SECTION IV
THEORY OF OPERATION

4.1. GENERAL CIRCUIT DESCRIPTION.

Owners of the KWS-1 Transmitter should become thoroughly familiar with operational theory before attempting to solve service or maintenance problems. This section outlines the operational theory in relation first, to the signal path through the Exciter/Power Amplifier and second, by a detailed description of all circuits in the signal path, especially those unique to single sideband, suppressed carrier transmission. Reference should be made to the block diagram in figure 4-1, the overall schematic diagram in figure 7-1, to the photographs in section VI, and to illustrations supplementing the text.

Throughout the text, reference will be made to various jack, tube, plug and switch terminals. In many instances, this reference is made by following the component symbol by a dash and the terminal number. For instance, J102-7 refers to jack J102, terminal seven, and S101C-3 refers to switch S101C, terminal three.

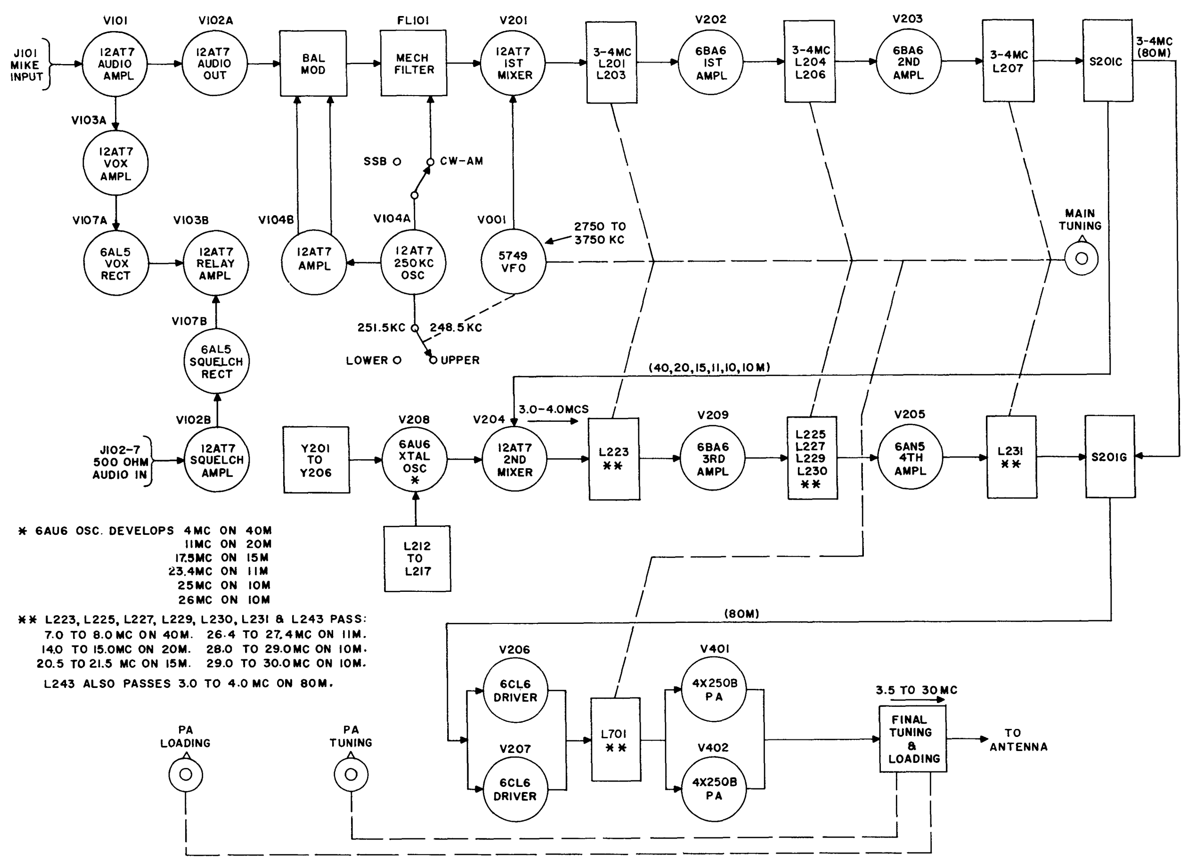

Figure 4-1. Exciter/Power Amplifier, Block Diagram

4.1.1. CIRCUIT DESCRIPTION, SSB SIGNALS.

The audio signal is fed from the microphone jack J101 on the front panel through a two-stage amplifier into a cathode follower audio output stage. The cathode follower matches the audio signal to the 1N67A diode balanced ring modulator. The output of a 250-kc oscillator is amplified and fed into the balanced modulator. The output of the modulator contains both upper and lower sidebands, but the carrier is attenuated by more than 50 decibels. The signal is fed through a mechanical filter, the input of which is series tuned to match the low impedance of the balanced modulator. The FL101 Mechanical Filter has an output containing either the upper or lower sideband, depending upon the selection of the operator. The carrier and undesired sideband are greatly suppressed, or, for all purposes of signal consideration, are eliminated.

The output of the FL101 Mechanical Filter is parallel tuned to match the high impedance of the first mixer grid. In addition to accepting output signals from the FL101 filter, the first mixer also accepts signals from the vfo. The mixer plate circuit contains a special feedback network which provides an additional 20 decibels of attenuation to undesired vfo signals appearing in the plate circuit. The desired output of the mixer is passed through two stages of linear amplification, including five high "Q" tuned circuits. The tuned circuits provide sufficient gain and selectivity to produce essentially spurious-free signals in the 80-meter band.

At this point, the 80-meter signals are fed directly into the paralleled driver stages, while the frequencies of the 40, 20, 15, 11, and 10-meter bands require further conversion. These signals are fed into a second mixer, which also receives an input from a crystal oscillator. The oscillator signal is selected by the BAND CHANGE control to provide correct output frequencies for the desired band. The conversion frequency output of the second mixer is fed through two stages of r-f amplification, including three high "Q" tuned circuits to produce a signal which is again, essentially spurious-free. The amplified signal is then fed into the 6CL6 driver stages. The output of the drivers is fed directly into the Power Amplifier.

The Power Amplifier is designed for linear class AB_1 operation with individual tuning and loading controls in the final amplifier output circuit. Grid-plate neutralization is included to provide improved stability of operation. An r-f feedback system is used to permit operation with lower distortion.

An Automatic Load Control circuit is also included in the Power Amplifier, however, a complete analysis of this circuit is included in the detailed circuit description.

4.1.2. CIRCUIT DESCRIPTION, AM SIGNALS.

For AM. signals, the output of the 250-kc oscillator is reinserted at the output of the mechanical filter to provide operation with carrier and one sideband. By adjustment of the CARRIER LEVEL control, it is possible to vary the amount of carrier reinserted and produce the proper relationship between the sideband and the carrier.

4.1.3. CIRCUIT DESCRIPTION CW SIGNALS.

Cw operation is produced by reinserting the 250-kc oscillator signal at the output of the mechanical filter, as in AM. operation, and by grid-block keying of the first mixer and the driver stages. The EMISSION control eliminates exciter circuits unnecessary for cw signals. A wave shaping network is included to reduce transients in the cw output.

4.1.4. CIRCUIT DESCRIPTION, FSK SIGNALS.

Although a 600-ohm audio input circuit is available for use with an external phone patch circuit, it is also possible to feed an external audio FSK oscillator into this circuit to provide for carrier shift FSK operation. With the EMISSION switch in the SSB position, the mark and space frequencies of the audio oscillator produce two r-f voltages in the exciter output, spaced by the correct amount for all bands.

4.2. DETAILED CIRCUIT DESCRIPTION.

4.2.1. EXCITER/POWER AMPLIFIER CIRCUITS.

4.2.1.1. AUDIO CIRCUITS.

a. SPEECH AMPLIFIER CIRCUITS. The audio input signals into the KWS-1 Transmitter are first amplified by a two-stage preamplifier consisting of a duotriode 12AT7; V101. These are conventional audio amplifiers, the output of which is coupled through condenser C132 to the control grid of audio output stage V102A.

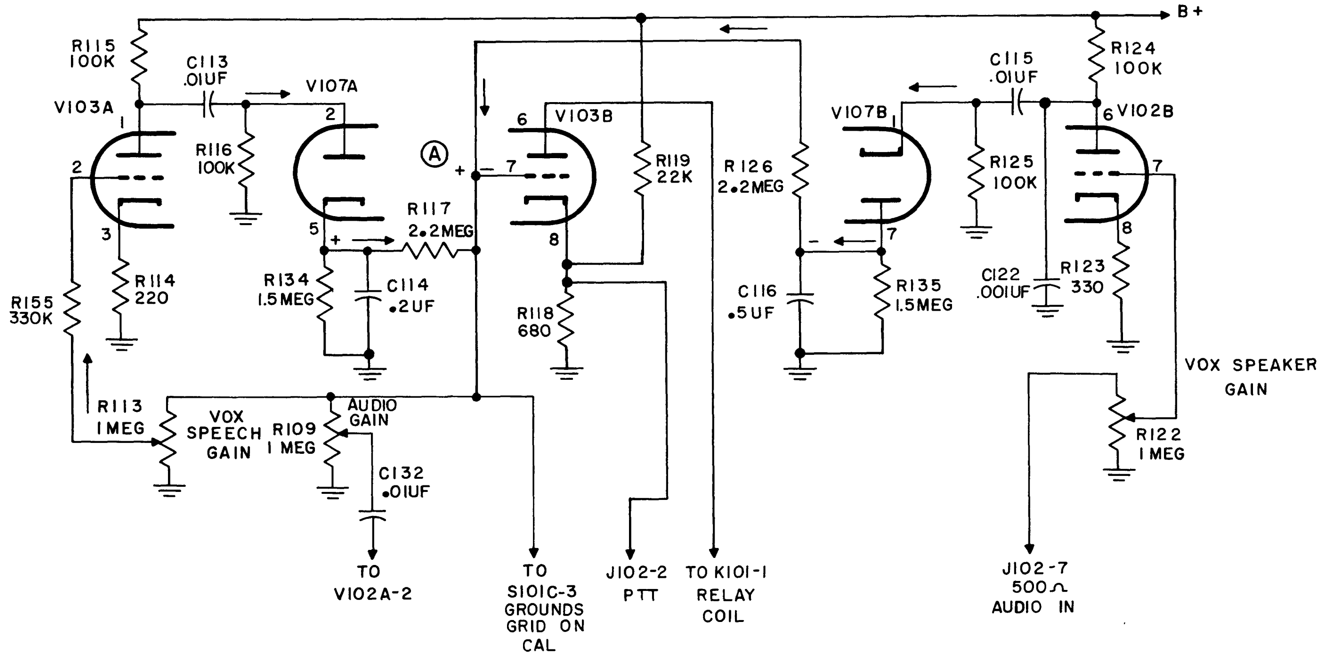

Figure 4-2. VOX Circuits, Simplified Schematic Diagram

The V102A audio output stage is connected as a cathode follower to provide the required low impendance audio input for the balanced modulator and FL101 Mechanical Filter. The audio signal is coupled from the V102A cathode through C106 to the junction of C109 and point Ⓒ in the balanced modulator circuit. Cathode resistance for V102A consists of R110 and R153 to ground through switch S101-C terminal eight. When the transmitter is switched to CW operation, S101-C terminal eight is open to prevent audio modulation of the cw signal.

b. VOX AND SPEAKER SQUELCHING CIRCUITS. The overall purpose of V103A VOX amplifier, V107A rectifier and V103B relay control amplifier is to operate relay K101 so transmitting occurs only when an audio input from the microphone is present on phone operations.

Part of the audio output from V101 is taken off the AUDIO GAIN potentiometer R109 and fed through the VOX SPEECH gain control R113 to the control grid of amplifier V103A. Thus, by R113, the amplitude of audio signals applied to V103A is regulated. V103A amplifies the signal, which is then coupled through C113 to rectifier V107A. (See figure 4-2.) This circuit includes the diode d-c return resistance R116, and diode load R134 and C114. The value of the diode load components is chosen to produce a time constant for "fast attack and slow release" characteristics. Thus, the condenser charges quickly and discharges slowly. V107A converts the amplified VOX audio signal immediately to a plus d-c voltage, but, due to the diode load time constant, the d-c charge tapers off slowly to prevent relay K101 from shutting off between words spoken into the microphone. The plus d-c voltage present on the cathode of V107A is passed through R117 to the control grid of relay amplifier V103B; the plate current of V103B operates relay K101, responding to the diode load voltage and time constant. Cathode resistors R118 and R119 hold the bias on V103B to a point where the relay is not quite operating. Thus, when audio is spoken into the microphone, a portion of the signal passes through the VOX SPEECH gain control R113, is amplified in V103A, and converted to a plus d-c voltage in V107A. The d-c is applied to V103B grid to overcome the bias on the cathode, causing the tube to conduct more, enough to operate relay K101. When the audio signal source ceases, the operating level of V103B is retarded by R118 and R119, which would normally shut off relay K101, but the time constant of the diode load holds the relay in operation long enough to carry over from word to word of the microphone input.

