# CHAPTER 2

# OPERATING PRINCIPLES OF A REPRESENTATIVE UHF RADIO TRANSMITTER (TED SERIES)

## INTRODUCTION

Radio Transmitting Equipment, Navy Model TED, is used for a-m radiotelephone (A-3) and modulated-carrier wave (A-2) communications at frequencies from 225 to 400 megacycles. These frequencies limit the reliable range of the equipment to approximately "line-of-sight" transmission. The equipment may be installed on ships, submarines, and at shore stations.

## GENERAL DESCRIPTION

The major components of the TED radio transmitting equipment (fig. 2-1) are the radio transmitter, Navy CFT-52373, two transmitter control units, Navy CFT-23555, and the cable assemblies.

The radio transmitter (fig. 2-2) contains all of the equipment required for transmission by voice or telegraph, except for such accessories as the handset, key, and antenna. The units comprising the transmitter are the power supply, radio modulator, radio frequency chassis, cabinet, and terminal box.

The power supply occupies the center of the drawer-type transmitter chassis, and is attached to the front panel. The radio modulator and radio frequency chassis are removable assemblies mounted, respectively, to the left and right of the power supply components. Small doors, one on either side of the front panel, provide access to the radio modulator and radio frequency chassis operating controls. Connections between the power supply and the other two units are made through plugs and cables connecting the units.

The power supply chassis contains the power transformers, high voltage rectifier tubes, low voltage selenium rectifiers, filters, and bleeder resistors needed to produce all voltages required for operation. Also located on the power supply unit are control relays which energize portions of the power supply to allow for the generation of the modulated carrier, and which also transfer the antenna from a receiver to the transmitter r-f circuits when the transmitter is keyed.

The meter mounted on the front panel (fig. 2-2) is used to monitor various currents and voltages in the entire transmitter. Control switches, indicators, and fuses, as well as microphone and handset jacks are also mounted on the transmitter front panel.

The radio modulator unit contains the audio transformers, tubes, and circuits required to effect a-m voice or mcw modulation of the r-f carrier. The conventional speech amplifying and modulating circuits are supplemented by special circuits to provide volume expansion, AVC, and clipper-filter action, all of which considerably increase the average carrier sideband power under voice-modulated conditions. This action is treated later. A 1000 cps oscillator is included for producing the mcw audio tone.

The radio frequency chassis (fig. 2-2) includes all of the electrical components required for the generation of the r-f carrier. The master oscillator contained in the radio frequency chassis unit is crystal-controlled, having its fundamental crystal frequency multiplied 12 times to produce output frequencies of approximately 225 to 400 megacycles.

Mountings for four oscillator crystals are provided. Any one of the crystals may be chosen by a crystal selector switch, permitting rapid selection of any of the four frequencies. Under emergency conditions, the oscillator circuit may be operated without using a crystal, but with some loss in frequency stability.

The rear portion of the radio frequency chassis is occupied by a blower (not shown) which provides forced-air ventilation.

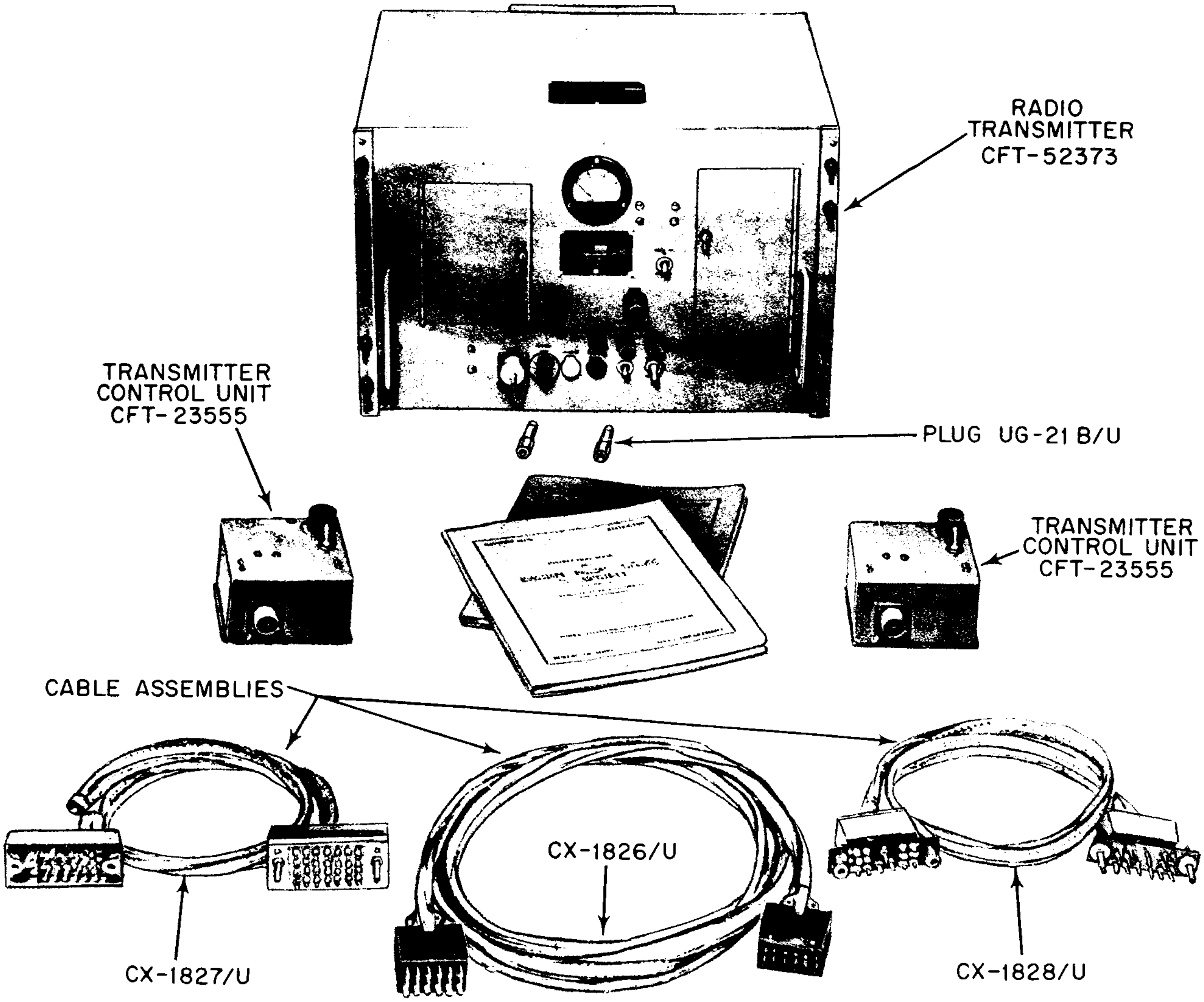


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Figure 2-1.—Radio Transmitting Equipment, Navy Model TED.

BLOCK DIAGRAM

The crystal oscillator, V113 (fig. 2-3) generates an output frequency between 18.75 and 33.33 megacycles. This signal is doubled in frequency (37.50 to 66.67 mc) by doubler, V114. Feedback from the doubler stage, V114, to the oscillator, V113, is provided to sustain the oscillations in V113. The doubler (V114) output is amplified in V115.

A second doubler stage, V116, multiplies the 37.50 to 66.67 mc output of V115 to a frequency between 75.00 and 133.33 mc. This output is applied to a tripler-power amplifier which is operated in push-pull, and comprises V117 and V118. The tripler-PA stage multiplies the V116 output to a frequency between 225.00 and 400.00 megacycles. This stage also amplifies the nominal carrier output to approximately 15 watts. A tuned output filter minimizes the radiation of harmonics.

The r-f output reaches the antenna via an antenna relay, K104, which is mounted on the power supply chassis. The relay functions to switch the antenna between the radio transmitter and the receiver being used, during periods of transmission and reception, respectively.

The radio modulator (fig. 2-3) comprises circuits which amplify the speech or mcw tone to a level sufficient to cause 100 percent amplitude-modulation of the r-f carrier output from the radio frequency chassis. The radio modulator also contains circuits which function to increase the average carrier sideband power,

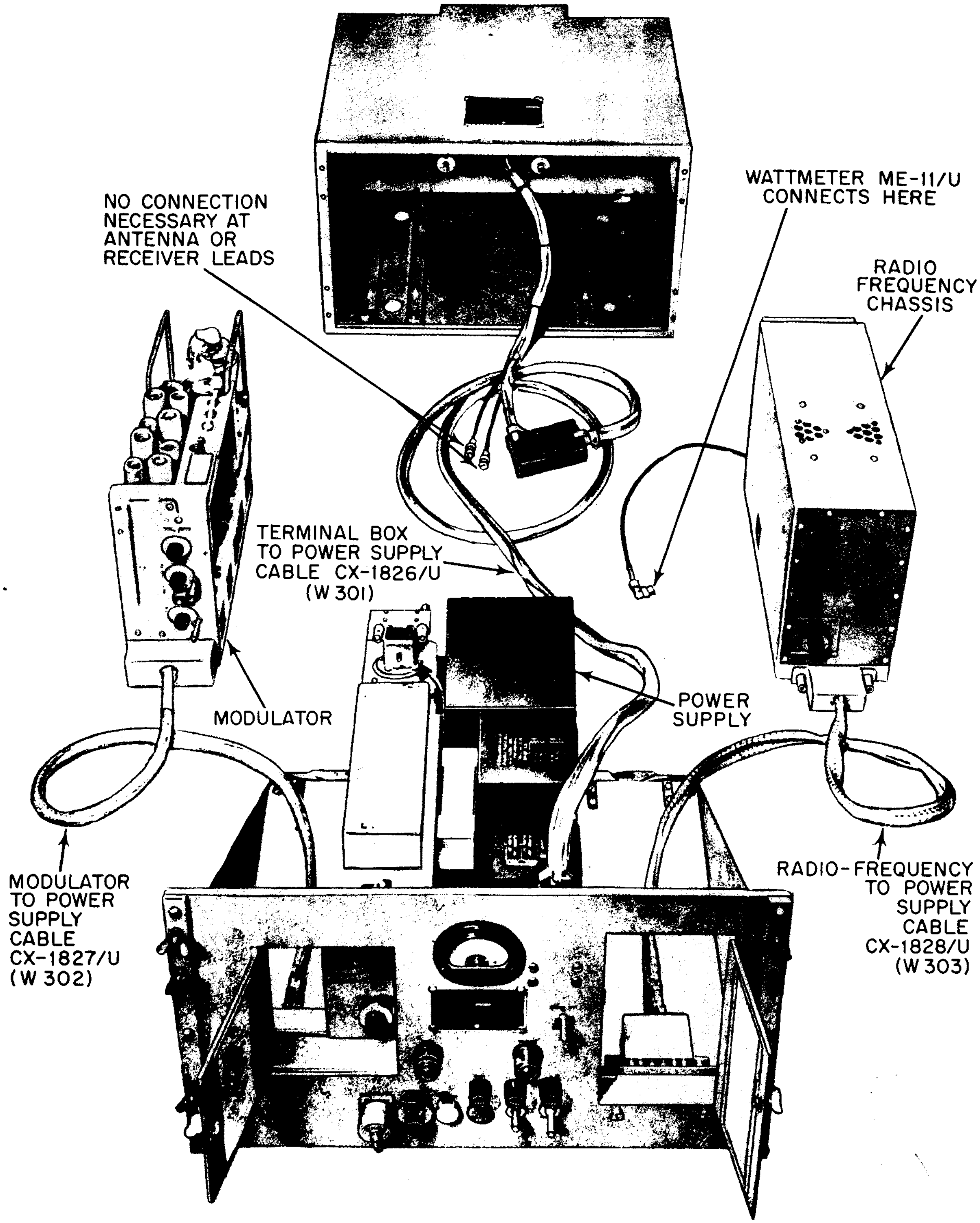


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Figure 2-2.—Radio Transmitter, Navy Model TED (Association of Parts).

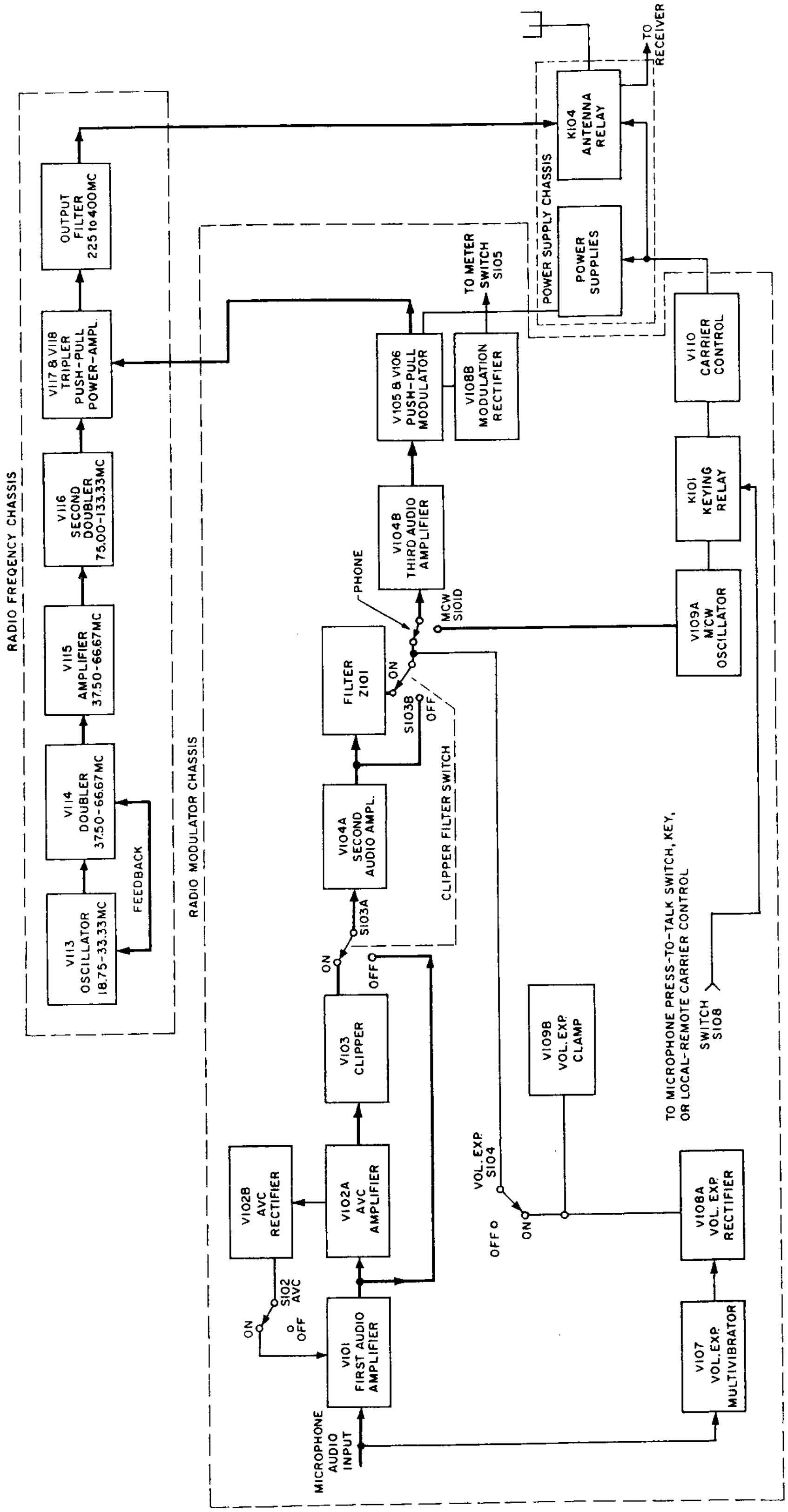


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Figure 2-3.—Functional Block Diagram, Radio Transmitting Equipment, (Navy Model TED).

although the action of these circuits is not to be considered as part of the basic audio modulation process.

