

CHAPTER 3

RADAR

As an avionics supervisor, you must be knowledgeable of the operation principles of various complex search radars, fire control radars, IFF sets, and the associated peripheral equipment. Chapter 2 of *Aviation Electronics Technician 2 (Organizational)*, NAVEDTRA 12330, explains the basics of radar. This chapter discusses the search radar found on the P-3C aircraft, the fire control training device 11D13A, and the IFF system found on the S-3 aircraft. The peripheral equipment, such as the tactical displays, computers, and navigational systems, are discussed in other chapters of this TRAMAN. (See table of contents.)

SEARCH RADAR SYSTEM

Learning Objective: Recognize components, operating principles, and characteristics of a typical search radar system.

The AN/APS-115B radar set used in the P-3C aircraft is an airborne, X-band search radar system. It provides detection and surveillance of submarines operating under snorkel conditions, surface vessels, and aircraft. It is made up of two radar receiver-transmitters, two antennas, two radar controls, an antenna control, an antenna position programmer, an antenna parking control, an antenna scan control, and a radar interface unit. The receiver-transmitters are selective, long and short pulse-type radar receiver-transmitters. The antennas are located in the nose and the aft of the aircraft, providing 360-degree azimuth coverage. Radar search scan and data pickup are performed independently by each radar set.

The antenna position programmer (APP) combines video information from both radar sets. The APP then sends this information to the radar interface unit (RIU), which sends it to the sensor data display (SDD) for display.

The two antennas are tilt-stabilized by servomechanisms, receiving pitch and roll data from

the central repeater system (CRS). The tilt of the antenna can move from 20 degrees down to 10 degrees up, referenced to the horizontal. Antenna scan is selectable to either full (360 degrees) or sector (45-degree scan about a selected heading). With only one antenna system, the scan can be no more than 240 degrees in azimuth. Either antenna may be stopped to searchlight a specific area. With both antennas in full scan, the crossover points are at 90 and 270 degrees relative to aircraft heading. In sector scan, crossover points are at 120 and 300 degrees when the antennas are rotating in a clockwise direction. The crossover points are 60 and 240 degrees when they are rotating in a counterclockwise direction (fig. 3-1).

The nonacoustic sensor operator station displays the search radar information. The display presentation is true north or aircraft heading stabilized, with a computer-generated symbol depicting aircraft true course. The nonacoustic operator station contains the radar systems operating controls.

AN/APS-115B MAJOR COMPONENTS

The APS-115B search radar system includes the following equipment:

- C-7511A/APS-115 radar antenna control panel
- MX-7930/APS-115 antenna position programmer
- RT-889/APS-115 receiver-transmitter
- AS-2146/APS-115 antenna
- A361 antenna elevation parking control
- C-7512/APS-115 radar control panel
- C-7557/ASA-69 radar scan converter control
- MX-7974/ASA-69 radar interface unit

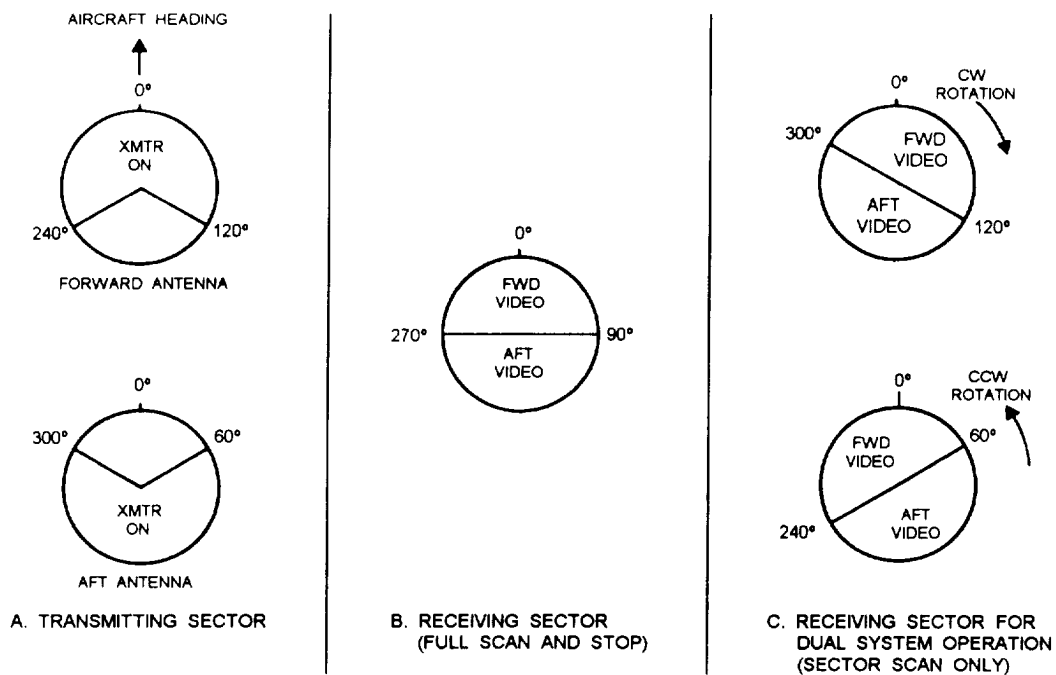


Figure 3-1.-Azimuth scan coverage.

C-7511A/APS-115 Radar Antenna Control Panel

The C-7511A/APS-115 (fig. 3-2) controls both of the radar antennas. There are six controls available to the operator for getting the presentation desired.

TILT KNOB.— This knob gives the operator the ability to vary the tilt of the antenna manually. The range of manual tilt is from +10 degrees to -20 degrees from aircraft horizontal.

NORTH STAB/HEADING STAB PUSH BUTTON.— With NORTH STAB selected (illuminated amber), the presentation displayed will be north stabilized. 000° displayed will be true north. With HEADING STAB selected (illuminated amber), the presentation will be heading stabilized. 000° displayed will be aircraft heading. Pressing the push button will alternately select NORTH or HEADING.

STAB/OUT SWITCH.— With STAB selected, the antennas will automatically correct for aircraft pitch and roll attitude changes. Mechanical limit for antenna stabilization is ±30 degrees, with respect to the aircraft. With OUT selected, the antenna stabilization is disabled.

SCAN SWITCH.— There are three selections possible to the operator. The FULL selection causes

the antenna scan to be 360 degrees during dual system operation. The antenna scan will be 240 degrees during single system operation. In the SECTOR position, the antennas will scan 45 (±4) degree sectors. This sector will center around the position established by the ANT HEADING control. With STOP selected,

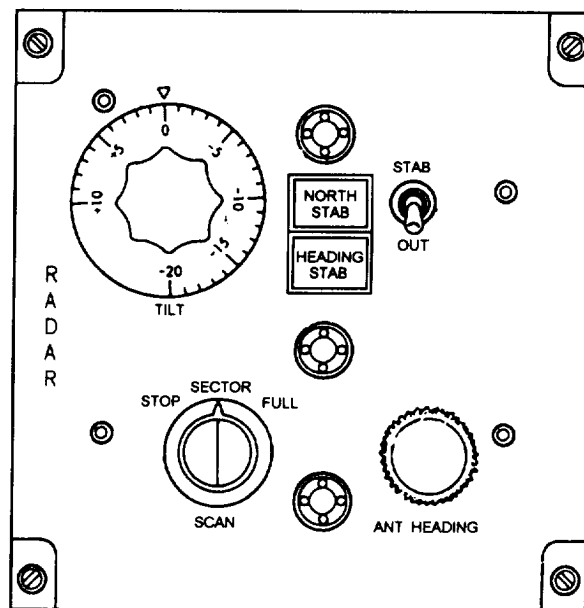


Figure 3-2.-C-7511A/APS-115 radar antenna control panel.

the antennas will stop at the position established by the ANT HEADING control.

ANT HEADING KNOB.— This knob provides control to change the heading of the antenna if the SCAN switch is in the SECTOR or STOP position.

TILT ALIGN ADJUSTMENT SCREW.— This control is located on the right side of the control box. It provides a limited amount of adjustment to align the tilt axis of the aft antenna to the tilt axis of the forward antenna due to boresight errors.

MX-7930/APS-115 Antenna Position Programmer (APP)

The antenna position programmer (fig. 3-3) ties the forward and aft systems together. It generates the azimuth and tilt drive signals for the antenna drive motors. The APP also generates timing and synchronization signals for the receiver-transmitters, radar interface unit (RIU), and IFF. It combines the forward and aft video returns into composite signals for full 360-degree coverage. The APP contains self-test circuits for automatic fault detection and

isolation, along with logic circuits for proper radar functions (pulsewidth, PRF, scan speed, and so forth).

On the face of the AFP, there are several operating devices. These are the circuit breakers, fault isolation meter, fault isolation switch, and an elapsed time meter.

CIRCUIT BREAKERS.— There are nine breakers on the APP. Three are for applying power to the forward system, three for applying power to the aft system, and three for applying power to the APP itself. Each circuit breaker applies one phase of 115 volts ac to its appropriate place.

FAULT ISOLATION METER.— The fault isolation meter provides GO/NO-GO indications of the BITE signals selected by the fault isolation switch.

FAULT ISOLATION SWITCH.— The fault isolation switch enables the technician to select the desired BITE signal for display on the fault isolation meter. This allows the technician to perform maintenance on the radar systems. Ensure that this switch is positioned to OFF for normal mode of operation.

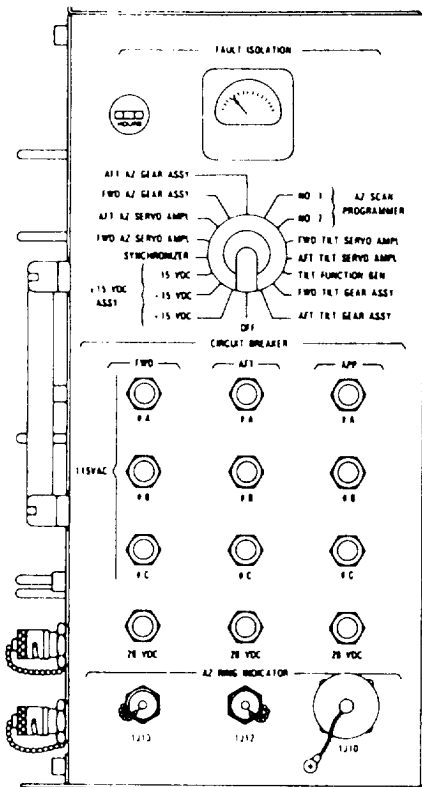


Figure 3-3.—MX-7930/APS-115 antenna position programmer.

WARNING

Rotation of the fault isolation switch will override radome safety interlock switches, possibly causing personnel injury.

CAUTION

Rotate fault isolation switch on the antenna position programmer clockwise only. Equipment damage may otherwise result.

RT-889/APS-115 Receiver-Transmitter

The receiver-transmitter generates the high energy RF radar transmission pulses, and receives the reflected target pulses. A pressurized waveguide system connects each RT to its respective antenna. Each RT is controlled by its own control box through the APP.

There are four major functional subsections in each receiver-transmitter. These subsections are the transmitter, the receiver, the waveguide pressurization system, and the BITE circuitry.

The transmitter contains a high-voltage power supply, modulator control circuitry, the modulator, and the magnetron RF output stage. Output pulses and transmitter output frequencies are generated in the transmitter. The magnetron output RF is waveguide coupled to the antenna for propagation.

