CHAPTER 11

COMMON OPERATING ADJUSTMENTS: RADAR AND LORAN EQUIPMENT

The ET must be familiar with the external adjustments on radar and loran sets.

Radar Set AN/SPS-10D and Loran Receiving Set AN/UPN-12 are used in the following discussions because they are considered to be the most representative sets now in use.

RADAR SET AN/SPS-10D

The AN/SPS-10 (series) is in service on a large number of ships. It is primarily a medium-range, high-definition, surface-search and limited air-search radar. The maximum range when detecting surface targets is normally greater than the optical horizon as received from the antenna reflector. (The optical horizon in miles equals 1.22 times the square root of the antenna reflector height in feet.) The strength of a received echo generally depends on the size and the shape of the target, its distance and altitude, the material of which it is made, and weather conditions.

Radar Set AN/SPS-10D (fig. 11-1) is used primarily in the detection, ranging and tracking of surface targets. It can be used to a limited extent to provide the same information regarding air targets.

Target range and bearing intelligence is displayed on a standard Navy Plan Position Indicator (PPI), such as the AN/SPA-8A. The AN/SPS-10D can be operated as a beacon or with an IFF (identification, friend or foe) system.

The functional operation of Radar Set AN/SPS-10D can be studied with the aid of figure 11-2. The modulator provides modulating pulses for the transmitter, and synchronizing pulses for the other units of the radar system. The transmitter, when triggered by the modulator output, transmits a series or burst of radio-frequency pulses (electromagnetic waves). This energy is radiated by a unidirectional rotating antenna reflector.

Radar Set AN/SPS-10D (fig. 11-1) operates in a frequency range of 5450 to 5825 mc (x-band). The pulsed output frequency is generated by keying a magnetron oscillator in the transmitter. The peak output power is between 190 and 285 kw.

During radar operation the output pulse duration is either 0.25 or 1.3 μs ($\pm$ 10%). The pulse repetition rate (prr) can be adjusted between 625 and 650 pulses per second. Approximately 0.08 μs of each magnetron keying pulse is required to place the magnetron in operation. Thus, the width of the input trigger pulses are 0.33 and 1.38 μs, respectively.

For beacon operation, the pulse duration is increased to 2.25 us, and the prr is decreased to 312 - 325 pulses per second. The total duty cycle of the system (ratio of pulse duration time to pulse repetition time) must be maintained at less than 0.001 to permit magnetron recovery time.

The beacon function of the radar set permits operation of the system in conjunction with responding ships or aircraft. The response signals are mixed in the beacon receiver with the beacon local oscillator output and are ultimately presented on the indicator. The received signal is therefore stronger, and causes bright spots in the indicator pattern. These bright spots are used to identify a responding object.

The antenna rotates at 15 rpm. During radar operation, the horizontal beam width of the radiated pattern is approximately 1.5 degrees. The vertical beam width is within 12 to 16 degrees.

Description And Function Of Units

Figure 11-1 illustrates the major units of Radar Set AN/SPS-10D. You must keep in mind that, on your ship, these units will probably be scattered in various compartments. Make

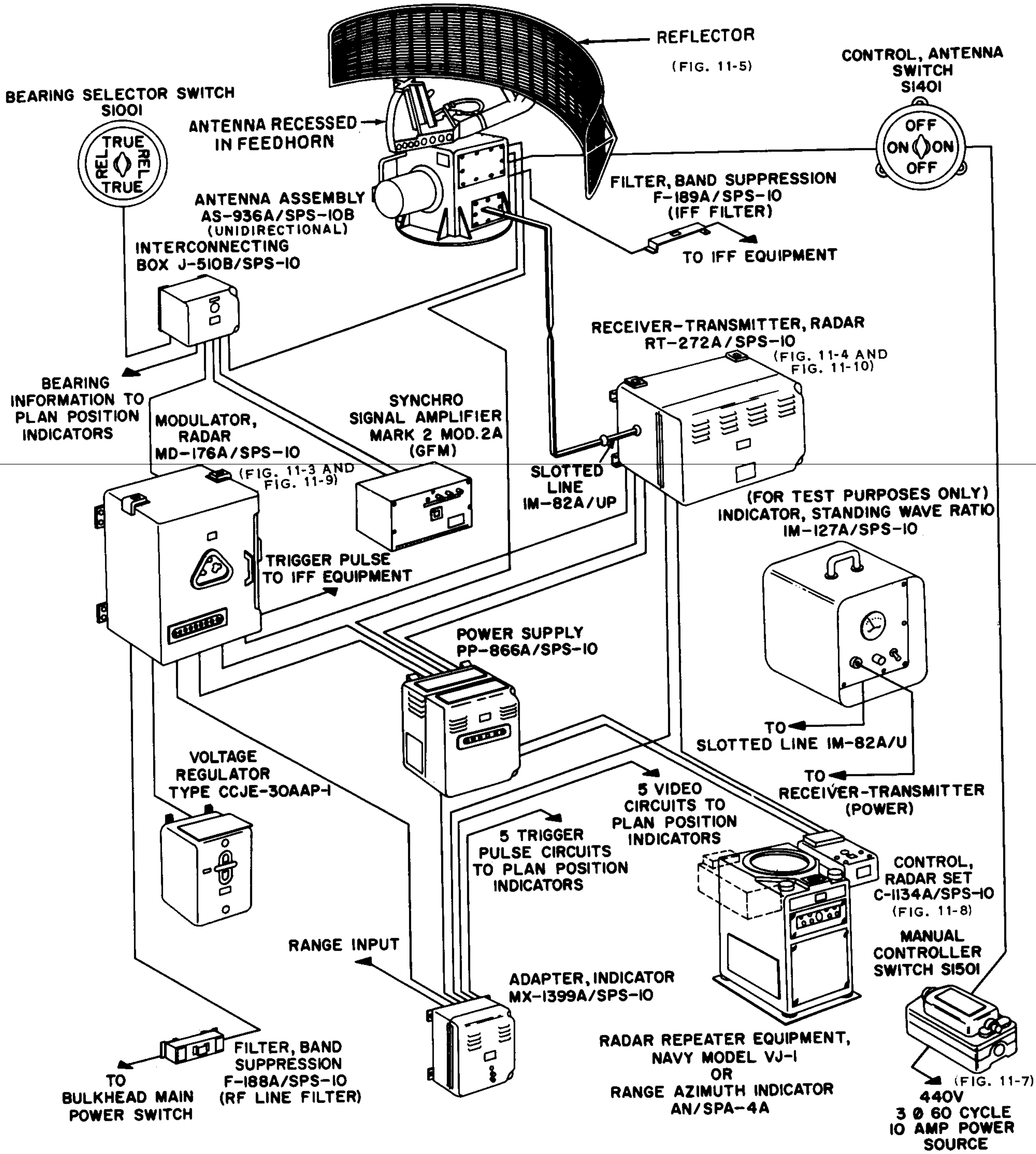

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Figure 11-1.—Radar Set AN/SPS-10D, Pictorial system diagram.

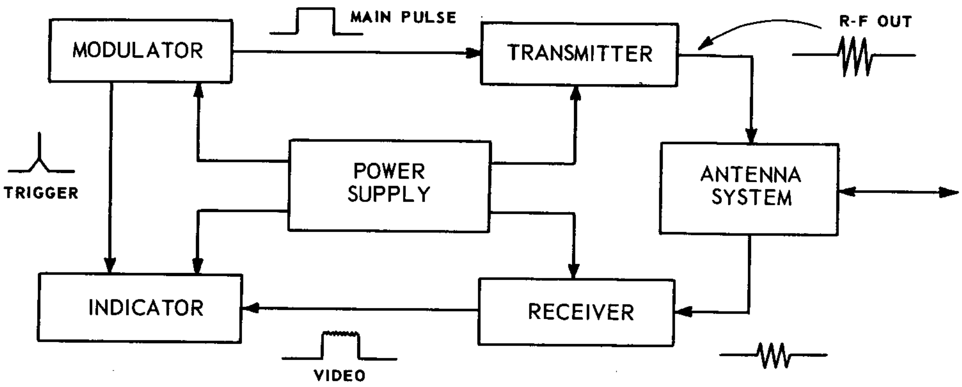

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Figure 11-2.—Radar Set AN/SPS-10D, Functional diagram.

it a point to learn the location of the units on your ship.

FILTER, BAND SUPPRESSION, F-188A/SPS-10 (sometimes called an R-F line filter): This filter serves to eliminate R-F leakage (conducted noise) from the primary power source to the radar set and from the radar set to the primary power source.

FILTER, BAND SUPPRESSION, F-189A/SPS-10 (IFF filter): This filter is connected to the antenna assembly, and minimizes interference from the radar set to the IFF equipment used in conjunction with Radar Set AN/SPS-10D.

VOLTAGE REGULATOR, TYPE CHS-30 AAP-1: The voltage regulator maintains the regulated primary voltage at 115 volts a-c plus or minus 2 percent. It is equipped with a NONREGULATING-REGULATOR ON selector switch so that the voltage regulator may be switched out of the radar system.

A voltmeter is provided for measuring the voltage output of the voltage regulator. A PRESS FOR LINE VOLTAGE pushbutton, when depressed, permits reading the line voltage without taking the voltage regulator out of the radar system, when the selector switch is in NONREGULATING. With selector switch in REGULATOR-ON, meter gives constant indication.

This unit includes its own full-wave d-c power supply for an electronic sensing circuit which controls a motor-driven variable autotransformer connected to an intermediate booster transformer. The booster transformer will either add voltage to or subtract voltage from the voltage delivered by the ship's mains. As a result, a regulated voltage input is maintained to the various circuits of the radar set.

POWER SUPPLY PP-866A/SPS-10: This unit provides four electronically regulated electron tube d-c power supplies for the receiver-transmitter. It also provides one unregulated (low-voltage) d-c power supply for the system control circuits.

When MAIN POWER switch on the radar set control is manually turned to the STDY (standby) position, a 3-minute time delay relay is energized. The delay prevents 115 volts a-c from being fed to the primary side of the power supply transformer of the unregulated power supply. This delay gives adequate time for certain tube filaments to heat sufficiently, thus preventing injury to these tubes when plate voltage is applied.