The purpose of squelch amplifier V102B and rectifier V107B is to prevent the audio signals of the receiver from operating K101 relay by feedback of the audio signals through the transmitter microphone and audio circuits. A connection is made to the receiver output transformer, which feeds the speaker audio signals into the transmitter through J102-7, through the VOX SPEAKER gain control R122, to the grid of V102B. At the same time, the same speaker signals are feeding through the transmitter microphone into the VOX amplifier V103A to produce a plus voltage on the V103B grid, to operate relay K101. However, the voltage applied to the V102B squelch circuit is amplified and fed through C115 to the cathode of rectifier V107B. This rectifier circuit is identical to V107A, except V107B is connected in reverse, such that a negative voltage is produced and applied through R126 to the grid of relay amplifier V103B. This occurs at the same time the plus voltage is being applied from V107A, at point Ⓐ in figure 4-2. The plus and minus voltages are adjusted by potentiometers R113 and R122 to a point at which they balance out, preventing the receiver speaker signals from operating the transmitter relay K101.

The lead from V103B grid to switch S101C-3 grounds the grid during calibration procedures, to prevent audio signals from operating relay K101 during calibration.

The lead from the V103B cathode to the PTT input on J101-2 or J102-2, permits use of an external, manual push-to-talk control, instead of the voice operate circuits built into the exciter circuits.

4.2.1.2. LFO, BALANCED MODULATOR AND FL101 MECHANICAL FILTER CIRCUITS. Development of the 250-kc carrier frequency in the KWS-1 Transmitting System is accomplished by a crystal controlled oscillator stage, V104. Figure 4-3 is a simplified schematic diagram to show only oscillator V104, the balanced modulator, FL101 Mechanical Filter, and the audio output cathode follower stage. This diagram may be used to study the KWS-1 methods of carrier development, modulation and filtering relative to single sideband transmission.

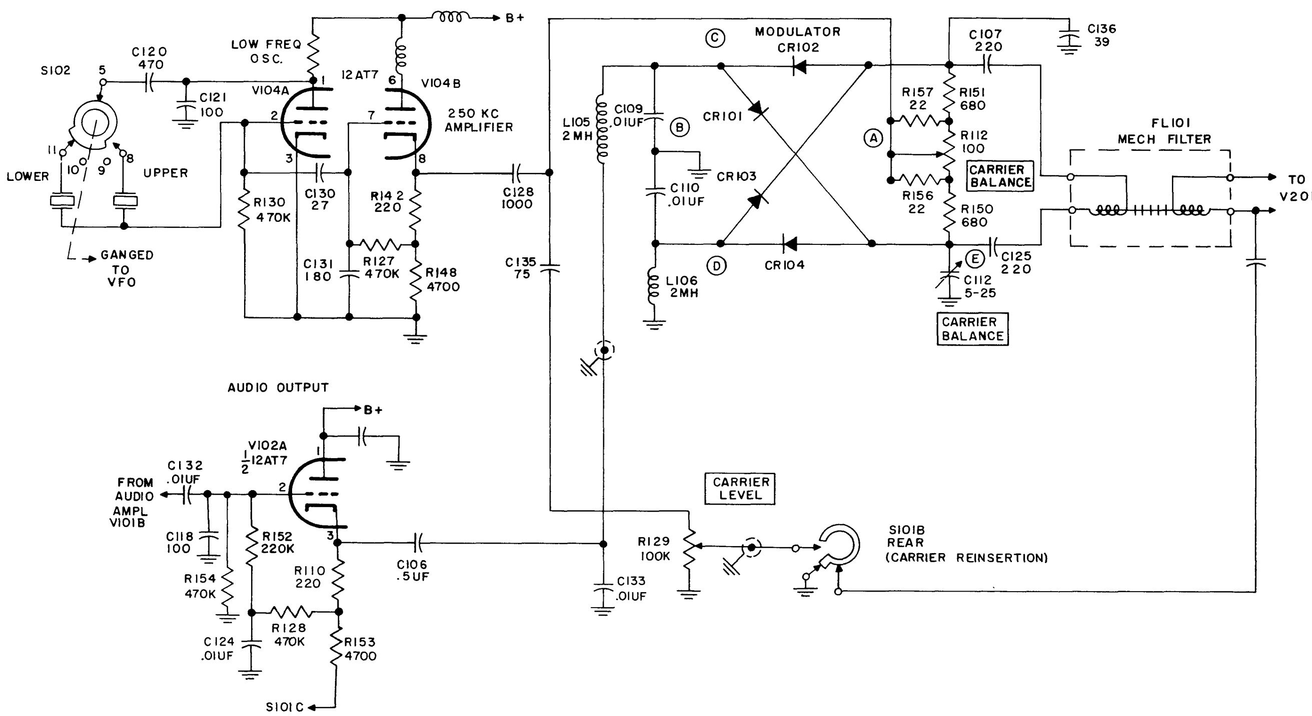

Figure 4-3. LFO, Balanced Modulator and FL101 Mechanical Filter, Simplified Schematic Diagram

a. SINGLE SIDEBAND SIGNALS.

(1) LFO. For the development of single sideband signals, the 250-kc output of V104A is coupled through condenser C130 into the grid of the 250-kc amplifier, V104B. The output of V104B is coupled from the cathode through C128 to point Ⓐ, and from the ground to point Ⓑ of the balanced modulator, to provide an r-f input to the modulator. (See figure 4-4.)

(2) BALANCED MODULATOR. The balanced modulator is a "ring type" modulator. It receives two signal inputs, the 250-kc carrier signal at points Ⓐ and Ⓑ in figure 4-4, and the audio signal at points Ⓒ and Ⓓ. The purpose of the modulator is to suppress the carrier frequency, and to pass only the upper and lower sideband frequencies resulting from modulation by the impressed audio. As shown by the component values, the modulator is a low impedance unit with two points of "balance" adjustment at points Ⓐ and Ⓔ in figure 4-4. R112 is adjusted for voltage balance, and C112 for capacity balance of the 250-kc r-f voltages applied.

The 250-kc carrier frequency, because of equal inputs at Ⓐ and Ⓑ, and because of the equal component values in the ring, is balanced out, or suppressed. As stated above, R112 and C112 provide vernier adjustments for the balance circuits to take care of component inherent value variations. The diode rectifiers are made up in matched sets at the factory. The adjustment procedure will be discussed in the chapter covering Maintenance and Alignment.

Although the ring is balanced insofar as the r-f carrier voltage is concerned, the audio input essentially "modulates" the carrier by causing unbalance of the ring voltages at an audio rate, relative to the positive and negative alternations of the audio cycles. Thus, on one audio alternation, for example, the CR101 plate is biased positive, causing its impedance to be lowered, while the CR102 cathode is biased positive, causing its impedance to be increased. On the following alternation, the impedance unbalance is the opposite. Thus, the carrier is "modulated" to produce two sidebands, but the carrier is suppressed by the ring balancing action. Assuming a 1000 cps audio note, the modulator output at the input of FL101 would be sideband frequencies of 249 kc and 251 kc, with the 250 kc carrier suppressed. (See figure 4-4.) R112 is adjusted to balance the inherent variations in R150 and R151.

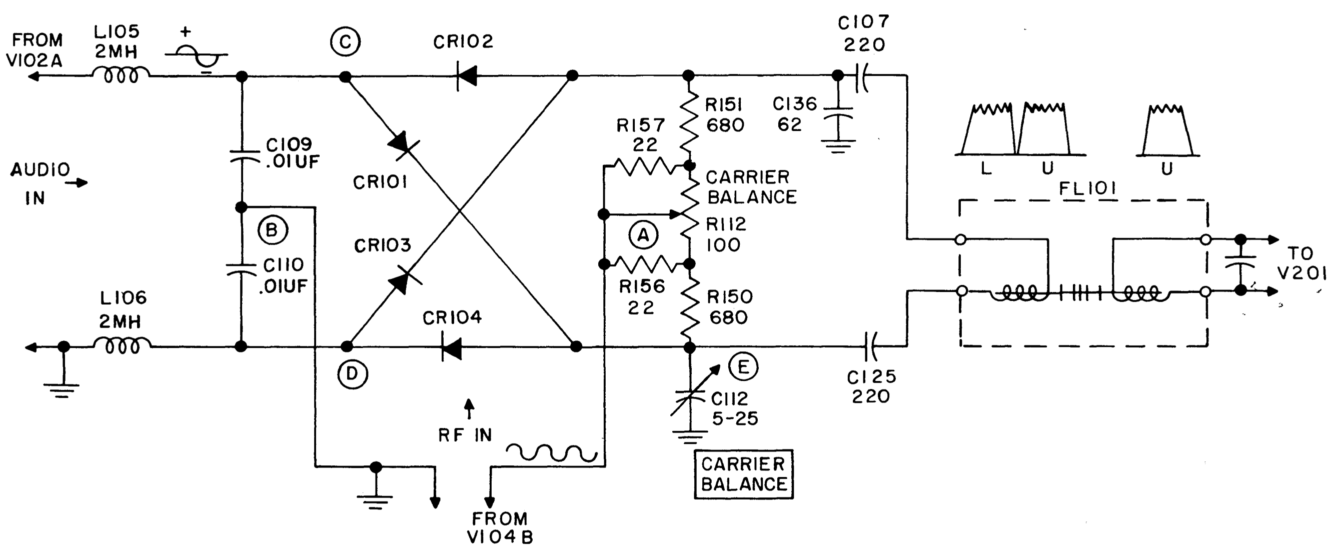

Figure 4-4. Balanced Modulator and FL101 Mechanical Filter, Simplified Schematic Diagram

Although figure 4-4 shows the modulator output in a practical "U and L" manner, the actual output waveform, when viewed on an oscilloscope, would be similar to figure 4-5, representing the 249-kc and 251-kc sideband signal plus the audio of the example stated in the preceding paragraph.

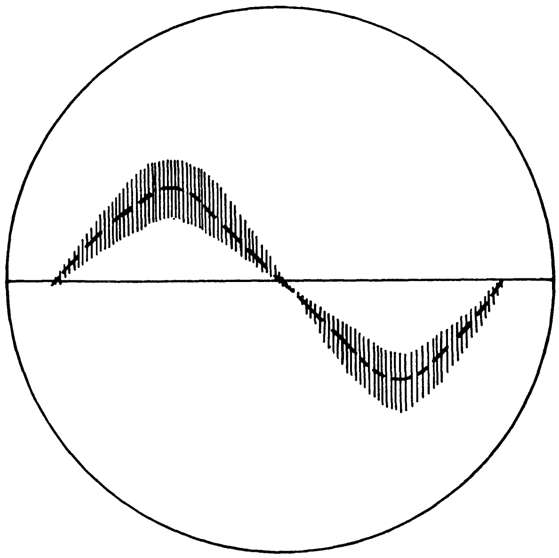

Figure 4-5. Balanced Modulator Output, Typical Oscilloscope Pattern

(3) FL101 MECHANICAL FILTER. A functional diagram of the Collins FL101 Mechanical Filter is shown in figure 4-6.

Mechanical Filter FL101 operates on the principle of magnetostriction to convert oscillating magnetic energy into mechanical vibrations and back to magnetic energy. In mechanical filter design, the magnetostriction transducer input coil is designed to resonate at a particular frequency or band of frequencies, contingent upon the desired purpose of the filter. For KWS-1 Transmitters, the FL101 Mechanical Filter input circuit contains a fixed value, series-tuned resonant circuit composed of C107, C125 and the transducer input coil. C107 and C125 are chosen to match the filter, and is a series resonant circuit for low impedance input to accept the low impedance output of the balanced modulator. Low impedance input characteristics are desired to attain stability of operation in the development of the low level, single sideband transmission signals.

Within the filter, a nickel wire in the input transducer coil vibrates mechanically and transmits this energy to the first of a series of nickel alloy discs. The mechanical vibration of the first disc is coupled to succeeding discs by means of nickel-wire coupling elements. Biasing magnets at either end of the filter polarize the filter elements to prevent frequency doubling in much the same manner as biasing magnets in a headphone prevent the phone diaphragm from bending the same direction for both alternations of an a-c cycle. The mechanical vibration of the last disc is coupled to a magnetostriction transducer element identical to the one used at the input of the filter. By a reverse principle of magnetostriction, the mechanical vibrations of the nickel-wire transducer core is converted to electrical impulses. Each of the discs used has a mechanically resonant "Q" exceeding 2000. Six of the discs are overcoupled to produce a mechanically-shaped response curve with a flat top and almost vertical sides. Thus the filter passes a band of frequencies very little wider than the flat top of the selectivity curve. In the case of FL101 Mechanical Filter, this band of frequencies is approximately 3 kc wide and centers on 250 kcs. Figure 4-4 shows a practical example of the FL101 Mechanical Filter output wave containing all the USB frequencies however, on an oscilloscope, the

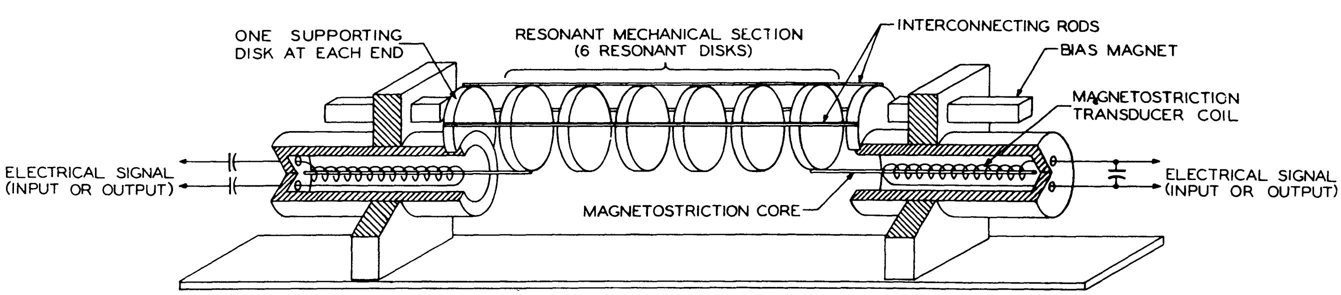

Figure 4-6. FL101 Mechanical Filter, Functional Diagram

wave shape would be that of figure 4-7, with a single r-f frequency when a single audio tone is applied to the balanced modulator, but actually contains the upper or lower sideband output of the modulator.