The transmitter consists of the necessary components to accept the synchronization signals from the APP and generate an output pulse. This pulse is then fed into the waveguide system and radiated out of the antenna. The transmitter system is conventional except for the frequency agile magnetron. The magnetron is mechanically modulated at 75 Hz to vary the output pulse frequency over a 60 MHz (nominal) range. This is accomplished with a motor-driven tuner that physically changes the interior characteristics of the magnetron. This agility enhances the clutter elimination capabilities of the system, and it is an option available to the operator.

The basic transmitter characteristics are as follows:

- Frequency: 8.5 to 9.6 GHz, manually tunable
- Peak Power: 143 kW minimum
- PRF: 1600 Hz, line locked with 0.5 microsecond pulsewidth (short pulse)
- Agility: 60 MHz nominal, 40 MHz minimum

The receiver system includes an AFC-controlled local oscillator, IF amplifiers, video detecting and processing circuits, range mark generating circuit, and BITE circuitry. The receiver processes received echo pulses, converts them to video, and delivers

them to the APP for subsequent distribution and display. A solid-state, frequency-agile AFC system allows continuous tuning of the receiver local oscillator to track the transmitter and provide a 60-MHz IF amplifier input. The receiver agile modulator-demodulator generates the synchronization, which locks the transmitter and the receiver AFC together.

The waveguide pressurization system consists of an air pump and a replaceable, air-drying desiccant cartridge. The pump furnishes dry pressurized air for the waveguides between the RT and the antenna. This pressurized air prevents arcing in the waveguide when the aircraft is flying at high altitudes.

The BITE circuits perform continuous monitoring of vital functions within the RT. The fault isolation meter and switch provide a means of monitoring selected functions to aid the technician in the removal and replacement of faulty components.

Figure 3-4 shows the controls on the RT-889/APS-115. There is a fault isolation switch and meter for checking the operation of the receiver-transmitter. The AFC section allows the operator to select the AFC required. There is also an elapsed time meter and two power reset circuit breakers.

CAUTION

Return fault isolation switch to the OFF position during normal operation. Failure to do so will result in improper operation of the system.

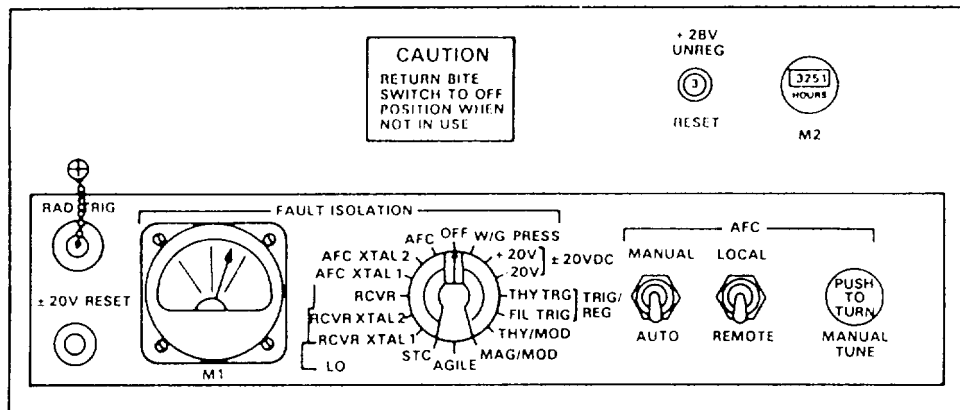


Figure 3-4.-RT-889/APS-115 receiver-transmitter control panel.

AS-2146/APS-115 Antenna

The radar antenna radiates the transmitter pulses in either a pencil beam mode or a cosecant squared (spoiled) beam mode. The mode of radiation is not operator selectable. A spoiler must be physically added to the antenna dish if the spoiled beam operation is required. This spoiler causes the beam to be a wide vertical beam.

The basic characteristics of the antenna are as follows:

| | |
|---------------------|---|
| Scan speed: | 6 RPM with 2.5 microsecond pulsewidth or 12 RPM with 0.5 microsecond pulsewidth |
| Radiation pattern: | Pencil beam 2.5 by 3.8 degrees; spoiled beam 2.5 by 20 degrees |
| Scan modes: | 45-degree sector, 360-degree full scan, 240-degree sector (single system operation) |
| Manual tilt: | +10 to -20 degrees |
| Tilt stabilization: | Pitch and roll ±30 degrees |

A361 Antenna Elevation Parking Control

The antenna elevation parking control is used to stow the aft antenna in a zero-degree elevation attitude, relative to the aircraft, when the aft radar is in the standby mode.

C-7512/APS-115 Radar Control Panel

There are two radar control panels (fig. 3-5), one for the forward and one for the aft system. This control panel enables the operator to turn the system on and control most of the functions of each system. There are 12 function switches and 2 fail lights on each control box.

WARNING

Ensure power is applied to the RADAR SCAN switch on the C324 TACCO control panel prior to applying power to the APS-115 radar system. If the RADAR SCAN switch is left off and then turned on after power is applied to the APS-115, the system will automatically cycle to high voltage on.

FREQ PUSH BUTTON.— This push button has two positions. With FIXED selected, the system will be in the fixed frequency mode of operation. With AGILE selected, the system will be operating in the sweep frequency mode. This mode is used in high clutter areas to improve target definition.

PULSE PUSH BUTTON.— The operator uses this button to select either LONG or SHORT pulsewidths for the system. In the LONG mode, the system has a 2.5 µsecond pulsewidth, 400 pps PRF, and 6-RPM antenna scan rate. In the SHORT mode, the system has a 0.5 µsecond pulsewidth, 1600 pps PRF, and 12-RPM antenna scan rate.

HV PUSH BUTTON.— This is the high-voltage select switch. There are three indications on the switch, of which only two are selectable. As soon as the system power is turned on, the WARMUP section illuminates. This section will remain illuminated until the system has warmed up. The operator cannot apply high voltage until the system has warmed up sufficiently. After approximately 3 minutes of

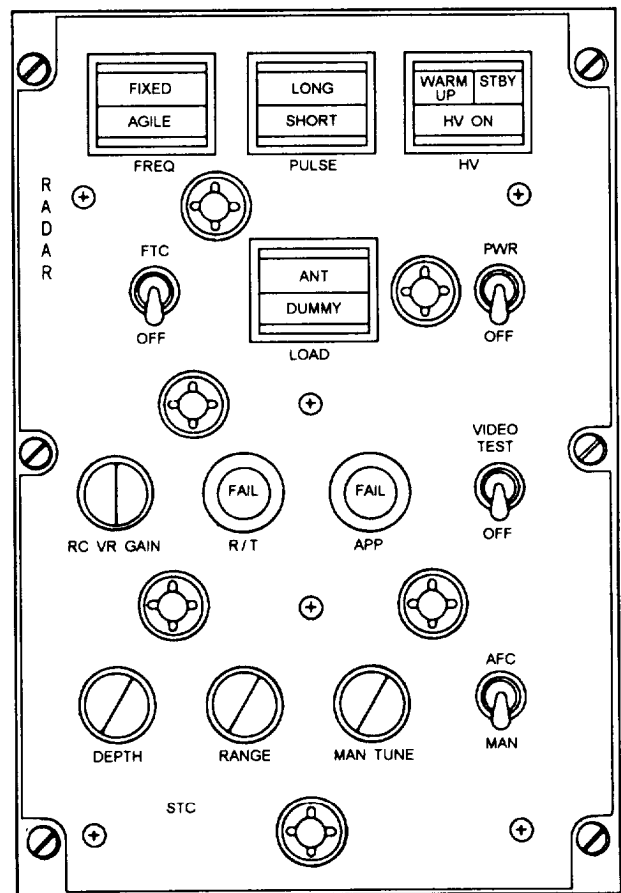


Figure 3-5.-C-7512/APS-115 radar control panel.

warm-up time, the WARM-UP section will extinguish, and the STBY section illuminates. This tells the operator that the system is ready for use. Press the HV push button now to apply the radar operating power. When the operating power is applied, the HV ON section will illuminate. Press the push button to alternately select HV ON and STBY.

FTC SWITCH.— This switch controls the receiver's fast time constant circuitry. With this switch in the FTC position, the targets displayed have strong leading edges and attenuated trailing edges. This improves the display when the target is near a landmass.

LOAD SWITCH.— This switch controls the waveguide switch on the ante ma unit. When the ANT section is illuminated, the RF energy is actually radiated by the antenna. In the DUMMY mode of operation, the RF energy is fed into the dummy load on the antenna. In this mode, there is no radiation out of the antenna

CAUTION

Ensure the radar system is in STBY prior to selecting or deselecting DUMMY Load to avoid damaging equipment.

PWR SWITCH.— This is the system power switch. It applies power to the system and starts the warm-up period.

RCVR GAIN KNOB.— This knob controls the receiver gain of the system. The operator will adjust the gain until the radar noise levels are matched between the forward and aft radars.

VIDEO TEST SWITCH.— This switch will select the video self-test circuitry in its respective RT for an overall performance check. If the PULSE push button is in the LONG position, the display should show simulated targets 1 nautical mile apart. In the OFF position, the system is in the normal mode of operation.

STC DEPTH KNOB.— This knob will vary the amount of receiver attenuation for close-in targets. It is used in conjunction with the STC RANGE knob.

STC RANGE KNOB.— This knob varies the range to which the intensity of target return is effectively reduced. It will vary the range between 0 and 20 nautical miles. If both the DEPTH and the

RANGE knobs are rotated fully clockwise, close-in targets could be blanked from the display.

AFC/MAN SWITCH.— This switch selects either the AFC mode or the manual tuning mode of operation. In the AFC position, the local oscillator has the automatic frequency control circuitry connected to it. With this switch in the MAN position, the operator can manually tune the local oscillator. If the system is manually tuned correctly, there should be no difference in the video in either position. The system is locked in the fixed-mode of operation if this switch is in the MAN position, regardless of the position of the FREQ push button.

MAN TUNE KNOB.— This is the knob the operator rotates to manually tune the local oscillator when the AFC/MAN switch is in the MAN position.

FAIL LIGHTS.— There are two lights located on the control panel to indicate there is a problem with the system. One is the RT light, and the other is the APP light. The RT light will illuminate when the receiver-transmitter BITE circuitry detects a failure in the RT. The APP light will illuminate when the BITE circuitry detects a failure in the antenna position programmer.

C-7557/ASA-69 Radar Scan Converter Control

The radar scan converter (fig. 3-6) and associated components provide the interface between the data processing system and the APS-115 radar set. It also

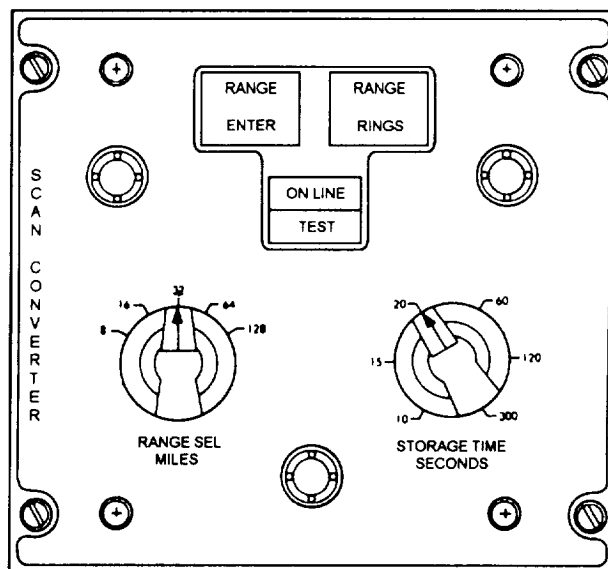


Figure 3-6.-C-7557/ASA-69 radar scan converter control

completes the processing of radar and IFF video for on-line/off-line display. It works in conjunction with the radar interface unit (RIU). The converter control routes the on-line/off-line selection to the RIU. There are five controls on the converter, of which four are used for off-line operation.

