CHAPTER 4 — RADAR NAVIGATION

RADARSCOPE INTERPRETATION

In its position finding or navigational application, radar may serve the navigator as a very valuable tool if its characteristics and limitations are understood. While determining position through observation of the range and bearing of a charted, isolated, and well defined object having good reflecting properties is relatively simple, this task still requires that the navigator have an understanding of the characteristics and limitations of his radar. The more general task of using radar in observing a shoreline where the radar targets are not so obvious or well defined requires considerable expertise which may be gained only through an adequate understanding of the characteristics and limitations of the radar being used.

While the plan position indicator does provide a chartlike presentation when a landmass is being scanned, the image painted by the sweep is not a true representation of the shoreline. The width of the radar beam and the length of the transmitted pulse are factors which act to distort the image painted on the scope. Briefly, the width of the radar beam acts to distort the shoreline features in bearing; the pulse length may act to cause offshore features to appear as part of the landmass.

The major problem is that of determining which features in the vicinity of the shoreline are actually reflecting the echoes painted on the scope. Particularly in cases where a low lying shore is being scanned, there may be considerable uncertainty.

An associated problem is the fact that certain features on the shore will not return echoes, even if they have good reflecting properties, simply because they are blocked from the radar beam by other physical features or obstructions. This factor in turn causes the chartlike image painted on the scope to differ from the chart of the area.

If the navigator is to be able to interpret the chartlike presentation on his radarscope, he must have at least an elementary understanding of the characteristics of radar propagation, the characteristics of his radar set, the reflecting properties of different types of radar targets, and the ability to analyze his chart to make an estimate of just which charted features are most likely to reflect the transmitted pulses or to be blocked from the radar beam. While contour lines on the chart topography aid the navigator materially in the latter task, experience gained during clear weather comparison of the visual cross-bearing plot and the radarscope presentation is invaluable.

LAND TARGETS

On relative and true motion displays, landmasses are readily recognizable because of the generally steady brilliance of the relatively large areas painted on the PPI. Also land should be at positions expected from knowledge of the ship's navigational position. On relative motion displays, landmasses move in directions and at rates opposite and equal to the actual motion of the observer's ship. Individual pips do not move relative to one another. On true motion displays, landmasses do not move on the PPI if there is accurate compensation for set and drift. Without such compensation, i.e., when the true motion display is sea-stabilized, only slight movements of landmasses may be detected on the PPI.

While landmasses are readily recognizable, the primary problem is the identification of specific features so that such features can be used for fixing the position of the observer's ship. Identification of specific features can be quite difficult because of various factors, including distortion resulting from beam width and pulse length and uncertainty as to just which charted features are reflecting the echoes. The following hints may be used as an aid in identification:

(a) Sandspits and smooth, clear beaches normally do not appear on the PPI at ranges beyond 1 or 2 miles because these targets have almost no area that can reflect energy back to the radar. Ranges determined from these targets are not reliable. If waves are breaking over a sandbar, echoes may be returned from the surf. Waves may, however, break well out from the actual shoreline, so that ranging on the surf may be misleading when a radar position is being determined relative to shoreline.

(b) Mud flats and marshes normally reflect radar pulses only a little better than a sandspit. The weak echoes received at low tide disappear at high tide. Mangroves and other thick growth may produce a strong echo. Areas that are indicated as swamps on a chart, therefore, may return either strong or weak echoes, depending on the density and size of the vegetation growing in the area.

(c) When sand dunes are covered with vegetation and are well back from a low, smooth beach, the apparent shoreline determined by radar appears as the line of the dunes rather than the true shoreline. Under some conditions, sand dunes may return strong echo signals because the combination of the vertical surface of the vegetation and the horizontal beach may form a sort of corner reflector.

(d) Lagoons and inland lakes usually appear as blank areas on a PPI because the smooth water surface returns no energy to the radar antenna. In some instances, the sandbar or reef surrounding the lagoon may not appear on the PPI because it lies too low in the water.

(e) Coral atolls and long chains of islands may produce long lines of echoes when the radar beam is directed perpendicular to the line of the islands. This indication is especially true when the islands are closely spaced. The reason is that the spreading resulting from the width of the radar beam causes the echoes to blend into continuous lines. When the chain of islands is viewed lengthwise, or obliquely, however, each island may produce a separate pip. Surf breaking on a reef around an atoll produces a ragged, variable line of echoes.

(f) Submerged objects do not produce radar echoes. One or two rocks projecting above the surface of the water, or waves breaking over a reef, may appear on the PPI. When an object is submerged entirely and the sea is smooth over it, no indication is seen on the PPI.

(g) If the land rises in a gradual, regular manner from the shoreline, no part of the terrain produces an echo that is stronger than the echo from any other part. As a result, a general haze of echoes appears on the PPI, and it is difficult to ascertain the range to any particular part of the land.

Land can be recognized by plotting the contact. Care must be exercised when plotting because, as a ship approaches or goes away from a shore behind which the land rises gradually, a plot of the ranges and bearings to the land may show an “apparent course and speed. This phenomenon is demonstrated in figure 4.1. In view A the ship is 50 miles from the land, but because the radar beam strikes at point 1, well up on the slope, the indicated range is 60 miles. In view B where the ship is 10 miles closer to land, the indicated range is 46 miles because the radar echo is now returned from point 2. In view C where the ship is another 10 miles closer, the radar beam strikes at point 3, even lower on the slope, so that the indicated range is 32 miles. If these ranges are plotted, the land will appear to be moving toward the ship.

In figure 4.1, a smooth, gradual slope is assumed, so that a consistent plot is obtained. In practice, however, the slope of the ground usually is irregular and the plot erratic, making it hard to assign a definite speed to the land contact. The steeper the slope of the land, the less is its apparent speed. Furthermore, because the slope of the land does not always fall off in the direction from which the ship approaches, the apparent course of the contact need not always be the opposite of the course of the ship, as assumed in this simple demonstration.

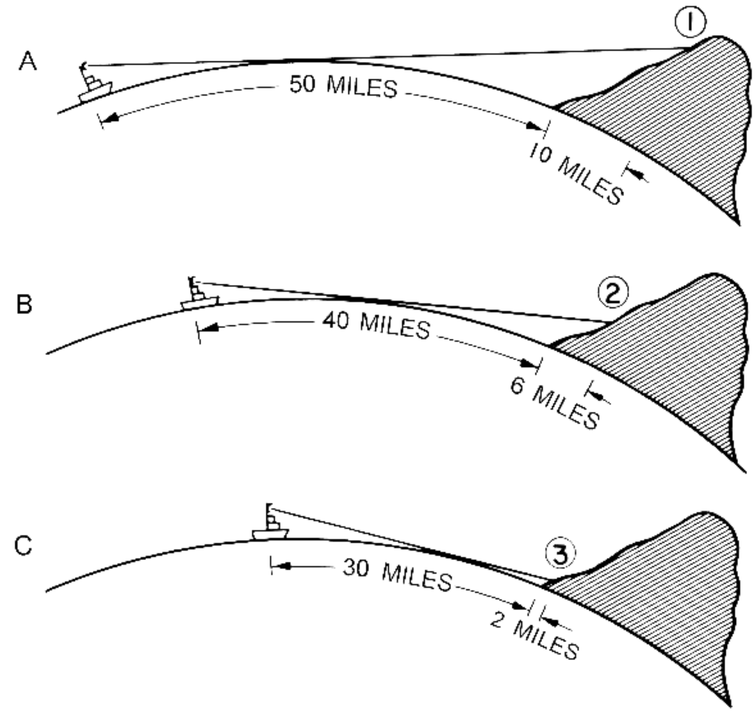

Figure 4.1 - Apparent course and speed of land target.

(h) Blotchy signals are returned from hilly ground because the crest of each hill returns a good echo although the valley beyond is in a shadow. If high receiver gain is used, the pattern may become solid except for the very deep shadows.

(i) Low islands ordinarily produce small echoes. When thick palm trees or other foliage grow on the island, strong echoes often are produced because the horizontal surface of the water around the island forms a sort of corner reflector with the vertical surfaces of the trees. As a result, wooded islands give good echoes and can be detected at a much greater range than barren islands.

SHIP TARGETS

With the appearance of a small pip on the PPI, its identification as a ship can be aided by a process of elimination. A check of the navigational position can overrule the possibility of land. The size of the pip can be used to overrule the possibility of land or precipitation, both usually having a massive appearance on the PPI. The rate of movement of the pip on the PPI can overrule the possibility of aircraft.

Having eliminated the foregoing possibilities, the appearance of the pip at a medium range as a bright, steady, and clearly defined image on the PPI indicates a high probability that the target is a steel ship.

The pip of a ship target may brighten at times and then slowly decrease in brightness. Normally, the pip of a ship target fades from the PPI only when the range becomes too great.

RADAR SHADOW

While PPI displays are approximately chartlike when landmasses are being scanned by the radar beam, there may be sizable areas missing from the display because of certain features being blocked from the radar beam by other features. A shoreline which is continuous on the PPI display when the ship is at one position may not be continuous when the ship is at another position and scanning the same shoreline. The radar beam may be blocked from a segment of this shoreline by an obstruction such as a promontory. An indentation in the shoreline, such as a cove or bay, appearing on the PPI when the ship is at one position may not appear when the ship is at another position nearby. Thus, radar shadow alone can cause considerable differences between the PPI display and the chart presentation. This effect in conjunction with the beam width and pulse length distortion of the PPI display can cause even greater differences.

BEAM WIDTH AND PULSE LENGTH DISTORTION

The pips of ships, rocks, and other targets close to shore may merge with the shoreline image on the PPI. This merging is due to the distortion effects of horizontal beam width and pulse length. Target images on the PPI always are distorted angularly by an amount equal to the effective horizontal beam width. Also, the target images always are distorted radially by an amount at least equal to one-half the pulse length (164 yards per microsecond of pulse length).

Figure 4.2 illustrates the effects of ship's position, beam width, and pulse length on the radar shoreline. Because of beam width distortion, a straight, or nearly straight, shoreline often appears crescent-shaped on the PPI. This effect is greater with the wider beam widths. Note that this distortion increases as the angle between the beam axis and the shoreline decreases.

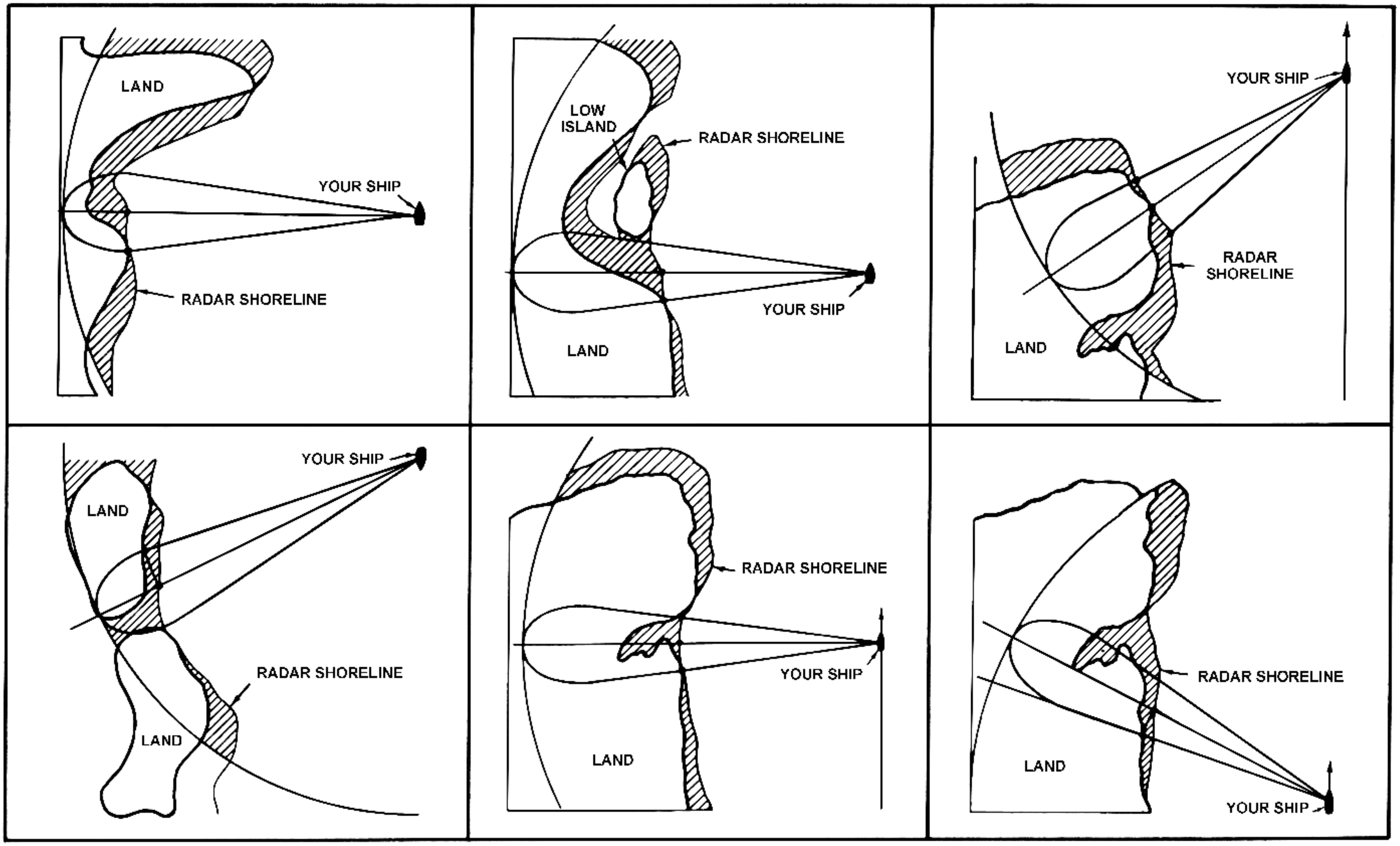

Figure 4.2 - Effects of ship's position, beam width, and pulse length on radar shoreline.

