DESCRIPTION

GENERAL

The Type TT-5A Television Transmitter illustrated in Figure 1 combines in one group of cabinets the components of both a visual (picture) transmitter, and an aural (sound) transmitter. Designed for operation in channels 2 to 13, the visual portion of the transmitter accepts a standard RMA picture signal between the limits of one to two and one-half volts, peak-to-peak, and produces a high-definition, modulated r-f signal at the desired frequency. The aural portion of transmitter converts a standard audio input of 10 dbm, plus or minus 2 dbm, into a frequency-modulated r-f signal.

For operation in channels two to six, 54 to 88 megacycles, three r-f stages precede the power amplifier in both the visual and aural sections. Channels seven to thirteen, 174 to 216 megacycles, include two additional high frequency stages in both sections. In all instances the r-f driver stages are straightforward, narrow-band amplifiers or multipliers. Power output of the aural section is nominally 2500 watts; normal peak power output of the visual section is 5000 watts.

High-power circuits are protected by quick-acting overload relays and thermal-type circuit-breaker switches. Similar circuit-breaker switches protect the water-cooler, blower, filament, and low-power circuits. Circuit fuses are of the visual indicating type and except for those in the line voltmeter circuit, are mounted in a group on the front of the Control panel.

Indicator lamps and most of the meters are mounted on the upper front of the cabinet sections; the remainder of the meters are situated within the equipment.

Where required, individual blowers are supplied for tube cooling. The Power Amplifier tubes are air and water cooled, utilizing a separate water cooling unit for temperature control of the distilled water in the system. Depending upon the transmitter series number, either of the water cooling units illustrated in Figures 3 and 4 may be supplied.

A control console is supplied with the TT-5A transmitter to facilitate control and monitoring of the aural and visual sections. Aural and visual level controls and switches, indicator lamps, and meters essential for transmitter operation are incorporated in the console which is shown in Figure 2.

A panel pushbutton switching system consisting of four banks of five buttons each aids monitoring by furnishing the console operator with a convenient means for viewing or checking the aural and visual signals at selected points in the transmitter system. Choice of circuits to the console VU meter, kinescope, and oscilloscope, as well as to the sound monitor, is provided by these pushbuttons.

A Type WP-33 series, or similar, power supply not furnished with the console, is required for supplying plate voltages to the master monitor in the console. This power supply may be mounted in the accessory Television Station Monitoring Equipment racks which provide the necessary space for this unit.

The Television Station Monitoring Equipment listed under the preceding heading "Equipment" provides accessory items required for complete monitoring of the transmitter. Two racks included with monitoring equipment furnish space for the various units listed. When all units are in use the visual and aural input signals may be monitored and controlled. In addition, the output of the visual modulator and the demodulated r-f output of the visual and aural sections may be monitored. Provision is also made for continuous monitoring of the r-f carrier frequency of each transmitter section.

A switch located at the bottom of each rack controls the a-c power to all equipment in that rack, except power to the frequency monitors. These switches are connected in series with the Console switch of the control console. Power for the frequency monitors is supplied from a separate circuit.

Detailed description of the monitoring equipment units is supplied in the instruction book accompanying each unit.

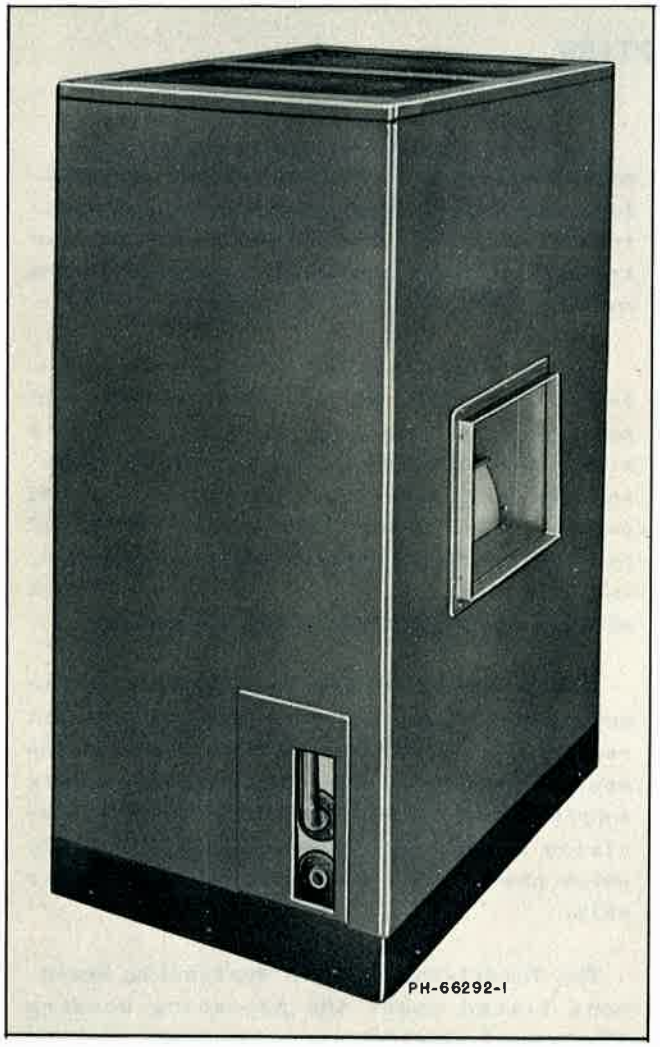

Figure 3 - Water Cooling Unit (MI-19045)

If ordered, a dummy r-f load and wattmeter are supplied with the transmitter. The r-f load and wattmeter provide the proper transmission line termination for testing purposes. Power into the load is indicated on the accompanying portable wattmeter. The sideband filter is permanently tuned and designed for installation between the visual power amplifier and the antenna. During transmission the filter operates by removing a portion of the lower sideband so that the signal passed will meet FCC and RMA requirements.

CONSTRUCTION

The TT-5A Television Transmitter is housed in eight steel cabinets bolted to base structures which are divided so that the eight cabinets may be placed in a straight line or in several "U"-type arrangements. Each cabinet is provided with a front and rear door. "Walk-in"-type construction is used with side-panel mounting of sub-assemblies. End trim and meter panels complete the transmitter enclosure.

Removable air filters are provided near the bottom of the rear doors. Exhaust fans are mounted on the ceiling, a light is installed in the top, and a convenience outlet provided at the bottom of each cabinet.

High-voltage grounding hooks are located in each cabinet with copper cable of sufficient length to reach all components.

The control console, of all-metal, turret-type construction, is designed with a control panel on each side of the centrally-positioned master monitor. The power control panel on the left side contains power switches and indicator lights. Monitoring controls, gain controls, and three meters are mounted on the monitor control panel at the right of the console. Each panel, fastened at each top corner by a fastener, is hinged at the bottom so that either panel assembly may be tilted forward for rapid inspection or adjustment.

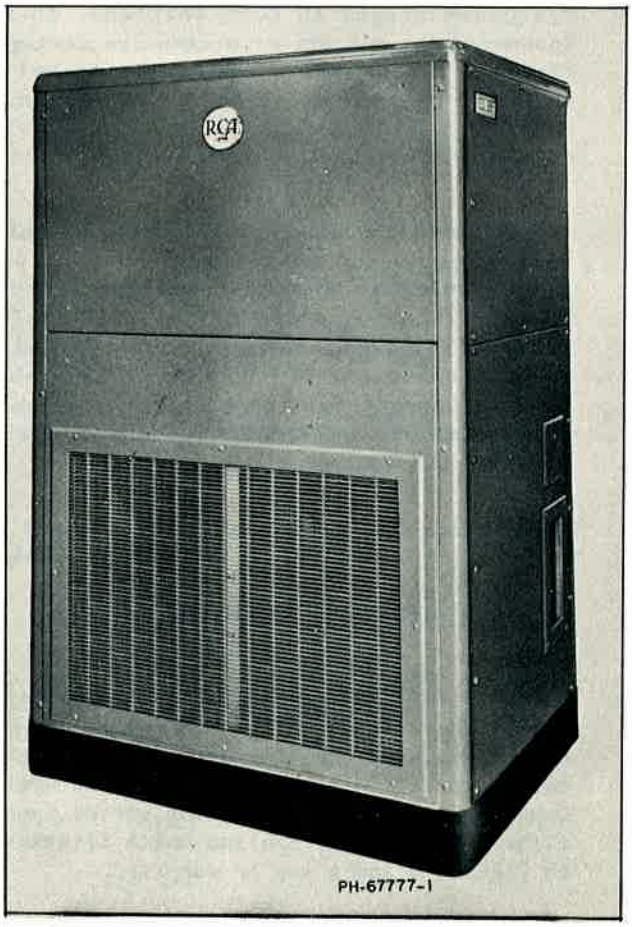

Figure 4 - Water Cooling Unit (MI-19045-A)

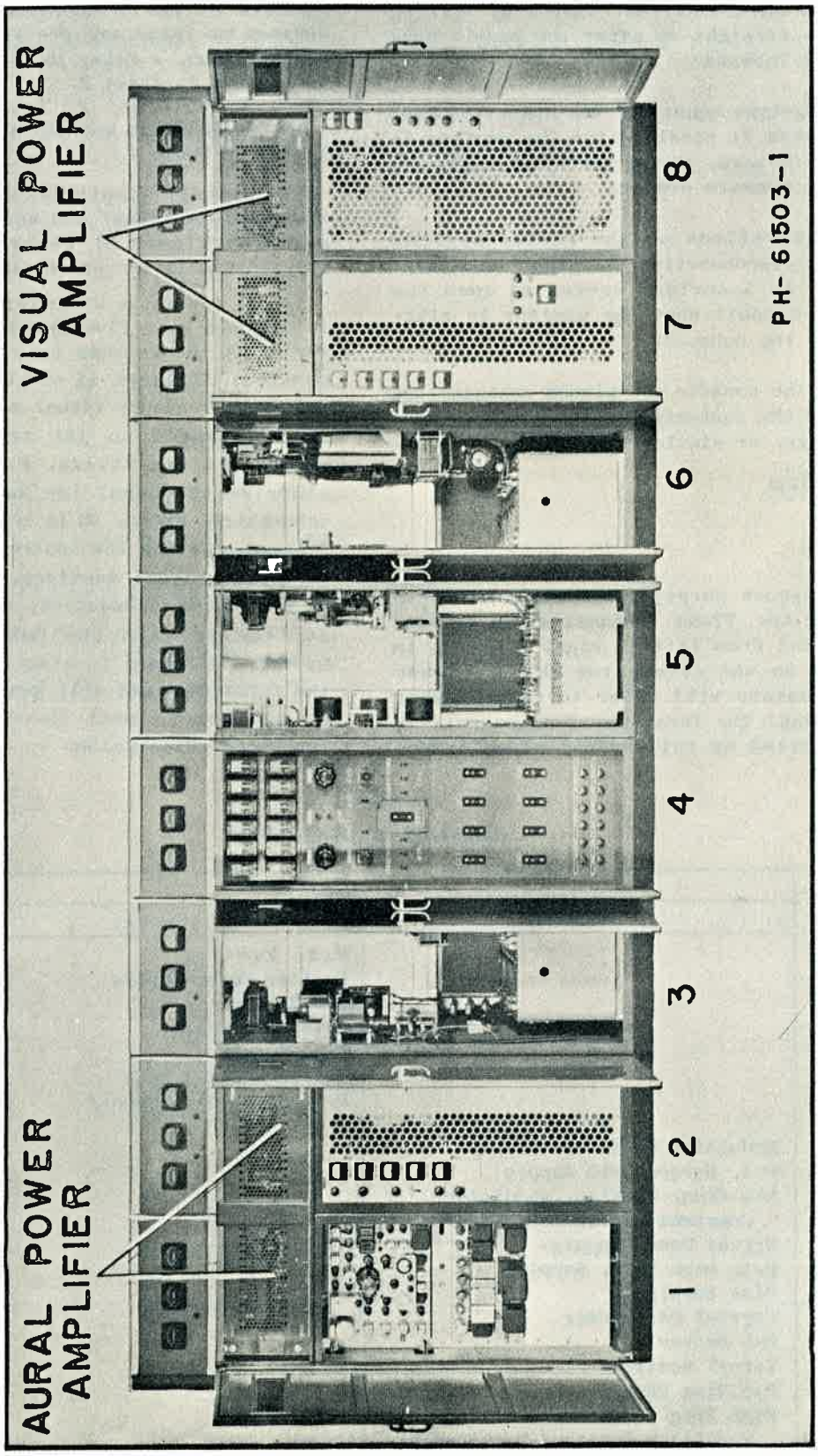

Figure 5 – TT-5A Transmitter, Front View, Doors Open

The turret covers may be removed by lifting the covers straight up after the panels have been swung forward.

