CHAPTER 2 — RADAR OPERATION

RELATIVE AND TRUE MOTION DISPLAYS

GENERAL

There are two basic displays used to portray target position and motion on the PPI's of navigational radars. The relative motion display portrays the motion of a target relative to the motion of the observing ship. The true motion display portrays the actual or true motions of the target and the observing ship.

Depending upon the type of PPI display used, navigational radars are classified as either relative motion or true motion radars. However, true motion radars can be operated with a relative motion display. In fact, radars classified as true motion radars must be operated in their relative motion mode at the longer range scale settings. Some radars classified as relative motion radars are fitted with special adapters enabling operation with a true motion display. These radars do not have certain features normally associated with true motion radars, such as high persistence CRT screens.

RELATIVE MOTION RADAR

Through continuous display of target pips at their measured ranges and bearings from a fixed position of own ship on the PPI, relative motion radar displays the motion of a target relative to the motion of the observing (own) ship. With own ship and the target in motion, the successive pips of the target do not indicate the actual or true movement of the target. A graphical solution is required in order to determine the rate and direction of the actual movement of the target.

If own ship is in motion, the pips of fixed objects, such as landmasses, move on the PPI at a rate equal to and in a direction opposite to the motion of own ship. If own ship is stopped or motionless, target pips move on the PPI in accordance with their true motion.

Orientations of Relative Motion Display

There are two basic orientations used for the display of relative motion on PPI's. In the HEADING-UPWARD display, the target pips are painted at their measured distances in direction *relative* to own ship's heading. In the NORTH-UPWARD display, target pips are painted at their measured distances in true directions from own ship, north being upward or at the top of the PPI.

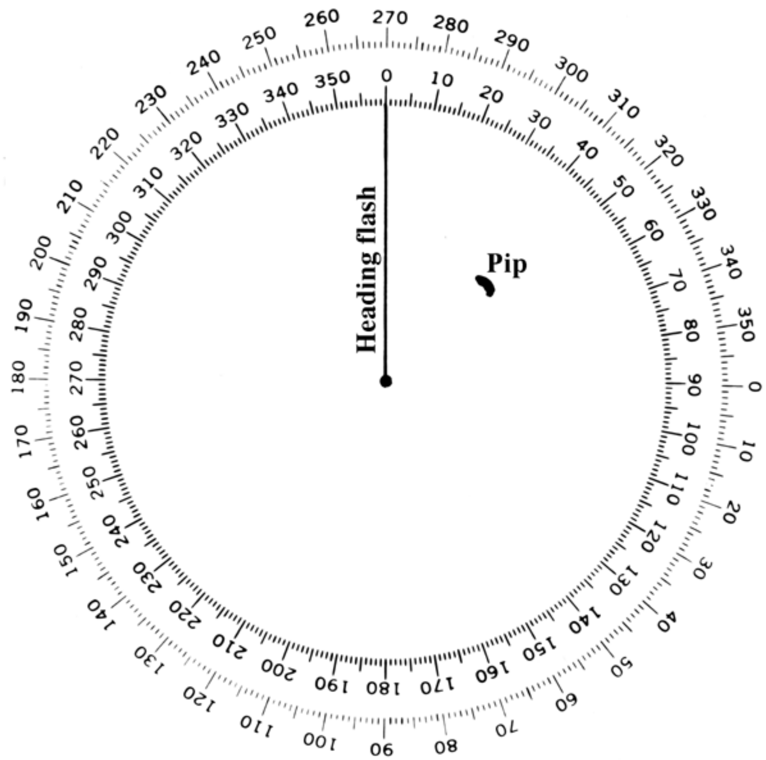


Figure 2.1 - Unstabilized Heading-Upward display.

In figure 2.1 own ship on a heading of 270˚ detects a target bearing 315˚ true. The target pip is painted 045˚ relative to ship's heading on this Heading-Upward display. In figure 2.2 the same target is painted at 315˚ true on a North-Upward display. While the target pip is painted 045˚ relative to the heading flash on each display, the Heading-Upward display provides a more immediate indication as to whether the target lies to port or starboard.

Stabilization

The North-Upward display in which the orientation of the display is fixed to an unchanging reference (north) is called a STABILIZED display. The Heading-Upward display in which the orientation changes with changes in own ship's heading is called an UNSTABILIZED display. Some radar indicator designs have displays which are both stabilized and Heading-Upward. In these displays, the cathode-ray tubes must be rotated as own ship changes heading in order to maintain ship's heading upward or at the top of the PPI.

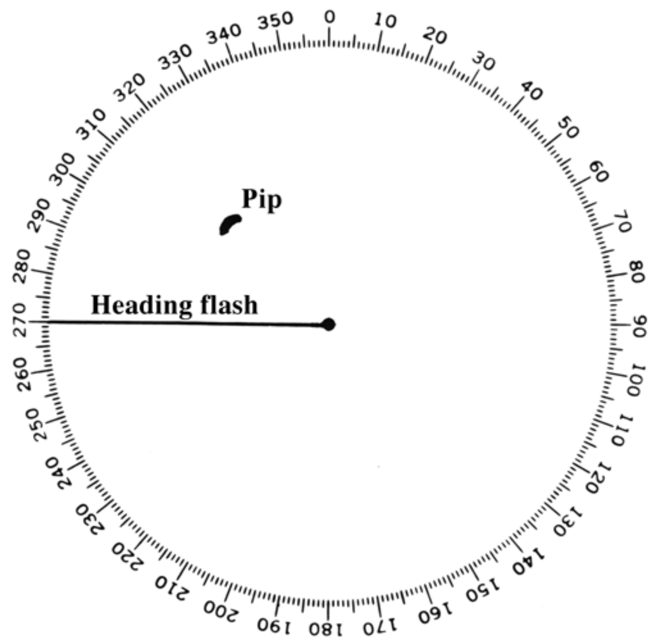


Figure 2.2 - Stabilized North-Upward display.

TRUE MOTION RADAR

True motion radar displays own ship and moving objects in their true motion. Unlike relative motion radar, own ship's position is not fixed on the PPI. Own ship and other moving objects move on the PPI in accordance with their true courses and speeds. Also unlike relative motion radar, fixed objects such as landmasses are stationary, or nearly so, on the PPI. Thus, one observes own ship and other ships moving with respect to landmasses.

True motion is displayed on modern indicators through the use of a microprocessor computing target true motion rather than depending on an extremely long persistence phosphor to leave "trails".

Stabilization

Usually, the true motion radar display is stabilized with North-Upward. With this stabilization, the display is similar to a plot on the navigational chart. On some models the display orientation is Heading-Upward. Because the true motion display must be stabilized to an unchanging reference, the cathode-ray tube must be rotated to place the heading at the top or upward.

Radarscope Persistence and Echo Trails

High persistence radarscopes are used to obtain maximum benefit from the true motion display. As the radar images of the targets are painted successively by the rotating sweep on the high persistence scope, the images continue to glow for a relatively longer period than the images on other scopes of lesser persistence. Depending upon the rates of movement, range scale, and degree of persistence, this afterglow may leave a visible echo trail or tail indicating the true motion of each target. If the afterglow of the moving sweep origin leaves a visible trail indicating the true motion of own ship, estimates of the true speeds of the radar targets can be made by comparing the lengths of their echo trails or tails with that of own ship. Because of the requirement for resetting own ship's position on the PPI, there is a practical limit to the degree of persistence (see figure 2.3).

Reset Requirements and Methods

Because own ship travels across the PPI, the position of own ship must be reset periodically. Depending upon design, own ship's position may be reset manually, automatically, or by manually overriding any automatic method. Usually, the design includes a signal (buzzer or indicator light) to warn the observer when resetting is required.

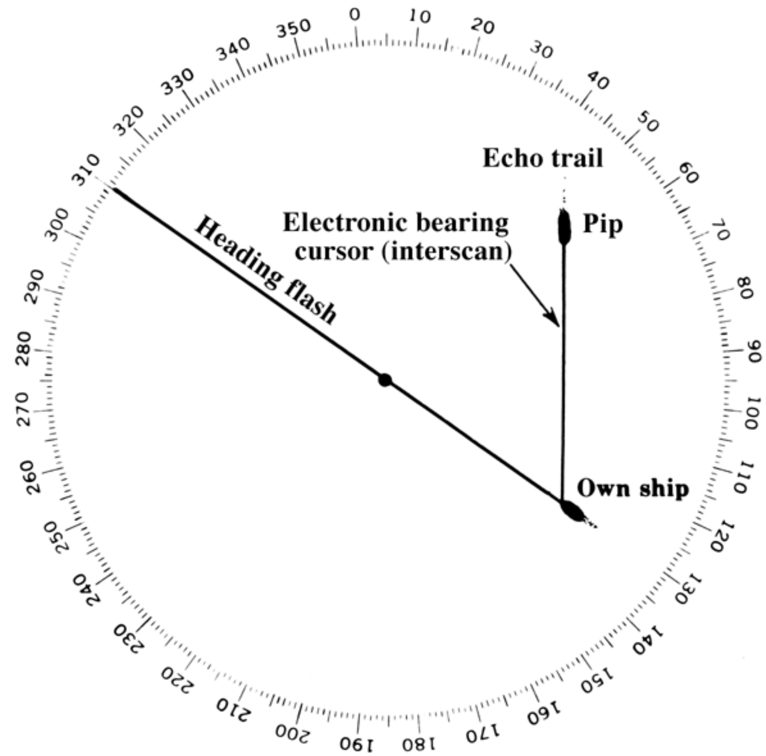


Figure 2.3 - True motion display.