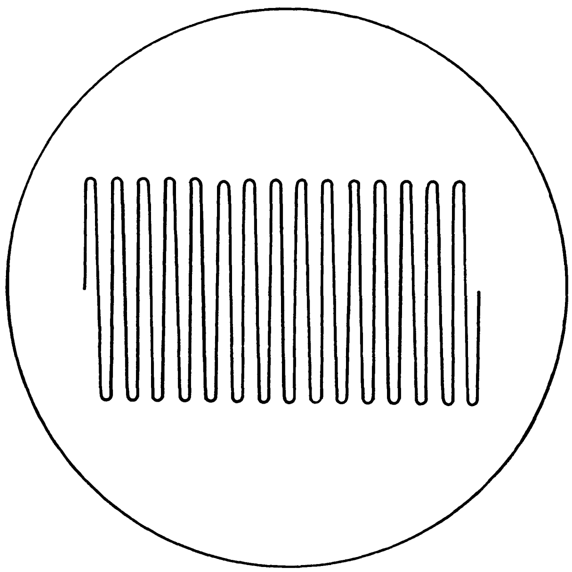

Figure 4-7. FL101 Mechanical Filter Output, Typical Oscilloscope Pattern

(4) SIDEBAND SELECTION. The operator has the choice of transmitting on either the upper or lower sideband. The selection is accomplished by switch S102 (see figure 4-3). The KWS-1 normally operates on the lower sideband, however, if S102 is switched to the U, or upper, position, the action selects the "UPPER" sideband crystal for the V104 250-kc oscillator, to change the output frequency of V104 by 3 kc. This is the same bandwidth as the FL101 Mechanical Filter output. In order to maintain the proper frequency relationships between the vfo and the 250 kc lfo, S102 is mechanically ganged to the vfo can. Adjustment of S102 to either sideband automatically adjusts the vfo output 3 kc in the opposite direction from the lfo adjustment. Thus if the lfo is adjusted down, the vfo is adjusted up 3 kc in their respective frequency ranges, to maintain proper output frequency in the overall KWS-1 Transmitter.

Vernier adjustments of S102 operation are accomplished on the switch itself. This adjustment will be discussed under Maintenance and Alignment.

b. CW AND AM. SIGNALS. Cw and AM. emission in relation to V104, V108A, the modulator and FL101 Mechanical Filter is somewhat different than single sideband.

For both cw and AM, a portion of the 250-kc carrier must be reinserted into the r-f circuits. This is accomplished by taking a part of the carrier frequency off the V104B cathode through condensers C128 and C135. (See figure 4-3.) This is fed through the CARRIER LEVEL control potentiometer R129, by which the operator may adjust the desired amount of reinserted carrier. The signal is then fed through switch S101B and C117 to the output side of Mechanical Filter FL101, through the filter output transducer coil to the V201 first mixer control grid.

On cw, the cathode circuit of audio output stage V102A is opened by switch S101-C, terminal eight, to prevent audio signals from interfering with cw operation. Thus, the modulator and filter are not used on cw, and the 250 kc carrier is essentially reinserted "around" the filter.

AM. operation is similar, except the audio output is present. The modulator and filter are utilized similar to SSB operation, but the carrier is reinserted into the FL101 filter output, and the total output then consists of AM. with the carrier and one sideband.

4.2.1.3. VFO AND RF CIRCUITS. The output of the FL101 Mechanical Filter is taken off condenser C108 which, with the filter output transducer coil, forms a parallel resonant circuit for high impedance. The output is fed through a coaxial cable and resistor R201, into the grid of the first mixer stage V201, pin number seven, in the r-f section of the exciter.

a. VFO CIRCUITS. (See figure 7-1.) The hermetically sealed, variable frequency oscillator is a permeability tuned, Hartley type circuit, tunable from 2750 kc to 3750 kc with control dial calibration of one kc per division. The tank circuit consists of condenser C001 and inductances L001 and L002. The remaining components designed and connected to promote stability of operation in the oscillator overall action. L001 and L002 are slug tuned, with L002 ganged to the main tuning system.

Operational stability of the vfo is improved by regulating the plate and filament supply voltage and current. This is accomplished for the plate circuit by feeding B plus voltage into the OB2 regulator tubes V106 and V105, connected in series to ground. A 210-volt regulated supply is taken off the V106 plate

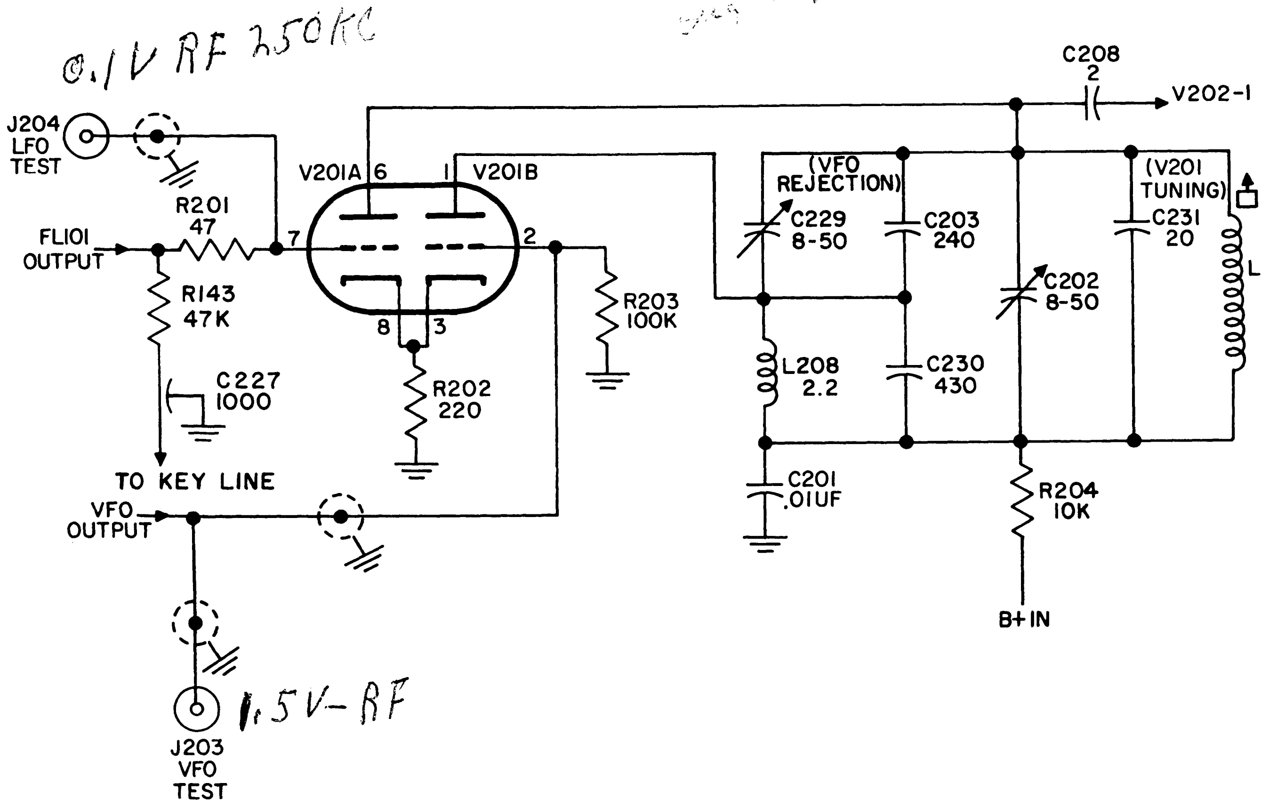

Figure 4-8. First Mixer V201, Simplified Schematic Diagram

and fed into the vfo plate circuit. Regulation for the filament supply is provided by RT101, which utilizes a 12.6-volt input to produce a 6.3-volt regulated output for the vfo filament.

The vfo generates frequencies from 2750 kc to 3750 kc. Vfo output is taken off the plate circuit and fed through a coaxial cable into the grid, pin number two, of the duotriode first mixer stage, V201.

b. RF CIRCUITS.

(1) V201 FIRST MIXER STAGE. A simplified schematic diagram of the first mixer stage appears in figure 4-8. This diagram will assist in understanding the theory involved in the first mixer design.

There are two test points available for each of the V201 grids. (See figures 5-1 and 7-1.) One is taken off pin number seven of V201A to jack J204, and the other off pin two of V201B to jack J203. J204 will provide a test voltage for signal input, and J203 for vfo input.

The ratio of voltage input on pin seven of V201A to that of pin two on V201B is approximately 0.1 volt to 1.5 volts. Thus, the vfo input is considerably stronger than the signal input. This is the reason for the rather complex tuned plate circuit consisting of L201, C231, C202, C203, C229 and C230. L208 is a choke in the V201B plate B plus supply circuit. The purpose of the tuned plate circuit is to reject a strong, undesired frequency component in the V201 output, which is a result of the strong vfo input signal at the V201B grid. The theoretical principle involved is selective feedback rejection. The actual tuned plate circuit consists of C202, C231 and L201, with C202 and L201 adjusted to resonate the circuit at the desired 3 to 4-mc output frequency. C203, C229 and C230 form a capacitive voltage divider. The selected values of C203 and C230 determine the amount of feedback for the undesired vfo frequency component. C229 is adjusted for null of the particular frequency to be rejected. Adjustment procedures will be discussed under Maintenance and Alignment.

Thus, by virtue of the heterodyne action in V201, and the selective feedback rejection in the tuned plate circuit, the output frequency of V201 contains a very satisfactory degree of selective band pass and stability characteristics for the desired 3.0 to 4.0-mc i-f range.

L201 and L203 are top coupled through C208, which serves to couple the V201 output into amplifier V202.

(2) FIRST AND SECOND AMPLIFIERS. The V202 and V203 amplifier stages are conventional, insofar as the signal amplification is concerned, but the associated circuitry contains several control and neutralization connections which are considered unique to the KWS-1 Transmitter.

Automatic Load Control d-c voltage from the power amplifier circuits is applied to the V202 and V203 control grids. (See figure 7-1.) The action here is similar to receiver avc circuits, and will be discussed in detail with power amplifier circuits. An ALC meter connection is made across the V202 cathode and a reference voltage at R209 to measure the amount of Automatic Load Control in decibels. The V202 cathode circuit also contains a potentiometer, R207, for an ALC meter zero adjustment. The ALC meter action is similar to the "S" meter of an amateur receiver.

Capacitors C268 and C322, off the bottom of the V203 plate tuned circuit inductance L207, are utilized in a circuit for neutralization of plate-to-grid and grid-to-cathode capacitance in the 6CL6 driver stages. These circuits will be discussed with the driver and power amplifier circuit description.

A d-c keying voltage is connected to the first mixer V201 control grid through R143 and FL101 Mechanical Filter output coil. The keying voltages are obtained through a wave shaping network for improvement of the cw keying characteristics.

Selectivity in the V202 and V203 amplifier stages is provided by grid and plate tuned circuits consisting of L203 - C206/C207, L204 - C211/C212, L206 - C216/C217 and L207 - C221/C222 inductance and capacitance combinations. Table 4-1 shows the inductance and capacitance combinations in all exciter circuits which provide selectivity for the respective amateur band frequencies. R210 and R211 form a voltage divider in the V202 screen grid plus supply circuit, while R215 and R216 perform the same purpose for V203.

The output of V202 is coupled by C218 into V203, while the V203 output is coupled by C293 into the C section of switch S201. From here, the 80-meter signals not requiring further frequency conversion, are passed directly into the driver stages. The signals for 40, 20, 15, 11 and 10 meters require further frequency conversion, thus are fed into the second mixer stage V204 through coupling condenser C232.

(3) CRYSTAL OSCILLATOR AND SECOND MIXER CIRCUITS.

(a) CRYSTAL OSCILLATOR. V208 oscillator stage is utilized to produce conversion frequencies for heterodyne action with the 40, 20, 15, 11 and 10-meter signals in mixer stage V204. Oscillation frequencies are selected by switches S201A and S201B from crystals Y201 to Y206, and inductances L212 to L217, respectively. V208 is shunt fed through L228 to keep B plus voltages off the tuned circuits. The output of V208 is fed through C224 to the second mixer V204B pin number two control grid.

(b) SECOND MIXER. V204 mixer stage is a conventional duotriode type, with the signal input frequencies fed into control grid pin number seven through condenser C232.