A sliding-type mount for the master monitor section makes it possible for the monitor to be pulled forward, either partly or completely out of the console proper.

Plug connections on the master monitor facilitate disconnecting the signal and power circuits. An interlock serves to open the d-c power circuit when the monitor is withdrawn from the console.

Each of the console end pieces contains two shelves for the convenient storing of records, station logs, or similar material.

TRANSMITTER

GENERAL

For reference purposes the eight cabinets into which the TT-5A transmitter is divided are numbered from left to right as shown in Figure 5. In the discussion which follows cabinet numbers will refer to these number designations. The location of components is also expedited by this system since symbol numbers of parts mounted in a particular cabinet or frame are prefixed by the cabinet number. Thus, a relay in the 200 series would be located in frame 2.

The major units mounted in each cabinet are listed in Table 1.

The overall simplified block diagram for the complete visual and aural transmitter is shown on Figure 6, while Figure 7 is the overall simplified schematic diagram.

Actual schematic diagram for the transmitter is divided into five drawings which are inserted at the extreme rear of this book. Two portions, Figures 91 and 93, cover the low and high-frequency visual sections, (channels 2 to 6, and 7 to 13) respectively. Two similar illustrations, Figures 92 and 94, comprise the aural low and high-frequency schematics. Figure 90 is the common schematic diagram covering the control circuits for the aural and visual sections. As will be noted on the actual schematics, each tube position is labeled with the tube socket symbol number. Reference to stages or tube types in the following text will generally be followed by the socket symbol (X---) to designate the tube under discussion.

TABLE 1

LOCATION OF MAJOR UNITS

CABINET NO.	UNITS		
	VISUAL	AURAL	COMMON
1		F.M. Exciter	
1		Exciter Power Supply	
2		R-F Driver	
1,2 (top)		Power Amplifier	
3		Bias Supply	
3		Driver Power Supply	
3		P.A. High Volt. Supply	
4			Control
5	Modulator Rectifier Supply		
5	P.A. Screen Grid Supply		
5	Low Freq. Section, Modulator Constant-Resistance Network		
6	Driver Power Supply		
6	P.A. High Volt. Supply		
6	Bias Supply		
7	Crystal Oscillator		
7	R-F Driver		
8	Visual Monitor		
8	P.A.Bias Supply		
8	High Freg. Section, Modulator Constant-Resistance Network		
7,8 (top)	Power Amplifier		

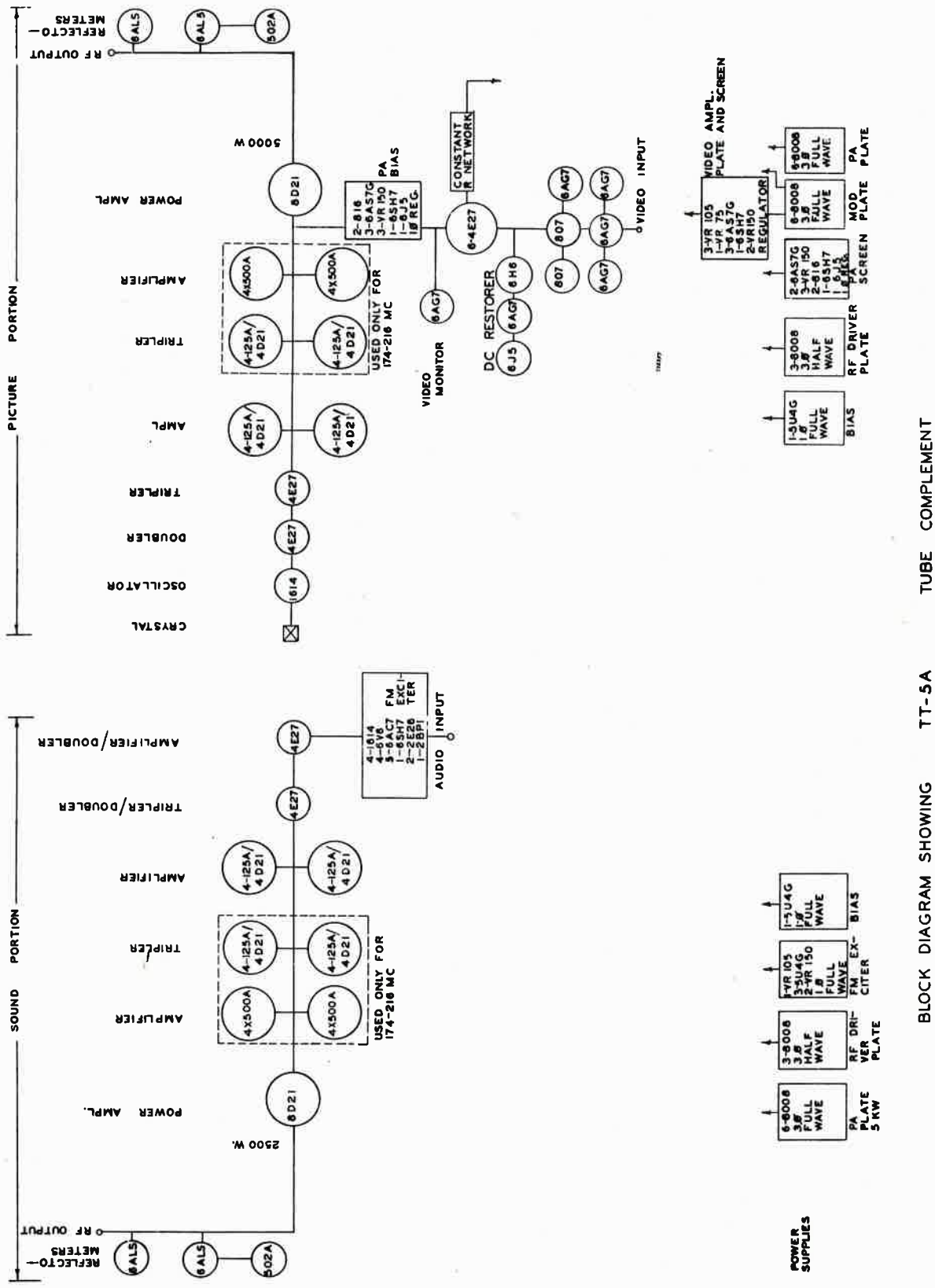

Figure 6 - Overall Simplified Block Diagram of TT-5A Transmitter (738359-sub 0)

VISUAL SECTION

R-F Circuits, Visual — The frequency of the visual section of the transmitter is controlled by a quartz crystal in the oscillator stage. Provision has been made for the insertion of three RCA type TMV-129C, thermostatically-controlled, crystal units, selection being made by switch S712. Indicator lamps are provided for each crystal to indicate functioning of the thermostat elements.

An RCA type 1614 tube (X704), with its plate circuit tuned to twice the crystal frequency, is used in the oscillator circuit, which is link-coupled to a doubler stage.

The doubler stage consists of an RCA type 4E27 tube (X710) with both the input and output circuits tuned. Capacitance coupling is used between the doubler and the tripler stage (X711).

The tripler stage is inductively coupled to the tuned grids of two RCA type 4-125A/4D21 tubes (X712, X713) connected in push-pull. For the frequency range of 54 to 88 megacycles, this stage is the driver, (intermediate-power-amplifier), for the power-amplifier tube. When the transmitter is operated in the range of 174 to 216 megacycles, this stage is inductively coupled to an additional tripler stage utilizing push-pull 4-125A/4D21 tubes (X716, X717). This tripler is also inductively coupled to the push-pull 4X500A tubes in the second IPA stage.

An RCA type 8D21 (X714) twin tetrode tube is used in the power-amplifier stage. R-F excitation is applied to the grids in push-pull, and the modulation voltage is applied to the control grids in parallel. The grid tank circuit tunes to one-quarter wavelength on channels two to six, 54 to 88 megacycles, and to three-quarters wavelength on channels seven to thirteen 174 to 216 megacycles.

Oscillator crystal frequencies and the operating frequencies of the visual r-f stages are included in the tuning data tabulations, Tables 9 and 10.

Damping resistor R735, connected to the grid tank circuit of the power amplifier, absorbs a constant amount of power from the driver tubes, and tends to minimize loading changes on the driver during the transition from zero grid current to maximum grid current white to black. The r-f driving voltage is thus held nearly constant over the modulating range, improving the linearity of the modulation characteristic in the high output region.

Power output is coupled from the plate tank to the series-tuned, inductively-coupled output circuit. The Plate and output circuits are tuned to achieve a broadband response characteristic.

The power-amplifier output circuit is the only broadband circuit in the r-f portion of the transmitter, the broadband response being achieved by tighter than critical coupling. A panel control facilitates adjustment of the mutual coupling. Similarly, plate tank tuning, and output circuit tuning controls are available on the front panel. For a complete discussion of television power amplifier "broad-banding," reference should be made to the tuning of the visual power amplifier under INSTALLATION.

A balun unit is used to match the push-pull output circuit to the single-ended transmission line.

Modulator, Visual -- Three RCA type 6AG7 tubes (X801, 2, 3,) are connected in parallel and used as an input amplifier stage for the visual signal. Input gain is controlled by potentiometer R922 in the grid circuit of this stage. Remote control of the input gain is achieved through a friction drive connection between the potentiometer and a reversible motor, B803, controlled by a switch on the console.

A rheostat, R921 in the input stage permits compensation for variations in input cable impedance. A variation of termination resistance in the range of plus or minus five per cent of 75 ohms is made possible by this control.

The input tubes are coupled to a second stage of amplification through a high-frequency compensating network. This stage consists of a pair of RCA type 807 tubes (X810, X811) connected in parallel. Leveling of the input signal due to grid current is provided to maintain the visual signal on the proper portion of the tubes operating characteristic, independently of the picture background (d-c component of the signal).

According to FCC standards, the synchronizing pulse must constitute 25 per cent of the input signal value. To compensate for the

