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Radio Material Office
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U. S. NAVAL AIR STATIONS AND AUXILIARY AIR STATIONS

AIR TRAFFIC CONTROL TOWER

Radio Communications Control System

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U. S. NAVAL AIR STATIONS & AUXILIARY AIR STATIONS
AIR TRAFFIC CONTROL TOWER

I. TOWER EQUIPMENT - LOCATION AND FUNCTIONS:

A. General Information: The function of the Airport Traffic Control Tower is to communicate with aircraft at the field or in its vicinity in order to convey necessary instructions and information for landings and take offs. To accomplish this purpose, transmitting and receiving facilities operating on various assigned frequencies are available to the operator. The receiver complement of a typical Control Tower normally consists of four crystal controlled high-frequency receivers, one or two tunable high-frequency receivers, and one or two crystal controlled very-high-frequency receivers. The transmitting facilities normally consist of three high-frequency transmitters, one or two very-high-frequency transmitters, and, if authorized, one low (or medium) frequency transmitter. The receivers are located in the Control Tower. The transmitters, with the exception of one emergency VHF transmitter installed in the Control Tower, are installed at the Transmitter Building and are controlled by remote lines from the tower. A recorder, usually located in the Operations Duty Office, automatically transcribes all outgoing and incoming transmissions. An intercommunication network connects the Tower to the Operations Office, Operations Radio, Aerology Office, and the Transmitter Building.

The control panels for the Tower equipment are mounted on a sloping panel which is part of the operator's desk, illustrated for a typical installation on Photograph (A). The "Main Control Panel", PSNY Model 130, provides for the control of transmitters, receivers, and microphone circuits. The "Crash Panel", PSNY Model 131, provides for independent control of the crash transmitter and receiver in emergency. The "Teletalk and VHF Control Panel" contains the intercommunication equipment and the controls for the emergency VHF transmitter-receiver installed in the Control Tower. These three panels provide all the controls necessary for the operation of the Tower radio equipment.

The equipment associated with the three control panels (with the exception of the VHF transmitter-receiver) is mounted in an equipment console, PSNY Model 135, located directly behind the operator. Preamplifiers for the microphone circuits, radio receivers, power supplies, and special equipments are mounted in this cabinet, as shown on Figure 1, and illustrated on Photograph (B). A typical Tower arrangement plan is shown on Figure 2.

B. Main Control Panel, PSNY Model 130: For normal operation, all necessary controls are included on the Main Control Panel (see Photograph (D)), which is mounted on the sloping panel of the control desk. This panel provides control of a maximum of six transmitters and eight receivers, and permits selection of either one of two microphones (and its associated limiting amplifier) which are part of the Tower equipment. An indicator lamp shows which of the microphone circuits is in operation. Transmitter control switches (toggle switches) are provided so that the operator may select and simultaneously transmit over any desired combination of transmitters. The frequencies of the transmitters are marked on the designation strips next to the switches, and a green "bull's-eye" is illuminated adjacent to any switch that is in the "operate" position, indicating that the transmitter will be placed in operation whenever the microphone button is pressed.

A single loudspeaker mounted in the control panel is connected to the combined outputs of all receivers. A squelch system keeps the output circuit of each receiver muted until an R.F. carrier is received. When a carrier is received on any channel, the muting voltage is removed by a relay in the "Carrier Operated Device", the signal is passed through to the loudspeaker, and a red "bull's-eye" lights up, indicating which channel received the signal. Volume of the loudspeaker output is adjustable by a gain control on the panel.

Underneath the red indicator lamps for the receivers is a set of three-position key switches. In the normal (center) position, the receiving system operates as described in the preceding paragraph. Under certain conditions, however, it may be desirable to listen to signals of insufficient strength to disable the muting system. This can be accomplished by throwing the key to the upper (locking) position. The squelch circuit is thereby made inoperative on that particular receiver. If it is desired to listen to one receiver only, without interference from receivers on other frequencies the key may be thrown to the lower (non-locking) position and all channels, other than the desired one, are silenced.

