

UNCLASSIFIED

No. 3

NAVAER 08-55-120

**PILOT'S
OPERATING MANUAL
FOR
Airborne Radar AN/APS-6 Series
For Night Fighters**

~~CONFIDENTIAL~~

FOR U. S. PERSONNEL

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17 February 1944

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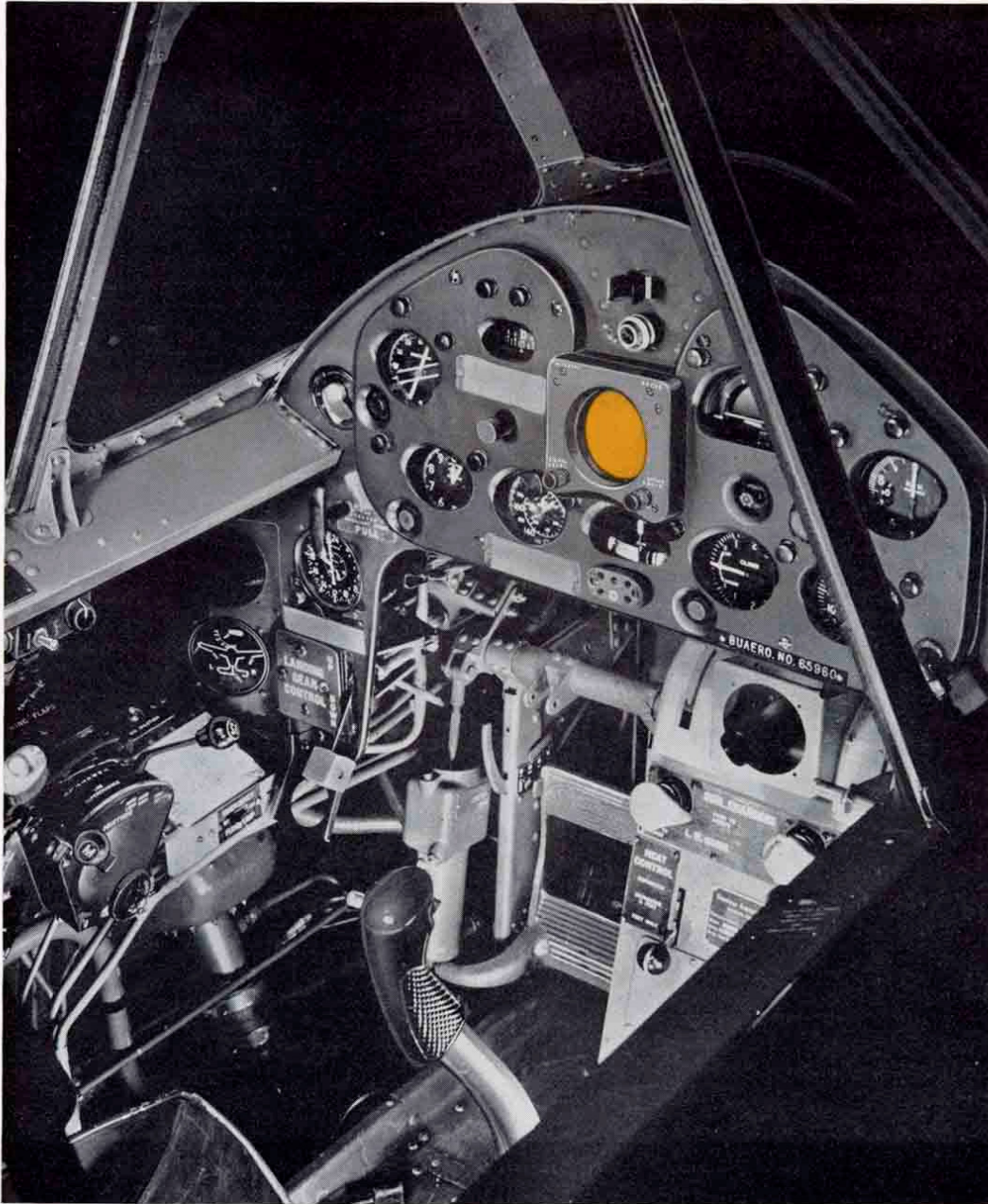


Figure 1—Cockpit of Night Fighter Craft Equipped with Radar AN/APS-6

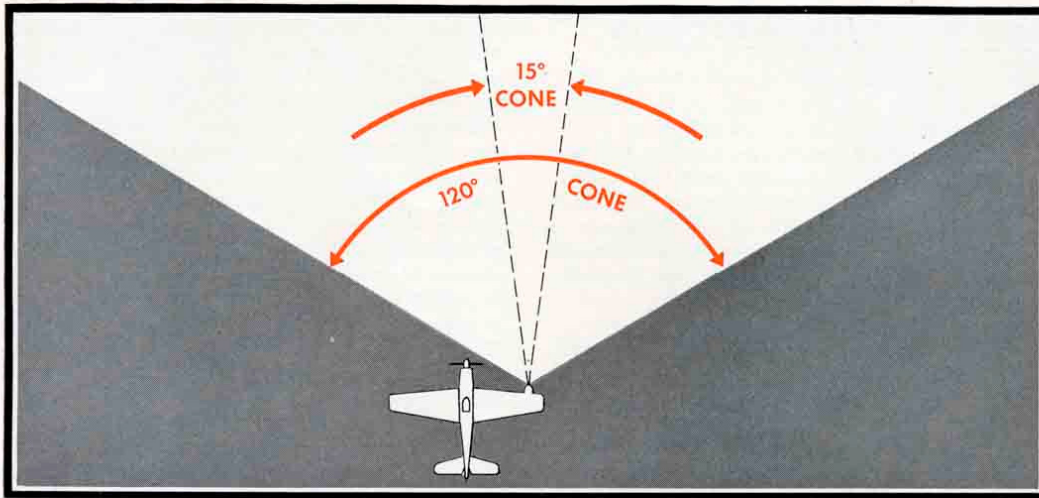


Figure 2—Field of View of AN/APS-6 Radar Equipment

GENERAL DESCRIPTION OF AN/APS-6 RADAR EQUIPMENT

The AN/APS-6 Airborne Radar Equipment is especially designed for carrier-borne night fighter planes. Its three principal functions are as follows:

1. *Search*—for enemy aircraft and surface vessels in darkness or fog.
2. *Gun Aim*—to fire on enemy craft when in proper position.
3. *Beacon*—to locate carrier, land or airborne beacon stations.