ON LINE/TEST SWITCH.— This push button is used to select on-line/off-line operation of the radar set. When the ON LINE section is illuminated, the RIU is slaved to the nonacoustic operator's keyset. In this mode of operation, all the manual selections on the RIU front panel are deactivated. The only exception to this is the power switch.

If you press the push button switch, it will illuminate the TEST section of the switch. With this section illuminated, the radar set is in the off-line mode of operation. This means the RIU will respond to inputs from the RIU front panel.

RANGE SEL MILES SWITCH.— This switch enables the operator to select radar range during off-line operation. The operator has the option of selecting either 8, 16, 32, 64, or 128 nautical miles.

RANGE ENTER PUSH BUTTON.— This push button enters the radar range, selected on the RANGE SEL MILES switch, into the RIU logic circuits during off-line operation. The indicator push button will illuminate amber, when pressed, denoting entry into RIU logic. The indicator will return to green when released.

RANGE RINGS PUSH BUTTON.— Range rings are added to radar video during off-line operation when this push button is pressed. The indicator will illuminate amber, denoting that the range rings are selected. If you press the push button again, it will deselect the range rings and return the indicator to green. Two range marks are developed for the 8 nautical mile range, four marks for the 16

and 32 nautical mile range, and eight marks for the 64 and 128 nautical mile range.

STORAGE TIME SECONDS SWITCH.— This switch is not used at this time.

MX-7974/ASA-69 Radar Interface Unit

The function of the radar interface unit (RIU) is to provide radar data interface and the command decoding interface. Figure 3-7 shows the control panel located on the RIU. The RIU combines raw radar video from the APS-115 and IFF video from the IFF synchronizer. This video is then amplified and routed to the nonacoustic operator's display.

There are nine operating controls on the control panel of the RIU, of which three are not used. These three are the OFFSET switch, the STOR switch, and the OFFSET X/Y switch. Of the other six, five are deactivated during on-line operation. Only the POWER switch is activated.

POWER SWITCH.— With this switch in the ON-NORMAL position, operating power is applied to the RIU. In the OFF position, there is no operating power applied.

ENTER PUSH BUTTON.— This switch enables the operator to enter commands selected on the front switch panel into the RIU logic circuits. It must be pressed after each selection.

HV ON/OFF SWITCH.— This switch enables high voltage to be turned on or off in the off-line mode. The HV ON/OFF position of the COMMAND SELECTION switch must be selected prior to changing the position of this switch.

COMMAND SELECTION SWITCH.— This rotary switch enables the operator to select the various commands for entry into the RIU logic circuits. The

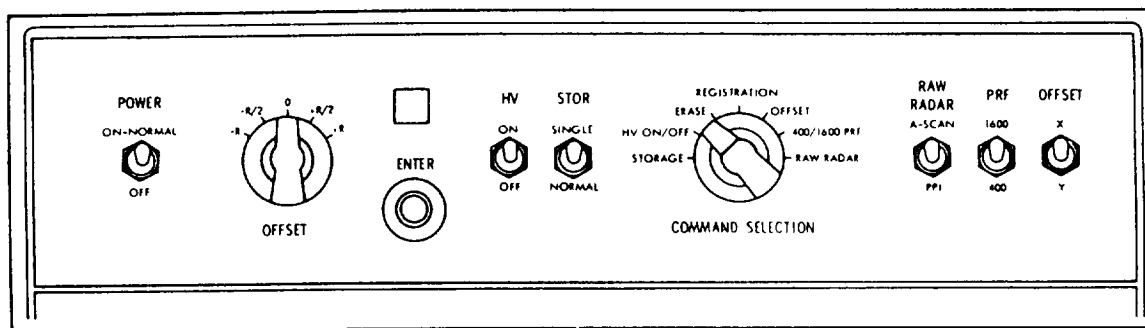


Figure 3-7. MX-7974/ASA-69 radar interface unit control panel.

operator rotates the switch to the particular command to be changed, changes the corresponding switch, and then presses the ENTER push button.

NOTE: The ENTER push button must be pressed after each selection on the COMMAND SELECTION switch to route each command to the RIU logic.

There are seven positions on this rotary switch. Only three of these positions are used. The usable positions are the HV ON/OFF position, the 400/1600 PRF position, and the RAW RADAR position.

RAW RADAR SWITCH.— This switch allows the operator to select the type of display presentation. The options available are either an A-scan, selected by the A-SCAN position, or a PPI scan, selected by the PPI position.

PRF SWITCH.— This switch enables the operator to select either a 1600 or 400 PRF (long or short pulse mode).

SEARCH RADAR FUNCTIONAL DESCRIPTION

The signal flow block diagram is shown in figure 3-8. The following section will explain in more detail the functional signal flow of the various components.

The forward and aft radar control boxes and the antenna control box provide mode control to the APP for execution and distribution throughout the radar set. The APP processes and coordinates forward and aft antenna position and scan functions, the application of power to both sets, and controls transmit and receive modes of the two RT's.

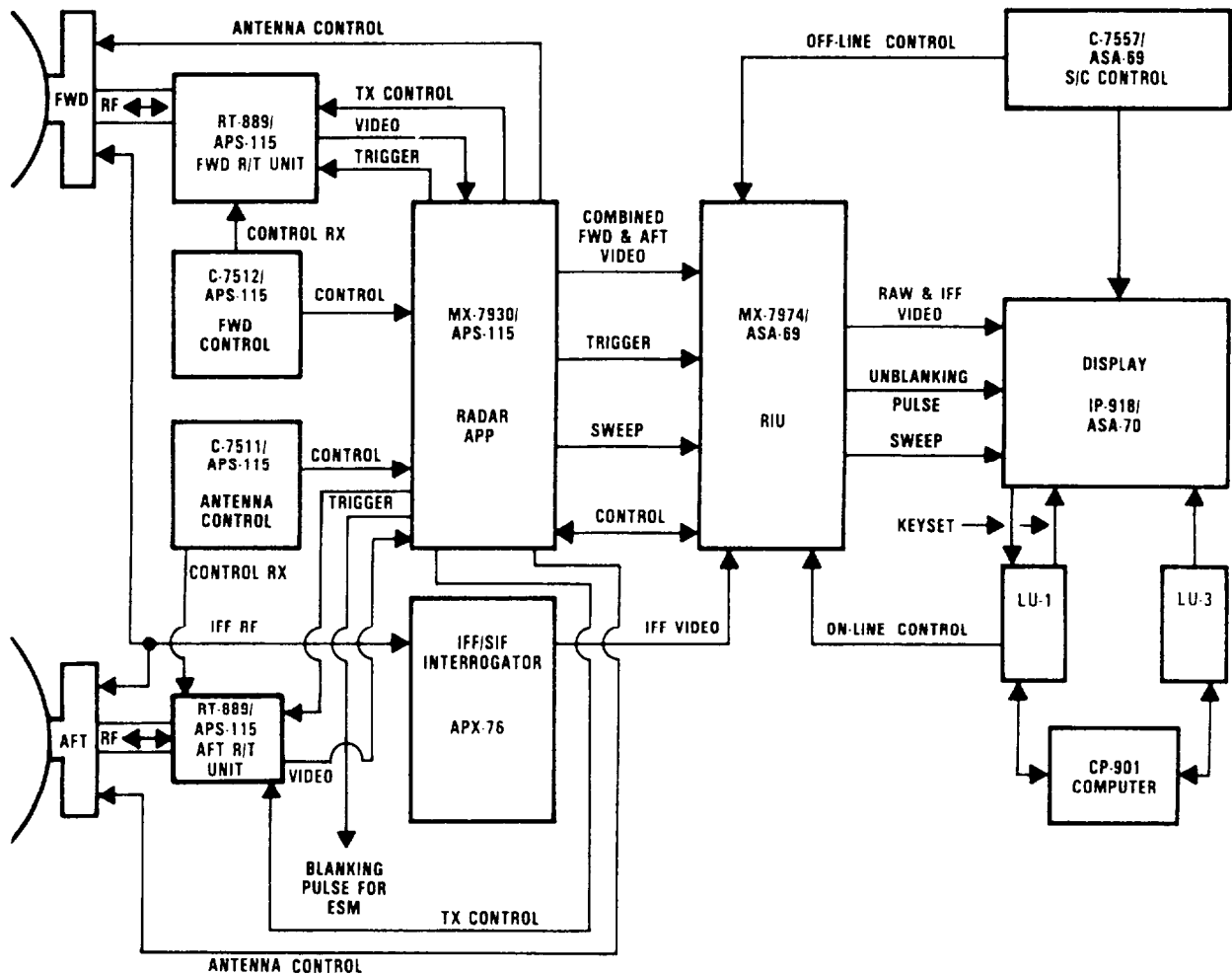


Figure 3-8.-APS-115 radar signal flow diagram.

In the on-line mode, the sensor station 3 keyset generates primary control signals, which are processed through the central computer, logic unit No. 1 (LU 1), and the RIU. The antenna control provides signals to control the radar scan functions and tilt servo loop stabilization. The two radar control boxes control the sensitivity time adjustments, receiver gain, fast time constant, automatic frequency control, and video test of the respective RT.

FIRE CONTROL RADAR

Learning Objective: Recognize operating modes and system controls used in a fire control radar.

The 11D13A radar maintenance trainer device is discussed in the following text. This system was selected because an actual operational system would require that classified information be included. Because the trainer is different from an operational system in some respects, these differences are noted when discussion will not violate security regulations.

The 11D13A trainer device includes all the elements essential for basic search radar ranging—transmitter, receiver, antenna, and synchronizer circuits. Additional elements, including tracking, stabilization, and target generation (simulated targets), allow operation as either a fire control (intercept) radar or a bomb director radar. The target generator unit, although not usually contained in operational radar systems, produces a three-dimensional target that is controllable in azimuth, range, and elevation in a manner typical of analog computing systems. It contains both mechanical and electronic elements found in analog computing systems. A block diagram of the trainer is shown in figure 3-9. The ranges in the trainer vary from 0 to 80,000 yards. An actual weapons control radar has much longer ranges, which are normally expressed in miles.

