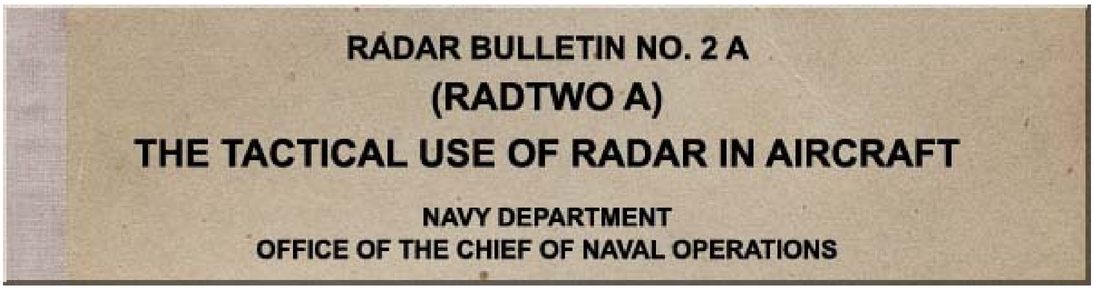

RADAR BULLETIN NO. 2 A

(RADTWO A)

THE TACTICAL USE OF RADAR IN AIRCRAFT

NAVY DEPARTMENT

OFFICE OF THE CHIEF OF NAVAL OPERATIONS

PART TWO
RADAR SYSTEMS

PRINCIPLES OF OPERATION OF THE RADAR SYSTEM

AN/APS-3

I. FUNCTION

A. PRIMARY PURPOSE. AN/APS-3 is an X-band air-borne radar employed primarily for search in medium patrol aircraft.

B. SECONDARY USES. This equipment can be used for radar navigation, homing on radar beacons (AN/CPN-6) and for radar bombing. When employed in conjunction with other suitable identification equipment it can be used to display IFF signals. (See Part IV, page 113.)

II. DESCRIPTION

A. MAIN COMPONENTS. AN/APS-3 consists of the following major units:

1. Antenna unit.
2. Transmitter-converter (r-f head).
3. Modulator unit.
4. Receiver amplifier.
5. Rectifier unit. 0. Control unit.
6. Azimuth calibrator.
7. Repeater indicator.
8. Connector cables, viewing hoods, and dummy indicator,

R-F head.-- The inclusion of the radio-frequency head in the AN/APS-3 design overcomes one of the main drawbacks to efficient operation so pronounced in the earlier ASD version of the equipment.

In the ASD (for purposes of comparison) the generated pulses were fed from the modulator to I he antenna through a long, complicated wave guide which both from a mechanical and electrical standpoint was inefficient. As a result, the effective power was attenuated before reaching the antenna.

In the AN/APS-3, part of the transmitter and receiver circuits are moved up to the r-f head, which is located close to the antenna. The transmitted pulses pass through a short wave guide direct to the antenna with no appreciable attenuation. Received echoes likewise pass through the short wave guide to the preamplifier located in the r-f head, where they are demodulated before being passed to the remainder of the equipment through flexible coaxial cables; thus, the long, inefficient wave guide is eliminated.

B. ANTENNA SCAN AND SCOPE PRESENTATION. 1. *Beam coverage*.--The antenna unit consists of a parabolic reflector and antenna feed assembly connected to a motor-driven gear box so that the antenna and parabola are mechanically and electrically caused to sweep an arc of 160° ahead of the aircraft at a repetition rate of about 35 cycles per minute. The parabola nods over an arc of 2° from the horizontal during the sweep.

The antenna-parabola assembly projects the r-f pulses in a conical beam of approximately 5°.

As the antenna sweeps the r-f beam through its 160° of arc (80° either side of center), a nodding action is imparted to the parabola at the completion of each sweep, resulting in a nod downward of 2°, a sweep of 160°, a nod upward of 2°, the return sweep, etc. Although the azimuth sweep angle is 160°, only 150° of this angle is calibrated, as 5° are used at each end of the sweep for the nodding action.

2. *Type of scan*.--Two scopes are provided; one is the main scope for the operator's use, the other, the auxiliary scope for pilot or navigator use. Both scopes are of the B-scan type. (When either scope is removed from the installation, it must be replaced by the dummy

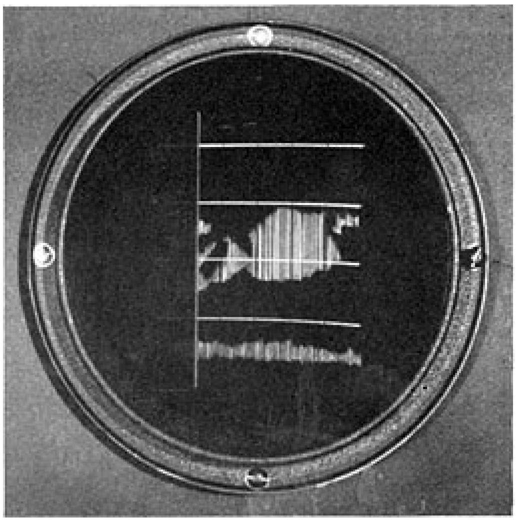

Figure 2-48.--In APS-3 the side-to-side motion of the trace produces a rectangular scope display on the circular scope face.