1. SEARCH—When used to search for enemy targets, the pilot has a choice of four operating ranges: 65-mile, 25-mile, 5-mile and 1-mile. A rotating beam of radio waves searches a 120-degree conical area extending ahead of the plane along its axis of flight. Targets within this area may be detected and located in range, azimuth and elevation.

When the 65-mile or 25-mile search range is employed, the pilot can determine:

- a. The range of a target in nautical miles.
- b. The relative location of the target in azimuth with relation to the plane's course.

When using the 5-mile and 1-mile range, the pilot can also tell the relative elevation of the target in relation to the axis of flight of his plane.

When a target is detected in the 65- or 25-mile range, the pilot, as he comes closer to the target, switches over to the 5-mile range. When the target is within 1 mile, he switches to the 1-mile range. He then tracks the target until he is within 1,000 yards by observing the indications on a cathode ray tube.

Provision has also been made for displaying IFF response when the aircraft is equipped with auxiliary IFF equipment.

2. GUN AIM—When the plane has approached to within one-half nautical mile (1,000 yards) of the target, the pilot switches to the Gun Aim position. By throwing the Search-Gun Aim Switch and observing the indications on the cathode ray tube screen in front of him, the pilot can determine the relative position of the target being approached within a 15-degree conical area along the gunfire axis of the aircraft.

When the Gun Aim range is 250 yards, the pilot is able to train his guns on the target accurately by means of the indications which will appear on the cathode ray tube.

3. BEACON—By switching from Radar to Beacon, the AN/APS-6 equipment will interrogate carrier, land based or airborne beacon equipment. Beacon ranges of 100, 25, 5 and 1 nautical miles are provided.

HOW THE AN/APS-6 OPERATES

Power is supplied by the aircraft's 24-volt D. C. supply and its 115-volt, 800-cycle A. C. generator to the Rectifier Power Unit of the equipment.

An electronic timing circuit in the Receiver-Amplifier Unit and an amplifying circuit in the Modulator Unit transforms this electrical current into high voltage pulses. These high voltage pulses are in turn fed into a transmitter located in the wing-tip nacelle. The transmitter generates high frequency waves which are fed to the antenna.

This set exhibits several important features:

- a. It acts both as a transmitting and receiving set, and includes "time-measuring" circuits to measure the elapsed time the radio waves require to travel to a target and return.
- b. The high frequency waves which it transmits are sent in definite and controllable directions.
- c. The character of the transmission may be varied to perform a number of different functions.

When the equipment is searching, the radio frequency waves are confined within a 120 degree conical area, the center of which is the flight axis of the aircraft. This cone of high frequency waves is formed by a narrow high frequency beam which spirals outward in front of the aircraft.

When these waves encounter any object within the range on which the equipment is operated, they are reflected back and are picked up by the antenna and

coupled to the receiving apparatus. Then they are passed through another series of electronic tubes, detected and registered on the cathode-ray indicator screen in front of the pilot. The position and character of these indications show the range, azimuth, elevation and, in some cases, the character of the enemy target.

Because these high frequency waves travel in a straight line and at a known speed, the *elapsed time* it takes for a reflected signal to return is proportional to the *distance* of the target, while the direction the antenna is pointing determines the *angular position* of the target.

These reflected waves produce bright areas on the indicator screen. Their form and interpretation will depend upon how the various control switches are set. Complete information regarding how to interpret these signals will be supplied on pages 14 to 16.

When operated for Gun Aim (gun sighting) the indications are seen by the pilot in a manner similar to the appearance of an enemy craft in a gunsight. From these indications, the pilot may *aim* at the enemy and *fire his guns* when at proper firing range.

A viewing visor is provided for use when needed, and a filter is built into the equipment to make viewing easier on the pilot's eyes.

The AN/APS-6 equipment will operate efficiently at altitudes up to 30,000 feet, in ambient temperatures from -30° to +50° Centigrade, and under humidity conditions up to 95 percent.