SUMMARY OF DISTORTIONS

Figure 4.3 illustrates the distortion effects of radar shadow, beam width, and pulse length. View A shows the actual shape of the shoreline and the land behind it. Note the steel tower on the low sand beach and the two ships at anchor close to shore. The heavy line in view B represents the shoreline on the PPI. The dotted lines represent the actual position and shape of all targets. Note in particular:

(a) The low sand beach is not detected by the radar.

(b) The tower on the low beach is detected, but it looks like a ship in a cove. At closer range the land would be detected and the cove-shaped area would begin to fill in; then the tower could not be seen without reducing the receiver gain.

(c) The radar shadow behind both mountains. Distortion owing to radar shadows is responsible for more confusion than any other cause. The small island does not appear because it is in the radar shadow.

(d) The spreading of the land in bearing caused by beam width distortion. Look at the upper shore of the peninsula. The shoreline distortion is greater to the west because the angle between the radar beam and the shore is smaller as the beam seeks out the more westerly shore.

(e) Ship No. 1 appears as a small peninsula. Her pip has merged with the land because of the beam width distortion.

(f) Ship No. 2 also merges with the shoreline and forms a bump. This bump is caused by pulse length and beam width distortion. Reducing receiver gain might cause the ship to separate from land, provided the ship is not too close to the shore. The FTC could also be used to attempt to separate the ship from land.

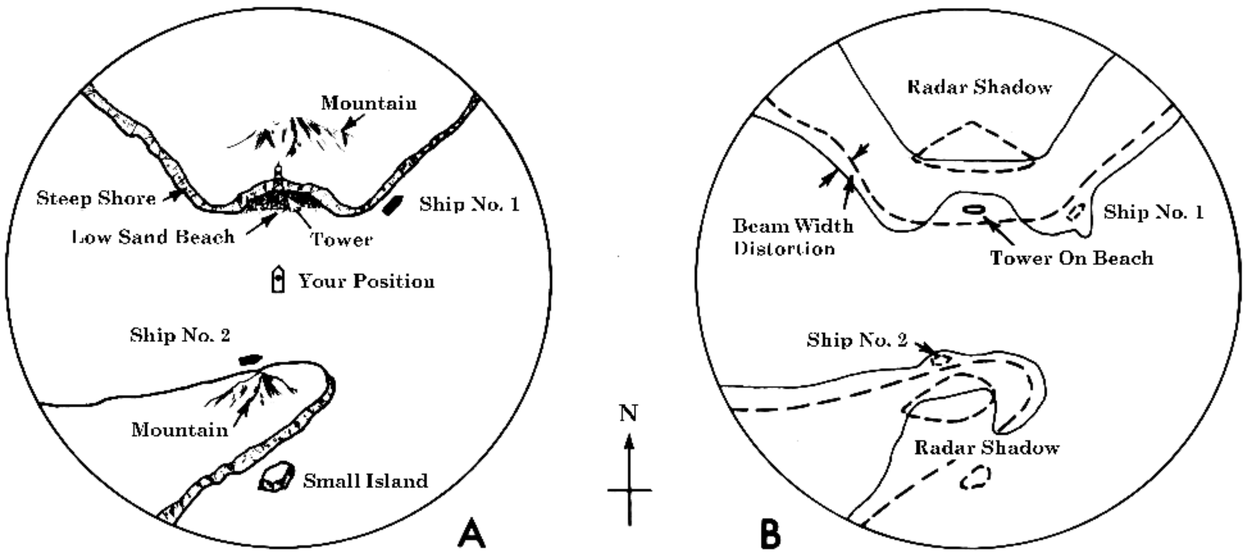

Figure 4.3 - Distortion effects of radar shadow, beam width, and pulse length.

RECOGNITION OF UNWANTED ECHOES AND EFFECTS

The navigator must be able to recognize various abnormal echoes and effects on the radarscope so as not to be confused by their presence.

Indirect (False) Echoes

Indirect or false echoes are caused by reflection of the main lobe of the radar beam off ship's structures such as stacks and kingposts. When such reflection does occur, the echo will return from a legitimate radar contact to the antenna by the same indirect path. Consequently, the echo will appear on the PPI at the bearing of the reflecting surface. This indirect echo will appear on the PPI at the same range as the direct echo received, assuming that the additional distance by the indirect path is negligible (see figure 4.4).

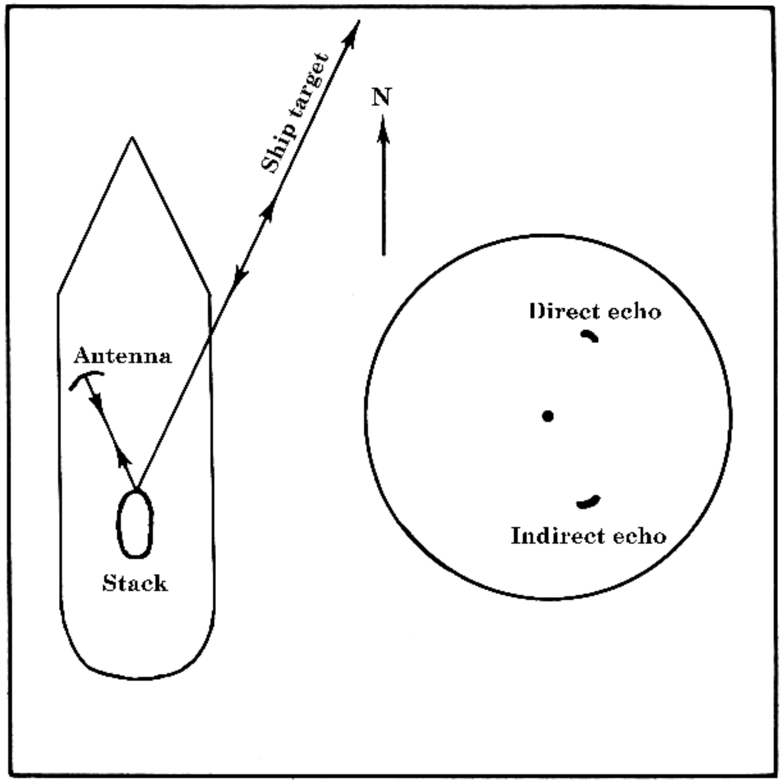

Figure 4.4 - Indirect echo.

Characteristics by which indirect echoes may be recognized are summarized as follows:

(1) The indirect echoes will usually occur in shadow sectors.

(2) They are received on substantially constant bearings although the true bearing of the radar contact may change appreciably.

(3) They appear at the same ranges as the corresponding direct echoes.

(4) When plotted, their movements are usually abnormal.

(5) Their shapes may indicate that they are not direct echoes.

Figure 4.5 illustrates a massive indirect echo such as may be reflected by a landmass.

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Figure 4.5 - Indirect echo reflected by a landmass.

Side-lobe Effects

Side-lobe effects are readily recognized in that they produce a series of echoes on each side of the main lobe echo at the same range as the latter. Semi-circles or even complete circles may be produced. Because of the low energy of the side-lobes, these effects will normally occur only at the shorter ranges. The effects may be minimized or eliminated through use of the gain and anticlutter controls. Slotted wave guide antennas have largely eliminated the side-lobe problem (see figure 4.6).

Multiple Echoes

Multiple echoes may occur when a strong echo is received from another ship at close range. A second or third or more echoes may be observed on the radarscope at double, triple, or other multiples of the actual range of the radar contact (see figure 4.7).

Second-Trace (Multiple-Trace) Echoes

Second-trace echoes (multiple-trace echoes) are echoes received from a contact at an actual range greater than the radar range setting. If an echo from a distant target is received after the following pulse has been transmitted, the echo will appear on the radarscope at the correct bearing but not at the true range. Second-trace echoes are unusual except under abnormal atmospheric conditions, or conditions under which super-refraction is present. Second-trace echoes may be recognized through changes in their positions on the radarscope on changing the pulse repetition rate (PRR); their hazy, streaky, or distorted shape; and their erratic movements on plotting.

As illustrated in figure 4.8, a target pip is detected on a true bearing of 090˚ at a distance of 7.5 miles. On changing the PRR from 2000 to 1800 pulses per second, the same target is detected on a bearing of 090˚ at a distance of 3 miles (see figure 4.9). The change in the position of the pip indicates that the pip is a second-trace echo. The actual distance of the target is the distance as indicated on the PPI plus half the distance the radar wave travels between pulses.

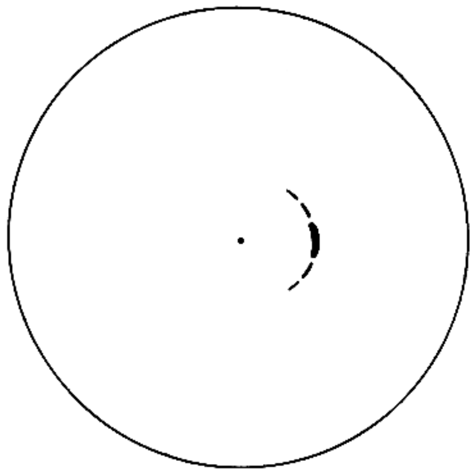

Figure 4.6 - Side-lobe effects.

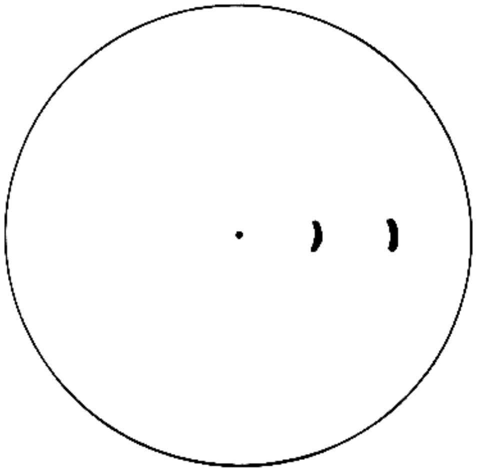

Figure 4.7 - Multiple echoes.

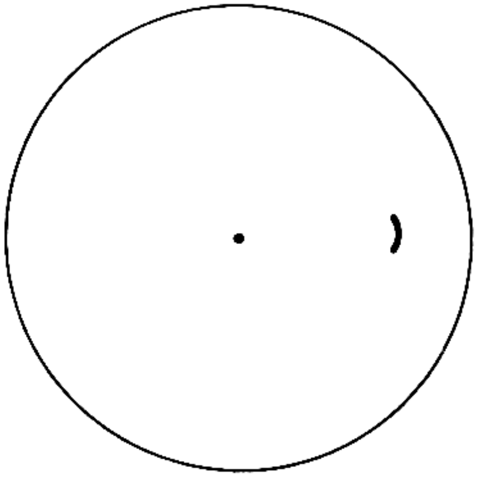

Figure 4.8 - Second-trace echo on 12-mile range scale.

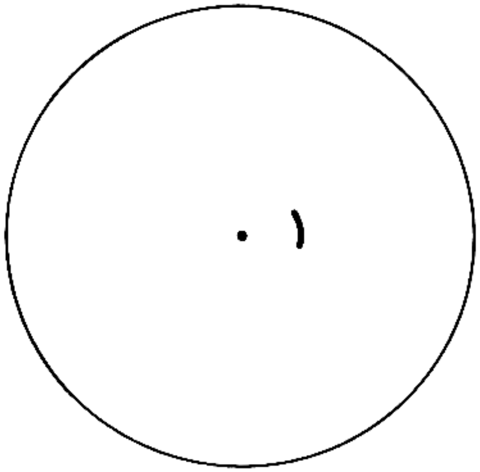

Figure 4.9 - Position of second-trace echo on 12-mile range scale after changing PRR.

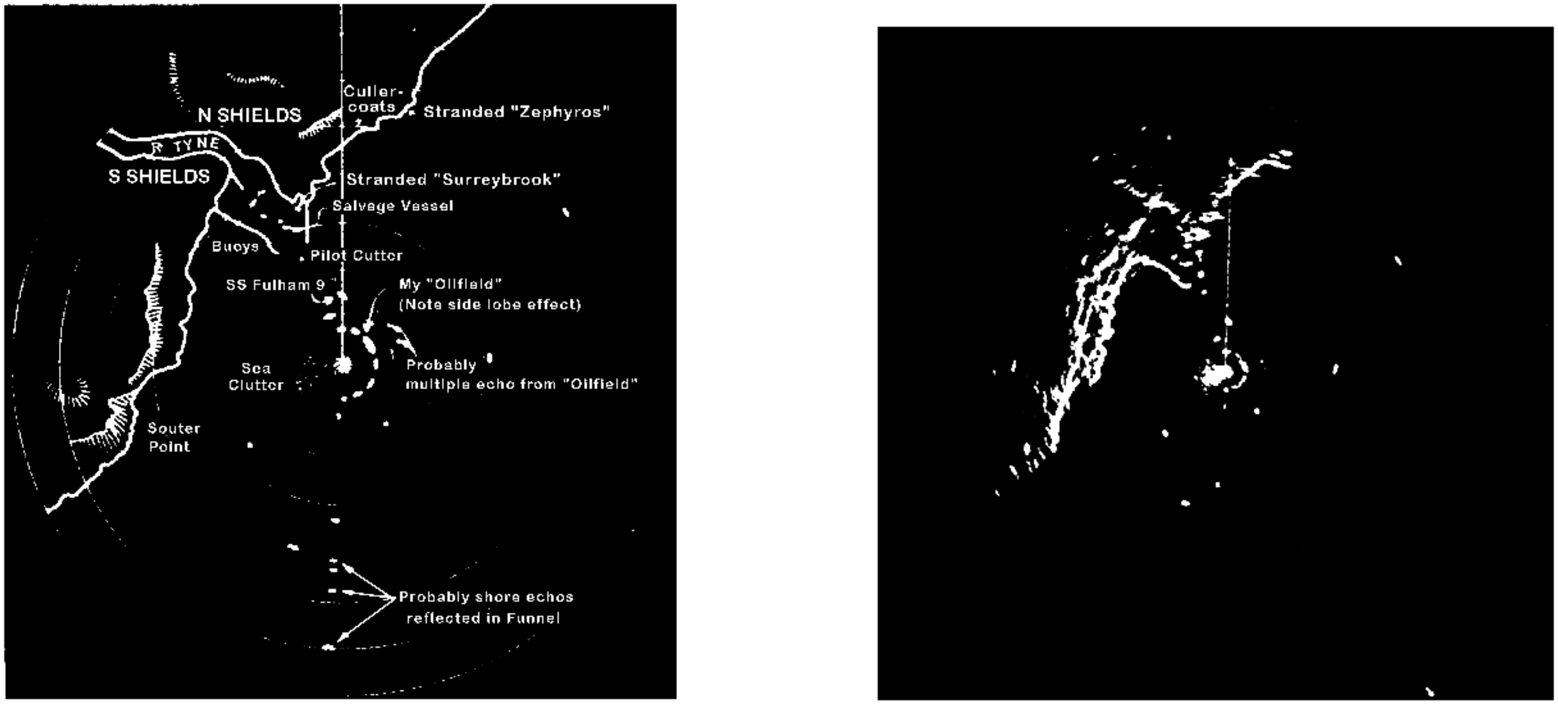

Figure 4.10 - Normal, indirect, multiple, and side echoes.