A design may include North-South and East-West reset controls to enable the observer to place own ship's position at the most suitable place on the PPI. Other designs may be more limited as to where own ship's position can be reset on the PPI, being limited to a point from which the heading flash passes through the center of the PPI.

The radar observer must be alert with respect to reset requirements. To avoid either a manual or automatic reset at the most inopportune time, the radar observer should include in his evaluation of the situation a determination of the best time to reset own ship's position.

Range setting examples for Radiomarine true motion radar sets having double stabilization are as follows:

Type CRM-NID-75 (3.2cm) and Type CRM-N2D-30 (10cm)

True motion range settings 1, 2, 6, and 16 miles	Relative motion range settings $^1/_2$, 1, 2, 6, 16, and 40 miles

Maximum viewing times between automatic resets in the true motion mode are as follows:

Speed (knots)	Range setting (miles)	Initial view ahead (miles)	Viewing time (minutes)
20	16	26	66
12	6	9.75	41
8	2	3.25	24
8	1	1.6	16

The viewing time ahead can be extended by manually overriding the automatic reset feature.

Modes of Operation

True motion radars can be operated with either true motion or relative motion displays, with true motion operation being limited to the short and intermediate range settings.

In the relative motion mode, the sweep origin can be off-centered to extend the view ahead. With the view ahead extended, requirements for changing the range scale are reduced. Also, the off-center position of the fixed sweep origin can permit observation of a radar target on a shorter range scale than would be the case with the sweep origin fixed at the center of the PPI.

Through use of the shorter range scale, the relative motion of the radar target is more clearly indicated.

Types of True Motion Display

While fixed objects such as landmasses are stationary, or nearly so, on true motion displays, fixed objects will be stationary on the PPI only if there is no current or if the set and drift are compensated for by controls for this purpose. Dependent upon set design, current compensation may be effected through set and drift controls or by speed and course-made-good controls.

When using true motion radar primarily for collision avoidance purposes, the *sea-stabilized* display is preferred generally. The latter type of display differs from the *ground-stabilized* display only in that there is no compensation for current. Assuming that own ship and a radar contact are affected by the same current, the sea-stabilized display indicates true courses and speeds through the water. If own ship has leeway or is being affected by current, the echoes of stationary objects will move on the sea-stabilized display. Small echo trails will be formed in a direction opposite to the leeway or set. If the echo from a small rock appears to move due north at 2 knots, then the ship is being set due south at 2 knots. The usable afterglow of the CRT screen, which lasts from about $1^1/_2$ to 3 minutes, determines the minimum rate of movement which can be detected on the display. The minimum rate of movement has been found to be about $1^1/_2$ knots on the 6-mile range scale and proportional on other scales.

The *ground-stabilized* display provides the means for stopping the small movements of the echoes from stationary objects. This display may be used to obtain a clearer PPI presentation or to determine leeway or the effects of current on own ship.

In the *ground-stabilized* display own ship moves on the display in accordance with its course and speed over the ground. Thus, the movements of target echoes on the display indicate the true courses and speeds of the targets over the ground. Ground-stabilization is effected as follows:

(1) The speed control is adjusted to eliminate any movements of the echoes from stationary targets dead ahead or dead astern. If the echoes from stationary targets dead ahead are moving towards own ship, the speed setting is increased; otherwise the speed setting is decreased.

(2) The course-made-good control is adjusted to eliminate any remaining movement at right angles to own ship's heading. The course-made-good control should be adjusted in a direction counter to the echo movement.

Therefore, by trial and error procedures, the display can be ground-stabilized rapidly. However, the display should be considered only as an approximation of the course and speed made good over the ground. Among other factors, the accuracy of the ground-stabilization is dependent upon the minimum amount of movement which can be detected on the display. Small errors in speed and compass course inputs and other effects associated with any radar set may cause small false movements to appear on the true motion display. The information displayed should be interpreted with due regard to these factors. During a turn when compass errors will be greater and when speed estimation is more difficult, the radar observer should recognize that the accuracy of the ground stabilization may be degraded appreciably.

The varying effects of current, wind, and other factors make it unlikely that the display will remain ground stabilized for long periods. Consequently, the display must be readjusted periodically. Such readjustments should be carried out only when they do not detract from the primary duties of the radar observer.

While in rivers or estuaries, the only detectable movement may be the movement along own ship's heading. The movements of echoes of stationary objects at right angles to own ship's heading are usually small in these circumstances. Thus, in rivers and estuaries adjustment of the speed control is the only adjustment normally required to obtain ground stabilization of reasonable accuracy in these confined waters.

PLOTTING AND MEASUREMENTS ON PPI

THE REFLECTION PLOTTER

The reflection plotter is a radarscope attachment which enables plotting of position and motion of radar targets with greater facility and accuracy by reduction of the effect of parallax (apparent displacement of an object due to observer's position). The reflection plotter is designed so that any mark made on its plotting surface is reflected to a point directly below on the PPI. Hence, to plot the instantaneous position of a target, it is only necessary to make a grease pencil mark so that its image reflected onto the PPI just touches the inside edge of the pip.

The plotter should not be marked when the display is viewed at a very low angle. Preferably, the observer's eye position should be directly over the center of the PPI.

Basic Reflection Plotter Designs

The reflection plotter on a majority of marine radar systems currently offered use a flat plotting surface.

The reflection plotters illustrated in figures 2.4 and 2.5 are designs that were previously used aboard many navy and merchant ships and may still be in use. The curvature of the plotting surface as illustrated in figure 2.4 matches, but is opposite to the curvature of the screen of the cathode-ray tube, i.e., the plotting surface is concave to the observer. A semi-reflecting mirror is installed halfway between the PPI and plotting surface. The plotting surface is edge-lighted. Without this lighting the reflections of the grease pencil marks do not appear on the PPI.

Marking the Reflection Plotter

The modern flat plotting surface uses a mirror which makes the mark appear on, not above, the surface of the oscilloscope as depicted in figure 2.5.

In marking the older flat plotter shown in figure 2.5, the grease pencil is placed over the pip and the point is pressed against the plotting surface with sufficient pressure that the reflected image of the grease pencil point is seen on the PPI below. The point of the pencil is adjusted to find the more precise position for the mark or plot (at the center and leading edge of the radar pip). With the more precise position for the plot so found, the grease pencil point is pressed harder against the plotting surface to leave a plot in the form of a small dot.

In marking the plotting surface of the concave glass plotters, the point of the grease pencil is offset from the position of the pip. Noting the position of the reflection of the grease pencil point on the PPI, a line is drawn rapidly through the middle of the leading edge of the radar pip. A second such line is drawn rapidly to form an "X", which is the plotted position of the radar target. Some skill is required to form the intersection at the desired point.

Cleanliness

The plotting surface of the reflection plotter should be cleaned frequently and judiciously to insure that previous markings do not obscure new radar targets, which could appear undetected by the observer otherwise. A cleaning agent which does not leave a film residue should be used. Any oily film which is left by an undesirable cleaning agent or by the smear of incompletely wiped grease pencil markings makes the plotting surface difficult to mark. A weak solution of ammonia and water is an effective cleaning agent. During plotting, a clean, soft rag should be used to wipe the plotting surface.

PLOTTING ON STABILIZED AND UNSTABILIZED DISPLAYS

Stabilized North-Upward Display

Assuming the normal condition in which the start of the sweep is at the center of the PPI, the pips of radar targets are painted on the PPI at their true bearings at distances from the PPI center corresponding to target ranges. Because of the persistence of the PPI and the normally continuous rotation of the radar beam, the pips of targets having reasonably good reflecting properties appear continuously on the PPI. As targets move relative to the motion of own ship, the pips, as painted successively, move in the direction of this motion. With lapse of time, the pips painted earlier fade from the PPI. Thus, it is necessary to record the positions of the pips through plotting to permit analysis of this radar data. Failure to plot the successive positions of the pips is conducive to the much publicized RADAR ASSISTED COLLISION.

Through periodically marking the positions of the pips, either on the glass plate (implosion cover) over the CRT screen or the reflection plotter mounted thereon, a visual indication of the past and present positions of the targets is made available for the required analysis. This analysis is aided by the HEADING FLASH (HEADING MARKER) which is a luminous line of the PPI indicating ship's heading.

