

UHF MILITARY EQUIPMENT

CHAPTER TWO

R-361/GR RECEIVER

1.0 GENERAL

The type R-361/GR receiver is a double conversion superheterodyne receiver utilizing two crystal controlled oscillators. There are two i-f sections, the first of which is 40.4 mc and the second is 6 mc. In each case the oscillator frequency is below the desired signal frequency. The receiver circuitry incorporates avc action, a series noise limiter and squelch circuits. It is capable of delivering one watt of audio power to a 600 ohm load at the output terminals. When one watt of audio power is delivered to a 600 ohm load at the output terminals, the audio power delivered to a 600 ohm load at the monitor terminals is +15 dbm.

This receiver can be tuned to any frequency in the UHF band, extending from 225 mc to 399.9 mc, inclusive. Tuning is accomplished by using the proper crystal in the first oscillator and tuning the r-f and first oscillator sections.

The first oscillator crystal is a CR-32/U type, operated in a thermostatically controlled crystal oven. The crystal frequency is multiplied nine times. The second oscillator crystal is a CR-23/U type, operating at a fixed frequency of 34.4 mc. The first i-f is 40.4 mc and the second i-f is 6 mc.

The antenna input circuit is unbalanced and is designed to work with a 52 ohm transmission line of the coaxial type. This receiver will produce at least one watt of audio power into a 600 ohm load at the output terminals when receiving a 50 microvolt signal modulated 30 percent by any frequency between 400 and 3,000 cps.

output is terminated on a board at the rear of the receiver, where terminals are provided for muting, monitoring and changeover from balanced to unbalanced output. In addition, an "AUDIO OUTPUT" jack is provided on the front panel for plugging in a 600 ohm headset.

The selectivity of the receiver, with reference to 6 mc (the 2nd i-f section), is such that the bandwidth at -6 db is greater than 85 kc and less than 225 kc at -60 db, except for sets having serial numbers of 800 or over, where the bandwidth at -6 db is greater than 60 kc and less than 175 kc at -60 db. The sensitivity of the receiver is such that a 3 microvolt signal modulated 30 percent with a 1,000 cps audio tone, will produce at least 10 milliwatts of audio power with a signal to noise ratio of at least 10 db.

This equipment will operate on a power source of either 105 to 125 V, single phase, 50 to 60 cps or 210 to 250 V, single phase, 50 to 60 cps. The average power consumption is 125 watts and the peak power consumption is 140 watts. This receiver will operate satisfactorily on continuous duty at temperatures ranging from -29°C (-20°F) to $+55^{\circ}\text{C}$ ($+131^{\circ}\text{F}$). The overall frequency stability for the entire frequency range is ± 10 kc. The equipment will be ready for operation five minutes after it is turned on, and should be within 10 kc of the required frequency after 20 minutes.

This receiver is provided with one fuse located on the front panel. The rating of the fuse depends on the power supply voltage used. A two ampere fuse is used for 115 V and a one ampere fuse for 230 V.

Several views of the receiver are shown in Figures 2-2 through 2-6.

2.0 THEORY OF OPERATION

With reference to Figure 2-7, the individual circuits of the receiver will now be considered in detail.

2.1 First Oscillator and First Tripler (V501)

The first oscillator is a Butler type circuit. Fundamentally it consists of a two-stage amplifier with sufficient positive feedback, from the cathode of the second to the cathode of the first amplifier, to sustain oscillation.

To understand the operation of this oscillator, imagine a random positive pulse at the cathode of the grounded grid amplifier V501A. Because the grid is grounded, a rise in cathode voltage will cause a decrease in plate current, therefore increasing the plate voltage. The positive pulse is then coupled to the grid of V501B. Since the cathode voltage follows the grid voltage, i.e., they are in phase, the positive pulse is coupled back to the cathode of the grounded grid amplifier, through the series mode crystal Y501. At series resonance, this crystal is a low impedance path of less than 40 ohms. The plate load of the grounded grid amplifier is tuned to the crystal frequency while the plate load of the output (tripler) amplifier is tuned to three times the crystal frequency. Oscillations are maintained since the feedback from the second to the first amplifier is sufficient to overcome losses. Note that one section of the dual triode tube V501 is designated as an oscillator. Actually, both sections of V501 are required in the operation of the oscillator. However, since the resonant frequency of the plate load of the "A" section is that of the crystal while that of the "B" section is three times that of the crystal, the "B" section is called the tripler.

If crystal Y501 fails, the capacity of its holder offers a low impedance path between the cathode of the amplifiers that comprise the 1st oscillator-1st tripler stage. To overcome the likelihood of the circuit going into oscillation, inductor L505 is connected in parallel with Y501.