If it is assumed that the AVC switch, S102, clip-filt switch, S103, and volume-expander switch, S104, are in the OFF position (opposite to that shown) the basic modulating circuit can be studied. The switches are shown in the ON position since this represents their position for normal operation of the transmitter.

The speech input from the microphone is amplified by the first audio amplifier, V101. The output of V101 passes through S103A (in the OFF position) to the second audio amplifier, V104A. The V104A amplified output is coupled through S103B (also in the OFF position) and through S101D (during PHONE operation) to the third audio amplifier, V104B. Output from V104B drives the push-pull modulator stage, V105 and V106, whose output variations are superimposed on the d-c input to the power amplifier.

During mcw operation, S101D is in the MCW position, and the audio output from the mcw oscillator, V109A, is applied directly to the input of the third audio amplifier, V104B. Less amplification is required for the mcw signals than for voice signals since the oscillator input is considerably higher than the microphone input voltage level.

When switches S102 and S103 are placed in the ON position (as shown), the clipper, V103, AVC rectifier and amplifier (V102B and A) and the filter, Z101, are connected into the audio channel. In this condition, the output from the first audio amplifier, V101, is increased in amplitude by AVC amplifier, V102A, and applied to a clipper, V103. The clipper stage clips the audio at a preset level so that the amplitude of the speech signal applied to the modulators (V105 and V106) remains fairly constant, thereby compensating for variations in voice amplitudes. V103 applies its output to the second audio amplifier, V104A through S103A in the ON position. The low-pass filter, Z101, at the output of V104A, attenuates all of the high frequency components (above 3500 cps) which are present in the clipped audio signal to prevent modulation of the carrier by those frequencies. Thus, the average modulation level is increased, and the effect of voice level fluctuations is minimized.

The clipper circuit is aided by AVC action provided by AVC rectifier, V102B. This stage rectifies a portion of the output from AVC amplifier, V102A, and applies the rectified signal, as an AVC bias, to the first audio amplifier, V101. The AVC action helps maintain an audio level which is suitable for continuously efficient clipping by V103.

A volume expansion circuit functions to eliminate transmission of extraneous background noise when pauses in speech occur during transmission. The expander circuit is active when S104 is in the ON position. The expander utilizes tubes V107, V108A, and V109B, in an electronic control circuit which disables the third audio amplifier, V104B, when the microphone input drops below a preset level.

V107 operates as a monostable (one shot) multivibrator, while V108A and V109B function as a rectifier and a clamping circuit, respectively. In the absence of microphone audio input (or when the microphone input drops below a preset level as mentioned), a bias voltage keeps V104B cut off. When an audio signal of sufficient amplitude to trigger V107 is received, V107 produces a square wave output which is rectified by V108A. The V108A output decreases the bias on the third audio amplifier, V104B, allowing the amplified audio to reach the modulator tubes (V105 and V106).

A portion of the output from the modulator tubes is rectified by modulation rectifier, V108B, for application to the radio transmitter meter circuit. When properly connected to the modulation rectifier circuit, the meter will indicate the relative (average) modulating audio voltage.

Keying relay, K101, is energized by the local or remote carrier control switch, S108, the microphone (or handset) press-to-talk switch, or the key (when mcw operation is employed). When energized, K101 causes the carrier control tube, V110, to operate other control relays, which, in turn, energize portions of the power supply. This action causes the generation of the modulated carrier, and transfers the antenna from the receiver to the output of the transmitter r-f circuits.

An audio signal from a receiver (not shown) associated with the radio transmitter is fed to the earpiece of the operator's telephone handset, providing transmitter monitoring. This arrangement also provides sidetone (a local path between microphone and earphone). Relay operation disconnects the receiver audio when the carrier is on.

The power supply utilizes conventional transformers, tube rectifiers, and filter circuits to develop the B supply voltage. A -42 volt bias supply is included, together with a -12 volt d-c supply. The -12 volt supply is used to operate pilot lamps and may be used as a source of microphone voltage for remote control operation.

A single front panel meter, which is used in conjunction with a selector switch, provides a method of measuring various grid and plate currents. The meter is also used to measure relative power output, AVC current, modulation level, and the volume expansion circuit output.

## CIRCUIT ANALYSIS

The circuit analysis of the radio frequency generating stages is presented first in this division. The audio stages and metering circuits are discussed in the latter portion of the chapter. Frequent reference to the system block diagram (fig. 2-3) will be helpful in understanding the overall operation.

## BUTLER OSCILLATOR

The master oscillator (fig. 2-4) for the transmitter comprises tubes V113 and V114 in a cathode-coupled crystal-controlled circuit called a Butler oscillator. One of the main advantages of the Butler oscillator is that it permits the oscillator crystal to be operated at some multiple of the fundamental crystal frequency, called a harmonic or "overtone." The oscillator tank circuit, comprising C145A, C144, and L105, is tunable through the frequency range from 18.75 to 33.33 megacycles.

To explain the operation of the oscillator, an equivalent but simplified circuit of the oscillator is illustrated in figure 2-5. L and C form a tank circuit in the plate circuit of V1 which is resonant at the frequency of the crystal, Y1.

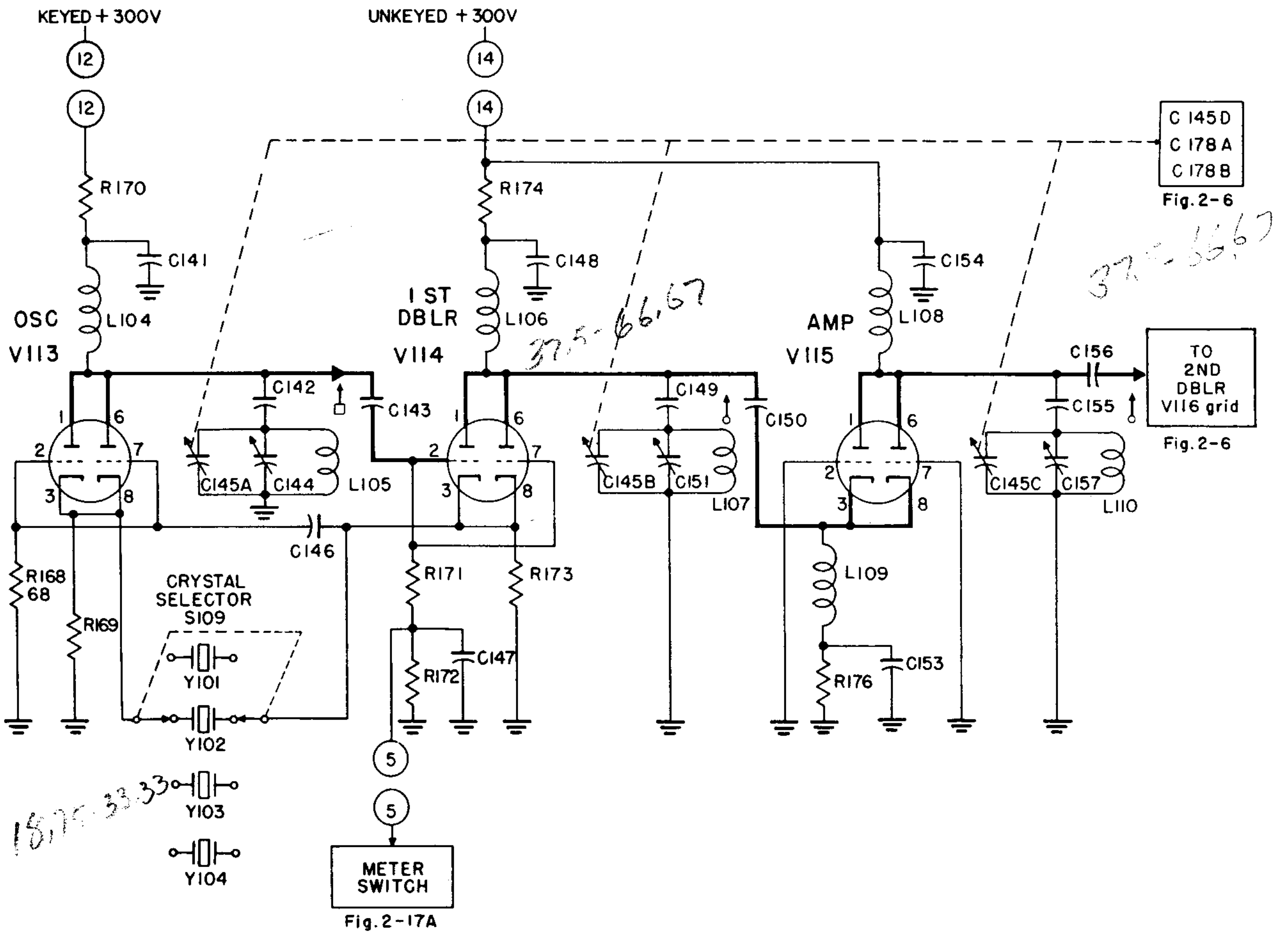


Figure 2-4.—Master Oscillator, First Doubler and Amplifier Stages. 32.25

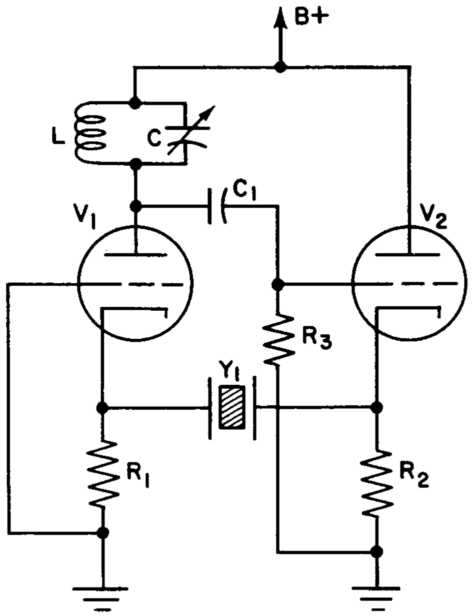


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Figure 2-5.—Butler Oscillator, Simplified Circuit.

Positive feedback, necessary to sustain oscillations in the tank circuit, is supplied via the crystal. The grounded grid amplifier has no phase shift between the cathode input and the plate output. Thus the input signal (across R1) to the V1 plate tank is in phase with the output voltage across the tank.

Oscillations appearing at the plate of V1 are coupled to the grid of V2 through C1. V2 acts as a cathode follower. Thus, the V2 cathode output voltage is in phase with the plate voltage oscillations of V1.

Crystal, Y1, oscillating in a series resonant mode, transmits the voltage at the cathode of V2 to the cathode of V1. Grounded grid amplifier, V1, in turn, reinforces the oscillations at its plate. Thus, the positive feedback required to sustain oscillations is obtained. To further analyze the oscillator operation, assume that the grounded grid amplifier is conducting, and that the cathode voltage is swinging in the positive direction. A more positive cathode will cause less plate current, and the V1 plate voltage rises. C1 couples the more positive plate voltage to the V2 grid, whereupon V2 conducts a heavier current to reproduce the positive-going voltage across the cathode resistor, R2. The positive rise in potential at the V2 cathode is coupled by the crystal, Y1, to the cathode of V1. The polarity of the voltage fed back to V1 is in the same direction as the voltage which initiated the feedback.

Another main advantage, and by far the most important in the selection of this type of oscillator for the TED transmitter, is that of frequency stability at the high frequencies for which the circuit is employed. The stability is maintained over a wide range of crystal frequencies.

The stage corresponding to V1 in the schematic diagram of figure 2-4 is V113, which is connected as a grounded-grid amplifier. R168 (68 ohms) is a parasitic suppressor, and the grid is essentially at ground potential.

## DOUBLER

V2 of figure 2-5 corresponds to V114 (fig. 2-4), having its cathode potential (developed across R173) applied to the selected crystal, Y101, Y102, Y103, or Y104. The V114 plate tank, comprising C145B, C151, and L107, tunes in a frequency range which begins at twice the frequency of the oscillator stage, or 37.50 to 66.67 megacycles. The V114 plate impedance at the oscillator frequency is low, and therefore, develops a relatively small amount of the fundamental oscillator frequency. The V114 plate tank impedance is high at twice the oscillator frequency, so that a large output signal is produced in the frequency range from 37.50 to 66.67 megacycles.

C145A tunes the oscillator to the crystal frequency. This capacitor section is ganged with the other sections of C145. C144 is the trimmer capacitor, and with L105 is varied to make the final tuning adjustments for proper tracking of the ganged circuits. The oscillator-doubler output is coupled by C150 to an amplifier stage, V115.