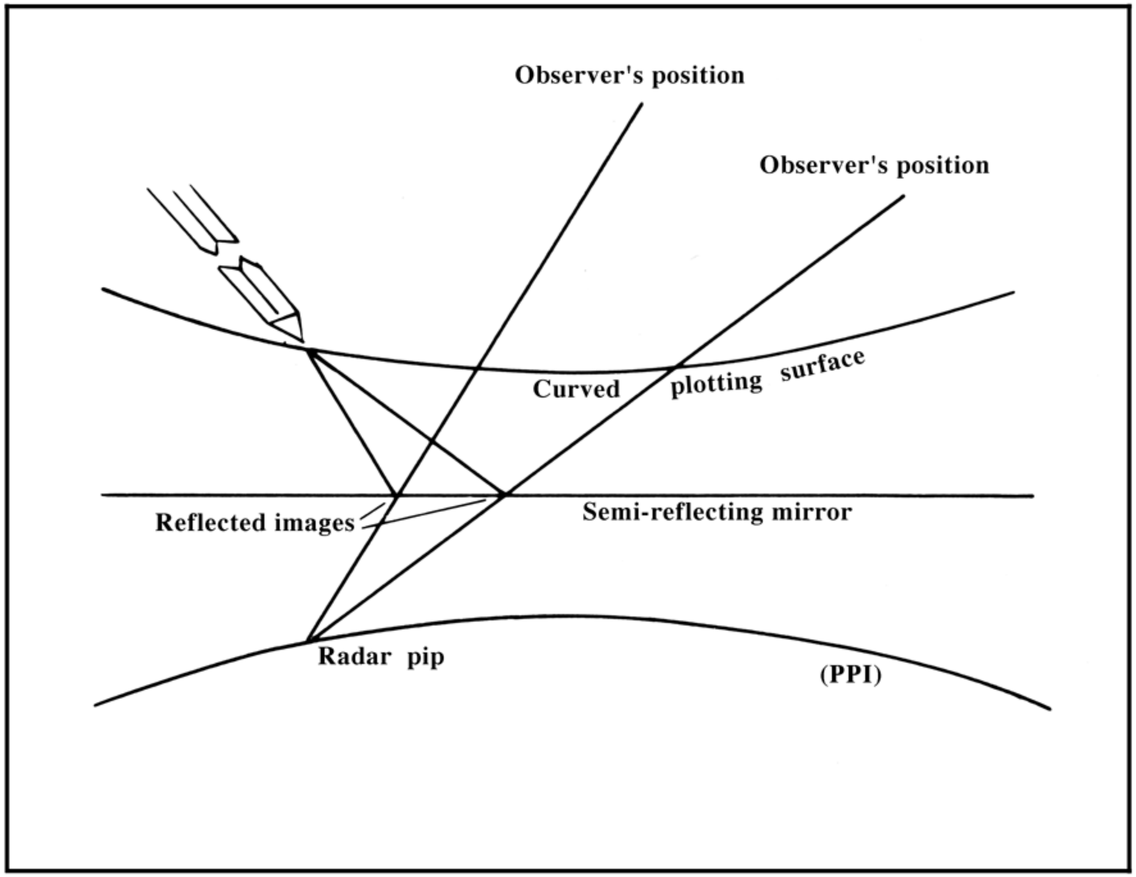


Figure 2.4 - Reflection plotter having curved plotting surface.

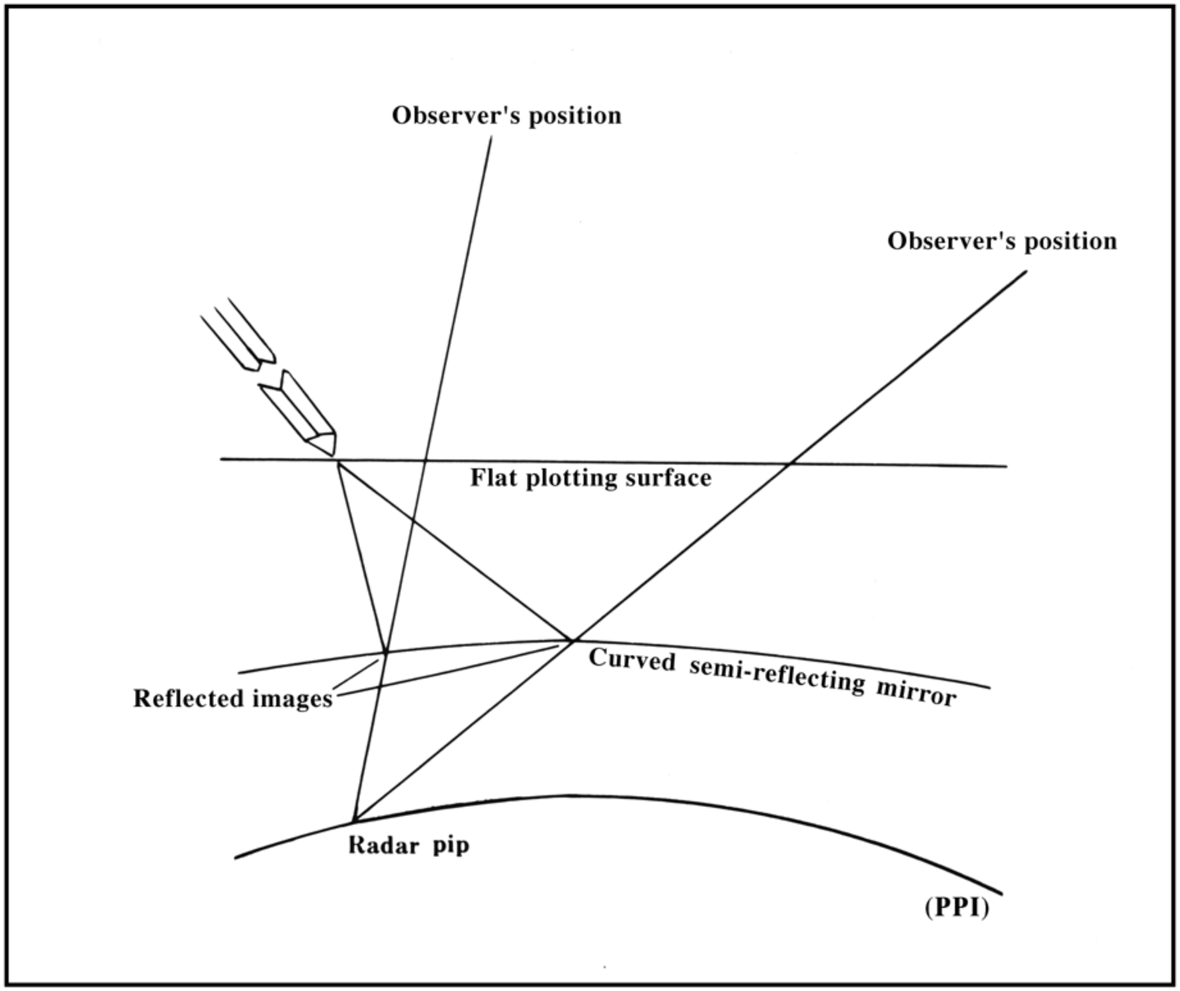


Figure 2.5 - Reflection plotter having flat plotting surface.

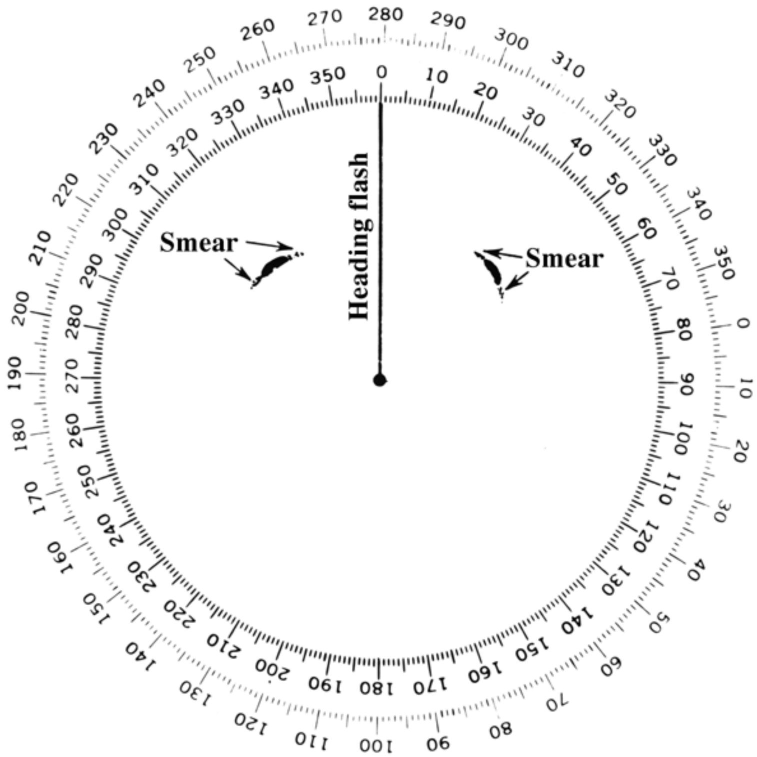


Figure 2.6 - Effect of yawing on unstabilized display.