A blown fuse indicator shunts each fuse of the power supply unit to provide a visual check of its condition. In addition, a warning lamp on the fuse panel is visible when the unit is open, and lights up when the power supply unit is energized. A thermal control switch provides a means of indicating overtemperature conditions by lighting an indicator light at the radar set control. You can get to a 115 volt a-c convenience outlet by opening the front cover of the unit.

MODULATOR, RADAR, MD-176A/SPS-10 (fig. 11-3): The modulator provides the modulating pulse for the transmitter, the synchronizing pulses for the other units of Radar

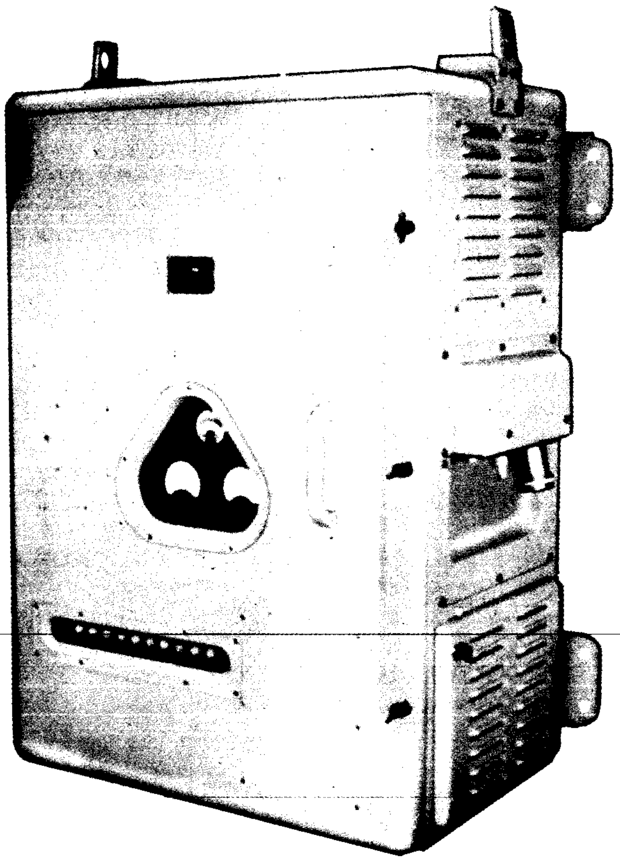

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Figure 11-3.—Modulator, Radar.

Set AN/SPS-10D, and, in addition, distributes 115-volt, 60-cycle power to the various units.

The modulator contains a trigger pulse generator chassis, a high-voltage switch chassis, a thyratron (keyer) tube chassis, and a rectifier tube chassis. The trigger pulse generator produces trigger pulse voltages of the proper waveform to fire the thyratron tube at a repetition rate of approximately 650 PPS during radar operation. This rate is adjustable from 625 to 650 PPS by means of a motor-driven capacitor which is remotely controlled by a pushbutton on the radar set control.

When the radar set is turned to beacon operation, a resistor-capacitor (RC) network in the high-voltage switch chassis provides a means for reducing the pulse repetition rate of the blocking oscillator in the trigger pulse chassis to half the frequency of the phase shift oscillator, or about 325 PPS.

A motor-driven, high-voltage, pulse-width switch selects one of three pulse widths (0.25-microsecond short pulse, 1.30-microsecond long pulse, or a 2.5-microsecond beacon pulse plus or minus 10%).

Low-amplitude samples of the modulating pulse, used to modulate the magnetron oscillator in the transmitter, are supplied to trigger and synchronize the indicator adapter. The modulating pulse and the trigger pulses are sent from the modulator through coaxial cables. These cables are connected to the jack assembly contained in the protective shield attached to the right side of the modulator cabinet.

A motor-driven blower and air cleaner (filter) provide ventilation for getting rid of heat generated by the modulator.

The power distribution circuit consists of an autotransformer, relays, a safety switch, and 11 fuses with blown fuse indicators.

Three meters are mounted on a hinged panel behind a viewing window in the front door of the unit. These are: (1) a time meter which shows directly the total number of hours during which the equipment is on; (2) a time meter which shows directly the number of hours during which the equipment is in the radiate condition; and (3) a milliammeter which measures relative magnetron average current for long-pulse, short-pulse, and beacon-pulse operation.

INTERCONNECTING BOX J-510A/SPS-10: The interconnecting box serves (by means of its internally connected terminal boards) as a junction point for the modulator, synchro signal amplifier, antenna assembly, and radar repeater equipment (one master indicator and four remote repeaters).

The interconnecting box contains two capacitors for improving the power factor of the 1-speed and 36-speed synchros, a stepdown transformer which provides the proper voltage for the relative bearing warning light at the radar repeater equipment, and a selector switch for feeding either true or relative bearing information to the radar repeater equipment.

RECEIVER-TRANSMITTER, RADAR, RT-272A/SPS-10D. The receiver and transmitter are housed together in one cabinet (fig. 11-4).

The receiver portion of this unit is mounted on a specially shielded, readily accessible, hinged panel inside the front cover. A hinged auxiliary control panel for local control is located above the receiver panel.

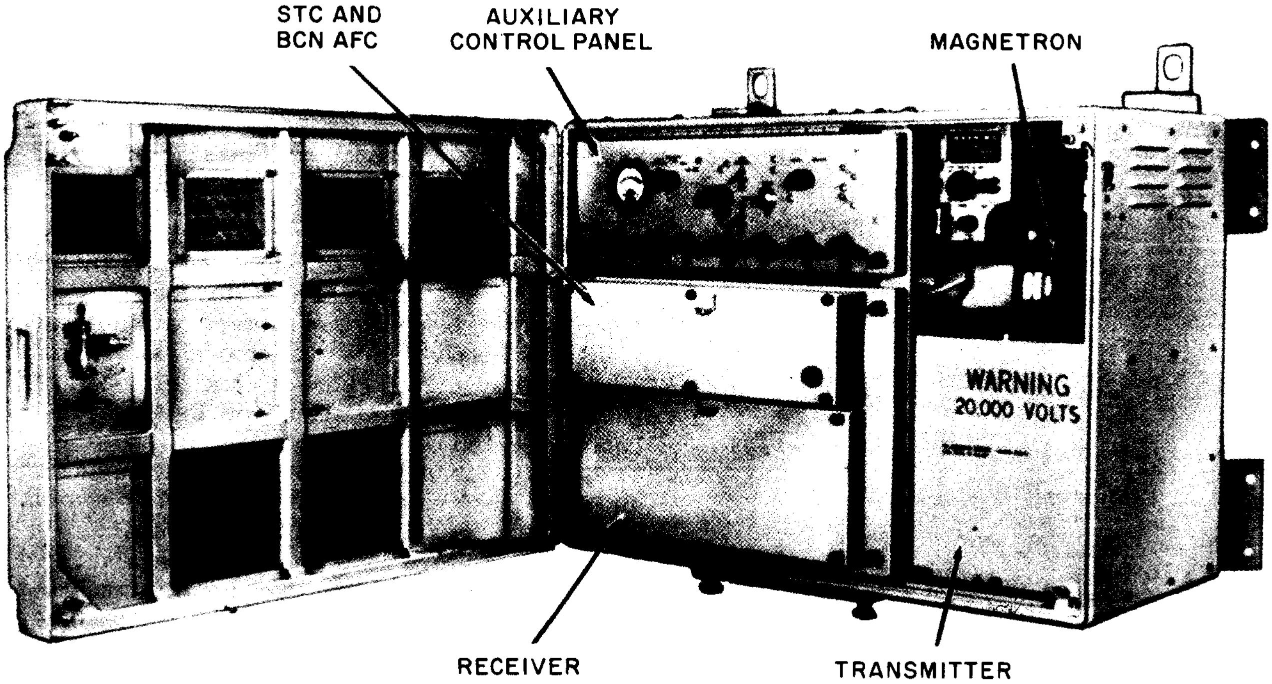

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Figure 11-4.—Receiver-Transmitter, Radar, Major units, Access door open.

The transmitter, with its associated equipment, is mounted in the receiver-transmitter cabinet behind the receiver panel and auxiliary control panel.

The receiver uses two local oscillators, one for radar operation and the other for beacon operation. By means of a selector switch on the radar set control, the receiver may be placed in either radar or beacon operation. The receiver contains broad-band I-F strip video stages, IAGC (instantaneous automatic gain control) circuits for reducing interference from strong returned signals, an FTC (fast time constant) circuit which can be used with or without IAGC to distinguish land-masked targets, an STC (sensitivity time control) circuit which reduces receiver gain for signals from targets at short range and yet maintains full gain for signals from targets at greater range, and separate AFC (automatic frequency control) circuits, one for radar and one for beacon operation.

The transmitter consists of a high-voltage pulse transformer, a magnetron oscillator, a duplexing system which includes a TR tube for protecting the receiver from excessive input during the transmission period, two ATR tubes to prevent a loss of received energy in the magnetron, a mixer, an echo box, a blower to provide a means of cooling, and other equipment such as the probe for the slotted line, interlocks, and fuses. An opening in the upper left side of the receiver-transmitter permits the slotted line or waveguide transmission line to be bolted directly to a waveguide flange on the duplexer.

An echo box (resonance chamber), located in the receiver-transmitter, can be tuned either by means of a toggle switch on the radar set control which operates the control motor of the echo box, or by means of a manual tuning knob attached to the shaft of the echo box motor.

The echo box constitutes a high Q (quality or figure of merit) tuned circuit at the transmitter frequency whose energy storage properties are used to provide an artificial echo on the plan position indicator. This artificial echo gives an indication of the overall performance of the radar set.