A meter (shown later) may be connected by a meter switch into the various circuits of the transmitter as an indicator for tuning purposes. The meter and meter circuits will be discussed later in this chapter.

## AMPLIFIER

V115 operates as a class C grounded-grid amplifier to provide sufficient drive for the second doubler stage, V116 which follows (see fig. 2-6). The V115 input signal is coupled to the cathode. L109 presents a high impedance in the signal input path which is necessary for developing the signal voltage, and prevents the shunting effect which would otherwise be presented by C153. R176 and C153 form a safety bias network in the V115 cathode circuit to protect the amplifier tube against excessive plate currents in case the grid drive should cease.

The plate tank of V115 is coupled to the V115 plate through C155, and tunes in the same frequency range as the doubler (37.50 to 66.67 megacycles). The shunt-fed arrangement of the plate tank isolates the tank from the B supply and permits one plate of the tuning capacitor, C145C, to be grounded. This minimizes the danger of electrical shock, the detuning effects of hand-capacitance during tuning procedures, and the construction problems associated with keeping the capacitor above d-c ground.

Alignment adjustments are made with L110 and C157 (both of which are variable) to ensure proper tracking of the ganged stages. The output at the V115 plate is coupled by C156 to the grid of the second doubler stage, V116 (fig. 2-6).

## SECOND DOUBLER

The second doubler stage, V116 (fig. 2-6), uses a 4X150A tetrode amplifying tube. Plate voltage for V116 is applied through the plate load inductor, L111. The plate r-f output is decoupled from the B+ supply by C159.

R178, R179, and R180 form a voltage divider network from the keyed +300 volt line to ground when the carrier-control relay, K102 (contact C closed) is energized. The screen voltage for V116 is tapped from the junction of R179 and R180. The screen is bypassed to ground by C160.

The carrier-control relay, K102, is energized only after the key or microphone switch has been closed to energize the keying circuits as will be shown later. In addition to supplying the V116 screen voltage, K102 (when energized) causes the application of the B+ voltage to various circuits of the transmitter as required to turn on the r-f carrier.

A -42 volts protective bias, obtained from the power supply, is applied to the V116 control grid (fig. 2-6,A). Grid leak bias is developed across C156 and R177 as a result of the grid driving signal derived from the V115 amplifier (fig. 2-4). The -42 volts from the bias supply protects the 4X150A tube from excessive plate current (fig. 2-6) in case the grid driving signal is lost.

The plate tank circuit of the second doubler, V116, consisting of L113, L122, C162, and C145D is shunt-fed through C161. This tank tunes over the range from 75.00 to 133.33 megacycles which is double the frequency of the input. The output of the tank circuit is link-coupled by L114 and L115 to the grid tank of the power amplifier.

L114 is a single winding, single layer, air core, unshielded coil, having 2 turns of silver plated copper wire with a diameter of .060 inch. L115 is of similar construction, having only a single turn. These coils are connected by a 6 1/2 inch length of RG-58/U coaxial cable.

Alignment adjustments are made with L112 and C162. C145D is a section of the main tuning capacitor.

## TRIPLER-POWER AMPLIFIER

The tripler-power amplifier comprises two 4X150A tubes, V117 and V118 (fig. 2-6,A) connected in a plate-and-screen modulated push-pull circuit arrangement. The stage functions as a tripler and power amplifier.

The +525 volt plate potential for V117 and V118 is applied through the center-tap of the PA plate tank, through L118, and through the plate winding (terminals 4 and 5) of the modulation transformer, T103 (fig. 2-9). Screen voltage (+190 volts) is applied through the screen modulation winding (terminals 8 and 9) of T103. The application of the screen voltage is controlled by the carrier-control relay, K102C. (See fig. 2-13.) This action is described later.

Fixed bias from the -42 volt supply (fig. 2-15) is applied through R182 and R181 (fig. 2-6,A) to the power amplifier grids. C181 and C176 filter the bias voltage.

The grid (input) tank to V117 and V118 is made up of L116, L117, C178A, and C179. The size of these components has the greatest effect in determining the resonant frequency of the grid tank. However, the inductance of the leads in the tube and in the external circuit, along with the wiring and tube capacitances are also effective in determining the tank frequency. C178A, the main grid tuning component, is a split-stator capacitor which is ganged with the four sections of C145, located respectively in the plate circuits of the oscillator, V113, first doubler, V114, amplifier, V115, and second doubler, V116. C179, also a split-stator capacitor, is used to make alignment adjustments.

The V117 and V118 plate tank circuit is composed of two shorted parallel transmission lines acting as inductances and two ganged parallel split-stator capacitors. These components comprise the complete plate tank assembly, designated Z102. Figure 2-6B shows a physical arrangement of the parallel tank inductors. A movable shorting bar across the right half of the assembly can be adjusted to assure the tuning of the tank to the proper frequency. The tank assembly is tuned to the third harmonic of the input signal from the second doubler, V116 (75.00 to 133.33 mc). Thus, the Z102 output tank covers the range of frequencies between 225 and 400 megacycles.

A frequent occurrence in high gain stages is the buildup of undesired oscillations caused by feedback through the interelectrode capacitance of the tube. The action is more common in triodes, since the interelectrode capacitance of a triode is considerably higher than that of tetrodes or pentodes.

The more conventional method of preventing these undesired oscillations is to construct a feedback circuit from the plate of the amplifying tube to the control grid (plate neutralizations), thus supplying a feedback signal which is 180° out-of-phase with the grid signal. This action degenerates oscillations at the frequency of the feedback, and prevents the amplifier stage from acting as an oscillator.

Another method of eliminating undesired oscillations is to place the screen grid of the tube at r-f ground potential so that any r-f signal voltages which may tend to feed back through the tube capacitance will find an easy path through the low screen-to-ground reactance. The feedback signals are shunted around the tube, and the amplification of the oscillations through the tube are eliminated. This method of preventing undesired oscillations is employed in the second doubler and power amplifier stages.

The screen grid of the doubler stage, V116, and power amplifier, V117 and V118, comprise built-in screen capacitors, corresponding to C160 and C183 (fig. 2-6, A), respectively. The screen has two connections (fig. 2-7, A), a pin at the bottom of the tube, and a concentric metal ring. The ring is used as a connection for the screen bypass capacitor. The bypass capacitor uses the chassis as one plate (fig. 2-7, B). In the power amplifier stage, strips of Teflon, an insulating material, are placed on the chassis. The screen grid connection is made through a metal plate mounted on the Teflon strips. The inner circumference of this plate is ringed with spring contacts which fit against the screen ring of the tube. Above the screen connecting plate are additional Teflon strips topped by another metal plate which makes up another section of the capacitor. The top plate is grounded to the chassis by spring contacts and the mounting screws which hold the assembly together.

The make up of the screen bypass capacitor (C160) for the second doubler, V116 (fig. 2-7, C) is the same as that just discussed, except that mica is used as the dielectric material instead of Teflon. By grounding the second doubler, V116, and power amplifier, V117 and V118, in this manner, the additional lead inductance of a normal capacitor is eliminated.

## OUTPUT FILTER

The V117 and V118 output is coupled by L119 to an output filter network. The purpose of the output filter is to prevent undesired frequencies, which may be developed in the frequency multiplier stages, from reaching the antenna and being radiated. The filter tunes over the entire range of the transmitter (225 to 400 mc) by two split-stator capacitors, C178B and C178C. C178B is ganged with the other sections of this capacitor (and with the sections of C145) to tune the filter. C178C is a trimmer capacitor for the filter network.

Power input to the filter network is accomplished by L119, a rectangular loop, which is inductively coupled to the power amplifier tank assembly, Z102. L120 is the tank inductance for the output filter.

The output of the radio frequency chassis, during transmission, is coupled through J109 and P104 to the antenna relay, K104 (shown energized), and thence to the antenna. During reception, K104 is deenergized, and the relay contacts connect the antenna to the receiver input.

## FIRST AUDIO AND AVC CIRCUITS

The input to the audio circuits of the transmitter may be voice signals from a microphone, or mcw signals originating from an mcw oscillator. The audio signals are coupled across the input transformer, T101 (fig. 2-8), and developed across R103 and R101. R101 serves as the speech amplifier gain control since the wiper arm position directly determines the amount of input voltage coupled to the V101 grid.

Mcw signals may be fed from the mcw oscillator, V109A (fig. 2-10) to the third audio amplifier, V104B. This action is treated later.

When the AVC switch, S102 (fig. 2-8) is in the OFF position (opposite to that shown), the V101 grid is returned to ground through R101, and the stage functions as a conventional voltage amplifier. The V101 plate output is coupled through C105 to the AVC amplifier, V102A. The

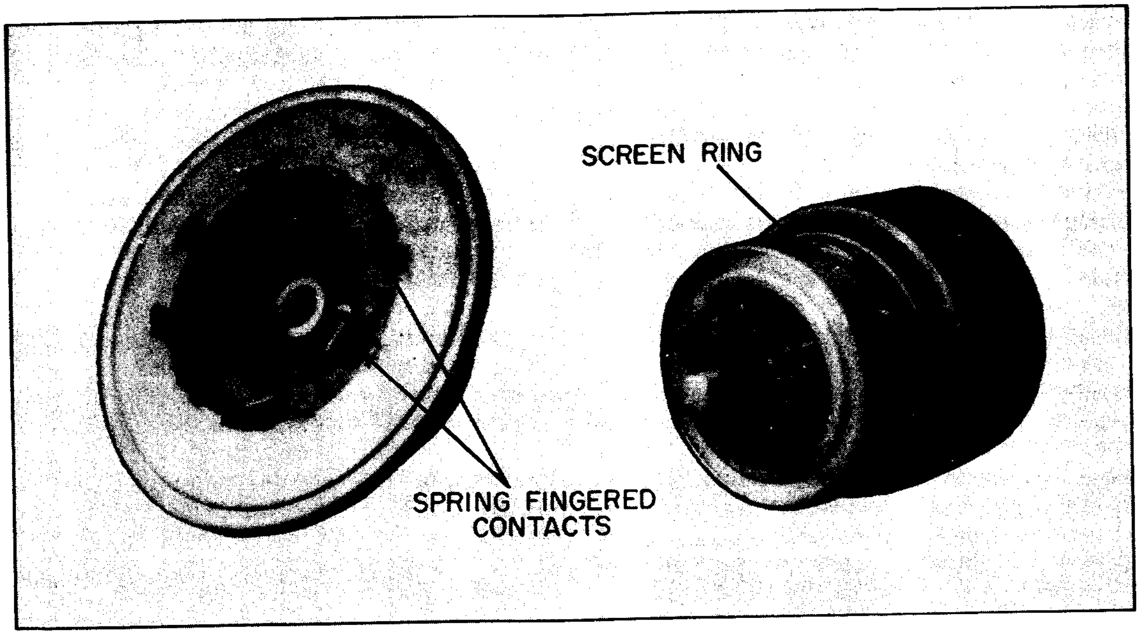


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Figure 2-7A.—4X150A Tube and Socket.

V101 output is also coupled by C106 to the second audio amplifier, V104A (fig. 2-9), if the clipper-filter switch, S103, is in the OFF position (opposite to that shown).

AVC is provided primarily to maintain a signal of relatively constant amplitude at the input to the clipper stage for efficient clipping, regardless of the variation in the speech amplitude. This action increases the average modulation level.

Because of the action of the AVC circuit to control the amplitude of the clipper input the AVC circuit is most likely to be utilized when the clipper circuit is also in use. When the AVC switch, S102 (fig. 2-8), is in the ON position (as shown), the control grid of V101 is returned to ground through R101 in series with R102.

The AVC circuit uses a conventional resistance-coupled AVC amplifier, V102A, whose grid is tied through R108 to a fixed bias of -10 volts. Output signals developed across R109 are coupled by C108 to the clipper stage, V103, and by C107 to the cathode of the AVC rectifier, V102B.

The AVC rectifier (V102B) plate is grounded, and the cathode is held positive (approximately 10 volts) to ground by a potential at the R110-R111 junction. These resistors (R110 and R111) form a voltage divider from the +300 volt supply to ground. Because of the -10 volt bias established between the grid and cathode of V102B, neither plate nor grid current flows when no signal is present.

When the negative-going output signals from V102A are applied through C107 and developed across R112 and R110, the cathode voltage on V102B is sufficiently reduced to allow grid current to flow in V102B. Consequently, an AVC voltage appears across R107 and R102 with the output and negative to ground. That portion of the voltage appearing at the R102-R107 junction is applied between the control grid and cathode of the first audio amplifier (V101) as a controlling bias voltage and therefore determines the signal gain in V101. R107 and R102, in conjunction with C104A and C104B, form a filter network having a time-constant long enough to eliminate the audio-frequency variation from the AVC voltage.

## CLIPPER

The cathodes of both sections of the duodiode clipper stage, V103, are connected together and tied through R114 to a -10 volt source. The B section plate of V103 is returned to ground through R115 (if S103A is in the ON position), while the A section plate is grounded through clipper-symmetry control, R113. Both diode sections, therefore, draw plate current through the common cathode resistor, R114.

