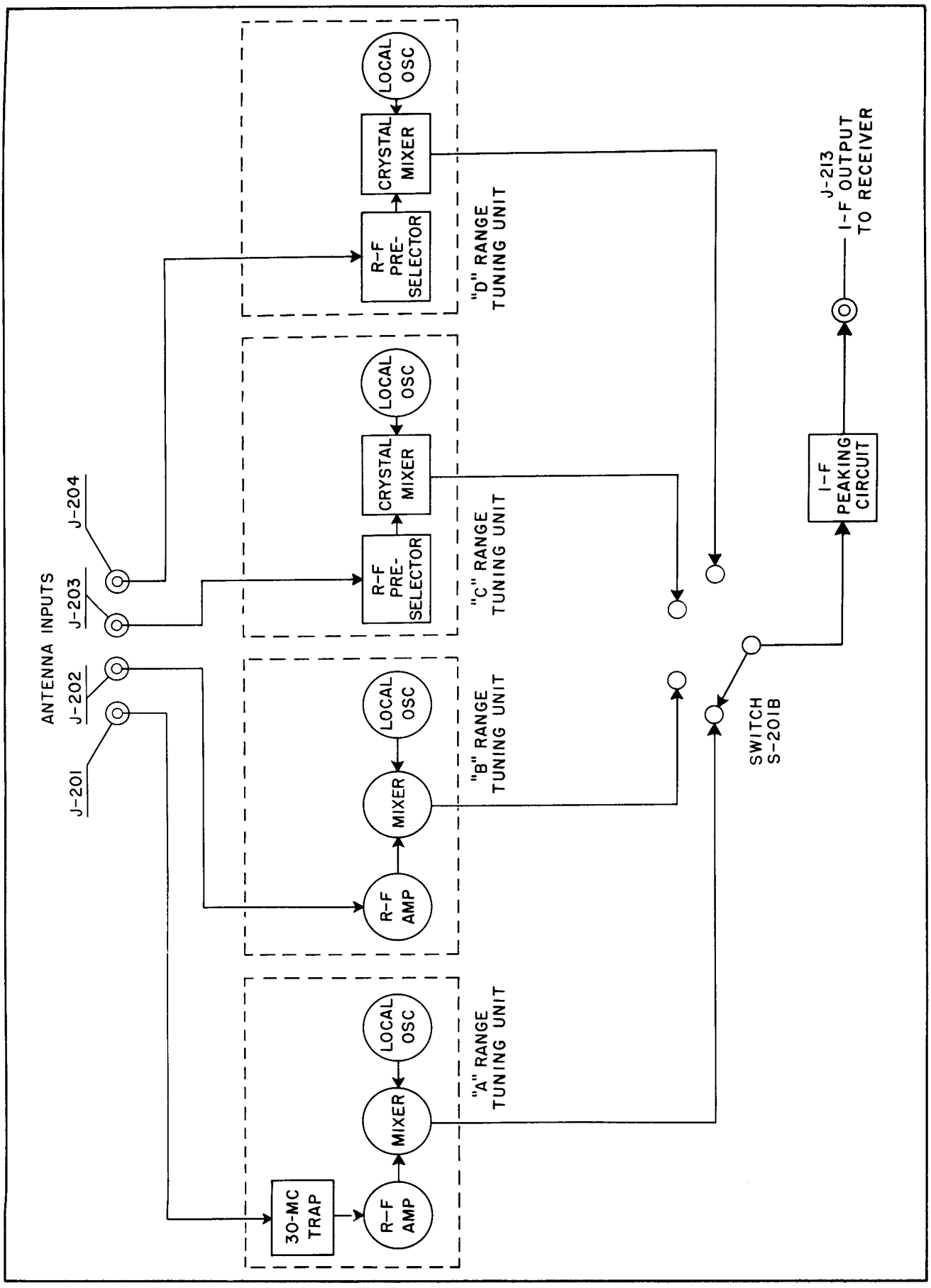


Figure 4-1. Block Diagram of the Frequency Converter

SECTION IV

THEORY OF OPERATIONS

4-1. GENERAL THEORY OF OPERATION. Signals received by the antenna are fed into the frequency converter, located in the well of the receiver. The desired signal is selected by tuned circuits within the frequency converter and mixed with the output of the local oscillator to form the 30 megacycle i-f signal. This i-f signal enters the first intermediate frequency amplifier of the radio receiver through the receiver input connector (10, figure 1-3) located on the rear wall of the well in the right front panel of the receiver. The signal then goes through five stages of intermediate frequency amplification. From the output of the fifth intermediate frequency amplifier, the i-f signal takes the following paths:

a. The intermediate frequency signal is fed to a connector marked 'PAN.' (3, figure 1-3) on the front panel of the receiver which may be used to feed the i-f signal to a panoramic adapter.

b. The signal is fed to an avc tube where the 30 megacycles signal is demodulated and an avc voltage is developed.

c. The signal is also fed to a limiter, then on to a frequency modulation detector and an amplitude modulation detector where either a frequency modulated or an amplitude modulated signal is demodulated. The output of either detector is selected by means of the 'N-W-FM' selector located on the lower left side of the receiver panel. Provision is made for "reading" CW intelligence by feeding the output of a heterotone oscillator into the fifth intermediate frequency amplifier stage. With the 'HET.' switch in the 'HET.' position any CW signal received will be audible, as a 1000 cycle note, in a headset plugged into either one of the 'PHONE' jacks (2, figure 1-3) on the front panel of the receiver. The audio signals from an audio output transformer in the plate circuit of V110 are fed to 'PHONE' jacks located on the front panel of the receiver.

4-2. BLOCK DIAGRAM OF FREQUENCY CONVERTER. (Figure 4-1).

4-3. DETAILED STAGE ANALYSIS OF THE FREQUENCY CONVERTER. (See figure 7-3). Signals from the antennas are coupled into the frequency converter by means of four coaxial connectors located in the lower right portion of the front panel. (4, figure 1-4).