Figure 4.10 illustrates normal, indirect, multiple, and side echoes on a PPI with an accompanying annotated sketch.

Electronic Interference Effects

Electronic interference effects, such as may occur when in the vicinity of another radar operating in the same frequency band as that of the observer's ship, is usually seen on the PPI as a large number of bright dots either scattered at random or in the form of dotted lines extending from the center to the edge of the PPI.

Interference effects are greater at the longer radar range scale settings. The interference effects can be distinguished easily from normal echoes because they do not appear in the same places on successive rotations of the antenna.

Blind and Shadow Sectors

Stacks, masts, samson posts, and other structures may cause a reduction in the intensity of the radar beam beyond these obstructions, especially if they are close to the radar antenna. If the angle at the antenna subtended by the obstruction is more than a few degrees, the reduction of the intensity of the radar beam beyond the obstruction may be such that a blind sector is produced. With lesser reduction in the intensity of the beam beyond the obstructions, shadow sectors, as illustrated in figure 4.11, can be produced. Within these shadow sectors, small targets at close range may not be detected while larger targets at much greater ranges may be detected.

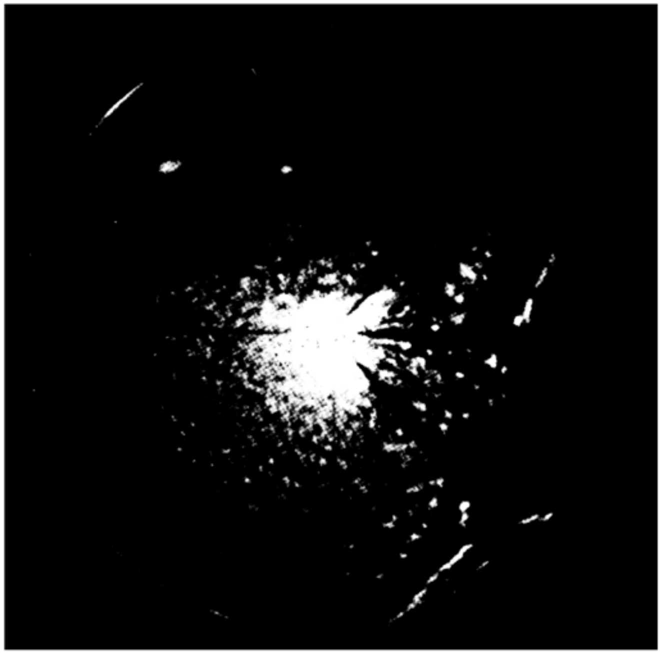

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Figure 4.11 - Shadow sectors.

Spoking

Spoking appears on the PPI as a number of spokes or radial lines. Spoking is easily distinguished from interference effects because the lines are straight on all range-scale settings and are lines rather than a series of dots.

The spokes may appear all around the PPI, or they may be confined to a sector. Should the spoking be confined to a narrow sector, the effect can be distinguished from a ramark signal of similar appearance through observation of the steady relative bearing of the spoke in a situation where the bearing of the ramark signal should change. The appearance of spoking is indicative of need for equipment maintenance.

Sectoring

The PPI display may appear as alternately normal and dark sectors. This phenomenon is usually due to the automatic frequency control being out of adjustment.

Serrated Range Rings

The appearance of serrated range rings is indicative of need for equipment maintenance.

PPI Display Distortion

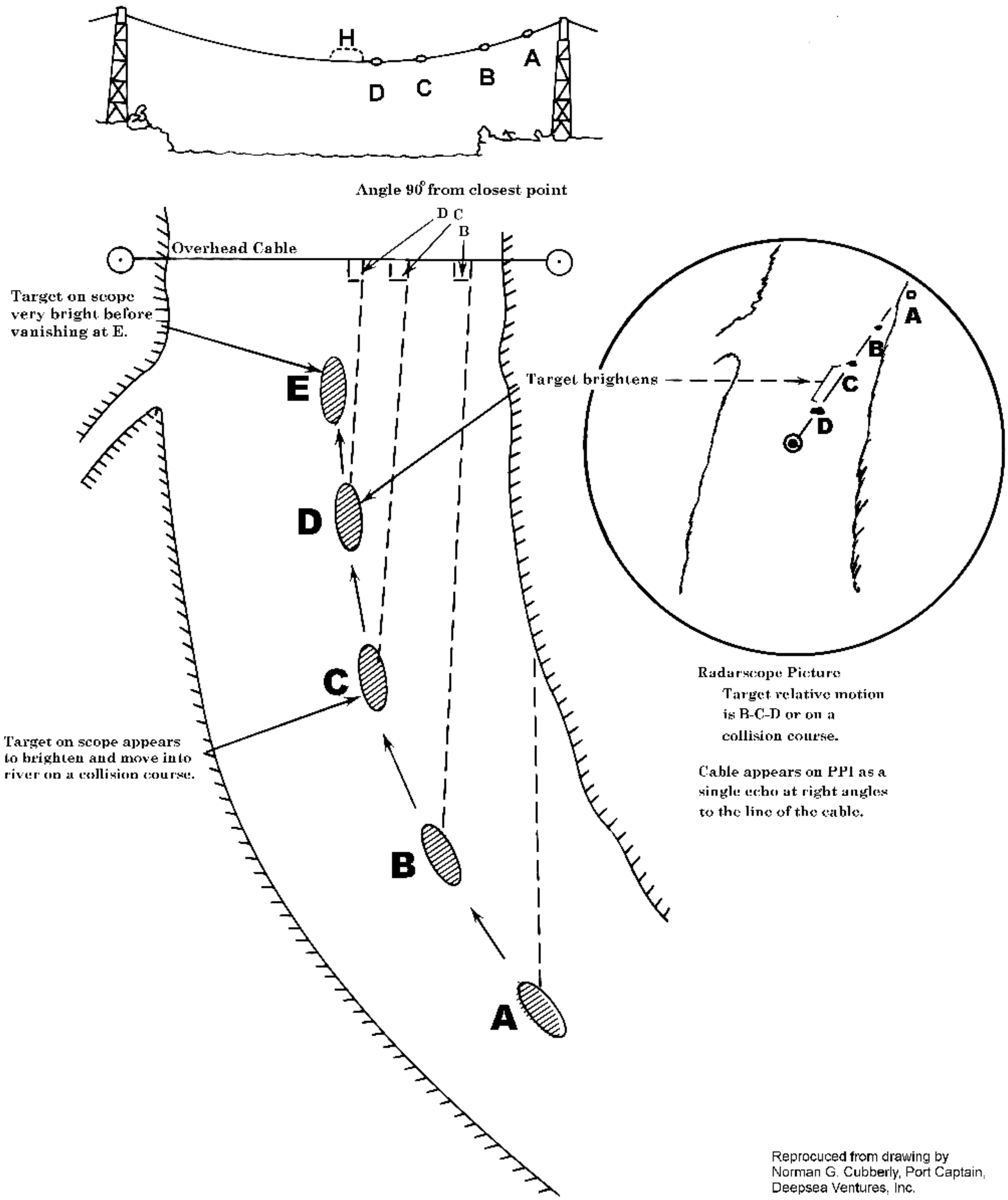
After the radar set has been turned on, the display may not spread immediately to the whole of the PPI because of static electricity inside the CRT. Usually, this static electricity effect, which produces a distorted PPI display, lasts no longer than a few minutes.

Hour-Glass Effect

Hour-glass effect appears as either a constriction or expansion of the display near the center of the PPI. The expansion effect is similar in appearance to the expanded center display. This effect, which can be caused by a nonlinear time base or the sweep not starting on the indicator at the same instant as the transmission of the pulse, is most apparent when in narrow rivers or close to shore.

Overhead Cable Effect

The echo from an overhead power cable appears on the PPI as a single echo always at right angles to the line of the cable. If this phenomenon is not recognized, the echo can be wrongly identified as the echo from a ship on a steady bearing. Avoiding action results in the echo remaining on a constant bearing and moving to the same side of the channel as the ship altering course. This phenomenon is particularly apparent for the power cable spanning the Straits of Messina. See figure 4.12 for display of overhead cable effect.



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Deepsea Ventures, Inc.

Figure 4.12 - Overhead cable effect.

AIDS TO RADAR NAVIGATION

Various aids to radar navigation have been developed to aid the navigator in identifying radar targets and for increasing the strength of the echoes received from objects which otherwise are poor radar targets.

RADAR REFLECTORS

Buoys and small boats, particularly those boats constructed of wood, are poor radar targets. Weak fluctuating echoes received from these targets are easily lost in the sea clutter on the radarscope. To aid in the detection of these targets, radar reflectors, of the corner reflector type, may be used. The corner reflectors may be mounted on the tops of buoys or the body of the buoy may be shaped as a corner reflector, as illustrated in figure 4.13.

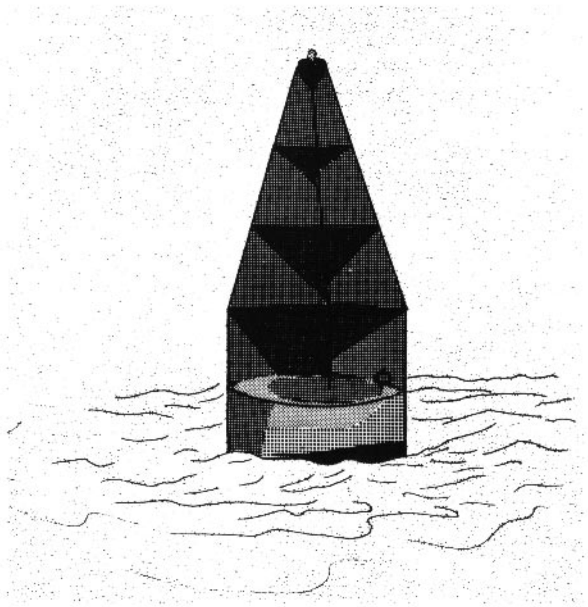

Figure 4.13 - Radar reflector buoy.

Each corner reflector illustrated in figure 4.14 consists of three mutually perpendicular flat metal surfaces.

A radar wave on striking any of the metal surfaces or plates will be reflected back in the direction of its source, i.e., the radar antenna. Maximum energy will be reflected back to the antenna if the axis of the radar beam makes equal angles with all the metal surfaces. Frequently corner reflectors are assembled in clusters to insure receiving strong echoes at the antenna.

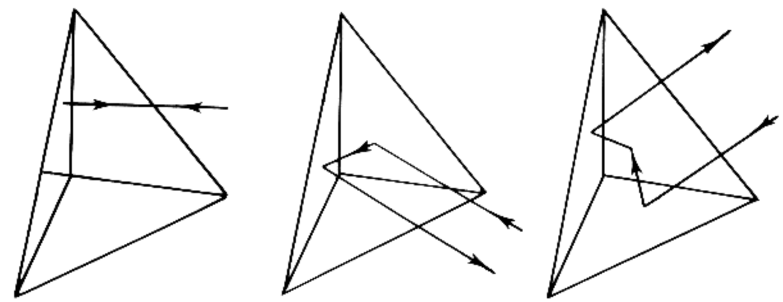

Figure 4.14 - Corner reflectors.

RADAR BEACONS

While radar reflectors are used to obtain stronger echoes from radar targets, other means are required for more positive identification of radar targets. Radar beacons are transmitters operating in the marine radar frequency band which produce distinctive indications on the radarscopes of ships within range of these beacons. There are two general classes of these beacons: *racon* which provides both bearing and range information to the target and *ramark* which provides bearing information only. However, if the ramark installation is detected as an echo on the radarscope, the range will be available also.

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Figure 4.15 - Racon signal.

Racon

Racon is a radar transponder which emits a characteristic signal when triggered by a ship's radar. The signal may be emitted on the same frequency as that of the triggering radar, in which case it is automatically superimposed on the ship's radar display. The signal may be emitted on a separate frequency, in which case to receive the signal the ship's radar receiver must be capable of being tuned to the beacon frequency or a special receiver must be used. In either case, the PPI will be blank except for the beacon signal.

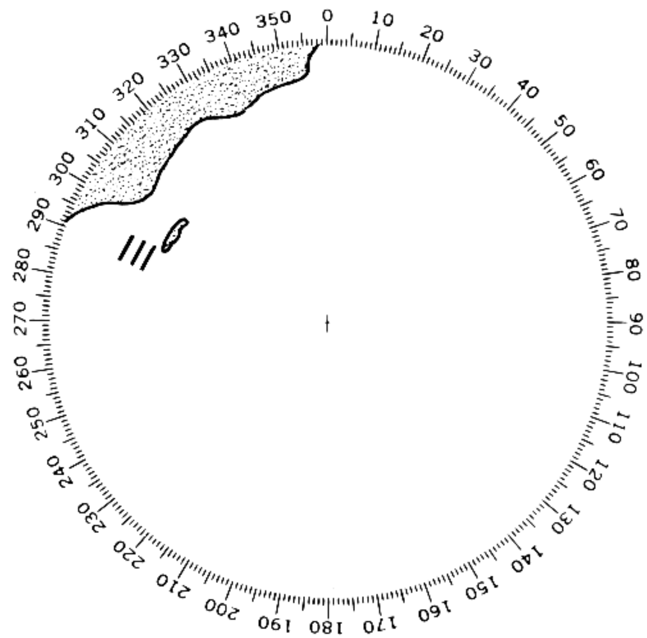


Figure 4.16 - Coded racon signal.