OPERATING MODES

The 11D13A trainer is capable of operating in three basic modes—search (PPI), fire control, and bomb director. Fire control is divided into five

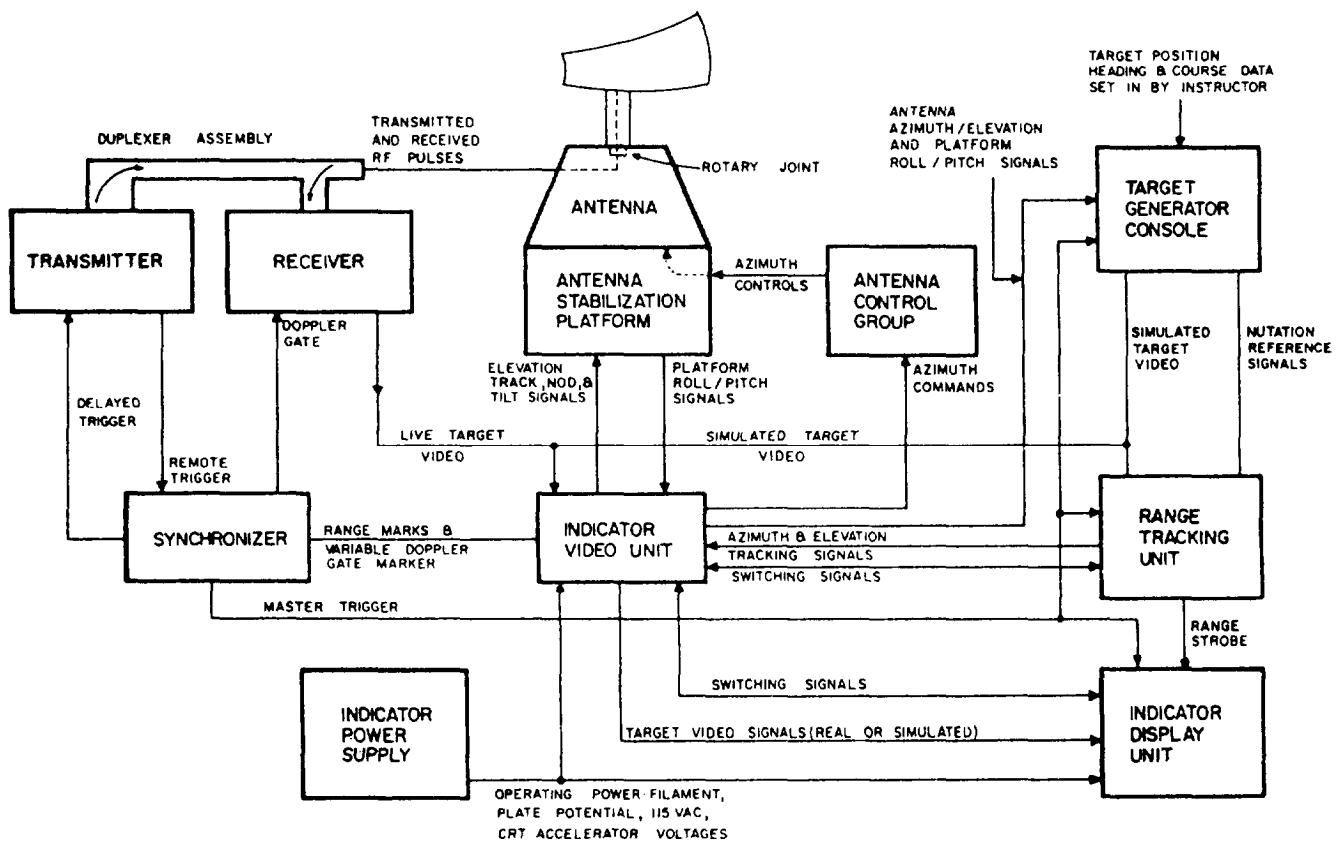


Figure 3-9.-Trainer 11D13A functional block diagram.

submodes—automatic search, manual search, lock on, automatic track, and breakaway. These submodes parallel the general submodes found in actual weapons control systems.

The trainer has no standby mode as such. (The purpose of a standby mode is to apply filament voltages for initial warm-up before selecting an operating mode.) Most radar sets include an automatic time-out (time-delay) circuit, which prevents application of power to the high-voltage sections prior to the necessary warm-up period.

Search Mode

Search operation for airborne and ground targets is provided with ranges of 0 to 6,000 yards and 0 to 12,000 yards. In this mode the antenna automatically scans the horizon, rotating in a clockwise direction at 6 RPM. Manual control of the antenna in this mode provides manual tracking of detected targets. There are some minor differences in the methods of manual control; however, they are of little consequence. Range marks are selectable in 1,000-, 2,000-, or 3,000-yard increments. In the basic search mode, the B-scope, which is also included in the indicator unit, is deactivated.

Fire Control Mode

When the fire control mode is selected, the target simulator provides a three-dimensional target (target with range, azimuth, and elevation information). In the fire control mode, there are five submodes—automatic search, manual search, lock on, automatic track, and breakaway. The five submodes permit the simulated target to be detected initially, manually tracked and acquired, and tracked automatically until minimum range is reached. At this time, a breakaway signal in the form of a large X is displayed on the B-scope indicator, warning the operator to break away from the target. In an actual weapons radar, the breakaway X also means that the aircraft is too close to the target to allow time for an air-to-air missile to properly track the target.

Minimum range in fire control operation is 3,500 yards. Three ranges are provided for target information while operating in the fire control mode—0 to 10,000, 0 to 40,000, and 0 to 80,000 yards. During this mode of operation, target information is displayed on both the PPI and B-scope of the indicator display unit. The B-scan display uses a dual-gun arrangement (to be discussed later), which

provides steering information in addition to the normal plot display.

Bomb Director Mode

Operation in the bomb director mode covers the same ranges provided in the fire control mode. Aiming information is displayed on the PPI display. Switching circuits, which are energized at the time of mode selection, cause the presentation to be altered to conform to typical bomb director system presentations. The PPI display has a depressed-center sector scan at twice the scale of the fire control mode. The indicator includes controllable range and azimuth marks (strobes), which act as cross hairs to facilitate aiming (aim point tracking).

SYSTEM CONTROLS

Through the manipulation of the basic controls, the operator has available all of the previously mentioned modes of operation. The controls of the trainer are decentralized to simplify construction and operation, but these controls can be grouped into five major categories according to their function. The five major control functions are as follows:

1. Power switch
2. Mode switch
3. Receiver gain control
4. Antenna control (hand control)
5. Auxiliary controls

Power Switch

The power switch is the system's off-standby-operate switch. The off position, of course, removes all power from the system. The standby position, as previously described, would apply filament power and keep alive voltage to the TR tubes. For purposes of training, the 11D13A has a power switch for each of the major units antenna transmitter, and so forth). This allows for operation of each of the units or any selected combination of units for training. During the discussion throughout this chapter, the appropriate control will be noted, along with its function and its relationship to one of the four major function controls, if necessary.

Mode Switch

The mode switch is practically self-explanatory. In the trainer, this switch sets up one of the basic operating modes available, such as search, bomb director, or fire control.

Receiver Gain Control

The receiver gain control is one of the most important controls available to the operator, whether the pilot in the aircraft or an operator on a trainer. This control, if not properly adjusted, will prevent the entire system from operating at peak performance. Some radar systems include a built-in test function, which provides a reasonable check of the adjustment of the receiver gain control. This control is normally adjusted for best definition of the weakest target available. There is only one acceptable method for adjusting this control to obtain peak detection, which provides maximum range. In each particular radar, this method is part of the minimum performance test.

Antenna Control (Hand Control)

The hand control of an actual radar installation allows the operator to select manual search operation and selection of targets. Through the use of this control, the operator may command the radar to acquire and/or release the target. The 11D13A has two controls, one for azimuth and one for range.

During automatic search, these controls have two functions---(1) to position the antenna in elevation and azimuth, and (2) to select the area to be searched in relation to the horizon. You can see that these controls and the receiver gain control are very important because they will affect target detection performance.

The hand controls have complete control of the antenna during manual search, and, in addition, also control the acquisition symbol to acquire the target.

Auxiliary Controls

Through the use of a scan switch in an operational radar, the operator may select either full azimuth or sector scan. The trainer, likewise, incorporates a scan switch that may be used to select the type of scan desired. In the trainer, the selections are automatic sweep at a 6-RPM rate, variable sweep from zero to 6 RPM manually controlled, or sector scan.

INDICATOR DISPLAYS

A description of the indicator displays (PPI or B-scope) in the three basic modes of operation and the submodes of fire control is given in the following paragraphs. The indicators are used to monitor system performance during simulated operation in all weather conditions.

Basic Search

In the basic search mode, information is displayed on the PPI only. As shown in figure 3-10, the PPI scan presentation may be a maplike picture of the earth's surface being seamed. The range sweep line rotates in synchronization with the antenna through a full 360-degree cycle. Targets appear on the face of the CRT as an intensified light spot. The range of the target is indicated by its position on the radius of the range sweep line, and target azimuth position is indicated by the angle of the sweep line at the time the target is painted. The top of the scope is 0 degree, and may indicate dead ahead.

If 1,000-yard marks are selected, the two range marks shown in the figure are 1,000 yards apart. The first range mark, which starts from the center of the scope and moves outward toward the edge of the scope face, indicates targets from zero to 1,000 yards. There are two targets shown in figure 3-10 that are between the 1,000- and 2,000-yard marks. Other targets are shown at greater ranges and at different

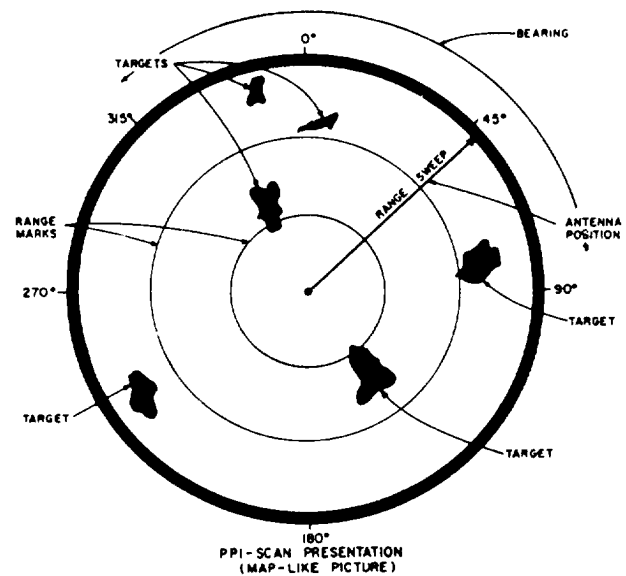


Figure 3-10.-PPI scan presentation basic search.

azimuth positions. The presentation shown could be a ground map of an area of the earth's surface showing several islands. The shape of the target appearing on the scope will be almost the actual shape of the target as viewed visually. If, however, the antenna were scanning above the horizon, an airborne target would be a very small bright spot, and the target shape would not be defined.

Fire Control (Automatic Search)

In the automatic search submode of fire control, information is displayed on both indicators. The PPI presents target range and azimuth information as before. Now, the B-scope also presents information that, if the system were operating in an aircraft, would be required to make a successful attack on an airborne target. This information is shown in figure 3-11.

In figure 3-11, which is a normal B-scan search display, four items of interest are painted electrically on the face of the CRT. The first is the range sweep line, sometimes referred to as the B-trace. This time, however, the sweep is from the bottom of the scope to the top. Range on a B-scope is measured from the bottom of the scope to the top. The length of the trace then is equal to the range selected. If the 0- to 10,000-yard range is selected, the length of the range sweep line is 10,000 yards. The position of the sweep line on the face of the scope, as was the sweep line on the PPI, indicates the azimuth position of the antenna. The trace scans back and forth, following the antenna.

You should notice that the scan line is not a single line, but is made up of several lines, causing it to become a 1/4-inch-wide scan line. This is called "jizzle," and is the result of simulated antenna spin modulation. In an actual radar system, this is accomplished by nutation of the antenna feed horn or reflector dish. In the trainer a scan generator produces the effect of the antenna nutation, but the antenna is not actually nutated. Figure 3-12, view A, shows an antenna pattern that is simulated in the trainer. In view B of figure 3-12, a boxlike pattern is produced. This is accomplished by introducing a nod at the end of the scan.