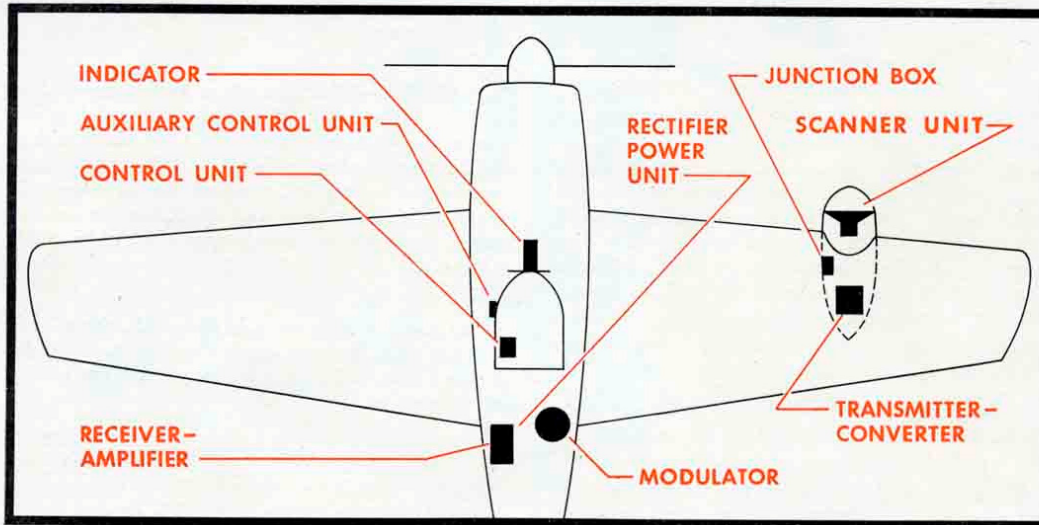


Figure 3—Location of Component Parts in a Typical Installation

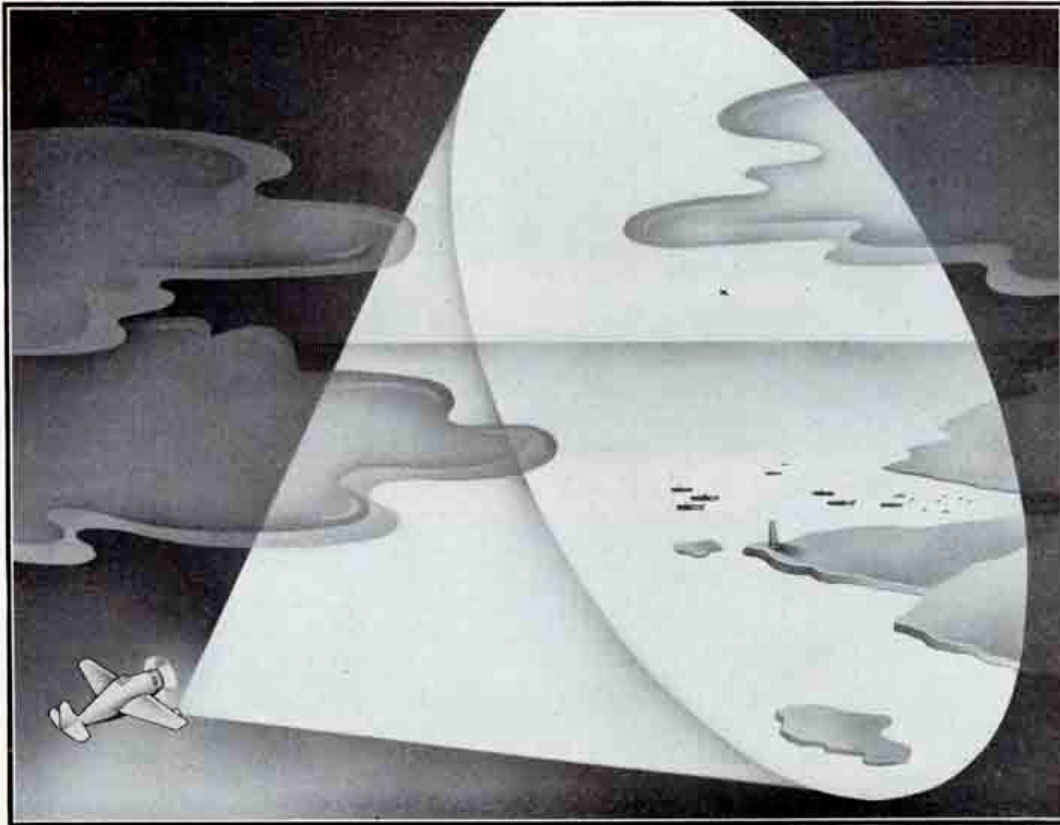


Figure 4—How Radar AN/APS-6 Sweeps the Area in Front of the Pilot

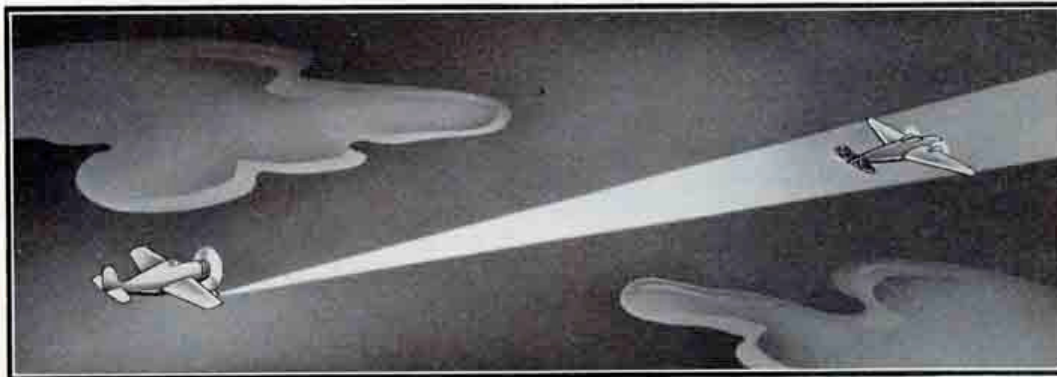


Figure 5—15° Gun Aim Scan

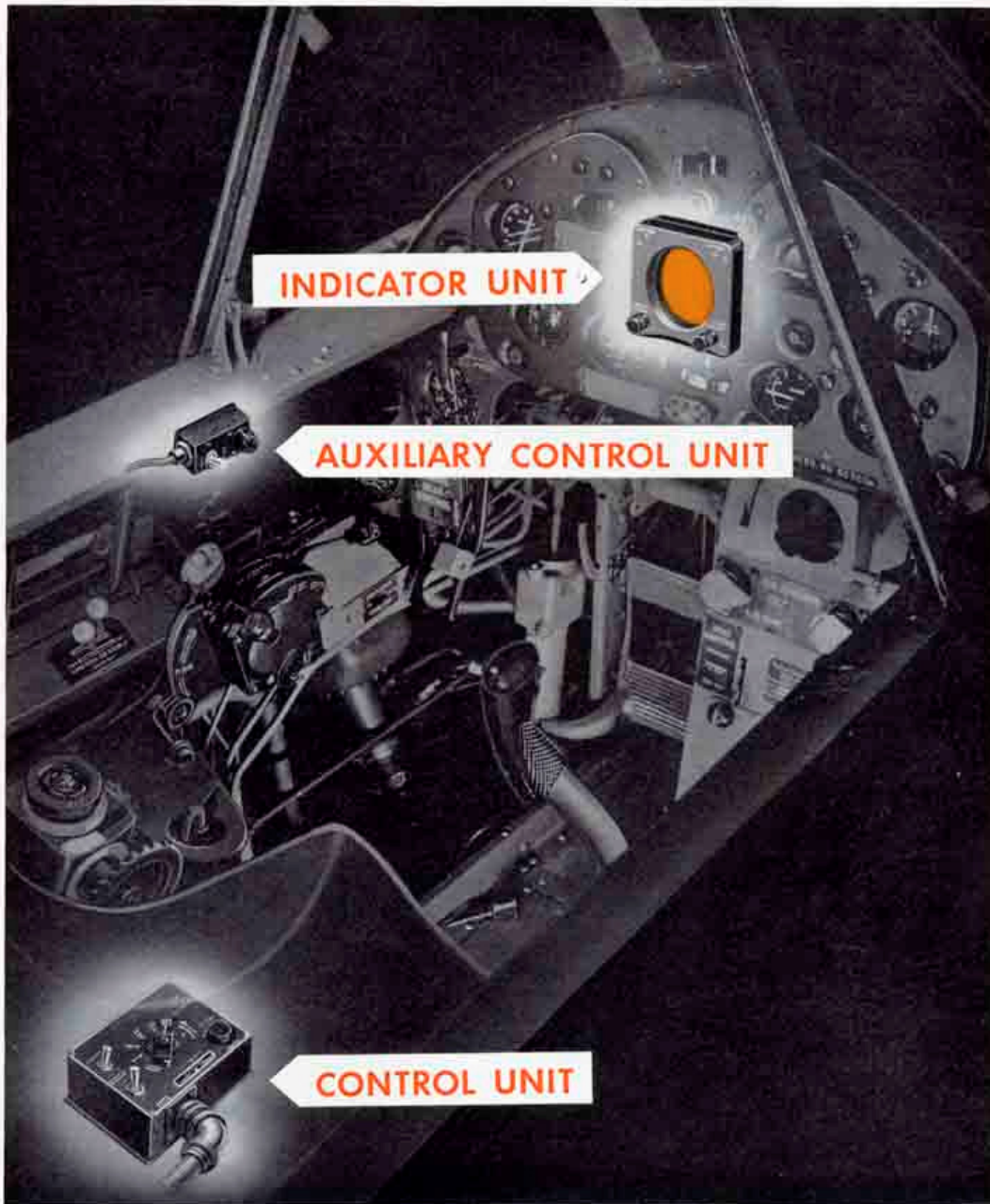


Figure 6—Location of Radar Operating Controls

OPERATING CONTROLS OF RADAR AN/APS-6

Three sets of controls may be used by the pilot to operate Radar Equipment AN/APS-6. These are located on:

1. The Control Unit—to the left of the pilot's seat.
2. The Auxiliary Control Unit—above the throttle.
3. The Indicator Unit—in the instrument panel of the plane.

1. THE CONTROL UNIT

The Master Switch on this unit controls the range and type of operation of the equipment until the Gun Aim Switch (at right) is thrown. It also contains the controls which turn the equipment on and off. The Radar-Beacon Switch determines whether the set is to operate in its "search" or "beacon" function. The Operate-Standby Switch turns the transmitting components OFF and ON. It is used in stopping and starting the equipment, a subject which will be treated more fully on Pages 10 and 11. The Receiver Gain and Manual-Automatic Tuning switches will also be explained in connection with Operating Adjustments (See Pages 17 to 18).

2. AUXILIARY CONTROL UNIT

This unit is located so that the Search-Gun Aim Switch may be operated by the pilot's thumb without removing his hand from the throttle. The function of the Sea-Suppress Control will be explained on Page 16.

3. INDICATOR UNIT

This unit contains the cathode-ray target indicator screen. The use of the two knobs, Signal Level and Wing Calibration, will be explained in connection with Operating Adjustments (See Pages 17 and 18).



Figure 7—Control Unit



Figure 8—Auxiliary Control Unit



Figure 9—Indicator Unit

HOW TO START AND TURN OFF RADAR AN/APS-6