The auxiliary control panel contains the following equipment and controls: an ECHO BOX TUNE knob, a LOCAL-REMOTE switch, an STC (ON-OFF) switch, an RDR BCN-AFC (ON-OFF) switch, an OFF-RADIATE-START switch, and a milliammeter and selector switch for measuring beacon AFC crystal current, radar AFC crystal current, magnetron current, receiver crystal current, and video detector current. It also includes seven manual controls, located near the bottom of the panel, that have the following adjustments: receiver tuning, beacon tuning, receiver gain, video detector zero set, STC duration, STC magnitude, and STC flat control.

SLOTTED LINE IM-82/UP: The slotted line (also called slotted waveguide) is a section of rectangular waveguide which bolts to the flange of the duplexer located in the upper left side of the receiver-transmitter.

This unit provides a means for making standing-wave measurements. The top surface of the slotted line has a slot cut through it and is provided with a sliding cover. The slot should be covered when measurements are not being taken. An R-F probe, normally stored on the inside of the door of the receiver-transmitter, is connected to an amplifier and a meter and is inserted into the slot to make the measurements.

ANTENNA ASSEMBLY AS-963A/SPS-10B: The antenna assembly (fig. 11-5) includes a truncated parabolic reflector, feedhorn, IFF dipole, IFF loadmatching section, IFF corner

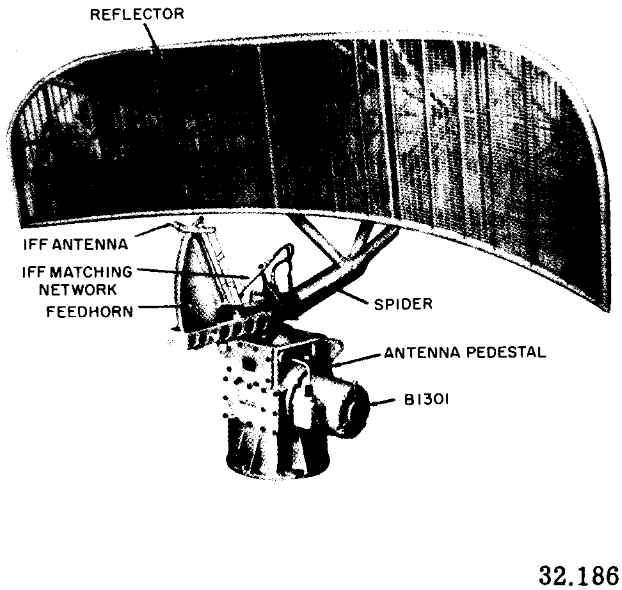

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Figure 11-5.—Antenna assembly AS-936A/SPS-10B.

reflectors, spider and pedestal SB-561A/SPS-10B. The radar horizontal beam width is about 1.5°, whereas the IFF horizontal beam width is about 6°.

The antenna pedestal rotates the Antenna Assembly in a clockwise direction at a speed of 15 rpm. The pedestal consists of a cast steel housing containing an upper rotating rotary joint, a lower stationary rotary joint, an antenna drive motor, a 5 G synchro, a thermostat and heater to control oil temperature, a gear train, and a pair of cam-actuated microswitches to operate the ship's heading marker circuit. The antenna requires a power source of 440 volts, three phase, 60 cycles, at 10 amperes.

Three switches (fig. 11-1) that function in conjunction with the antenna are the Bearing Selector Switch S1001, the Control, Antenna Switch S1401, and the Manual Controller Switch S1501 (discussed later).

The Bearing Selector Switch is a remote control whose function is to feed either true or relative bearing information to the Radar Repeater equipment. It is a double-pole single-throw rotary type snap switch, located adjacent to the Radar Set Control.

The Control, Antenna switch removes power from the antenna drive motor, thereby disabling the antenna and allowing maintenance personnel to safely perform necessary maintenance procedures. It is mounted on the ship's mast below the antenna assembly, and is employed as a safety measure. The switch is a snap-action, two-position, 2-ampere, 450-volt a-c rotary packet switch with markings OFF and ON engraved on the switch to indicate its positions.

ADAPTER, INDICATOR, MX-1399/SPS-10: The indicator adapter contains its own power supply, a ship's heading marker circuit, a video amplifier circuit, a trigger pulse delay circuit, and video mixer circuit for range marks.

The video amplifier stages provide enough video power amplification of the echo video pulses to give five identical low-impedance outputs. These outputs may be distributed individually to five standard Navy plan position indicators.

The trigger pulse delay circuit has an adjustable compensating time delay between the transmitted microwave pulse and the trigger pulse generated by the modulator. The trigger pulse time delay is accomplished by the combination of several low-pass filter networks. Forty-eight sections provide a total time delay of 2.4 microseconds in steps of 0.05 microsecond each.

The delayed trigger pulse is amplified and fed to five cathode followers which supply five identical synchronizing trigger pulses for triggering indicator repeaters.

An amplifier and a multivibrator circuit furnish the ship's heading marker signals for mixing with the video signals. Provisions are also made for mixing a positive 5-volt range marker signal with the video signal.

The power supply provides both plate and bias voltages for the unit. The unit has a fuse and a blown fuse indicator for its 115-volt, 60-cycle input supply.

CONTROL, RADAR SET, C-1134/SPS-10: The radar set control, called the general control unit on many radars, contains all necessary controls for operating the radar system.

The infrequently used controls are located near the top of the front panel behind a hinged cover. These controls are: STC magnitude, STC duration, STC flat, antijam selector switch, pulse repetition rate (PRR) control switch, and a ship's heading marker (SHM) ON-OFF switch.

The normal operating controls mounted openly on the front panel are: an echo box switch, toggle switch, three overtemperature indicating lights (modulator, receiver-transmitter (RT), and power supply (PS); a d-c monitoring meter with selector switch for measuring receiver crystal current, radar and beacon AFC crystal current, magnetron current; a main power switch; a pulse-width selector switch (BCN radar); an AFC (ON-OFF) switch; an STC (ON-OFF) switch; and adjustments for receiver gain and receiver tuning. The control identifications are illuminated for dark space adaptation; a dimmer controls the intensity of the illumination.

The radar set control can be mounted on either side of the indicator of Radar Repeater Equipment, Navy Model VJ-1 or Range Azimuth Indicator AN/SPA-4A.

ACCESSORY EQUIPMENT: A standard Navy plan position indicator (Radar Repeater Equipment, Navy Model VJ-1) and a Synchro Signal Amplifier Mk 2 Mod 2A may be used with the radar set.

The AN/SPA-4A and/or AN/SPA-8A is a radar repeater that is replacing most VJ's, and is suitable as a master indicator or a remote indicator. It is designed for use with any type of naval search radar capable of presenting range and bearing information.

FUNCTIONAL BLOCK DIAGRAM

The detailed functional block diagram, figure 11-6, shows all of the major units of Radar Set AN/SPS-10D. The main system flow is indicated by heavy lines, and supplementary circuits by light lines.

The following consideration of the block diagram emphasizes the purpose and relationship of all major units of the radar system. A detailed block diagram of each major unit is presented before the discussion of the major circuits of that unit.

Synchronizing trigger pulses for the radar set are obtained from the modulator. The primary a-c power is fed to the modulator through an r-f line filter. This filter serves to eliminate the transfer of r-f noise from the a-c power source to the radar set and from the radar set to the power source.

An electronically controlled voltage regulator maintains the a-c power input voltage at 115 volts ± 2 percent. A power supply converts the a-c input voltage into regulated and nonregulated d-c voltages for distribution to the various circuits.

The modulator pulse output is formed in any one of three pulse forming networks each of which produces pulse outputs of different time durations. The main pulse output is a negative-going rectangular pulse which is fed to the transmitter. The transmitter then develops r-f pulses of either 0.25, 1.30, or 2.25 μs as determined in the pulse forming network selected at the modulator. The length of the transmitter trigger pulses is sufficient to compensate for the delay in the starting of the transmitter.

The negative pulses (main pulses) generated in the modulator are applied to a pulse transformer in the transmitter, where the amplitude is increased from 5 kv to approximately 20 kv. The pulses from the transformer are applied to a magnetron oscillator with no change in the original waveform polarity. Application of the pulses to the magnetron places the magnetron in operation, and causes it to generate microwave r-f energy for a time interval equal to the length of each input pulse, minus the time required to key the magnetron (0.08 μs).

The modulator also provides low amplitude samples of the main pulses. These pulses are