C. Crash Panel, Model 131: Under normal conditions, the Crash Panel (Photograph (G)) is not in service. The receiver and transmitter associated with the crash system are connected to the Main Control Panel and operate in the same manner as the other receivers and transmitters. However, in emergency, the crash units may be isolated from the main control system by throwing the switch on this panel from "standby" to "crash". This operation connects the output of the crash receiver to the crash speaker (through an amplifier in the panel) and connects the spare microphone circuit of the Main Control Panel to the crash transmitter. The crash system and the regular tower system then operate independently. A red

indicating lamp is illuminated with the switch in the emergency position, and a green lamp is lighted when it is in the standby position. A gain control on the panel provides adjustment of the loudspeaker volume.

D. Teletalk and VHF Control Panel, Model 132: The intercommunication and VHF Control Panel is illustrated in Photograph (J). The teletalk unit provides communication to the Operations Office, Aerology, Air Traffic Control, and the Transmitter Station. The VHF control unit, also installed on this panel, is part of the SCR-522 VHF transmitter-receiver, which is installed in the Control Tower.

E. Equipment Console, Model 135: The equipment console, illustrated on Photographs (B) and (C), mounts the receivers, amplifiers and auxiliary equipment necessary for the operation of the system. For normal operation, no adjustments are necessary after the equipment has been initially set up. A maximum of eight receivers may be installed in the rack and connected to the "Electronic Mixer" and "Carrier Operated Device" panels. The antenna system for the H.F. receivers consists of a single whip antenna, mounted on the Tower roof, feeding the antenna distribution system in the equipment console through a cathode follower type impedance matching device and a coaxial transmission line. A separate VHF quarter-wave, ground plane antenna is furnished for each VHF receiver.

Where remote receivers are used in addition to the Tower receivers, a remote C.O.D. unit is also provided, and at the equipment console a local-remote switching panel is installed to select either the remote receiver or the tower receiver, on any of the eight channels.

F. Recorder Unit: The recorder unit is ordinarily located in the Operations Duty Office. Whenever a signal is transmitted or received, the recorder is automatically started and the transmission recorded. Details of the circuits involved are described in the following section.

II. CIRCUIT DETAILS:

A. Main Control Panel: As described briefly in the preceding section, the functions of the Main Control Panel, PSNY Model 130, are:

(1) To reproduce over its loudspeaker the audio signals received on any Tower channel when a carrier of sufficient strength to disable the muting relay is present on that channel.

(2) To indicate, by means of an illuminated lamp, which channel (or channels) is receiving the signal.

(3) To provide means, by operation of key switches, for disabling the muting relay on any receiving channel, regardless of whether a carrier exists on that channel, to permit listening to weak signals.

(4) To provide means, by operation of key switches, for selecting any one receiving channel and excluding all others.

(5) To select, by means of toggle switches, any combination of available transmitters for simultaneous operation, and to indicate, with signal lamps, which transmitters have been selected.

(6) To select, through a rotary switch, one of two microphone circuits, with its associated preamplifier, for control of Tower transmissions.

The input to the loudspeaker of the Main Control Panel is connected, via a matching transformer and gain control, to the output of the Electronic Mixer, located in the Equipment Console (See Figure 3 and 4 for schematic, Figure 5 for intercabling diagram). With no carrier received and the receiving channel keys in the normal (center) position, all channels are silenced by a blocking bias of -60 volts which is impressed on the grids of the mixer tubes in the Electronic Mixer unit. The bias is furnished by a rectifier unit in the mixer and is applied to the grid of the tube via the normal contacts of the receiver key at the Main Control Panel and the "carrier off" contacts of the muting relays located in the "Carrier Operated Device". When a carrier is received on a channel, an A.V.C. voltage is generated in the receiver on that channel and this voltage is amplified in the C.O.D. unit. The amplified direct current is used to control the muting relay, and when a carrier is received, the relay is actuated. This operation disconnects the grid return of the mixer tube from the -60 volts squelch circuit and connects it to another circuit which is normally short-circuited to ground. The audio signal is permitted to pass on that particular channel, and it is heard in the loudspeaker. At the same time, the plate current of the mixer tube energizes a relay in the Electronic Mixer which turns on the recorder so that the signal is transcribed. A second set of contacts on the C.O.D. relay closes a low voltage lamp circuit and lights the signal on the Main Control Panel which is associated with the channel that is operating.