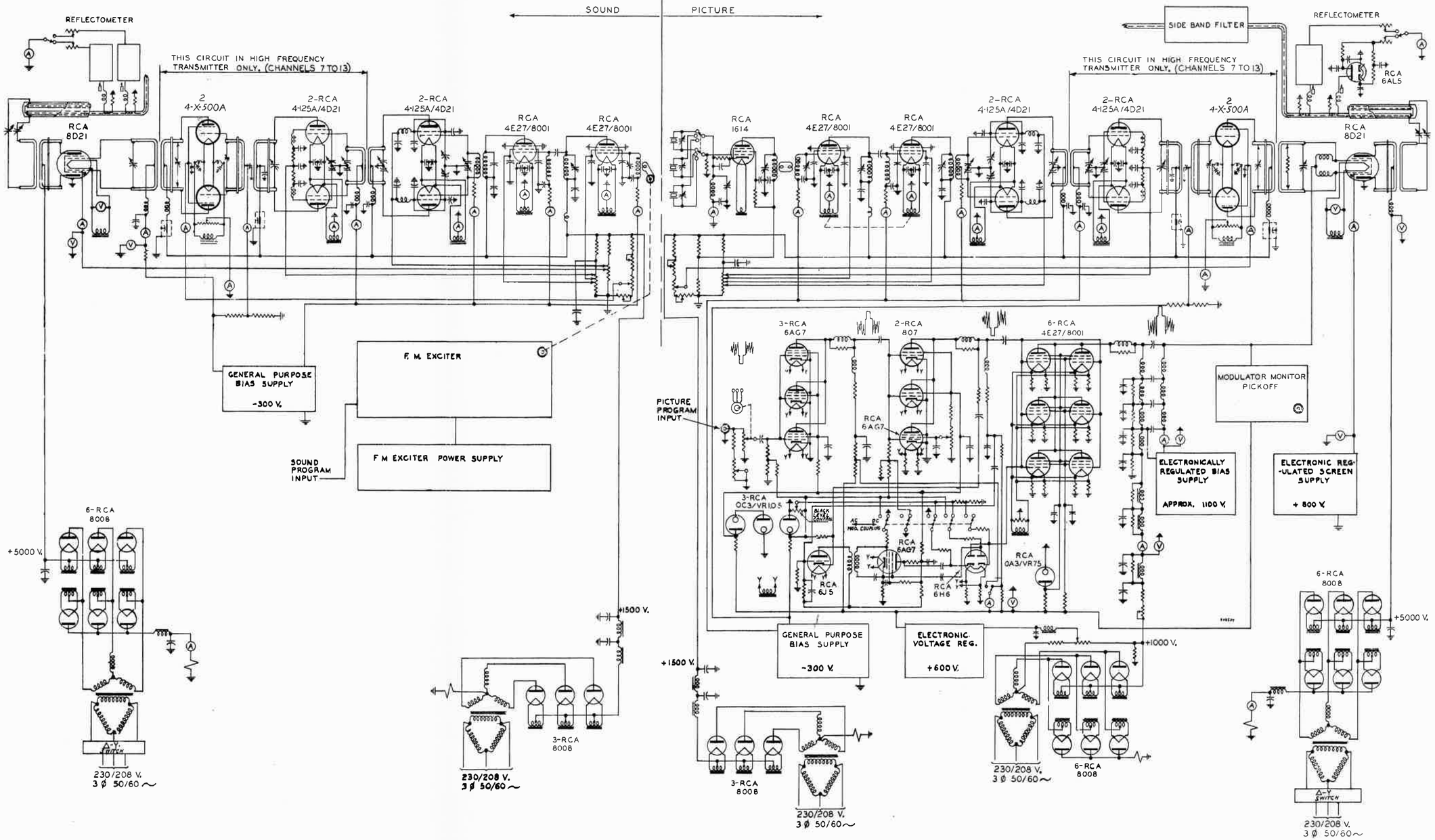

Figure 7 – Overall Simplified Schematic Diagram of TT-5A Transmitter (308834-sub 2)

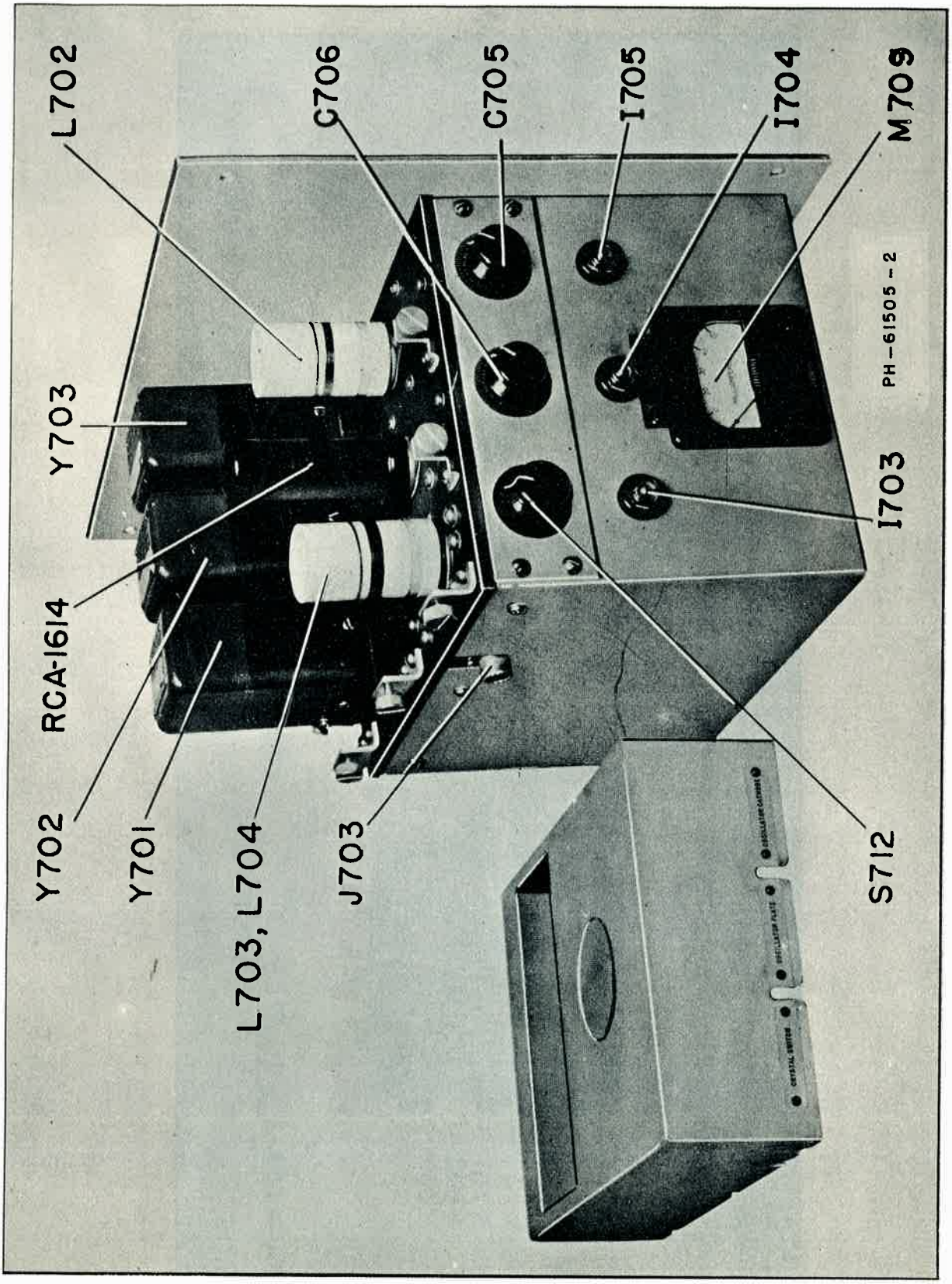

Figure 8 – Crystal Oscillator, Visual - Top View

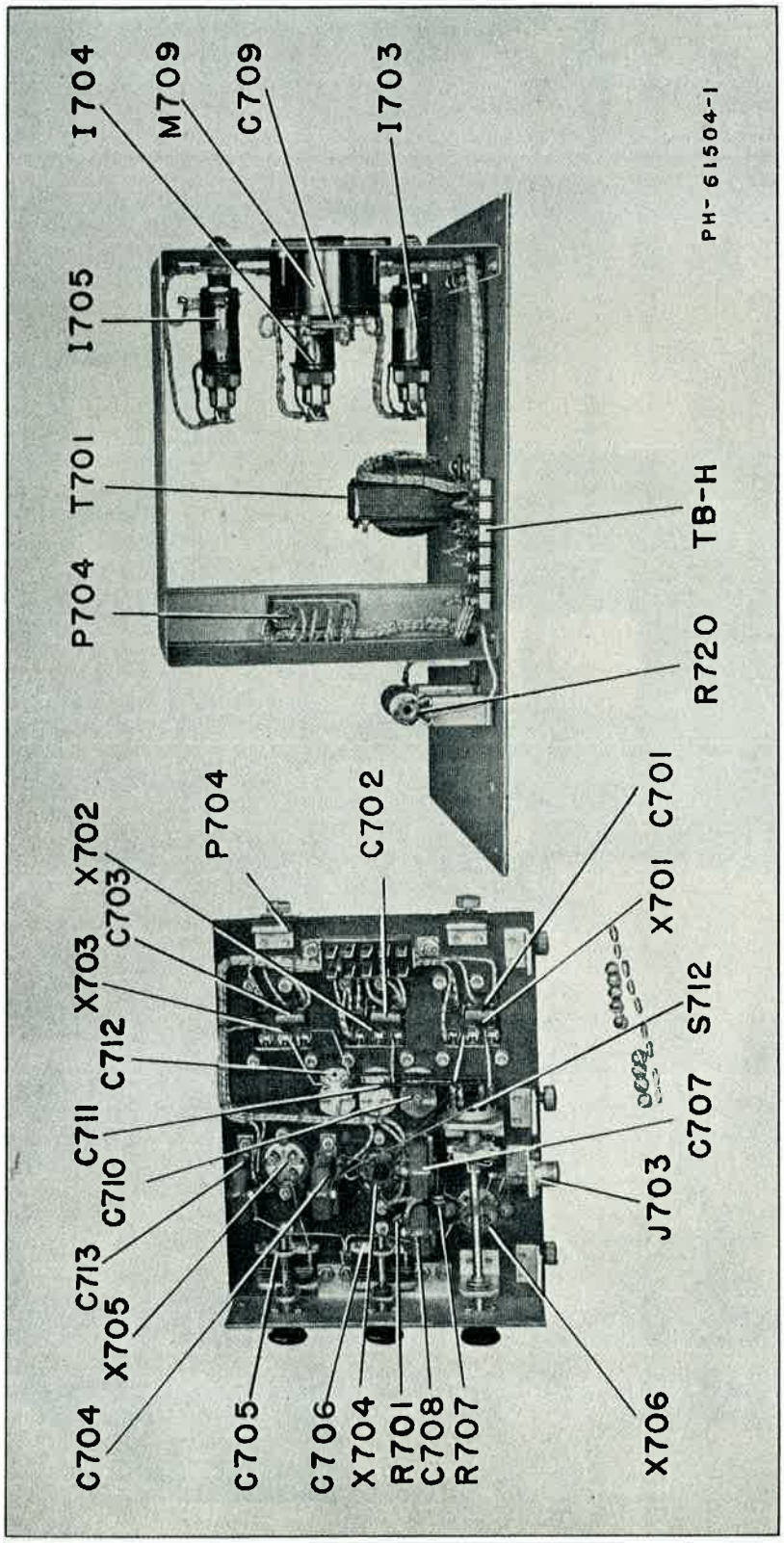

Figure 9 - Crystal Oscillator, Visual - Bottom View

loss in amplitude of this pulse due to compression in the modulator and PA stages, an RCA type 6AG7 tube (X806) is connected in parallel with the two type 807 tubes. As the 6AG7 tube has a sharp cut-off feature and a high mutual conductance, this tube can be adjusted to expand the synchronizing pulse. Expansion is accomplished by increasing the combined plate current through the load during the pulse interval. The amount of current flowing in the plate circuit of the 6AG7 tube is controlled by potentiometer R904 in the screen grid circuit of the tubes.

A "clamp" type of d-c restorer used in the modulator consists of an RCA type 6J5 tube (X813) used as a grounded-grid, synchronizing pulse separator. This stage is transformer-coupled to an RCA type 6AG7 tube (X814). The transformer (L805) is tuned by the associated tube and stray circuit capacities so that one-half cycle at resonant frequency is between the limits of two, and two and one-half microseconds' duration.

During the horizontal synchronizing pulse interval, the 6J5 tube is conducting and causes a charging current to flow in the transformer circuit. After the synchronizing-pulse interval the 6J5 is cut off by reason of the bias voltage accumulated on its coupling capacitor. The tuned transformer then dissipates its stored energy in the form of a damped oscillation. Transformer L805 is highly damped by core losses and to some extent by circuit losses so that the first pulse, the one immediately following the synchronizing or charging pulse, is the only pulse of any consequence. This is applied with positive polarity to the 6AG7 which levels because of grid current, thereby placing all of the unwanted portions of the signal below cutoff.

The single pulse amplified by the 6AG7 is slightly less than two microseconds' duration. The transformer secondary is raised above ground by the cathode-follower action of the 6AG7 during the pulse interval. To obtain the required out-of-phase pulses for driving the clamp tube X815, the 6AG7 is used as a pulse amplifier and phase inverter.