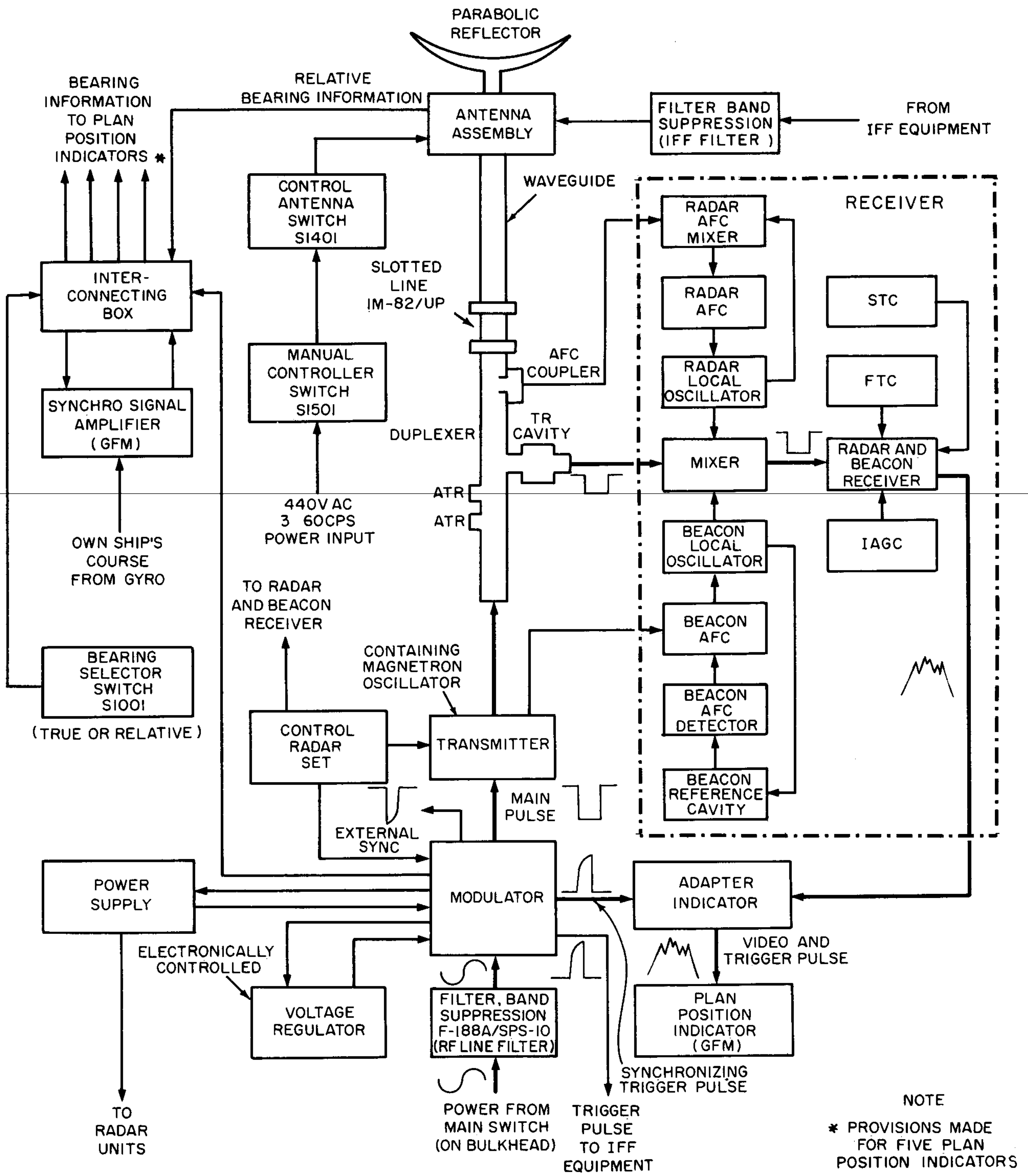

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Figure 11-6.—Detailed functional block diagram.

applied along one path to an adapter indicator. Other samples of the main pulse from the modulator are used for synchronizing external and auxiliary equipments which may operate in conjunction with the radar set.

In the adapter indicator, the trigger pulses are delayed to compensate for the time delay between the trigger pulse generated by the modulator and the actual transmission of the microwave r-f pulse. After delay, the trigger pulse is amplified and applied to five conventional cathode-followers. The output pulses are used separately to trigger as many as five plan position indicators.

The microwave r-f output energy of the magnetron oscillator is conducted to the antenna assembly through a duplexer, a slotted line, and a rectangular waveguide. This energy is then directed by a feedhorn (fig. 11-1) to the surface of a slotted parabolic reflector.

During transmission, the antenna reflector concentrates and radiates the energy into space in a narrow beam pattern. The pattern forms a horizontal angle at the reflector of approximately 1.5 degrees and a vertical angle of from 12 to 16 degrees. The antenna pattern is formed by phase addition and subtraction of the microwave r-f energy components radiated to its surface by the feedhorn.

The antenna rotates at 15 rpm. The transmitted beam sweeps over the surrounding area to search for both surface and airborne targets within the limits of the antenna reflector.

When the radiated energy strikes a target, a small portion returns to the antenna reflector. The reflector directs this reflected energy to the receiver (fig. 11-6) through the waveguide, slotted line, duplexer, and t-r cavity. The t-r cavity acts as an automatic electronic shorting switch to block the receiver from the high energy r-f pulses of the transmitter while the transmitter is radiating, and to unblock the receiver to the waveguide while the transmitter is not radiating.

Two a-t-r (anti-t-r) tubes, located near the magnetron oscillator in the transmitter, present a high impedance to the returned signal energy (echo), thus preventing dissipation of the returned signal at the magnetron oscillator during the receiving interval.

The returned echo is fed to a mixer stage, where it is mixed with a signal from either the radar or beacon local oscillator. The radar local oscillator operates on a frequency 30 mc higher than the returned signal frequency or 5480 to 5855 mc. The beacon local oscillator operates at a single frequency (5420 mc) or 30 mc below the received beacon signal. For either radar or beacon operation, the difference frequency component at the output of the mixer is selected and amplified by the i-f amplifiers in the receiver.

Since the radar and beacon local oscillators are coupled to the same mixer, the use of a common i-f amplifier section for either radar or beacon reception is possible. Either the radar or beacon local oscillator is turned on independently for the desired type of operation.

After amplification and detection in the receiver, a video output signal from the receiver is delivered to the adapter indicator. The output from the adapter indicator can be used to operate as many as five plan position indicators.

The adapter indicator output is applied to the control grid of the cathode-ray tube in the PPI and causes intensity modulation of the electron beam. The target signal is thus converted into visible intelligence on the screen of the PPI scope, where it appears as a bright spot.

Automatic frequency control (afc) circuits are provided for the radar and beacon local oscillators. The function of the radar afc circuit is to maintain the frequency of the radar local oscillator 30 mc higher than the magnetron frequency, regardless of minor drifts in the magnetron frequency. The radar afc circuit compares the radar local oscillator and magnetron frequencies in a circuit which produces a voltage to correct the radar local oscillator for the proper intermediate frequency. The beacon afc circuit ensures that the beacon local oscillator operates 30 mc below the magnetron frequency during beacon operation.

The sensitivity time control (stc) circuit is of value in reducing saturation of the i-f stages due to strong echoes from the sea at close ranges (sea-return saturation) so that nearby targets can be distinguished. The stc circuit reduces the gain of the receiver instantaneously in coincidence with each transmitted pulse. The gain is reduced for only a short period of the sweep time and is permitted to rise exponentially to normal gain so that weak echoes from distant targets will receive normal amplification in the receiver. The stc circuit does not affect the presentation on the plan position indicator of targets which are beyond the stc range. The time interval needed to fully restore the receiver gain limits the period over which the stc can remain effective after each transmitted pulse.

The fast time constant (ftc) circuit makes it possible to distinguish more clearly individual small targets (short duration) in an area of large targets having considerably longer durations. This feature is useful when there are many strong close-in targets. The ftc circuit differentiates all return signals in a short time constant circuit and causes each signal to be of approximately equal duration.

An instantaneous automatic gain control circuit (iagc) prevents strong signals from saturating the i-f amplifiers. The iagc circuit reduces the gain of the i-f amplifiers for the duration of the strong received signal.

The bearing selector switch provides a means of selecting either true or relative bearing information for presentation on the plan position indicators. Relative bearing information is fed from an antenna synchro (not shown) through the interconnecting box to the plan position indicators. Relative bearing information is also fed to the synchro signal amplifier.

The synchro signal amplifier combines the relative bearing information from the antenna synchro and own ship's course information from the ship's gyro compass to present true bearing information on the plan position indicators.

The manual controller switch (Fig. 11-7) is a power switch used to start and stop antenna rotation. The switch also contains an overload relay which removes power from the antenna when the current reaches an overload value. The control antenna switch also removes power from the antenna and is mounted on the ship's mast below the antenna. The switch is intended for use by maintenance personnel to remove antenna power during maintenance procedures.

The IFF filter minimizes interference from the radar set to the IFF equipment which may be used in conjunction with the AN/SPS-10D.

OPERATION OF THE AN/SPS-10D

Safety features have been installed on the radar set for protection of operating personnel and the radar set itself. However, it is absolutely necessary that the Technician or operator practice all safety precautions whenever using the set or making adjustments.

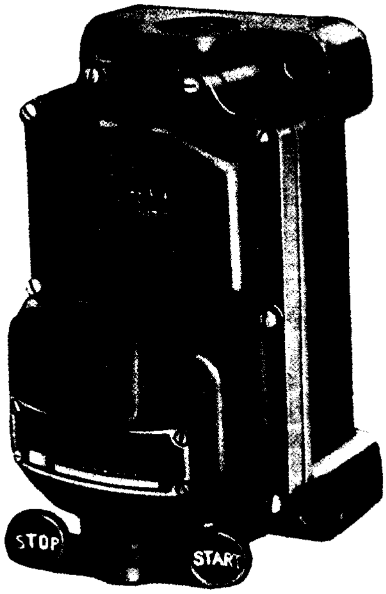

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Figure 11-7.—Manual controller switch S1501.

You should familiarize yourself with the operation of this equipment, concentrating on the function and location of all operating controls. Learn the procedure on the instruction plaque that you will find located near the radar set control.

Be sure to follow the operating procedures for equipment accessory to the AN/SPS-10D outlined in the instruction books for the standard Navy plan position indicator-the AN/SPA-4A on the AN/SPA-8A.

Prechecks

WARNING—High voltage is used in the operation of this equipment. Death on contact may result if personnel fail to observe safety precautions.

1. MAIN POWER: Before the equipment is placed in operation and the main power switch on the bulkhead (which controls primary power to the radar set) is turned on, all safety interlocks must be closed. The battle short switch in the modulator and the main power switch on the radar set control (fig. 11-8) should be placed in the OFF position. The drive motor disabling switch on the antenna assembly must be in the ON position.

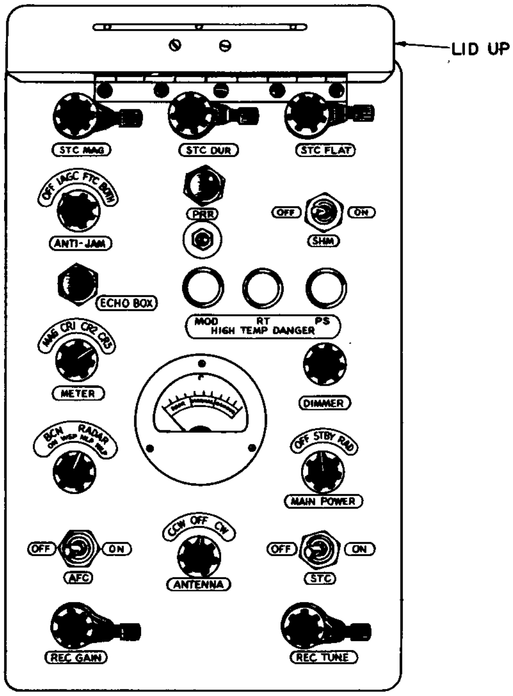

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Figure 11-8.—Radar set control—front panel controls.