In order to make it possible to listen to weak signals which are not capable of actuating the C.O.D. relay, the key switches on the Main Control Panel are wired such that when thrown to the upper position (locking), the bias on the mixer tube is reduced to -12 volts and is independent of the C.O.D. relay. This bias permits the audio signals to be heard at the loudspeaker, but it is sufficient to limit the plate current of the mixer tube to a value incapable of operating the relay which starts the recorder.

Throwing the key switch to the lower (non-locking) position accomplishes two functions. It reduces the bias on the mixer tube to its normal value, which permits transmission of the audio signals and energizes the recorder starting relay. It also blocks all other channels which might interfere by removing the ground from the grid bias return circuit, applying -60 volts (through a 100,000 ohm resistor) to the "carrier on" contacts of all C.O.D. relays.

The toggle switches which select the desired transmitters for multiple operation are double pole, single throw switches. When in the closed or "operate" position, one pole of the switch closes a low voltage signal lamp circuit, illuminating a green lamp adjacent to the switch. The voltage for this circuit is obtained from the Crash Panel. The other pole of the switch connects the transmitter control line to a common control "hub". This hub is grounded when the Tower transmitter control relay K1 is actuated. Grounding a control line permits current to flow from the 24-volt rectifier at the Transmitter Station through the winding of the associated line relay at the station, and the line relay places the transmitter in operation. Therefore, any desired combination of transmitters can be controlled simultaneously by relay K1, if the proper transmitter switches are turned on at the Main Control Panel. (Transmitter and receiver channels #6 may be isolated from the Main Control Panel for emergency operation by throwing a switch on the Crash Panel.)

Carrier control relay K1 is energized by pressing the carrier control button at the microphone, grounding one side of the relay winding. The other side of the winding is connected to a source of voltage supplied from the Electronic Mixer. In the normal, unoperated position of the relay, the back contacts complete the ground return circuit of the mixer bias for receiver channels which have their C.O.D. relays actuated to the non-muting position, or which have their key switches thrown to the lower (non-muting) position. When the relay K1 is operated, in addition to grounding the control line hub, the mixer bias ground return circuit is broken, and a negative blocking potential of 60 volts reaches the bias circuit through a 100,000 ohm resistor, referred to in a previous paragraph. The effect is to silence the receiving channel whenever the carrier control relay is energized. However, this action does not occur

on receiver channels for which the key switch is in the upper (locking) position, and these channels remain unmuted.

The microphone switch, SW 15, selects either of two microphones, and its associated limiting amplifier, for Tower Transmissions and places the other in the "standby" or "crash" circuit (depending upon the position of the Crash Panel switch). The front gang of the microphone switch connects the carrier control lead of the desired microphone to the winding of relay K1. A second set of contacts supplies potential to the proper microphone indicator lamp. The control lead of the "standby" microphone is connected to the winding of relay K2 for "crash" operation.

The back gang of the switch transfers the audio circuits. The audio is picked up from the output leads of the two limiting amplifiers. Audio from the preamplifier of the "active" microphone is transferred to the Tower audio line to the Transmitter Station. Audio from the "standby" circuit is transferred to the "Crash Panel" where its disposition depends on the position of the crash switch.

B. Crash Panel: The purpose of the Crash Panel, PSNY Model 131, is to isolate the crash circuit from the main Tower circuits in emergency. Normally, the crash switch (Switch #1, Figure 6) is thrown to the standby position. Under this condition, the receiving and transmitting functions for the crash frequency are handled by the Main Control Panel in the same manner as for all other Tower circuits. The crash receiver is muted until a carrier sufficient to disable the squelch relay (C.O.D. Panel) is received, and the output of the crash channel is then applied to the speaker in the Main Control Panel. The crash transmitter may be operated by throwing the toggle switch at the Main Panel, and it will then be in parallel with all other transmitters which have been placed in the "operate" position. Audio to this transmitter is obtained from the regular Tower microphone circuit, and reaches the transmitter audio line via the crash switch.