Tube X815, using an RCA type 6H6, clamps during the last quarter of the blanking period and tends to reduce to a negligible amplitude spurious low-frequency signals such as

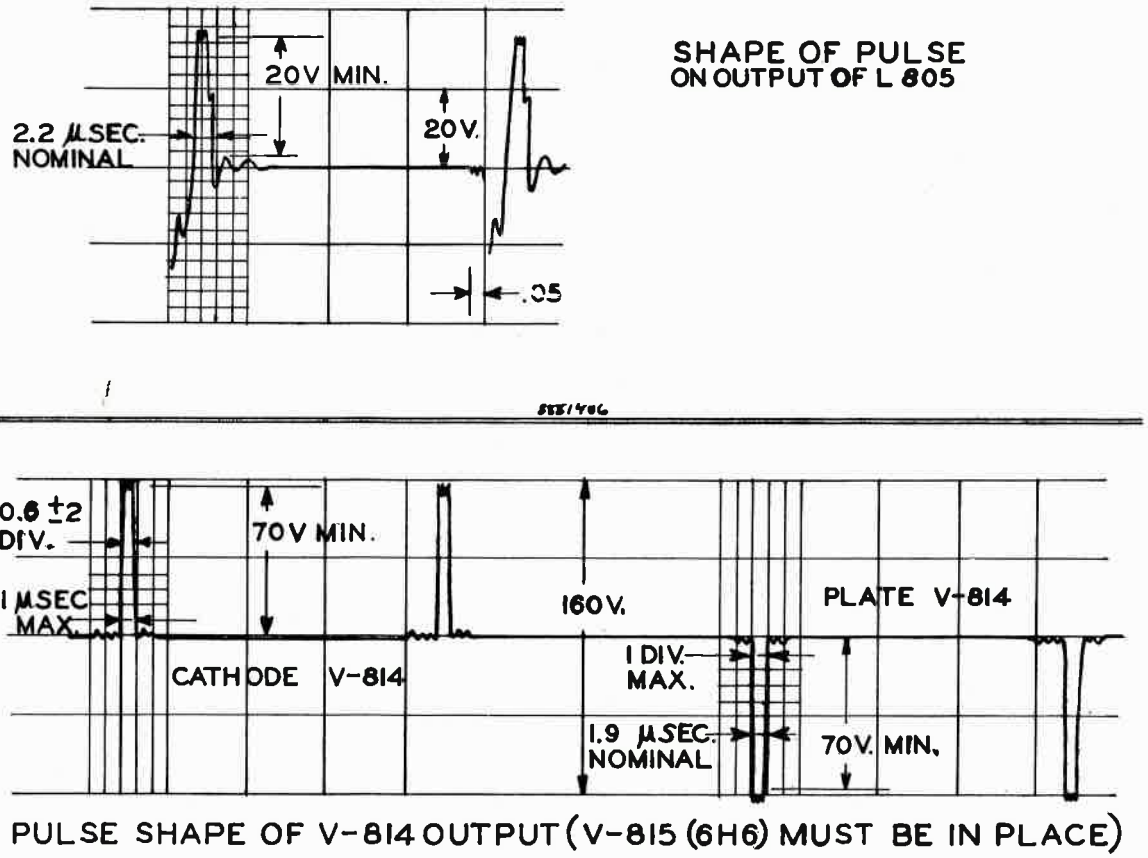

Figure 10 - Clamp Circuit, Visual - Pulse Shapes (8881406-sub 0)

microphonics, power-supply surges, or 60-cycle hum introduced in preceding stages. The clamp circuit holds the grids of the modulator at the correct black level bias during the blanking interval. This action restores the d-c component to the signal at the modulator grids.

Certain tests require modulation of the transmitter with a symmetrical signal such as a sine wave, video sweep, or square wave. This type of signal is unorthodox for a television transmitter, and an "AC-DC" switch, S801 has, therefore, been provided in the d-c restorer circuit. When this switch is thrown to the AC position, the bias voltage for the modulator and power-amplifier tubes may be set by adjustment of the BLACK LEVEL control R908 for mid-characteristic operation. Potentiometer R908 is connected across regulator tube X819. At the same time the grids of the 6AG7 driver (X814) and the clamp tube (X815) are biased to cutoff. This eliminates clamp circuit action and prevents the circuit from following the modulation envelope of any symmetrical signal appearing at the input.

Six RCA type 4E27 tubes (X807 to X812) connected in parallel, are used to modulate the grid circuit of the power amplifier tube. The modulator tubes are coupled to the power-amplifier grids by means of a constant-resistance network. This network serves as the modulator plate load and maintains a constant impedance of 500 ohms over the entire frequency range. The network consists of one series and shunt peaking coil section, three high-frequency sections, and three low-frequency sections. Each section is used for a specified frequency band in the overall frequency range.

The lowest-frequency section of the constant-resistance network utilizes the internal resistance of the modulator power supply as a portion of the plate load, permitting excellent frequency response down to and including d-c. In addition, the three low-frequency sections provide sufficient filtering to act as the 60-cycle filter network of the picture modulator rectifier.

Since direct coupling must be utilized between the modulator plate and the p-a grid, due to the d-c components in the modulator output, the PA bucking (or "floating") bias supply is utilized as the coupling means. This bucking bias supply serves to maintain the potential relationship between these two points which operate at approximately -350 volts on the PA grid and approximately +700 volts on the modulator plate. Thus the bucking supply output is in the range of +1050 volts, as shown on Figures 7 and 60.

Modulator Monitor, Visual -- An RCA type 6AG7 tube (X831) is coupled to the output of the visual modulator through an attenuating network. This tube acts as a phase inverter so that standard negative polarity is present at J803, for monitoring by the kinescope and CRO in the console.

Visual signal voltage, negative polarity, is also developed across resistors in the filament leads of the modulator tubes. This signal may be monitored by using the coaxial cable normally connected to J803, for connection to the coaxial fitting J802. Voltage developed is taken from the junction of R862-R863 in the output of T801.

Power Supplies, Visual -- The visual driver rectifier supplies plate and screen voltages to the crystal oscillator, multiplier, and driver stages of the visual transmitter section. Three RCA type 8008 rectifier tubes (X601, 2, 3) are mounted in cabinet number six, along with the plate supply filter. The driver plate transformer is in cabinet number five, and the output voltage dividers are in cabinet number seven.

The power amplifier plates are supplied from a 5000 volt supply mounted in cabinet number six. Six RCA type 8008 tubes (X606 to X611) are used in a three phase full-wave rectifier circuit. Switch S601 is used to change the transformer primary connections from a delta to a wye circuit, the operating and tuning positions, respectively. Screen voltage to the power-amplifier tube is disconnected when S601 switch is open. A regulated 800 volt, d-c supply (X520, X521) is used to furnish the screen grid voltage to the power-amplifier tube. The regulated low voltage supply for the visual modulator and the screen-grid voltage supply for the power-amplifier are located in cabinet five. A 3-phase full-wave 1000-volt d-c supply (X507 to X512) furnishes the voltage for the visual modulator tubes.

Bias voltages for the r-f driver stages, and for the visual modulator unit are obtained from a supply using an RCA type 5U4G tube (X604) connected as a full-wave rectifier.

An electronically-regulated, single-phase, full-wave rectifier (X820, X821) is used to supply bias voltage to the grids of the power amplifier tube. This power supply is connected between the plate circuit of the modulator tubes and the grids of the power amplifier tube through the high-frequency portion of the constant-resistance network.

Since the visual power-amplifier bias supply and the power-amplifier screen grid voltage supply are identical in basic design, the operation of the bias supply alone will be explained in detail. The regulating circuit of the bias supply is a degenerative network so arranged that any variation in output voltage due to load or source changes causes a change in a series impedance between the source and the load. This change in impedance is automatically controlled in direction and magnitude so that the output voltage is maintained near a predetermined value.

Referring to the simplified schematic, Figure 11, three RCA type VR150 tubes (X827, X828 and X829), resistors R943, R969 and R970, and potentiometer R946 form a bridge circuit in which the balance is a function of the voltage across the bridge and the setting of resistor R946. Any change in the output voltage causes a change in the grid-to-cathode voltage of the RCA type 6SH7 tubes (X826). This change is amplified by the RCA type 6SH7 and 6J5 tubes (X826 and X825) and is applied to the parallel-connected control grids of three RCA type 6AS7G tubes (X822, X823, and X824). The plate-to-cathode impedance of the 6AS7G tubes is thus changed in such direction as to counteract the variation in output voltage. The large amount of amplification in the circuit permits a very small change of output voltage to cause a large change in the plate-to-cathode impedance of the 6AS7G tubes.

Capacitor C854 is required to suppress oscillations which otherwise might occur in the amplifier circuit under extreme conditions of load or supply voltage. Resistor R946 permits adjustment of the output voltage over a limited range. In addition to being part of the reference bridge, the VR150 tubes (X827, X828, and X829) also serve as a regulated source of voltages for the amplifier tubes.

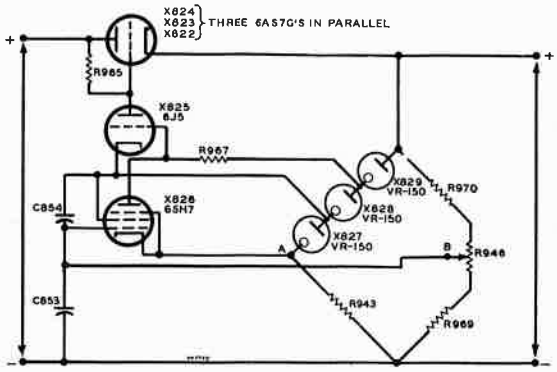

Figure 11 - Simplified Schematic Diagram, Visual PA Bias Supply Regulator (445749-sub 0)

AURAL SECTION

The aural transmitter section incorporates an exciter unit which feeds the r-f driver unit. Reactance tube modulation is used in the master oscillator stage to produce the frequency modulated signal. Center-frequency stability is automatically maintained by a control circuit which compares a sub-harmonic of the modulated signal with a sub-harmonic from a crystal-controlled oscillator. Figure 7 contains the simplified schematic diagram for the aural section. The schematic diagram for the exciter and exciter power supply is shown on Figure 89.

Exciter Circuits, Aural — In the exciter unit the master oscillator frequency is varied at an audio rate by the reactance modulation tubes, producing a frequency-modulated signal. This signal is multiplied in frequency by succeeding stages and is fed to the final r-f stages outside the exciter unit. Automatic-frequency-control circuits and a 2-inch cathode ray tube for checking and alignment, complete the exciter equipment.

The master oscillator, (X103) utilizes an RCA type 6V6 tube in a Hartley oscillator circuit employing a permeability-tuned coil, T115. Tables 11 and 12 list the exact oscillator frequencies for all channels. A portion of the oscillator output is fed to the grids of the reactance modulator tubes (X101 and X102) through a coaxial link from T115). The grid tank circuit places each grid 180 degrees out of phase with the other insofar as r-f oscillator voltage is concerned. However, the same voltage on each grid is 90 degrees out of phase with its r-f plate voltage. On one tube the plate current then leads the plate voltage by 90 degrees and on the other tube the plate current lags the plate voltage by 90 degrees. These tubes, therefore, act as a capacitive reactance and inductive reactance, respectively, across oscillator coil T115. Amplitude of the audio signal on the reactance tube grids, accordingly, will vary the reactive plate current in direct proportion, causing a proportional frequency shift or modulation of the oscillator frequency at an audio rate.

The frequency-modulated output is then passed through two multipliers and an amplifier stage employing one type 6V6 tube and two type 2E26 tubes. These stages (X104, X105, and X106) provide frequency multiplication as listed in Tables 11 and 12. The final exciter amplifier output is tuned by capacitor C171 and is coupled to coaxial output jack J101.

The automatic frequency control is composed of a crystal-controlled reference frequency source, a frequency source from the modulated oscillator section, and a frequency control system.

The reference frequency is supplied by a type 6SH7 crystal oscillator (X116) with two temperature-controlled crystals either of which may be switched into the circuit by means of switch S103. Exact frequency adjustment is made with trimmer capacitors C160 and C162. The output of the crystal oscillator is used to excite the crystal divider, which is a "locked-in" oscillator that divides the crystal frequency by five. Its output is inductively coupled to a phase-shifting network, C150-L105 and C151-L104, which divides the reference frequency into two voltages, 90 degrees out of phase with each other. These voltages appear across R132 and R133 and are used to furnish quadrature voltages to the primary windings of the frequency-correcting mechanism input transformers, T102 and T103.