The second item on the scope is video (targets). As the antenna scans back and forth, any target within the range of the radar appears as a bright spot on the face of the CRT. The range of the target is indicated by its vertical distance from the bottom of the scope. The azimuth position of the target is indicated by the position of the target either to the left or to the right of

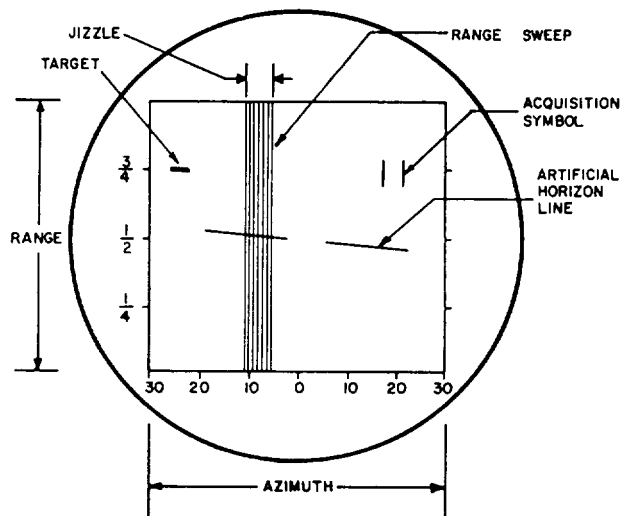


Figure 3-11.-B-scan presentation in automatic search.

the center. For example, if the target appears as shown in figure 3-11, its range is 7,500 yards (on the 10,000-yard range scale), and it is to the left of the attacking aircraft. Most radars installed in fighter-type aircraft also have an indication of the antenna tilt, which is used to indicate elevation position of the target relative to the attack aircraft. If the target were above the attacking aircraft, the antenna would have to be tilted up to receive a target echo. The amount of tilt can then be read from the indicator, and the pilot may steer the aircraft accordingly to intercept the target.

The third item on the B-scope is the acquisition symbol. During automatic search, the acquisition symbol is relatively unimportant, but it is movable, and could be used to mark the area of target return. The symbol, as shown in figure 3-11, is made of two short vertical lines slightly separated. Position of the symbol in the vertical indicates range, and is controlled by the range circuits, which, in turn, are controlled by the hand control in an actual radar system. Movement of the hand control back or forward decreases or increases range voltage, which causes the acquisition marks to move in or out in range. The acquisition marks are also controllable in azimuth by movement of the hand control either to the left or to the right. Therefore, the acquisition marks may be positioned anywhere on the face of the scope. This is described in greater detail later.

The fourth symbol on the face of the scope is the artificial horizon line. This symbol is a straight line with the center blanked out, and is positioned horizontally on the face of the indicator tube. The

purpose of the horizon line is to indicate aircraft attitude. In automatic search, the horizon line represents the earth's horizon; when the aircraft rolls or pitches, the artificial horizon banks or moves up or down with the aircraft's movement. This movement of the horizon line is controlled by outputs from the aircraft vertical gyro or stable platform.

Fire Control (Manual Search)

Manual search allows the operator to stop the antenna from scanning and to direct it toward any desired target detected during automatic search. Tilt or elevation control of the antenna, which was provided in automatic search, is still available in manual search. In addition, control of the antenna in azimuth is now available. In the operation of an actual radar installation, control of the antenna in both elevation and azimuth is a function of the hand

control. In the trainer, however, azimuth and elevation controls are separate. The provision of separate controls is of no great significance, except for convenience of operation.

When manual search is initiated, the acquisition marks bracket the range sweep line (B-trace), and both the B-trace and the acquisition marks move together in azimuth. The position of the acquisition marks in range is also available in the manual search mode. This allows them to be positioned anywhere on the B-trace from zero to maximum range, depending on range selected. For example, if the radar is operating in the 0- to 10,000-yard range, and a target appears at 5,000 yards, the acquisition marks may be moved to bracket the target by use of the range control.

The major display differences between automatic search and manual search are that the acquisition

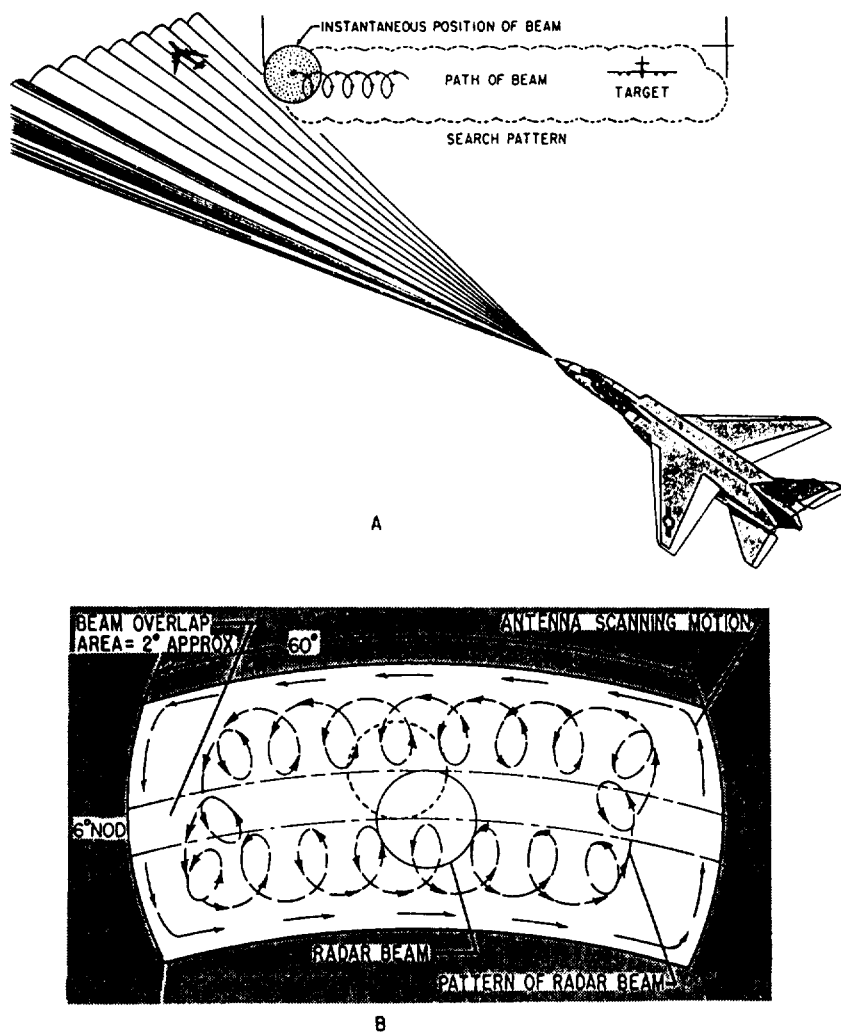


Figure 3-12.-A. Antenna scan pattern. B. Antenna coverage pattern.

marks bracket and move with the B-trace, and the antenna is controllable in azimuth. All symbols that were present in automatic search, including the artificial horizon, are present in manual search. The horizon line still functions to indicate aircraft attitude. It should also be reasonable to expect to see no targets other than the ones that appear on the range sweep line, since the antenna is no longer scanning.

Fire Control (Lock on)

The lock on mode is a momentary mode of operation between manual track and automatic track. Some radars combine the previously described manual operations and lock on mode into one mode called "acquisition." The term *acquisition*, as used in operation of a radar set, refers to a momentary mode of operation. The time period for acquisition begins at the moment the operator depresses a control switch transferring antenna control from automatic search to manual search. During this period, the operator has complete control of antenna position, both in azimuth and elevation, and may also control a symbol on the indicator called an "acquisition symbol." If the operator places the acquisition symbol over the selected target, it causes coincidence between the tracking gate and the target in the range and tracking circuits of the radar. Acquisition is complete when lock on occurs, and the system switches to automatic track. Lock on is accomplished by a change in the B-scope presentation and the blanking of the PPI scope. However, in the trainer, manual track may be continued after lock on, if desired.

On the B-scope, the acquisition symbol is removed and replaced with a range strobe or notch superimposed on the target, as shown in figure 3-13. The artificial horizon remains as before. Note there are two symbols present now that were not previously present. One of these is a small dot, called a steering dot. The purpose of the steering dot is to indicate antenna position, which also presents target position with respect to the attacking aircraft. For a pure pursuit course, the pilot need only maneuver the aircraft to cause the steering dot to remain in the center of the scope. When the steering dot is in the center of the scope on a pure pursuit course, the target is dead ahead of the attacking aircraft.

The second symbol, which was not present in the previous modes, is a circle. This circle is called a "range circle," and its diameter is proportional to range. Normally, lock on occurs at near maximum range, which produces a range circle of maximum

size. As the range between the attacking aircraft and the target decreases, the diameter of the circle also decreases, keeping the operator informed of the range to the target. In addition to these symbols, two other indications of range are presented at the time the radar locks on. A light, known as the lock on or acquisition light, is illuminated when the target has been acquired and lock on has been accomplished. Range is also presented in digital form in a small window similar to the mileage counter of an automobile.

Fire Control (Automatic Track)

The automatic track submode of fire control results from the manual track mode upon release of the manual controls (range and azimuth). Remember, prior to automatic tracking, the antenna had been manually controlled in both elevation and azimuth, and the range strobe (notch) had been controlled by the range control. To initiate automatic tracking, the operator releases the manual controls, and the radar switches to automatic track. At this time, the antenna is caused to track the target by the antenna servo system error circuits.

Range tracking is accomplished in the range tracking circuits. Automatic tracking continues until one of three things occurs. First, lock on will be lost if the attacking aircraft is closing on the target at a rate greater than 700 knots, or if an opening rate greater than 200 knots should occur. Second, the target will be lost, and the radar will unlock if the target does not remain within the tracking window (antenna limits in azimuth and elevation). Finally, the target will be lost if the range exceeds maximum tracking range.

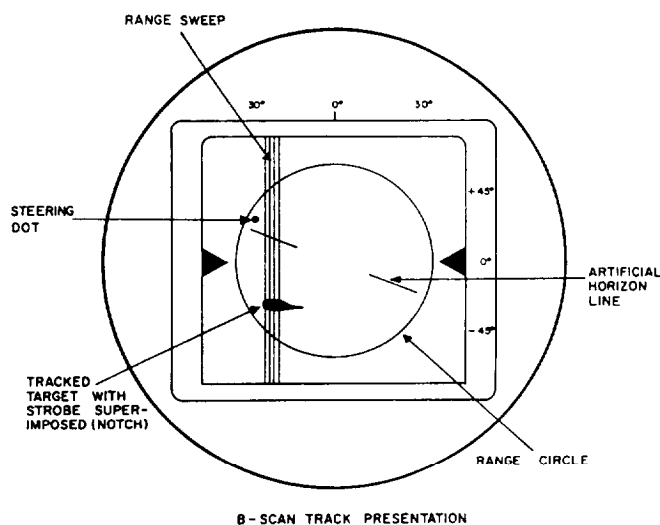


Figure 3-13.-B-scan presentation after lock on.

Maximum range for tracking is 40,000 yards. At ranges beyond 40,000 yards, the return echo will be too weak to maintain lock on. If unlock occurs, the system is automatically returned to automatic search, and the cycle of manual track and acquisition must be repeated to regain target tracking.

Fire Control (Breakaway)

The final submode of fire control is known as breakaway. This mode occurs automatically if the target is tracked to a range that would endanger the attacking aircraft. During automatic track of a target that has a decreasing range (attacking aircraft is closing on the target), the range circle is removed at the time the range to the target gets to 3,500 yards. In its place, a large **X** is displayed, which indicates time to breakaway from the attack (fig. 3-14). Also at this time, the steering dot will move to a position on the scope to indicate the safe direction for the attacking aircraft to turn to execute a safe breakaway. In the illustration, minimum range has been reached and the breakaway **X** has appeared. The steering dot is presently positioned to the right and above center.