The output signal voltage of the AVC amplifier, V102A, is applied through C108 to the

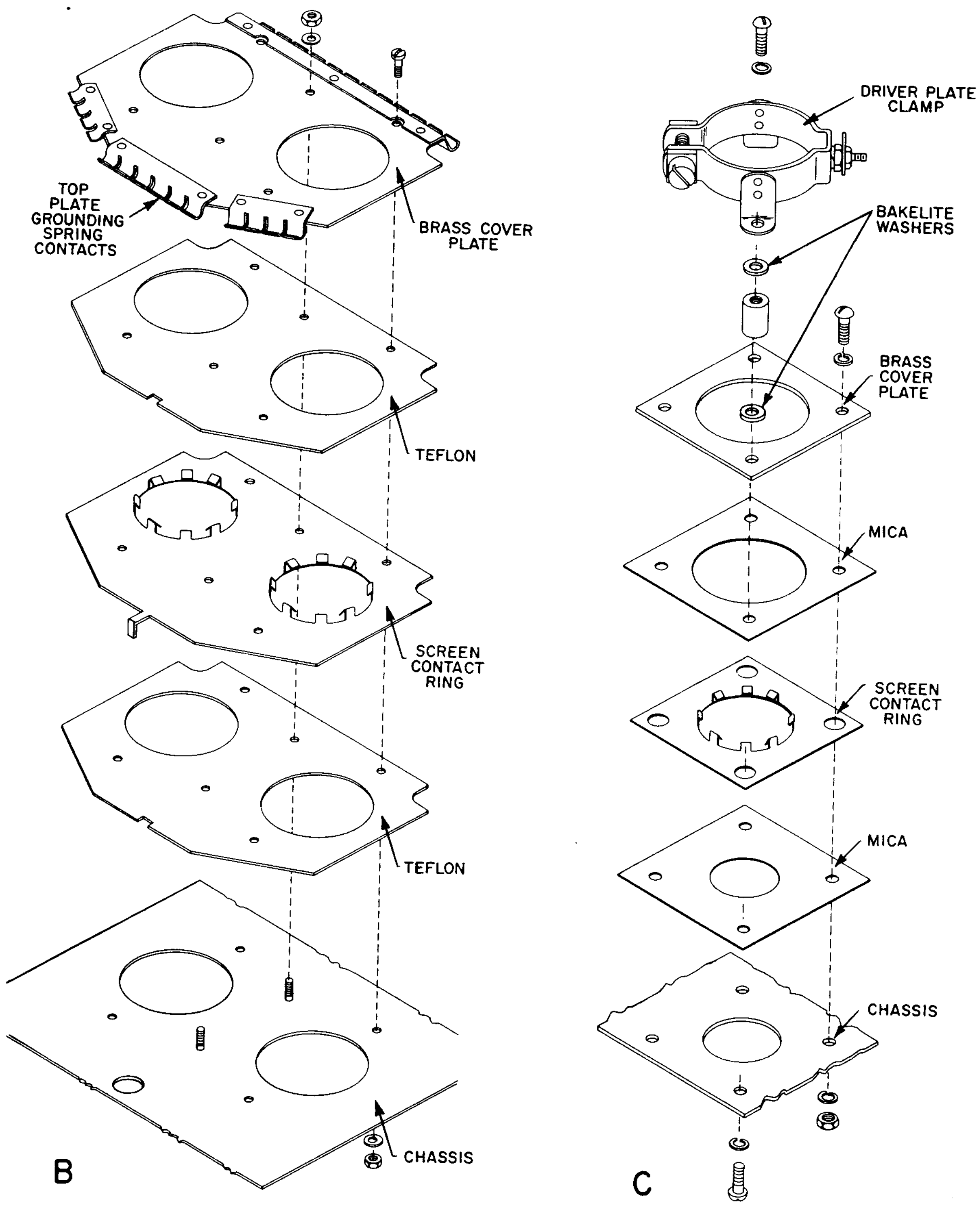


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Figure 2-7B.—Power Amplifier Screen Bypass Capacitor.
C.—Second Doubler Screen Bypass Capacitor.

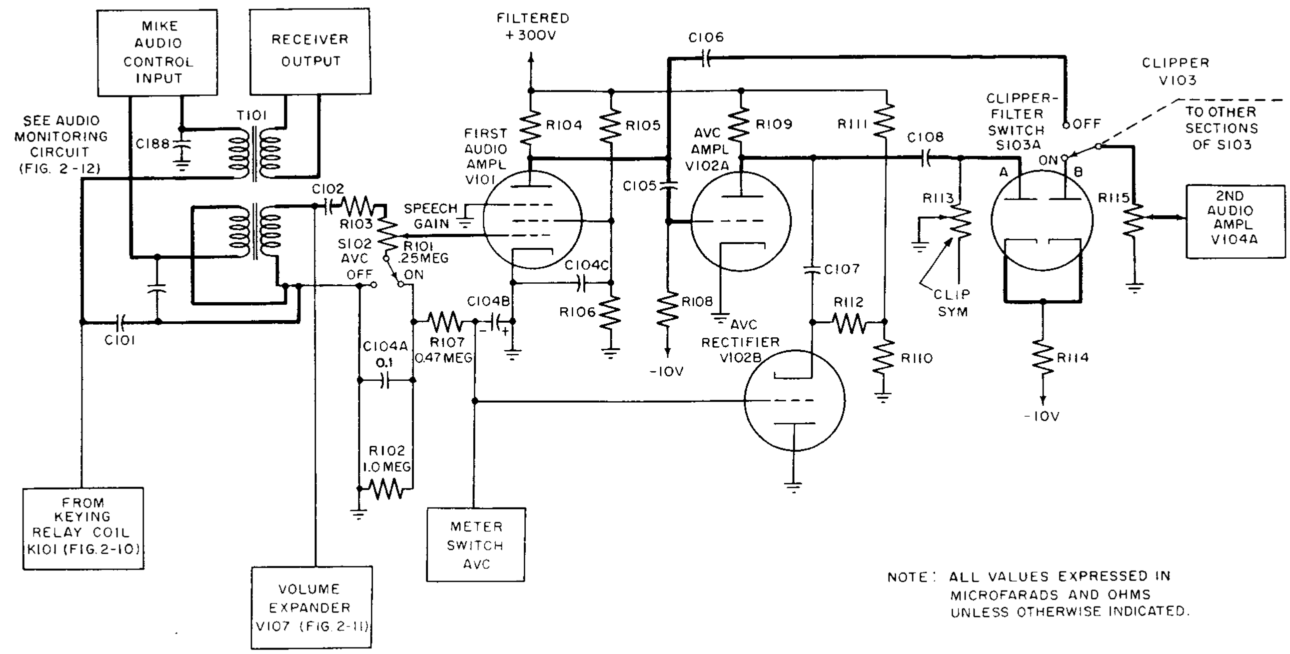


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Figure 2-8.—First Audio Amplifier, AVC, and Clipper Circuits.

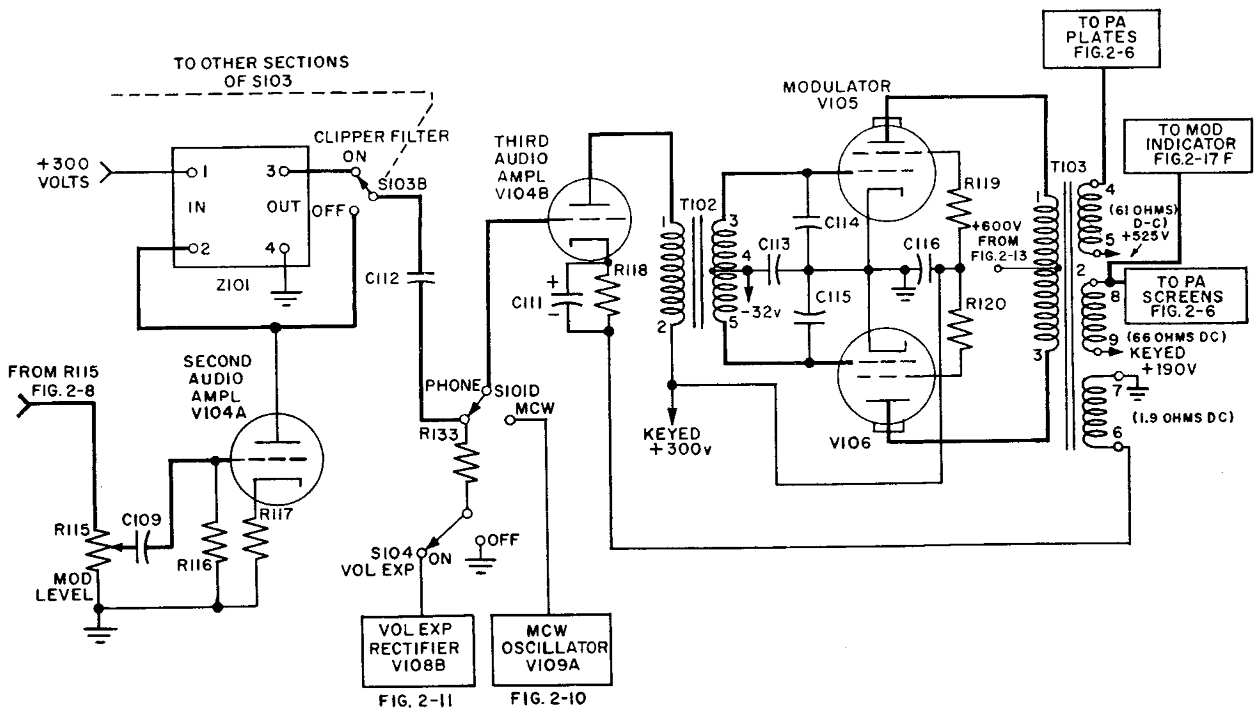


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Figure 2-9.—Second and Third Audio Amplifiers and Modulator Stages.

V103A plate. During the negative swing of the input signal, a voltage is developed across R113 which decreases the voltage at the V103A plate with respect to the cathode. The resulting drop in the V103A diode current lowers the voltage across R114 and moves the cathodes of V103A and V103B more negative. Therefore, the conduction of the V103B diode increases, causing an increased negative-going output signal voltage to be developed across R115. This voltage is applied to the grid of the second audio amplifier as will be seen later.

When the negative-going input to V103A reaches approximately -3.3 volts, the plate of V103A is sufficiently negative with respect to the cathode to cut off this tube section. Any further negative increase in the signal amplitude has no effect on V103A, since it remains cut off. Thus, the voltage at the cathodes of the diodes, the current through V103B, and the voltage across R115, will each remain constant beyond the point of cut-off of V103A. This action clips that portion of the input signal which exceeds the negative 3.3 volt level.

On the positive swing of the input signal, the increased conduction through V103A increases the voltage across R114 and makes the cathodes of both the diode sections less negative. This action causes the current flow through V103B to drop. The negative voltage to ground from the R115 wiper is decreased, and the signal to the second audio amplifier, V104A, moves in the positive direction.

When the input to V103A becomes sufficiently positive, the current flowing through R114 (caused by the conduction of V103A) causes the voltage at the cathode of V103B to go positive with respect to ground, thereby cutting off the B section of the clipper stage. Any further positive increase in signal amplitude cannot be transmitted to the second audio amplifier, clipping the positive peaks of the input signals.

Clipper-symmetry control, R113, in conjunction with R114, form the diode load for V103A. The setting of R113 determines the voltage which will appear across R114 for a given V103A input signal amplitude. The R114 voltage, in turn, acts to cut off the clipper diodes, producing the clipping action just described. The optimum setting of R113 is that which results in symmetrical clipping of the positive and negative signal peaks.

The action of the clipper stage, V103, and the AVC stages, comprising V102A and B, assures high average sideband power and constant modulation level over a wide range of input signal amplitudes. The action of these circuits also increases the intelligibility of speech when receiving signals of low signal-to-noise ratios.

## SECOND AUDIO AMPLIFIER

As previously stated, the input to the second audio amplifier, V104A (fig. 2-8), may be obtained from either of two sources. When the clipper-filter switch, S103A, is in the ON position, the second audio input is obtained from the clipper stage, V103. With S103A in the OFF position, the V104A input is obtained, via C106, from the first audio amplifier, V101. In either case, the input signal voltage is developed across modulation level control, R115.

The second audio amplifier, V104A (fig. 2-9), functions as a conventional Class A voltage amplifier. Cathode bias is provided by R117, which is unbypassed to introduce a small amount of degenerative feedback.

When the peaks of the audio signals are being clipped by V103 (fig. 2-8), the resulting square-topped waveforms contain harmonics of the fundamental audio frequency. To minimize high-frequency distortion and prevent modulation of the r-f carrier by these frequencies, a filter, Z101 (fig. 2-9), is contained in the plate circuit of the second audio amplifier, V104A.

Filter, Z101, is a bandpass network whose cut-off frequencies are 300 and 3500 cps. Consequently, Z101 will pass frequencies within this range, but will attenuate all others.

The circuit diagram of the filter is not shown. It is sufficient to note that the impedance between terminals 2 and 1 of Z101 serves as the plate load impedance of V104A. When S103B is in the OFF position (opposite to that shown), the output from V104A is obtained directly from the V104A plate, with Z101 having no effect upon the signal other than functioning as the V104A plate load. When the clipper-filter switch (section S103B) is in the ON position, as shown, the audio input to the third audio amplifier, V104B, is developed between terminals 3 and 4 of Z101, and applied through C112 and S101D (in the PHONE position) to the V104B grid.

## THIRD AUDIO AMPLIFIER

The audio input to the third audio amplifier, V104B, may be obtained from either of two sources, depending upon the setting of the mcw-phone switch, S101D. When S101D is in the PHONE position, as shown, the audio input from the second audio amplifier is coupled to the V104B grid through C112 as discussed. With

S101 in the mcw position, a 1000 cps tone from the mcw oscillator, V109A (fig. 2-10), is applied to the grid of V104B.

Volume expander switch, S104 (fig. 2-9), may be either on or off during "phone" operation. When S104 is in the OFF position, the grid of V104B is returned to ground through R133, and V104B operates as a conventional Class A amplifier. Cathode bias is provided by R118 and C111. With S104 in the ON position, the grid of V104B is returned to a -42 volt biasing circuit (shown later) which cuts off V104B and permits its operation only when the volume expander circuit acts to remove the bias.

Degenerative feedback is introduced into the cathode circuit of V104B by an additional secondary winding on the modulation transformer, T103. This winding (between terminals 6 and 7 of T103) is connected from the bottom of the V104B cathode biasing circuit to ground, and introduces a negative feedback voltage into the third audio amplifier to reduce distortion generated in the modulator.

The output of the third audio amplifier, V104B, is applied via T102 to the grids of the modulator stages, V105 and V106.

## MODULATOR STAGE

The modulator stage comprising V105 and V106 is push-pull connected and operated Class AB1. A -32 volt bias is established between the control grid and cathodes of V105 and V106 from the bias supply. Since the stage operates Class AB1, no grid current flows, and very little loading of the third audio amplifier occurs via the transformer, T102. C113 serves to hold a constant bias on the tubes by keeping the center tap of the T102 secondary at a-c ground potential. C114 and C115 are connected from their respective modulator grids to ground to attenuate higher voice frequencies which may be present when the audio filter (Z101) is not used. The capacitors accomplish this action without materially affecting the lower frequencies.