1. HOW TO START THE EQUIPMENT

It is extremely important that the starting procedure given here be followed literally when starting this equipment. The AN/APS-6 is a sensitive, precision-built equipment. Hence, careless handling may quite

easily cause serious damage and make this equipment useless at a time when the pilot needs it most. Before any action is taken toward starting the equipment, the pilot should be sure that controls are set in the following manner:

CONTROL UNIT

- Master Range Switch—OFF.
- Radar-Beacon Switch to Radar.
- Tuning Control to AUTOMATIC.
- Receiver Gain at CENTER.



Figure 10—How Control Unit Should be Set Before Starting Equipment

AUXILIARY CONTROL UNIT

- Search-Gun Aim Switch to GUN-AIM (This places less starting load on the aircraft's electrical circuits).
- Sea-Suppression Control to MINIMUM (full counterclockwise).

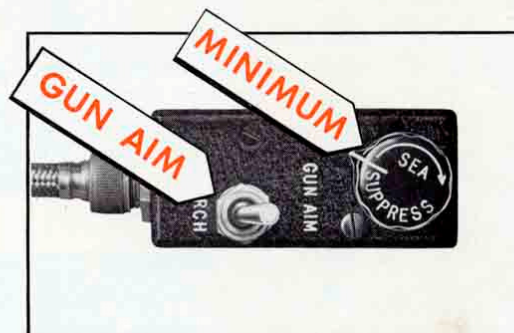
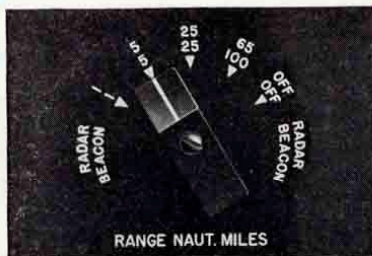


Figure 11—How Auxiliary Control Unit Should be Set Before Starting Equipment

1. STARTING SEQUENCE

FIRST



Turn Master Range Switch on Control Unit to 1- or 5-mile range.

Figure 12—How Master Switch Should be Turned to Start Equipment

WAIT THREE MINUTES!

SECOND

Operating the operate-standby switch applies 15,000-volts to a small tube in the Modulator Unit of this apparatus. This tube is certain to be damaged unless time is allowed for it to warm up before the 15,000-volts is applied. If this happens, the equipment is worthless until this tube is replaced.

If for any reason this warming-up period is interrupted, allow the full three minutes when operation is resumed. This particular vital tube heats up slowly but cools quickly. For example, two periods of two minutes each, with only a momentary break between, will not be sufficient. A full *uninterrupted* three minutes must be allowed at this point in the starting procedure.