The frequency derived from the modulated oscillator is supplied to the grids of the control tubes for the frequency-correcting mechanism through four permeability-tuned, locked-in, frequency dividers. The first divider (X107) is synchronized with the modulated oscillator through capacitors C131 and C132. Its tank coil, T108, is tuned to one-third the mean frequency of the modulated oscillator, X103. Voltage obtained from this circuit is used to excite the second divider (X108) through capacitor C134. The second divider tank coils, T109, are tuned to one-fourth the frequency of the first divider. Voltage obtained from this circuit is used to excite the third divider (X109) through capacitor C138. Third divider tank coils, T110, are tuned to one-fourth the frequency of the second divider, and are coupled to the fourth divider (X110) through capacitor C142. The fourth divider tank coils, T111, are tuned to one-fifth the frequency of the third divider and voltage derived here, therefore, represents the mean output frequency of the modulated oscillator divided by 240. This voltage is fed through C147 and R149 to the secondary center taps of the motor tube input transformers, T102 and T103.

The frequency correcting mechanism consists of two pairs of balanced modulators (X111-X112 and X113-X114) in which the output of fourth frequency divider (X110) is compared with the output of crystal oscillator divider (X115). The quadrature voltages developed across R132 and R133 introduce push-pull voltages on the grids of each pair of balanced modulator tubes, with a 90-degree phase difference between each pair of modulators. Fourth frequency divider (X110) introduces push-push in-phase voltages on the grids of both modulator pairs. Output of each modulator pair is connected to a pair of field coils in the two-phase control motor B101.

Any difference in frequency between the output of the master oscillator frequency dividers and the output of the crystal divider results in a rotation of the magnetic field in the control motor. This causes the motor shaft to rotate a small fraction of a degree in one direction if the frequency of the modulated oscillator is high and in the opposite direction if the frequency is low. A split-stator capacitor, C115, is attached directly to the motor shaft and connected electrically across tank coil T115 of the modulated oscillator. In this manner the master oscillator frequency is maintained at a fixed ratio to the crystal oscillator frequency - the requirement for a zero beat output from the balanced modulator tubes.

A test circuit is provided to aid in checking modulation and alignment of the reactance tube modulators. D-c bias voltage is applied to the circuit by means of a three-position switch, S107, in the secondary circuit of T101. When the switch is set at either of the two outside positions, a d-c test voltage is applied to the grid of one reactance tube. The center position is the neutral or operating position. The test voltage applied to the reactance tube modulators serves as an indication that the modulators are operating properly, checks the performance of the frequency control, and also aids initial tuning of the reactance tubes grid tank.

A fuse, F101 and F102, in each crystal oscillator circuit furnishes protection for these components.

For use in alignment and servicing, a 2BP1 cathode ray tube (X119) is provided with its viewing face above the exciter chassis. This tube enables a frequency comparison check to be made on the circuits listed in Table 2. Focus and intensity knobs alongside the tube provide the necessary operating controls for this tube.

TABLE 2
CIRCUITS CHECKED BY CATHODE RAY TUBE (X119)
AURAL SECTION

SWITCH POSITION (S101)	CIRCUITS OBSERVED
1	Output of Crystal Osc. (X116) and Crystal Freq. Div. (X115).
2	Output of Crystal Freq. Div. (X115) and 4th Mod. Freq. Div. (X110).
3	Output of 3rd and 4th Mod. Freq. Div. (X109 and X110).
4	Output of 2nd and 3rd Mod. Freq. Div. (X108 and X109).
5	Output of 1st and 2nd Mod. Freq. Div. (X107 and X108).
6	Output of Mod. Osc. (X103) and 1st Mod. Freq. Div. (X107).
7	Output of 1st Freq. Multiplier (X104) and Mod. Osc. (X103).
8	Output of 1st and 2nd Freq. Multipliers (X104 and X105).
9	Output of 1st Freq. Multiplier (X104) and Amplifier X106).

R-F Amplifier, Aural -- The output of the F-M exciter unit is link-coupled to the aural r-f driver unit in cabinet number two. This r-f driver unit contains the same number of stages as the visual portion of the transmitter, the major difference being in the way frequency multiplication is obtained. Following the driver unit is the aural PA which is similar to the visual PA.

Power Supplies, Aural -- The F-M exciter unit obtains its required operating voltages from a power supply using three RCA type 5U4G rectifier tubes (X201, X202, X207) in two full-wave, single-phase circuits. A selenium bridge-type rectifier, SR201, is used to supply 19 volts d-c to operate the filaments of the two reactance tubes, the modulated oscillator tube, and the first frequency multiplier tube.

A 1500-volt d-c supply (X301, X302, X303) furnishes the plate and screen voltages to the aural r-f driver chain. The screen grid voltage of the aural power-amplifier tube is taken from a voltage divider on the output of this supply. This supply is identical to the picture driver rectifier. The rectifier and filter are in cabinet three, the power transformer in cabinet one, and the output voltage divider in cabinet two.

An individual bias supply (X304) is used to furnish the necessary bias to the aural r-f driver and power amplifier.

The power-amplifier plate voltage is supplied by a 5000-volt d-c supply (X306 to X311) mounted in cabinet three. Switch X301 in this power supply is used to change the transformer connections from a delta to a wye circuit, operating and tuning, respectively. The fourth connection on this switch is used to remove the screen grid voltage from the power-amplifier tube when the switch is open.

REFLECTOMETERS, VISUAL AND AURAL

Two reflectometers are coupled to the transmission line in the visual section of the transmitter, and two to the transmission line in the aural section. Each reflectometer is basically a uni-directional, peak-reading, vacuum-tube voltmeter.

The reflectometer input pick-up coil assembly is designed to have both electromagnetic (inductive) and electrostatic (capacitive) coupling to the field existing between the inner and outer conductors of the transmission line. The pick-up coil is designed and adjusted so that when coupled properly in a perfectly-terminated line, substantially unity standing-wave ratio, the voltage pick-up due to inductive coupling is equal to the capacitive coupling.

If the inductively-coupled voltage is of the same polarity as the capacitively-coupled voltage, the meter in the output circuit of the diode rectifier will read a value proportional to the sum of these voltages. If, however, the polarity of the inductively-coupled voltage is reversed so that the two induced voltages are 180-degrees out of phase, the output meter will read zero.

In any transmission line, the waves traveling from the generator (transmitter) to the load (antenna) will be polarized oppositely from those reflected from the load and traveling back toward the generator. Therefore, the reading of the output meter for a given orientation of the pick-up coil is a function of whether the waves are traveling to, or from the load. Hence, the reflectometer can be made responsive to either the incident or reflected wave. In this way a constant check on the operation of the line, antenna, and transmitter output power can be maintained.

Power output is proportional to the SQUARE of the reflectometer reading. Half-scale reading indicates one-quarter power output when compared to full-scale reading.

One reflectometer in each transmission line is normally adjusted to read the incident wave, the other the reflected wave. Switch S802 is provided in the visual and aural sections of the transmitter to connect meter M801 across the output of the reflectometer used to measure the incident wave, or across the output of the reflectometer which measures the reflected wave. With this combination the following transmitter functions may be checked.

1. The standing wave ratio on the transmission line can be determined during normal operation of the transmitter by making two relatively simple readings. The sum of the two readings divided by the difference gives the standing-wave ratio on the line. The standing-wave ratio on the transmission line is extremely important in television transmission since any reflected energy, exceeding five per cent, from the antenna may result in multiple images in the picture.

2. The r-f power output of the transmitter may be read directly, provided the unit has been calibrated previously with a dummy load. This reading is indicated by the reflectometer used to measure the incident wave.

3. The reflectometer response to the reflected wave is also used to control the bias voltage of an RCA type 502-A tube (X832). When, due to a large reflected wave, this voltage exceeds a predetermined amount, the tube will "fire" and actuate overload circuits which will remove the transmitter from the air. In the case of an arc-over, this may prevent serious damage to the line. For instance, such an arc-over might be caused by lightning. An otherwise harmless spark in the line would be serious if an r-f arc followed.

CONTROL CIRCUITS, VISUAL AND AURAL

General — The ladder diagram, Figure 90, outlines in schematic form the complete control circuit of the TT-5A transmitting equipment. Essentially two ladder diagrams are shown: one for the aural portion, and one for the visual section. Any given circuit of the ladder originating at the "common" line which separates the visual and aural portions of the ladder must, without exception, eventually terminate at the opposite side of the control bus. Only those contacts, windings, indicator lamps, and other components directly associated with, or part of the control circuits are shown on the diagram.

In addition to the contacts employed in the power circuits, one or several auxiliary contacts may be employed to control other circuits. Dashed lines are used to indicate contacts associated with each contactor, or relay winding. In some instances, only contacts or windings are shown on the diagram. This will occur when the windings or contacts are controlled by, or operated from circuits not directly associated with the control circuits. For example, only the contacts of the several overload relays are shown, inasmuch as the windings are usually connectedin power supply circuits.

Various terminal points have been shown on the diagram to aid in checking through a circuit believed to be at fault. For instance, to check the door interlock circuits of the visual transmitter continuity should be checked between terminals 4C5 and 4A5.

In the lower-right-hand corner of the control ladder on Figure 90 is a block diagram showing the distribution of the primary power circuits. The thermal breakers, K401 to K409, are accessible on the front of the control panel. Power enters the equipment through main line breaker K401 and branches into several separately-protected circuits, one of which is the control circuit. The control circuits are energized from the incoming power through a protective De-Ion breaker, K402, and isolation transformer T401.

Common Control Circuits -- Although the control circuits for the visual and aural portions of the transmitter are, for the most part, separated, two common points, 4M5 and 4C5, are shown on the control ladder of Figure 90. Beyond these points the circuits divide and continue through the individual control equipment items.

Arrows shown on the drawing indicate the major circuit paths of the plate circuits as they progress from contact "B" on K410, to the visual and aural plate contactors, K418 and K434.

With circuit breakers K401 and K402 closed, the control circuits are energized. Switches S1107, on the console, and S404 must be closed to start the equipment: opening either switch will stop the equipment. Contactor K410 is energized when these switches are closed, starting the water cooling equipment and energizing the fan and blower circuits. The fans and blowers will not operate unless the filament switches, S405 (visual) and S419 (aural) are closed. Auxiliary contacts on K410 energize the water and door interlock circuits. Contact "A" on K410 connects the "common" side to terminal 4E12. The dummy

load and sideband filter water interlocks are inserted between this point and terminals 4E11 (visual circuit) and 4N12 (aural circuit).

Visual Section Control Circuits — From terminal 4E11 the control circuit progresses through the water interlocks, S810, S807, and S703 to the water interlock, auxiliary contactor K444. The latter contactor energizes the circuit up to filament switch S405 and causes "Water" pilot lamps I1100 (console) and I701 to light. Switch S405 controls the filaments, fans, and blowers for the visual section.

Through contact "B" on contactor K410 the common side of the control circuit is connected to door interlock switch S420 and thence to a junction point separating the aural and visual transmitter sections (terminals 4C5 and 4M5). Switch S420 is the rear door interlock of the power control cabinet and controls both sections of the transmitter. For the visual section, the circuit progresses from S420 through a series of door interlocks and the picture plate switch, S701. Toggle switch S701 is located on the front of the low-frequency exciter, and may be used to control the plate circuits of the picture section alone. With all door interlock switches and S701 closed, the three high-voltage grounding switches, K501, K601, and K604, will operate and remove grounds from the modulator, driver, and power-amplifier plate supplies.

During normal operation, the plate power of both sections of the transmitter may be controlled by push button switches located on the front panel of cabinet four and in duplicate on the control console. These are shown on the diagram as S406 and S1109, Plate Power ON, and S407 and S1110, Plate Power OFF. The contacts of the Plate Power ON and Plate Power OFF switches are normally open and control the transmitter by means of contactor K413.

Contactor K413 is of the latch-trip type. Pressing the Plate Power ON button energizes coil K413A, causing the contactor to operate and mechanically latch-in. Pressing the Plate Power OFF button energizes coil K413B, causing the contactor to release. The circuit progresses through contact "D" of K413 to a contact on K411, and through the three normally-closed contacts of K422, K423, and K418, to the "Automatic Start" pilot lamps. These pilot lamps serve as a warning, and indicate that plate power will be applied as soon as plate time-delay relay K412 closes.