Similar to V201 mixer, there are two test points provided for V204. (See figure 5-1.) One is taken off pin number seven to jack J206 for measuring signal input levels. The other test point is taken off pin number two to jack J205 for measuring the V204 input level from crystal oscillator stage V208. Usage of all test points will be discussed in detail in the chapter on Maintenance and Alignment.

L220 and C249 form an eight-megacycle trap circuit to reduce the second harmonic of the crystal oscillator on the 40-meter range of frequencies. A similar trap is not needed for the higher frequency bands, because the harmonic frequencies would fall outside the KWS-1 selectivity circuits' band pass.

The main output tuning inductance is L223. By itself, this inductance is used for the 40-meter band. (See table 4-1.) When S201D is switched to the 20, 15, 11 or 10-meter bands, L218, L219 and L221 are placed in parallel to L223 to provide the proper tuned circuit inductance. Variable capacitors C248, C250, C252, C254, C255 and C256 are provided for high frequency trimming of the respective coils for the frequencies passed by the second mixer. Each coil is inductively trimmed at the low frequency end by an iron slug.

(4) THIRD AND FOURTH AMPLIFIERS V209 and V205 amplifier stages provide the final amplification and selectivity in the r-f section of the KWS-1 Transmitter.

The tuned output circuit of V209, which could also be considered the tuned input circuits of V205, consists of inductances L225, L227, L229, L230 and trimmers C257, C301, C302, C304, C306 and C308. Switch S201E governs the selection of these components for operation on the 40, 20, 15, 11 or 10-meter bands. (See table 4-1.)

The tuned plate circuit of V205, also considered the tuned grid input circuits for the 6CL6 drivers, consist of inductances L231, L234, L236 and L237, with capacitors C264, C265, C266, C267, C269 and C272 providing the high frequency trimming. Switching of the tuned circuits is accomplished by S201-F-2, while S201-F-1 opens the V205 cathode circuit when the KWS-1 Transmitter is operating on 80-meters. This prevents undesired signals from leaking into the 80-meter output. R237 thru R243 are loading resistors for all bands except 10 meters high.

C273 off the B plus supply input to V205 is in a capacitance neutralization circuit which will be discussed in relation to the driver and power amplifier stages.

The output of V205 is switched through S201-G into the driver stages V206 and V207.

4.2.1.4. DRIVERS AND POWER AMPLIFIER CIRCUITS.

a. SIGNAL CIRCUITS. Single sideband and AM. r-f input signals to the two, parallel connected 6CL6 driver stages passes directly through the E201 and E202 parasitic suppression components to the tube control grids.

Cw keying voltage to the driver stages is fed through R229, E201 and E202 to the 6CL6 control grids.

The 6CL6 plate circuits are shunt fed through L238 and the parasitic suppression components E203 and E204.

Two test points are provided for the 6CL6 driver stages. One, for the control grids, is taken off the R229-E202 Junction to jack J207. (See figures 5-1 and 7-1.) The other, for the cathode circuit, is taken directly off the 6CL6 cathode and fed into J208.

Driver stage output signals are coupled through C305 and switched over the amateur bands by S201-I to include the correct power amplifier tuned grid input circuits for the respective bands. The tuned circuit component combinations for each band are shown in table 4-1.

TABLE 4-1. TUNED CIRCUIT COMPONENTS

METER	2ND MIXER OUTPUT (SWITCH S201D)			3RD AMPL. OUTPUT (SWITCH S201E)			4TH AMPL. OUTPUT (SWITCH S201F-2)			6CL6 DRIVER OUT. (SWITCH S201I)		
BAND	IND.	TRIM.	PAD.	IND.	TRIM.	PAD.	IND.	TRIM.	PAD.	IND.	TRIM.	PAD.
80										L701	C710	C703
40	L223	C248	C247	L225	C308	C309	L231	C272	C271	L701 L703	C711	C704
20	L223 L218	C250	C329	L225 L230	C306	C330	L231 L237	C269		L701 L702	C712	
15	L223 L219	C252		L225 L229	C304		L231 L236	C267		L701 L704	C713	
11	L223 L221	C254		L225 L227	C302		L231 L234	C266		L701 L705	C707	C331
10 (LO)	L223 L221	C255		L225 L227	C301		L231 L234	C265		L701 L705	C708	
10 (HI)	L223 L221	C256		L225 L227	C257		L231 L234			L701 L705		

The 4X250B power amplifier tubes V401 and V402 are operated in parallel and as class AB_1 amplifiers. Output signals are coupled through C406 to the power amplifier tuning and loading circuits, and through J401/P401 to the antenna.

The power amplifier final tuning and loading circuits consists of a PI-L network, with C407, L406, L401, C408 and C409 forming the pi tuning circuit, and C408, C409 and L402 and the L-type loading circuit. For final stage tuning purposes, C407 and L401 are ganged together and brought out to the front panel. In the same manner, C408, C409 and L402 are ganged together and brought out to the front panel. The controls provide individual vernier tuning and loading adjustments of the output amplifiers over the entire frequency range of the KWS-1 Transmitter without the use of band switches.

Inductance L404 operates as a static drain to prevent dc voltages from building up on the antenna circuits.

The V401 and V402 screen grid circuits are series fed through L405, while the plate circuits are shunt fed through L403. Control grid bias is received from circuits in the high voltage power supply and fed through TB501-6 and J103-2 to L239 and the respective grid tank inductance for whichever band is selected.

b. NEGATIVE FEEDBACK AND NEUTRALIZATION CIRCUITS.

(1) NEGATIVE FEEDBACK. A portion of the power amplifier r-f output is fed back through C402 into the 6CL6 cathode circuit for the ultimate purpose of improving final amplifier stage linearity. (See figure 4-9.) At the 6CL6 cathodes, the feedback circuit consists of R708, L706 and C714. The choke, L706, provides a d-c return for the cathode. R708 loads the choke to lower the circuit "Q", preventing oscillations which could be caused by L706 resonating at the feedback frequencies. C714 forms a capacitive voltage divider with C402 off the 4X250B plate to provide the proper value of feedback voltage which produces approximately 12 db of feedback.

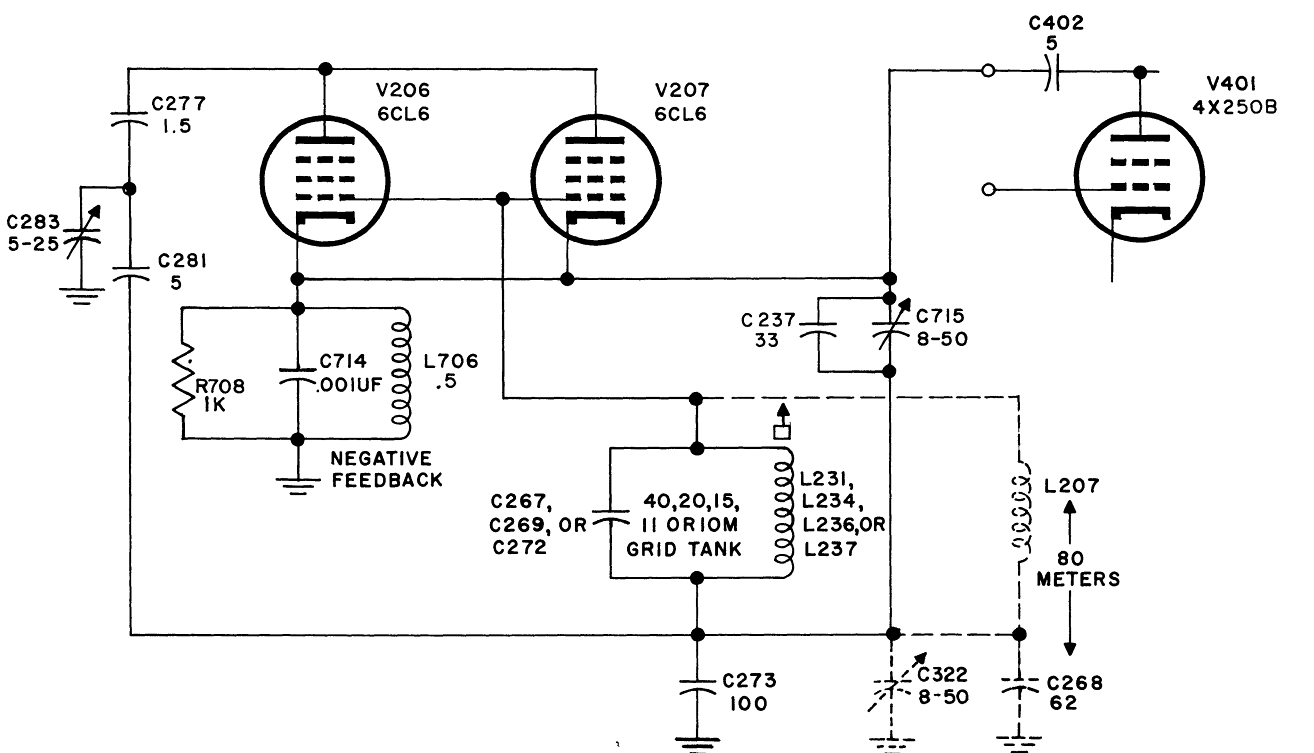

Figure 4-9. 6CL6 Driver Feedback and Grid-to-Cathode Neutralization Circuits, Simplified Schematic Diagram

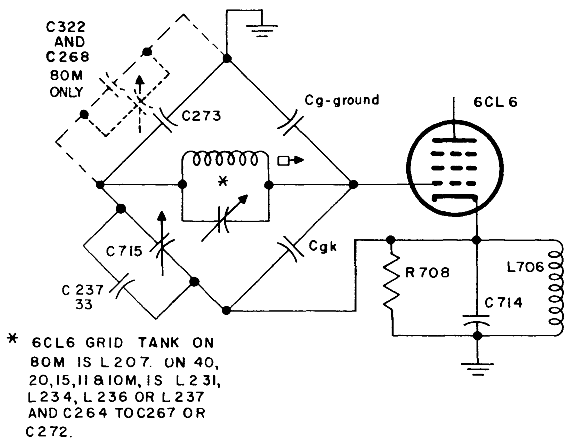

Figure 4-10. 6CL6 Driver Grid-to-Cathode Neutralization Bridge Diagram

(2) NEUTRALIZATION. Certain types of inherent feedback voltages in high level output amplifier stages produce undesirable oscillations which reduce the efficiency of operation. It is this type of feedback the neutralization circuits of the KWS-1 Transmitter eliminates, to improve the linearity and efficiency characteristics. There are four such neutralization circuits, which are discussed below.

(a) 6CL6 GRID TO CATHODE NEUTRALIZATION. (See figures 4-9 and 4-10.) The cathode feedback voltage in the 6CL6 stages will appear on the grid tank circuits to cause stage oscillation, unless the feedback is neutralized. On the bridge diagram of figure 4-10, the feedback voltage is carried over from cathode to grid by the tube's internal grid-to-cathode (Cgk) capacitance. This capacitance forms a voltage divider with the tube's grid-to-ground (Cgg) capacitance. The two capacitances, in series, comprise one side of the neutralization bridge. Neutralization is provided on the 40, 20, 15, 11 and 10-meter bands by condenser C715 and C273, which are in series and form a voltage divider from the 6CL6 cathode to ground. In this position, these capacitors form the other side of the neutralization bridge to balance out the undesired feedback voltage impressed across the Cgk and Cgg arms of the bridge. With the grid tank circuit across the midpoint of both bridge arms, the feedback is balanced out to eliminate this source of stage oscillations. The components of the bridge are shown on the simplified practical diagram of figure 4-9. On 80 meters only, C268 and C322 are placed in parallel to C273 to provide sufficient divider capacitance for neutralization at the 80-meter frequencies.

(b) 6CL6 GRID TO PLATE NEUTRALIZATION (80 Meters). The neutralization of grid-to-plate feedback voltages in the 6CL6 stages when operating on 80 meters is accomplished by the use of condensers C277, C281 and C283 in combination with C268, C322 and C273. (See figures 4-11 and 4-12.) The combination of C277, C281 and C283 is necessary to provide the very small amount of capacitance required in the neutralization arm of the bridge. The feedback voltage is carried over from the tube plate to grid by the internal grid-to-plate (Cgp) capacitance, and from grid-to-ground by the Cgg capacitance, which, together, are in series to form one side of the bridge, with the top of the 6CL6 grid tank circuit connected to the midpoint of the bridge arm. Neutralization balance is provided by the bridge arm consisting of C277, which is in series to ground with the arm consisting of C322, C273, C268, C281 and C283. The bottom of the grid tank circuit is connected to the midpoint of this bridge

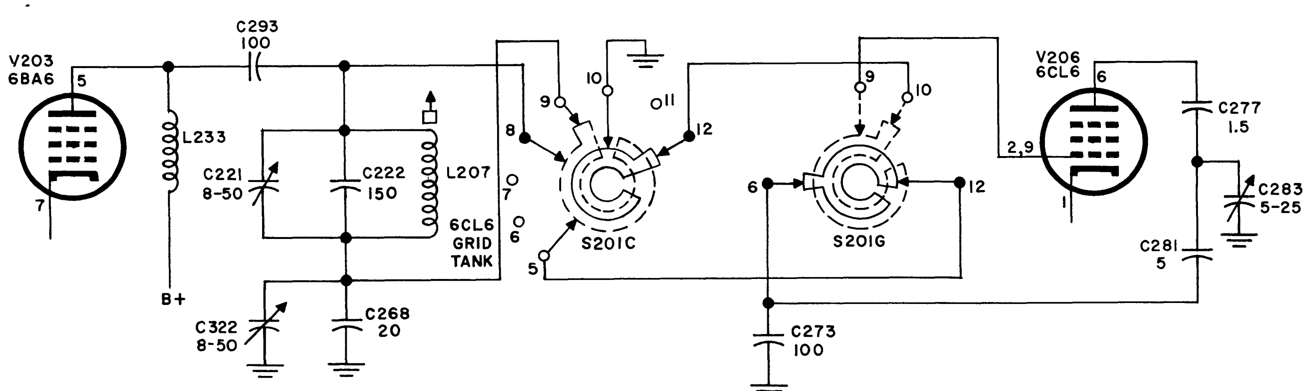

Figure 4-11. 6CL6 Driver Grid-to-Plate Neutralization Circuits (80 Meters), Simplified Schematic Diagram

arm, thus, the tank is across the bridge, and the balanced-out feedback voltage will not affect the stage.