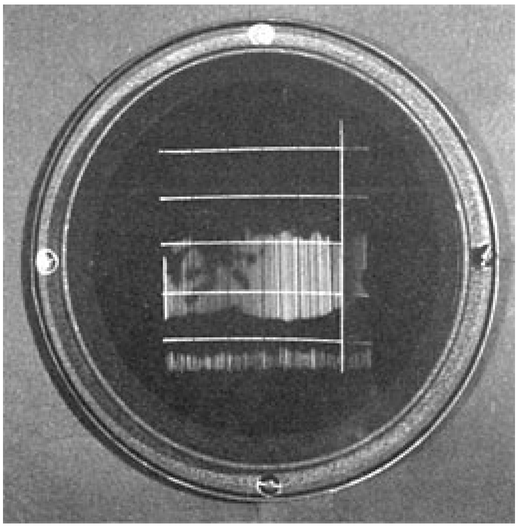

Figure 2-49.--Variations in the brilliance of the laterally moving trace activates the fluorescent coating of the cathode-ray tube indicator producing the target patterns. Above is shown a typical landmass pattern as it appears when the equipment is set to the 10-mile range.

indicator so as not to disturb circuit characteristics.)

The effective 150° of lateral scan of the antenna assembly is translated on the scope into a lateral motion of a vertical trace which moves from side to side in step with the antenna motion, to cover a rectangular area on the scope face. See figue 2-48. The conversion of an angular antenna scan into a rectangular scope display introduces certain disadvantages due to distortion effects (see B-scan distortion, figs. 2-9, 2-10, 2-11, and 2-12), but the advantages of spreading the display of targets close in far outweighs the inherent distortion disadvantages.

Reception of target echoes causes the moving trace to brighten momentarily in its lateral sweep. The bright spots on the trace appear on the scope screen at a range and azimuth corresponding to the target's range and bearing from the searching aircraft. Because of the persistence of the fluorescent coating of the scope screen, target echoes displayed on the scope remain visible for a short period of time after the trace has swept by. Each succeeding trace sweep renews the target echo brilliance. Single ship or aircraft targets are displayed as small spots of light. Land masses, islands, coast lines, etc., show up as relatively large patches of light. See figure 2-49.

3. *Range settings*.--At the control unit, when the beacon-search switch is set for search operation, the equipment can be used on four ranges of 4, 10, 40, and 80 nautical miles. When set for beacon operation, the ranges are 4, 10, 40, and 120 nautical miles.

As the trace moves from side to side on the rectangular screen, bright spots appearing at graduated intervals along the trace leave a trail behind them to form range markers. These range markers assist in judging the approximate range of target echoes. See figure 2-50.

Range (miles)	Number of range markers	Range mark intervals (miles)
4	3	½
10	5	2
40	4	10
80	4	20
120*	6	20

*Beacon only.

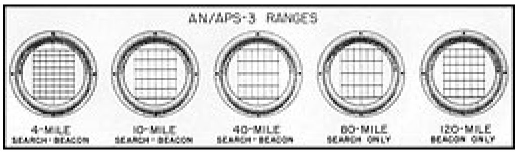

Figure 2-50.--The horizontal lines on the scope patterns shown here are brilliant lines of light
which enable the operator to judge target range.

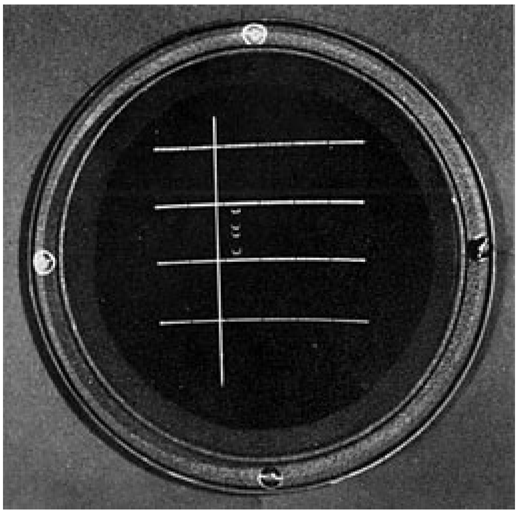
Figure 2-51.--A typical beacon signal appearing on the 40-mile range of the APS-3.

4. *Bearing*.--To indicate bearing, the rectangular screen is covered with a plastic scale containing seven scribed vert ical lines. These lines divide the 150° screen into three 25 sections either side of zero degrees at the vertical center. The zero-degree line represents the ail-craft's heading.