a. Antenna Connector A(J-201) couples the received signals into the A range tuning unit of the converter which covers the frequency range from 38 to 135 megacycles.

b. Antenna Connector B(J-202) couples the received signals into the B range tuning unit covering the frequency range from 125 to 300 megacycles.

c. Antenna Connector C(J-203) couples the received signals into the C range tuning unit covering the frequency range from 290 to 550 megacycles.

d. Antenna Connector D(J-204) couples the received signals into the D range tuning unit covering the frequency range from 530 to 1000 megacycles.

4-4. The signals from the Antenna Connector J-201 are transmitted through a 50 ohm coaxial cable to the r-f amplifier stage V-201 of the A range tuning unit. An interference filter network, consisting of circuit elements R-201, C-201 and L-201, is placed in parallel with the cable to prevent any 30 megacycle signal from being coupled into the r-f amplifier stage. The desired signal to be amplified by the r-f stage is selected from the signals received by means of the tuning circuit L-203, L-202, C-204 and R-202. L-203 is the primary tuning element of this circuit and is mechanically linked to L-209 the local oscillator tuning element, L-205 the r-f amplifier plate tuning element, and the main tuning mechanism. L-205, L-204, C-207 and R-207 form the interstage coupling network between the r-f amplifier stage and the mixer stage V-202. The primary tuning element of this network is L-205 which is also mechanically linked to L-209, L-203 and the main tuning mechanism.

4-5. V-203 is the local oscillator stage. The variable inductance L-209 is the primary tuning element of the oscillator circuit and is mechanically linked to L-205, L-203 and the main tuning mechanism. The oscillator is tuned to a frequency which is 30 megacycles above that of the received signal to the r-f amplifier. The oscillator signal is mixed with the received signal from the r-f stage in the input circuit of the mixer stage V-202. L-202 and C-204 of the antenna tuning circuit, and L-207 and C-218 of the oscillator tuning circuit, are adjustments for tracking these two tuning circuits. The inductances L-202 and L-207 are the means for adjusting the high frequency end of the range, and C-204 and C-218 are the adjustments for the low frequency end of the range.