"Frequency agile" racons are now in widespread use. They respond to both 3 and 10 centimeter radars.

The racon signal appears on the PPI as a radial line originating at a point just beyond the position of the radar beacon or as a Morse code signal displayed radially from just beyond the beacon (see figures 4.15 and 4.16).

Racons are being used as ranges or leading lines. The range is formed by two racons set up behind each other with a separation in the order of 2 to 4 nautical miles. On the PPI scope the "paint" received from the front and rear racons form the range.

Some bridges are now equipped with racons which are suspended under the bridge to provide guidance for safe passage.

The maximum range for racon reception is limited by line of sight.

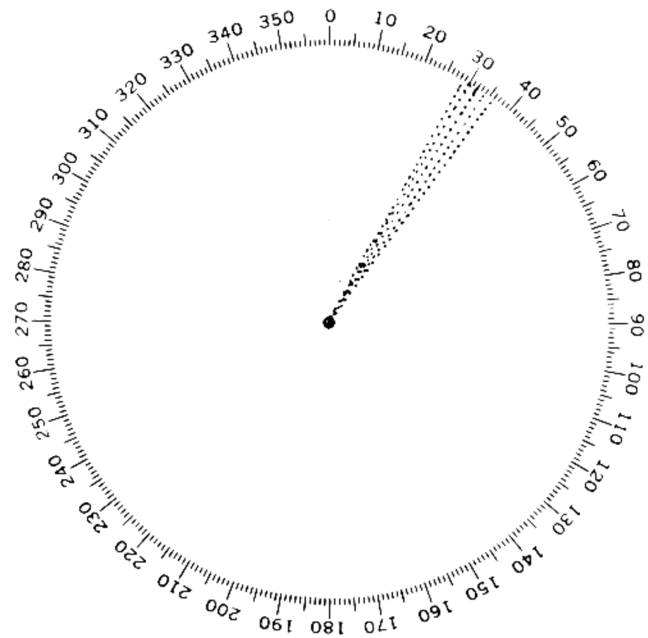


Figure 4.17 - Ramark signal appearing as a dotted line.

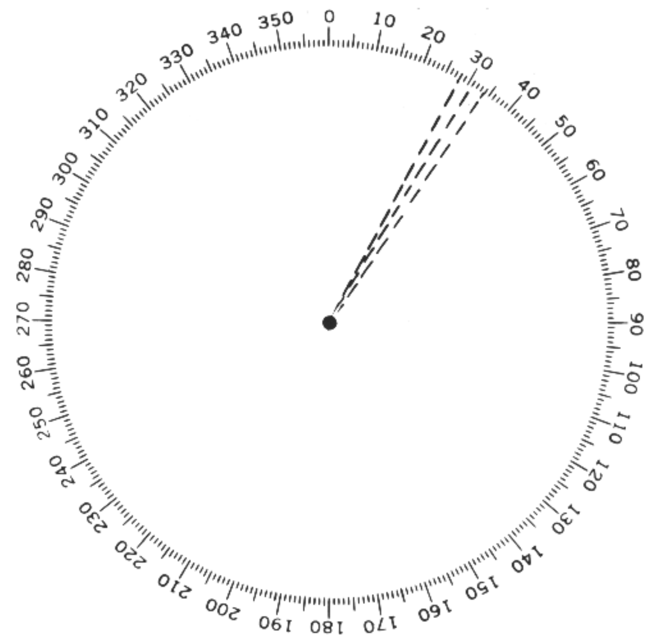


Figure 4.18 - Ramark signal appearing as a dashed line.

Ramark

Ramark is a radar beacon which transmits either continuously or at intervals. The latter method of transmission is used so that the PPI can be inspected without any clutter introduced by the ramark signal on the scope. The ramark signal as it appears on the PPI is a radial line from the center. The radial line may be a continuous narrow line, a series of dashes, a series of dots, or a series of dots and dashes (see figures 4.17 and 4.18).

RANGE AND BEARING TO A SINGLE OBJECT

Preferably, radar fixes obtained through measuring the range and bearing to a single object should be limited to small, isolated fixed objects which can be identified with reasonable certainty. In many situations, this method may be the only reliable method which can be employed. If possible, the fix should be based upon a radar range and visual gyro bearing because radar bearings are less accurate than visual gyro bearings. A primary advantage of the method is the rapidity with which a fix can be obtained. A disadvantage is that the fix is based upon only two intersecting position lines, a bearing line and a range arc, obtained from observations of the same object. Identification mistakes can lead to disaster.

TWO OR MORE BEARINGS

Generally, fixes obtained from radar bearings are less accurate than those obtained from intersecting range arcs. The accuracy of fixing by this method is greater when the center bearings of small, isolated, radar-conspicuous objects can be observed.

Because of the rapidity of the method, the method affords a means for initially determining an approximate position for subsequent use in more reliable identification of objects for fixing by means of two or more ranges.

TANGENT BEARINGS

Fixing by tangent bearings is one of the least accurate methods. The use of tangent bearings with a range measurement can provide a fix of reasonably good accuracy.

As illustrated in figure 4.19, the tangent bearing lines intersect at a range from the island observed less than the range as measured because of beam width distortion. Right tangent bearings should be decreased by an estimate of half the horizontal beam width. Left tangent bearings should be increased by the same amount. The fix is taken as that point on the range arc midway between the bearing lines.

It is frequently quite difficult to correlate the left and right extremities of the island as charted with the island image on the PPI. Therefore, even with compensation for half of the beam width, the bearing lines usually will not intersect at the range arc.

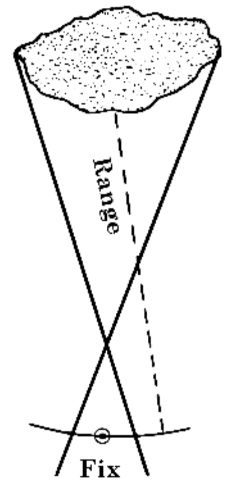


Figure 4.19 - Fixing by tangent bearings and radar range.

TWO OR MORE RANGES

In many situations, the more accurate radar fixes are determined from nearly simultaneous measurements of the ranges to two or more fixed objects. Preferably, at least three ranges should be used for the fix. The number of ranges which it is feasible to use in a particular situation is dependent upon the time required for identification and range measurements. In many situations, the use of more than three range arcs for the fix may introduce excessive error because of the time lag between measurements.

If the most rapidly changing range is measured first, the plot will indicate less progress along the intended track than if it were measured last. Thus, less lag in the radar plot from the ship's actual position is obtained through measuring the most rapidly changing ranges last.

Similar to a visual cross-bearing fix, the accuracy of the radar fix is dependent upon the angles of cut of the intersecting position lines (range arcs). For greater accuracy, the objects selected should provide range arcs with angles of cut as close to 90˚ as is possible. In cases where two identifiable objects lie in opposite or nearly opposite directions, their range arcs, even though they may intersect at a small angle of cut or may not actually intersect, in combination with another range arc intersecting them at an angle approaching 90˚, may provide a fix of high accuracy (see figure 4.20). The near tangency of the two range arcs indicates accurate measurements and good reliability of the fix with respect to the distance off the land to port and starboard.

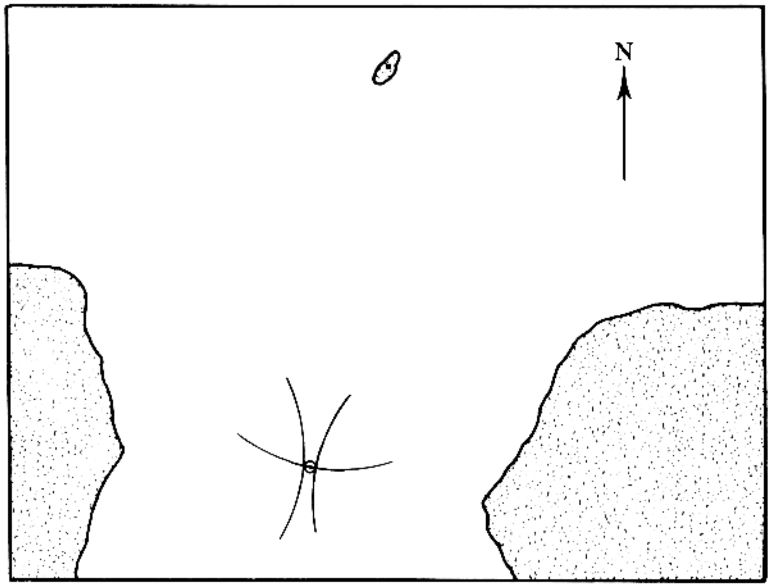


Figure 4.20 - Radar fix.

Small, isolated, radar-conspicuous fixed objects afford the most reliable and accurate means for radar fixing when they are so situated that their associated range arcs intersect at angles approaching 90˚.

Figure 4.21 illustrates a fix obtained by measuring the ranges to three well situated radar-conspicuous objects. The fix is based solely upon range measurements in that radar ranges are more accurate than radar bearings even when small objects are observed. Note that in this rather ideal situation, a point fix was not obtained. Because of inherent radar errors, any point fix should be treated as an accident dependent upon plotting errors, the scale of the chart, etc.

While observed radar bearings were not used in establishing the fix as such, the bearings were useful in the identification of the radar-conspicuous objects.

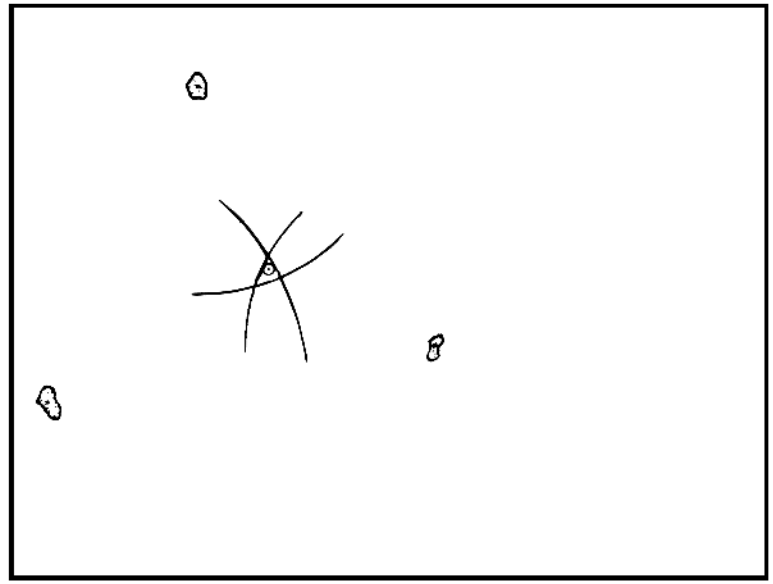


Figure 4.21 - Fix by small, isolated radar-conspicuous objects.

As the ship travels along its track, the three radar-conspicuous objects still afford good fixing capability until such time as the angles of cut of the range arcs have degraded appreciably. At such time, other radar-conspicuous objects should be selected to provide better angles of cut. Preferably, the first new object should be selected and observed before the angles of cut have degraded appreciably. Incorporating the range arc of the new object with range arcs of objects which have provided reliable fixes affords more positive identification of the new object.

MIXED METHODS

While fixing by means of intersecting range arcs, the usual case is that two or more small, isolated, and conspicuous objects, which are well situated to provide good angles of cut, are not available. The navigator must exercise considerable skill in radarscope interpretation to estimate which charted features are actually displayed. If initially there are no well defined features displayed and there is considerable uncertainty as to the ship's position, the navigator may observe the radar bearings of features tentatively identified as a step towards their more positive identification. If the cross-bearing fix does indicate that the features have been identified with some degree of accuracy, the estimate of the ship's position obtained from the cross-bearing fix can be used as an aid in subsequent interpretation of the radar display. With better knowledge of the ship's position, the factors affecting the distortion of the radar display can be used more intelligently in the course of more accurate interpretation of the radar display.

Frequently there is at least one object available which, if correctly identified, can enable fixing by the range and bearing to a single object method. A fix so obtained can be used as an aid in radarscope interpretation for fixing by two or more intersecting range arcs.

The difficulties which may be encountered in radarscope interpretation during a transit may be so great that accurate fixing by means of range arcs is not obtainable. In such circumstances, range arcs having some degree of accuracy can be used to aid in the identification of objects used with the range and bearing method.

With correct identification of the object observed, the accuracy of the fix obtained by the range and bearing to a single object method usually can be improved through the use of a visual gyro bearing instead of the radar bearing. Particularly during periods of low visibility, the navigator should be alert for visual bearings of opportunity.

While the best method or combination of methods for a particular situation must be left to the good judgment of the experienced navigator, factors affecting method selection include:

(1) The general need for redundancy—but not to such extent that too much is attempted with too little aid or means in too little time.
(2) The characteristics of the radar set.
(3) Individual skills.
(4) The navigational situation, including the shipping situation.
(5) The difficulties associated with radarscope interpretation.
(6) Angles of cut of the position lines.

PRECONSTRUCTION OF RANGE ARCS

Small, isolated, radar-conspicuous objects permit preconstruction of range arcs on the chart to expedite radar fixing. This preconstruction is possible because the range can be measured to the same point on each object, or nearly so, as the aspect changes during the transit. With fixed radar targets of lesser conspicuous, the navigator, generally, must continually change the centers of the range arcs in accordance with his interpretation of the radarscope.

To expedite plotting further, the navigator may also preconstruct a series of bearing lines to the radar-conspicuous objects. The degree of preconstruction of range arcs and bearing lines is dependent upon acceptable chart clutter resulting from the arcs and lines added to the chart. Usually, preconstruction is limited to a critical part of a passage or to the approach to an anchorage.