(c) 6CL6 GRID-TO-PLATE NEUTRALIZATION (40, 20, 15, 11 and 10 Meters). There are only two differences between neutralization of grid-to-plate neutralization on 80 meters, and on the higher frequency bands. For the higher bands, C322 and C268 are not placed in parallel to C273 in the bridge circuit. Also, the grid tank components will be different for each band of operation. These differences are shown in the practical diagram of figure 4-13, and the bridge diagram of figure 4-14. Neutralization is accomplished in the same manner as described in subparagraphs (a) and (b) above.

(d) 4X250B GRID-TO-PLATE NEUTRALIZATION. (See figures 4-15 and 4-16.) In this instance, the internal tube capacitances from grid-to-plate (Cgp), and from grid-to-cathode, which is grounded (Cgk), form one side of the bridge. The other side of the neutralization bridge is composed of the Cn capacitance off the 4X250B plate, and C298 off the bottom of the grid tank. The balance of the feedback voltage is accomplished in the same manner as described in preceding subparagraphs (a), (b) and (c). Neutralization capacitor C/N (see figure 6-10) is an adjustable metal bracket mounted close to the plates of the power amplifier 4X250B.

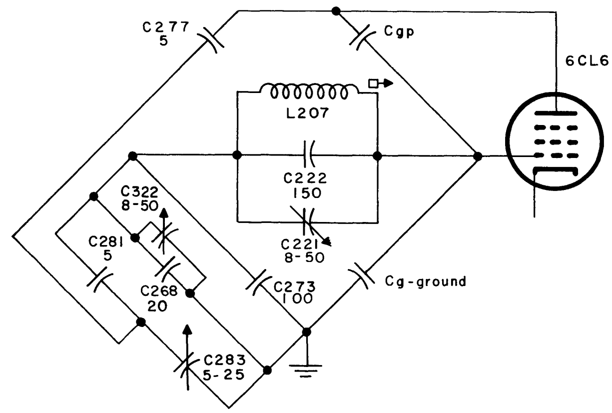

Figure 4-12. 6CL6 Driver Grid-to-Plate Neutralization Bridge Diagram (80 Meters)

c. RECEIVER INJECTION. (See figure 7-1). J201 is connected to the 6CL6 plate circuit to provide receiver injection during calibration procedures. The receiver can be connected to J201 through a "T" fitting in the coaxial line going to the receiving antenna. During calibration, all sections of the KWS-1 Transmitter are turned ON, except the power amplifier. Thus the calibration signal may be heard by the operator to assist in making the proper adjustments. During power amplifier neutralization adjustments, the receiver is connected to J201, and

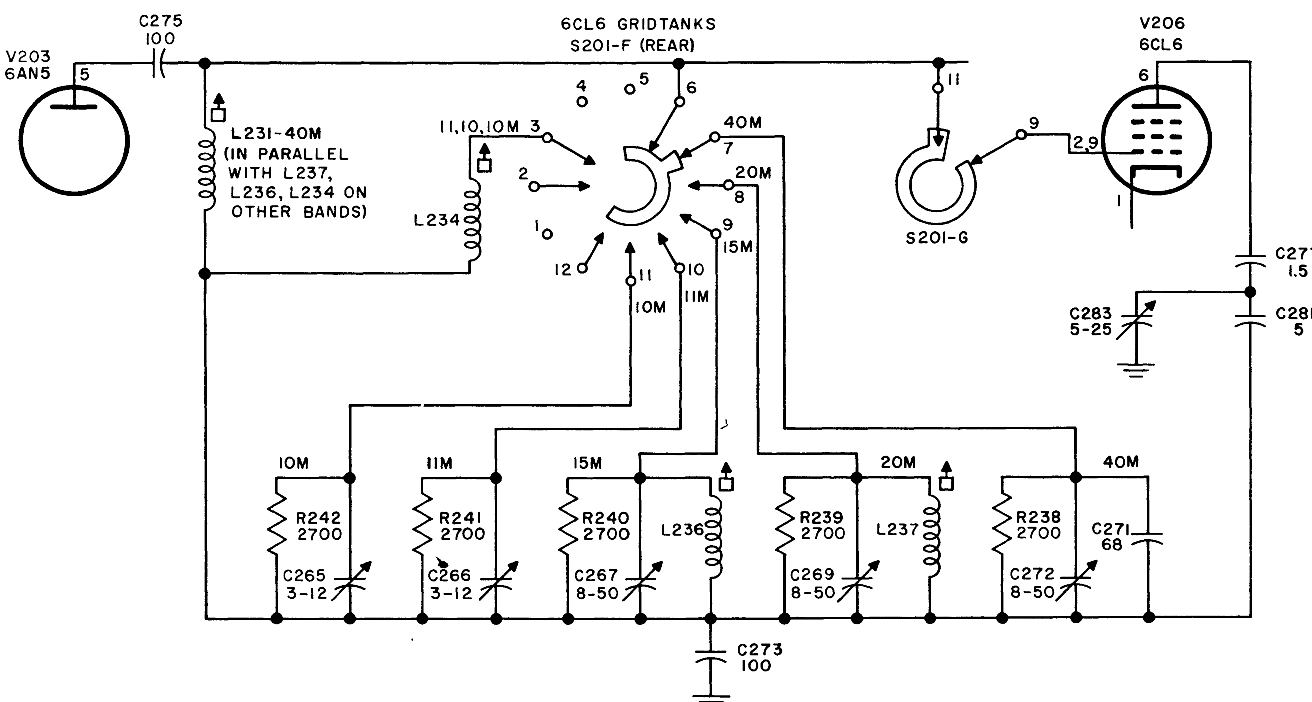

Figure 4-13. 6CL6 Driver Grid-to-Plate Neutralization Circuits, (40, 20, 15, 11 and 10 Meters), Simplified Schematic Diagram

the r-f signal is injected into output connector J401.

d. AUTOMATIC LOAD CONTROL (ALC). The power amplifier circuits include a 6AL5 (V403) duo-diode tube used as a rectifier in the Automatic Load Control system. This system operates very similar to receiver avc circuits to provide a dc voltage on the higher peaks of the 4X250B input. The d-c control voltage is fed back into the Exciter, amplifier stages V202 and V203 to reduce the KWS-1 overall gain, preventing the higher excitation peaks from causing power amplifier grid current flow with resulting distortion in the power amplifier output.

The simplified schematic diagram of figure 4-17 will assist in understanding the circuitry and operational theory of ALC.

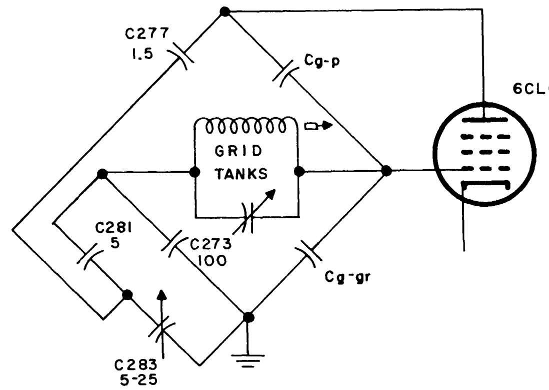

Figure 4-14. 6CL6 Driver Grid-to-Plate Neutralization Bridge Diagram (40, 20, 15, 11 and 10 Meters)

When PA grid current flows, it causes a rise in the PA DC grid voltage across the grid resistors R514 and R515 of the power supply cabinet. This change in voltage is coupled through C403 to the diode clamper and rectifier, V403. V403 gives a DC ALC output voltage whose attack and decay times are controlled by C325, R248, and C324, R247. The action is automatic and actually very narrow pulses of PA grid current do flow. However, they are so short in duration that no ill effects are caused. The ALC voltage is fed out of the power amplifier

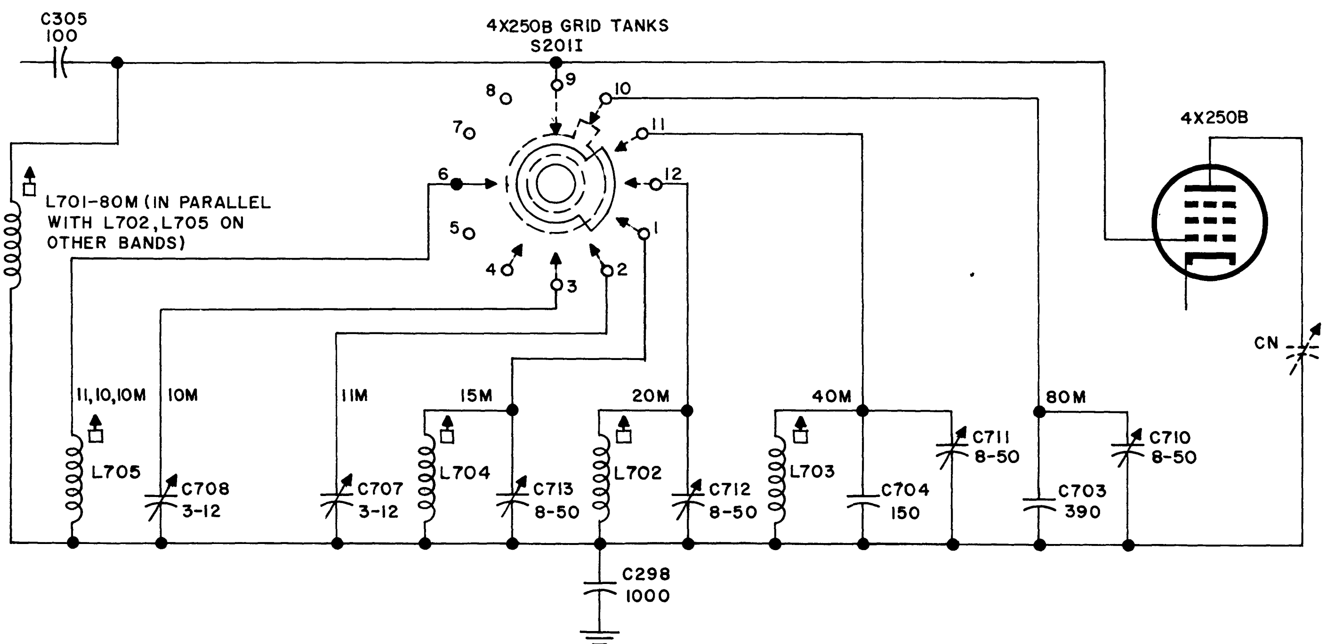

Figure 4-15. 4X250B Final Amplifier Grid-to-Plate Neutralization Circuits, Simplified Schematic Diagram

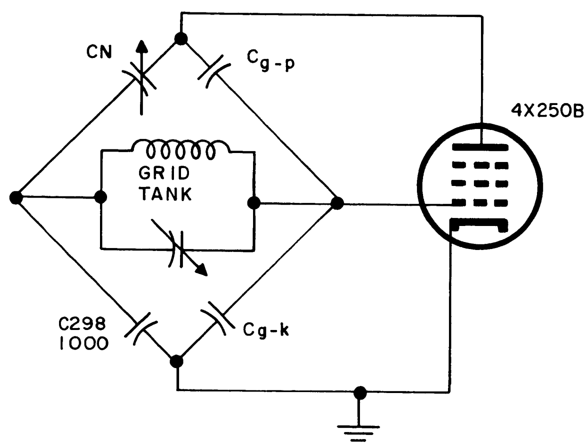

Figure 4-16. 4X250B Final Amplifier Grid-to-Plate Neutralization Bridge Diagram

section, through L247, R205 and the V202 amplifier grid tank circuit inductance L203 and through R213 and the V203 grid tank inductance L206. The additional d-c bias voltage on the V202 and V203 grids decrease the over-all KWS-1 gain, and the excitation peaks which were overdriving the output stages. The measurement of d-c ALC control voltage on amplifiers V202 and V203 is explained in paragraph 4.2.1.5.c. below, under MULTIMETER ALC position.

R406 and C413 are connected in series to ground from the V403 plates to prevent motorboating.