Bomb Director Mode

When the bomb director mode of operation is selected, information is displayed on the PPI indicator. In this mode, the antenna automatically goes to sector scan, scanning a 60-degree arc, 30 degrees to each side of dead ahead. Antenna elevation is manually controlled. The PPI scope has a

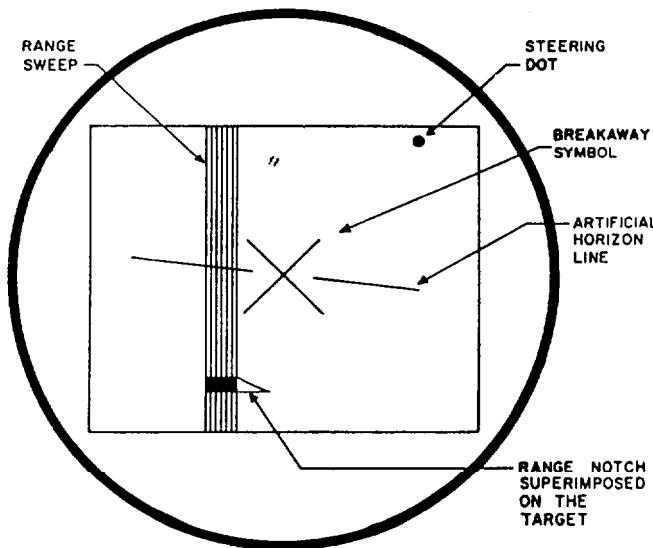


Figure 3-14.-B-scan presentation breakaway indication.

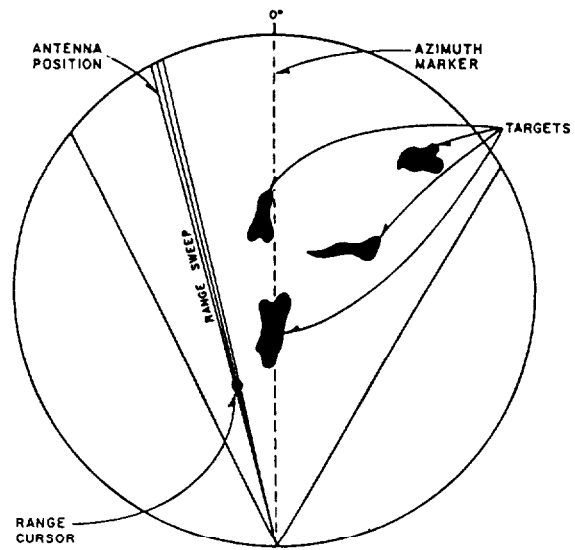


Figure 3-15.-PPI presentation in bomb director mode.

depressed center, which appears as a wedge-shaped scan on the indicator face, as shown in figure 3-15. The antenna is positioned in elevation so it will scan the surface of the earth during a bomb attack. The B-scope will only display the artificial horizon in the bomb director mode.

The target tracking range and azimuth strobes appear on the indicator; they are moved manually so the marks form a cross hair effect, and are centered over the target to be tracked. Tracking is maintained manually in the bomb director mode. The azimuth and range strobes are controllable from 0 to 80,000 yards, and, in azimuth, 25 degrees to either side of center.

IFF SYSTEMS

Learning Objective: *Recognize components and operating principles of an IFF transponder set and an IFF interrogator set.*

There are two systems that make up the IFF system on an S-3 aircraft. These systems are the AN/APX-76A and the AN/APX-72. Both systems work in conjunction with the radar set for total and secure identification.

TRANSPONDER SET AN/APX-72

The transponder set provides Identification Friend or Foe (IFF) radar replies when challenged by a valid IFF interrogator. The IFF transponder

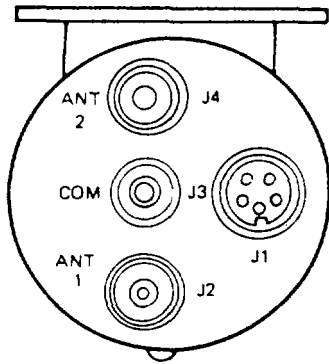


Figure 3-16.-SA-176/A RF transmission line switch.

processes valid IFF interrogations and provides coded pulse train replies to give automatic radar identification of the aircraft in one of five modes. The five modes are discussed later in this chapter.

The transponder set also provides the Selective Identification Feature (SIF) to permit a specific aircraft to be selected from other properly responding aircraft.

Major Components

The transponder set consists of four main boxes and a test set. These components will be discussed in the following text.

RF TRANSMISSION LINE SWITCH SA-1769/A.— The RF transmission switch (fig. 3-16) alternately connects the transponder set to the top or bottom UHF L-band antenna. This switching (lobing)

operates at 38 Hz. The lobing action prevents the antenna system from being blanked out during aircraft maneuvers.

TRANSPONDER SET CONTROL C-6280(P)/APX.— The IFF control box (fig. 3-17) provides the IFF transponder operational and test controls. The IFF transponder control box controls the transponder in any of the five modes: modes 1, 2, 3A, C, and 4.

RECEIVER-TRANSMITTER RT-859/APX-72.— The receiver-transmitter (fig. 3-18) will

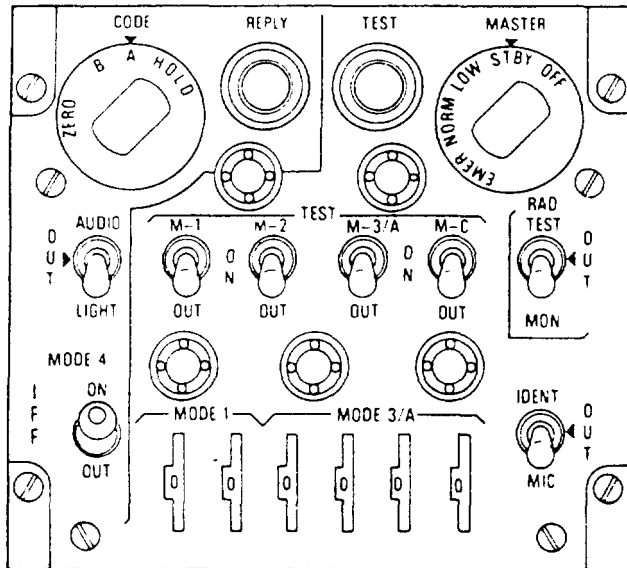
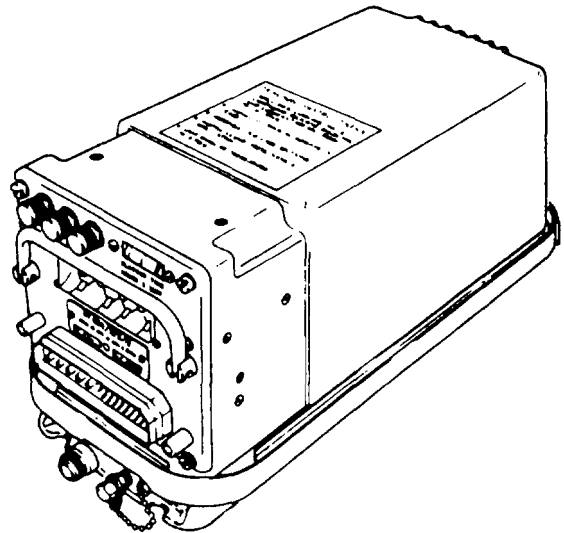


Figure 3-17.-C-6280(P)/APX transponder control box.

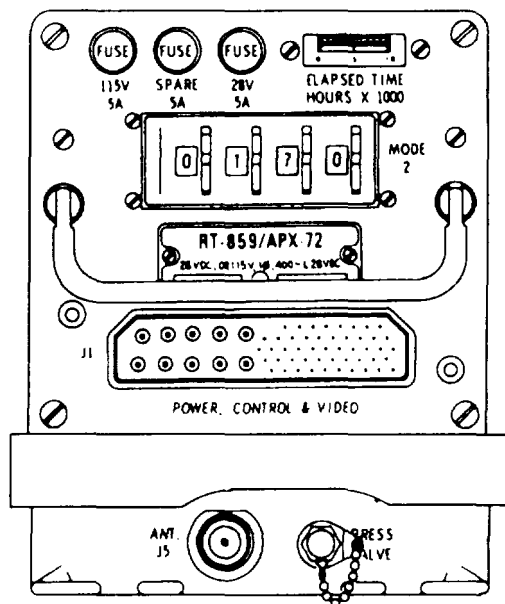


Figure 3-18.-RT-859/APX-72 receiver-transmitter.

transmit a reply when RF interrogation is received from an IFF interrogator. If the interrogation is valid, a coded reply is transmitted. This reply is received by the interrogator and processed for display for aircraft identification and location. The transponder is capable of operating in five modes and superimposing four special signals on the mode replies.

COMPUTER KIT-1A/TSEC.— This computer allows the IFF transponder to respond to mode 4 interrogations. Mode 4 is a secure mode of operation.

TRANSPONDER TEST SET TS-1843/APX.— The test set (fig. 3-19) generates properly coded test signals for the desired mode. These interrogation signals are then applied to the transponder. The test set then checks the replies for frequency, bracket-pulse spacing, power, and antenna standing-wave ratio. The resulting IFF system check will provide a GO/NO-GO indication on the IFF transponder control box.

Transponder Set Functional Description

The IFF transponder control box allows an automatic IFF capability when the aircraft is interrogated by a valid interrogation. Special modes and codes can be manually set on the IFF control box, receiver-transmitter, and on the computer. The control box also initiates the self-test function through the test set.

RECEIVED SIGNALS.— The interrogator-transmitted signals are received by the aircraft through the UHF L-band blade antennas. These signals are on a frequency of 1030 MHz. The receiver-transmitter recognizes the signals through pulsewidth and spacing detection. Modes 1, 2, 3/A, C, and TEST use two interrogation pulses and one side-lobe suppression pulse that are 0.8 (± 0.1) microsecond wide. Pulse spacings between the two interrogation pulses are slightly different, depending on the mode. These spacings are as follows:

| | |
|-----------|---------------------------------|
| Mode 1: | 3.0 (± 0.2) microseconds |
| Mode 2: | 5.0 (± 0.2) microseconds |
| Mode 3/A: | 8.0 (± 0.2) microseconds |
| Mode C: | 21.0 (± 0.2) microseconds |
| TEST: | 6.5 (± 0.2) microseconds |

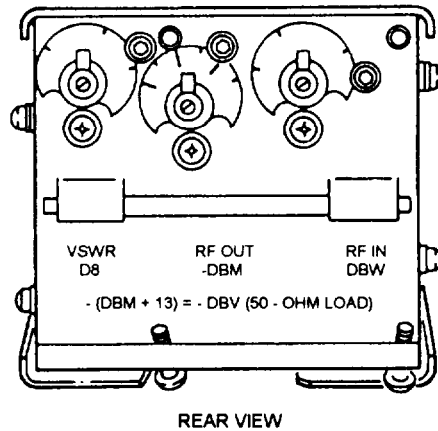
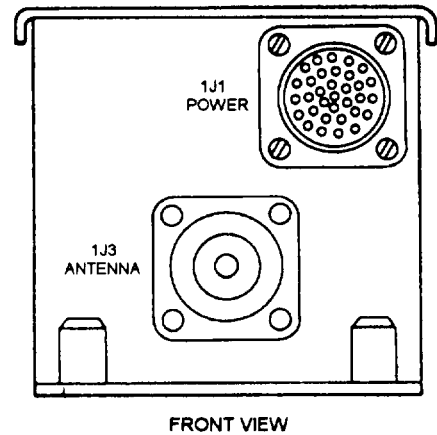


Figure 3-19.-TS-1843/APX test set.

IFF TRANSPONDER RECOGNITION.— Recognition of the interrogation mode is done by passing the first interrogation pulse through a time-delay circuit and matching this first pulse with the second pulse position. The delays are of 3, 5, 8, or 21 microseconds. Mode 4 capability is provided when the computer is operating in the system. Mode 4 interrogation pulse characteristics consist of four pulses 0.5 (± 0.15) microsecond wide, referenced from the leading edge of the first pulse in multiples of 2 microseconds. The 4 pulses maybe followed by as many as 33 additional pulses spaced as close as 2 microseconds. The side lobe suppression pulse is placed 2 (± 0.15) microseconds from the leading edge of the fourth pulse.