CONTOUR METHOD

The contour method of radar navigation consists of constructing a land contour on a transparent template according to a series of radar ranges and bearings and then fitting the template to the chart. The point of origin of the ranges and bearings defines the fix.

This method may provide means for fixing when it is difficult to correlate the landmass image on the PPI with the chart because of a lack of features along the shoreline which can be identified individually. The accuracy of the method is dependent upon the navigator's ability to estimate the contours of the land most likely to be reflecting the echoes forming the landmass image on the PPI. Even with considerable skill in radarscope interpretation, the navigator can usually obtain only an approximate fit of the template contour with the estimated land contour. There may be relatively large gaps in the fit caused by radar shadow effects. Thus, there may be considerable uncertainty with respect to the accuracy of the point fix. The contour method is most feasible when the land rises steeply at or near the shoreline, thus enabling a more accurate estimate of the reflecting surfaces.

Figure 4.22 illustrates a rectangular template on the bottom side of which radials are drawn at 5-degree intervals. The radials are drawn from a small hole, which is the position of the radar fix when the template is fitted to the chart.

In making preparation for use of the template, the template is tacked to the range (distance) scale of the chart. As the ranges and bearings to shore are measured at 5 or 10-degree intervals, the template is rotated about the zero-distance graduation and marked accordingly. A contour line is faired through the marks on each radial.

On initially fitting the contour template to the chart, the template should be oriented to true north. Because of normal bearing errors in radar observations, the template will not necessarily be aligned with true north when the best fit is obtained subsequently.

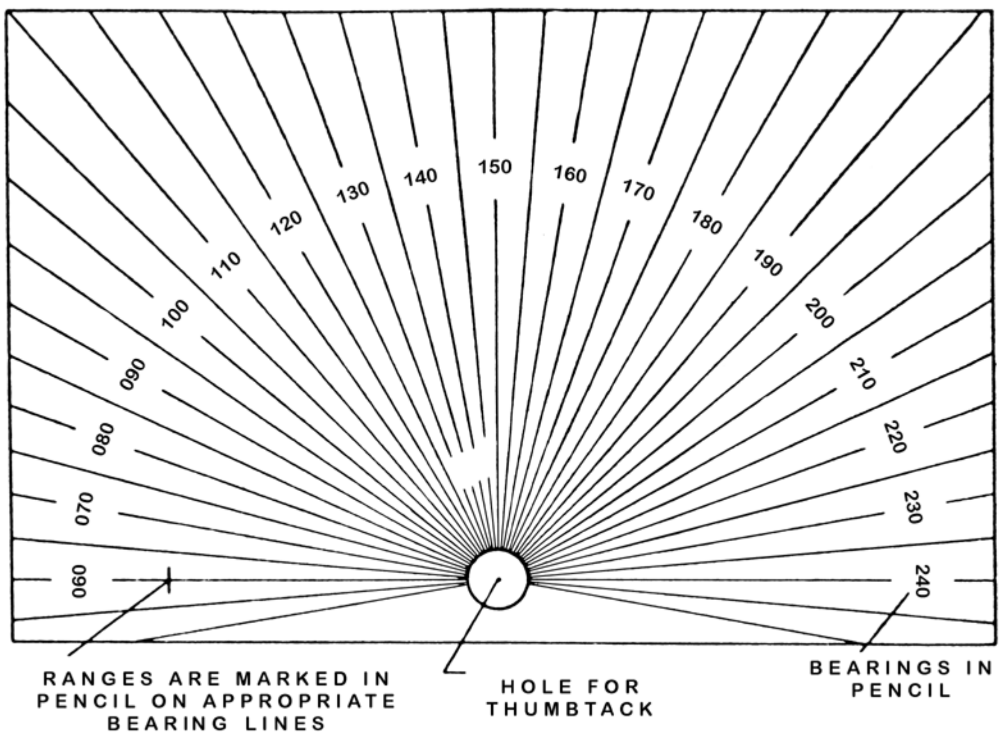


Figure 4.22 - Transparent template used with contour method.

IDENTIFYING A RADAR-INCONSPICUOUS OBJECT

Situation:

There is doubt that a pip on the PPI represents the echo from a buoy, a radar-inconspicuous object. On the chart there is a radar-conspicuous object, a rock, in the vicinity of the buoy. The pip of the rock is identified readily on the PPI.

Required:

Identify the pip which is in doubt.

Solution:

(1) Measure the bearing and distance of the buoy from the rock on the chart.
(2) Determine the length of this distance on the PPI according to the range scale setting.
(3) Rotate the parallel-line cursor to the bearing of the buoy from the rock (see figure 4.23).
(4) With rubber-tipped dividers set to the appropriate PPI length, set one point over the pip of the rock; using the parallel lines of the cursor as a guide, set the second point in the direction of the bearing of the buoy from the rock.
(5) With the dividers so set, the second point lies over the unidentified pip. Subject to the accuracy limitations of the measurements and normal prudence, the pip may be evaluated as the echo received from the buoy.

Note:

During low visibility a radar-conspicuous object can be used similarly to determine whether another ship is fouling an anchorage berth.

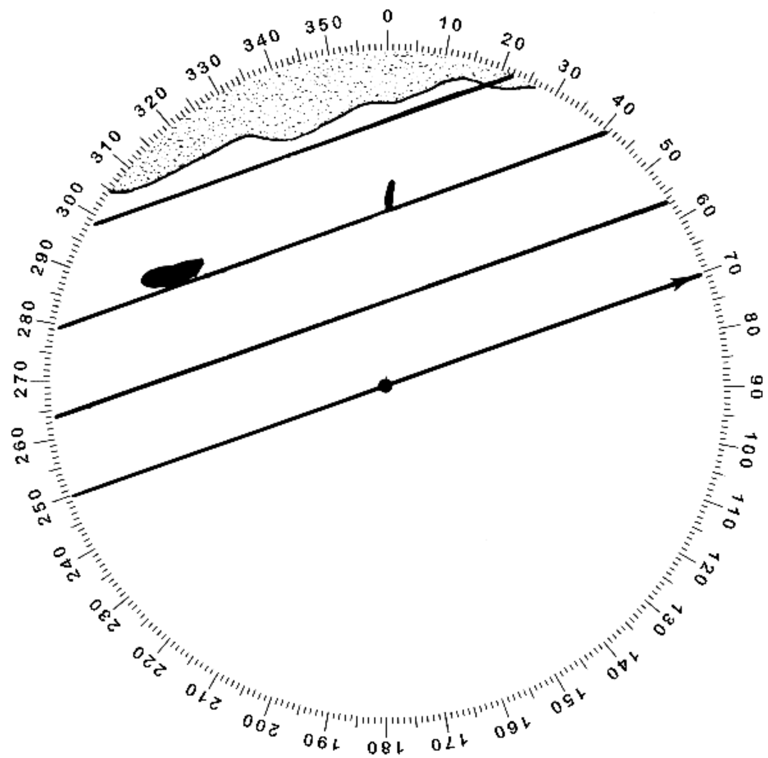


Figure 4.23 - Use of parallel-line cursor to identify radar-inconspicuous object.

FINDING COURSE AND SPEED MADE GOOD BY PARALLEL-LINE CURSOR

Situation:

A ship steaming in fog detects a prominent rock by radar. Because of the unknown effects of current and other factors, the navigator is uncertain of the course and speed being made good.

Required:

To determine the course and speed being made good.

Solution:

(1) Make a timed plot of the rock on the reflection plotter.
(2) Align the parallel-line cursor with the plot to determine the course being made good, which is in a direction opposite to the relative movement (see figure 4.24).
(3) Measure the distance between the first and last plots and using the time interval, determine the speed of relative movement. Since the rock is stationary, the relative speed is equal to that of the ship.

Note:

This basic technique is useful for determining whether the ship is being set off the intended track in pilot waters. Observing a radar-conspicuous object and using the parallel-line cursor, a line is drawn through the radar-conspicuous object in a direction opposite to own ship's course.

By observing the successive positions of the radar-conspicuous object relative to this line, the navigator can determine whether the ship is being set to the left or right of the intended track.

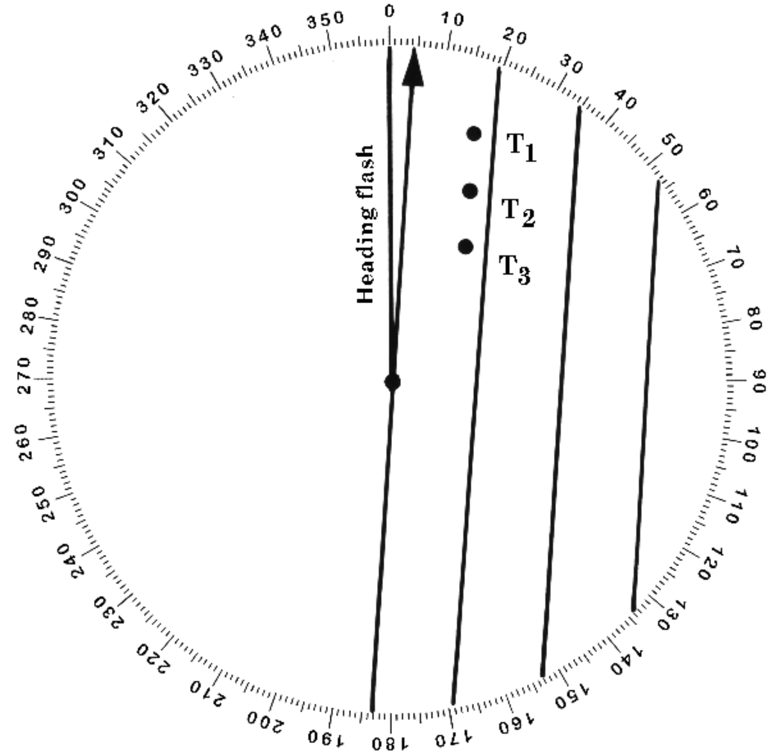


Figure 4.24 - Use of parallel-line cursor to find course and speed made good.

USE OF PARALLEL-LINE CURSOR FOR ANCHORING

Situation:

A ship is making an approach to an anchorage on course 290˚. The direction of the intended track to the anchorage is 290˚. Allowing for the radius of the letting go circle, the anchor will be let go when a radar-conspicuous islet is 1.0 mile ahead of the ship on the intended track. A decision is made to use a parallel-line cursor technique to keep the ship on the intended track during the last mile of the approach to the anchorage and to determine the time for letting go. Before the latter decision was made, the navigator's interpretation of the stabilized relative motion display revealed that, even with change in aspect, the radar image of a jetty to starboard could be used to keep the ship on the intended track.

Required:

Make the approach to the anchorage on the intended track and let the anchor go when the islet is 1.0 mile ahead along the intended track.

Solution:

(1) From the chart determine the distance at which the head of the jetty will be passed abeam when the ship is on course and on the intended track.
(2) Align the parallel-line cursor with the direction of the intended track, 290˚ (see figure 4.25).
(3) Using the parallel lines of the cursor as a guide, draw, at a distance from the center of the PPI as determined in step (2), the relative movement line for the head of the jetty in a direction opposite to the direction of the intended track.
(4) Make a mark at 290˚ and 1.0 mile from the center of the PPI; label this mark "LG" for letting go.
(5) Make another mark at 290˚ and 1.0 mile beyond the LG mark; label this mark "1".
(6) Subdivide the radial between the marks made in steps (4) and (5). This subdivision may be limited to 0.1 mile increments from the LG mark to the 0.5 mile graduation.
(7) If the ship is on the intended track, the RML should extend from the radar image of the head of the jetty. If the ship keeps on the intended track, the image of the jetty will move along the RML. If the ship deviates from the intended track, the image of the jetty will move away from the RML. Corrective action is taken to keep the image of the jetty on the RML.
(8) With the ship being kept on the intended track by keeping the image of the jetty on the RML, the graduations of the radial in the direction of the intended track provide distances to go. When the mark labeled "1" just touches the leading edge of the pip of the islet ahead, there is 1 mile to go. When the mark label ".5" just touches the leading edge of the latter pip, there is 0.5 mile to go, etc. The anchor should be let go when the mark labeled "LG" just touches the leading edge of the pip of the islet.