When this switch is placed in the "emergency" position, the crash circuits are isolated from the Tower circuits, and a red lamp on the Crash Panel is lighted instead of the normal green lamp. Channel six has been wired as the crash channel for both send and receive circuits. The audio input to channel six of the Electronic Mixer is also bridged to the Crash Panel audio input circuit. With the crash switch in the "standby" position, this input circuit is terminated in a 500 ohm resistor and no signal is heard on the crash speaker. With the switch in

the emergency position, the audio is applied via the normally closed contacts of relay K2 (Main Panel) to the input transformer of a single stage amplifier which feeds the crash speaker. Relay K2 is energized when the "crash" microphone pushbutton is operated. It then grounds the transmitter control line with one set of contacts (turning on the transmitter carrier) and with a second set of contacts it silences the crash speaker by short circuiting the input to the amplifier.

The audio circuits to the Transmitter Station for both Tower and crash transmissions are routed through the Crash Panel. With the crash switch in the standby position, the Tower audio line is bridged to the crash audio line, so that both lines carry the same circuit. When the switch is in the emergency position, the crash audio line is disconnected from the Tower audio, and is conhected to the output of the standby microphone and preamplifier. In order to keep constant the impedance across the Tower audio line, a 500 ohm resistor is bridged across it. The crash switch performs one other function. The carrier control line for transmitter #6 is routed to the Crash Panel (via the Main Panel). The Tower control circuit (taken from one pole of transmitter control switch #6) and the crash control circuit (taken from a set of contacts of relay K2) are also connected to the Crash Panel. The switch connects the transmitter control line to the Tower control circuit when in the normal position and to the crash control circuit when in the emergency position.

C. Electronic Mixer: The functions of the Electronic Mixer, PSNY Model 128, are as follows:

(1) To receive signals from up to eight audio channels, and to combine these signals into a single audio output circuit.

(2) To pass or block signals from the various receiving channels, depending upon the condition of channel control circuits from the C.O.D. unit and the setting of control keys at the Main Panel.

(3) To close a control circuit which will start the P.E. recorder unit when an audio signal is being received.

The mixer circuit, shown on Figure 7, consists of four 6SN7 double triode tubes, providing eight audio input circuits. The grid circuits are transformer coupled to the individual receiver channels. The grid bias circuits are wired via the channel switches at the Main Panel to the

muting relays at the C.O.D. Panel. For the normal condition, when no carrier is being received and all channel switches are in the center position, a blocking voltage of -60 volts, generated in the mixer power supply, is applied on the grids of each mixer unit, reaching the tube by way of the normal contacts of the muting relays and the receiver control switches. This high negative grid voltage silences all channels.

When one or more channels are receiving an R.F. carrier, the respective C.O.D. muting relays are operated to the non-blocking condition, and the grid bias is removed on these channels. A cathode resistor self-biases the tubes to the correct operating value. The plate current of the mixer tube flows through the winding of relay RY-1, closing its contacts. This energizes the starting circuit at the P.E. recorder unit.

If a channel control key at the Main Control Panel is operated to the lower (non-locking) position, the muting relay for that channel is by-passed and the blocking bias of the mixer tube is removed, even though there may be no carrier signal present. The receiver output on that channel will be transmitted through the mixer unit to the loudspeaker. The recorder will be started as before. At the same time, all other channels, with keys normal, will be silenced, regardless of whether they are receiving a carrier or not, because the blocking voltage will be applied to their grids. This feature was discussed in the section describing the Main Control Panel.

If the channel control key is operated to the upper (locking) position, the C.O.D. relay is again cut out of the circuit for that channel, and a bias of -12 to -13 volts is applied to the mixer grid. This bias is obtained from the mixer power supply and reaches the grid via the channel key of the Main Panel. It is insufficient to block the audio signal, so the audio appears at the loudspeaker. However, the bias is sufficient to keep the plate current of the mixer tube below the value required to operate relay RY-1, and therefore the recorder will not be started.

The Electronic Mixer includes a compressor stage which limits the output levels of the audio signals passing through the unit. The 6SK7 tube is used for this purpose. Part of the audio output of the tube is applied across a gain control potentiometer to the grid of a 6SC7 phase inverter which drives the push-pull 6V6 output tubes. A portion of the audio from the 6SK7 is amplified by the 6SJ7 and the output coupled to a 6H6 diode. The diode rectifies the voltage and applies it back to the grid circuit of the 6SK7 compressor, making the gain of the tube inversely dependent upon the strength of the input signal.