The resultant parallel resonant circuit has sufficiently high impedance to effectively open the cathode feedback circuit.

2.2 First Amplifier (V502)

The first amplifier is a Class C power amplifier, used to provide enough drive for the second tripler. The plate circuit is tuned to three times the oscillator frequency.

2.3 Second Tripler (V503)

The second tripler is a Class C amplifier used as a frequency multiplier. The tuned plate circuit, U501, is tuned to nine times the crystal frequency. U501 consists of a strap inductance mechanically and electrically attached to an air variable capacitor as shown in figure 2-1. The tuning action is as follows: When the capacitor is completely closed, there is maximum capacity and inductance. Therefore, the second tripler is tuned to the lowest frequency. As the capacitor is opened, the capacity decreases and the rotor begins to fill the space within the inductor strap. Since the rotor is brass, this has the same effect as tuning a coil with a brass slug, that is, it decreases the inductance. Note that this element is essentially a variable capacitor connected in parallel with and ganged to a variable inductor. This combined action results in a greater tuning range than would be available from the change in tuning capacity only.

2.4 Second Amplifier (V504)

The second amplifier is a Class C power amplifier used to provide the required drive to operate the first mixer efficiently. The plate tank circuit, U502 is tuned to nine times the crystal frequency. The construction of U502 is the same as U501.

2.5 Second Oscillator (V505)

The second oscillator is a Butler type circuit similar to the first oscillator. Section "B" is a grounded grid amplifier. Its plate circuit is tuned to 34.4 mc. Section "A" of V505 is a cathode follower as the plate is at r-f ground potential.

2.6 First R-F Amplifier (V401) and Second R-F Amplifier (V402)

The first and second r-f amplifiers are grounded grid triodes. The antenna circuit input impedance of U401 is approximately 50 ohms over the frequency range. The construction of U401, U402, U403 and U404 is similar to U501 and U502.

2.7 Third R-F Amplifier (V403)

V403 is a shunt fed r-f amplifier. Amplification in this stage has been reduced, to remove all traces of regeneration, by tapping down on the tank circuit U403 of the previous stage and by placing a loading resistor, R420, across the output tank circuit U404.

2.8 First Mixer (V404) and First I-F (40.4-Mc) Network

The first mixer is a pentode with the r-f signal fed to the first grid, and the signal from the first oscillator injected on the cathode. The oscillator signal frequency at this point is nine times the frequency of the first oscillator crystal Y501. The output frequency of the first mixer is 40.4 mc.

The first i-f section is a triple tuned network, consisting of transformer T301, capacitors C301, C351 and C425 and inductor L307. Because of the capacity of C301, the over-all triple tuned network is just under critical coupling. T301 is tuned to 40.4 mc. L307 in parallel with C351 is also tuned to 40.4 mc.

2.9 Second Mixer (V301)

The second mixer is a pentagrid converter. The first i-f signal (40.4 mc) is fed to the third grid of V301. The 34.4 mc signal from the second

oscillator, V505, is injected on the first grid, and the plate load is tuned to 6 mc.

Capacitor C337 is not used in receivers with serial numbers of 800 and above. Eliminating this capacitor reduces adjacent channel interference by narrowing the bandwidth at 6 mc.

2.10 Second I-F (6-Mc) Section (V302, V303 and V304)

The 6-mc i-f circuits are conventional pentode amplifiers. Four slightly overcoupled, double-tuned i-f transformers provide a selectivity curve having a broad peak with comparatively sharp sides.

Capacitor C352 is not used in receivers with serial numbers of 800 and above. Eliminating this capacitor reduces adjacent channel interference by narrowing the bandwidth at 6 mc.

2.11 Second Detector and Noise Limiter (V305)

One diode, V305A, operates in the usual form of second detector. The other diode, V305B, has its plate circuit connected across a portion of the second detector-diode-voltage divider and acts as a variable resistor in series with the audio output circuit. The audio is taken from the cathode of the noise limiting diode and as long as the noise pulses are of less amplitude than the audio frequency components of the desired signal, the noise limiting diode functions like a closed switch and passes the audio on to the a-f section of the receiver. When the noise impulse exceeds the signal component, the noise limiting diode performs as an open switch, or high resistance, and prevents any signal or noise from passing through the audio amplifier.

The modulated r-f voltage appearing across the secondary of T306 is detected by V305A. R322 and R323 have been selected to give the proper load for V305A while preventing the noise limiter from clipping below 80-percent modulation.