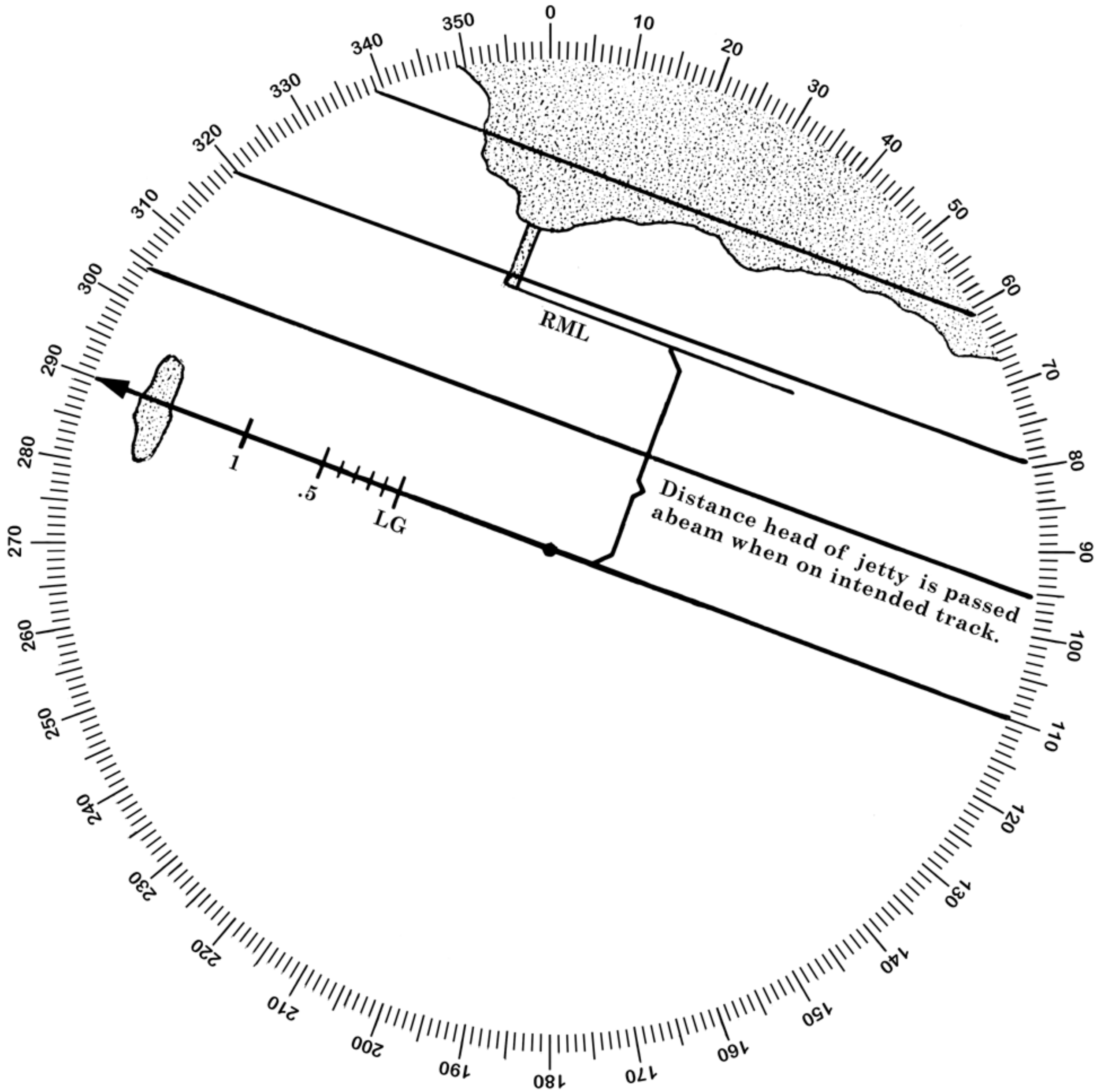


Figure 4.25 - Use of parallel-line cursor for anchoring.

PARALLEL INDEXING

Parallel Indexing has been used for many years. It was defined by William Burger in the *Radar Observers Handbook* (1957, page. 98) as equidistantly spaced parallel lines engraved on a transparent screen which fits on the PPI and can be rotated. This concept of using parallel lines to assist in navigation has been extensively used in Europe to assist in maintaining a specified track, altering course and anchoring. It is best suited for use with a stabilized radar. When using an unstabilized radar, it can pose some danger to an individual that is unaware of problems inherent in this type of display.

With the advent of ARPA with movable EBLs (Electronic Bearing Lines) and Navigation Lines, parallel indexing on screen can be accomplished with greater accuracy. Index lines that are at exact bearings and distances off can be displayed with greater ease. A number of diagrams are included on the pages that follow to explain the use of parallel indexing techniques as well as its misuse.

Cross Index Range (“C”)

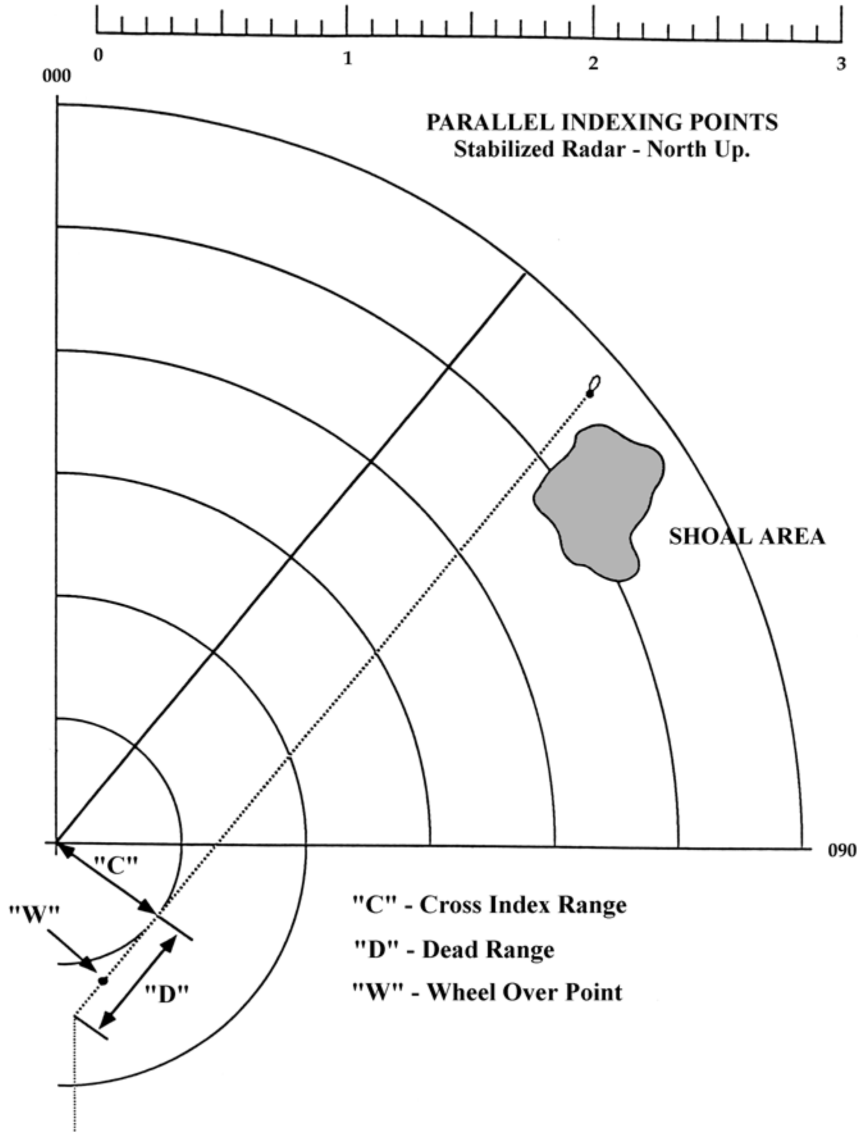
The distance of an object when abeam if the vessel was to pass the navigation mark. A parallel line is drawn through this mark. The perpendicular distance from the center of the display to this parallel line is the *Cross Index Range* (1964, Admiralty Manual of Navigation).

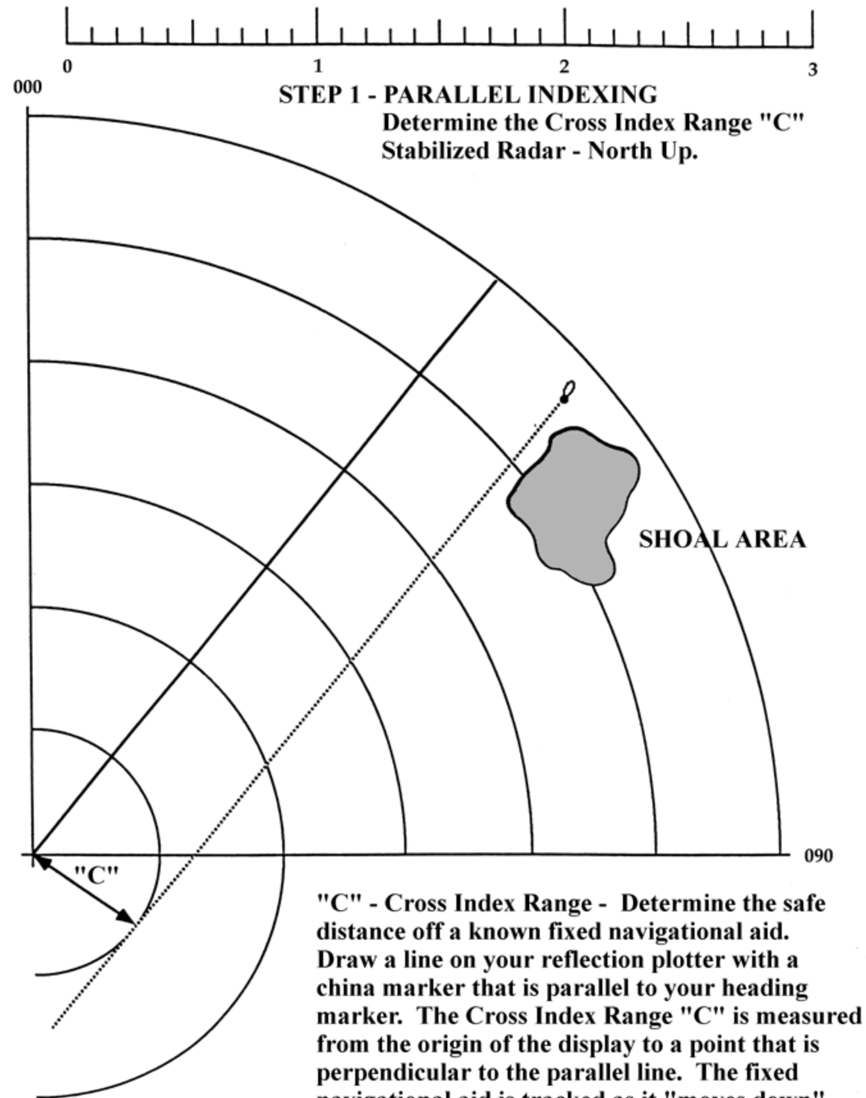
Dead Range (“D”)

The distance at which an object tracking on a parallel line would be on a new track line (ahead of or behind the beam bearing of the object).

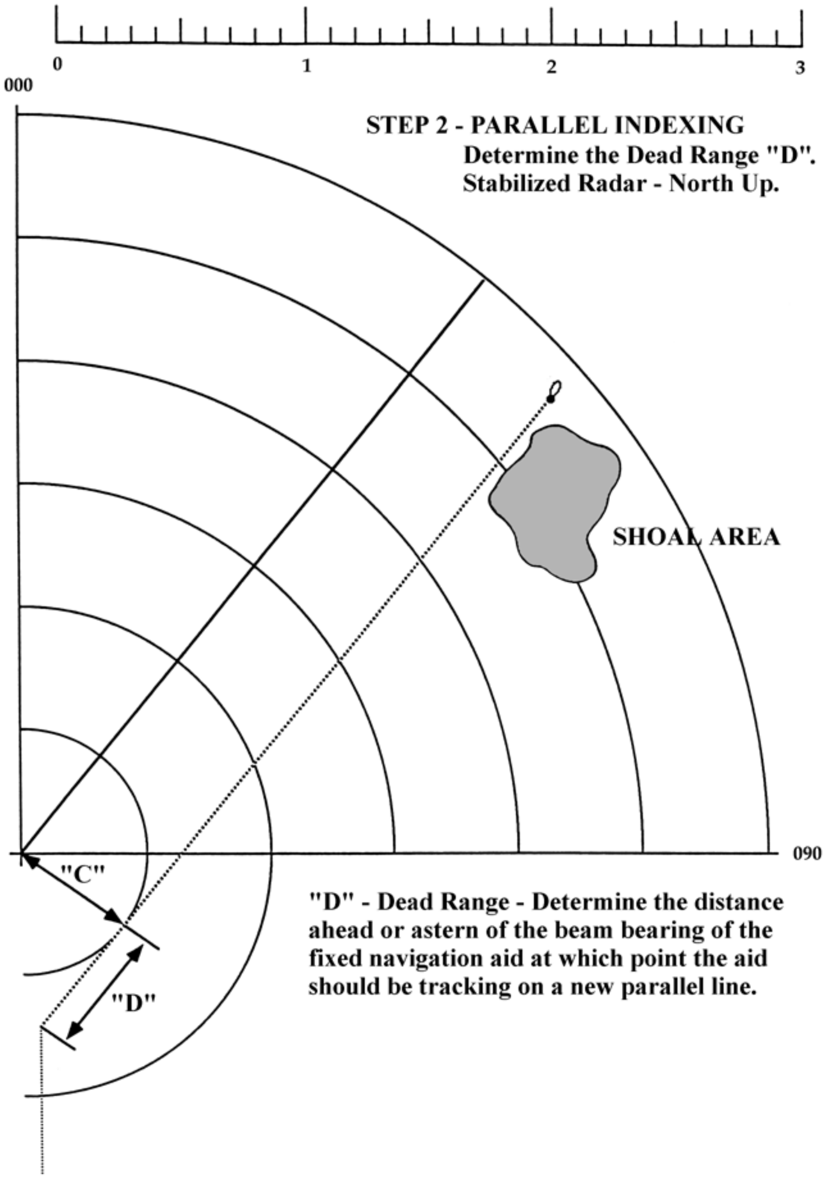
Wheel Over Point (“W”)

The point at which the actual maneuver is made to insure that the object being “indexed” is on the new track line taking into account the advance and transfer of the vessel.