The lock-in feature of K413 permits the transmitter to be entirely controlled by switches S404 or S1107 (console). The "Automatic Start" indicator lamps will be energized after closing S1107 or S404, if K413 has remained in the Plate Power ON position from previous operations. By pressing the Plate Power OFF button, K413 will release, the "Automatic Start" pilot lamps will be de-energized, and plate power can not be applied until the Plate Power ON button is operated.

Plate time-delay relay K412 will close approximately 30 seconds after the application of filament voltage, thereby closing contact "E" and energizing K425 and K417. Relay K425 is an inverse time-delay relay which serves to bypass the plate time-delay relay for three seconds after all power to the transmitter is removed, thus avoiding a 30-second delay in the event of a momentary power failure. Relay K417 controls the two bias supplies in the visual section. An interlocking contact on K417 permits the circuit to continue to the bias dc interlock contacts of K602 and K801 located on the bias supply units. Bias pilot lamps I801 and I1102 are energized when the bias interlocks close.

The circuit continues through the seven normally-closed contacts of the overload relays, K414, K415, K416, K420, K427, K426, and K430, through the normally-closed contact, "H", of K424 to the interlocking contacts of the three high-voltage grounding switches. Since the grounding switches are energized as described previously, the circuit is completed to the main plate contactor, K418, energizing driver, modulator, and PA plate primary circuits when circuit breakers K405, K406, and K407 are closed. Auxiliary contacts on K418 serve to energize the PLATE ON indicator lamps, I1104 and I802, and also to extinguish the "Automatic Start" pilot lamps.

The application of primary power to the p-a plate transformer also energizes the one second time-delay relay, K419, in turn causing the surge-suppressor relay, K603, and the PA screen relay, K446 to operate. Contacts on relay K446 will energize the grid bias protective resistor relay, K802, and complete the circuit to the Delta/Wye switch, S601.

All overload relays are provided with one normally-open and one normally-closed contact. For instance, if an overload occurs in the picture modulator, overload relay, K414 will operate. Contact "G" will open and

release plate contactor K418, removing all plate voltages from the picture section. Simultaneously, contact "F" will close and energize inverse time-delay relay K424 and notching relay K422. Operation of K424 causes contact "H" to open and remain open for a short interval, approximately one second, to allow any fault to clear.

The notching relay, K422, is provided with three sets of contacts labelled "I", "J", and "K" on the ladder diagram. The letters adjacent to each of these contacts indicates the order in which the contacts are opened or closed for the several notching positions of the relay. Therefore, in the initial position, contact "I" is closed, and contacts "J" and "K" are open.

After the first and second overload, contacts "I", "J", and "K" of K422 will be closed. The circuit to the bias and plate contactors will be maintained through contact "I" and plate power will be re-applied as soon as K424 re-closes. Contact "J" will energize the overload indicator lamps, I1108 and I601, and cause contactor K423 to operate. Operation of K423 will open contact "L", but if switch S417 is closed, operation of the circuit will not be affected. If switch S417 is open the automatic recycling feature of the overload system is eliminated and the transmitter will not restart automatically after the first overload. Contact "K" controls time-delay relay K421. Should only one or two overloads occur, K421 will operate in one minute and energize K422A of the notching relay, resetting the overload system. After a third overload, contact "I" will open, thus removing all bias and plate voltages. Contact "K" likewise will open, preventing automatic reset relay K421 from resetting notching relay K422. The circuit may then be reset only by manually operating the overload reset switches, S1108 or S418.

Automatic reset relay K421 will function only during normal transmitter operation, i.e., all doors closed and both plate switches closed.

Aural Section Control Circuits—The control ladder for the aural portion of the transmitter is essentially the same as for the visual section.

WATER CIRCULATING SYSTEM

The water system for the TT-5A transmitter consists of a cooler unit, and the plumbing in frames one, eight, and the two p-a cabinets. As shown in Figure 12, the water enters at "J" and "K" at the bottom of frames one and eight, and goes to the p-a frame where it divides into several circuits--to the anodes of the 8D21 tube, to the tube header plate, and in frame eight only to a water-cooled resistor.

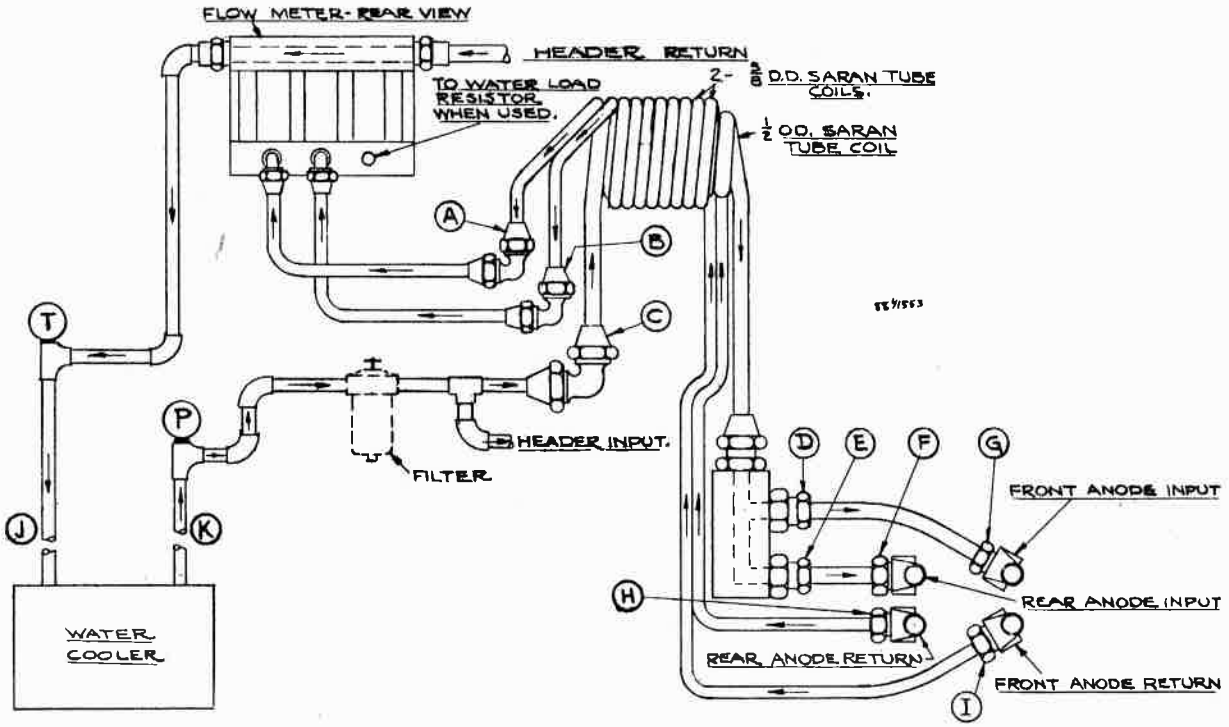

Figure 12 - Diagram, Water Circulating System (8841553-sub 0)

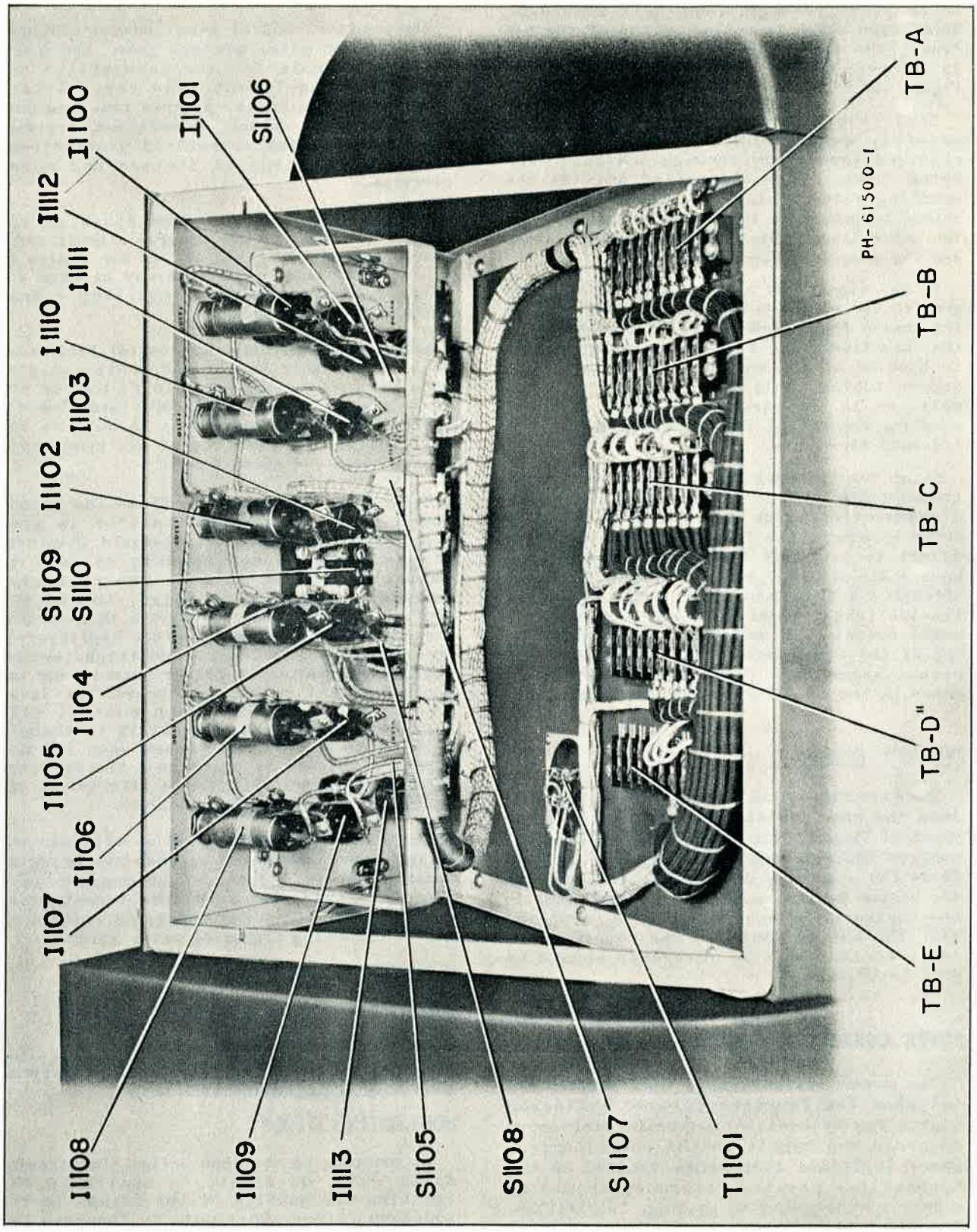

Figure 13 – Power Control Panel, Console - Rear View

The anode water is fed to the ends of the anode lines through a one-half inch O.D. Saran tube which is coiled on top of the p-a frame. The water divides in a fitting just to the rear of the anode lines, as shown on Figure 12.

Since the water flows are individually metered, water from each anode line is returned separately through 3/8-inch O.D. Saran tubes, which are coiled outside the entering water tubing. The Saran tubes are coiled to provide a long water column between the anode lines, which operate at 5000 volts, and the grounded copper piping.

In the visual end only an extra water flow goes to the water-cooled damping resistor and its return is metered in the front element of the anode flowmeter. A flow-restricting orifice is located at the end of the 3/8-inch O.D. copper tubing, which is nearest the balun unit, or in the large end of the reducing coupling connecting the copper tubing to the 1/4-inch Saran tube.

Water for the 8D21 tube header plate flows through the rubber hose with its quick-disconnect coupling and then divides into three branches. The flow to the filaments is direct to the tube through the connecting hose while the grid and screen grid flows go through 1/4-inch O.D. Saran tubes coiled to provide longer water columns. Return water paths are similar and the flows combine in top of the tube header plate flowmeter. This return water then joins the anode return water in the top of the anode flowmeter.

CONTROL CONSOLE

The circuits in the console may be grouped into the same divisions which occur in the physical layout of the console: power control, monitor control, and Master Monitor. Figure 81 is the schematic diagram for the console: the Master Monitor schematic is contained in the instruction book, IB-36021-2, supplied with the Master Monitor. For complete details on the Monitor, reference should be made to IB-36021-2.