4-6. V-202 is the mixer (first detector) stage. Both the received r-f and the local oscillator signals are fed into the grid of this stage. These signals are mixed within the tube producing the desired 30 megacycle intermediate frequency (i-f). L-206 is the plate load impedance for the mixer and is adjusted for maximum response at the 30 megacycle i-f signal.

4-7. From the Antenna Connector J-202, the received signals from the antenna are transmitted by means of a 50 ohm coaxial cable to the r-f amplifier stage V-204 of the B range tuning unit. The B and the A range tuning units are very similar and follow the same theory of operation. V-205 is the mixer and V-206 is the local oscillator.

4-8. The signals from the Antenna Connector J-203 are transmitted through a 50 ohm coaxial cable to the first stage of the C range tuning unit. The first stage is a r-f pre-selector circuit with the tuning being

accomplished by the variable inductances L-222 and L-225. V-207 is the local oscillator stage. The oscillator circuit is tuned by the variable inductance L-230. CR-201 is a crystal mixer stage. The preselector and oscillator stages are adjusted for tracking by L-223, C-250, L-224, C-252 in the preselector, and C-258 and L-231 in the oscillator circuit. L-227 and C-256 are tuned to resonance with the 30 megacycles i-f signal received from the mixer. The primary tuning elements L-222, L-225 and L-230 are mechanically linked to one another and to the main tuning mechanism.

4-9. The operation of the D range tuning unit is very similar to that of the C range tuning unit. The first stage is the r-f pre-selector tuned by L-235 and L-236. V-208 is the oscillator and CR-202 is the crystal mixer. L-244 tunes the oscillator and is mechanically linked to L-236, L-235 and the main tuning mechanism. L-237, C-264, L-238, C-265, C-271 and L-242 are the adjustments for preselector and oscillator tracking.

4-10. The i-f output signal from the proper tuning unit is selected by means of the 'RANGE' selector S-201B. The i-f signal is fed into the tuned circuit consisting of L-248 and C-276 which is adjusted for maximum i-f signal response. From the tuned circuit the i-f signal is coupled to the first i-f amplifier stage of the radio receiver being used, by means of a coaxial connector J-213 (5, figure 3-1) on the rear wall of the converter mating with a connector on the rear wall of the receiver well. The second section of the 'RANGE' selector S-201A applies plate voltages to the tuning unit in use and removes plate voltages from the other three rendering them inoperative.

4-11. The required voltages for the operation of the converter are supplied by the radio receiver by means of three banana type plugs on the rear wall of the receiver well. These mate with three banana type connectors J-214A, J-214B and J-214C (6, 7, 8, figure 3-1) located on the rear wall of the converter when it is inserted in the receiver well. J-214A (6) supplies the 300 volt dc plate and screen voltages for the converter tubes, J-214B (7) supplies the 6.3 volt ac for the tube filaments, and J-214C (8) supplies the 28 volt dc voltage for the operation of the tuning drive motor.

4-12. BLOCK DIAGRAM OF THE RADIO RECEIVER. (Figure 4-2).