Plate voltage for V105 and V106 is supplied from the +600 volt tap on the high voltage power source through the center tap of the T103 primary. Screen voltage is obtained from the keyed +300 volt supply.

Suppressor resistors R119 and R120 are connected in the modulator screen circuits to prevent the occurrence of parasitic oscillations. C116 serves as a common screen bypass capacitor.

Modulation of the plates and screen grids of the radio frequency power amplifier (fig. 2-6) is accomplished by two separate secondary windings of T103 (fig. 2-9). The d-c potentials for the PA plates and screens are applied through their respective T103 windings. The audio voltage produced in the T103 secondaries varies the d-c voltage applied to the r-f power amplifier plates and screens at an audio rate, and thereby amplitude-modulates the r-f carrier.

## MCW OSCILLATOR

A 1000 cps oscillator (fig. 2-10) is required to produce the audio tone necessary to modulate the r-f carrier during mcw operation. This oscillator comprises V109A connected in a phase shift oscillator circuit.

A network of resistors and capacitors consisting of R135 through R138 and C121 through C124 and C129 is connected between the plate and grid of the oscillator to produce the necessary 180° phase shift required to sustain oscillations. Since the gain in V109A is sufficient to overcome network losses at only one frequency (determined by the plate-grid R-C time constant), oscillations will be sustained at this frequency only. C124 is a screwdriver-adjusted variable capacitor to provide a limited amount of frequency adjustment. The required amount of cathode bias for the phase shift oscillator is provided by C120 and R134.

The mcw oscillator is keyed by operation of the keying relay, K101, which has two sets of contacts that operate simultaneously. When S101A is in the mcw position (with K101 energized), the B contacts of K101 ground the common connection of R136, R137, and R138, to make the oscillator operative. The A contacts provide the necessary ground on the carrier-control circuit as will be seen later.

Output from V109A is developed across the divider comprising R139, C125, and mcw-modulation level adjust control, R141. When S101D is in the mcw position, the A-C signal at the arm of R141 is applied through the switch contacts to the grid of the third audio amplifier, V104B (fig. 2-9).

## CARRIER-CONTROL CIRCUIT

The carrier-control circuit comprising V110 (fig. 2-10) is used to activate the carrier-control relay, K102 and the antenna change-over relay, K104. These relay solenoids are connected in

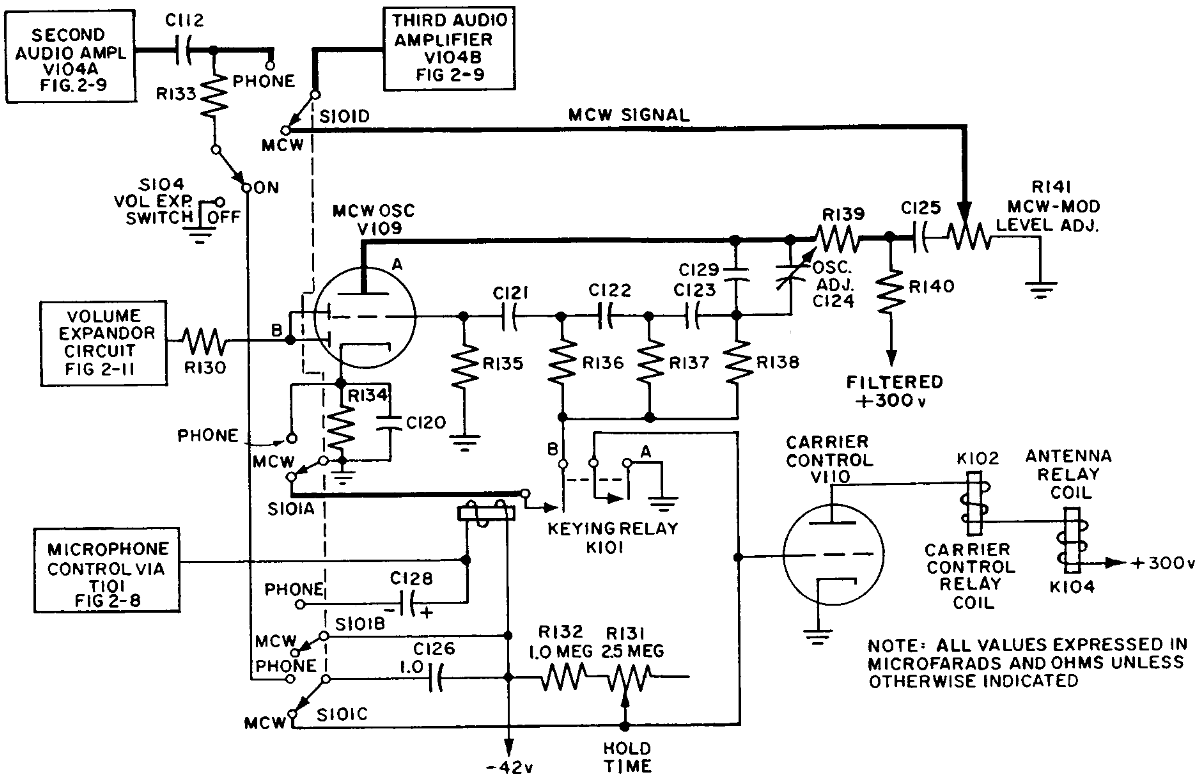



Figure 2-10.—MCW Oscillator, Carrier Control Circuit, and MCW Phone Switch Circuits.

series between the V110 plate and the +300 volt B supply, and are energized when V110 conducts.

The carrier-control relay determines the carrier-on and carrier-off condition of the transmitter r-f carrier during periods of transmission and reception. The antenna changeover relay operates simultaneously with the carrier-control relay to connect the antenna to the transmitter or receiver.

When the transmitter is not keyed (K101 deenergized as shown), a -42 volt bias is applied between the grid and cathode of V110 from the bias power supply. When the -42 volt bias is applied, V110 is held in a nonconducting condition, and K102 and K104 are therefore deenergized. No r-f carrier is generated by the r-f circuits, and the transmitter is in the standby condition. In this condition, K104 connects the antenna to the receiver being used in conjunction with the transmitter.

When the microphone or handset press-to-talk switch is operated, keying relay, K101, is energized from the -42 volt supply. The A contacts of K101 directly ground the grid of V110, and this tube conducts to energize K102 and K104. The carrier-control relay (K102) contacts apply B+ voltage to the various circuits of the transmitter (fig. 2-13), thereby rendering the transmitting circuits operative. The antenna relay, K104 (fig. 2-10), transfers the antenna (fig. 2-6) from the receiver to the transmitter. The -42 volt bias is not shorted by grounding the grid of V110, since R132 and that portion of R131 in use are always connected between ground and the -42 volt source.

When mcw-phone switch, S101, is in the mcw position, provision is made for holding the carrier "on" during the short intervals that the keying relay K101 is deenergized. (Mcw signals are transmitted by keying the audio oscillator when the carrier is on.) S101C connects C126 to the grid of V110, in parallel with the series combination of R131 and R132. When the grid of V110 is grounded by contact A of keying relay, K101, C126 charges rapidly to the -42 volt bias potential, so that it is negative toward the C126-R132 junction. When the key is opened and the ground is removed from the grid, the discharge of C126 through R131 and R132 (positive-going toward the V110 grid) opposes the negative -42 volt bias, and maintains V110 in the conducting condition until the capacitor has partially discharged through R131 and R132. The minimum time constant of the discharge path is sufficiently long to hold the carrier on the air approximately one second after the key is opened. At the end of this time, V110 is again cutoff by the bias voltage, and K102 and K104 are deenergized to return the equipment to the standby condition.

R131 is variable in order to allow the time delay (hold time) of this circuit to be adjusted. Moving the R131 arm to the right will increase the hold time, and therefore the time which can exist between elements of the mcw coded signals before the transmitter carrier is discontinued. Leftward movement of the R131 arm decreases the circuit "hold time."

The constant-carrier feature of the carrier-control circuit is not active during phone operation (S101 in the PHONE position). This feature is eliminated since during phone operation the microphone press-to-talk switch is normally kept closed until the transmission is completed, at which time the carrier is no longer needed nor desired.

## VOLUME EXPANDER

The volume expander circuit (fig. 2-11) is used to prevent modulation of the r-f carrier by background noise during voice transmission. This is accomplished by cutting off the third audio amplifier, V104B, whenever the speech input to the microphone ceases.

The volume expander multivibrator, V107, is connected as a monostable (one-shot) circuit whose input trigger pulses are derived from the microphone via audio input transformer, T101 (fig. 2-8). The grid of the B triode section of V107 (fig. 2-11), is returned to ground through

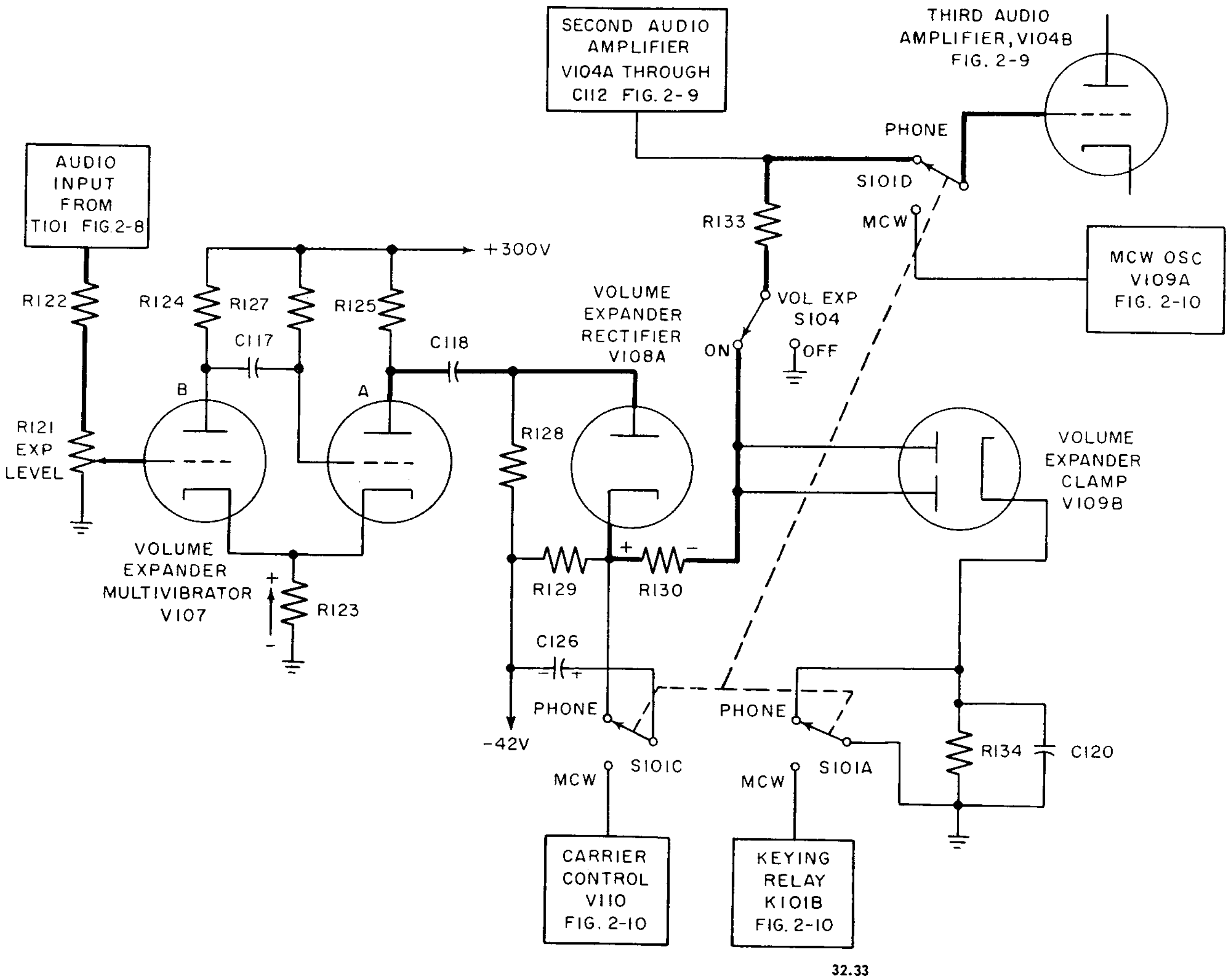



Figure 2-11.—Volume Expander Circuit.

expander level control, R121, while the grid of the A-section triode is connected to the +300 volt supply through R127.

Signals applied from the microphone (via T101) are developed across R122 and R121. R122 prevents overloading of the T101 secondary at times when the grid of V107B will draw a grid current during positive peaks of the audio input. R121 provides an adjustment for the signal voltage level which is fed to the V107B grid circuit.

The square wave output of V107A is continuous as long as an audio voltage of sufficient amplitude is present at the V107B grid to trigger this stage. The V107A output is a succession of positive square waves which are developed across the series load resistors, R125 and R126. (These resistors are shown in this diagram as a single resistor.) R121 should be adjusted so that the square wave output is obtained from V107A whenever the operator talks.

The output of V107A is coupled by C118 to diode rectifier, V108A. Since the reference level of the square waves is shifted by the action of the coupling circuit (C118 and the resistance from the V108A plate to ground) V108A is used to rectify the input square waves. Both the plate and cathode of V108A are returned to the -42 volt supply through R128 and R129, respectively.

When mcw-phone switch (section S101D) is in the PHONE position (as shown), and the volume expander switch, S104, is in the ON position, the -42 volt bias from the bias supply is applied to the grid of the third audio amplifier, V104B, through R129, R130, and R133. This value of bias voltage established between the grid and cathode of V104B is sufficient to hold this tube section cut off.