In other words, noise pulses and audio signals above 80-percent modulation will be clipped. The rectified carrier voltage across R322 is used as a reference voltage between the plate and cathode of the noise limiting diode (V305B). This reference voltage does not vary with the audio frequencies or with noise pulses, because of the long time-constant in the R-C network composed of R324, R325 and C326. The polarity of this reference voltage is such that the noise limiting diode will conduct. The path for the audio signal is from the top side of R323, through the noise limiting diode, through C327, through R326, through the "A-F GAIN" control to ground, then to the ground side of R323. The arrangement of the circuit is such that the positive half of the audio cycle applies a negative voltage on the plate of the noise limiting diode, with respect to its cathode. Also, positive noise pulses developed across R323 will appear as negative pulses on the plate of the noise limiting diode. If these positive noise pulses are greater than the reference voltage, the limiting diode is cut off and the path for the audio signal is opened and there is no output from the receiver. Likewise, if the positive half of the audio cycle is greater than the reference voltage, the limiting diode is cut off.

2.12 Squelch Circuits and First Audio Amplifier (V306, V307A and V308A)

The purpose of the squelch circuit is to reduce the objectionable noise that occurs between periods of signal input. Automatic volume control action increases the sensitivity of the receiver when there is weak or no signal input and causes an objectionable hiss or roar in the loud-speaker if the audio volume control is turned up very high. The squelch circuit is designed to silence the audio frequency amplifier for all carrier signals below a certain predetermined level.

A direct-coupled amplifier (V307A) and a diode (V308A) are connected in the grid circuit of the first audio amplifier (V306A) in such a manner that it is biased beyond cutoff when, in the absence of an r-f signal input, no avc voltage is impressed on the grid of the direct-coupled amplifier. When the r-f signal input is sufficient to set up a large enough

value of avc voltage, the diode will conduct, acting like a switch, and permit the a-f amplifier bias to reduce to a value that permits normal audio output. The first audio amplifier is paralleled with an auxiliary amplifier (V306B) whose audio input level can be adjusted so as to bypass incoming a-f signals around the first audio amplifier permitting reduced output while the first audio amplifier is "squelched".

The squelch circuit is in operation when switch S302 is open. With a weak or no signal input, the avc voltage will not be sufficiently negative to cut off the squelch amplifier (V307A). Resistor R337 is the plate load of the squelch amplifier (V307A). Since the value of R337 is much greater than the plate resistance of V307A, the voltage on the plate of V307A, with respect to ground, is small. This same positive voltage is on the grid of V306A and on the plate of the squelch diode (V308A). However, V306A is cut off, because the positive voltage on its cathode, with respect to ground, is greater than the positive voltage on its grid, with respect to ground. This positive voltage on the cathode of V306A is the voltage drop across R331, which is part of a voltage divider composed of R331, R340 and R341. This bleeder is connected between +200 volts and ground. The positive voltage on the cathode of V306A is also on the cathode of the squelch diode (V308A). Since the positive voltage on the cathode of V308A, with respect to ground, is greater than the positive voltage on the plate of V308A, with respect to ground, V308A does not conduct.

Now, if switch S302 is closed, the positive voltages on the grid and cathode of V306A would be removed, the operation of V306A would be normal and its bias would be determined by R330 in its cathode circuit. With S302 open, a signal that is strong enough to make the squelch diode conduct will have the same effect as closing S302, because the squelch diode is connected across the switch. Squelch diode V308A will conduct when the avc voltage is large enough to cut off the squelch amplifier (V307A). When V307A is cut off, the positive voltage on its plate increases. This increased voltage is also on the plate of the squelch diode

(V303A), causing V303A to conduct, giving the effect of closing switch S302.

Resistor R330 in the cathode circuit of V306A is unbypassed to decrease audio distortion. The strength of signal needed to overcome the squelch is determined by setting of the "R-F GAIN" control, which adjusts the amplification of the i-f strip. As the gain of the i-f strip is decreased, a larger signal is required at the antenna to produce sufficient average voltage to close the squelch. For example, if the "R-F GAIN" control is set to make the receiver operate at an input signal of 5 microvolts, a weaker signal will be heard only if the "AUDIO QUIETING DB" control is set for the weaker signal.

2.13 Second Audio Amplifier and Power Output Stages (V307B and V309)

The output of V306 is fed to the second audio amplifier V307B for further amplification. The output of V307B is used to drive the power amplifier tube V309. This amplifier is required to supply adequate audio power to output transformer T308. The cathode and plate of this tube have separate tuned networks. These tuned networks enable the audio response above 1,000 cps to taper off gradually. A pad consisting of R346, R347 and R348 supplies +15 dbm of power for a 600 ohm telephone line when the "A-F GAIN" control is set to deliver one watt of audio power into a 600 ohm load connected at J301. The monitoring output is obtained between terminals 3 and 4 on terminal board E303. Terminals 1 and 2 are provided for a muting circuit. These terminals are in parallel with the "AUDIO OUTPUT" jack J301 and are connected across the secondary winding of T308. In some installations where receivers and transmitters are connected to operate on a common antenna system, the muting terminals are connected to a shorting relay in the transmitter. With this relay in the transmitting position, the antenna is connected to the transmitter and the muting terminals short circuited to prevent the receiver output from operating during transmission periods. The remaining terminals 5 and 6 on E303 are used to connect the center tap of the output winding on T308 to ground. By connecting

a jumper between 5 and 6 the audio output across J301 is balanced to ground.