THIRD

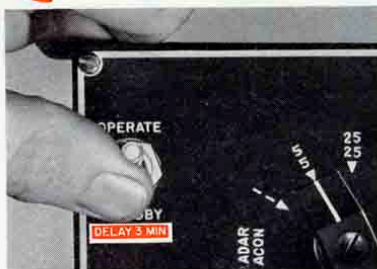


Figure 13—Operate-Standby Switch

Push the Operate-Standby Switch on Control Unit to OPERATE. Hold for two seconds. Release the switch and it will return to its center position. Set the Gun-Aim-Search Switch to SEARCH. The equipment is now in operation and signals should begin to appear on the screen.

2. STANDBY OPERATION

Push the Operate-Standby Switch to STANDBY, hold two seconds, and release. The equipment is now in standby condition, with the Modulator and Transmitter turned off. It may be started by pushing the Operate-Standby switch to OPERATE.

NOTE: If any operating peculiarities have been observed, notify maintenance personnel.

3. HOW TO TURN OFF EQUIPMENT

- Set Search-Gun Aim Switch to GUN AIM.
- Set Radar-Beacon Switch to RADAR.
- Push Operate-Standby Switch to STANDBY and release.
- Turn Master Range Switch to OFF position.
- If Tuning Control has been adjusted, return to AUTOMATIC.

INTERPRETATION OF PATTERNS ON INDICATOR SCREENS

The AN/APS-6 provides for five distinct operating ranges. They are:

- 65-mile Search Range.
- 25-mile Search Range.
- 5-mile Search Range.
- 1-mile Search Range.
- Gun Aim Range (1,000 yards) with markers at Firing Range (250 yards)

In addition, four Beacon Ranges are provided, 100-mile, 25-mile, 5-mile and 1-mile.

Each of these ranges and operating conditions produces its own patterns on the screen and the observer must interpret these patterns correctly in order to use the equipment properly.

1. SEARCH FUNCTION

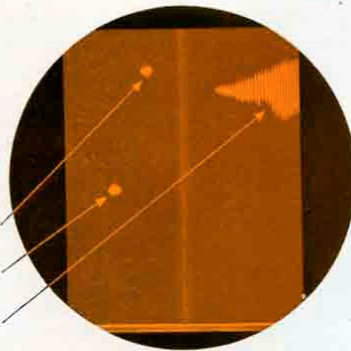
In the search pattern the position of the aircraft is at the bottom center of the screen. The relative azimuth angle between the plane's course and the target is shown by the right or left position of the indications on the screen in relation to the vertical centerline of the screen.

When operating in the 65-mile or 25-mile ranges, detected targets appear as bright dots on the indicator screen. Large masses, such as islands, mainland and signals reflected from the near-by surface of the sea are visible as larger bright filled-in areas. As the distance to the target decreases, the signal on the indicator screen will gradually move downward.

65-MILE RANGE

Figure 14—65-Mile Range

Convoy, 60 miles, -20° azimuth
Island, 20 miles, -40° azimuth
Coast, 50 miles, +10° azimuth



25-MILE RANGE

Figure 16—25-Mile Range

Center of Convoy, 20 miles, -10° azimuth
Island, 15 miles, +40° azimuth

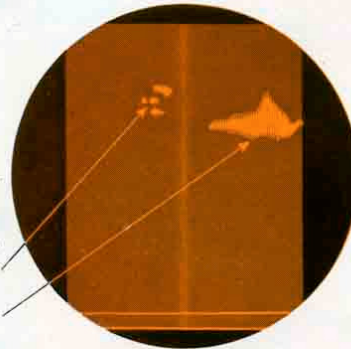


Figure 15—65-Mile Range

Convoy, 20 miles, -30° azimuth
Island, 15 miles, +20° azimuth

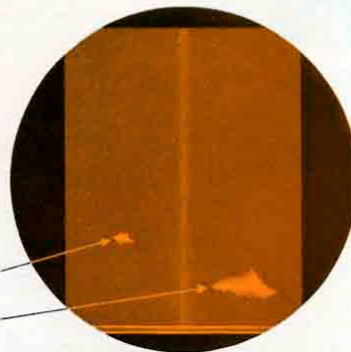
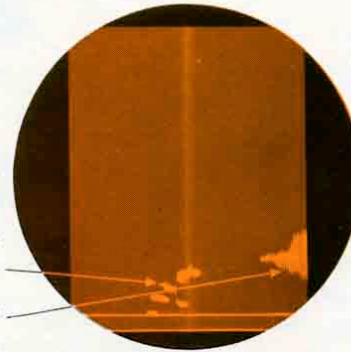


Figure 17—25-Mile Range

Center of Convoy, 3 miles, -10° azimuth
Island, 8 miles, +60° azimuth



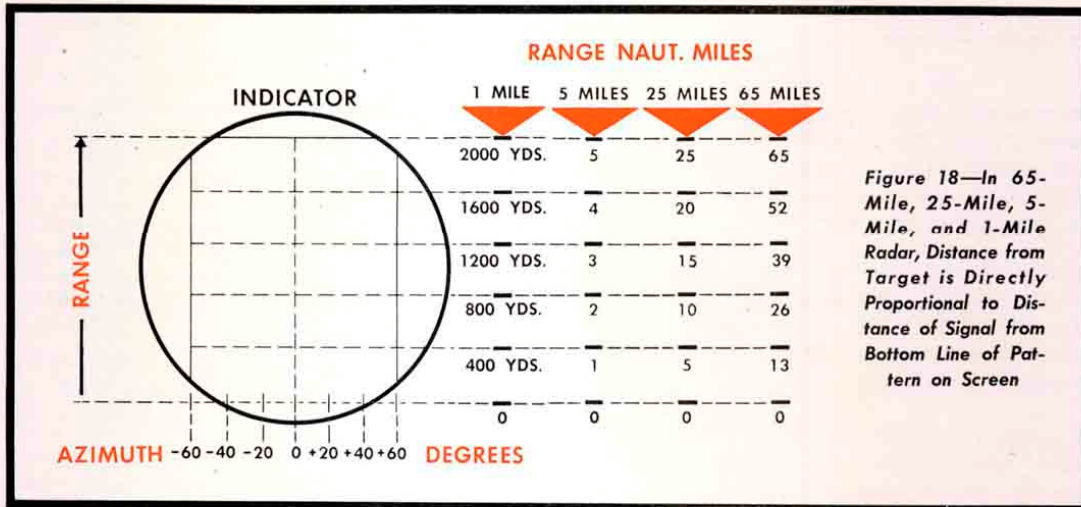


Figure 18—In 65-Mile, 25-Mile, 5-Mile, and 1-Mile Radar, Distance from Target is Directly Proportional to Distance of Signal from Bottom Line of Pattern on Screen

CAUTION!