When the operator presses the press-to-talk button on the microphone and provides a voice input signal, volume expander multivibrator, V107, is triggered to produce the square wave output as discussed. Since the plate and cathode of V108A are held at the same d-c potential (-42 volts), V108A will conduct during positive portions of the square wave from V107A. The conduction path for this diode for positive inputs (C118 charging) is from the -42 volt terminal through R129, through the cathode-to-plate resistance of V108A, through C118, R125, and R126 to the +300 volt supply to ground. That portion of the voltage which appears across R129 is positive-going at the V108A cathode end of the resistor, and therefore acts to reduce the bias on V104B, so that V104B is permitted to amplify the audio input signals received through S101D from the second audio amplifier, V104A.

During speech pauses or between syllables of a word, it is desired to keep the bias on V104B above cutoff to prevent distorting the audio signals. For this reason, a long time constant circuit comprising C126 and R129 is connected in the V108A cathode bias circuit to maintain the cathode potential, and the potential at the V104B grid, slightly positive (to ground) during these periods. C126 is connected in the V108A cathode circuit by mcw-phone switch section, S101C. When V108A initially stops conducting, as a result of the termination of positive square pulses from V107A, C126 (which during the conducting period became charged positive toward the V108A cathode) can discharge through R129. This action produces a potential at the R129-R130 junction which holds the V104B grid bias along the linear portion of the eg-ip curve long enough to prevent the cutoff of V104B during normal speech pauses and between syllables of a word.

If the grid of V104B is held too positive, the tube will be operated on a nonlinear portion of the eg-ip curve, resulting in distortion of the audio signal. A clamping circuit comprising V109B is included, therefore, in the volume expander to clamp the V104B grid voltage at the desired potential.

The plates of V109B are connected through R130 to the cathode of V108A. If the potential at the V108A cathode goes positive to ground, V109B will conduct. The conduction path will be from ground (at the V109B cathode) through the shorted contacts of S101A (in the position shown) through the cathode-plate resistance of V109B, through R130, through the conducting resistance of V108A, through C118, R125, and R126, and through the +300 volt B supply to ground, thereby completing the circuit. The voltage thus produced across R130 will be negative toward the V104B grid, keeping the grid practically at ground potential as long as V109B conducts, regardless of the magnitude of the positive voltage at the V108A cathode.

R134 and C120 (in the cathode circuit of V109) are shorted during phone operation by mcw-phone switch section S101A. These components function as part of the mcw oscillator circuit (fig. 2-10) when S101 is set to the MCW position as discussed. Similarly, C126 serves as a part of the volume expander or carrier control circuit depending upon the setting of S101C.

## AUDIO MONITORING CIRCUIT

The audio monitoring circuit (fig. 2-12) enables the operator to listen to the output of the receiver when the transmitter carrier is off, and to the speech sidetone when the carrier is on. Monitoring may be accomplished either locally or remotely.

Receiver audio is brought into the monitoring unit via terminals 13 and 14 of E102. When the carrier is off, the carrier control relay, K102, is deenergized, and its contacts are closed (in the position shown). Thus, the receiver output passes through the K102A contacts to be developed across the earphone level control, R161, and the 5-6 winding of the input transformer, T101. The receiver audio may be monitored locally by plugging phones into the earphone jack, J105, which is situated on the transmitter front panel.

For remote monitoring when Transmitter Control, Navy 23555 (not shown) is used, the receiver audio is induced into the 4-3 winding of T101. The receiver signal is then applied to the remote station via the control circuit which connects to terminals 5 and 10 of G101.

When Remote Radiophone Unit, Navy 23500 is used for remote operation, connections are made directly between that unit and terminals 13 and 14 of E102, in addition to those from the receiver. Thus, the receiver audio output is applied directly to the remote unit.

Microphone or telegraph key jack, J104, is provided to key the transmitter locally from the audio monitoring unit. Completing the circuit across the J104 contacts by closing the key

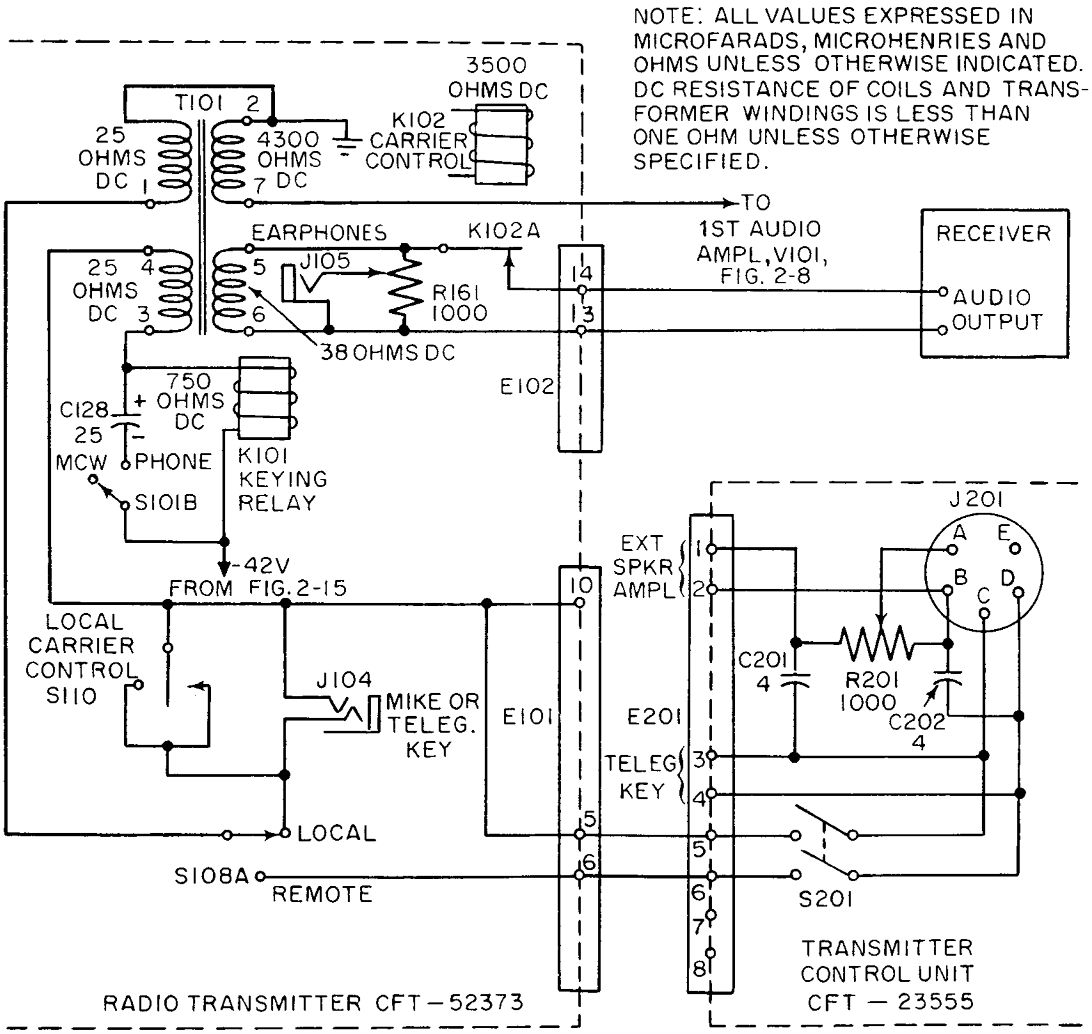



Figure 2-12.—Audio Monitoring Circuit. 32.34

connects the keying relay, K101, from the -42 volt supply through the K101 solenoid, through the 3-4 winding of T101, through the closed key or microphone press-to-talk switch contacts, through S108A in the LOCAL position (position shown), and through the 1-2 winding of T101 to ground. The circuit is completed from ground through the -42 volt supply bridge rectifier, CR102 (fig. 2-15), and the 12-13 winding of T104.

It should be recalled that closing the K101A contact (fig. 2-10) causes the carrier control relay, K102, and antenna change-over relay, K104, to become energized, placing the r-f carrier on-the-air. At the same time the closing of the B contacts of K101 provides the ground on the grid components of the mcw oscillator, V109A (during mcw operation), to energize this circuit. (During phone operation, the audio voltage is introduced via T101 of figure 2-8 to the first audio amplifier, V101 grid.) Thus, the carrier and audio circuits are energized.

When keying the transmitter from a remote location, closing the remote key or microphone press-to-talk button completes the circuit comprising the 4-3 winding of T101 and the K101 solenoid. The energizing of K101 permits carrier control relay, K102, to become energized (as discussed) and the A contacts of K102 are opened. Thus, the path to the receiver is opened, while any microphone input will be induced into the 2-7 winding of T101 and applied at the first audio amplifier, V101, input (fig. 2-8).

The sidetone signal which is induced into the 5-6 winding of T101 (fig. 2-12) during transmission, is developed across R161, and may be obtained locally by plugging the headphones into the headphone jack, J105. If operation of the equipment is accomplished remotely from Transmitter Control, Navy 23555, the microphone sidetone is obtained directly from the remote control unit. When employing Remote Radiophone Unit, Navy 23500 or equivalent, sidetone is obtained from the receiver.

## POWER SUPPLIES

Three power supplies (the high voltage, low voltage, and bias supplies) provide operating voltage for the TED series equipment.

### HIGH VOLTAGE RECTIFIER

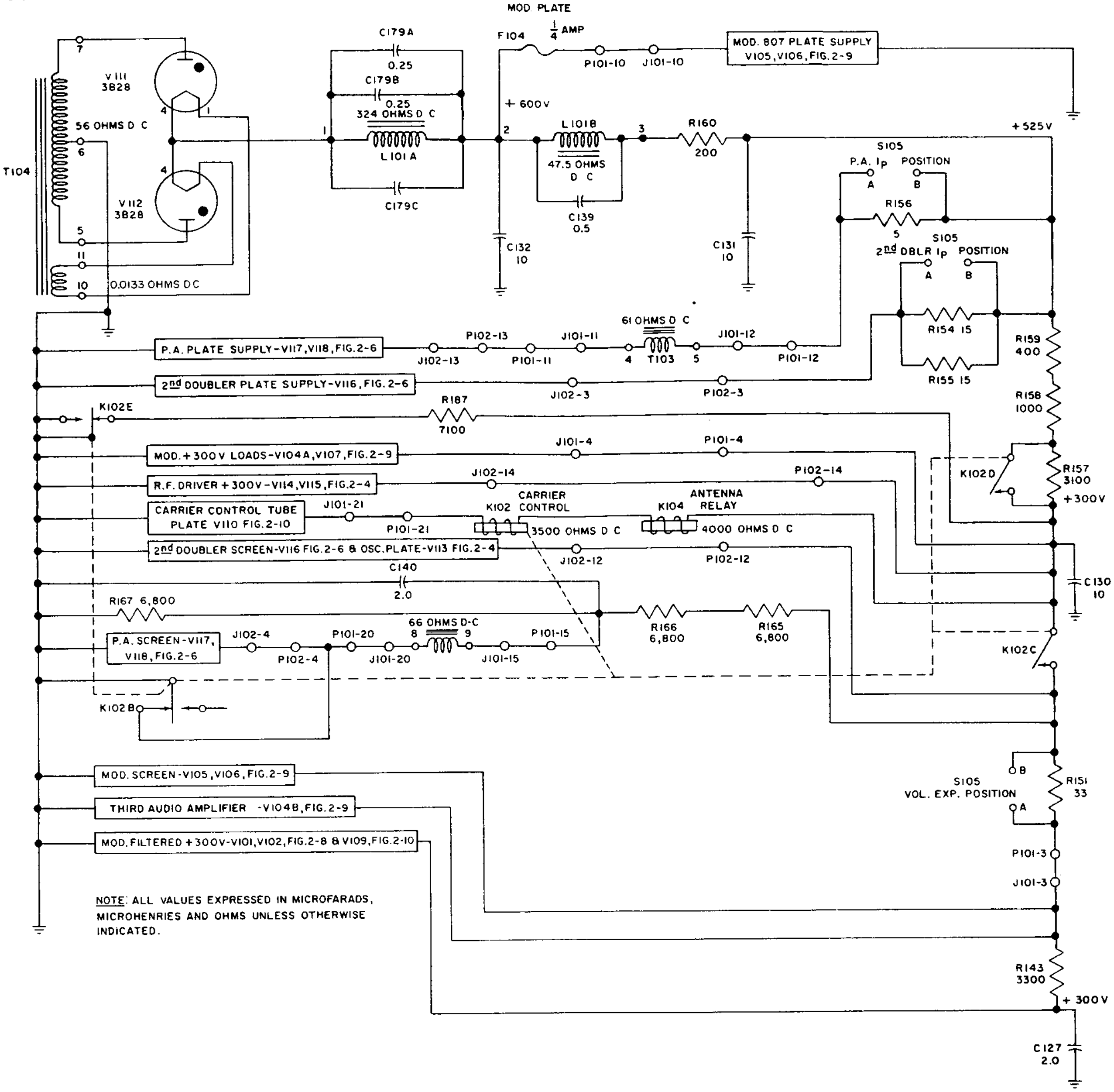
The high voltage rectifier (fig. 2-13) uses two 3B28 gas-filled tubes, (V111 and V112) arranged in a full-wave rectifier circuit, to supply all of the stages of the Radio Transmitter with plate and screen power. A 720 volts a-c potential is induced in each half of the power transformer, T104 secondary, from the primary circuit (not shown). The filter is a two-section double inverted "L" whose output at the termination of the second section is +525 volts d-c at 370 milliamperes. The output at the junction of the two "L" sections is +600 volts d-c at 130 milliamperes.

The plate voltage for the modulator tubes, V105 and V106 (fig. 2-9), is obtained from the +600 volt tap on the power supply filter (fig. 2-13). This potential is applied through a 1/4 amp fuse, F104, to the center-tap (terminal 2) of the modulation transformer, T103 (fig. 2-9).

The +525 volt output at the R160-C131 junction (fig. 2-13) is applied through meter shunts to the second doubler and PA plates, respectively (fig. 2-6). This output is also constantly applied through series dropping resistors R157, R158, and R159 (fig. 2-13), to (1) all of the unkeyed +300 volt tube loads in the radio modulator and radio frequency chassis; (2) to the R187 load, which is shunted across the power supply by contacts E of K102; and (3) to contact C of K102. This potential is also filtered by C130.