2.14 Automatic Volume Control (AVC) (V308B and V310)

The function of the avc circuit is to permit maximum gain until a pre-determined output level is reached, and then to reduce the gain with increasing signal so as to keep the output level constant. In the R-361/GR receiver, constant output level is maintained by using a delayed avc with a forward feed.

With no avc, the output is proportional to the input, limited only by some practical considerations such as the signal handling capabilities of tubes in the various stages of the receiver. With ordinary avc, the output is no longer proportional to the input; the avc goes into action as soon as a signal is received and the system can handle larger signals.

An amplified avc is characterized by a more rigid control of the output, while delay in the operation of this avc permits a usable output at lower input voltages. If a portion of this avc voltage is fed to a stage following the avc take-off point, it is possible to have fairly constant output with variable input, and finally to have the output decrease with very strong signals. The R-361/GR receiver utilizes this type of avc action.

Before a signal is applied, V310 is conducting, making the cathode of V308B positive with respect to ground while the plate of V308B is at ground potential. As a signal is supplied from the plate of V303 in the 6 mc i-f section, it is amplified by V310 and fed to the avc detector V308B. When the positive amplitude on the plate of V308B is greater than the d-c voltage across R354, V308B will conduct. The voltage across R354 is the effective avc delay voltage for the circuit. When V308B is conducting, the top of R353 becomes negative with respect to ground. This voltage is then fed back to the previous stages, and

also ahead to V304 in the 6 mc i-f section. Note that the avc voltage is derived from V303, amplified and delayed by its own avc amplifier (V310) and detected by its own detector (V308B); the developed avc voltage is then applied to almost all stages in front of V303 and also to V304. Such a system is called an amplified, delayed avc with forward feed.

2.15 Power Supply (V311 and V312)

A full-wave rectifier circuit is used for the power supply. V311 and V312 are connected in parallel to provide the current and voltage requirements for the receiver. A capacitor input filter network consisting of C347, C348 and L305 is used in the B+ line to reduce the ripple voltage. A high frequency capacitor input filter is incorporated in each side of the a-c line to reduce radiation.