The audio output of the mixer is fed to the speaker on the Main Control Panel, via a "T" pad gain control on that panel. A separate audio line for crash use is made available by a connection to the audio terminals of receiver #6, at the Mixer Panel. This audio is applied to the crash speaker when the crash switch is in the emergency position.

D. C.O.D. Relay Amplifier: The purpose of the C.O.D. Relay Amplifier, PSNY Model 125, is to:

(1) Provide an indication at the Main Control Panel to show what channels are receiving a carrier signal, and

(2) Control a muting circuit for each receiver channel, so that all circuits, except those receiving a carrier, will be silenced at the Electronic Mixer unit (unless the muting circuit is intentionally disabled by operating a key at the Main Control Panel).

The control of the C.O.D. unit (See Figure 8) is obtained by a connection to the A.V.C. lines of the receivers. The method of picking up the receiver A.V.C. voltage differs on the various types of receivers. It is shown for a CR3G receiver in Figure 18. The A.V.C. voltage obtained depends upon the type of receiver and strength of signal, but is usually in the range of 1 to 5 volts. For receiving channels 1 to 6 inclusive, the A.V.C. voltage of each receiver is applied to the grid of an individual 6SN7 tube. The plate of the first section is direct coupled to the grid of the second section of the tube in a conventional D.C. amplifier circuit. The plate current of the second section flows through the muting relay associated with the receiving channel. When no carrier is being received, there is no A.V.C. voltage and the relay is not energized. The armature of one set of contacts of the relay is connected to the mixer unit squelch input for that channel, via the control switch at the Main Control Panel. When the relay is not energized, the armature is connected to a negative potential of about -60 volts, supplied from the Electronic Mixer. This voltage is therefore applied to the grid of the mixer tube and blocks all signals on the channel. The muting action of a relay on any channel may be nullified by operation of the key at the Main Control Panel to either the upper or lower position.

When a relay is energized, the blocking bias circuit on that channel is replaced by a connection which normally grounds the grid return circuit at the Main Control Panel. With the high blocking bias removed, the received signal is transmitted through the Electronic Mixer unit. At the same time a second set of contacts on the relay are closed and

apply a low potential to the indicator lamp on the Main Control Panel, to show which channel is receiving the signal.

The ground return circuit mentioned in the preceding paragraph may be interrupted either by operating any key at the Main Panel to the lower (non-locking) position or by pressing the carrier control button at the microphone, actuating relay K1. With ground removed, a blocking bias reaches the relay contacts through a 100,000 ohm resistor in the Main Panel, and the channel is muted even though a carrier signal is present.

Channels 7 and 8 of the C.O.D. unit have an additional stage of D.C. amplification for the A.V.C. voltage, utilizing a 6AC7 tube direct coupled to the 6SN7 input. The effect of adding a single stage of D.C. amplification is to invert the D.C. output so that when there is no A.V.C. voltage, a large current flows from the plate of the final stage of the D.C. amplifier through the relay winding, and when there is an A.V.C. voltage present, the current is blocked. The normal or "carrier off" position of the relay armature is therefore opposite that of the other relays, and the connections to the relay contacts are therefore reversed, in order to maintain the same action as for the first six channels. The purpose of the additional stage of amplification is for use with receivers having low A.V.C. voltage, such as the RCO.

E. Remote C.O.D. Unit, Model 145, and Remote Switching Panel: The Remote C.O.D. Unit, Model 145, (See Figure 9) is similar to and performs the same general functions as the C.O.D. Unit, Model 125, described in the preceding section, except that it is used when the receivers are remotely located from the Tower. The A.V.C. leads from the receivers on each channel are connected to the D.C. amplifier tubes, and the output of each tube controls a "carrier operated" relay. Channels 7 and 8 have an additional stage of amplification, the same as for Model 125. The Remote Relay Unit does not directly light a lamp at the Main Control Panel, nor does it directly control the blocking bias of the Electronic Mixer. Instead, it furnishes either ground potential (for no carrier) or a negative D.C. voltage (when a carrier is received) to the A.V.C. input of the local C.O.D. Unit, which then controls the indicator lights and the blocking bias in the same manner as for local receivers. The negative D.C. voltage is generated in the power supply of the Remote Unit and is applied through the "carrier-on" contacts of the channel relays. A second set of contacts lights a channel indicator lamp on the Remote Unit when a carrier is received. In order that the Control Tower operator may be able to select either local or remote receivers on any channel, a Remote Receiver Switching Panel is provided wherever remote receiving installations are used. This panel consists of eight keys which are wired in such a manner as to connect

the A.V.C. input of each amplifier tube of the local C.O.D. Unit to either the A.V.C. line of the local receiver or the channel control voltage from the Remote C.O.D. At the same time, another set of contacts on the key connects the audio input of the Electronic Mixer to the local receiver audio output on the audio line from the remote receiver.