2. ANTENNA OIL HEATER: A thermostatically controlled heater is provided in the oil compartment of the antenna gear box. It prevents the lubricant from thickening in cold weather. The oil heater can be turned off only by turning off the main power switch to the radar set (on bulkhead).

3. BLOWERS: A blower is provided in the modulator and in the receiver-transmitter to circulate air during periods of operation. The two blowers are immediately energized when the main power switch, located on the radar set control, is in either standby or radiate position. Additional protection for magnetron cooling is provided by an air flow switch. Failure of the blower in the receiver-transmitter closes the air flow switch causing the HIGH TEMP DANGER (RT) indicator light to glow.

4. LOCAL-REMOTE AND OFF-RADIATE-START SWITCHES (auxiliary control panel): During normal operation of the radar set control, make certain that the local-remote switch is on REMOTE and the off-radiate-start switch is on RADIATE.

5. EMERGENCY STOP: To turn off the equipment in an emergency, the following methods can be used:

a. Turn main power switch on the radar set control to the OFF position.

b. Turn main power switch to the radar set (on bulkhead) to the OFF position.

CAUTION.—If the main power switch to the radar set (on bulkhead) is used to turn off the equipment in an emergency during cold weather, it should be turned back on without delay because damage may occur to the antenna gear box due to thickening of lubricant.

Operational Checks

To start, make the following checks to prevent damage to the radar set by improper operation.

1. Check the overtemperature indicators (table 11-1) on the radar set control (fig. 11-8). If any of these indicators glow, turn off the radar set. In an emergency, operation may continue for a limited time.

Table 11-1.—Overtemperature Indicators.

Designation	Location	Color of light
PS	Radar set control	Red
RT	Radar set control	Red
MOD	Radar set control	Red

2. Check the magnetron current on the transmitter current meter located in the modulator (fig. 11-9). It should read in the NORMAL portion of the meter scale. If the meter reads in the DANGER portion of the scale, the equipment must be shut off immediately.

In an emergency, operation may continue for a brief time.

Starting the Equipment

The following procedures must be followed, otherwise damage may occur to the set.

1. Check that the main power switch to the radar set (on bulkhead) is ON. This switch must remain on at all times.

2. Check that the following control switches are in the indicated positions:

a. MAIN POWER switch on the radar set control at OFF.

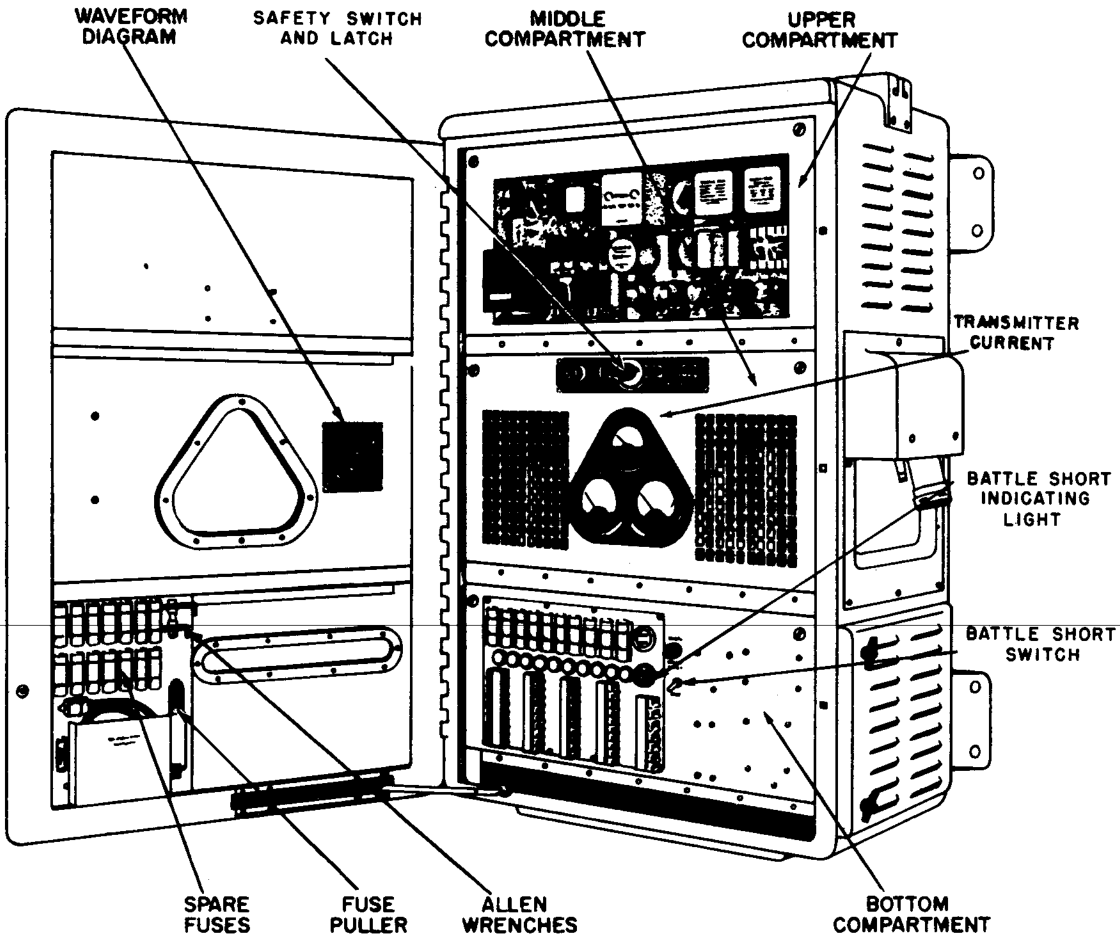

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Figure 11-9.—Radar modulator—front panel controls.

b. BATTLE SHORT switch on the modulator at OFF.

c. NONREGULATING-REGULATOR ON switch on the voltage regulator at NONREGULATING.

3. Check that the following control switches on the auxiliary control panel of the receiver-transmitter are in the indicated position (fig. 11-10):

a. OFF-RADIATE-START switch at RADIATE.

b. LOCAL-REMOTE switch at REMOTE.

4. Turn the main power switch on the radar set control to STBY. Adjust the intensity of the panel illumination to the desired brilliance using the dimmer control.

5. Turn on the plan position indicator and synchro signal amplifier. Refer to their instruction books, if necessary.

6. At the voltage regulator depress the PRESS FOR LINE VOLTAGE switch and read the line voltage on the meter. The line voltage should be 115 plus or minus 10 percent (103.5 volts a-c to 126.5 volts a-c). If the line voltage is outside this operating range, deenergize the radar set.

7. Turn the NONREGULATING-REGULATOR ON switch on the voltage regulator to the REGULATOR ON position.

8. At the voltage regulator, read the regulator output voltage on the meter. The regulated voltage should be 115 plus or minus 2 volts. (The meter reads the regulated output voltage

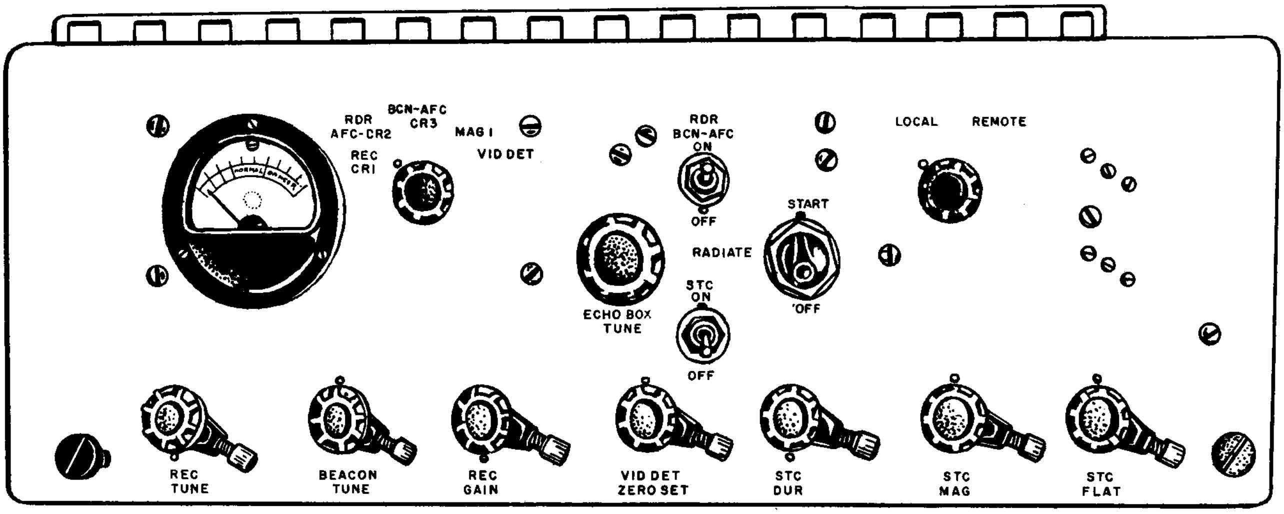

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Figure 11-10.—AN/SPS-10 receiver-transmitter—auxiliary control panel, front panel controls.

when the PRESS FOR LINE VOLTAGE switch is NOT depressed.

9. Turn the ANTENNA switch at the radar set control to the desired position (CW or CCW).

10. Turn the TRUE-RELATIVE bearing switch on the interconnecting box to the desired position (TRUE or RELATIVE).

11. Three minutes after switching to STBY, turn the main power switch to RAD.

12. Turn the BCN-RADAR selector switch at the radar set control to the desired position. See table 11-2.

Table 11-2.—Radar Selector Switch Positions.

Position	Purpose and pulse types
WSP	Wide receiver bandwidth, short pulse, least range, high definition.
WLP	Wide receiver bandwidth, long pulse, medium range, good definition.
NLP	Narrow receiver bandwidth, long pulse, longest range, least definition.
ON	Beacon operation.