C. SPECIAL FEATURES. A number of special design features contribute to the flexibility of use of AN/APS-3. With the exception of one--the azimuth calibrator--all these special features are controlled from the panel of the control unit. They are:

1. Antenna tilt.
2. Beacon reception.
3. Expanded sweep (with electronic lubber line and azimuth calibrator).
4. Phantom target.

1. *Antenna tilt*.--By means of a toggle switch control located on the control unit panel, the beam from the antenna can be tilted through a vertical range 8° above and 8° below the longitudinal axis of the aircraft. Degree of tilt is indicated on the control unit tilt meter. Tilt control enables the beam, with its 2° nod, to cover an area 24° in the vertical plane.

2. *Beacon reception*.--Controls are provided (beacon-search switch and manual timing) which permit the equipment to be retimed to the X-band radar beacons for reception of radar beacon signals. When the. equipment is switched from search to beacon operation, the manual timing control must be employed to retune the receiver away from the radar's pulse-and-echo frequency to the frequency of the radar beacon (AN/CPN-6). When this is done, radar target echoes do not appear on the scope screen. Only radar beacon signals from beacon stations within range are displayed. See figure 2-51.

3. *Expanded sweep*.--When the expanded sweep is employed, the scope presentation appears over the entire circular area of the scope screen instead of in the form of a rectangle. This operation "magnifies" or expands the center area of the scope so that only the central 60° portion of the rectangular pattern is displayed.

With the "expand"' feature being used, an electronic lubber line flashes on the screen each time the antenna scanner passes the dead-ahead position. See figure 2-52.

An azimuth calibrator control can be employed to shift the position of the electronic lubber line. When the electronic lubber line is aligned with a target echo, the dial of the azimuth calibrator will indicate the bearing of the

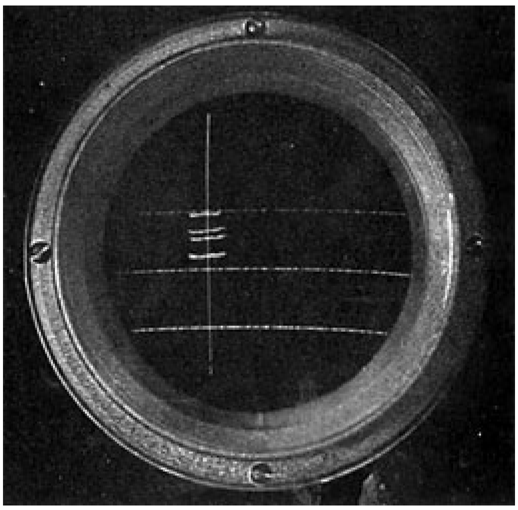

Figure 2-52.--Here the range-coded radar beacon signals appear on the expanded

sweep scope display.
Positioning of the electronic lubber line allows the relative bearing of the beacon to be accurately determined.

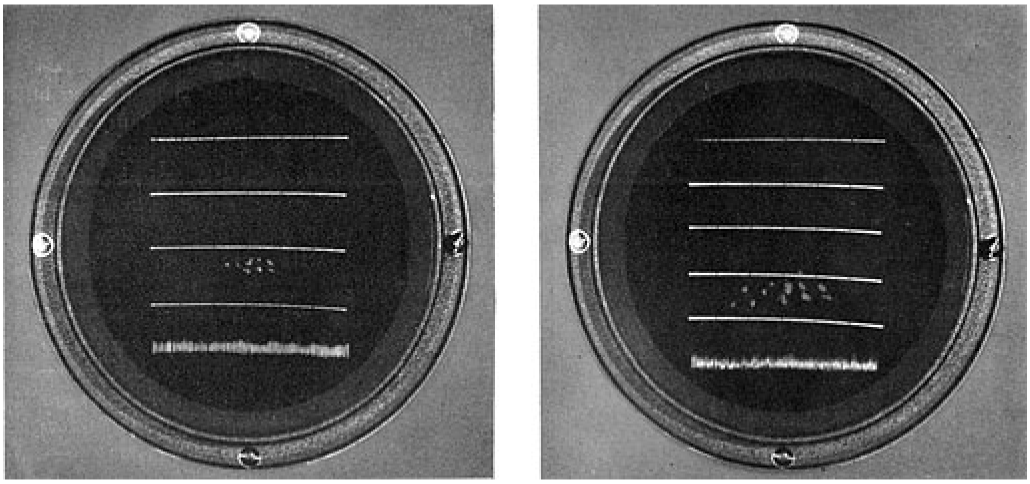

Figure 2-53.--At the left a convoy is shown at about 16 miles on the 40-mile range setting of the AN/APS-3.
At the right, the same convoy is shown when the range has closed to the 10-mile range is used.

target with respect to the heading of the aircraft.