F. Miscellaneous Tower Control Equipment: Miscellaneous equipment associated with the Tower control circuits are:

(1) Limiting Amplifiers for use with the microphone circuits.

(2) Cathode follower antenna matching unit.

(3) Recorder and Recorder Control unit.

The Limiting Amplifiers are of two types, the older Model #1, and the later Model #142. Circuit diagrams are given on Figures 10 and 11, respectively. The circuits involved are conventional amplifier and compressor circuits which provide a limited range of volume output over a considerable range of volume input from the microphone.

The Cathode Follower Impedance Matching Units, Model 106A or 106B (Figures 12 or 13, respectively) are used to couple the whip antennas on the Tower to the coaxial transmission line to the receivers. One unit is installed for each Tower and it is mounted in a watertight box near the antenna. The function of the Cathode Follower is to offer a high load impedance to the antenna currents, and to transmit the signals received from the antenna to a low impedance transmission line with small loss in voltage amplitude. Owing to the nature of the circuit, the voltage output of a Cathode Follower is slightly less than the voltage input, but because the impedance of the output is much less, there is considerable power amplification in the device. The Model 106A unit uses a type 6AC7 impedance matching tube and a type 80 rectifier. Model 106B, which is modified to provide either balanced or unbalanced output, uses a 6AC7 impedance matching tube and a 5W4 rectifier.

The Recorder units are the Navy standard PE or PE-1. Separate audio input circuits are provided for monitoring the Crash audio transmissions, the Tower transmissions, and the received audio (Crash and Tower audio both go through the Mixer, and one connection is sufficient to pick up both). Three starting relays are provided for turning on the Recorder unit automatically. The contacts of the relays are connected in parallel, in order that the closing of any relay will start the machine. The

winding of one relay is connected in series with the contacts of relay RY-1 in the Electronic Mixer, and the Recorder is started whenever a carrier is received. The windings of the other two relays are energized, respectively, when the Crash or Tower transmitter control circuits are grounded (placing the transmitters involved on the air).

III. MAINTENANCE AND TEST DATA:

A. General: In this section, the method of setting up the adjustments on the equipment and the procedure for locating various types of trouble will be described briefly. The initial adjustments required to place the equipment in operation are;

(1) Adjustment of C.O.D. Unit to respond properly to A.V.C. signals from the various receivers, taking into account the local noise level and other factors.

(2) Adjustment of the audio input for the mixer to a suitable value on each channel.

(3) Adjustment of gain of microphone preamplifiers.

After the equipment has been placed in service, failures of the receiving facilities may be due to the following causes:

(1) Failure to receive audio signals or visual indication of carrier on one or more channels, in the presence of a modulated carrier.

(2) Failure of channels to mute properly when no carrier is present.

(3) Failure of channel keys to control muting of the receiving channels, or failure of receiving channels to mute when the Tower is transmitting.

Failures of the transmitting facilities at the Control Tower will fall into two classes:

(1) Inability to control the transmitter carriers.

(2) Breakdown in audio circuits.

Except where otherwise stated, the following discussions refer to the regular Tower facilities, rather than the Crash system.

B. Initial Adjustments: The most important adjustment of the Tower equipment is the setting of the C.O.D. unit sensitivity. A potentiometer is provided on each channel of the C.O.D. for this purpose. It is necessary to adjust the C.O.D. sensitivity sufficiently high to receive desired transmissions, and at the same time to hold the sensitivity low enough so that static or local interference peaks will not trigger the system. As the interference level is different at each station, and probably on each channel, the settings of the C.O.D. sensitivity will vary widely. It is suggested that a start on the adjustments, on H.F. channels, be made by feeding 15 microvolts from a signal generator into the radio receiver of the channel under test, and the sensitivity of the C.O.D. unit be reduced to a point where the relay is just operated. The receiver sensitivity should be at maximum and the receiver squelch (if any) turned off. If bursts of static or interferance operate the C.O.D. after this adjustment has been made, reduce the sensitivity further. If tests on the air indicate some desired signals are not strong enough to actuate the C.O.D., increase the sensitivity. When the optimum setting of the control has been found, record the input to the receiver in microvolts and the A.V.C. voltage output, measured by a VT voltmeter, as this information may be useful on future tests.