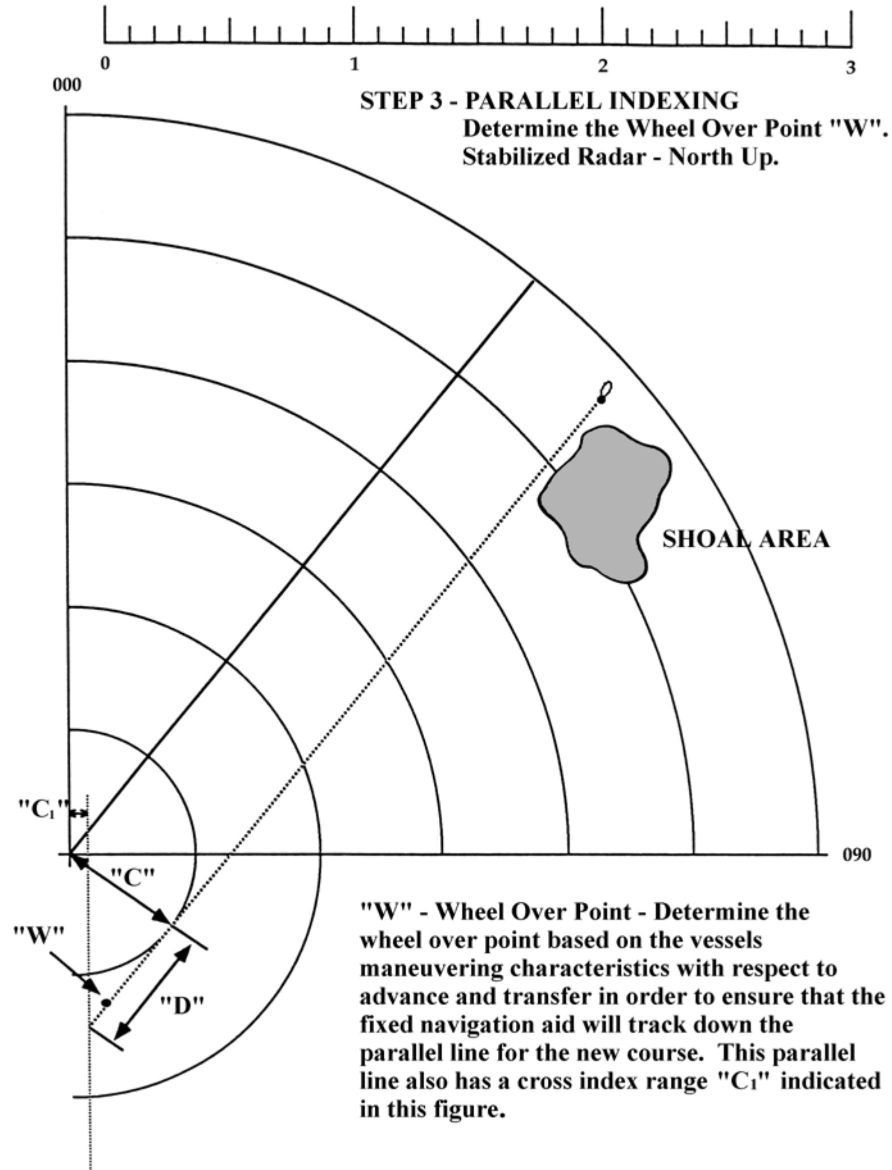


"C" - Cross Index Range - Determine the safe distance off a known fixed navigational aid. Draw a line on your reflection plotter with a china marker that is parallel to your heading marker. The Cross Index Range "C" is measured from the origin of the display to a point that is perpendicular to the parallel line. The fixed navigational aid is tracked as it "moves down" the parallel line. If the navigational aid moves off the parallel line, there is a set and drift present.



STEP 2 - PARALLEL INDEXING
Determine the Dead Range "D".
Stabilized Radar - North Up.

"D" - Dead Range - Determine the distance ahead or astern of the beam bearing of the fixed navigation aid at which point the aid should be tracking on a new parallel line.

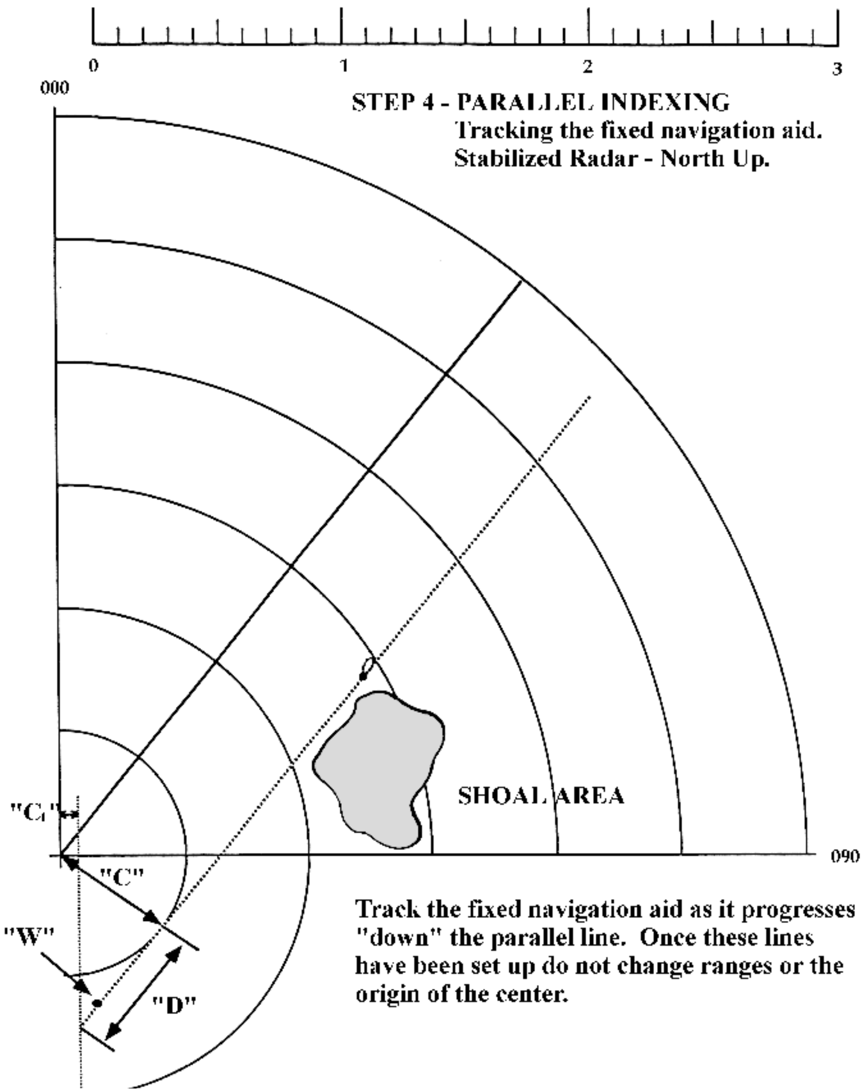


STEP 3 - PARALLEL INDEXING
Determine the Wheel Over Point "W".
Stabilized Radar - North Up.

"W" - Wheel Over Point - Determine the wheel over point based on the vessels maneuvering characteristics with respect to advance and transfer in order to ensure that the fixed navigation aid will track down the parallel line for the new course. This parallel line also has a cross index range "C_1" indicated in this figure.

STEP 4 - PARALLEL INDEXING

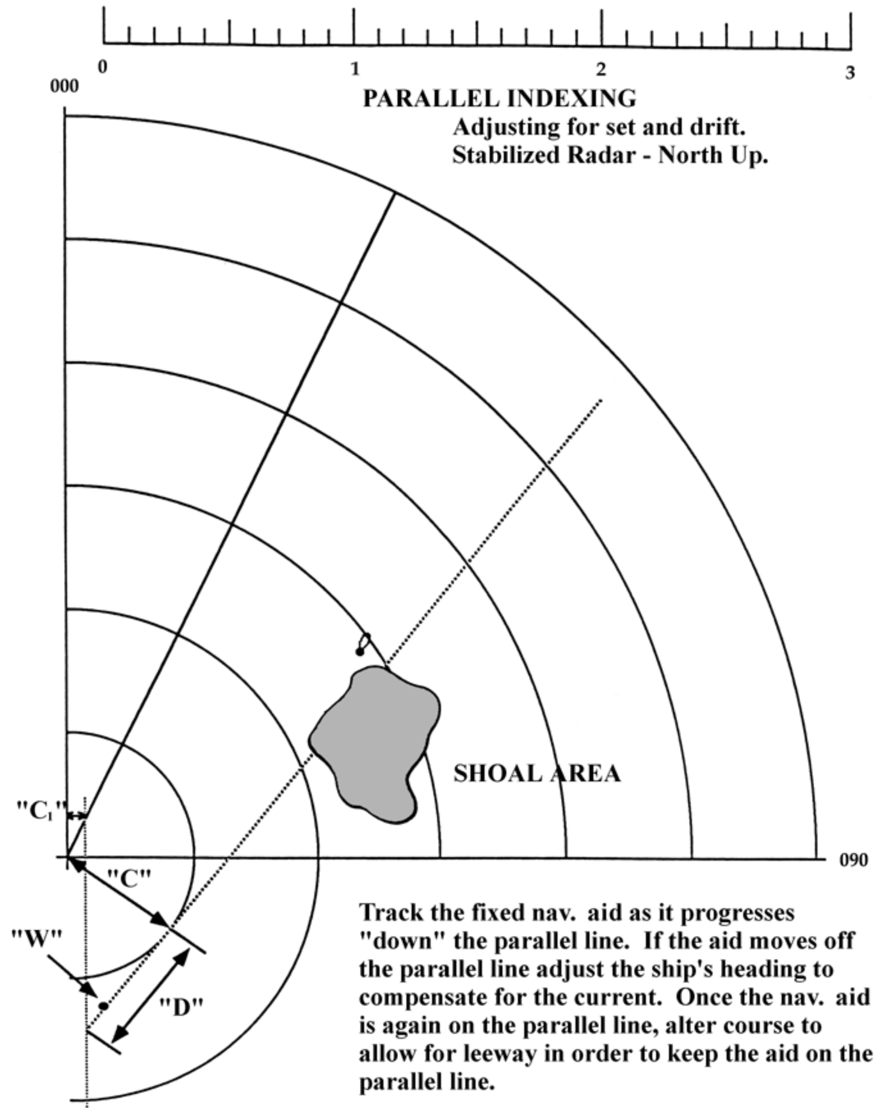
Tracking the fixed navigation aid.
Stabilized Radar - North Up.



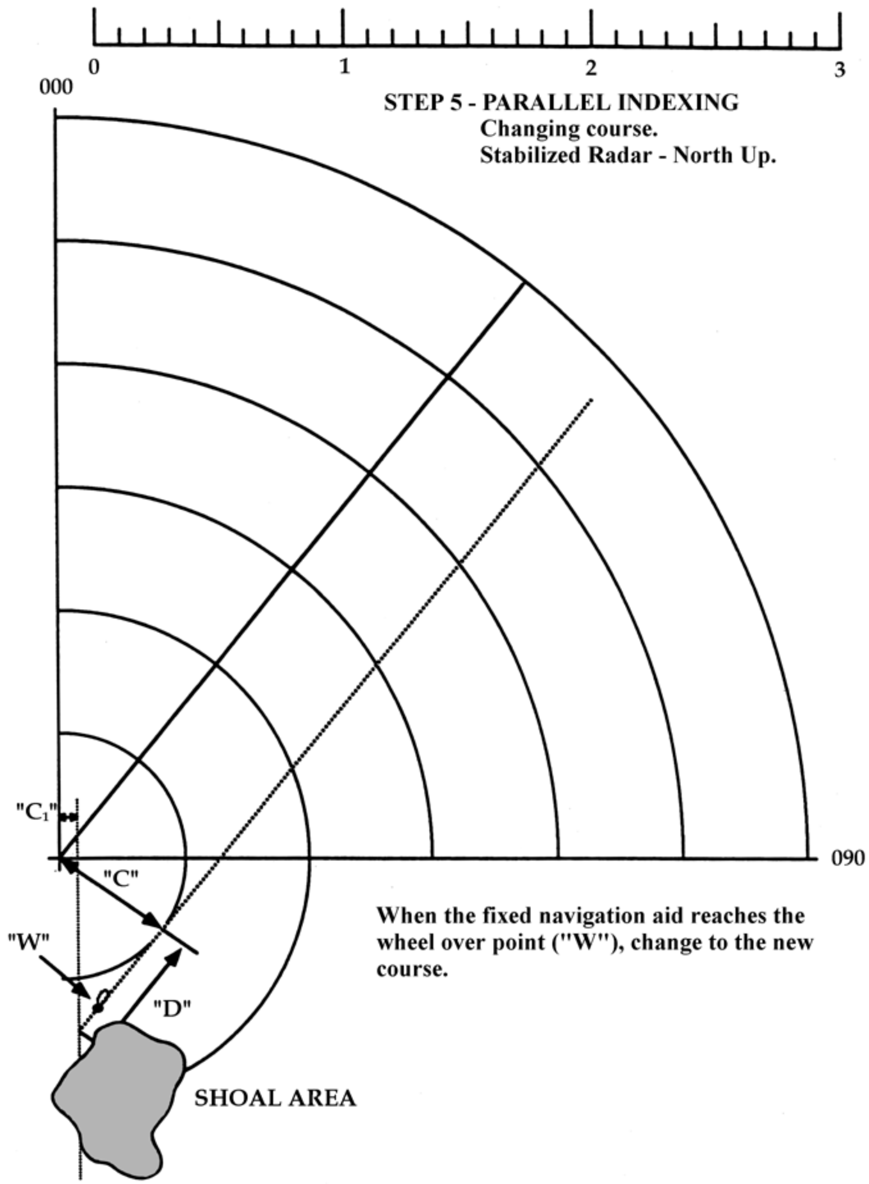
Track the fixed navigation aid as it progresses "down" the parallel line. Once these lines have been set up do not change ranges or the origin of the center.