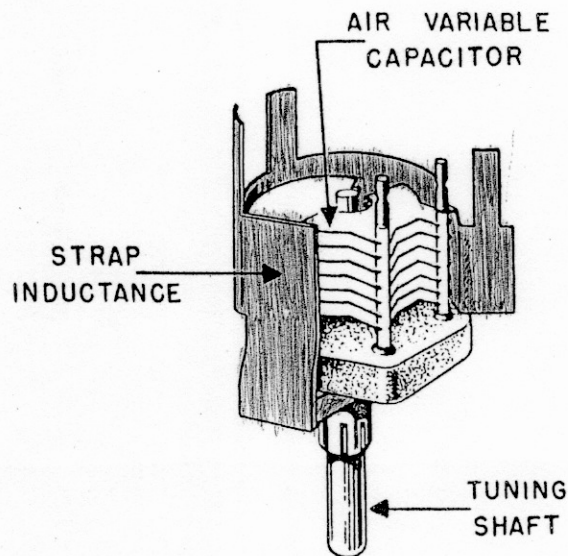


Figure 2-1. Radio Receiver R-361/GR, R-F Tuning Unit

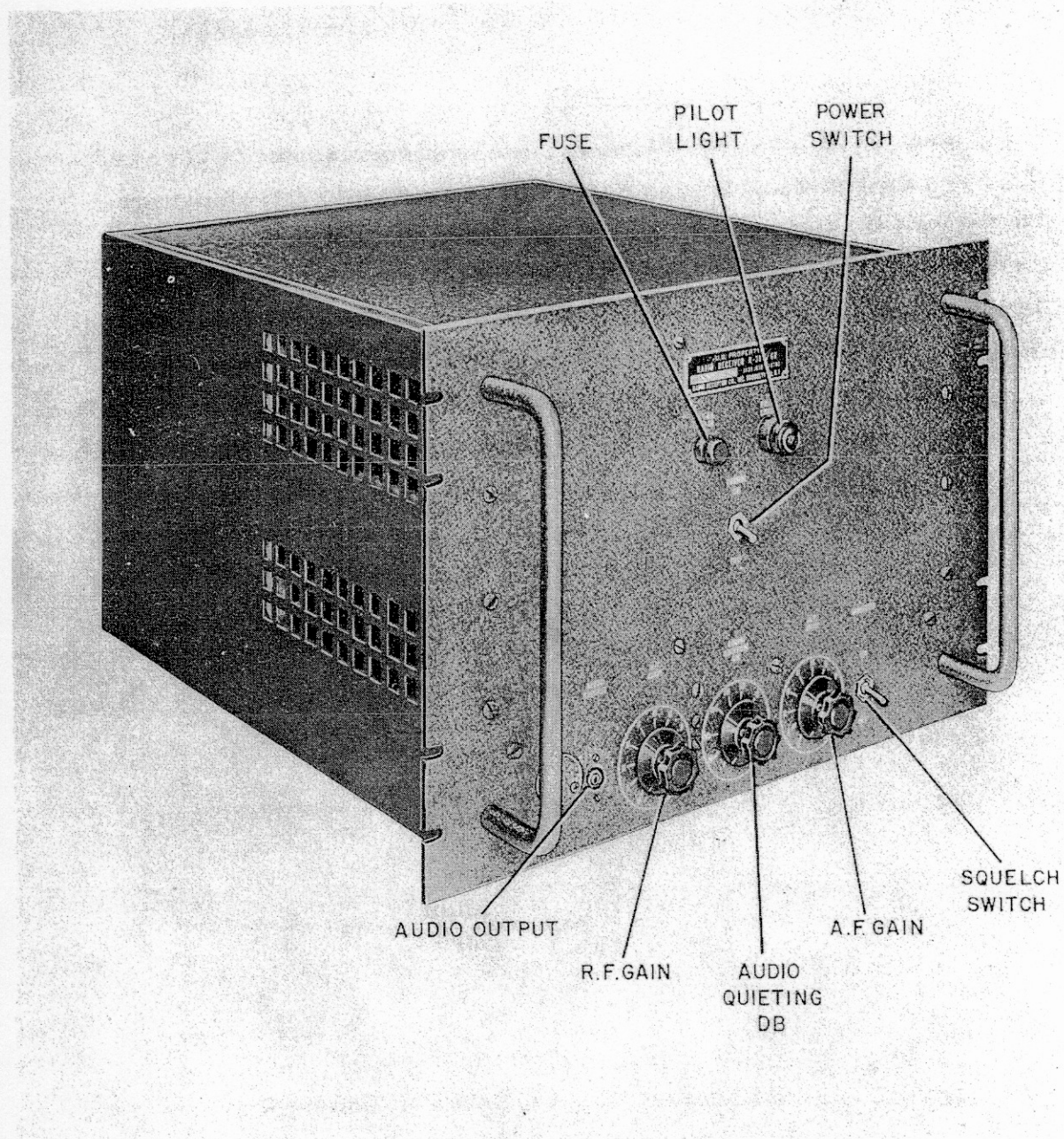


Figure 2-2. Radio Receiver R-361/GR, Front View

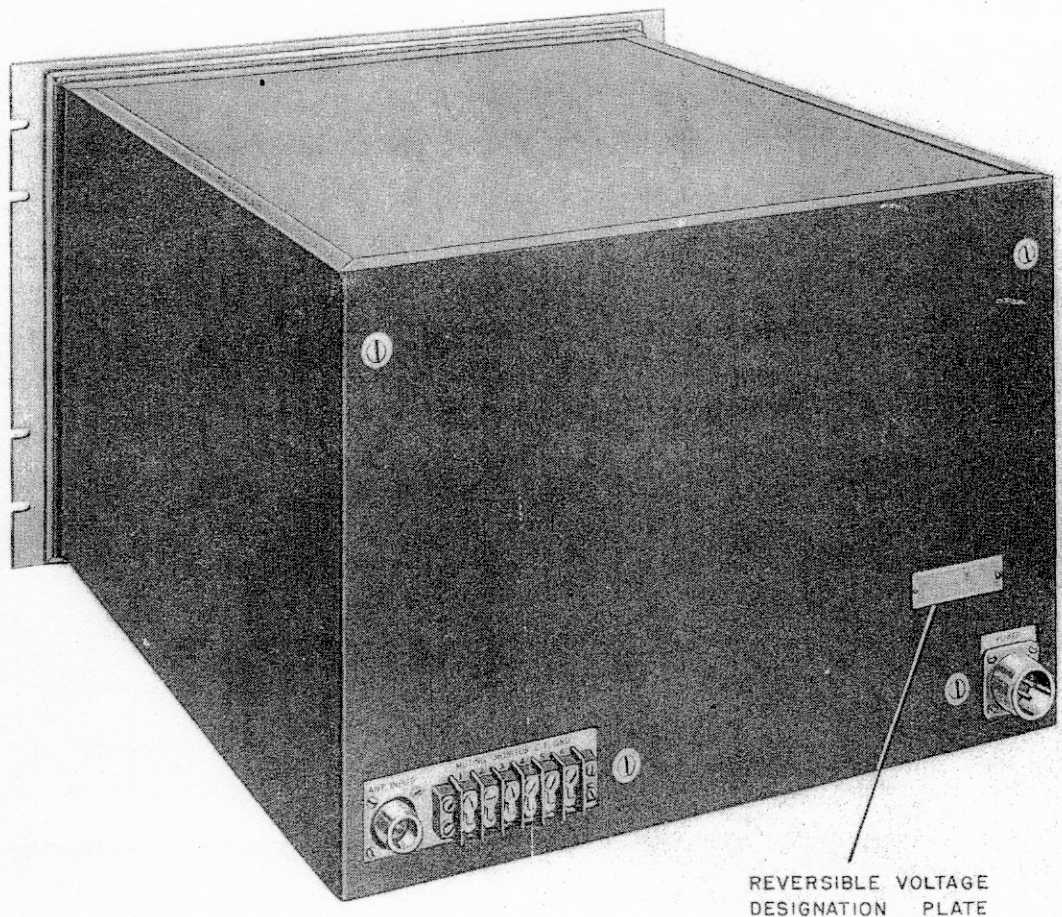


Figure 2-3. Radio Receiver R-361/GR, Rear View, Dust Cover On