SIDE-LOBE SUPPRESSION.— The side-lobe suppression pulse allows the transponder to accept the main lobe and to reject minor lobe signals from the interrogation stations. This ensures correct operation of the system.

Table 3-1.-Correlation of Dial Settings with Pulse Position

| Dial Setting | First Dial | A1 | A2 | A4 |
|--------------|-------------|----|----|----|
| | Second Dial | B1 | B2 | B4 |
| | Third Dial | C1 | C2 | C4 |
| | Fourth Dial | D1 | D2 | D4 |
| 0 | | - | - | - |
| 1 | | + | - | - |
| 2 | | - | + | - |
| 3 | | + | + | - |
| 4 | | - | - | + |
| 5 | | + | - | + |
| 6 | | - | + | + |
| 7 | | + | + | + |

Note: + means pulse is present.
- means pulse is absent.

IFF TRANSPONDER RESPONSE.— Table 3-1 shows the correlation of dial settings with pulse positions. If you use this table, along with the examples given in figure 3-20, you will get an idea of what the pulse trains will look like for the various codes. Figure 3-21 shows the interrogation and reply pulse train characteristics.

Mode 4 reply pulse video characteristics are determined by the computer. The reply is framed by two pulses spaced 23 (±0.05) microseconds apart. In modes 1, 2, and 3/A, the presence or absence of information pulses at predetermined spacings is determined by the settings on the transponder control box. In mode C, this information is determined by the

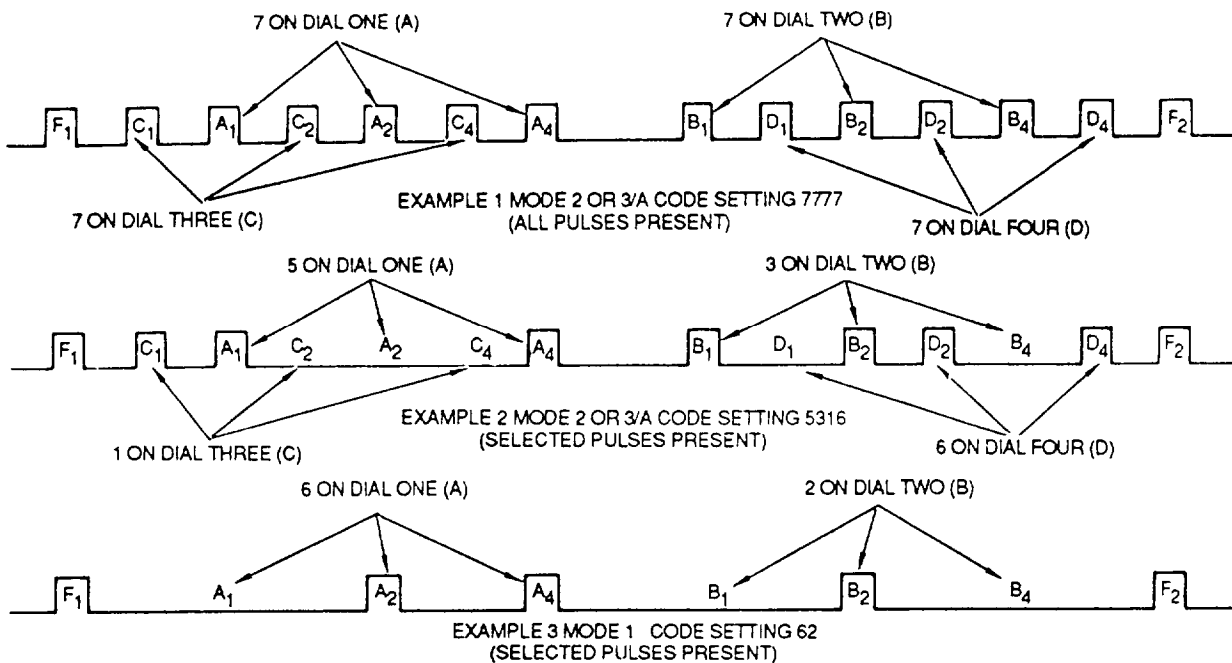


Figure 3-20.-Information pulse train examples.

airspeed-altitude computer. All framing and information reply pulses are 0.45 (± 0.1) microsecond wide. All modes are transmitted by the RT at a frequency of 1090 MHz.

Mode 1.— The reply pulse train consists of from zero to five information pulses framed by two framing pukes. The spacing between the information pulses is in multiples of 2.9 (± 0.05) microseconds from the initial framing pulse. The position where the sixth information pulse would be (17.4 [± 0.05] microseconds from the initial framing pulse) is not used. There are 32 different codes available for use from the specified five information pulses.

Mode 2 and 3/A.— When transmitted, these reply trains contain from zero to 12 information pulses, plus the two framing pulses. The information pulse spacing is in multiples of 1.45 (± 0.05) microseconds from the initial framing pulse. The position where the seventh information pulse would be (10.5 [± 0.05] microseconds from the initial framing pulse) is normally not used. There are a possible 4,096 different codes available from the specified 12 information pulses.

Mode C.— When the Airspeed-Altitude Computer is connected in the system, the reply train consists of from 1 to 11 information pulses and 2 framing pulses. The information pulses are spaced in multiples of 1.45 (± 0.05) microseconds from the initial framing pulses. The positions where the seventh and the ninth pulses are normally located (10.5 [± 0.05] and 13.05 [± 0.05] microseconds from the initial framing pulse) are not used. When there is a pulse in the thirteenth position (18.85 [± 0.05] microseconds from the initial framing pulse), there is

a special position indicator pulse also generated in the train. This pulse is located 24.65 (± 0.05) microseconds from the initial framing pulse. There is a total of 2,048 possible codes available from the specified 11 information pulses. When the airspeed-altitude computer is not on-line, the reply train will be the framing pulses only.

Mode 4.— This reply train is determined by the KIT-1A/TSEC.

IDENT Function.— The identification-of-position (IDENT) function is used in modes 1, 2, and 3/A. The IDENT function, which can be selected by the pilot for transmission for approximately 20-second intervals, is used to distinguish between aircraft displaying the same coding. When used in mode 1, the reply pulse train containing the code in use is transmitted twice for each trigger puke received. The second train is 24.65 (± 0.05) microseconds from the leading edge of the first framing pulse of the first reply train. The IDENT function in modes 2 and 3/A uses the special position indicator (SPI) pulse. The reply pulse train containing the code in use is followed by a pulse for each trigger received. This SPI pulse is 24.65 (± 0.05) microseconds from the leading edge of the first framing pulse of the reply train.

Emergency Function.— The EMERGENCY signals are selected by the pilot to indicate an in-flight emergency. The emergency function is used with modes 1, 2, and 3/A. For modes 1 and 2, the reply pulse train containing the code in use is transmitted once for each trigger pulse received, followed by three sets of framing pulse pairs with no information pukes. The three sets of framing pulses are located 24.65 (± 0.1), 44.95 (± 0.15), 49.30 (± 0.20), 69.60

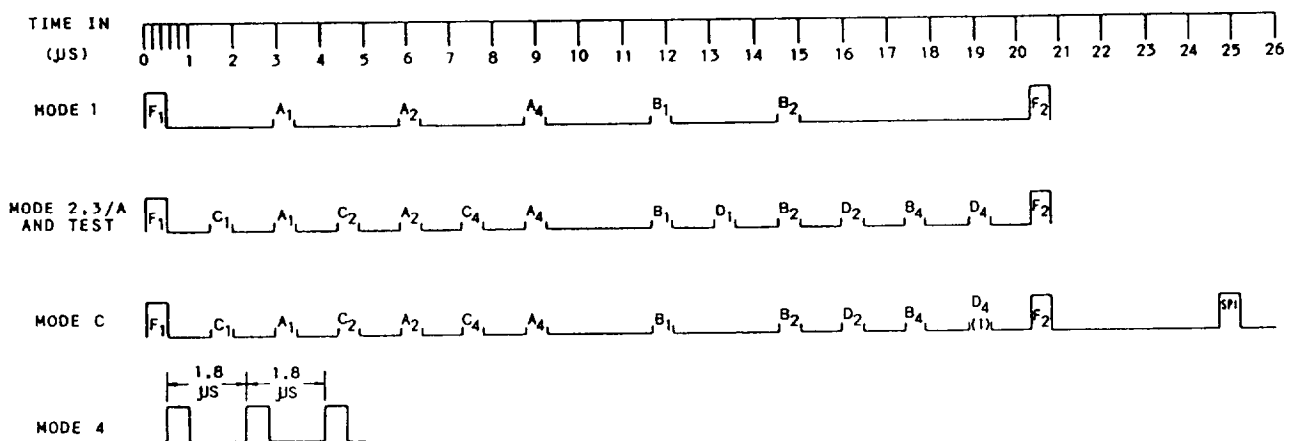


Figure 3-21.-Normal reply pulse characteristics.

(±0.25), 73.95 (±0.30), and 94.25 (±0.35) microseconds from the leading edge of the initial framing pulse. In mode 3/A, one reply pulse train containing the code 7700 is transmitted, followed by the three sets of framing pulse pairs with no information pulses. The location of these framing pulse pairs is the same as in modes 1 and 2.

Special Position Indicator.— The special position indicator (SPI) allows the air traffic controller to differentiate aircraft above or below a given altitude. This pulse is present in the reply pulse train in mode C when a D4 pulse (18.85 [±0.05] microseconds from the initial framing pulse) is used. The SPI pulse is located 24.65 (±0.01) microseconds from the initial framing pulse. This pulse is sometimes called the mode C caboose pulse. This SPI pulse is the initial framing pulse for the second reply pulse train. The SPI pulse is the same pulse used in the mode 2 and 3/A IDENT function.

X-Pulse Function.— Special aircraft, such as drones, are identified by the transmission of the X-pulse. This pulse (10.15 [±0.05] microseconds from the initial framing pulse) appears in a normally unused position. This pulse is generated when the IFF transponder control box is modified by grounding a single external control lead. With this modification, all replies in modes 1, 2, and 3/A will include this pulse, along with the normal framing and information pulses.

SELF-TEST MODE.— When the TEST switches on the IFF transponder control box are enabled, an interrogation pulse pair is applied from the test set to the receiver-transmitter. Upon receiving these interrogation pulses, the RT replies to the test set. The test set then analyzes the replies for bracket-spacing frequency, power, and antenna circuit VSWR. The test set will give a GO/NO-GO indication on the control box. There is a switch for each of the modes 1, 2, 3/A, and C.

MONITOR OPERATION.— When the RAD TEST-OUT-MON switch on the IFF transponder control box is set to the MON position, the transponder performance is checked. The test set will monitor the performance by detecting the replies generated in response to external interrogation signals. If a GO condition is detected, the TEST indicator on the transponder control box will illuminate. For a NO-GO condition, the TEST indicator remains off.

INTERROGATOR SET AFUAPX-76A(V)

The interrogator set is used in conjunction with the aircraft's radar set. It provides air-to-air modes 1, 2, 3/A, 4, SIF, and IFF mode 4 challenges. The IFF interrogator receives a basic trigger from the radar set, and a delayed radar trigger is returned to the radar after generation of the IFF interrogator trigger. The IFF replies are decoded and combined with the displayed radar return video. The interrogator set uses receiver side-lobe suppression (RSLS) and interrogator side-lobe suppression (ISLS). The video output is developed in the IFF interrogator, and is applied to the radar set for display.

Interrogator Set Major Components

The interrogator set consists of six major components. These six are discussed in the following text.