4.2.1.5. MULTIMETER CIRCUITS (See figure 7-1.) Paragraph 4.2.4.6. in this section lists the positions of the MULTIMETER switch (S701) on the Exciter unit front panel. The circuitry involved in each of the five switch positions is described below. Switch terminals 1 and 7 are long contacts connected to either side of meter M201, and are in constant contact with the switch rotor in all positions.

a. PA FIL POSITION. To measure the power amplifier filament voltage, S701 rotor tabs are on terminals 2 and 8. This connects the switch meter terminal 1 to ground through terminal 2, and connects meter terminal 7 to switch terminal 8, which goes through rectifiers CR701 and CR702, and resistor R707 to the 6.3-volt filament supply through jack J103-20 and the power supply TB502-17.

b. PA SCREEN POSITION. The power amplifier screen-grid current is measured when the switch S701 rotor tabs are on terminals 3 and 9. This shunts the one-ohm resistance R705 across meter terminals 1 and 7. Switch terminal 3 is connected to the power amplifier screen grid circuit through feedthrough condenser C415 and choke L405. Switch terminal 9 is connected to jack J103-8 through the K101 relay connections eight and nine. J103-8 is connected to TB501-7 in the Power Supply. This meter circuit is tied in with the TUNE-OPERATE switch S204, which is explained below in paragraph 4.2.1.7.

c. ALC POSITION. The ALC d-c control voltage is fed into amplifiers V202 and V203 through L247 to the control grids. (See figure 4-17.) The ALC meter is connected through MULTIMETER switch S701 across the V202 cathode to the screen grid through R210. The purpose of the meter connected in this manner is to measure the amount of Automatic Load Control voltage in decibels.

To understand how the meter can register decibels in this circuit, the following points should be considered:

a. The R210 screen-grid meter connection provides a reference voltage from the R210-R209 divider.

b. The S701-10 connection to R206 provides a method of measuring the change in V202 cathode voltage due to the ALC d-c control voltage applied to the control grid.

c. The remote cutoff characteristics of V202 produces a change in cathode voltage equivalent to decibels of ALC applied.

Under these conditions, if a curve was plotted for the change in cathode voltage due to the ALC applied, it would essentially duplicate a curve plotted for decibels of change in gain for V202 due to ALC voltage applied to the control grid. Therefore, the MULTIMETER ALC position is calibrated in decibels.

The principles of this circuit are equivalent to the "S" meter hookup in the Collins 75A amateur receivers.

d. PA GRID POSITION. Measurement of the power amplifier control grid current is accomplished when the S701 switch rotor tabs are on switch terminals 5 and 11. This position shunts the five-ohm resistance R706 across switch meter terminals 1

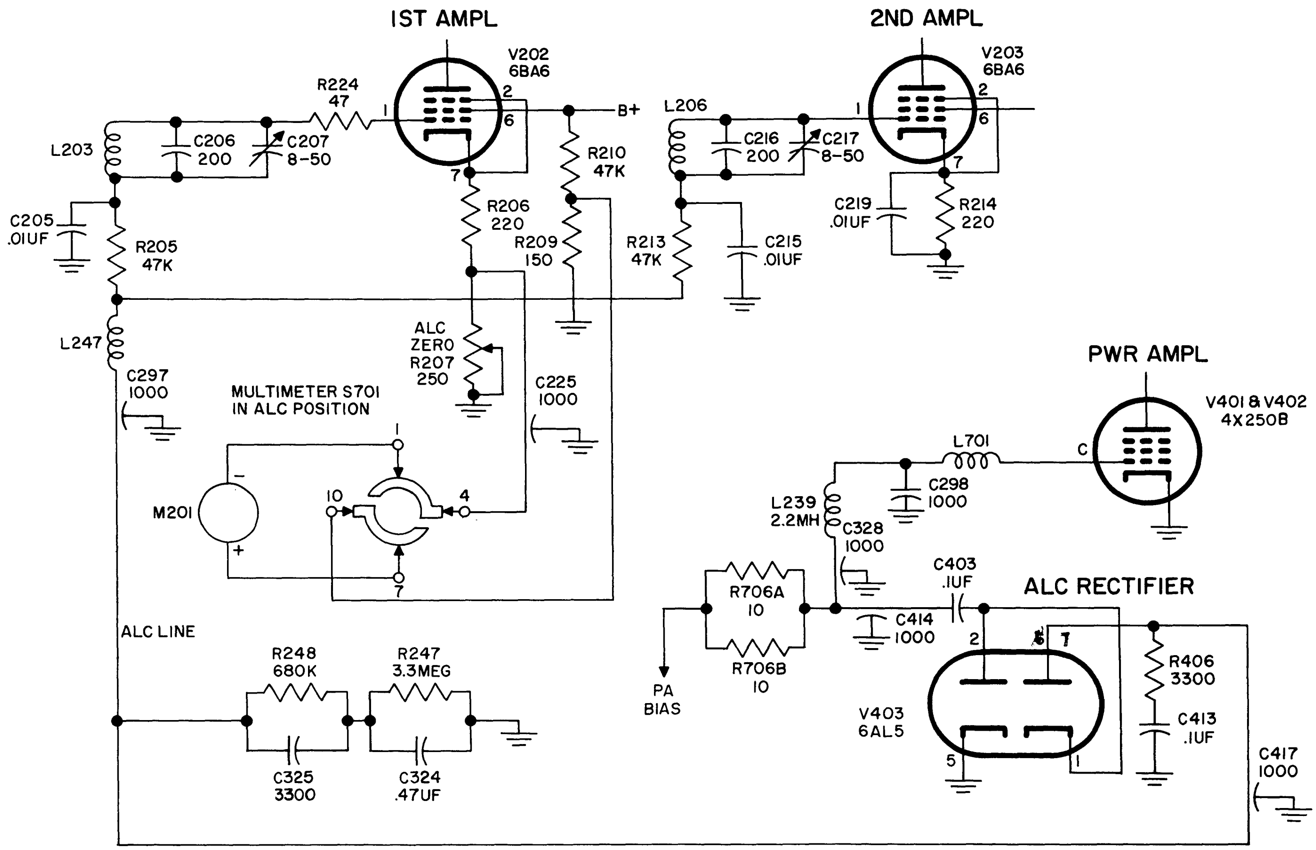

Figure 4-17. Automatic Load Control Circuits, Simplified Schematic Diagram

and 7. Terminal 5 is then connected to the V401 and V402 control grids through feedthrough condenser C328, inductance L239 and the respective grid tank circuits. Switch terminal number 11 is connected to jack J103-2, and to power supply TB501-6. In the Power Supply, the circuit goes to the PA BIAS voltage circuit consisting of R513, R514 and R515, and from here to TB502-19 on the low voltage power supply which is the -150 volt bias supply source.

e. 2000-VOLT POSITION. Adjustment of the MULTIMETER switch S701 to the 2000 VDC position places the switch rotor tabs in contact with terminals 12 and 6. Terminal six grounds one side of the M201 meter, while terminal 12 connects through jack J103-12 and the power supply TB501-9 to the high voltage meter circuit. This circuit in the Power Supply connects to the high voltage source through the meter resistance divider consisting of R517 to R521.

4.2.1.6. PA PLATE CURRENT METER. Constant metering of the power amplifier plate current is registered on the meter in the upper right-hand corner of the front panel. The plus side of this meter, M701, is grounded, while the minus side is connected to J103-14. A connection is made from J103-14 through the interconnecting cable to the power supply TB501-4, and from that point to the ungrounded side of R516. This point is connected to the center tap on the high transformer T503 through the overload relay mounted on K502. R516 serves as safety resistance for the meter circuit.

4.2.1.7. PA TUNE-OPERATE CIRCUIT. The normal 4X250B screen-grid voltage (350 volts) originates in the Power Supply off the cathode of V504, and is fed through TB501-1 and J103-3 to switch S204 on the exciter front panel, labeled TUNE-OPERATE. In its normal position, S204 is closed and the screen grid 350 volts is fed through the switch to terminal eight on K101 relay, and out of the relay through terminal nine to MULTIMETER switch terminal 9. From the switch terminal nine, the circuit passes through R705 to switch terminal 3 and from there to the 4X250B screen grid.

When the TUNE-OPERATE switch is placed in the TUNE position, the above circuit is altered at the source, in that the 350-volt supply passes through R524. The screen-grid voltage, reduced in value, is taken off the lower end of R524 and fed through TB501-7 and J103-8 directly to relay K101 terminal 8, completely bypassing switch S204 which is open.

4.2.1.8. CW WAVE SHAPING NETWORK. The resistive-capacitive network mounted on TB103 provides the necessary circuitry for accepting the -150 volt bias supply from the low voltage power supply, and reducing the supply to the proper value for cw keying of the V206 and V207 driver stages, and V201 first mixer.

The -150 volt supply is fed out of the low voltage supply through TB502-19 to J103-11 on the exciter rear panel. From here, the supply goes directly to TB103.

The cw key lead-in is connected to the Exciter through J102-3, and through S101C-12, S101A-7 to TB103. On TB103, the key is connected across R141 and C134 to improve the cw wave shape during keying operations.

The -150 volts for the cw key is fed through a divider on TB103, consisting of R139, R138 and R141. The key is connected at the junction of R138 and R141. Keying voltage for the driver stages is taken off the divider junction between R139 and R138. Condenser C129 provides additional wave shaping for this circuit. The driver keying voltage is fed out of TB103, through feedthrough C299 and the parasitic suppression components E201 and E202, into the 6CL6 control grids.

Another lead from the R139-R138 junction is connected to a divider consisting of R137 and R136. For the V201 first mixer, the circuit is through TB103-1, R143, the FL101 Mechanical Filter output coil and R201, into the V201 control grid. C127 provides additional wave shaping in this circuit.

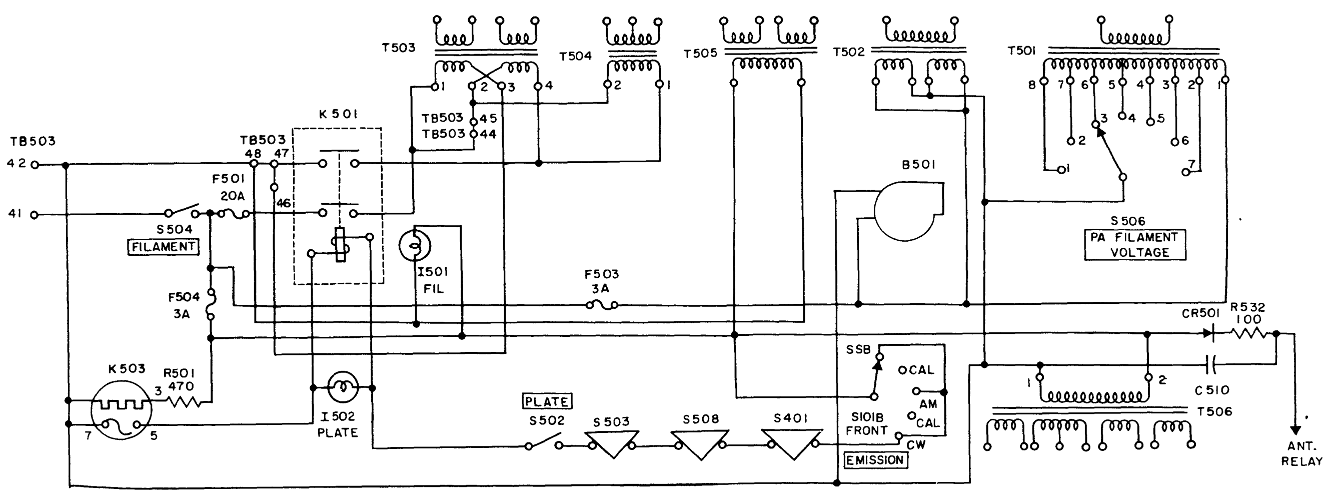

Figure 4-18. Primary Circuits, Simplified Schematic Diagram

The purpose of keying the drivers and the first mixer during keying operation is to bias these tubes past the cutoff point, eliminating "back wave" of the cw signal.

4.2.1.9 INTERCONNECTION OF THE EXCITER AND POWER AMPLIFIER WITH THE POWER SUPPLIES. (See figure 7-3.) Intercabling between the two cabinets of the KWS-1 Transmitter is accomplished by connecting all signal circuits of the Exciter and Power Amplifier to J102 and all supply circuits to J103 on the exciter rear panel. From here, an interconnecting cable (W1) carries all power circuits to the power supply cabinet. The control and signal circuits emerge at J102 into a pendent cable that can be attached directly to the sources of control (key etc.) The supply circuits in the power supply cabinet connect to TB501 or TB502, according to whether the leads are for the high or low voltage Power Supplies. TB503 is for either a 230-volt or 115-volt a-c input to the cabinet from the external source.

The 2000-volt supply for the final amplifier plate circuits is fed from the high voltage Power Supply through a separate cable (W2) directly to jack J402 on the power amplifier chassis. J402 is mounted inside a metal "can" which is mounted on the power amplifier chassis, but protrudes through the exciter rear panel at the lower left-hand corner below antenna jack J401.

4.2.2. POWER SUPPLY CIRCUITS

4.2.2.1. GENERAL. The Power Supply of the KWS-1 Transmitter is designed for either a 230-volt or 115-volt a-c input. The schematic diagram in figure 7-2 shows alternate connections for either input value, whichever is available at the installation. Power supply primary circuits are shown in the simplified schematic diagram of figure 4-18.