III. TACTICAL EMPLOYMENT

A. SEARCH. When employing AN/APS-3, the prime consideration to be borne in mind is that the narrow 5° beam, like a searchlight, "illuminates" only those targets that fall within the path of the beam.

Whether or not the radar beam will strike a target depends upon:

1. The altitude of the search aircraft.
2. The range of the target.
3. The antenna tilt.

1. *Types of targets*.--Depending upon the character of the radar echo spots, the screen display can be interpreted to indicate land masses, islands, coast line, harbors, rivers, airports, and surface ships. Land is indicated on the screen as a relatively large bright patch of light. Coast lines and harbors appear distinctly outlined, but, because of the distortion effect inherent in the B-scan, the scope display of such targets is not a true replica of the actual coastal outline. Rivers and lakes show up as dark areas within the bright land mass patches.

Ships in convoy, at long ranges, produce target spots which appear on the scope as one large spot or as a group of indistinct spots closely bunched together. As the range is closed, however, and the shorter ranges of the equipment used, the group tends to break up into separate, distinct target spots. See figure 2-53.

At extremely close ranges, a single ship target echo will appear on the screen as a long, horizontal line of light, ragged in appearance.

2. *Altitude/range*.--With the aircraft in level flight, the antenna of AN APS-3 points to the horizon when the tilt meter indicates zero tilt. Depending upon the altitude, then, intermediate distances to the horizon can be covered only when the antenna is tilted downward, or when the altitude is reduced.

3. *Tilt control*.--Because of the comparative narrowness of the beam (5°), tilt control of the AN/APS-3 is critical. As a general rule, operation of AN/APS-3 requires that tilt control be employed almost continuously in order to insure adequate coverage of the area being searched. This is particularly true as the range settings are altered. For instance, for any given altitude, low angles of title will be required to search the area immediately ahead of the aircraft when the 4-mile range setting is employed; but if the equipment is set to any one

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of the higher range settings, the tilt must be moved upward in order that the radar beam may encompass the more distant areas.

Target definition can be improved in many cases if, after the target appears on the screen, the tilt control is employed to "aim"' the beam directly on the target area. Then, as the range is closed, successive adjustments of downward tilt are necessary in order to keep the target in the beam.

B. NAVIGATION. Because the AN/APS-3 scope screen presentation is maplike in character, radar navigation is relatively simple of accomplishment. Again, the only disturbing factor present is the distortion inherent in the rectangular presentation of a fan-shaped area.

1. *Drift determination mid homing on targets*.-- When either a radar target or beacon signal is homed on. dri ft will be apparent if the signal shifts from the central lubber line. The degree of drift can be determined by adjusting the flashing lubber line to bisect the target echo. Degree of drift is read from the dial of the azimuth calibrator.

To home on a selected target, the aircraft is maneuvered until the target appears on the centrally scribed (0°) lubber line. After a period of time, the aircraft's drift will be indicated by the movement of the target away from the zero-degree lubber line, and the course is corrected to compensate for the drift. This course correction will put the target echo on the opposite side of the lubber line from that at which it was observed at the time of drift determination. With the new heading maintained, the electronic lubber line can be set to bisect the new target position. As the aircraft is homed on the target, the echo will move down the electronic lubber line (parallel to the zero-degree line) as the range is closed.

Homing on one of many closely positioned targets is simplified by the use of the "expand" function of AN/APS-3. When this function is employed, the central 60° of the full 150° sweep is displayed over the entire circular area of the scope screen and, in effect, spreads apart or magnifies the target display.

2. *Homing: Beacon*.--When set for beacon operation, AN/APS-3 will display radar beacon signals from beacons located as far away as 120 miles. To receive radar beacon signals, however, the AN/APS-3 must be retuned to the beacon frequency and the aircraft pointed in the general direction of the known beacon stations. Also, to pick up beacon signals at 120 miles the altitude must be such that the beacon station will be within the aircraft's radar horizon.

Received beacon signals appear on the scope screen as a vertical series of short horizontal lines which are range coded. See figure 2-51. At the extreme ranges, the lines will tend to merge together but, as the range is closed, they will separate to show the range coding by wmich the radar beacon station is identified. Hominy on a radar beacon signal is similar to othei radar homing techniques.

C. BOMBING. Low-altitude bombing of radar targets presupposes the employment of a homing procedure such as that previously described. In this connection, deviations from the collision course must be watched for, particularly within the last mile.

When the expanded scan is used, the echo will broaden considerably and its center is the only reference point of value. Tilt and gain controls must be used constantly to get best target definition. With normal gain, the target will leave a slight "tail," in appearance much like a comet's tail, as it moves down the screen. This can be used in determining a collision course, since the tail must be parallel to the zero line if target bearing remains unchanged.