It should always be kept in mind that the pattern on the screen is not a scale map of the surface of the field of view. The horizontal distances on the screen are distorted, and this distance may only be used to represent the relative azimuth angle. It does *not* represent horizontal distance on the water. Likewise, range is measured as a straight line from the plane to the target. Elevation information does not appear on the indicator in the 65-mile or 25-mile range.

As soon as possible, the pilot should switch from the 65-mile position, if he happens to be operating in that range, to the 25-mile position, then to the 5-mile and 1-mile range. The 65-mile range should only be used to locate large objects at long ranges. The system should not be operated in this range unnecessarily, as there is always the danger of triggering the beacon equipment on a carrier or at a land base.

The elevation information presented in the 5-mile and 1-mile Radar range is relative information with respect to the axis of the plane (See Fig. 19). Fig. 20 shows how the two dots appear when plane being approached is below Radar plane's axis.

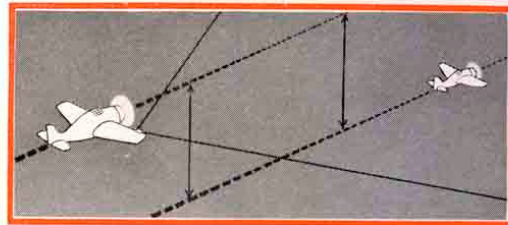


Figure 19—Elevation Diagram

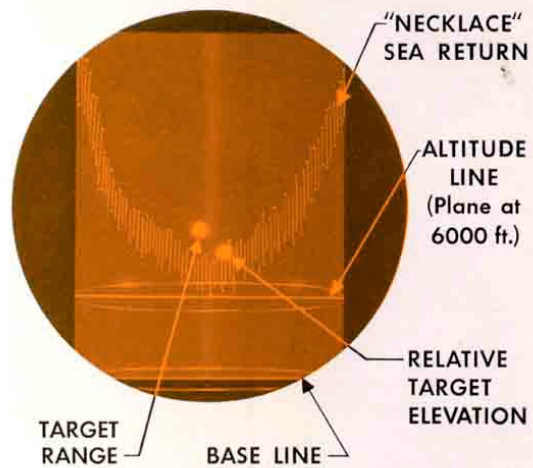


Figure 20—Interpretation of Typical 5-Mile Pattern (1-Mile Range is Interpreted Similarly)

5-MILE RANGE

As soon as the plane gets to within five miles of the target (See Fig. 20) the pilot should switch to the 5-mile range. Then the target he has selected will appear as two dots on the screen, separated horizontally, about 3 millimeters apart (See Fig. 21).

The azimuth position of the target is indicated by the position of a theoretical centerline between the two dots. The range to the target is represented by the distance from the bottom of the screen to the left-hand dot. (See Fig. 18).

If target is above the flight axis of the plane, the right-hand dot will be higher on the screen than the left-hand dot, and viceversa.

When the plane is headed (in elevation) directly

toward the target, the dots will appear on a horizontal line.

HEADING TOWARDS THE TARGET

When a target has been selected, the plane should be turned until the theoretical centerline between the dots is on the centerline of the screen. This will indicate that the plane is headed (in azimuth) towards the target. (See Fig. 22).

The plane should then be flown up or down until the two dots are in a horizontal plane. This will indicate that the plane is headed (in elevation) toward the target. (See Fig. 23).

The two dots will gradually approach the base line of the indicator as the plane nears the target. (See Fig. 24).

Figure 21—Target Below. Radar Signal, 3½ miles, -40° azimuth, on 5-Mile Range

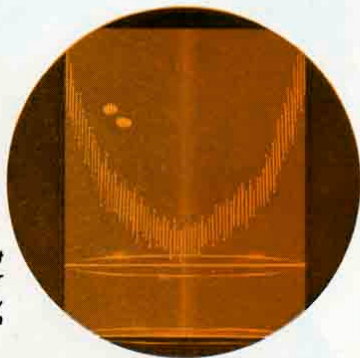


Figure 23—Target Same Elevation. Radar Signal, 3 miles, 0° azimuth, on 5-Mile Range

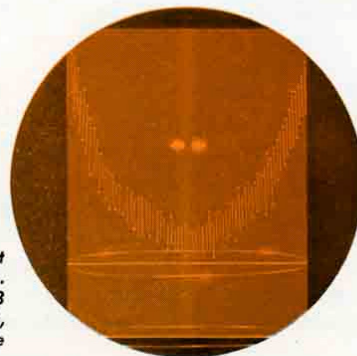


Figure 22—Target Below. Radar Signal, 3½ miles, 0° azimuth, on 5-Mile Range

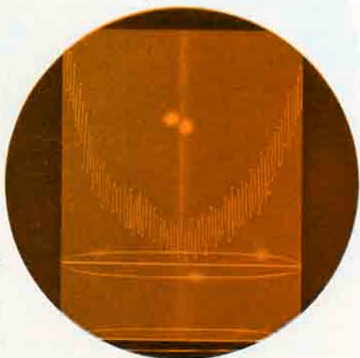
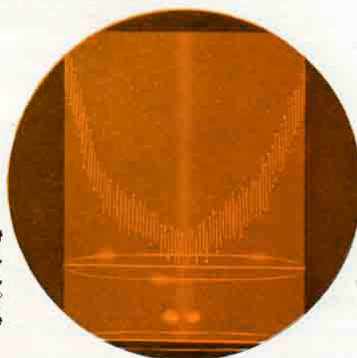


Figure 24—Target Same Elevation. Radar Signal, 1,000 yards, 0° azimuth, on 5-Mile Range



2. GUN-AIM FUNCTION

When the pursuing plane is within one-half a nautical mile of the target, the pilot should throw the switch on the Auxiliary Control Unit from SEARCH to GUN-AIM.

If the target was properly centered in the "Search" operation, the target will appear on the screen as a dot with a small pair of wings, and will seem to jump around, much like an enemy plane in a gunsight. (See Figs. 26 and 27).