The complete Power Supply is essentially divided into two sources, the low voltage Power Supply and the high voltage Power Supply. The circuitry for each is conventional, and the a-c input for both is brought into the cabinet on terminal board TB503. The input is fed through fuses F501 and F502 to HV transformer T503. Fuse F503 protects the filament transformers and the blower; fuse F504 protects filament transformers and the low voltage supply.

4.2.2.2. LOW VOLTAGE POWER SUPPLY. This Power Supply is constructed as a integral unit, to the high voltage supply cabinet with all leads brought out to terminal board TB502. (See figure 6-16.)

Two duodiode rectifier tubes, V508 and V509, operate from one transformer, T506, the primary of which is connected through fuse F504 to the a-c input on TB503-41 and 42.

A connection across the T506 transformer primary coil feeds 110 ac through a selenium rectifier, CR501, which is filtered by R532 and C510 to provide approximately 110 dc for operation of an antenna relay. This output is made available on TB502-14.

Transformer terminals 3, 4, 5, 6, and 7 are taken off the T506 high voltage secondary winding, with the full voltage taken from 3 and 7, and fed directly to the plates of full-wave rectifier V508. The 275-volt d-c output of V508 is filtered and fed to TB502-18 to provide plate and screen-grid supplies for the Exciter.

Transformer terminals 8 and 9 furnish 5 volts a-c for the V508 filaments, while 10 and 11 furnish 6.3 volts a-c to TB502-17 which is fed through the interconnecting cable into jack J103-20 for the exciter circuit tube filaments.

The cathode bias rectifier V509 receives an a-c input from transformer terminals 4 and 6. Connected in this manner, a -150-volt d-c output is available off the plates, which is fed through a filter network to TB502-19, and through the interconnecting cable to exciter jack J103-11 for use in the cw keying and wave shaping network. Another lead off TB502-19 is fed into the high voltage Power Supply, into a resistive voltage divider consisting of R513, R514 and R515. Off the movable arm of potentiometer R515, a negative bias supply voltage is fed through TB501-6 to J103-2 to supply the power amplifier 4X250B stages with the proper value of grid bias voltage.

Transformer terminals 12 and 13 of T506 provides a 12.6-volt a-c source through TB502-15 and 16, to exciter J103-4 and 5 for the RT101 filament regulation circuit of the vfo. The output of RT101 is 6.3 volts, regulated.

4.2.2.3. HIGH VOLTAGE POWER SUPPLY. The leads in the high voltage source feeding off the a-c input line through FILAMENT switch S504 are as follows:

a. Panel light I501, which is mounted on the power supply front panel above the FILAMENT switch. When ON, this light indicates that voltage is being supplied to the filaments of all tubes and the low voltage Power Supply is turned ON.

b. Transtormer T502, which supplies the V501 and V502 with 2.5 volts.

c. Blower B501, connected to the a-c input line through TB505.

d. Thermal Relay circuit K503 and K501. This is the circuit which causes a thirty-second time delay for the high voltage transformer after switch S504 is turned ON, to prevent application of 2000 volts to the plates of V501 and V502 before the tubes have warmed up. Lamp I502 above the switch lights when the time delay period has expired with the PLATE switch S502 ON.

e. The low voltage Power Supply and antenna relay power source.

f. The 115 or 230-volt a-c input to the high voltage Power Supply is fed into two transformers, T503 and T505.

The T505 circuit includes rectifier V503, the output of which is filtered and fed through a voltage regulation circuit consisting of V504, V505 and V506 to provide a regulated 350-volt d-c supply at TB501-1 for the power amplifier screen grids. The PA TUNE-OPERATE circuit components are across the 350-volt supply to ground. This circuit description was given in paragraph 4.2.1.7. above.

V507, a 2D21 thyratron, is used in a screen protect circuit. (See figure 7-2.) Should the bias supply fail, the grid of V507 would lose its bias and allow a large amount of plate current to flow through V507. This plate current is enough to blow screen fuse F505, through which it is drawn, and cut off the PA screen supply. Likewise should a short occur between the plate and screen of the 4X250B tubes, the thyratron would strike and blow the screen fuse. (The plate fuse F506 would likely blow too.)

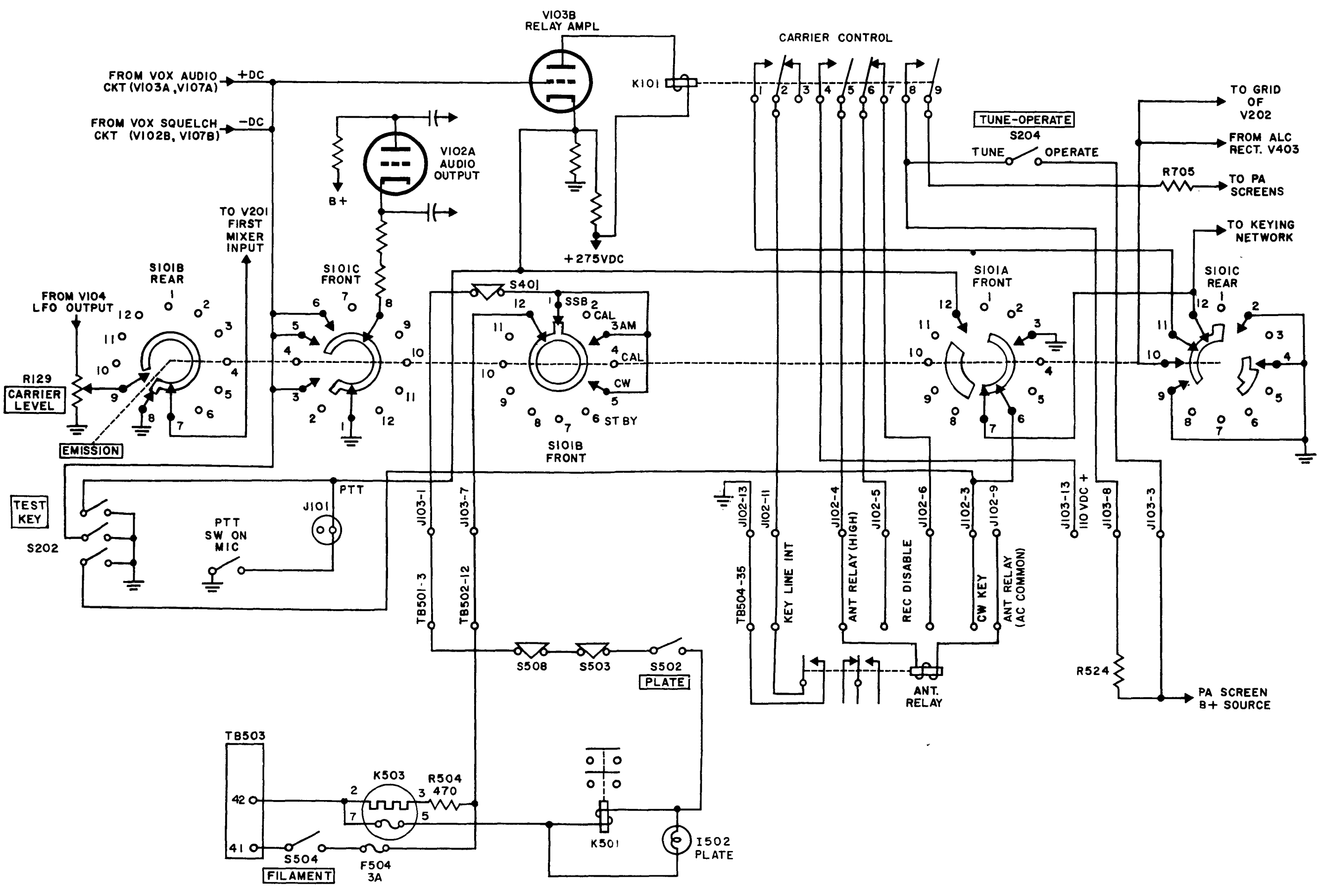

Figure 4-19. Control Circuits, Simplified Schematic Diagram

High voltage transformer circuit of T503 includes the rectifiers V501 and V502. This output is filtered and fed into a separate coaxial cable off an E501 standoff, directly to the Power Amplifier. Resistor R516 is in the power amplifier plate current meter circuit, and is connected from TB501-4 to J103-14. The PA plate current is measured in the negative side of the power supply 2000-volt output, to keep high voltages off the exciter terminals.

4.2.3. CONTROL CIRCUITS.

4.2.3.1. GENERAL. The carrier control circuits are shown in figure 4-19. All filaments and the entire low voltage supply are energized upon closing FILAMENT switch S504. Assuming that the contacts of time relay K503 are closed, the circuit to close plate contactor K501 is from S504 through S101B (front), S401, S508, S503, PLATE switch S502, the coil of plate contactor K501, K503 to TB503 terminal 42. Notice that EMISSION switch S101B (front) opens the circuit in CAL and STBY positions.

Refer to figure 4-19. The following control functions take place at the various positions of the EMISSION selector switch. S101.

4.2.3.2. SSB. S101A front, no action, except key circuit is fed through contacts 6 and 7; S101B front, contacts 1 and 12 are closed to allow PA plate current to be turned on; S101B rear, contacts 7 and 8 are closed to ground the lead going to V201 grid circuit to prevent rf from feeding around the balanced modulator; S101C front, contacts 1 and 3 are open so that the VOX circuits will operate, contacts 1 and 8 are closed so that the audio output tube V102A will operate; S101C rear, contacts 11 and 12 are closed so that the carrier can be turned on by the relay amplifier tube V103B by means of the VOX circuits.

4.2.3.3. CAL. S101A front, no action except key circuit is fed through contacts 6 and 7; S101B front, PA plate current relay circuit is opened at contacts 12 and 2; S101B rear, output of CARRIER LEVEL control is fed through contacts 9 and 7 to provide an r-f signal for calibration purposes; S101C front, VOX control circuit is grounded at contacts 1 and 3 to prevent VOX from interfering with calibration procedure; S101C rear, Exciter is keyed by grounding the key line through contacts 2 and 12.

4.2.3.4. AM. S101A front, no action except key circuit is fed through contacts 6 and 7; S101B front, PA plate current relay circuit is completed through contacts 1 and 3; S101B rear, output of CARRIER LEVEL control is fed through contacts 9 and 7 to provide r-f signal unhindered by balanced modulator; S101C front, contacts 1 and 4 unground VOX circuit so that it may be used to control carrier; S101C rear. contacts 11 and 12 route keying circuit through K101. 1 and 2 so that the VOX circuits control turning the carrier on and off.

4.2.3.5. CAL. This position is treated the same as the first CAL position - refer to paragraph 4.2.3.3. above.

4.2.3.6. CW. S101A front, contacts 3 and 12 ground the cathode of relay tube V103B to close Carrier Control Relay K101, the key circuit continues to feed through contacts 6 and 7; S101B front, PA plate current relay circuit is completed through contacts 12 and 5; S101B rear, output of CARRIER LEVEL control is fed through contacts 7 and 9 to provide excitation; S101C front, contacts 1 and 6 ground the VOX circuit to render the VOX inoperative; contacts 1 and 8 open to disconnect the cathode of audio output tube V102A; S101C rear, contacts 11 and 12 are open to make contacts 1 and 2 of K101 inoperative, contacts 9 and 10 are closed to render the ALC inoperative.

4.2.3.7. STBY. S101A, contacts 6 and 7 open to prevent operation of the key circuits, contacts 3 and 12 open to disable Carrier Control Relay K101; S101B front, contacts 12 and 6 are open to disable the PA plate relay circuit; S101B rear, no function; S101C front, contacts 1 and 8 are open to disable V102A; S101C rear, no function.

4.2.3.8. CARRIER CONTROL RELAY K101. The coil of Carrier Control Relay K101 is excited by the plate current of V103B when (a) the grid of V103B is positive with respect to cathode or (b) when the cathode of V103B is grounded to remove its fixed cathode bias. The first condition occurs when SSB or AM. is selected and the microphone is spoken into; the second condition occurs when CW is selected by the EMISSION switch or when a push-to-talk button circuit is used.

Contacts 1 and 2 of K101 perform the keying function in SSB and AM. emission through the NO key line interlock contacts of the antenna relay. Contacts 2 and 3 (NC contacts) are not used. Contacts 4 and 5 (NO contacts) are used to connect antenna relay coil voltage to J102-4. Contacts 6 and 7 (NC contacts) are used to disable a receiver. Contacts 8 and 9 connect the PA tubes' screen source when transmitting.

4.2.4. FUNCTION OF OPERATING CONTROLS (See figures 3-1 and 3-2.)

4.2.4.1. BAND CHANGE. Selects the proper exciter tuning elements for the amateur band upon which operation is desired. The knob rotates 30° between adjacent bands. Clockwise rotation selects higher frequency bands. The band selected is indicated by the control knob and appears on the slide rule dial.

4.2.4.2. KILOCYCLES TUNING KNOB. Operates both the slide rule pointer and the vernier dial to select the exact frequency upon which operation is desired.