The audio input to the Mixer unit should be set near 0-DB (referred to 6MW) by adjusting the receiver volume control when receiving a normal voice signal. If the volume input is set too high, severe distortion will result in the volume compressor stage, and the effectiveness of the compressor in maintaining a steady output level is reduced.

The output of the microphone preamplifiers should be set to give approximately 0-DB level at the transmitter station DB meter.

C. Receiving System, Servicing: The receiving circuits are shown in simplified form on Figure 16. In the event of failure to receive an audio signal or visual indication of carrier on a channel when an R.F. carrier exists, the circuit may be traced on this diagram to the point of fault. If the C.O.D. relay fails to operate, the trouble may be lack of A.V.C. voltage from the receiver, tube failure in the C.O.D. unit, or improper adjustment of the D.C. amplifier sensitivity in the C.O.D. unit. If the C.O.D. relay responds properly when a carrier is present on the channel, the audio input and grid bias of the input tube at the Electronic Mixer should be checked. A lack of audio suggests an open or short circuited line to the receiver, or receiver failure. If the grid return is biased, the trouble is an open ground return on the bias circuit and may be caused by an open back contact of the keying relay K1, or an open contact in one of the eight channel switches, which are all in series.

Failure of a channel to mute when no carrier is present may be due to a number of causes. The C.O.D. relay should be checked to see if it is in the "carrier off" position. It not, the C.O.D. sensitivity may be adjusted too high. If the relay is in the correct position, check the control switch contacts of the channel in question for an open circuit, and then trace the 60 volt blocking bias line back to the point where the bias is lost. An open 1 megohm resistor or a short-circuited .05 mf. condenser at the control switch may cause this trouble.

Failure of channel keys to control the muting circuit or failure of the receivers to mute when the transmitting relay is keyed probably is caused by poor contacts of the switches or relays.

D. Transmitting Facilities: The transmitter control circuits are shown on Figure 14 in simplified form. The carrier control relay at the transmitter station is energized when the control line circuit is completed to ground, through the transmitter control switches and the contacts of relay K1. If the transmitter carriers stay on when the carrier control pushbutton is not closed, open all transmitter toggle switches and observe whether any carriers still remain on the air. If so, the most probable causes of trouble are grounded control lines on any transmitter which fails to shut down.

If opening the toggle switches shuts down each of the transmitters, the short circuit to ground must be on the common side of the switches, and may be caused by closing of relay K1. Relay K1 will close if there is a short circuit to ground of the line from the relay winding to the microphone pushbutton. This type of trouble may be isolated by rotating the microphone switch to the other microphone circuit and observing whether the trouble is cleared. If the trouble is not cleared, inspect for grounds at the relay, microphone switch and microphone input jack.

Another type of trouble which may be encountered is the failure of one or more transmitter units to come on when the microphone button is closed. If only one circuit fails, the trouble is probably a defective transmitter control switch or an open line to the transmitter (inspect associated jacks, plugs, and terminal strips). Test by grounding the control line at various places and observing to see whether the relay at the Transmitter Building is operated. Control circuit six is also wired for crash use, and is routed through the Crash Panel, so inspection for open circuits on this line should include the plugs, jacks, and Crash switch. The cause of the trouble in this case may be isolated by switching the Crash switch to the emergency position and operating the Crash microphone.

Failure of the transmitter audio circuit may be due to trouble in the microphone or preamplifier, and this may be determined by operating the microphone switch. If neither circuit works, the audio should be traced with a headset from the amplifier output to the input of the transmitter audio line, following the simplified schematic Figure 15. Short or open circuits at jacks, plugs, switch contacts, and terminal strips are also possible sources of trouble.