4-13. DETAILED STAGE ANALYSIS OF THE RADIO RECEIVER. (See figure 7-1). The 30 megacycle intermediate frequency signal from the frequency converter or tuning unit enters the first intermediate frequency amplifier tube (V-101) of the receiver through connector J-107. The coupling between each stage of the intermediate frequency amplifiers is by means of the interstage coupling transformers T-101, T-102, T-103, T-104 and T-105. The coils L-101A, L-103A, L-105A, L-108A and L-110A are used to tune the plate circuits of the intermediate frequency amplifiers. The coils L-101B, L-103B, L-105B and L-108B are used to tune the grid circuits of the intermediate frequency amplifiers. L-110B is used to tune the secondary of coupling transformer T-105. The coils L-102, L-104, L-106, L-109 and L-111 provide sufficient mutual coupling to give a 4 megacycle band pass. The primary loading resistors R-105, R-112, R-119, R-126, R-134 and the secondary loading resistors R-108, R-115, R-121, R-128 and R-137 terminate the coupling networks and keep the gain uniform over the 4 megacycle band. The capacitors required for resonating both the primary and secondary sides of the coupling networks are provided by the tubes and the distributed circuit capacitances. If it is desired to reduce the width of the band pass from 4 megacycles to approximately 0.45 megacycles, the band width selector, S-101, is operated to remove the T network, T-104, from the circuit and to substitute a single-tuned, high Q circuit composed of coil L-107 and capacitor C-124. Selector S-104 controls the intermediate frequency gain by varying the resistance in the cathode circuits of the first two intermediate frequency amplifiers, tubes V-101 and V-102.

4-14. One section of the second detector, V-106B, is the signal rectifier and the other section, V-106A, is the avc rectifier. From the plate of V-106B the intermediate frequency signal for panoramic viewing is fed through R-143 to a front panel connector, J-101. The 200 microampere diode current meter, M-101, is connected in series with the signal rectifier load resistance to indicate the presence of any signals. Capacitor C-140 and coil L-112 prevent the i-f signal from reaching the grid of the first video stage V-109. The avc rectifier has a delay voltage of approximately 1.5 volts which is obtained from the divider, resistor R-139 and resistor R-141. AVC voltage is filtered by resistors R-140, R-138 and capacitors C-137 and C-136A, before being applied to the first four i-f stages. In the extreme counter-clockwise position of selector S-104, the ground is disconnected from the avc circuit and permits avc operation. In all other positions of the selector, the avc circuit is inoperative.

4-15. V-107 is the limiter tube of the limiter-discriminator detector for frequency demodulation. The limiter is an amplifier which receives the i-f signal from the plate of V-106A. Its primary purpose is amplitude limiting. Should the FM i-f signal contain AM (amplitude modulation) variations, the limiter system will remove these amplitude variations. The resultant output from the limiter, V-107, will be a frequency modulated signal which is varying in frequency only and which has a constant amplitude.

4-16. V-108 is the detector tube for frequency modulated signals. The detector circuit is a Foster-Seeley type discriminator. T-106 is the discriminator transformer, and is tuned by L-113B the limiter plate tank circuit, and L-113A the discriminator plate tank circuit. R-147 and R-148 are the load resistors for the discriminator. R-149 and C-149 form an i-f filter network for compensation of the high frequencies. R-150A is the gain control for the output signal of the discriminator stage. It is mechanically linked to resistor R-150B, a gain control in the cathode of the first video amplifier V-109. R-150B is effective for both AM and FM operation; however, R-150A is inoperative when S-102 is in 'N' or 'W' positions.

4-17. Selector S-102 is mechanically linked to S-101.

Wide or narrow band pass operation of the fifth i-f amplifier stage is selected by means of selector S-101. S-102 selects either the output from the amplitude demodulator stage or the output from the frequency modulator stage and feeds either one or the other outputs to the first video amplifier, V-109.

4-18. V-109 and V-110 are the video amplifier tubes. L-115 is a peaking coil which helps to reduce the effect of the stray circuit capacities. Video output is obtained across the unbypassed cathode resistor R-158 of the output stage of tube V-110. Audio output exists across transformer T-107 connected in the plate circuit of tube V-110. E-141 is a surge arrestor for the protection, in the absence of a load on the secondary, of the audio output transformer T-107. It has the characteristic that the current through this arrestor increases by approximately the square of the voltage. When the voltage across T-107 tends to approach a dangerous magnitude this device automatically limits the voltage to a safe value by acting as a low resistance, thereby rapidly dissipating the energy developed across T-107. At low impressed voltages it acts as a high resistance, thereby allowing normal operation of T-107 as an audio transformer.