POWER CONTROL CIRCUITS

The power control panel incorporates six switches and fourteen colored indicator lights for transmitter control. Since most controls and lights on the power control panel duplicate components located on the transmitter panels, reference should be made under the preceding heading, TRANSMITTER, for detailed information. A complete résumé of all facilities on the power control panel is given in Table 3 which lists all components by designation, description, and function.

MONITOR CONTROL CIRCUITS

The monitor control panel mounts all necessary sound gain, picture gain, and monitoring controls for the transmitter and associated equipment. The three meters indicate volume units, picture power output, and sound power output. In addition, the four pushbutton switch assemblies provide convenient switching of picture and sound circuits.

Facilities for two sound lines in the console provide for one program circuit and a spare, with a reversing switch for choice of lines. The spare sound line may be used for intercommunication by installing a desk telephone at the console.

Additional monitoring or control facilities such as a remote On-the-Air Monitor may be incorporated in the console by use of the spare pushbutton positions provided. Table 4 lists these spare positions as well as the description and function of all components on the monitor control panel.

Miscellaneous Circuits—Since the normal sound input to the transmitter is pre-emphasized according to a standard 75-microsecond curve, a de-emphasis network is installed in the console for listening purposes. When switch S1112, behind the monitor control panel, is in the IN position, the signal to the sound monitor amplifier is de-emphasized. In the OUT position, switch S1112 disconnects the filter network and the monitor signal is then unchanged. The level at the Sound Monitor Gain control will increase about 20 db when S1112 is changed from IN to OUT due to losses when the de-emphasis network is connected. The VU meter reading, however, will not be affected by the status of the de-emphasis network.

Transformer T1100 is used to maintain the proper impedance match between the bridging potentiometers and the sound monitor gain control, R1137. The step-down transformer, T1101, is provided for supplying voltage to the illuminating lights of meter M1100.

MONITORING EQUIPMENT

MONITORING RACK EQUIPMENT

For detailed description of the monitoring rack equipment units, refer to the instruction book accompanying each unit.

MONITORING DIODE

In addition to the rack units, a monitoring diode unit, MI-19051, is available for checking the quality of the signal to the sideband filter. This unit is designed for mounting on the r-f transmission line between the visual section output and the sideband filter, and is used for feeding a signal to the master monitor in the console.

TABLE 3

POWER CONTROL PANEL, CONSOLE
(Left Side)

PANEL DESIGNATION	DESCRIPTION	SYMBOL	REMARKS
CONSOLE	SPST switch.	S1105	Completes power circuit to monitor racks and console. Installed in series with monitor power source.
TOWER LIGHTS	SPST switch, 20a-220V.	S1106	Controls tower lights. Recommended installation is in series with tower light relay coil. Where load requirements are within rated limits, S1106 may be used for direct control of tower lights. If not used for tower light control, this switch can be used as a "dimming" control to turn off most of the transmitter room lights and aid picture monitoring.
TRANSMITTER ON-OFF OVERLOAD PLATE POWER ON PLATE POWER OFF	DPST switch. DPST switch, momentary contact, normally off. Black pushbutton, SPST switch. Red pushbutton, SPST switch.	S1107 S1108 S1109 S1110	These controls duplicate switches located on the transmitter panels. See "TRANSMITTER, Control Circuits" and "TRANSMITTER, Control Circuit Checks" under DESCRIPTION and INSTALLATION, respectively.
PICTURE WATER SOUND WATER PICTURE BIAS SOUND BIAS PICTURE PLATE SOUND PLATE PICTURE AUTO-START SOUND AUTO-START PICTURE OVERLOAD SOUND OVERLOAD PICTURE FILAMENTS SOUND FILAMENTS	Blue indicator lights. Red indicator lights. Red indicator lights. White indicator lights. Amber indicator lights. Green indicator lights.	I1100 I1101 I1102 I1103 I1104 I1105 I1106 I1107 I1108 I1109 I1110 I1111	These indicating lights duplicate lights located on the transmitter panels. See "TRANSMITTER, Control Circuits" and "TRANSMITTER, Control Circuit Checks" under DESCRIPTION and INSTALLATION, respectively.
TOWER LIGHTS CONSOLE	White indicator light, 220-230V. White indicator light.	I1112 I1113	Indicates voltage to tower lights. Use in conjunction with S1106. Indicates power to monitor racks and console.

TABLE 4
MONITOR CONTROL PANEL, CONSOLE
(Right Side)

PANEL DESIGNATION	DESCRIPTION	SYMBOL	REMARKS
SOUND LINES	3-position lever switch: -Line 1 position -Line 2 position -Mid-position	S1100	Connects Line 1 to program amplifier input and Line 2 to telephone. Reverses above connections. OFF position. In this position, incoming lines are terminated with resistance. A resistor is also connected across the program amplifier input. This does not affect operation of the monitor circuits.
VU METER Line 1 Line 2 Transm-Input Transm-Output (Blank)	Pushbutton switch, five buttons:	S1101	Check sound level on VU meter M1100. Spare. Suitable for bridging 600-ohm line.
SOUND MONITOR Line 1	Pushbutton switch, five buttons:	S1102	Level control R1124. Level control R1123. Level control R1122. Level control R1121. } Check sound quality on monitor speaker. Level controls provide for same monitor circuit level to Sound Monitor Gain control, R1137. Spare. Level control R1120. Suitable for bridging 600-ohm line.
KINESCOPE Transm-Input Mod. Output Transm-Output (Blank) (Blank)	Pushbutton switch: five buttons:	S1103	Signal from stabilizing amplifier monitor output. Signal from modulator monitor pick-off. Signal from WM-12A (auxiliary equipment). } Check signal quality on console kinescope. Spare. Normally used for output of MI-19051 diode. Spare. 75-ohm input impedance.

TABLE 4 (Cont.)
MONITOR CONTROL PANEL, CONSOLE
(Right Side)

PANEL DESIGNATION	DESCRIPTION	SYMBOL	REMARKS
CRO Transm-Input Mod. Output Transm-Output (Blank) (Blank)	Pushbutton switch: five buttons	S1104	Level control R1130. Signal from stabilizing amplifier monitor output. Level control R1129. Signal from modulator monitor pickoff. Level control R1128. Signal from WM-13 series unit (auxiliary equipment). Spare. Level control R1126. Normally used for output of MI-19051 diode. Spare. Level control R-1125. Check waveform on console CRO. (Level controls, except R1128, simultaneously adjust kinescope input.)
PICTURE GAIN	SPDT switch	S1111	Controls picture input level to transmitter. Energizes reversible motor in transmitter to operate picture gain control.
VU METER	Weston Type 30	M1100	Sound level monitoring. Circuits selected by VU meter switch, S1101.
PICTURE POWER OUTPUT	0-50 microammeter	M1101	Repeats reading of meter M801 in transmitter. See "TRANSMITTER, Reflectometers" and "TRANSMITTER, Reflectometer Adjustments" under DESCRIPTION and INSTALLATION, respectively.
SOUND POWER OUTPUT	0-50 microammeter	M1101	Repeats reading of meter M104 in transmitter. See "TRANSMITTER, Reflectometers" and "TRANSMITTER, Reflectometer Adjustments" under DESCRIPTION and INSTALLATION, repectively.
SOUND MONITOR GAIN	Volume control	R1137	Control gain to sound monitor.
(None)	Volume control	R1138	Vernier control, to vary M1100 indication ±0.5 db. For calibration of VU meter.
SOUND GAIN	Volume control	R1139	Controls sound input level to transmitter.
VU ATTENUATOR	Volume control	R1140	Step-by-step control + 4 to+40 VU for meter M1100.