13. Check that the following control switches on the radar set control are in the indicated positions:
   a. AFC switch at ON.
   b. STC switch at OFF.
   c. ANTI-JAM switch at OFF.

14. Adjust the REC GAIN control on the radar set control and the appropriate controls on the plan position indicator to obtain the desired presentation.

15. Special operating features STC, IAGC, and FTC can be energized at the radar set control. These controls should not be used except for the conditions described.
Remember that other stations usually use the same radar for other purposes, such as the officer of the deck, for example, to keep the ship on station while in formations. If you play with these controls, you might endanger the ship.

Tuning Adjustments

1. Receiver tuning (radar set control):
   a. Place the radar set in normal operation.
   b. Check that the following controls are in the indicated positions:
      (1) AFC switch to ON.

(2) BCN-RADIATE switch at WSP, if switch is set in this position, radiation must be turned off before changing.
(3) STC switch at OFF.
(4) ANTI-JAM switch at OFF.
(5) ANTENNA switch at CW.
(6) REC GAIN control at the position which gives the desired presentation on the plan position indicator.

c. Turn the METER selector switch to MAG. The meter should read in the NORMAL portion of the scale. If the meter reading is abnormal, repair is indicated.
d. Turn the METER selector switch to CR1 (receiver crystal current).
e. A steady meter reading indicates that the receiver is tuned. If the meter reading flutters, adjust REC TUNE to obtain a steady reading; then secure the REC TUNE knob.
f. Turn the METER selector switch to CR2 (radar AFC crystal current). If the meter reading is not between 0.4 and 0.6 milliampere, repair is indicated.
g. Energize the echo box motor by depressing the ECHO BOX pushbutton switch. (This motor remains energized until the ECHO BOX pushbutton is again pressed.)
h. Echo box ring time should be greater than 4000 yards for BCN-RADAR switch positions WSP, NLP, and WLP, with REC GAIN control set at full gain. If the ring time is less than 4000 yards for any of these positions, repair is indicated.

2. Beacon receiver tuning check. Follow procedures given for receiver tune.

3. Adjustment of STC controls: The STC controls require adjustment from time to time to allow for different conditions of sea return, depending on the roughness of the sea. The sea return appears on the plan position indicator as a solid disc extending radially for a range of several miles. The following procedure is suggested for an approximate setting of the controls. Final adjustments will probably have to be made by trial and error.

a. Start the equipment
b. Tune the receiver.
c. Set the REC GAIN control to obtain the best presentation on long-range targets.
d. Turn the STC switch to ON.
e. Turn the STC FLAT control near its midposition.
f. Turn the STC DUR control fully CCW.
g. Adjust the STC MAG control to break up the solid disc at the center of the plan position indicator into individual targets.
h. Turn the STC FLAT control fully CCW so that the solid disc reappears at the center of the indicator. Then slowly turn the STC FLAT control clockwise until the solid disc barely disappears.
i. Adjust the STC DUR control to best define the targets slightly beyond the solid disc.

LORAN RECEIVING EQUIPMENT

The principle of operation of the loran system of obtaining navigational fixes is described briefly in chapter 5 of this training course. A loran receiver located aboard ship is used to determine the difference in time required for pulsed radio signals to arrive from a pair of synchronized transmitters (master and slave stations simultaneously pulses) installed on shore several hundred miles apart.

LORAN RECEIVING SET AN/UPN-12

The AN/UPN-12 Loran Receiving Set (fig. 11-11) is a navigational aid that gives a direct reading in microseconds (at the loran receiver) of the time difference in arrival of signal pulses from master and slave transmitters of a loran transmitting group. In the loran system it is neither necessary (1) to know the exact location of the transmitting station, nor (2) to measure the direction of arrival of the radio signals.

The antenna signals are fed into the r-f circuit through an antenna coupler, an antenna tune switch, S1, and an attenuator. When S2 is in the distant position, signals bypass the attenuator. The antenna may be either a wire or whip type and the antenna coupler is used to match the input impedance for optimum signals. The desired set of loran stations is selected by means of a channel control switch, S3 (fig. 11-12,) which selects one of four

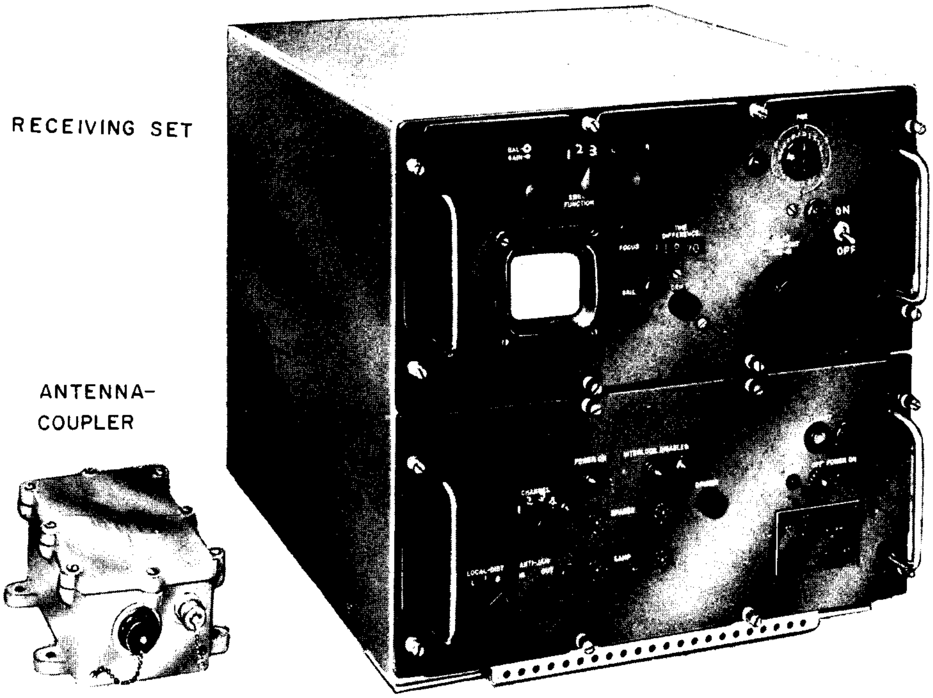

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Figure 11-11.—Loran Receiving Set AN/UPN-12.

available channels. The input signals are amplified in the r-f amplifier, V1; heterodyned in a crystal controlled converter, V2; again amplified in two stages of i-f amplification (V3 and V4) and detected in V5A. The input signal level to the r-f amplifier stage, V1, is controlled by a three-position, local distant (L-I-D) switch, S2.

The detected pulses from V5A (fig. 11-12) are coupled through video amplifier-limiter V6A and a high-pass filter, to video amplifier V6B. A clipper stage, V5B, eliminates negative portions of the V6A output. Since the V6B output is applied through another video amplifier, V7, to the indicator tube, V60, the action of clipper stage V5B eliminates the portion of the V60 input below the established reference.

An antijam switch, S4, functions to reduce the effects of jamming by removing low-frequency components of the video signal. High-frequency components are retained to preserve the rise time (leading edge) of the input pulse.

The video output of V6B is coupled along dual paths to the video amplifier, V7, and to video amplifier V10. The V7 output is applied to the indicator tube, V60, as discussed. The V10 output is applied to the A and B gate stages, V11 and V12, respectively, and is effective in controlling the automatic frequency control circuits.

The positive output of the pedestal amplifier, V55, is applied to the A multivibrator, V8, in the frequency control circuits. The frequency control stages synchronize the repetition rate of the receiving set with that of the received signals to hold the pattern displayed on the indicator stationary while readings are being taken. Either automatic or manual frequency control is used, depending upon the setting of the AFC switch, S5.

When AFC is used, the repetition rate of the incoming signals is compared with the receiving set repetition rate in stages V9 through V15. The error voltage derived from the comparison at the discriminator, V15, is used to hold the receiving set pulse rate and the rate of the received signals in synchronism. When manual control is desirable, the AFC switch (fig. 11-12) is placed to OFF. Fine control of the receiving set pulse repetition rate is then determined by the drift control, R86.

The time base of the receiving set is produced by an 80-kc sine wave crystal-controlled oscillator, V17 (fig. 11-12). The oscillator output is shaped in a ringer stage, V18, and clipped in V19 to produce sharp negative driving pulses for a group of 11 counter stages, V20 through V30. Actually 12 counter stages are used. The action of the twelfth counter, V31, is considered presently. The oscillator, V17, is reactance-tube controlled by V16, whose input is the error voltage derived from the comparison of the receiving set repetition rate, and the rate of the received signals at the discriminator, V15, as discussed.

Frequency division is used in the counter stages, V20 through V31, to produce a square wave at each counter output, which is one-half the frequency of its input. Each of the counter stages is an Eccles-Jordan multivibrator.

The square waves at the plates of the third to eleventh counter (V22 to V30) are employed in the repetition rate and variable delay circuits. The 10-kc (100 us) output of the third counter is coupled to the shaper, V50A (a part of the variable delay stages), and the 1600-us output of the seventh stage, V26, is coupled to the fixed delay stages.

In the pulse repetition rate circuits the input square waves from the third to eleventh counter stages (V22 to V30) are combined in a reset thyratron tube, V37, to produce a positive and negative reset pulse when the predetermined count selected by the PRR switch, S6, is reached. The positive reset pulse is used to trigger all of the counter stages, V20 through V31, thereby resetting the counter stages to start a new cycle. The negative reset pulse is used to drive the sweep generator, V57, and the blanking d-c restorer, V59.

The recurrence frequency of the reset pulse from V37 is twice that of the received signals. However, each negative reset pulse from the V37 plate (as seen later) triggers the twelfth counter stage,-V31, which produces the final output frequency of the counter chain. Thus, since two input pulses are required to produce a single output pulse from the counter chain, the period of the output of the twelfth counter, V31, is equal to the period of the received signals.

The twelfth (final) counter (V31) plates produce two square waves of opposite polarity, each of which has a period equal to that of the transmitting group recurrence interval.