E. Summary: The preceding paragraphs are intended chiefly for the purpose of suggesting general methods of locating the causes of failures of various types. As maintenance personnel become familiar with the equipment, numerous shortcuts should become apparent. The schematic wiring diagram, Figure 3, which shows the entire Tower Control System, should be used as an aid in all tests and measurements.

A table of voltage and resistance measurements for the equipment has been compiled and is included in the Appendix, along with other information which may be of assistance.

APPENDIX

VOLTAGE AND RESISTANCE MEASUREMENTS

Crash Panel, PSNY Model 131

	Voltage	Resistance
Power Supply Plate to Plate	650 AC	800 ohms
Power Supply Filament to Ground	425 DC	.6 to .8 Megohms
6V6 Plate to Ground	"	"
6V6 Screen to Ground	"	"
Filament Voltage 6V6	6.1 AC	
Filament Voltage 5U4	5.0 AC	
Cathode to Ground 6V6	43.0 DC	400 ohms

T_1 Primary DC resistance 250 ohms with plug in phone jack
T_1 Secondary DC resistance 11,125 ohms.

L_1 Choke 650 ohms.
T2 Power transformer primary 650 ohms.

Power consumption of Crash Panel 25 watts.

T_1 Primary 240 ohms DC
T_1 Secondary 12,000 ohms DC

T_9 Primary 4 ohms DC
T_9 Secondary 180 ohms DC

T_{10} Primary 300 ohms DC
T_{10} Secondary 16 ohms DC

Power supply output resistance 40,000 ohms.

6SN7
Plate to ground 95,000 ohms
Cathode to ground 1,250 ohms
Grid to ground 10,000 ohms

6H6
Diode #3, 3.5 megohms
Diode #5 Infinity
Cathode #4 Infinity
Cathode #8 0

6SC7
Grid #4 1 megohm
Grid #3, 13,000 ohms
Plate #2, 30,000 ohms
Plate #5, 30,000 ohms
Cathode 2,000 ohms

6SK7
Plate to ground 75,000 ohms
Cathode to ground 4,000 ohms
Grid to ground 3.5 megohms

6V6
Plate to ground 40,000 ohms
Screen to ground 41,000 ohms
Cathode to ground 450 ohms
Grid to ground 700,000 ohms

6SJ7
Plate to ground 40,000 ohms
Cathode to ground 650 ohms
Grid to ground 34,000 ohms

(All measurements below with Electronic Voltmeter)

6SN7
Plate (5) 24 volts
Grid (1) -.7 volts
Cathode (3) .7 volts

6SC7
Plate (2) 160 volts
Plate (5) 155 volts
Grid (3)
Grid (4)
Cathode (6) 2 volts

6SK7
Plate (8) 210 volts
Grid (4) -25 volts
Cathode (5) 25 volts

6SJ7
Plate (8) 5 volts
Grid (4)
Grid (6) 60 volts
Cathode (5) 2 volts

Electronic Mixer, PSNY Model 128 (Continued) - All measurements with Electronic Voltmeter.

6H6

Diode (3) -.2 volts
Diode (5) -.1 volts
Cathode (4)
Cathode (8) 0

6V6

Plate (3) 335 volts
Screen (4) 280 volts
Cathode (8) 20 volts
Grid (5) -20 volts

Power supply output 350 volts

Consumption 60 watts

Carrier Operated Device

(All Voltage Measurements with Electronic Voltmeter)

First six 6SN7s

Plate (2)	2 megohms	-.6 volts
Plate (5)	7,500 ohms	260 "
Grid (1)	1 megohm	-.5 "
Grid (4)	2 megohm	-.5 "
Cathode (3)	10,000 ohms	.1 "
Cathode (6)	2,000 ohms	13.0 "

6AC7

Plate (8)	56,000 ohms	10.0 volts
Screen (6)	5,000 ohms	65.0 "
Grid (4)	1.8 megohms	-.2 "
Cathode (5)	0	0

Last two 6SN7s

Plate (2)	50,000 ohms	160 volts
Plate (5)	7,500 ohms	230 "
Grid (1)	58,000 ohms	9 "
Grid (4)	48,000 ohms	170 "
Cathode (3)	10,000 ohms	160 "
Cathode (6)	7,000 ohms	160 "

Power supply output 290 volts

Consumption 84 watts