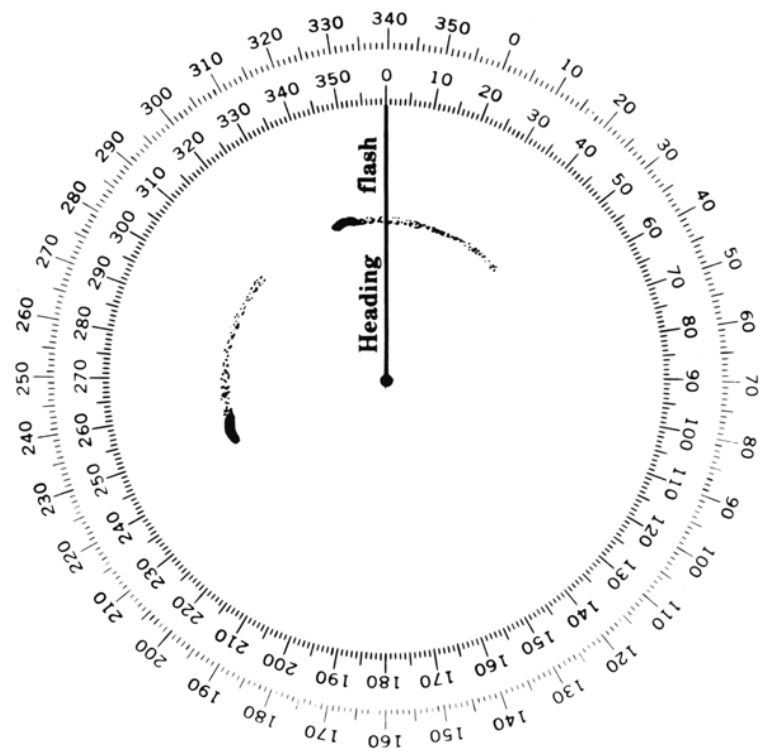


Figure 2.7 - Effect of course change on unstabilized display.

Unstabilized Heading-Upward Display

Plotting on the unstabilized Heading-Upward display is similar to plotting on the stabilized North-Upward display. Since the pips are painted at bearings relative to the heading of the observer's ship, a complication arises when the heading of the observer's ship is changed. If a continuous grease pencil plot is to be maintained on the unstabilized Heading-Upward relative motion display following course changes by the observer's ship, the plotting surface of the reflection plotter must be rotated the same number of degrees as the course or heading change in a direction opposite to this change. Otherwise, the portion of the plot made following the course change will not be continuous with the previous portion of the plot. Also the unstabilized display is affected by any yawing of the observer's ship. Plots made while the ship is off the desired heading will result in an erratic plot or a plot of lesser accuracy than would be afforded by a stabilized display. Under severe yawing conditions, plotting on the unstabilized display must be coordinated with the instants that the ship is on course if any reasonable accuracy of the plot is to be obtained.

Because of the persistence of the CRT screen and the illumination of the pips at their instantaneous relative bearings, as the observer's ship yaws or its course is changed the target pips on the PPI will smear.

Figure 2.6 illustrates an unstabilized Heading-Upward relative motion display for a situation in which a ship's course and present heading are 280˚, as indicated by the heading flash. The ship is yawing about a heading of 280˚. In this case there is slight smearing of the target pips. If the ship's course is changed to the right to 340˚ as illustrated in figure 2.7, the target pips smear to the left through 60˚, i.e., an amount equal and in a direction opposite to the course change. Thus, to maintain a continuous grease pencil plot on the reflection plotter it is necessary that the plotting surface of this plotter be rotated in a direction opposite to and equal to the course change.

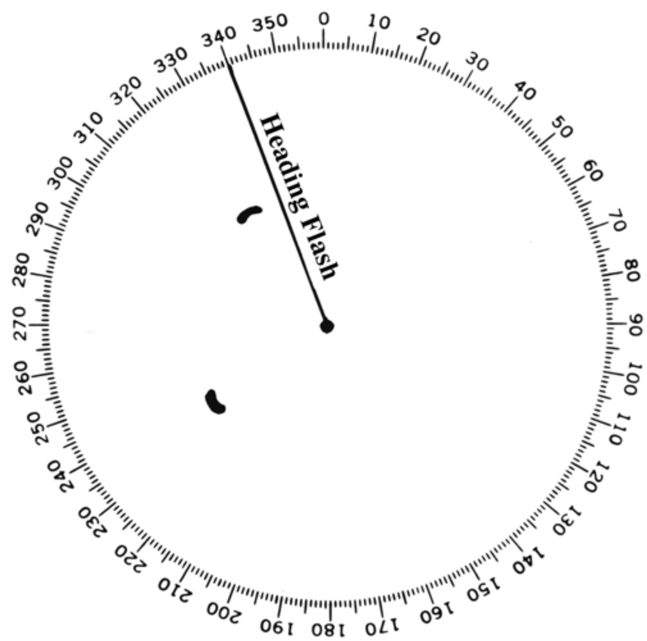


Figure 2.8 - Stabilized display following course change.

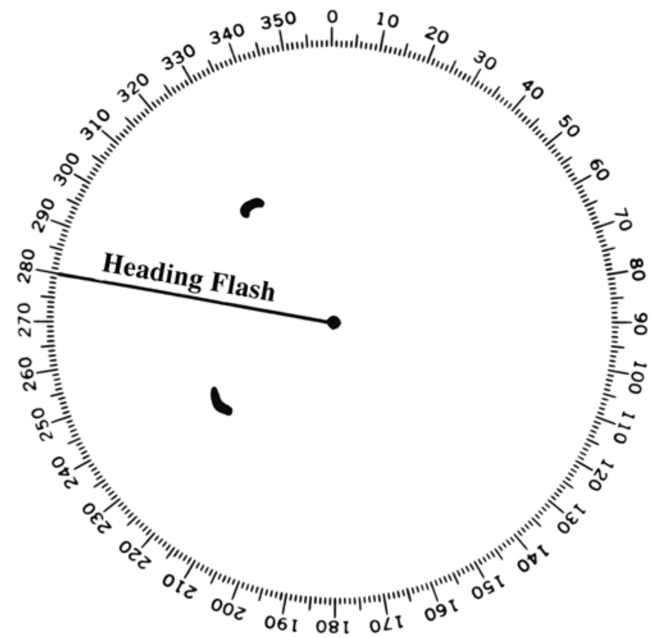


Figure 2.9 - Stabilized display preceding course change.

Figures 2.8 and 2.9 illustrate the same situation appearing on a stabilized North-Upward display. There is no pip smearing because of yawing. There is no shifting in the positions of the target pips because of the course change. Any changes in the position of the target pips are due solely to changes in the true bearings and distances to the targets during the course change. The plot during and following the course change is continuous with the plot preceding the course change. Thus, there is no need to rotate the plotting surface of the reflection plotter when the display is stabilized.

RANGE AND BEARING MEASUREMENT

Mechanical Bearing Cursor

The mechanical bearing cursor is a radial line or cross hair inscribed on a transparent disk which can be rotated manually about its axis coincident with the center of the PPI. This cursor is used for bearing determination. Frequently, the disk is inscribed with a series of lines parallel to the line inscribed through the center of the disk, in which case the bearing cursor is known as a PARALLEL-LINE CURSOR or PARALLEL INDEX (see figure 2.10.) To avoid parallax when reading the bearing, the lines are inscribed on each side of the disk.

When the sweep origin is at the center of the PPI, the usual case for relative motion displays, the bearing of a small, well defined target pip is determined by placing the radial line or one of the radial lines of the cross hair over the center of the pip. The true or relative bearing of the pip can be read from the respective bearing dial.

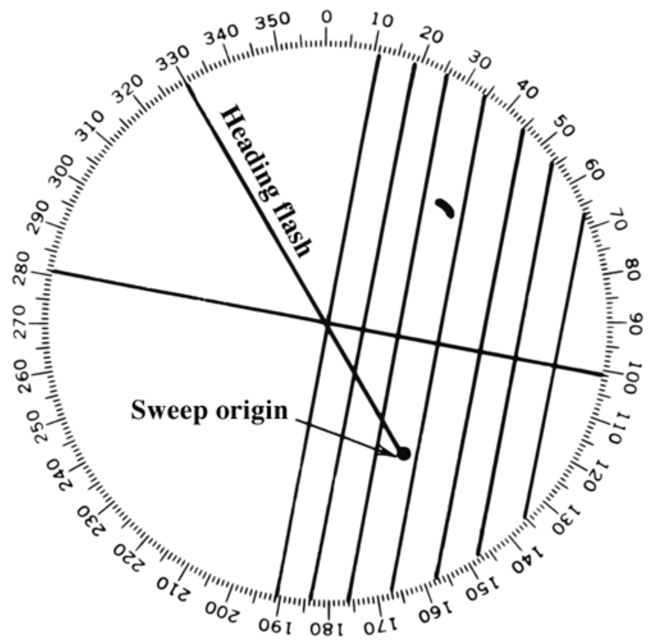


Figure 2.10 - Measuring bearing with parallel-line cursor.

Variable Range Marker (Range Strobe)

The variable range marker (VRM) is used primarily to determine the ranges to target pips on the PPI. Among its secondary uses is that of providing a visual indication of a limiting range about the position of the observer's ship, within which targets should not enter for reasons of safety.

The VRM is actually a small rotating luminous spot. The distance of the spot from the sweep origin corresponds to range; in effect, it is a variable range ring.

The distance to a target pip is measured by adjusting the circle described by the VRM so that it just touches the leading (inside) edge of the pip. The VRM is adjusted by means of a range crank. The distance is read on a range counter.

For better range accuracy, the VRM should be just bright enough to see and should be focused as sharply as possible.