Those stages requiring a keyed +300 volts do not have power applied until the carrier is turned on by the action of the carrier-control relay, K102 (fig. 2-10). When K102 is energized, contact C of K102 (fig. 2-13) completes the path for the keyed +300 volts to the second doubler, V116, screen and oscillator (V113) plate, and for the PA and modulator screens, and to the first audio and AVC amplifiers. The closing of the C contacts of K102 also completes the circuit to the third audio amplifier, V104B, and to the mcw oscillator, V109. The additional load as a result of the added stages is prevented from increasing the voltage drop across the series resistors, R157, R158, R159, and R160, by the action of the K102D contacts which close to short R157, and the K102E contacts which open to remove the R187 load from the power source. The action of the K102D contacts is to decrease the series voltage drop by decreasing the series resistance, while the action of the K102E contacts is to reduce the total power supply current through the series resistance, (R187), thereby keeping the output voltage at a constant +300 volts.

The inductive reactance of L101A (in the power supply filter) and the capacitive reactance of C179A, B, and C, are selected to form a parallel resonant circuit at the power supply ripple




32.35

Figure 2-13.—High Voltage Rectifier and D-C Distribution Circuits.

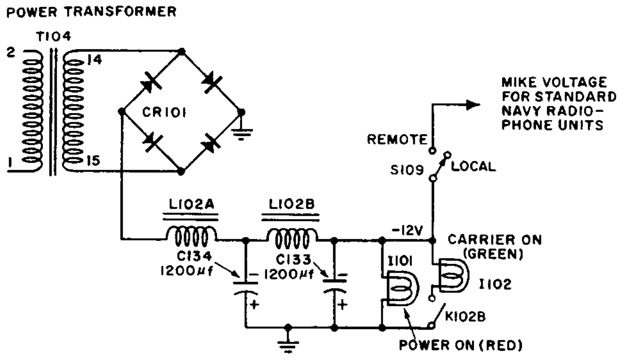
frequency. This increases the impedance at the ripple frequency to provide better filtering. Similarly, C139 is connected across L101B to improve the filtering of the second filter section.

## LOW VOLTAGE RECTIFIER

The -12 volt output of the full-wave bridge rectifier, CR101 (fig. 2-14), is used to supply the remote microphone power when Remote Radiophone Unit, Navy 23500, or equivalent, is used. This supply also provides the power for the local indicator lamps, I101 and I102, which are the "power-on" and "carrier-on" lamps. When the remote radiophone unit is not used, the low voltage rectifier supplies the indicator lamps only.

## BIAS RECTIFIER

The bias rectifier, CR102 (fig. 2-15), is connected as a full wave rectifier bridge circuit.




32.36
Figure 2-14.—Low Voltage Rectifier.

This power source provides a -42 volt output to the voltage divider comprising R147, R148, R149, and R150. The various outputs supply the keying relay, K101, the microphone (for local or remote operation when using Transmitter Control, Navy 23555) and the bias potential for all of the fixed bias stages discussed in this chapter. Safety bias for the second doubler and PA stages is also obtained from this rectifier.

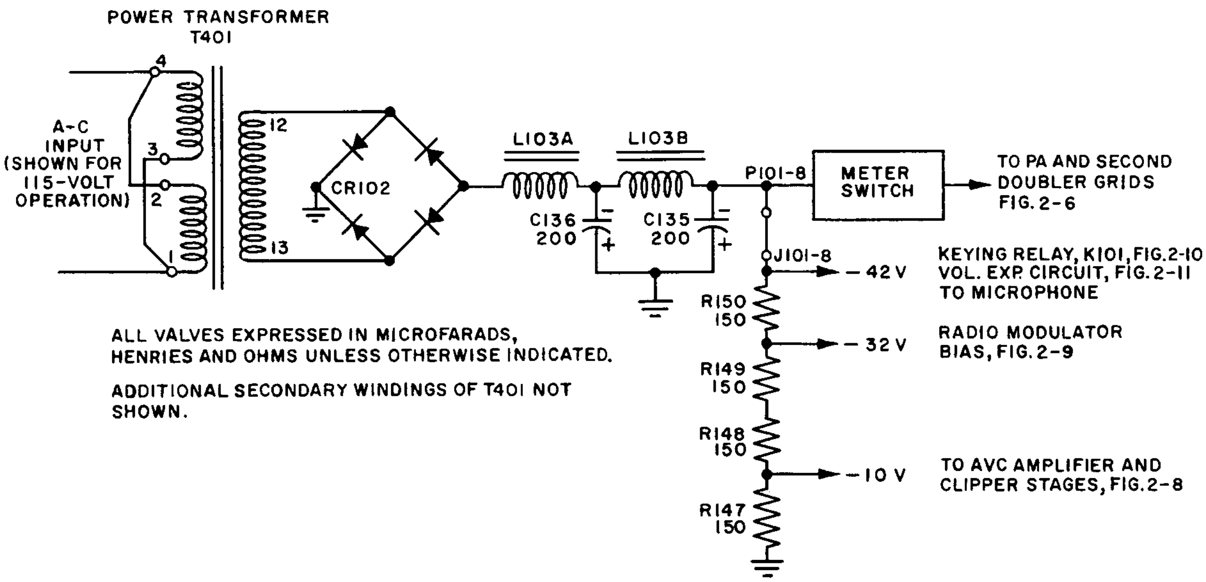
## METERING CIRCUIT

A 0-200 microampere meter situated on the transmitter front panel (fig. 2-16) is provided to assist personnel in tuning and performing maintenance on the transmitter. A meter switch, S105, enables the operator to place the meter (M101) in any one of nine meter positions. These positions are as follows:

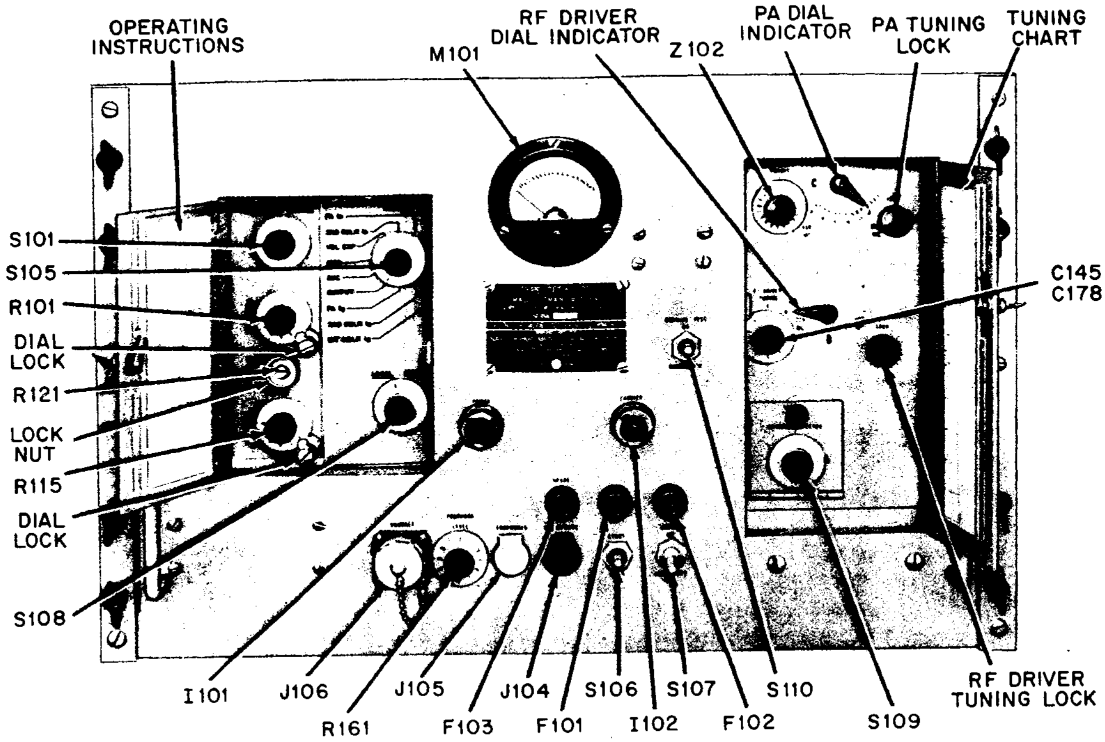
| Position | Indication |
|---|---|
| 1 | 1st Doubler Ig |
| 2 | 2nd Doubler Ig |
| 3 | PA Ig |
| 4 | Output |
| 5 | AVC |
| 6 | Mod (level) |
| 7 | Vol. Exp. |
| 8 | 2nd Doubler Ip |
| 9 | PA Ip |

Through proper switching of the meter, all currents and voltages necessary for tuning and aligning the equipment may be measured.

A simplified schematic diagram of each circuit selected by the meter switch, showing only those components which directly affect the meter current, is shown in figure 2-17. Refer to the appropriate illustration used in the discussion of the particular circuit if a more complete circuit diagram is desired. A brief description of each of the circuits is given below.




32.37
Figure 2-15.—Bias Rectifier.




LEGEND

C145 AND C178–RF DRIVER TUNING CONTROL B
F101 AND F102–LINE FUSES
F103 ——— SPARE FUSE
I101 ——— POWER ON INDICATOR LIGHT WITH DIMMER CONTROL
I102 ——— CARRIER ON INDICATOR LIGHT WITH DIMMER CONTROL
J104 ——— MICROPHONE JACK
J105 ——— EARPHONES JACK
J106 ——— HANDSET JACK
M101 ——— METER
R101 ——— SPEECH AMPLIFIER GAIN CONTROL
R115–SPEECH MODULATION LEVEL CONTROL
R121–EXPANSION LEVEL
R161–EARPHONE LEVEL
S101–MCW-PHONE SWITCH
S105–METER SWITCH
S106–START-STOP SWITCH
S107–POWER ON-EMERGENCY OFF SWITCH
S108–LOCAL-REMOTE SWITCH
S109–CRYSTAL SELECTOR SWITCH A
S110–CARRIER TEST SWITCH
Z102–PA TUNING CONTROL C

32.38

Figure 2-16.—Radio Transmitter (Model TED) Showing Operating Controls.

1. 1st Doubler, Ig Position. With S105 set to this position (fig. 2-17A) the meter, M101, and its series current limiting resistance, R164, is connected across the meter shunt, R172, and meter bypass capacitor, C147. The parallel grouping of these components is connected in series with grid leak resistance, R171, so that the 1st doubler grid current passes through the shunt (R172) and the meter movement. The value of the shunt is selected so that the meter needle deflects full-scale when 200 microamperes of current is passed through the meter movement.

Since the doubler receives the driving signal from the oscillator (fig. 2-4), it follows that the doubler grid current will be maximum when the oscillator driving signal fed to the doubler stage is also maximum. Thus, the oscillator is tuned for maximum meter deflection when S105 is in this position.

2. 2nd Doubler, Ig. Figure 2-17B shows the circuit connections when S105 is in the 2nd DOUBLER, Ig position. The -42 volts applied to the 2nd doubler grid (fig. 2-6) does not prevent grid current since the grid driving signal from amplifier, V115 (fig. 2-4) is of sufficient

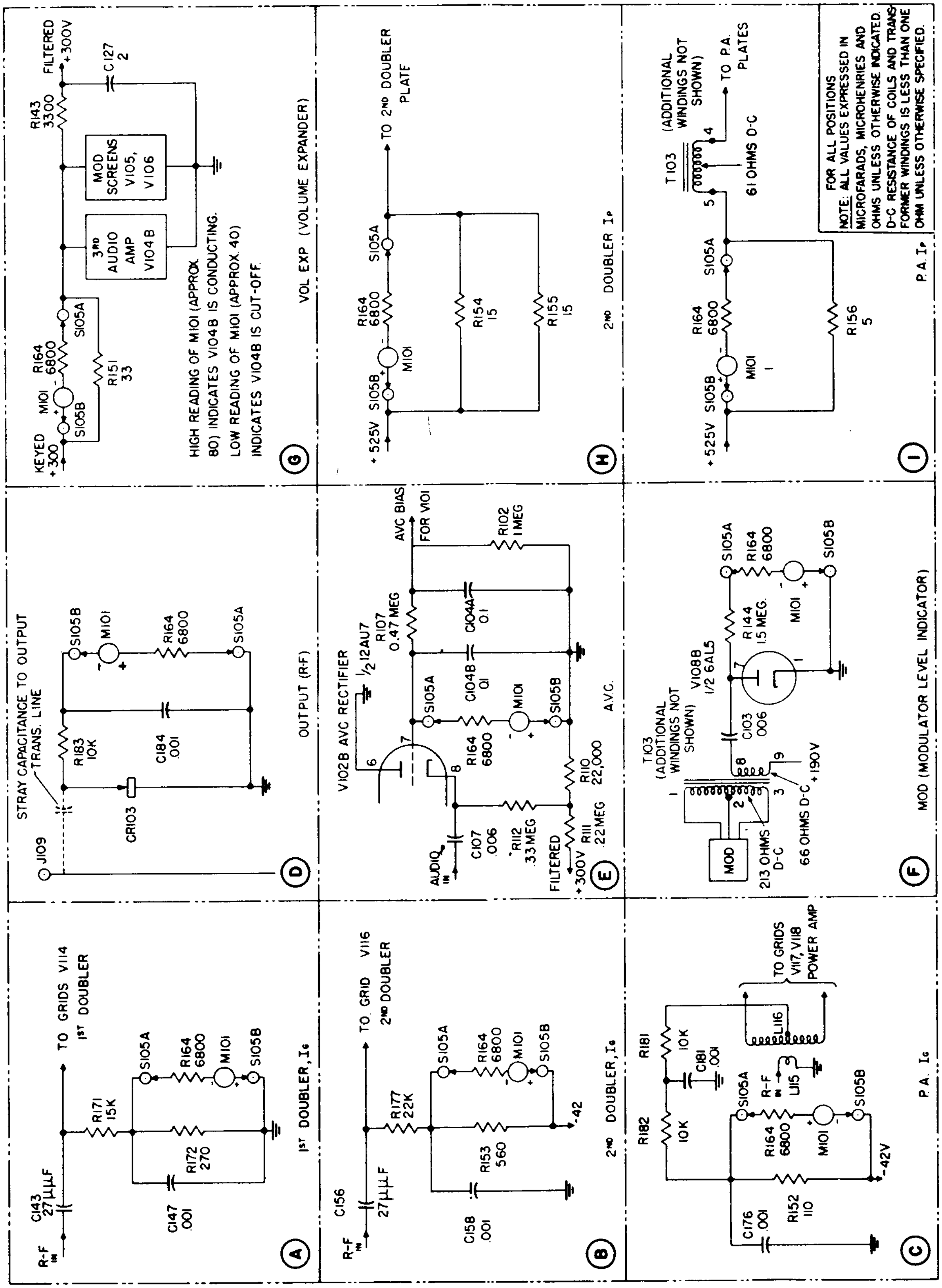



Figure 2-17.—Meter Circuits for all Positions of the Meter Switch.

amplitude to drive the grid potential positive to ground during each input cycle. The resulting discharge of C156 (fig. 2-17B) during periods when no grid current flows causes the deflection of the M101 meter needle which indicates the 2nd doubler grid current. Maximum deflection while tuning the r-f driver control (C145A through D, and C178A and C178B of figures 2-4 and 2-6) indicates optimum tuning of the first doubler and grounded grid amplifier stages.