The twelfth counter stage (V31) output is also fed through the twelfth amplifier, V38A, to the trace separation amplifier, V62. The trace separation amplifier uses the V38A input to produce a voltage, which positions the electron sweep beam toward the upper section of the indicator (V60) screen during the period of reception of the pulse from the master transmitter of a transmitting group. The total period of this sweep is designated the A period.

During reception of the pulse from the slave transmitter, the trace separation amplifier (V62) output causes the electron beam to be positioned toward the lower section of the indicator tube. The total period of this sweep is called the B period (fig. 11-13).

The shaper V50A, 10-kc filter, and goniometer circuit comprising V46, B1, V47, and V48 (fig. 11-12) produces a sine wave from the 10-kc, 100-us output of the third counter, V22, which is used in the fixed and variable delay circuits. The fixed and variable delay stages, in turn, combine their various inputs to produce a trigger pulse, which is coupled to the pedestal generator, V54.

The variable delay voltages from V39 through V45 are combined with the output of the clipper, V48, in the delay thyratron, V49. The fixed delay is derived by combining the output from the seventh counter, V26A, with the output of a clipper, V51, in the 1625-us gate stage, V52. Clipper V51 is driven by the 10-kc output of V50B.

Two pedestal pulses are produced by the receiving set shown in figure 11-13. One pedestal is produced during the A period, and the other during the B period. The time of occurrence of the A pedestals is fixed by the arrival of the trigger pulse from the seventh counter stage, V26.

A delay crank (fig. 11-12) controls the variable delay system so that the B output pedestal pulse is gated by the input from the twelfth counter, V31, to occur only during the B period. The B pedestal is variable from a time shortly after the reset pulse initiating the B period to the end of the available delay time incorporated in the receiving set. Both A and B pedestal pulses are coupled (during their respective periods) from the pedestal amplifier V55, to the lower vertical deflection plate of V60, and to the automatic frequency-control circuits, as discussed. The accuracy of the

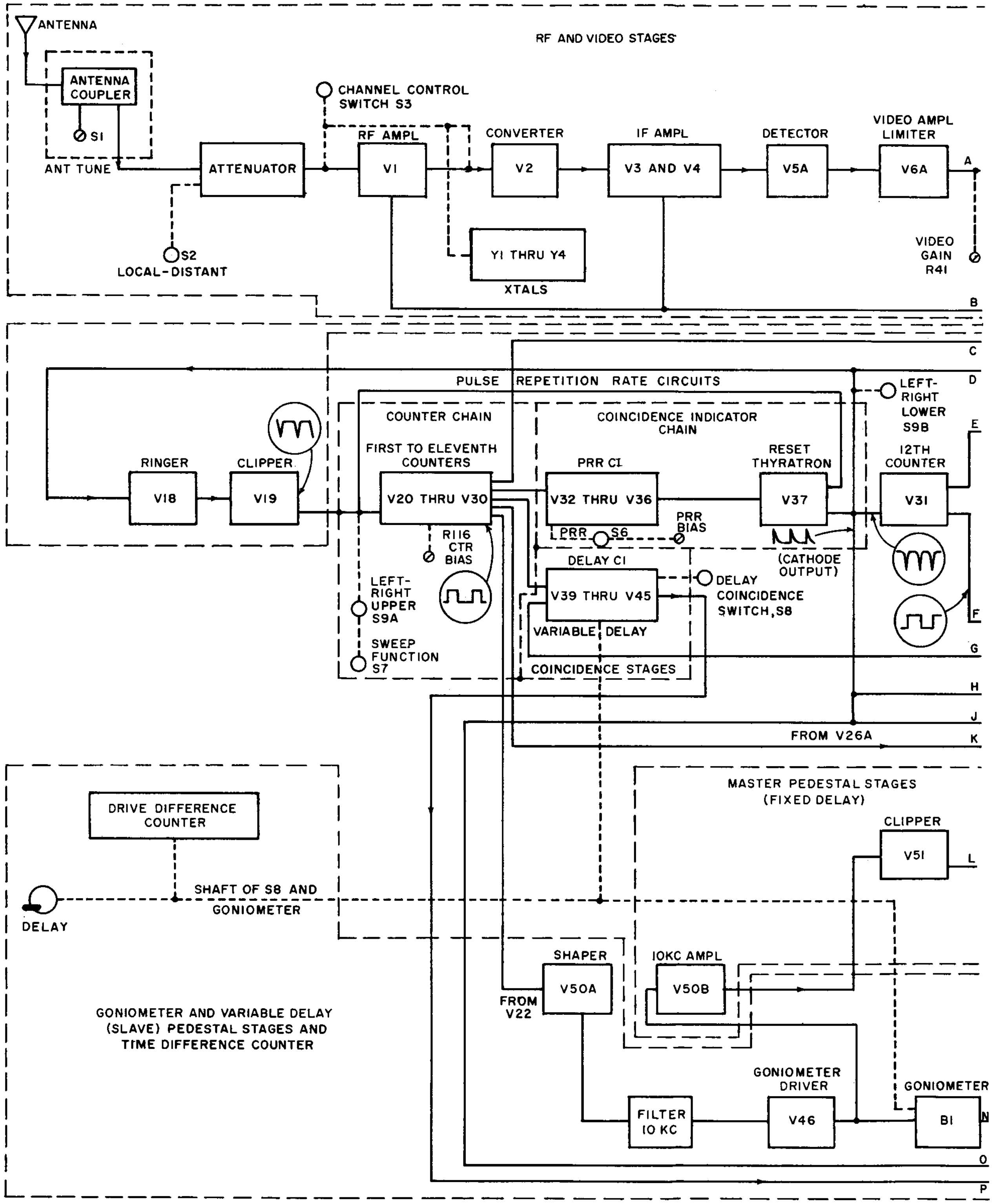

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Figure 11-12.—Loran Receiving Set AN/UPN-12, block diagram.

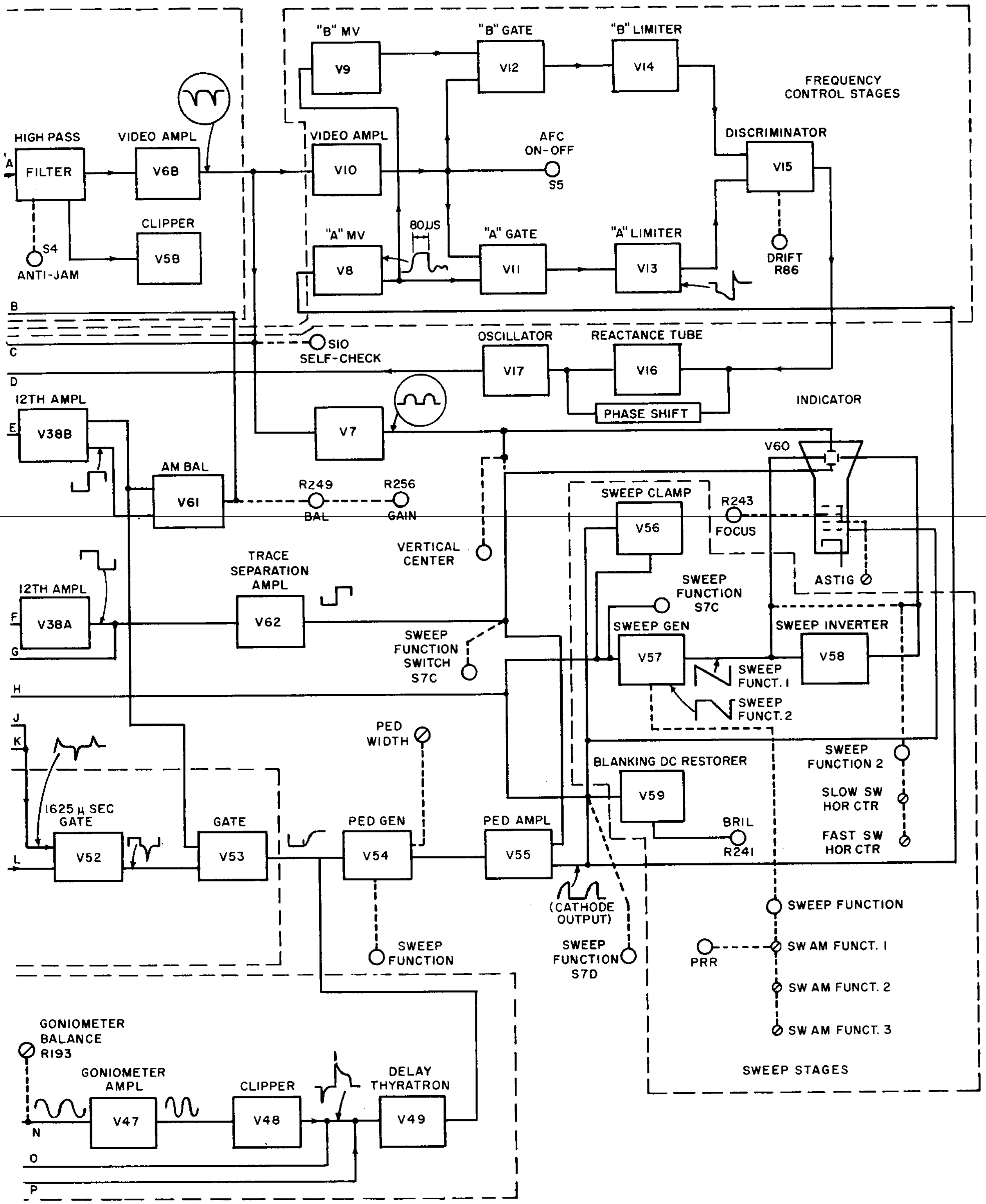

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Figure 11-12.—Loran Receiving Set AN/UPN-12, block diagram—Continued.