Electronic Bearing Cursor

The designs of some radar indicators may include an electronic bearing cursor in addition to the mechanical bearing cursor. This electronic cursor is a luminous line on the PPI usually originating at the sweep origin. It is particularly useful when the sweep origin is not at the center of the PPI (see figure 2.3). Bearings are determined by placing the cursor in a position to bisect the pip. In setting the electronic cursor in this manner, there are no parallax problems such as are encountered in the use of the mechanical bearing cursor. The bearings to the pips or targets are read on an associated bearing indicator.

The electronic bearing cursor may have the same appearance as the heading flash. To avoid confusion between these two luminous lines originating at the sweep origin on the PPI, the design may be such that the electronic cursor appears as a dashed or dotted luminous line. Another design approach used to avoid confusion limits the painting of the cursor to that part of the radial beyond the setting of the VRM. Without special provision for differentiating between the two luminous lines, their brightness may be made different to serve as an aid in identification.

In the simpler designs of electronic bearing cursors, the cursor is independent of the VRM, i.e., the bearing is read by cursor and range is read by the rotating VRM. In more advanced designs, the VRM (range strobe) moves radially along the electronic bearing as the range crank is turned. This serves to expedite the reading of the range and bearing to a pip.

Interscan

The term INTERSCAN is descriptive of various designs of electronic bearing cursors, the lengths of which can be varied for determining the range to a pip.

Interscans are painted continuously on the PPI; the paintings of the other electronic bearing cursors are limited to one painting for each rotation of the antenna. Thus, the luminous lines of the latter cursors tend to fade between paintings. The continuously luminous line of the interscan serves to expedite measurements.

In some designs the interscan may be positioned at desired locations on the PPI; the length and direction of the luminous line may be adjusted to serve various requirements, including the determination of the bearing and distance between two pips.

Off-Center Display

While the design of most relative motion radar indicators places the sweep origin only at the center of the PPI, some indicators may have the capability for off-centering the sweep origin (see figure 2.11).

The primary advantage of the off-center display is that for any particular range scale setting, the view ahead can be extended. This lessens the requirement for changing range scale settings. The off-centering feature is particularly advantageous in river navigation.

With the sweep origin off-centered, the bearing dials concentric with the PPI cannot be used directly for bearing measurements. If the indicator does not have an electronic bearing cursor (interscan), the parallel-line cursor may be used for bearing measurements. By placing the cursor so that one of the parallel lines passes through both the observer's position on the PPI (sweep origin) and the pip, the bearing to the pip can be read on the bearing dial. Generally, the parallel lines inscribed on the disk are so spaced that it would be improbable that one of the parallel lines could be positioned to pass through the sweep origin and pip. This necessitates placing the cursor so that the inscribed lines are parallel to a line passing through the sweep origin and the pip.

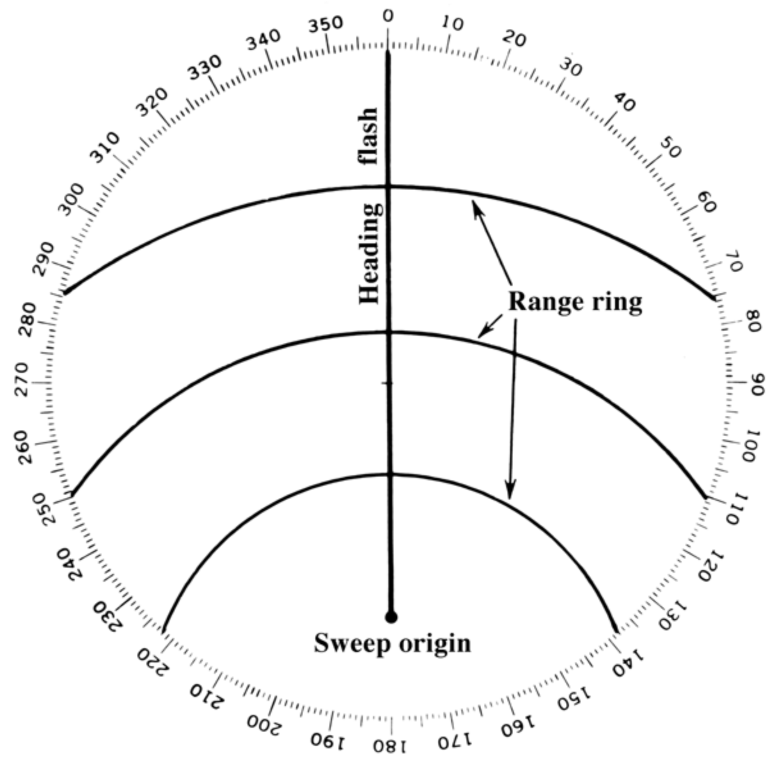


Figure 2.11 - Off-center display.

Expanded Center Display

Some radar indicator designs have the capability for expanding the center of the PPI on the shortest range scale, 1 mile for instance. While using an expanded center display, zero range is at one-half inch, for instance, from the center of the PPI rather than at its center. With sweep rotation the center of the PPI is dark out to the zero range circle.

Ranges must be measured from the zero range circle rather than the center of the PPI. While the display is distorted, the bearings of pips from the center of the PPI are not changed. Through shifting close target pips radially away from the PPI center, better resolution or discrimination between the pips is afforded. Also because of the normal small centering errors of the PPI display, the radial shifting of the target pips permits more accurate bearing determinations.

Figure 2.12 illustrates a normal display in which range is measured from the center of the PPI. Figure 2.13 illustrates an expanded center display of the same situation.

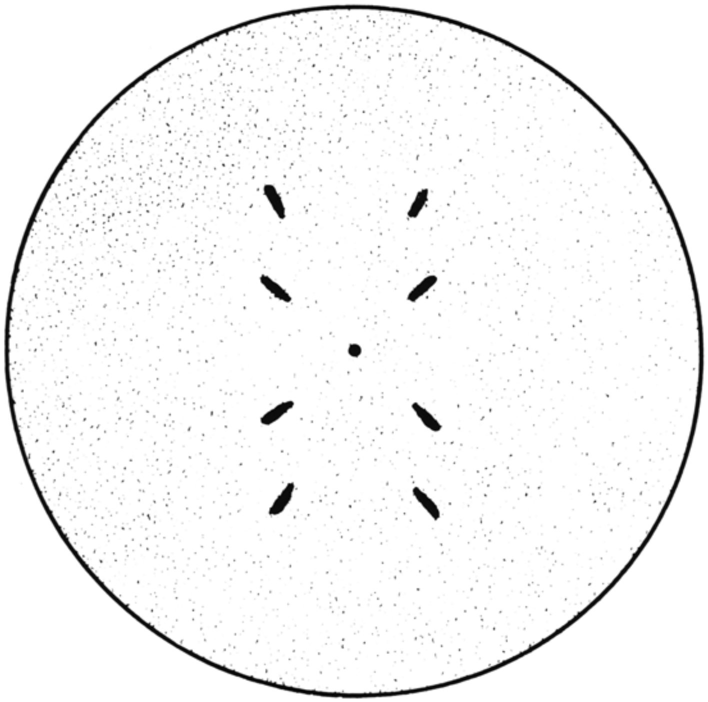


Figure 2.12 - Normal display.

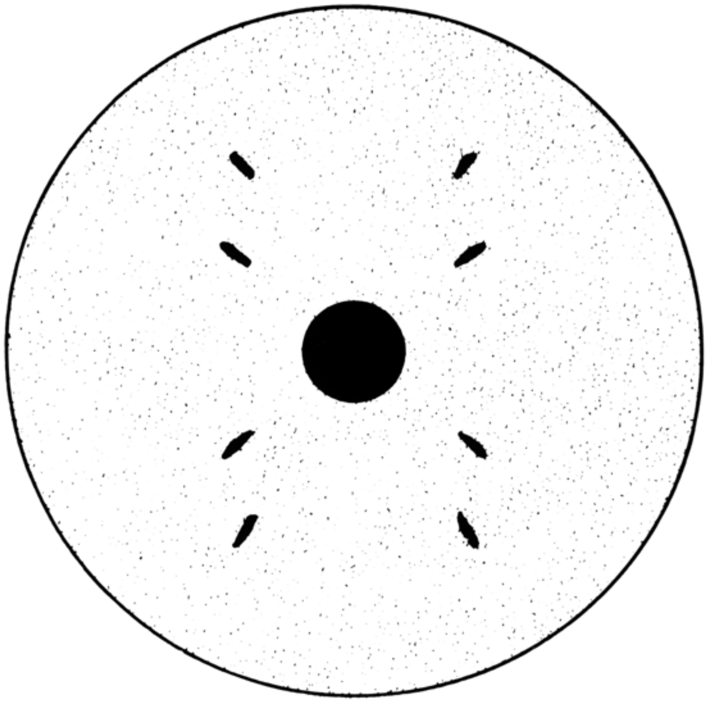


Figure 2.13 - Expanded center display.