4-19. The heterotone oscillator, tube V-111, uses a "bridged" T resistance-capacitance circuit. When the heterotone switch S-103 is turned to the 'HET.' position, the cathode of V-111 is connected to ground through resistor R-160 and switch S-103. At the same time, the negative side of the diode current meter is ungrounded and reaches a value of approximately 1.0 volt positive because of the divider composed of resistors R-176 and R-177 located in the power supply section. This voltage provides bias for the signal diode V-106B. With no signal input to the receiver, a stray heterotone signal is developed due to the 1000 cycle signal from the heterotone oscillator mixing with the noise generated by the i-f amplifier tubes. This bias voltage will suppress most of this stray heterotone signal. The output of the heterotone oscillator is coupled through capacitor C-156 and the divider composed of resistors R-131 and R-129 into the fifth i-f amplifier stage (V-105). Signals being received by the fifth i-f amplifier stage are modulated by the 1000 cycle tone from the heterotone oscillator.

4-20. The power transformer, T-108, is designed to operate from an alternating voltage of 115 volts and any frequency from 380 to 1000 cycles. Two separate rectifiers, V-112 and V-113, are used, each with its own filter circuit. Rectifier V-112 supplies voltage for the tuning unit and the screen grids of all receiver i-f amplifier stages and limiter stage. V-114, a glow-discharge diode, is a voltage regulator for the voltage output of rectifier V-112. V-113 supplies all other voltage required by the radio receiver.