4.2.4.3. EMISSION SWITCH. Selects the type of emission desired. The different switch positions are explained below:

a. STBY POSITION. Adjusts transmitting operation to a standby status. The high voltage is OFF, the cathode circuit of the audio output (V102A) is open, the Automatic Load Control line is open, and the cw key line is open.

b. CW POSITION. Switches transmitting operation for the purpose of cw keying. The cw key is connected into the transmitting circuits and high voltage is ON. The carrier level control is activated, the audio output cathode circuit is open, and the relay amplifier (V103B) grid is grounded. The Automatic Load Control line is also grounded.

c. CAL POSITION. Adjusts the transmitter circuits for the purpose of frequency calibration. The high voltage is OFF and the carrier level control is activated. The grid of Relay Amplifier V103B is grounded. The cathode of Audio Output Amplifier V102A is closed to provide the operator the opportunity of calibration by "talking self on frequency". This position of the EMISSION control provides a signal for calibration procedures through switch S101A and S101C, which closes the cw key line to unblock the first mixer, second amplifier and driver control grids.

d. AM POSITION. Causes the transmitter to produce an AM. output utilizing the carrier and one sideband. The high voltage in ON, the carrier level circuit is connected, and the audio output amplifier cathode circuit is closed. Carrier Control Relay, K101, completes the cw key circuit when VOX or push-to-talk circuits are activated.

e. CAL POSITION. Same as the CAL position described under position c. above.

f. SSB POSITION. Adjusts the transmitter circuits for the purpose of single sideband, suppressed carrier operation. The high voltage is ON and the carrier level control circuit is open. The cathode circuit of the audio output stage is closed. The K101 relay completes the cw key circuit when VOX or push-to-talk circuits are activated.

4.2.4.4. SIDEBAND SELECT. Selects either the upper or lower sideband for transmission by altering the frequency of the low frequency (250 kc) oscillator V104. This control shifts the vfo frame to maintain proper dial calibration.

4.2.4.5. CARRIER LEVEL. Adjusts the amount of carrier reinserted for CW, CAL and AM. operations.

4.2.4.6. MULTIMETER AND PA PLATE CURRENT METER. The MULTIMETER switch on the exciter front panel selects the various circuits to be measured on the meter in the upper left-hand corner.

The PA plate current meter does not have a control knob associated with its operation, but constantly indicates the value of final stage plate current.

Each position of the MULTIMETER switch, and, the PA plate current meter, is functionally explained below. Table 4-2 gives full scale and typical readings for the MULTIMETER.

a. PA FIL. This position of the MULTIMETER switch causes the upper left-hand meter to indicate filament voltage values of the power amplifier final stage. Variations of line voltage will cause the filament voltage to vary, reducing the efficiency of overall operation. Adjustment of this voltage to the correct value (6 volts) should be made after the initial warmup period has expired. The adjustment is accomplished by the PA FILAMENT VOLTAGE control on the power supply front panel.

b. PA SCREEN. The MULTIMETER switch in this position gives the operator a reading of the final amplifier screen grid current. It is used during the operation adjustments of the PA LOADING control on the exciter front panel. (See paragraph 5.1.3.2.) When first switched to this position, the screen current indicated will appear rather high, but this value should fall to 17 ma when the proper level of PA loading is obtained.

c. ALC. This position of the MULTIMETER switch provides a reading in decibels for the amount of Automatic Load Control attenuation being applied to the exciter first and second amplifier stages.

The manner in which a decibel reading is obtained is explained in paragraph 4.2.1.5.c.

In this position, the meter may be adjusted to zero reading by operating the PLATE switch on the power supply front panel to the OFF position and adjusting the ALC ZERO control until the meter needle comes to rest at zero. The ALC ZERO control is a screwdriver adjustment inside the top of the exciter cabinet. (See figure 5-1 and paragraph 4.2.4.20.c. below).

The ALC position of the MULTIMETER switch is also used to monitor the KWS-1 output during actual transmitting operation. This is explained in the operation procedure of paragraph 5.1.3.2. below.

d. PA GRID. This position of the MULTIMETER switch is used in the operation procedure explained in paragraph 5.1.3.2. below, relative to the level of PA grid current necessary for proper operation of the KWS-1 Transmitter.

e. 2000 V DC. This MULTIMETER position is used for measuring the final stage plate supply voltage. The measurement procedure is explained in section V, paragraph 5.1.4.3.b.(8).

f. PA PLATE CURRENT METER. The power amplifier final stage plate circuit operates with an idling plate current, which means the plate current meter in the upper right-hand corner of the exciter front panel should register at least 100 milliamperes at all times during transmitter operation. Adjustment of the transmitter to this level of operation should be made after the initial warmup period has expired, and is accomplished as follows:

(1) The final stage idling plate current adjustment should be made with no r-f drive applied, therefore, the CARRIER LEVEL control should be operated to its zero position, TUNE-OPERATE in OPERATE and PA BIAS ADJUST in CCW position.

(2) To attain proper final stage plate current adjustment, the final stage screen grid voltage should be properly adjusted to 350 volts dc. To accomplish this, connect a voltmeter to M201 terminal with MULT switch in PA SCREEN position. The voltage adjustment is made with a screwdriver on the potentiometer R511 inside the power supply cabinet. (See paragraph 4.2.4.19a, below, and figure 6-12.) In order to make this adjustment, the power supply cabinet front door panel will have to be removed, breaking the interlock connections. Therefore, the adjustment must be made, the door panel returned to position, and the new reading observed on the voltmeter. This procedure should be repeated until a 350-volt dc (300-V Canada) value is obtained on the voltmeter.

(3) After the PA screen-grid voltage is properly adjusted, operate the PA BIAS ADJUST control on the power supply front panel until the plate current meter on the exciter front panel reads 100 milliamperes.

4.2.4.7. PA TUNING. Tunes final amplifier (V401 and V402) plate circuit (continuous coverage from 80 through 10 meters).

4.2.4.8. PA LOADING. Adjusts amount of loading for final output circuit (continuous coverage from 80 through 10 meters).

4.2.4.9. TUNE-OPERATE. This is the toggle switch in the front panel lower left-hand corner. It lowers the power amplifier (V401 and V402) screen-grid voltage when the control is in the TUNE (down) position. Prevents plate current soar during initial tuning.

4.2.4.10. TEST KEY. Energizes the transmitter signal circuits for tune-up procedures.

4.2.4.11. DIAL DRAG. This control applies a braking action to the KILOCYCLES, vernier tuning control to prevent its turning when the SIDEBAND SELECT control is operated. The purpose of the DIAL DRAG is not to completely lock the vernier control dial, and should never be left in a tight adjustment.

4.2.4.12. ZERO SET. Operates the slide-rule pointer on the KILOCYCLES vernier scale during calibration adjustments. Once it has been set, further adjustments will be unnecessary over long periods of time.

4.2.4.13. VOX SPEECH. Adjusts the gain of the V103A voice operate circuits.

4.2.4.14. VOX SPEAKER. Adjusts the gain of the V102B speaker squelching circuit. This control is a potentiometer located inside the exciter cabinet. It is accessible by raising the top cover, and may be found at the inside top edge of the front panel, toward the right end. (See figures 3-1 and 6-2).

TABLE 4-2

TYPICAL METER READINGS

CONTROL POSITION	CIRCUIT METERED	FULL SCALE READING	TYPICAL READING
PA FIL	PA Filament Voltage	10 V, ac	6 Volts
PA SCREEN	PA Screen Current	50 ma, dc	Starts at approximately full scale, and decreases as PA is loaded, reaching about 17 ma when proper loading level is obtained.
ALC (Automatic Load Control)	Decibels of ALC attenuation	18 db	Typical reading depends upon final stage drive.
PA GRID	PA Grid Current	10 ma, dc	Typical reading depends upon amount of final stage drive. In AM. and SSB grid current is zero. In CW grid current can be as high as 7 ma.
2000 V DC	Final stage plate supply	5000 V, dc	Approximately 2000 volts, dc.

4.2.4.15. PA FIL ADJUST. Adjusts the 6-volt filament supply applied to V401 and V402.

4.2.4.16. PA BIAS VOLTAGE. Adjusts the grid bias voltage applied to V401 and V402. This is utilized for adjustment of final stage plate current to proper idling level. (See paragraph 4.2.4.6.f. above).

4.2.4.17. FILAMENT. Applies supply voltages to all filaments in the KWS-1 Transmitter, the blower, the low voltage power supply, and to the regulated final screen-grid supply circuit. To prevent damaging the power amplifier tubes, the screen grid supply is never applied to the tubes unless the high voltage is ON. When the FILAMENT switch is operated, a green light above the switch goes ON.

4.2.4.18. PLATE. Turns ON high voltage to tubes V401 and V402. In this circuit, there is a time delay of thirty seconds provided by Thermal Relay K501, after the filament circuits have been activated.

4.2.4.19. INTERNAL SCREWDRIVER ADJUSTMENTS.

a. PA SCREEN VOLTAGE. Adjusts amount of voltage applied to the power amplifier stage screen grids to 350 volts. This adjusting facility (R511) is located in the power supply cabinet. (See figure 6-12 and paragraph 4.2.4.6.f.(2) above.)

b. ALC ZERO. This adjustment is inside the exciter cabinet top side, to the left of center. Its purpose is to adjust the multimeter ALC action to zero, and is made only when the FILAMENT switch is ON and final amplifier supply is OFF. The EMISSION switch should be in the CAL position.

4.2.5. EXTERNAL CONNECTIONS.

4.2.5.1. EXCITER/POWER AMPLIFIER CABINET.

a. FRONT PANEL. (See figure 3-1.)

The only external connection to be made on the exciter front panel is to the J101 microphone jack. This jack is located in the lower right-hand corner of the front panel.

b. REAR PANEL. (See figure 2-1.)

There are five external connections to be made on the exciter and power amplifier rear panel.

(1) J102/P102. All signals and control circuits of the Exciter which require external connections are brought out to J102/P102 on the rear panel and fed through the interconnecting pendent cable.

(2) J103/P103. This connection provides an input from the high voltage Power Supply and low voltage Power Supply for all B plus and filament supplies necessary for the operation of the Exciter and Power Amplifier, except the 2000-volt supply to the final amplifier stages. All wiring to J103 is fed through the W1 interconnecting cable from terminal boards TB501 and TB502 in the power supply cabinet.

(3) J104. This receptacle is located on top of the exciter's audio chassis. It is a 600-ohm connection for phone patch. Use a 1 mf capacitor in series if the phone patch does not have dc isolation.

(4) J402/P402. The power amplifier 2000-volt supply is brought directly from the high voltage Power Supply output at E501, and through separate interconnecting cable (W2) to the power amplifier chassis. J402 is mounted on the power amplifier chassis, and protrudes through the exciter rear panel in a shielding "can" located at the lower left-hand corner below the antenna jack J401.

(5) J401/P401. This connection provides the r-f output for the KWS-1 Transmitter.

(6) BLOWER. The blower for the KWS-1 forced air cooling system is located in the power supply cabinet and is interconnected to the power amplifier chassis through a flexible hose. The connection is made to an elbow on the rear wall of the Power Amplifier, which protrudes through the center of the exciter rear panel wall.

(7) A good, external ground connection may be made to the ground stud adjacent to the terminal strips.

4.2.5.2. HIGH VOLTAGE AND LOW VOLTAGE POWER SUPPLIES.

a. FRONT PANEL. (See figure 3-2.)

There are no front panel connections to be made on this unit.

b. REAR PANEL. (See figure 6-15.)

The "rear panel" referred to is the horizontal plate, mounted about one third the distance up from the chassis bottom TB502 and TB501 terminal boards are the inner left and right-hand boards, respectively, on the horizontal plate, looking into the rear of the cabinet. (See figure 6-15.) TB503 is the black-colored terminal board (to which either a 230 or 115-volt a-c input connection is made). TB503-42 should be used for the a-c common connection. The control and signal circuits are brought out of pins in plug P102 at the rear of the exciter unit. The circuits are explained below.

(1) J102-2. Connects to the exciter V103B relay amplifier cathode, which operates Carrier Control Relay K101. Externally, J102-2 connects to the high side of the push-to-talk switch.

(2) J102-3. This lead is fed through to switch S101B (front) terminals 7 and 6, to the grid-block keying network. Externally, this line connects to the high side of the cw key.

(3) J102-4. Feeds through to the normally open contacts 5 and 4 of Carrier Control Relay K101. When these contacts close, the circuit is fed through J103-13 to the low voltage Power Supply TB502-14. This is a rectified 110 volts dc, 22 milliamperes supply for operating a 4000-ohm antenna relay coil mounted externally to the KWS-1 Transmitter. The low side of this circuit is furnished by J102-9.

(4) J102-5 and 6. These leads connect through to the normally closed contacts 6 and 7 of the Carrier Control Relay K101. Externally, the leads connect into a receiver's standby circuits.

(5) J102-7. Provides a 500-ohm audio frequency input through to the VOX SPEAKER gain

control potentiometer R122, and to the grid of amplifier V102B in the speaker signal squelch circuits. Externally, this lead connects to the high side of the 500-ohm VOX audio source.

(6) J102-9. This lead feeds directly out J103-6 to TB502-11 of the low voltage Power Supply a-c common connection. Externally, J102-9 connects to the low side of the antenna relay.

(7) J102-13. Provides a ground connection in the Exciter, and a ground for the externally connected cw key, push-to-talk VOX circuits and ant. interlock circuits.

(8) J102-11. This lead (along with the ground lead above) connects to a set of normally open contacts on the antenna relay. This prevents the carrier from coming on before the antenna is connected to the transmitter output.