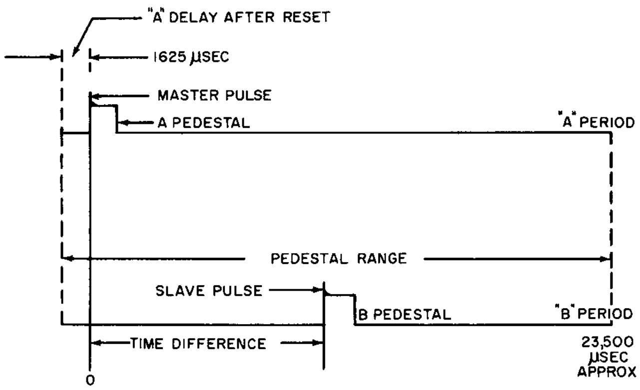

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Figure 11-13.—CRT presentation (sweep function 1 operation)

delay readings obtained depends upon the accuracy with which the master and slave pulses can be superimposed (see figure 11-14, C).

The master and slave pulses may vary considerably in amplitude. An amplitude balance circuit, V61 (fig. 11-12) whose output is adjusted by the balance and gain controls, R249 and R256, provides a means of equalizing the master and slave pulse amplitudes in the A and B periods, respectively.

The sweep stages, V56, V57, and V58, produce the push-pull horizontal sweep voltages for the indicator tube, V60. The balancing d-c restorer, V59, blanks the indicator tube during the retrace periods.

The sweep function switch (fig. 11-12) may be moved to either of three positions to determine the type of pattern presented on the indicator tube. In SWEEP FUNCTION 1 position (see figure 11-14) the pedestal pulses are displayed on the Separated A and B traces respectively. In sweep function 2, the pedestals are not used for display purposes. In sweep function 3, superimposition of the traces is accomplished for matching of the two pulses (A and B), and trace separation is not used.

Figure 11-13 depicts the waveform components on the indicator tube when the sweep function switch (fig. 11-12) is in the SWEEP FUNCTION 1 position. The leading edge of the A pedestal is formed a short time after the reset of the A period. (The resetting action is accomplished by the reset thryatron, V37, as discussed.) This period is termed "A delay

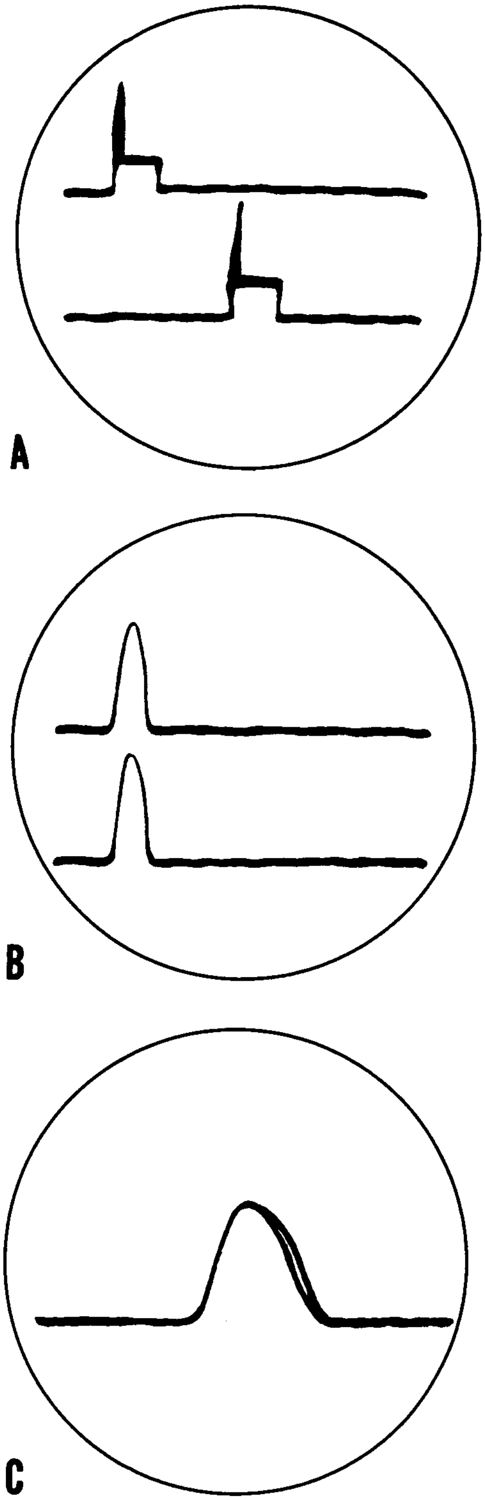

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Figure 11-14.—Cathode-ray tube presentations for sweep functions 1, 2 and 3.

after reset.'' The end of this period (corresponding to the time of the leading edge of the A pedestal in figure 11-13 represents zero timing on the A and B period sweeps.

As the delay crank (fig. 11-12) is rotated clockwise, the B pedestal (fig. 11-13) moves to the right, and the delay counter reading displays the time between reset of the B period and the leading edge of the slave pedestal, less the A delay. The time-difference counter reading is thus equal to the indicated time difference when the received master pulse is placed at the leading edge of the upper A pedestal, and the slave pulse is situated at the leading edge of the lower B pedestal.

In sweep function 2 (fig. 11-12) the sweep function switch, section S7D permits the pedestal amplifier, V55, pedestal output to be applied to the sweep clamp stage, V56. The V56 output, in turn, drives the sweep generator, V57. At the same time, the pedestals are removed from the indicator display by S7C, and only the signals occurring on the pedestals during sweep function 1 are displayed by the indicator, V60.

For sweep function 3 of the sweep function switch, S7, the indicator trace displays the video signals which are present during the first 160 μs (approx) of the pedestal period. The trace separation stage, V62, is disabled by S7C, and the two traces are superimposed for matching of the received pulses.

OPERATING PROCEDURES

All controls necessary for the operation of the AN/UPN-12 are located on the front panel (fig. 11-15). Below is a summary of the operating procedure to obtain a loran fix.

1. Turn the STANDBY-OFF-POWER-ON switch to the standby position; wait about one minute for the set to warm up then turn the switch to the power on position.

2. Set the ANTI-JAM switch to the out position, the SWEEP-FUNCTION switch to position 1, the AFC switch to off, and the LOCAL-DIST switch to the D (distant) position. The

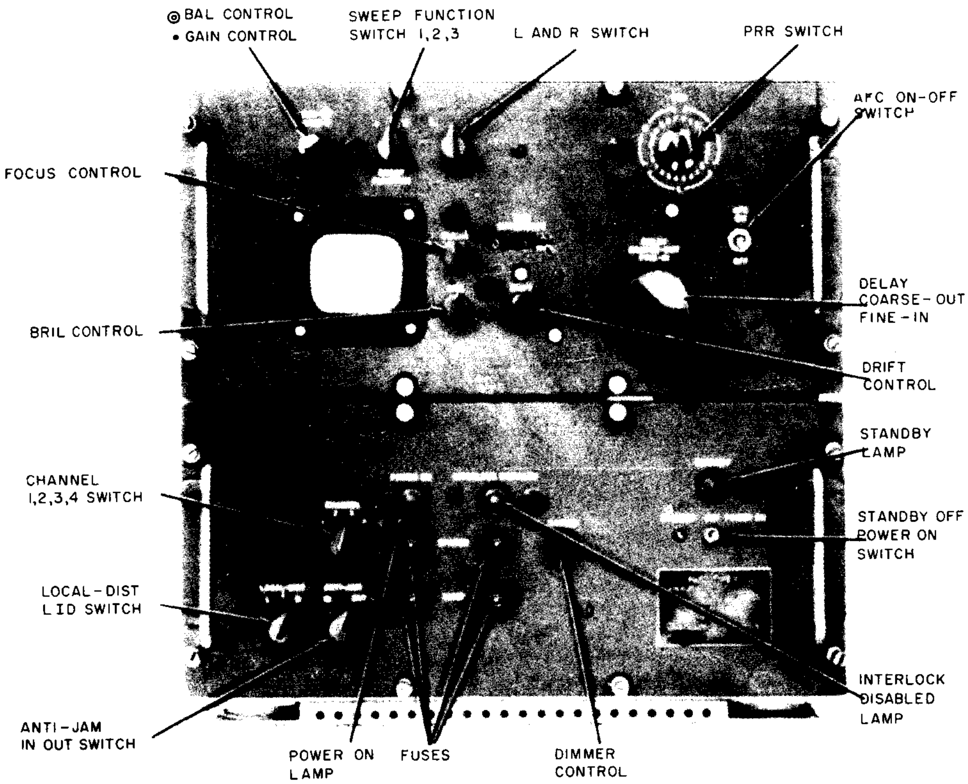

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Figure 11-15.—Front panel controls, AN/UPN-12.

ANTI-JAM switch is used in the out position unless jamming or heavy interference is experienced. The LOCAL-DIST switch is normally used in the D position for maximum sensitivity.

3. Refer to the loran charts and set the PRR (pulse recurrence rate) and CHANNEL switches to positions corresponding to one of the transmitting pairs covering the area. Set the TIME DIFFERENCE counter to 11000 with the DELAY crank.

4. Adjust the GAIN and BAL controls until the amplitude of the signals are approximately twice that of the pedestals, then stop any movement of the signals with the DRIFT control.

5. Examine the pulses and determine whether ground or sky-wave matching is to be used. Use the L-R switch to position the upper (master) pulse at the leading (left) edge of the upper pedestal, then use the DELAY crank in the coarse position to place the leading edge of the lower pedestal under the lower (slave) pulse (fig. 11-14A). Turn the AFC switch to on.

6. Set the SWEEP-FUNCTION switch to position 2 and use the DELAY crank to align the two pulses (fig. 11-14B).

7. Set the SWEEP-FUNCTION switch to position 3, and readjust the pulses with the GAIN and BAL controls, then use the DELAY crank in the fine position to superimpose the two pulses (fig. 11-14C).

8. Record the reading on the TIME-DIFFERENCE counter, and the time it was made.

9. Set the PRR and CHANNEL switches to positions corresponding to the other of the transmitting pairs and repeat steps 4 through 8 to obtain the second TIME-DIFFERENCE reading.

10. Apply the necessary corrections to the TIME-DIFFERENCE readings, plot the lines of position, and determine the loran fix.