RADAR OPERATING CONTROLS

POWER CONTROLS

Indicator Power Switch

This switch on the indicator has OFF, STANDBY, and OPERATE (ON) positions. If the switch is turned directly from the OFF to OPERATE positions, there is a warm-up period of about 3 minutes before the radar set is in full operation. During the warm-up period the cathodes of the tubes are heated, this heating being necessary prior to applying high voltages. If the switch is in the STANDBY position for a period longer than that required for warm-up, the radar set is placed in full operation immediately upon turning the switch to the OPERATE position. Keeping the radar set in STANDBY when not in use tends to lessen maintenance problems. Frequent switching from OFF to OPERATE tends to cause tube failures.

Antenna (Scanner) Power Switch

For reasons for safety, a radar set should have a separate switch for starting and stopping the rotation of the antenna. Separate switching permits antenna rotation for deicing purposes when the radar set is either off or in standby operation. Separate switching permits work on the antenna platform when power is applied to other components without the danger attendant to a rotating antenna.

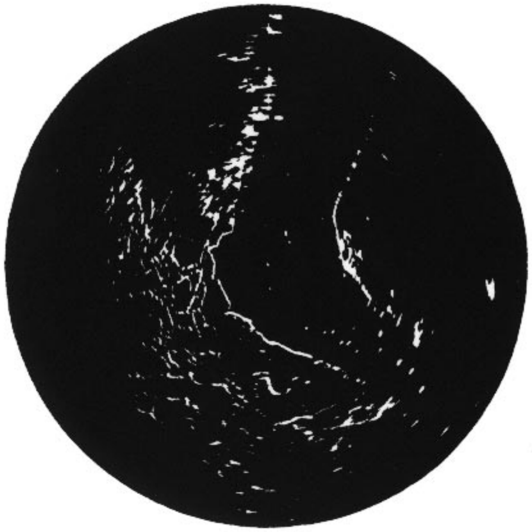
Special Switches

Even when the radar set is off, provision may be made for applying power to heaters designed for keeping the set dry. In such case, a special switch is provided for turning this power on and off.

Note: Prior to placing the indicator power switch in the OPERATE position, the brilliance control, the receiver gain control, the sensitivity time control, and the fast time constant switch should be placed at their minimum or off positions. The setting of the brilliance control avoids excessive brilliance harmful to the CRT on applying power. The other settings are required prior to making initial adjustments of the performance controls.

Brilliance Control

Also referred to as Intensity or Brightness control. The brilliance control, which determines the overall brightness of the PPI display, is first adjusted to make the trace of the rotating sweep visible but not too bright. Then it is adjusted so that the trace just fades. This adjustment should be made with the receiver gain control at its minimum setting because it is difficult to judge the right degree of brilliance when there is a speckled background on the PPI. Figures 2.14, 2.15, and 2.16 illustrate the effects of different brilliance settings, the receiver gain control being set so that the speckled background does not appear on the PPI. With too little brilliance, the PPI display is difficult to see; with excessive brilliance, the display is unfocused.



Reproduced by Courtesy of Decca Radar Limited, London.

Figure 2.15 - Normal brilliance.

Reproduced by Courtesy of Decca Radar Limited, London.

Figure 2.14 - Too little brilliance.

Reproduced by Courtesy of Decca Radar Limited, London.

Figure 2.16 - Excessive brilliance.

Receiver Gain Control

The receiver gain control is adjusted until a speckled background just appears on the PPI. Figures 2.17, 2.18, and 2.19 illustrate too little gain, normal gain, and excessive gain, respectively. With too little gain, weak echoes may not be detected; with excessive gain, strong echoes may not be detected because of the poor contrast between echoes and the background of the PPI display.

In adjusting the receiver gain control to obtain the speckled background, the indicator should be set on one of the longer range scales because the speckled background is more apparent on these scales. On shifting to a different range scale, the brightness may change. Generally, the required readjustment may be effected through use of the receiver gain control alone although the brightness of the PPI display is dependent upon the settings of the receiver gain and brilliance controls. In some radar indicator designs, the brilliance control is preset at the factory. Even so, the brilliance control may have to be readjusted at times during the life of the cathode-ray tube. Also the preset brilliance control may have to be readjusted because of large changes in ambient light levels.

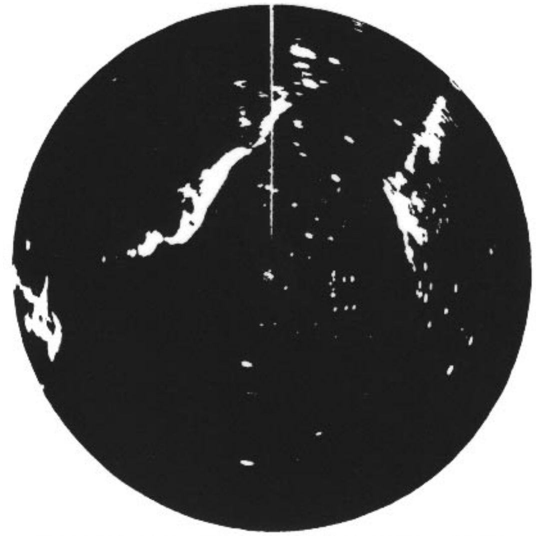


Figure 2.18 - Normal gain.

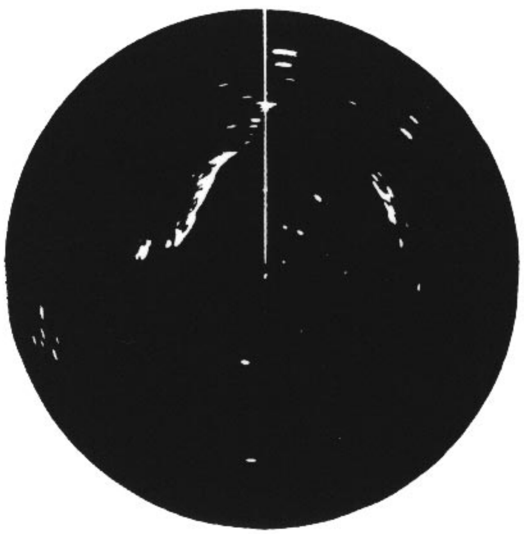


Figure 2.17 - Too little gain.

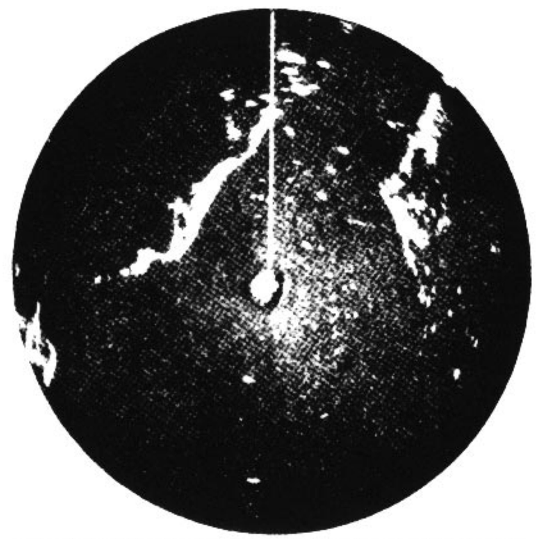


Figure 2.19 - Excessive gain.

Tuning Control

Without ship or land targets, a performance monitor, or a tuning indicator, the receiver may be tuned by adjusting the manual tuning control for maximum sea clutter. An alternative to the use of normal sea clutter which is usually present out to a few hundred yards even when the sea is calm, is the use of echoes from the ship's wake during a turn. When sea clutter is used for manual tuning adjustment, all anti-clutter controls should be either off or placed at their minimum settings. Also, one of the shorter range scales should be used.

PERFORMANCE CONTROLS - ADJUSTMENTS ACCORDING TO OPERATING CONDITIONS

Receiver Gain Control

This control is adjusted in accordance with the range scale being used. Particular caution must be exercised so that while varying its adjustment for better detection of more distant targets, the area near the center of the PPI is not subjected to excessive brightness within which close targets may not be detected.

When detection at the maximum possible range is the primary objective, the receiver gain control should be adjusted so that a speckled background is just visible on the PPI. However, a temporary reduction of the gain setting may prove useful for detecting strong echoes from among weaker ones.

Fast Time Constant (FTC) Switch (Differentiator)

With the FTC switch in the ON position, the FTC circuit through shortening the echoes on the display reduces clutter on the PPI which might be caused by rain, snow, or hail. When used, this circuit has an effect over the entire PPI and generally tends to reduce receiver sensitivity and, thus, the strengths of the echoes as seen on the display.

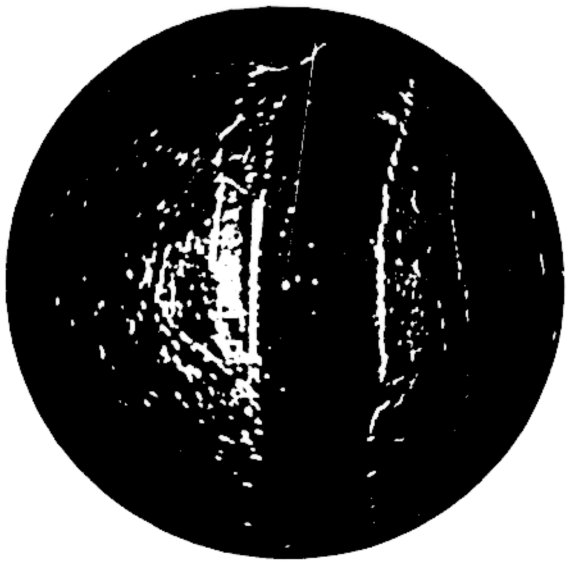
Rain Clutter Control

The rain clutter control provides a variable fast time constant. Thus, it provides greater flexibility in the use of FTC according to the operating conditions. Whether the FTC is fixed or variable, it provides the means for breaking up clutter which otherwise could obscure the echo of a target of interest. When navigating in confined waters, the FTC feature provides better definition of the PPI display through better range resolution. Also, the use of FTC provides lower minimum range capability.