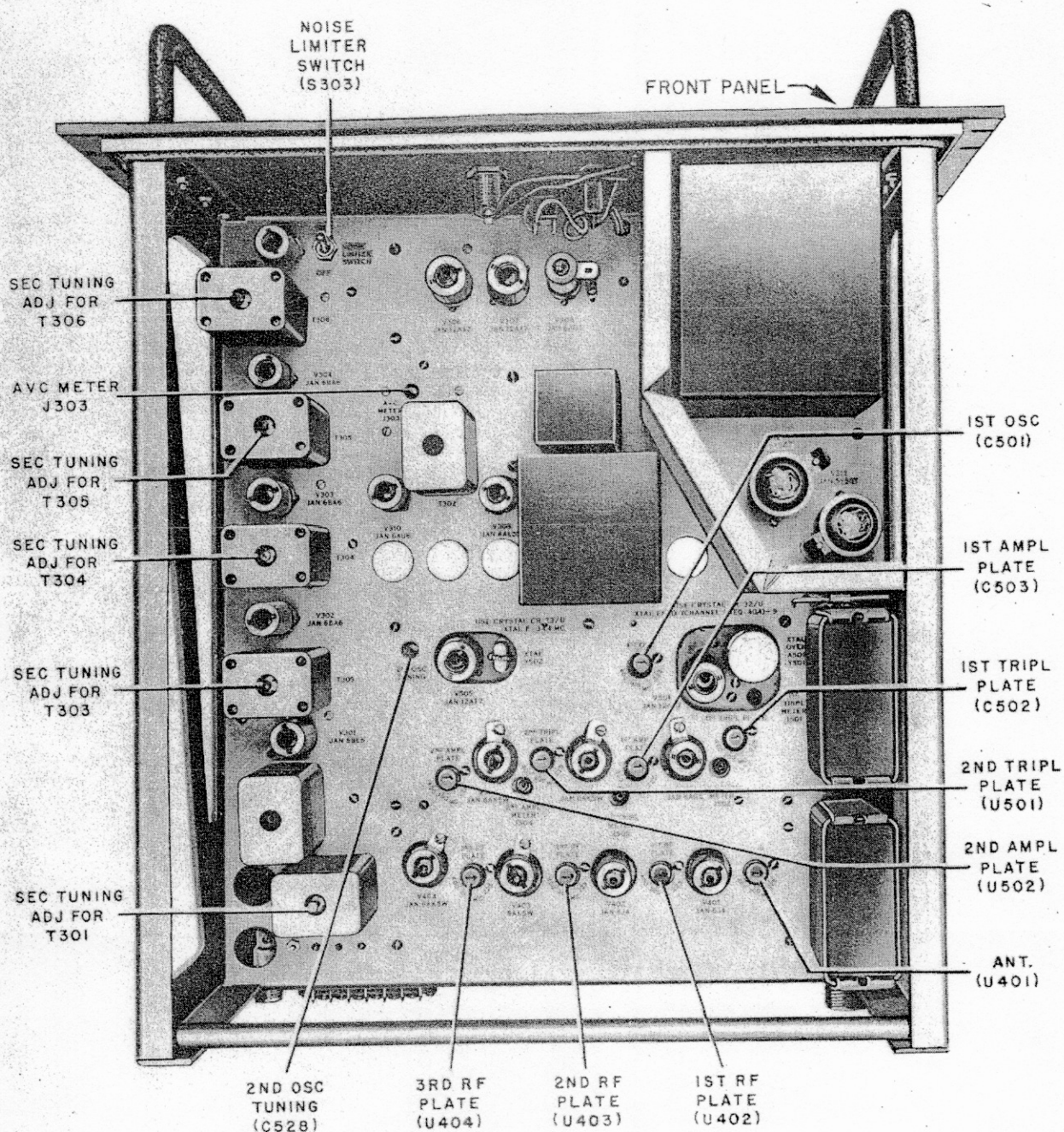


Figure 2-4. Radio Receiver R-361/GR, Top View, Dust Cover Removed

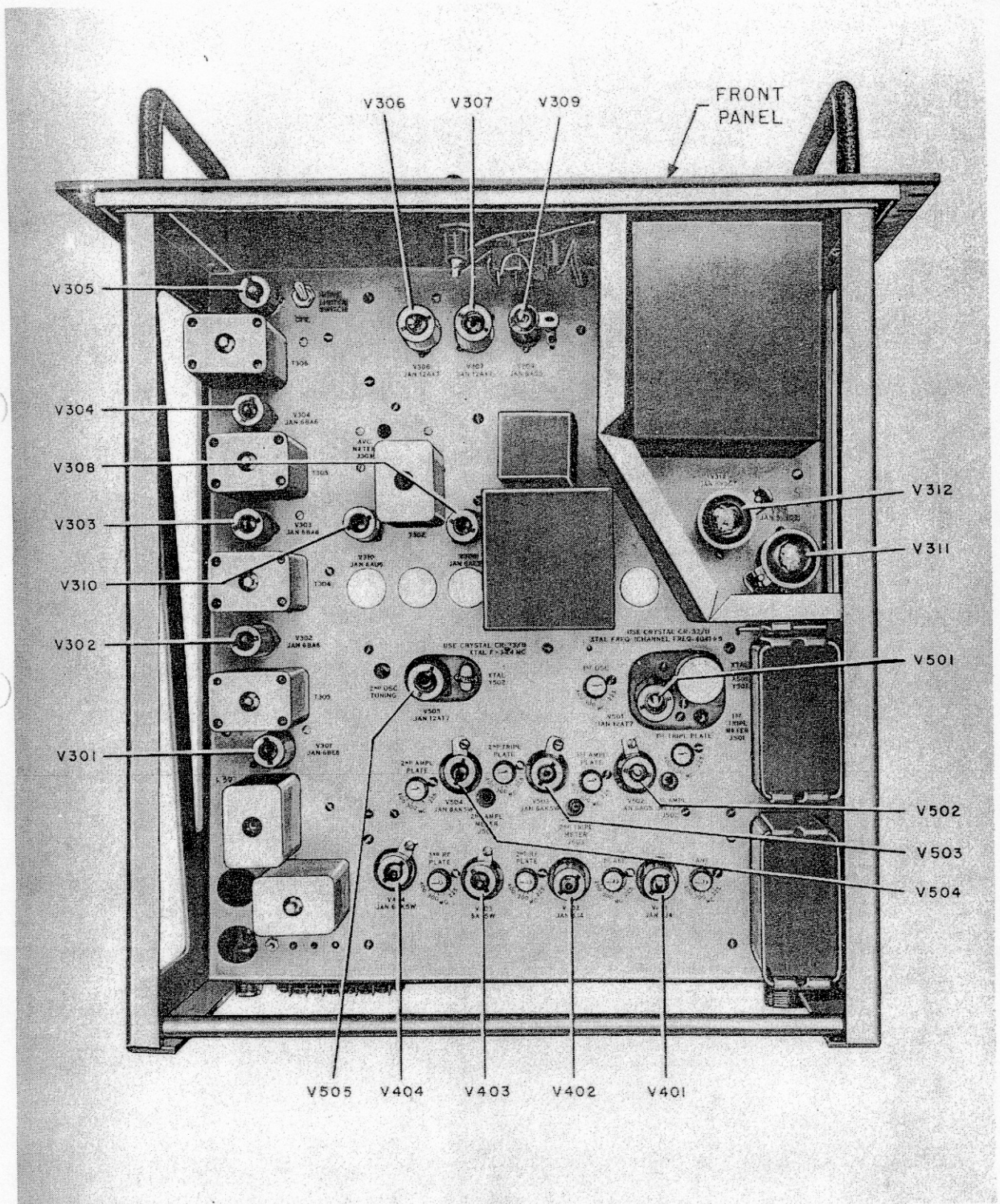


Figure 2-5. Radio Receiver R-361/GR, Top View, Tube Location

359.
80.8

40.4
80.8

2-16