If only a stationary dot appears in the center, the target is not in the field of vision and the pilot should return to the 5-Mile or 1-Mile Search to re-locate the target and again head the plane for it.

As the plane continues to overtake the target (on Gun-Aim), wings will grow out of the target spot. The plane should be turned until target is centered on screen. Two parallel lines are etched on the indicator screen. (See Fig. 24). When the wings have grown until they just reach these lines, the plane is at the firing range (250 yards). (See Fig. 29). Do not approach within 150 yards of the target, otherwise the target will disappear from the screen because it will be closer than the minimum range of the equipment.

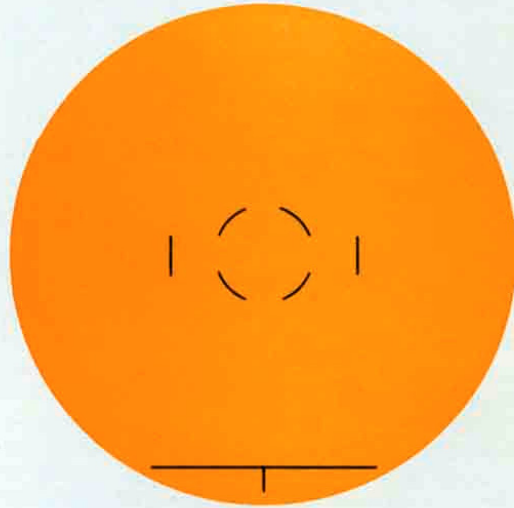


Figure 25—Engraving on Indicator Screen

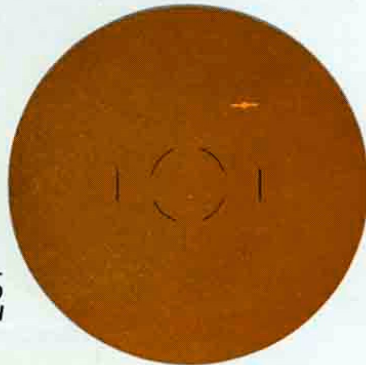


Figure 26—Target, Approx. 800 Yards, Above and to Right

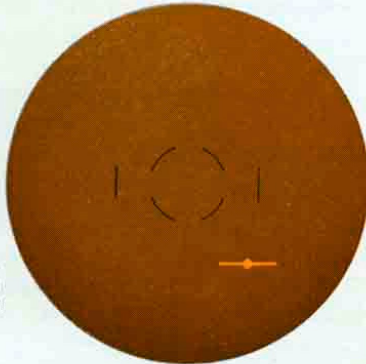


Figure 27—Target, Approx. 600 Yards, Below and to Right

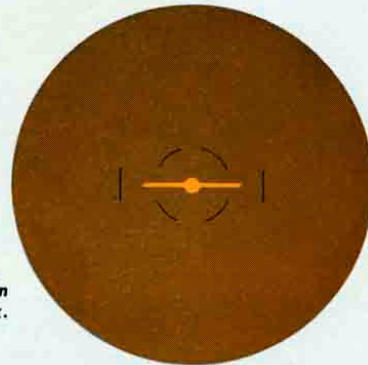


Figure 28—On Target, Approx. 320 Yards

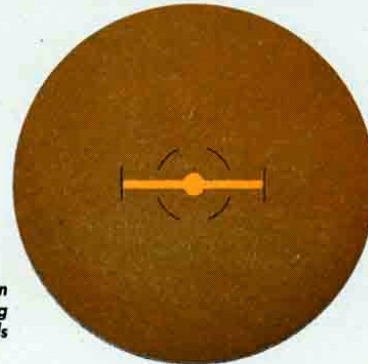


Figure 29—On Target, At Firing Range, 250 Yards

3. BEACON FUNCTION

When pilot is ready to return to his carrier, or locate other Beacons, he should throw the Radar-Beacon Switch on the Control Unit from RADAR to BEACON. On AN/APS-6 Equipments, both Manual and Automatic beacon tuning are available, but on AN/APS-6A Equipments, Manual Tuning must be used. Adjust the TUNING Control to the center of the MANUAL range, and retune for maximum signal when a beacon signal is received. With the Master Control Switch, he should select the Beacon Range which he estimates is necessary to reach the mother ship, a land base or airborne beacon.

The transmitter will now transmit waves which will trigger all Radar Beacon equipment within range. The Beacon will transmit a coded signal and it will appear on the indicator screen as coded series of dashes. When the correct coded pattern appears, the pilot can identify the beacon, and can determine its range and direction in azimuth. Beacon range is read from the signal nearest the bottom of the screen on all ranges.

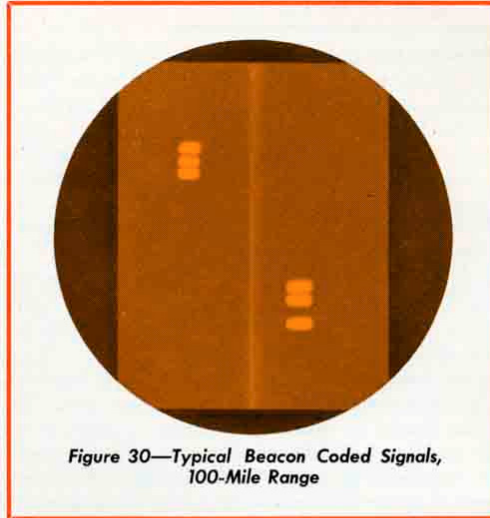


Figure 30—Typical Beacon Coded Signals, 100-Mile Range

OPERATING ADJUSTMENTS

1. SEA-SUPPRESS CONTROL

Reflections from the surface of the sea often come back so strongly that they confuse the signal from the selected target. These signals cause a luminous mass of dots to appear on the bottom and sides of the screen. (See Fig. 31). They can be eliminated by advancing the "Sea-Suppress Control" on the Auxiliary Control Unit.