Figure 2.20 illustrates clutter on the PPI caused by a rain squall. Figure 2.21 illustrates the break up of this clutter by means of the rain clutter control.

Reproduced by Courtesy of Decca Radar Limited, London.

Figure 2.20 - Clutter caused by a rain squall.



Reproduced by Courtesy of Decca Radar Limited, London.

Figure 2.21 - Break up of clutter by means of rain clutter control.

Figure 2.22 illustrates the appearance of a harbor on the PPI when the FTC circuit is not being used. Figure 2.23 illustrates the harbor when the FTC circuit is being used. With use of the FTC circuit, there is better definition.

Figure 2.22 - FTC not in use.

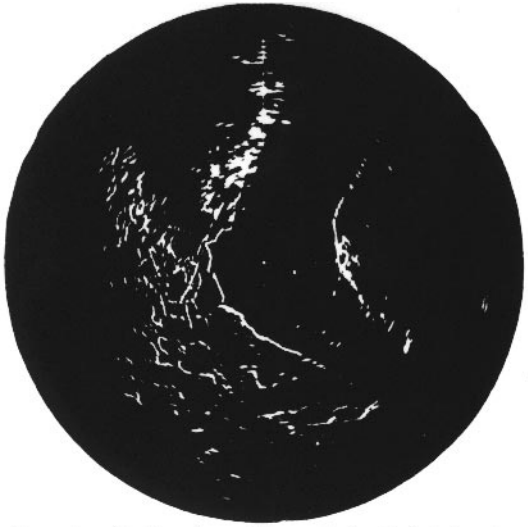
Figure 2.23 - FTC in use.

Sensitivity Time Control (STC)

Also called SEA CLUTTER CONTROL, ANTI-CLUTTER CONTROL, SWEPT GAIN, SUPPRESSOR.

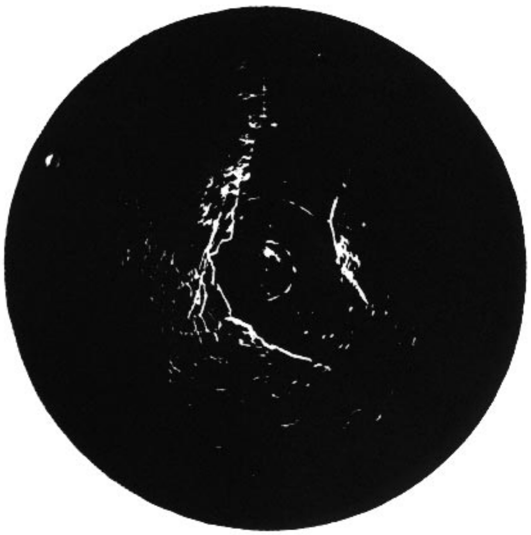
Normally, the STC should be placed at the minimum setting in calm seas. This control is used with a circuit which is designed to suppress sea clutter out to a limited distance from the ship. Its purpose is to enable the detection of close targets which otherwise might be obscured by sea clutter. This control must be used judiciously in conjunction with the receiver gain control. Generally, one should not attempt to eliminate all sea clutter with this control. Otherwise, echoes from small close targets may be suppressed also.

Figures 2.24, 2.25, and 2.26 illustrate STC settings which are too low, correct, and too high, respectively.



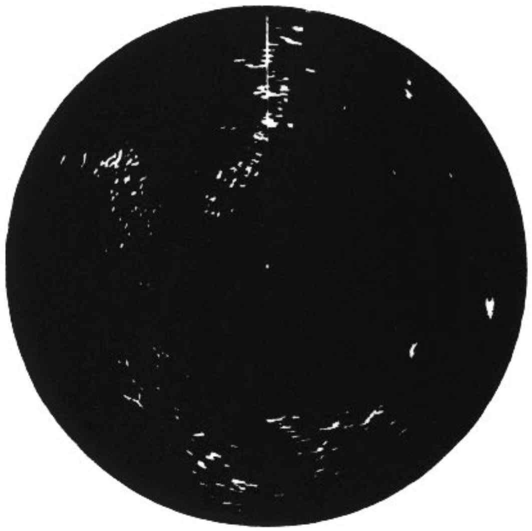
Reproduced by Courtesy of Decca Radar Limited, London.

Figure 2.25 - STC setting correct.



Reproduced by Courtesy of Decca Radar Limited, London.

Figure 2.24 - STC setting too low.



Reproduced by Courtesy of Decca Radar Limited, London.

Figure 2.26 - STC setting too high.

Performance Monitor

The performance monitor provides a check of the performance of the transmitter and receiver. Being limited to a check of the operation of the equipment, the performance monitor does not provide any indication of performance as it might be affected by the propagation of the radar waves through the atmosphere. Thus, a good check on the performance monitor does not necessarily indicate that targets will be detected.

When the performance monitor is used, a plume extends from the center of the PPI (see figure 2.27). The length of the plume, which is dependent upon the strength of the echo received from the echo box in the vicinity of the antenna, is an indication of the performance of the transmitter and the receiver. The length of this plume is compared with its length when the radar is known to be operating at high performance.

Any reduction of over 20 percent of the range to which the plume extends when the radar set is operating at its highest performance is indicative of the need for tuning adjustment. If tuning adjustment does not produce a plume length within specified limits, the need for equipment maintenance is indicated.

With malfunctioning of the performance monitor, the plume appears as illustrated in figure 2.28.

The effectiveness of the anti-clutter controls can be checked by inspecting their effects on the plume produced by the echo from the echo box.

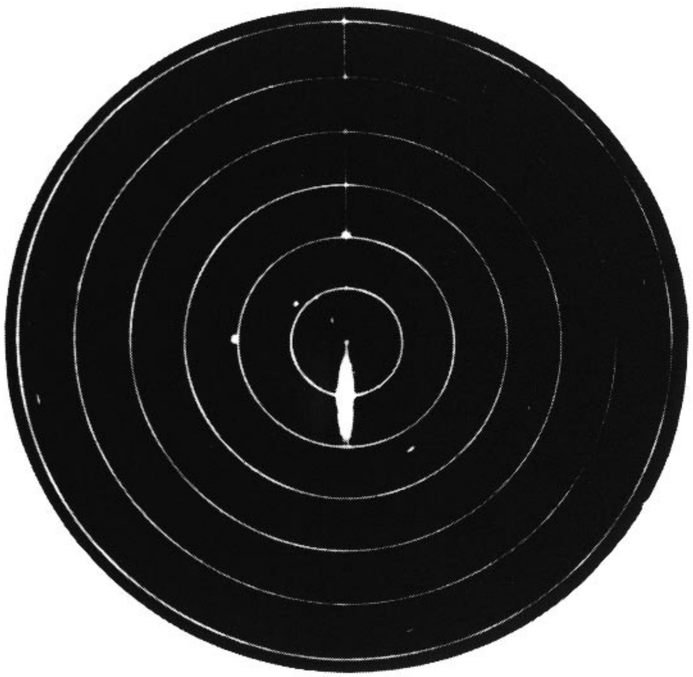


Figure 2.27 - Performance monitor plume.

Figure 2.28 - Appearance of plume when performance monitor is malfunctioning.

Pulse Lengths and Pulse Repetition Rate Controls

On some radar sets the pulse length and pulse repetition rate (PRR) are changed automatically in accordance with the range scale setting. At the higher range scale settings the radar operation is shifted to longer pulse lengths and lower pulse repetition rates. The greater energy in the longer pulse is required for detection at longer ranges. The lower pulse repetition rate is required in order that an echo can return to the receiver prior to the transmission of the next pulse. At the shorter range scale settings, the shorter pulse length provides better range resolution and shorter minimum ranges, the higher power of the longer pulse not being required. Also, the higher pulse repetition rates at the shorter range scale settings provide more frequent repainting of the pips and, thus, sharper pips on the PPI desirable for short range observation.

On other radar sets the pulse length and PRR must be changed by manual operation of controls. On some of these sets pulse length and PRR can be changed independently. The pulse lengths and PRR's of radar sets installed aboard merchant ships usually are changed automatically with the range scale settings.

LIGHTING AND BRIGHTNESS CONTROLS

Reflection Plotter

The illumination levels of the reflection plotter and the bearing dials are adjusted by a control, labeled PLOTTER DIMMER.

The reflection plotter lighting must be turned on in order to see reflected images of the grease pencil plot on the PPI. With yellowish-green fluorescence, yellow and orange grease pencil markings provide the clearest images on the PPI; with orange fluorescence, black grease pencil markings provide the clearest images.