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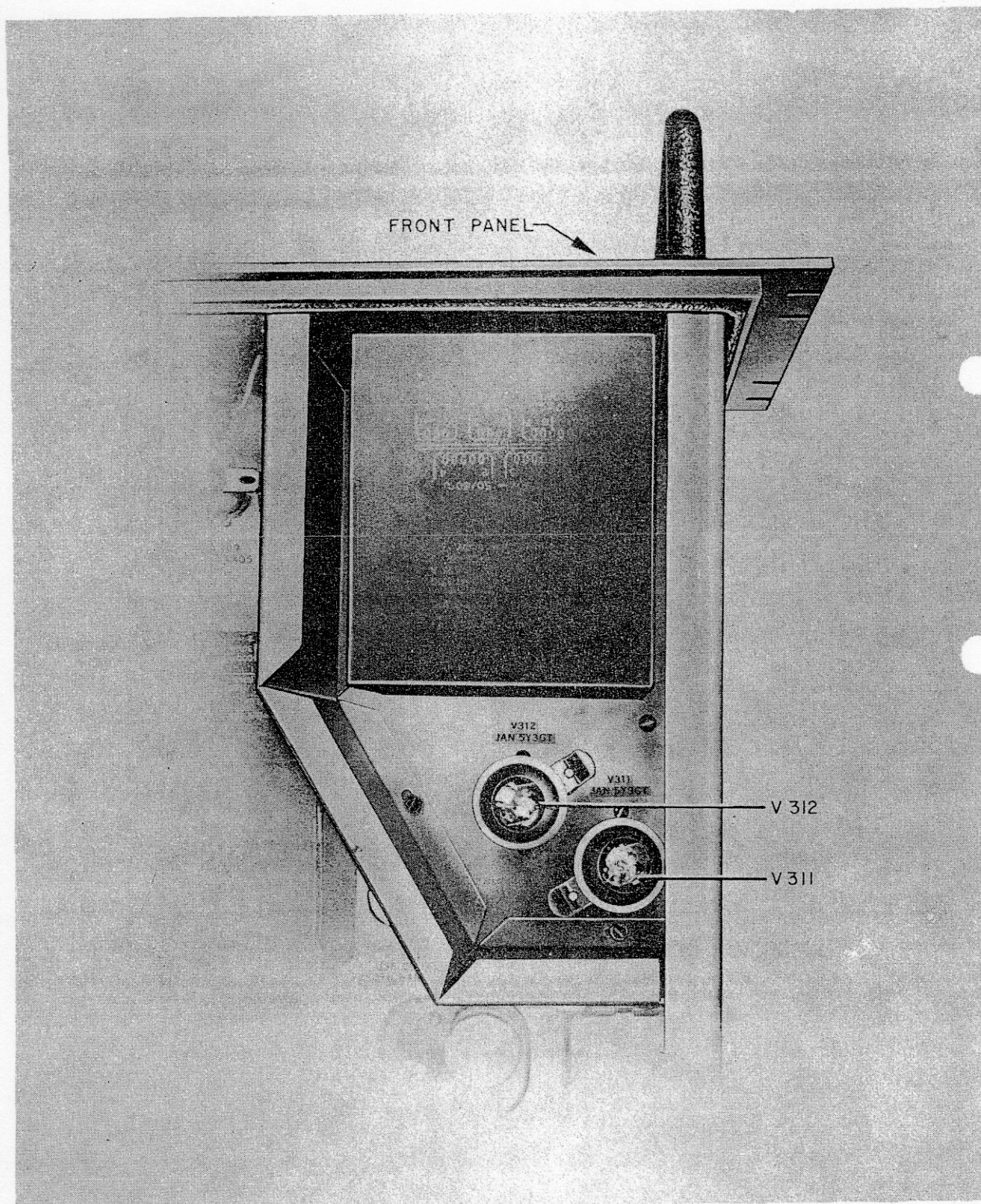


Figure 2-6. Radio Receiver R-361/GR, Power Supply Section, Dust Cover Removed

3 uV input modulation 30% 1 MC
will produce at 10 dB with S/N at least 10 dB

150. Butler CR-32/U
1st i-f three tuned circuits
40.4 mc. primary purpose
good image rejection
2nd i-f three stages of
amplification 6 mcs. primary
purpose selectivity.

r-f minus 1st i-f = Xtal freq.
9
image freq = r-f $\pm$ (2 i-f)

r-f = 80.8
i-f = (f_s - f_o)

f_s = 2(f_s - f_o)

f_i = 2f_o - f_s

uses series noise limiter &
squeld circuit for noise
control