3. PA Ig position. In the PA Ig position (fig. 2-17C), M101 measures the grid current flow of the r-f power amplifier which comprises tubes V117 and V118. The PA grid tank is tuned using this position.

4. OUTPUT position. When the meter switch, S105, is set to the OUTPUT position, (fig. 2-17 D), the output monitoring circuit, comprising CR103, R183, R184, and the meter, M101, provides a relative indication of the r-f output power. The reading obtained is not an absolute indication of the output power, since it will vary with the frequency of the output, increasing as the output frequency increases, and decreasing as the output frequency decreases. The output will also vary with changes in loading, and with the standing wave ratio on the line to the antenna.

There is no physical connection of the monitoring circuit to the transmitter output circuit. The signal fed to the monitoring circuit depends upon wiring capacitance to pick up the energizing signal. This signal is rectified by crystal diode CR103, and filtered by R183 and C184. The d-c voltage thus produced causes a current through the meter movement, causing the meter to show a relative indication of the output power.

5. AVC Position. Placing S105 in this position connects the meter (M101) across the output of the AVC rectifier, V102B (fig. 2-17 E), to provide an indication of the AVC voltage. This position of the meter switch is intended to be used as a method of checking AVC voltage during tests or adjustments. When the metering circuit is placed across the AVC diode load resistance (as shown) the operation of the AVC circuit is impaired by the shunting of the high V102B diode load impedance by the low impedance of the meter circuit, and the AVC output voltage decreases. S105 should not be left in the AVC position during actual operation.

6. MOD Position. A modulation rectifier tube, V108B, (fig. 2-17 F) and the meter, M101, are connected to indicate the average modulating signal amplitude when S105 is in the MOD position. In this switch position, the meter and meter limiting resistor, R164, are connected in series with R144 across the modulation rectifier diode, V108B. The modulation voltage is coupled to this circuit through C103 from the 8-9 secondary winding of the modulation transformer, T103.

During positive half cycles of the input, V108B conducts to effectively short-circuit the meter. Negative alternations will not permit V108B to conduct, and the only current path is from terminal 8 of T103 through C103, R144, R164, M101 meter movement to ground, to return to terminal 9 of T103 through the +190 volt supply. The magnitude of the meter current is a measure of the average modulation signal amplitude.

7. VOL EXP Position. With the meter switch, S105, in this position (fig. 2-17 G) the meter (M101) and its associated resistors, are placed in the keyed +300 volt line to the audio circuits. Plate voltage for V104B, as well as screen voltage for the modulator tubes, (V105 and V106) is then applied through R164 and the M101 meter movement. R143 and C127 provide additional filtering for the +300 volt power before it is applied from the R143-C127 junction to the plates of the audio amplifier, V101, the AVC amplifier, V102A, and to the mcw oscillator, V109A.

The major portion of the current passing through the meter (when S105 is in the VOL EXP position) is derived from the third audio amplifier, V104B. It should be recalled that the volume expander circuit, comprising V107, V108A, and V109B (fig. 2-11), functions to determine the bias voltage applied to the third audio amplifier. When a voice input is received, the volume expander circuit reduces the bias on V104B to a level which allows V104B to conduct. When no voice input is received, the action of the volume expander circuit is to apply a sufficiently negative voltage to the V104B grid to maintain this stage beyond cutoff throughout the no-voice input period.

With S105 in the VOL EXP position and V104B at cutoff (corresponding to a condition of no voice signal input) the reading of M101 is relatively low (approximately 40 microamperes). However, when the output from the volume expander circuit permits V104B to conduct (corresponding to a condition when a voice signal is being received) the meter reading rises to a higher value (approximately 80 microamperes). Thus, the meter reading provides an indication of volume-expander action for voice-signal and no-voice-signal input conditions.

8. 2nd Doubler Ip Position. With S105 in this position (fig. 2-17 H), M101 is connected between

the plate of the 2nd doubler stage and the +525 volt B supply. The meter movement is shunted by two parallel resistors, R154 and R155. C145D (fig. 2-6) is tuned for minimum plate current when S105 is in this position.

9. PA Ip Position. M101 indicates power amplifier plate current when S105 (fig. 2-17 I) is set to this position. R156 serves as the meter shunt for this position, and is of smaller resistance value than the total 2nd doubler shunt resistance, since R156 must be capable of shunting a higher current around the meter movement. The Z102 shorting bar (PA tuning control) shown in fig. 2-6, is adjusted so that the meter indicates minimum PA plate current.

## BASIC SIMILARITIES IN MODEL TED SERIES EQUIPMENTS

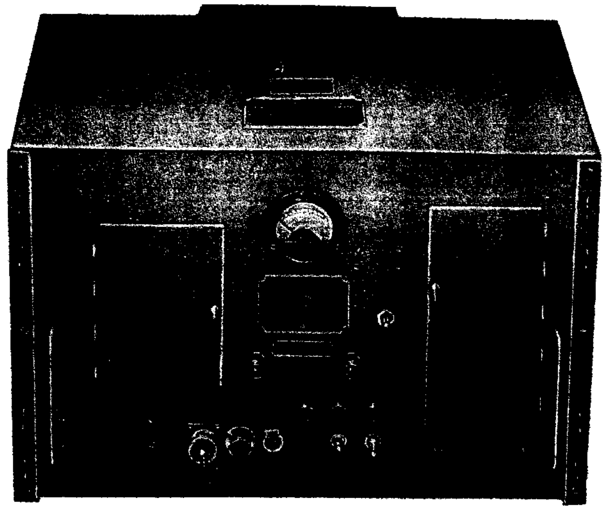
The series of TED transmitters comprises models TED, and TED 1 through TED 9 (table 2-1). The TED transmitters are functionally the same. The circuit operation of each of the TED transmitters is generally the same except for a minor change in the AVC circuit of the TED 2. This change does not alter the circuit operation sufficiently to warrant separate consideration.

There are also minor differences in some mechanical details of the TED equipments. These differences are not discussed in this chapter.

Transmitter control units, CFT 23555, are supplied as component parts of the TED equipment as shown in figure 2-1. These units are not included in subsequent members of the TED series.

## RELATIONSHIP OF THE MODEL TED SERIES TO VHF EQUIPMENT

Ship-to-ship communications generally is accomplished by equipments which operate in the UHF range, since these equipments perform more efficiently than similar VHF equipments. Sometimes, however, under emergency conditions, or as a secondary communications channel, equipments operating in the VHF range are employed. A representative example of VHF transmitting equipments is the Radio Transmitting Set, AN/URT-7 (fig. 2-18).



32.40

Figure 2-18.—Radio Transmitting Set, AN/URT-7.

Radio Transmitting Set, AN/URT-7, functions the same as the transmitters of the model TED series, except that the AN/URT-7 operates in the 115 to 156 megacycle (VHF) range. In many cases, the component size and schematic nomenclature is the same.

Because the operating frequency range of the AN/URT-7 is lower than that of the model TED series, fewer frequency multiplier stages are needed in the r-f chassis of the AN/URT-7. The block diagram of the AN/URT-7, shown in figure 2-19, can be compared with that of the model TED series (fig. 2-3) to show the

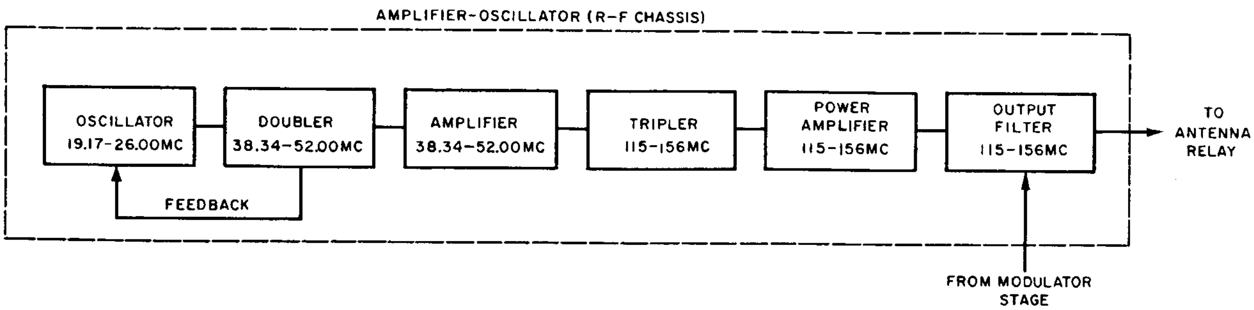



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Figure 2-19.—Radio Transmitting Set, AN/URT-7, Block Diagram lower total multiplication of the oscillator frequency.

In the AN/URT-7, one doubler stage and one tripler stage is used to yield a total frequency multiplication of 6 times. The model TED series employs two doubler stages and one tripler stage to produce a total multiplication of 12 times the oscillator frequency.

Both equipments employ Butler oscillator circuits for frequency stability. In all other respects, the AN/URT-7 and the transmitters of the model TED series are generally the same.

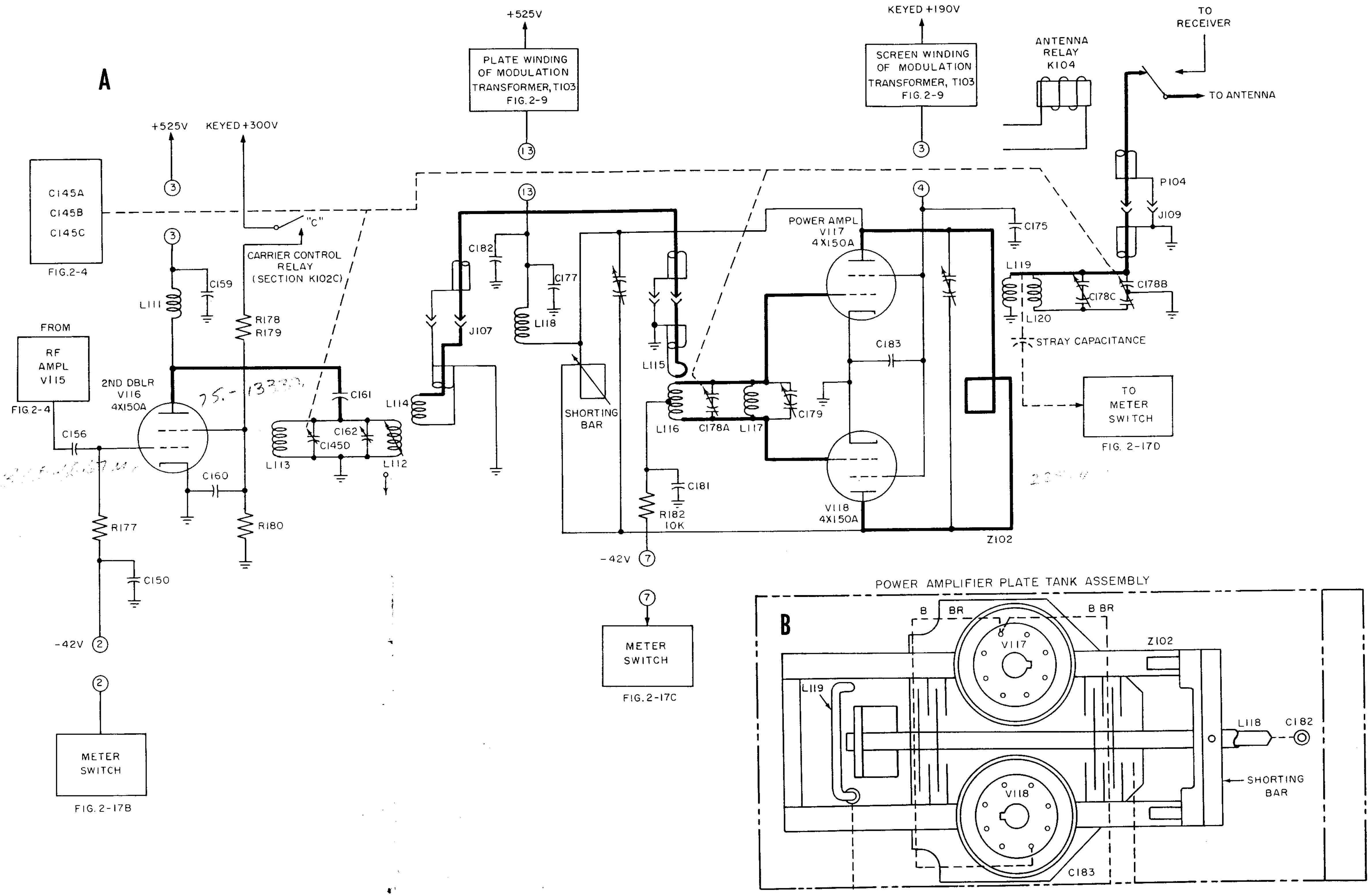


Figure 2-6A.—Second Doubler and Power Amplifier Stages.
B.—Top view of PA plate tank.