Heading Flash

The brightness of the heading flash is adjusted by a control, labeled FLASHER INTENSITY CONTROL. The brightness should be kept at a low level to avoid masking a small pip on the PPI. The heading flash should be turned off periodically for the same reason.

Electronic Bearing Cursor

The brightness of the electronic bearing cursor is adjusted by a control for this purpose. Unless the electronic bearing cursor appears as a dashed or dotted line, the brightness levels of the electronic bearing cursor and the heading flash should be different to serve as an aid to their identification. Radar indicators are now equipped with a spring-loaded switch to temporarily disable the flash.

Fixed Range Markers

The brightness of the fixed range markers is adjusted by a control, labeled FIXED RANGE MARK INTENSITY CONTROL. The fixed range markers should be turned off periodically to avoid the possibility of their masking a small pip on the PPI.

Variable Range Marker

The brightness of the variable range marker is adjusted by the control labeled VARIABLE RANGE MARK INTENSITY CONTROL. This control is adjusted so that the ring described by the VRM is sharp and clear but not too bright.

Panel Lighting

The illumination of the panel is adjusted by the control labeled PANEL CONTROL.

MEASUREMENT AND ALIGNMENT CONTROLS

Range

Usually, ranges are measured by means of the variable range marker (VRM). On some radars the VRM can be used to measure ranges up to only 20 miles although the maximum range scale setting is 40 miles. For distances greater than 20 miles, the fixed range rings must be used.

The radar indicators designed for merchant ship installation have range counter readings in miles and tenths of miles. According to the range calibration, the readings may be either statute or nautical miles. The range counter has three digits, the last or third digit indicating the range in tenths of a mile. As the VRM setting is adjusted, the range is read in steps of tenths of a mile. The VRM control may have coarse and fine settings. The coarse setting permits rapid changes in the range setting of the VRM. The fine setting permits the operator to make small adjustments of the VRM more readily. For accurate range measurements, the circle described by the VRM should be adjusted so that it just touches the inside edge of the pip.

Bearing

On most radar indicators bearings are measured by setting the mechanical bearing cursor to bisect the target pip and reading the bearing on the bearing dial.

With unstabilized Heading-Upward displays, true bearings are read on the outer, rotatable dial which is set either manually or automatically to ship's true heading.

With stabilized North-Upward displays, true bearings are read on the fixed dial. With loss of compass input to the indicator, the bearings as read on the latter dial are relative. Some radar indicators designed for stabilized North-Upward displays have rotatable relative bearing dials, the zero graduations of which can be set to the heading flash for reading relative bearings.

Some radar indicators, especially those having true motion displays, may have an electronic bearing cursor and associated bearing indicator. The electronic cursor is particularly useful when the display is off-centered.

Sweep Centering

For accurate bearing measurement by the mechanical bearing cursor, the sweep origin must be placed at the center of the PPI. Some radar indicators have panel controls which can be used for horizontal and vertical shifting of the sweep origin to place it at the center of the PPI and, thus, at the pivot point of the mechanical bearing cursor. On other radar indicators not having panel controls for centering the sweep origin, the sweep must be centered by making those adjustments inside the indicator cabinet as are prescribed in the manufacturer's instruction manual.

Center Expansion

Some radar indicators have a CENTER EXPAND SWITCH which is used to displace zero range from the center of the PPI on the shortest range scale setting. With the switch in the ON position, there is distortion in range but no distortion in the bearings of the pips displayed because the expansion is radial. Using center expansion, there is greater separation between pips near the center of the PPI and, thus, better bearing resolution. Also, bearing accuracy is improved because centering errors have lesser effect on accuracy with greater displacement of pips from the PPI center. When center expansion is used, the fixed range rings expand with the center. However, the range must be measured from the inner circle as opposed to the center of the PPI.

The use of the center expansion can be helpful in anti-clutter adjustment.

Heading Flash Alignment

For accurate bearing measurements, the alignment of the heading flash with the PPI display must be such that radar bearings are in close agreement with relatively accurate visual bearings observed from near the radar antenna.

On some radar indicators, the heading flash must be set by a PICTURE-ROTATE CONTROL according to the type of display desired. Should there be any appreciable difference between radar and visual bearings, adjustment of the heading flash contacts is indicated. The latter adjustment should be made in accordance with the procedure prescribed in the manufacturer's instruction manual. However, the following procedures should prove helpful in obtaining an accurate adjustment:

(1) Adjust the centering controls to place the sweep origin at the center of the PPI as accurately as is possible.

(2) In selecting an object for simultaneous visual and radar bearing measurements, select an object having a small and distinct pip on the PPI.

(3) Select an object which lies near the maximum range of the scale in use. This object should be not less than 2 nautical miles away.

(4) Observe the visual bearings from a position as close to the radar antenna as is possible.

(5) Use as the bearing error the average of the differences of several simultaneous radar and visual observations.

(6) After any heading flash adjustment, check the accuracy of the adjustment by simultaneous radar and visual observations.

Range Calibration

The range calibration of the indicator should be checked at least once each watch, before any event requiring high accuracy, and more often if there is any reason to doubt the accuracy of the calibration. A calibration check made within a few minutes after a radar set has been turned on should be checked again 30 minutes later, or after the set has warmed up thoroughly.

The calibration check is simply the comparison of VRM and fixed range ring ranges at various range scale settings. In this check the assumptions are that the calibration of the fixed range rings is more accurate than that of the VRM, and that the calibration of the fixed range rings is relatively stable. One indication of the accuracy of the range ring calibration is the linearity of the sweep or time base. Since range rings are produced by brightening the electron beam at regular intervals during the radial sweep of this beam, equal spacing of the range rings is indicative of the linearity of the time base.

Representative maximum errors in calibrated fixed range rings are 75 yards or 1.5 percent of the maximum range of the range scale in use, whichever is greater. Thus, on a 6-mile range scale setting the error in the range of a pip just touching a range ring may be about 180 yards or about 0.1 nautical mile. Since fixed range rings are the most accurate means generally available for determining range when the leading edge of the target pip is at the range ring, it follows that ranging by radar is less accurate than many may assume. One should not expect the accuracy of navigational radar to be better than plus or minus 50 yards under the best conditions.

Each range calibration check is made by setting the VRM to the leading edge of a fixed range ring and comparing the VRM range counter reading with the range represented by the fixed range ring. The VRM reading should not differ from the fixed range ring value by more than 1 percent of the maximum range of the scale in use. For example, with the radar indicator set on the 40-mile range scale and the VRM set at the 20-mile range ring, the VRM range counter reading should be between 19.6 and 20.4 miles.

TRUE MOTION CONTROLS

The following controls are representative of those additional controls used in the true motion mode of operation. If the true motion radar set design includes provision for ground stabilization of the display, this stabilization may be effected through use of either set and drift or speed and course-made-good controls.

Operating Mode

Since true motion radars are designed for operation in true motion and relative motion modes, there is a control on the indicator panel for selecting the desired mode.

Normal Reset Control

Since own ship is not fixed at the center of the PPI in the true motion mode, own ship's position must be reset periodically on the PPI. Own ship's position may be reset manually or automatically. Automatic reset is performed at definite distances from the PPI center, according to the radar set design. With the normal reset control actuated, reset may be performed automatically when own ship has reached a position beyond the PPI center about two thirds the radius of the PPI. Whether own ship's position is reset automatically or manually, own ship's position is reset to an off-center position on the PPI, usually at a position from which the heading flash passes through the center of the PPI. This off-center position provides more time before resetting is required than would be the case if own ship's position were reset to the center of the PPI.

Delayed Reset Control

With the delayed reset control actuated, reset is performed automatically when own ship has reached a position closer to the edge of the PPI than with normal reset. With either the normal or delayed reset control actuated, there is an alarm signal which gives about 10 seconds forewarning of automatic resetting.

Manual Reset Control

The manual reset control permits the resetting of own ship's position at any desired time.

Manual Override Control

The manual override control when actuated prevents automatic resetting of own ship's position. This control is particularly useful if a critical situation should develop just prior to the time of automatic resetting. Shifting from normal to delayed reset can also provide more time for evaluating a situation before resetting occurs.

Ship's Speed Input Selector Control

Own ship's speed and course being necessary inputs to the true motion radar computer, the ship's speed input selector control permits either manual input of ship's speed or automatic input of speed from a speed log. With the control in the manual position, ship's speed in knots and tenths of knots can be set in steps of tenths of knots.

Set and Drift Controls

Set and drift controls, or their equivalent, provide means for ground stabilization of the true motion display. When there is accurate compensation for set and drift, there is no movement of stationary objects on the PPI. Without such compensation, slight movements of stationary objects may be detected on the PPI. The set control may be labeled DRIFT DIRECTION; the drift control may be labeled DRIFT SPEED.

Speed and Course Made Good Controls

The radar set design may include speed and course made good controls in lieu of set and drift controls to effect ground stabilization of the true motion display. The course made good control permits the input of a correction, within limits of about 25° to the course input to the radar set. The speed control permits the input of a correction to the speed input from the underwater speed log or from an artificial (dummy) log.

Zero Speed Control

In the ZERO position, the zero speed control stops the movement of own ship on the PPI; in the TRUE position own ship moves on the PPI at a rate set by the speed input.