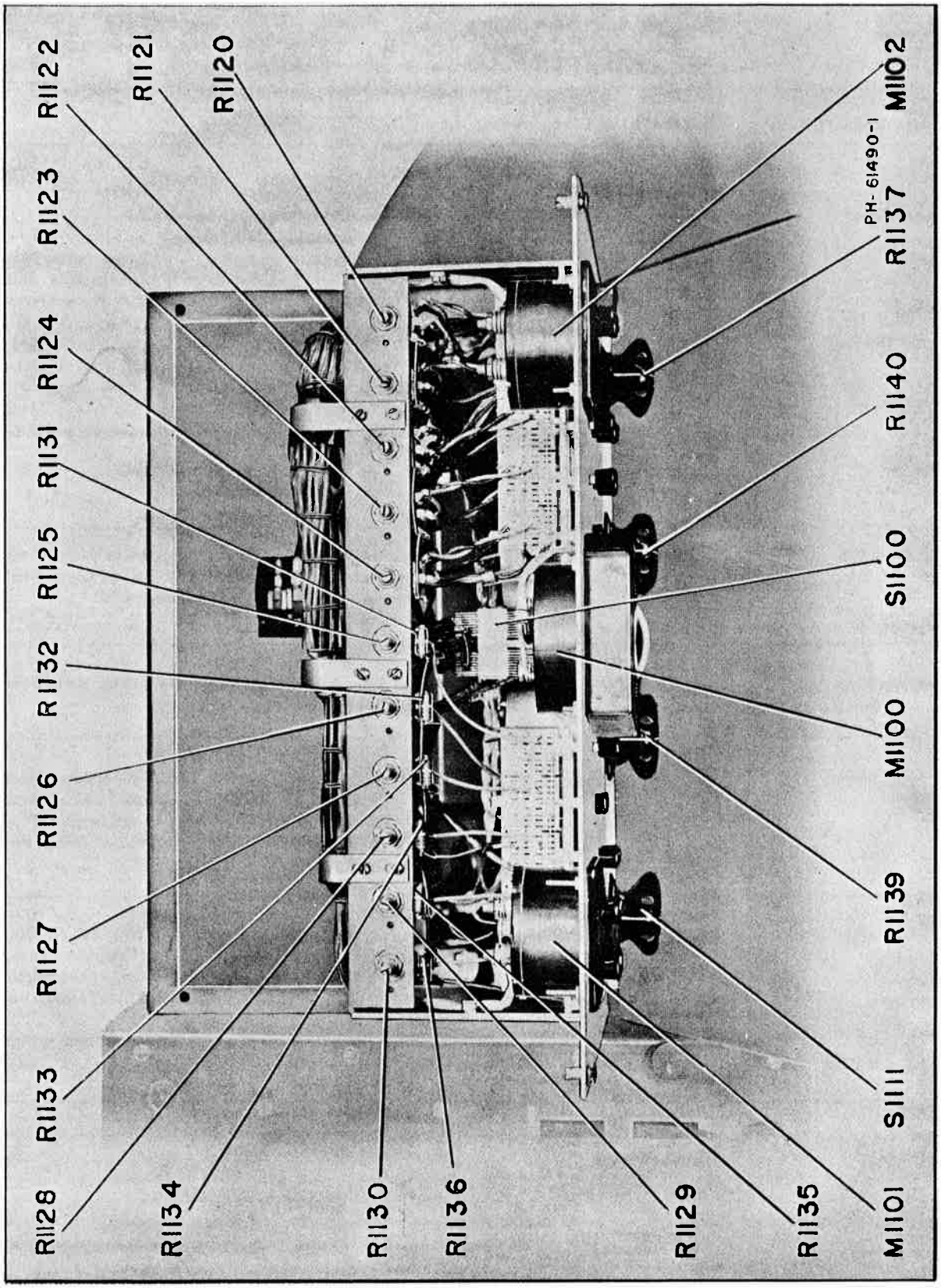

Figure 14 – Monitor Control Panel, Console – Front Interior View

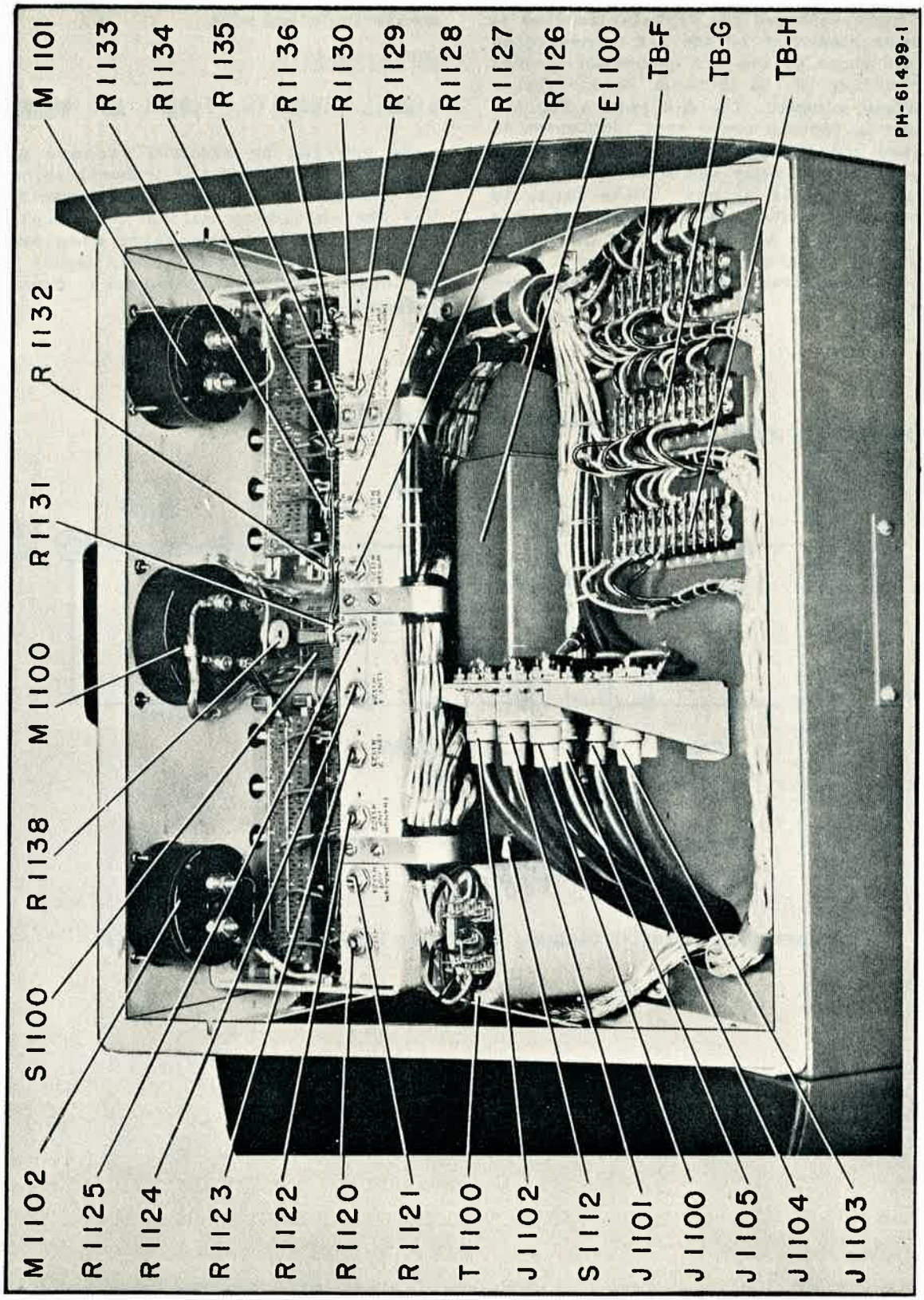

Figure 15 - Monitor Control Panel, Console - Rear View

The monitoring diode unit includes a double diode whose cathodes are capacity coupled to the inner conductor of the r-f transmission line and whose plates are connected through an r-f filter to the 1000-ohm load resistor and output circuit. The d-c return for the cathodes is through choke coil L102 which is operated considerably above the resonant frequency of the choke and input capacity of the tube. In this manner, choke L102, in conjunction with the capacity pickup, forms a capacity divider across the r-f line. The filament of the diode is supplied by a self-contained transformer requiring 115 volts a-c supply.

Figure 16 is the schematic diagram for the monitoring diode unit.

MISCELLANEOUS

SIGNAL CIRCUITS, VISUAL AND AURAL

To provide an overall picture of the relationship between the transmitter proper, the control console, the monitoring equipment, and the auxiliary units, two simplified "signal circuit" schematic diagrams are furnished. These two diagrams, Figure 17 and 18, cover the visual and aural hook-ups, respectively.

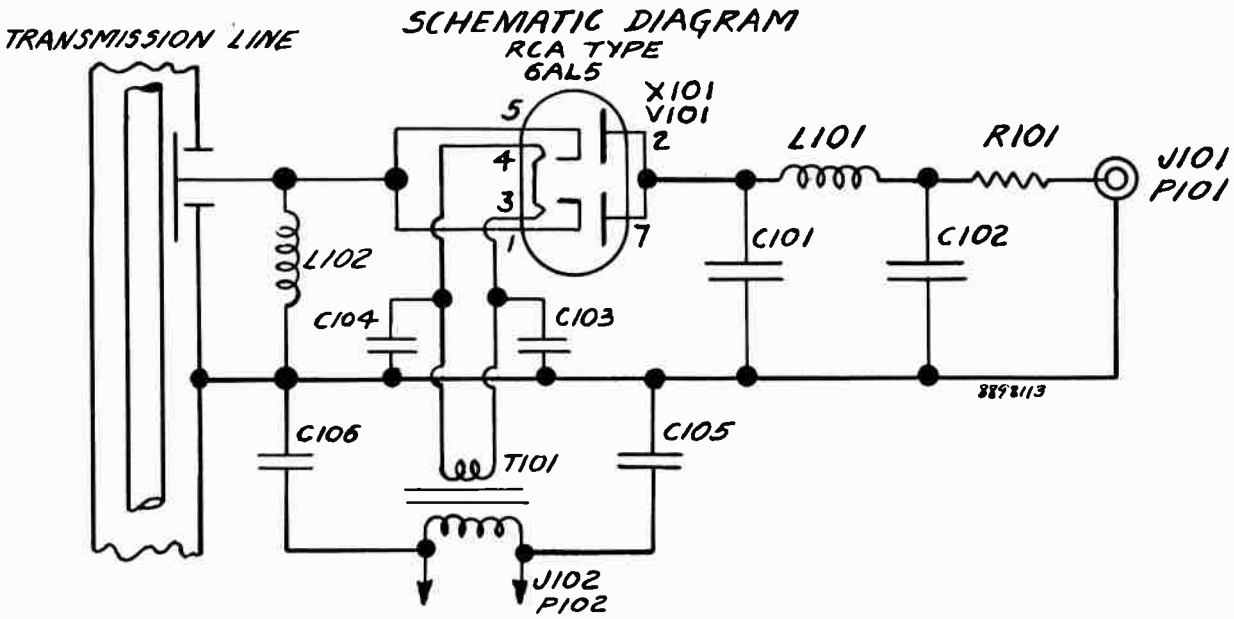

Figure 16 - Schematic Diagram, Monitoring Diode Unit (8898113-sub 2)

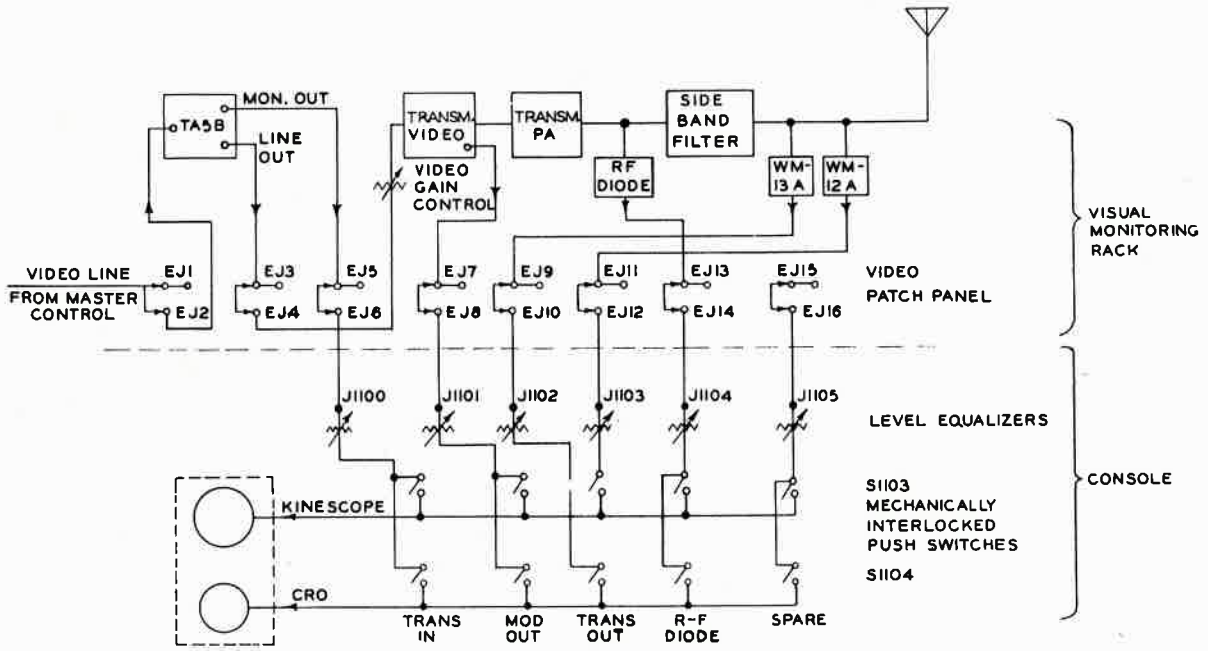

Figure 17 - Schematic Diagram, Signal Circuits - Visual (450176-sub 2)

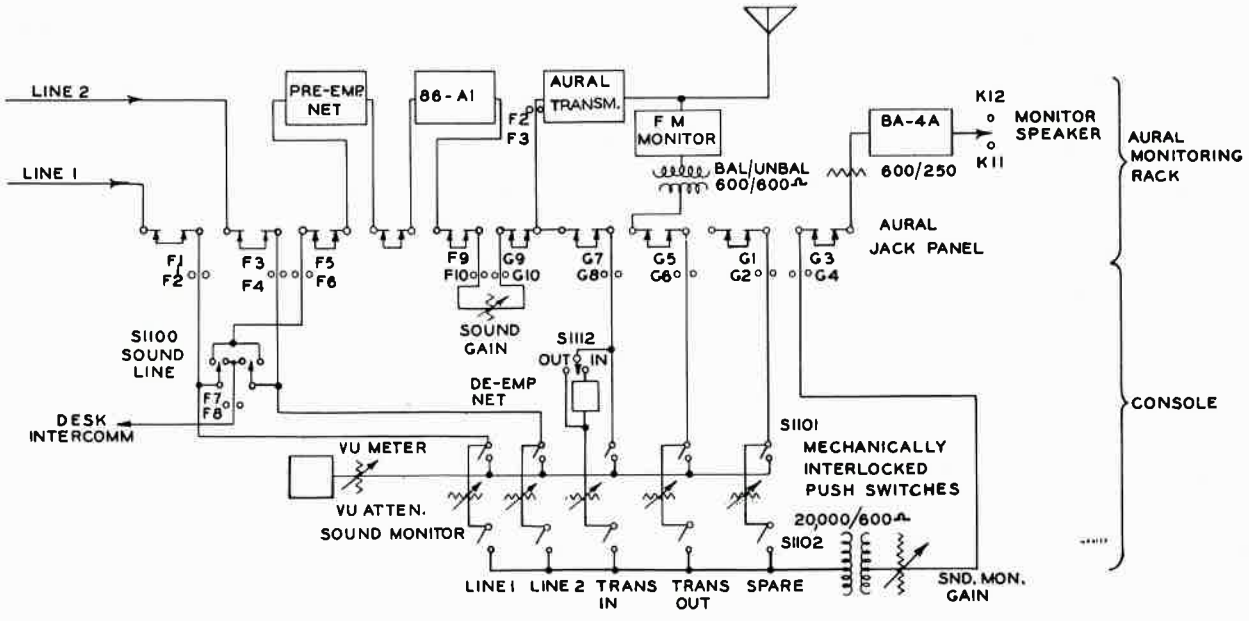

Figure 18 - Schematic Diagram, Signal Circuits - Aural (450177-sub 2)