ANTENNA AS-2719/AP.— The interrogator set uses an antenna that is hard mounted to the radar set antenna. The IFF portion of the antenna is imbedded in the upper part of the antenna dish, and consists of 10 IFF elements.

INTERROGATOR SET CONTROL C-7383/APX-76A(V).— The interrogator control box (fig. 3-22) provides operating mode selection of the SIF, or mode 4 code. The control box contains five thumbwheel switches to select the desired interrogation mode, or standby, and the desired code. A momentary two-position toggle switch (TEST/CHAL CC) allows for loop-testing the IFF, or to provide correct code challenge. The loop-testing allows for the interrogation of the onboard transponder set (AN/APX-72) by the IFF interrogator. Correct code challenge enables interrogations for which IFF display pulses are generated if the received

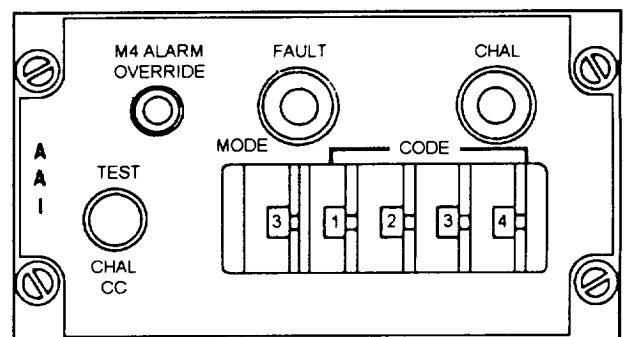


Figure 3-22.-C-7383/APX-76A(V) interrogator control box.

SIF reply code is identical to the code switch settings. There are two indicators (FAULT and CHAL) that indicate correct operating status of the system. The mode 4 alarm may be overridden by using the toggle switch M4 ALARM OVERRIDE.

RECEIVER-TRANSMITTER RT-868A/APX-76A(V).— The receiver-transmitter (fig. 3-23) takes the mode 1,2, 3/A, or 4 interrogation and ISLS pulses and modulates a 1030 MHz carrier wave with them. This is the transmitted signal from the interrogator set. The transponder reply signal, at the reply frequency of 1090 MHz, is amplified, detected, and processed by the receiver section. The reply video is then sent to the radar set for display on the various indicators.

There are three fault flags on the front of the RT that indicate malfunctions in one of the three functional sections of the receiver-transmitter.

SWITCH-AMPLIFIER SA-1568A/APX-76A(V).— The switch-amplifier (fig. 3-24) switches the interrogator's RF output from the sum antenna channel to the difference antenna channel for the duration of the ISLS pulse. During this time, the output is amplified by 4 to 7 dB. This amplification provides the required antenna output characteristics.

ELECTRONIC SYNCHRONIZER SN-416A/APX-76A(V).— The synchronizer (fig. 3-25) generates the initiation and interrogation cycles. The synchronizer provides a functional link between the

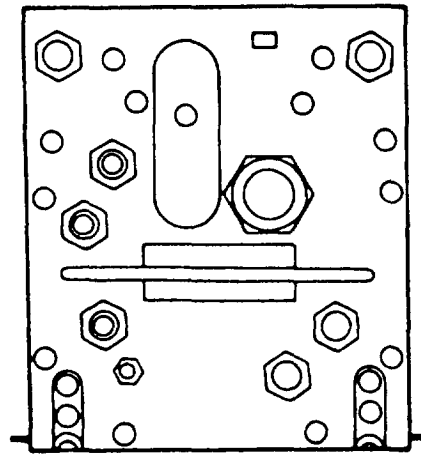


Figure 3-24.-SA-1568A/APX-76A(V) switch-amplifier.

radar trigger generation and the radar modulation circuits.

COMPUTER KIR-1A/TSEC.— This computer is used for mode 4 security and decoding for secure operation.

Interrogator Functional Description

The IFF interrogator challenges and identifies properly equipped targets on the display groups. It challenges in modes 1, 2, 3/A, SIF, or mode 4. Target responses are shown on the display group next to the target in the form of numbered cues.

MODES 1, 2, AND 3/A TRANSMISSION.— When the TEST-CHAL CC switch on the interrogator control box is set to the CHAL CC position, the interrogation cycle is initiated and lasts for 5 to 10 seconds. The basic radar trigger is applied to the

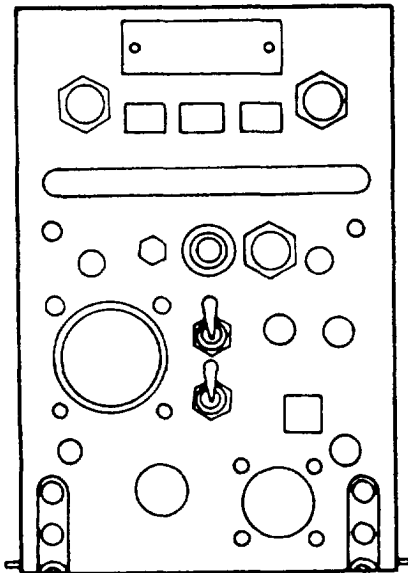


Figure 3-23.-RT-868A/APX-76A(V) receiver-transmitter.

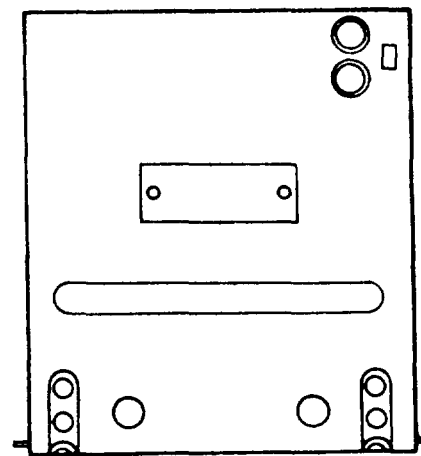


Figure 3-25.-SN-416A/APX-76A(V) synchronizer.

synchronizer, and a delayed radar trigger is sent back to the radar set after the interrogation trigger is generated. The synchronizer develops three basic signals:

- The interrogator trigger which, via the receiver-transmitter modulating circuit, modulates the transmission. The interrogation trigger consists of three pulses. P1 and P3 are interrogation pulses spaced either 3, 5, or 8 microseconds apart. In mode 1, the spacing is 3 microseconds, mode 2 has a 5-microsecond space, and mode 3/A has an 8-microsecond space. The ISLS pulse (P2) is always 2 microseconds after the P1 pulse.

- The gain time control (GTC) trigger, which initiates the receiver gate and the GTC circuits in the receiver-transmitter.

- The ISLS control gate, which controls switching of the antenna pattern for ISLS purposes.

The ISLS control gate, which precedes the P2 ISLS pulse by about 0.6 microsecond, is applied to the switch amplifier. When triggered by the interrogation trigger, the receiver-transmitter generates RF pulses at the transmitting frequency of 1030 MHz at a nominal peak power level of 2 kW. These pulses are applied to the sum channel of the switch-amplifier. The difference channel path between the receiver-transmitter and the switch-amplifier is not used during transmission. When the ISLS control gate is not present at the switch-amplifier, the RF pulses from the RT sum channel are passed straight to the antenna via the sum channel line for radiation out of the sum antenna pattern. This pattern is a main lobe with its axis along the antenna's boresight, and small side lobes on either side of the boresight. The P1 and P3 interrogation pulses are radiated in the sum pattern.

When the ISLS gate arrives at the switch-amplifier, shortly before the P2 pulse, the sum channel input at the switch-amplifier is switched to the difference channel coax to the antenna. The switch-amplifier amplifies the P2 ISLS pulse to a nominal peak power of 8 kW prior to its being sent to the antenna. This pulse is transmitted through the difference antenna pattern, which is two main lobes with their axes about 20 degrees on either side of the antenna's boresight, with a minimum signal strength along the boresight.

The reason for the two radiation patterns is to narrow the antenna beamwidth effectively in

conjunction with the operation of the ISLS circuit at the transponder. The IFF transponder responds only to the P1 and P3 interrogation pulses, which are at least 9 dB above the P2 pulse. The transponder will not respond if the P2 pulse level exceeds the P1 level. If an IFF transponder is located more than a small angle off of the antenna's boresight, the P2 pulse will be received at a much higher level than the P1 and P3 pulses, and no reply will be generated.

MODE 4 TRANSMISSION.— Mode 4 operation is very similar to that of modes 1,2, and 3/A. The major difference is that the KIR-1A computer generates the interrogation trigger, GTC trigger, and the ISLS control gate instead of the synchronizer. The synchronizer generates a mode 4 pretrigger that is sent to the computer. The computer then prepares the challenge video, which is sent back to the synchronizer for entry onto the interrogator trigger line to the RT. Mode 4 transmission is the same as in the other modes as far as the patterns are concerned. Both the sum antenna pattern and the difference antenna pattern are used.

RECEPTION.— During reception, both the sum and difference antenna patterns are open for IFF transponder reply energy. The purpose of this is to effectively narrow the reply reception antenna bandwidth. This function is called RSLs. The reply RF energy is applied to the receiver-transmitter via the switch-amplifier's sum and difference channels. If the energy is above maximum receiver sensitivity, and the sum channel energy is greater than the difference channel energy by a fixed factor, the receiver will develop video pulses for decoding.

These video pulses are applied to the mode 4 decoding circuits within the receiver-transmitter and to modes 1, 2, and 3/A decoding circuits in the synchronizer. For modes 1, 2, and 3/A, the video pulses are checked for the presence of the standard IFF reply bracket pulses spaced 20.3 microseconds apart. If these pulses are there, a single video pulse is applied to the radar set for display. The coded pulses between the brackets are checked against the code selected at the IFF interrogator control. If the codes match, another single display video pulse is applied to the radar set for display. This second pulse is delayed 12 microseconds (or 28 microseconds if the long-range display is enabled) from the first pulse. When the correct code challenge is used to initiate the interrogation, the first pulse (bracket decode) is not sent to be displayed.

In mode 4, the reply video pulse is checked by the RT for proper pulse spacing and width. A single reply pulse is forwarded to the computer for further decoding. The mode 4 decoded video is applied to the synchronizer, where two pulses spaced 12 or 28 microseconds apart are generated for display by the radar set.

PERFORMANCE MONITORING.— The IFF interrogator set includes performance monitoring circuits in each of the boxes. When a fault is detected, a signal is sent through the synchronizer to the control box. This signal will cause a FAULT light to illuminate instead of the normal CHAL light.

When the TEST-CHAL CC switch is set to TEST, the IFF interrogator and the IFF transponder are linked together. This is done by disabling the normal suppression, ISLS, and RSLS operations. The trigger timing is also modified to place the zero-range replies at approximately 4 nautical miles on the radar display. In this configuration, the two sets are checked by each other for proper performance.

REVIEW QUESTIONS

Q1. What type of search radar is the APS-115B?

Q2. What is the tilt range of the AS-2146/APS-115?

Q3. Which control switch on the C-7511A/APS-115 is used to select the antenna sector mode?

Q4. How many functional subsections are in a RT-889/APS-115?

Q5. What is the scan rate of the AS-2146/APS-115 in the long pulse mode of operation?

Q6. How many operating modes are available on the 11D13A?

Q7. What is the minimum range in fire control operations?

Q8. In the fire control (automatic search) mode, what name is given to the 1/4-inch scan line?

Q9. At what closing rate will lock on be lost in the fire control (automatic track) mode?

Q10. What indication on the scope indicates breakaway?

Q11. What are the five modes used in IFF operations?

Q12. What antenna(s) is/are used by the IFF transponder system?

Q13. The APX-76 interrogator uses what carrier frequency for transmission?

Q14. What light illuminates when one of the APX-76 components fail?