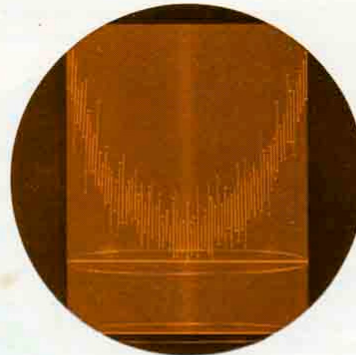


Figure 31—Sea Return Signals

CAUTION

This control acts as though it pulls a curtain across the bottom of the screen. Therefore, great care should be exercised in advancing it. There is always the danger that, while eliminating sea "echo" signals, possible signals from surface vessels and aircraft may be also eliminated. Hence, this control should be advanced no farther than is absolutely necessary to eliminate confusion, and should be returned to its off position as soon as possible.



Figure 32—Sea Suppress Control

2. RECEIVER GAIN CONTROL

The Receiver Gain Control on the Control Unit has two principal uses:

- a. By turning the knob clockwise, weak signals on the screen are made stronger and more visible.
- b. When static noise appears (visible as many tiny dots of light over the entire screen face), it can be reduced by turning the knob slightly counterclockwise.

This control should be so adjusted that it brings in the signal clearly without amplifying static indications. When this point is reached, the screen is usually faintly luminous.

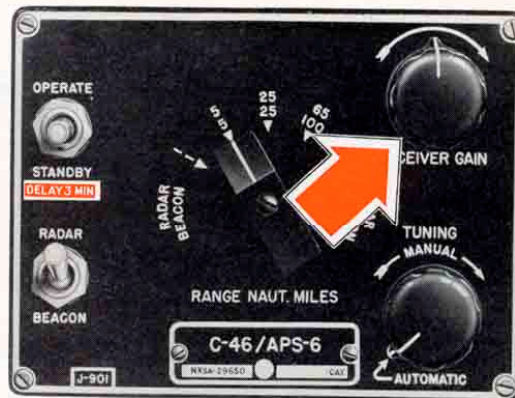


Figure 33—Receiver Gain Control

3. SIGNAL LEVEL CONTROL

If the signal echoes from large nearby targets are so bright as to make it difficult to see the signal of the selected target, the Signal Level Control on the Indicator Unit should be retarded slightly until a workable balance is obtained. The Signal Level Control should be maintained as far advanced as possible. Normally it is not touched during flight.



Figure 34—Signal Level Control

4. TUNING CONTROL

Should no return signals be detected after making the foregoing adjustments, or should the returned signals appear and then disappear in cycles of short duration, advance the "Tuning Control" on the Control Unit until it is out of the AUTOMATIC position. Then tune manually, slowly over the range, setting this control for the best reception of signals, much as an ordinary radio is tuned.

Should this manual tuning fail to produce results, turn off the apparatus immediately. Inform maintenance personnel.

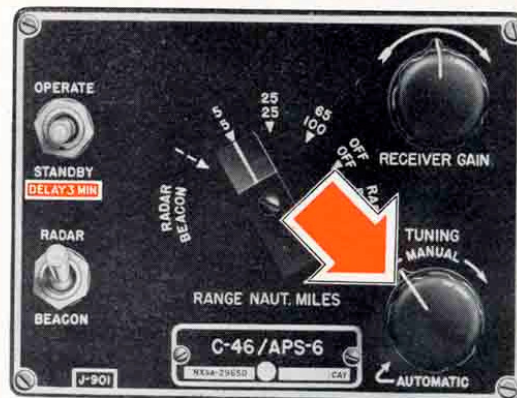


Figure 35—Tuning Control

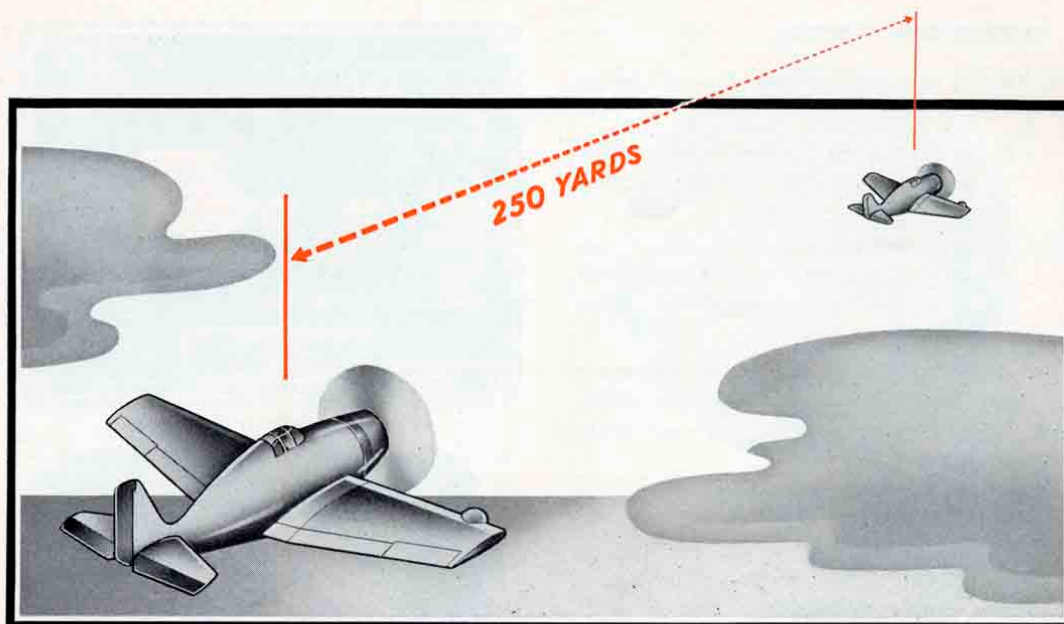


Figure 36—Calibration of Gun Aim Wing with Aid of Friendly Plane

5. WING CALIBRATION

This adjustment should be made by each pilot to establish accurately the firing point. This is done by flying 250 yards (or the range for which the aircraft's guns are bore-sighted) behind a friendly ship, determining the distance by the optical gun sight.

While in this position, slowly adjust the Wing Calibrate knob on the indicator until the wings on the target spot just meet the markers on the screen. This knob must be pulled out to engage the related control gears. Upon release, it will spring back to the "dis-engaged" or safety position.

This adjustment should be repeated at intervals necessary to maintain the required accuracy.



Figure 37—Wing Calibration Control

SPECIAL CAUTION

Should the pilot observe any unusual vibration being set up by the Radar antenna, he should turn this equipment off immediately.