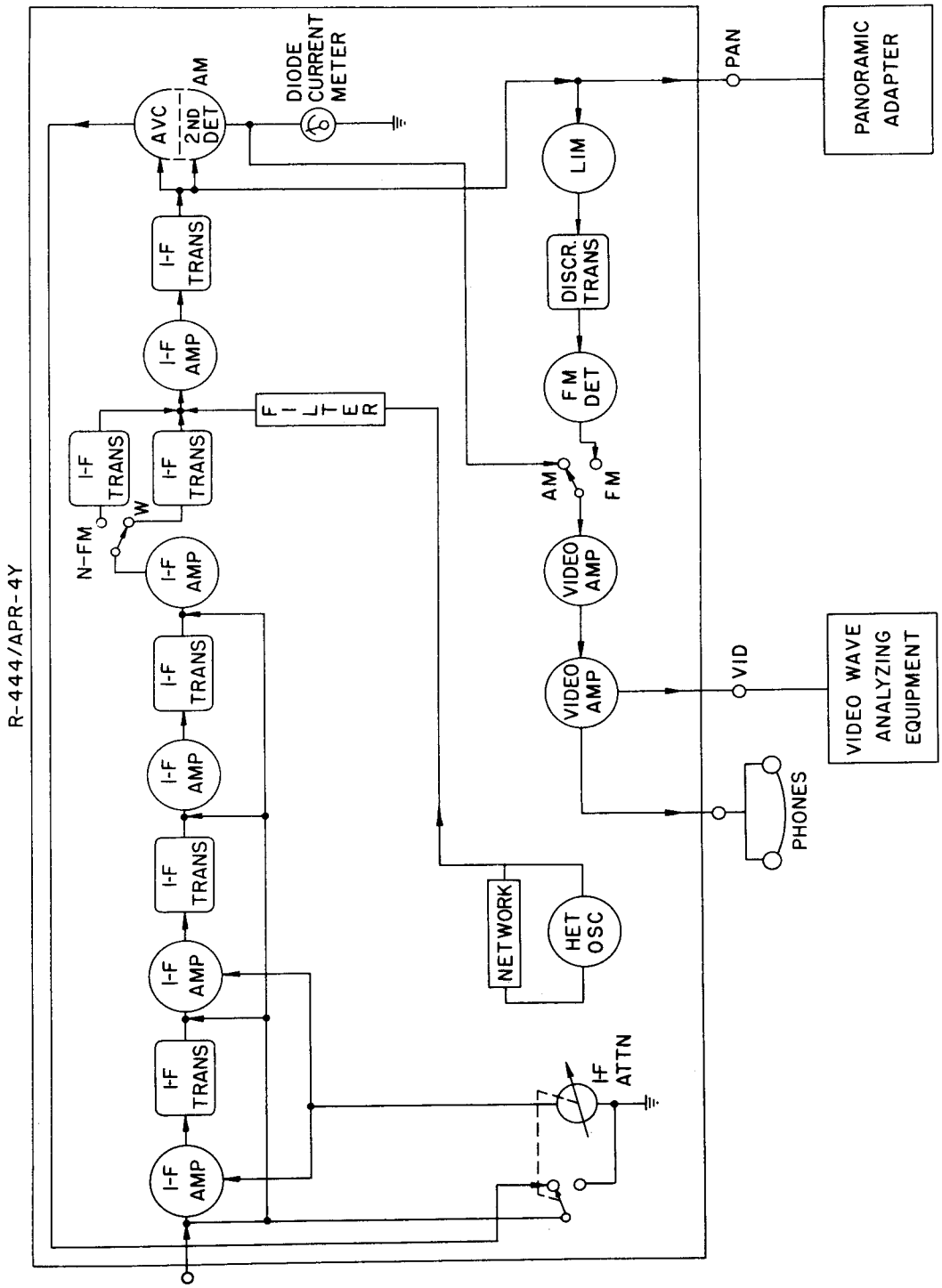
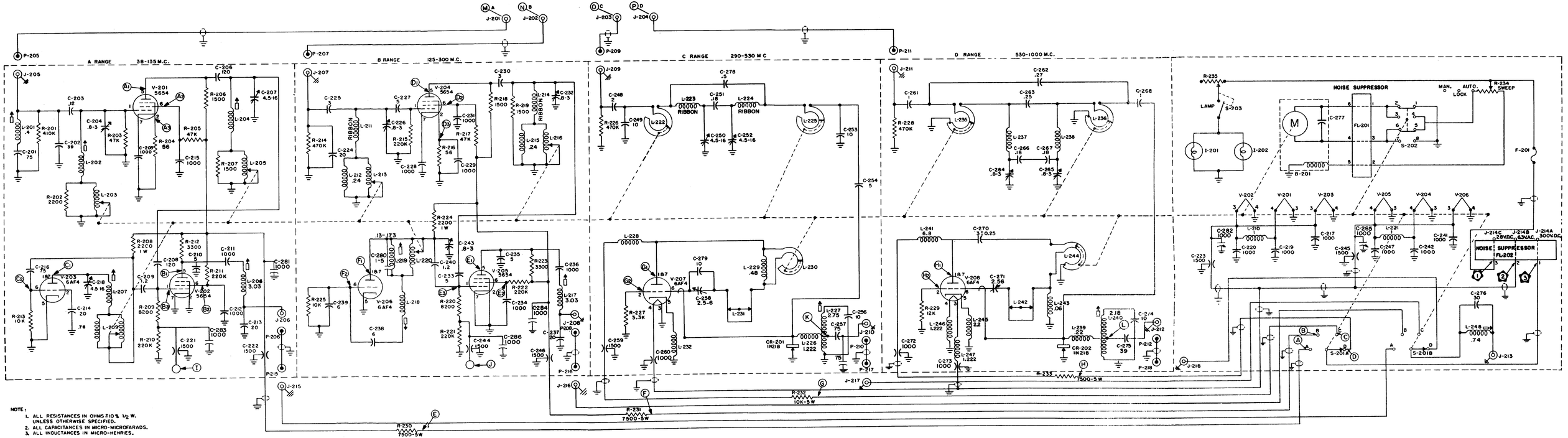


Figure 4-2. Block Diagram of the Radio Receiver



NOTE:
1. ALL RESISTANCES IN OHMS ±10% ½ W. UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITANCES IN MICRO-MICROFARADS.
3. ALL INDUCTANCES IN MICRO-HENRIES.

Revised 1 November 1955

Figure 3-8. Electrical Schematic Diagram of Frequency Converter