PARALLEL INDEXING

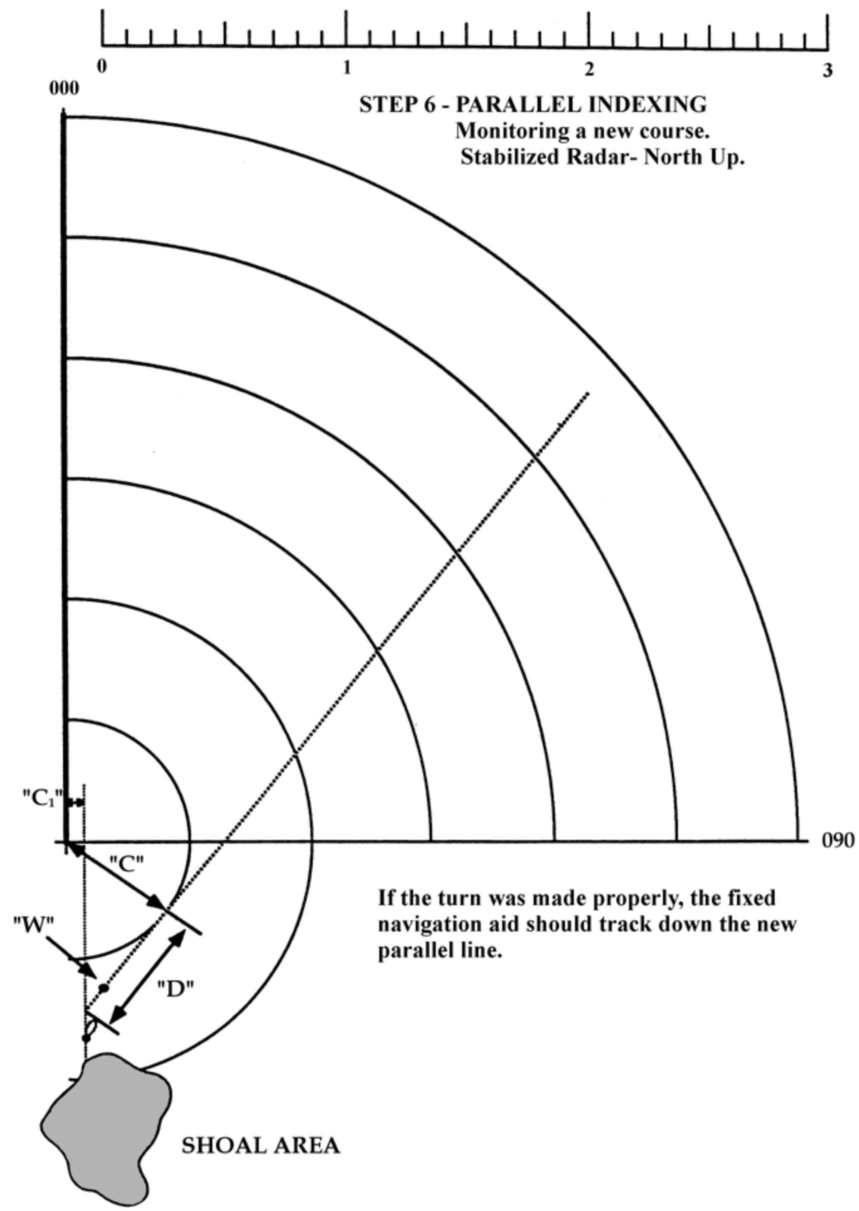
Adjusting for set and drift.
Stabilized Radar - North Up.



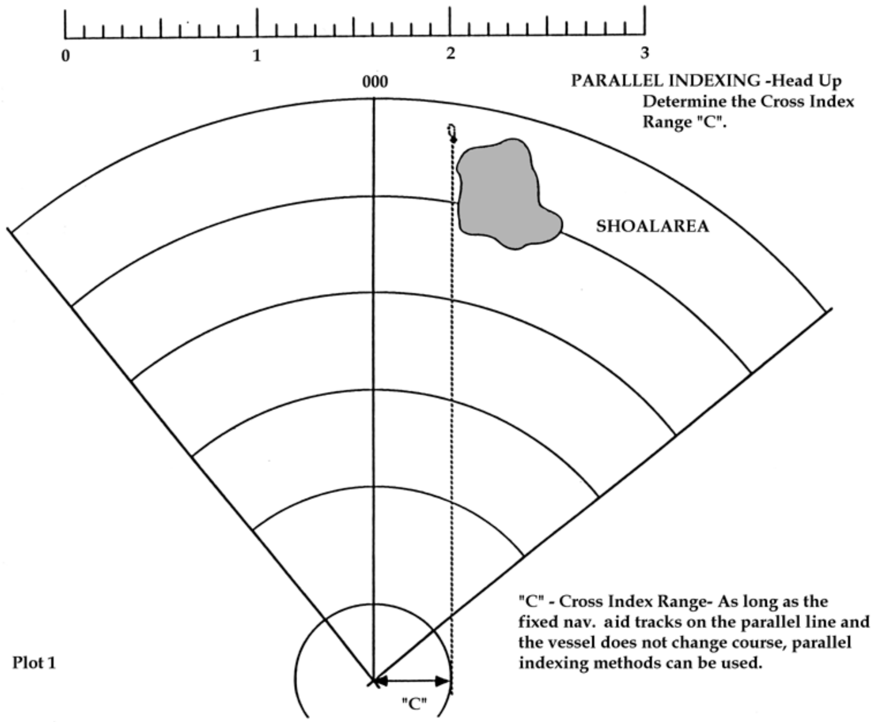
Track the fixed nav. aid as it progresses "down" the parallel line. If the aid moves off the parallel line adjust the ship's heading to compensate for the current. Once the nav. aid is again on the parallel line, alter course to allow for leeway in order to keep the aid on the parallel line.



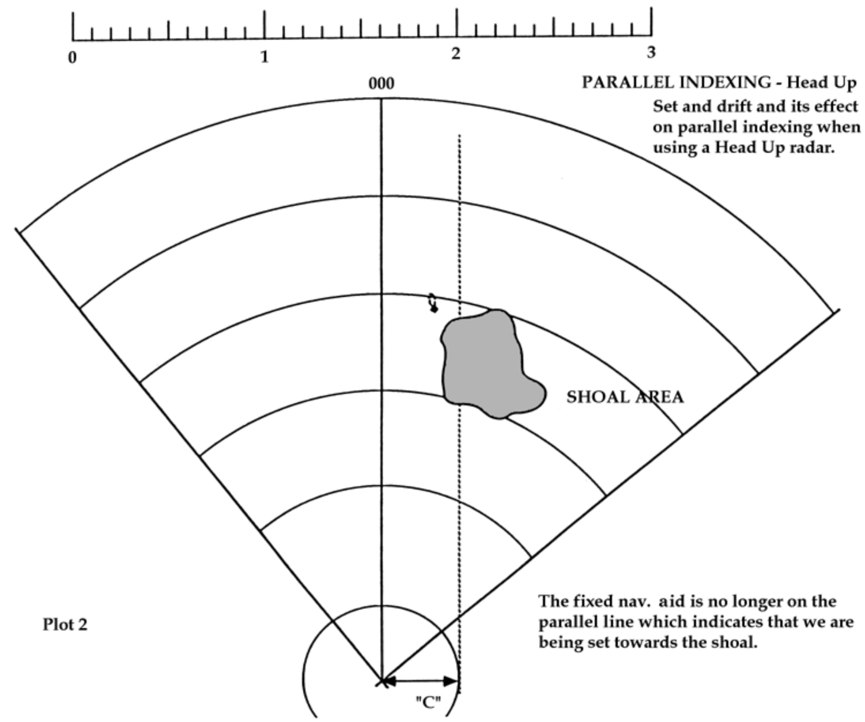
When the fixed navigation aid reaches the wheel over point ("W"), change to the new course.



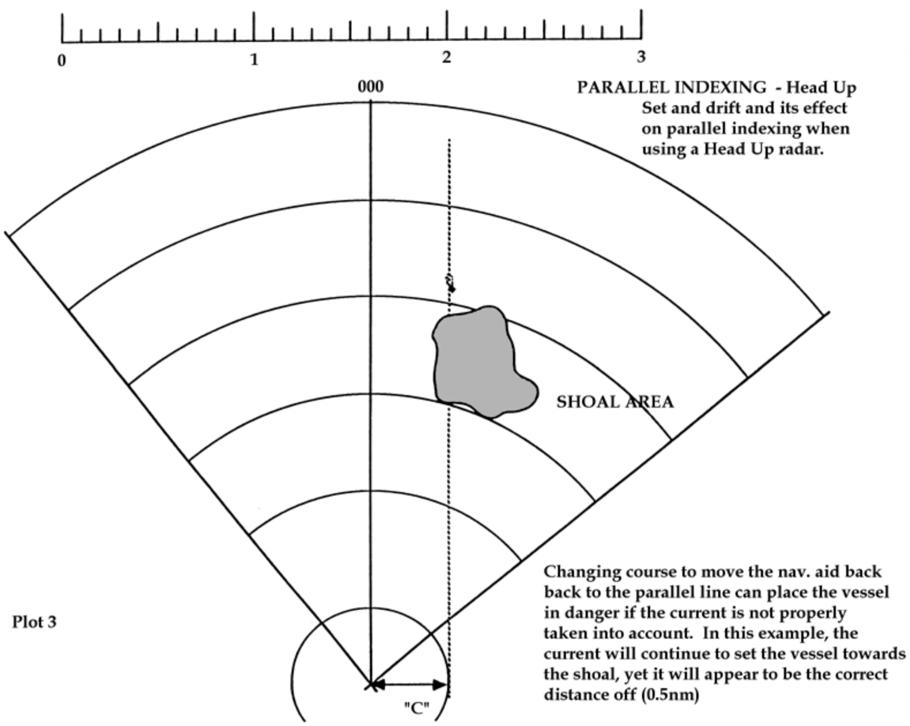
If the turn was made properly, the fixed navigation aid should track down the new parallel line.


0
1
2
3
000
PARALLEL INDEXING -Head Up
Determine the Cross Index Range "C".
SHOALAREA
"C" - Cross Index Range- As long as the fixed nav. aid tracks on the parallel line and the vessel does not change course, parallel indexing methods can be used.
"C"

Plot 1

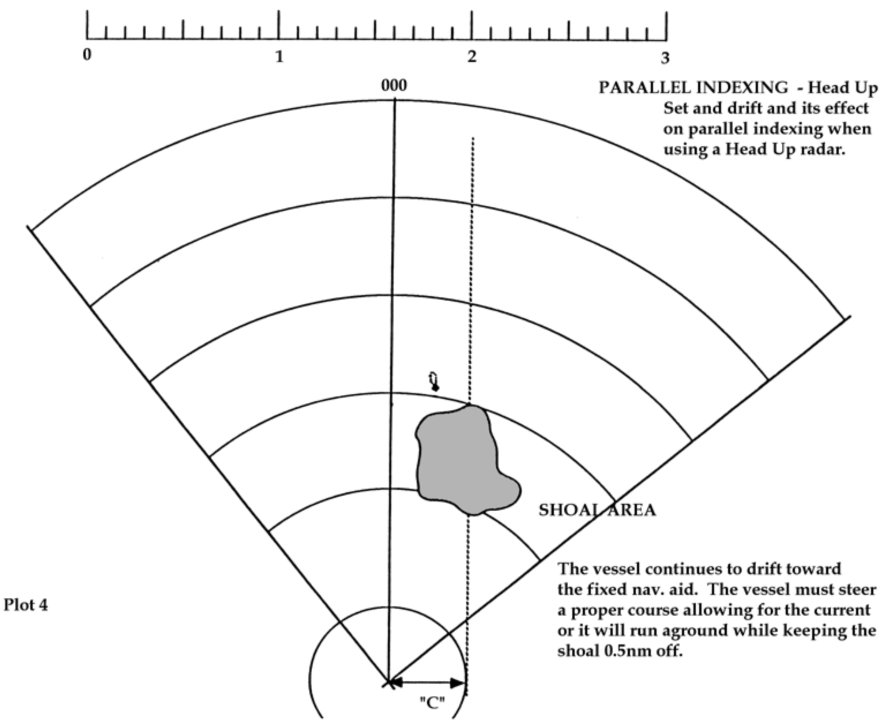

0
1
2
3
000
PARALLEL INDEXING - Head Up
Set and drift and its effect on parallel indexing when using a Head Up radar.
SHOAL AREA
The fixed nav. aid is no longer on the parallel line which indicates that we are being set towards the shoal.
"C"

Plot 2



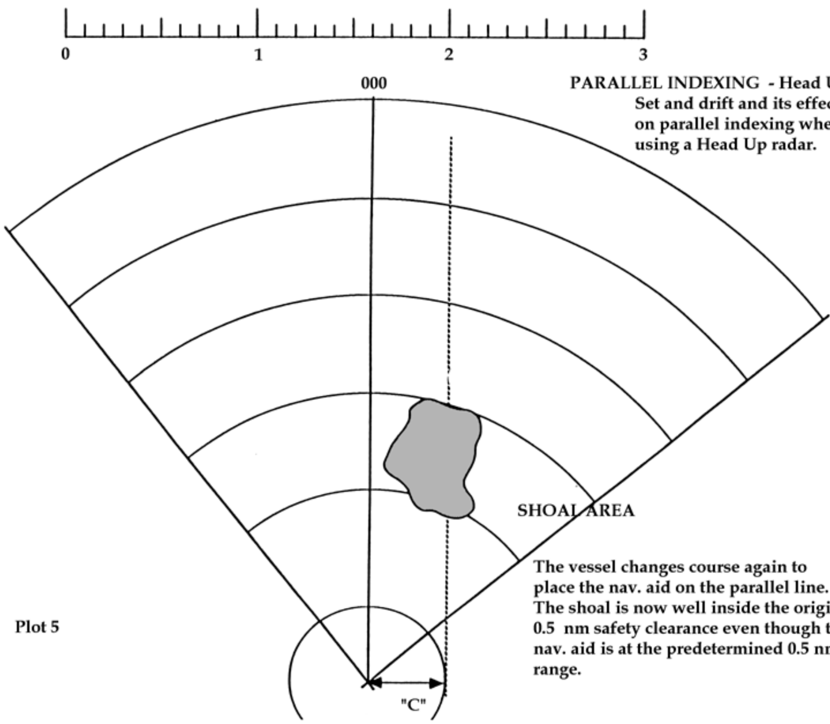
0
1
2
3
000
PARALLEL INDEXING - Head Up
Set and drift and its effect
on parallel indexing when
using a Head Up radar.
SHOAL AREA
Changing course to move the nav. aid back
back to the parallel line can place the vessel
in danger if the current is not properly
taken into account. In this example, the
current will continue to set the vessel towards
the shoal, yet it will appear to be the correct
distance off (0.5nm)
"C"

Plot 3



0
1
2
3
000
PARALLEL INDEXING - Head Up
Set and drift and its effect
on parallel indexing when
using a Head Up radar.
SHOAL AREA
The vessel continues to drift toward
the fixed nav. aid. The vessel must steer
a proper course allowing for the current
or it will run aground while keeping the
shoal 0.5nm off.
"C"

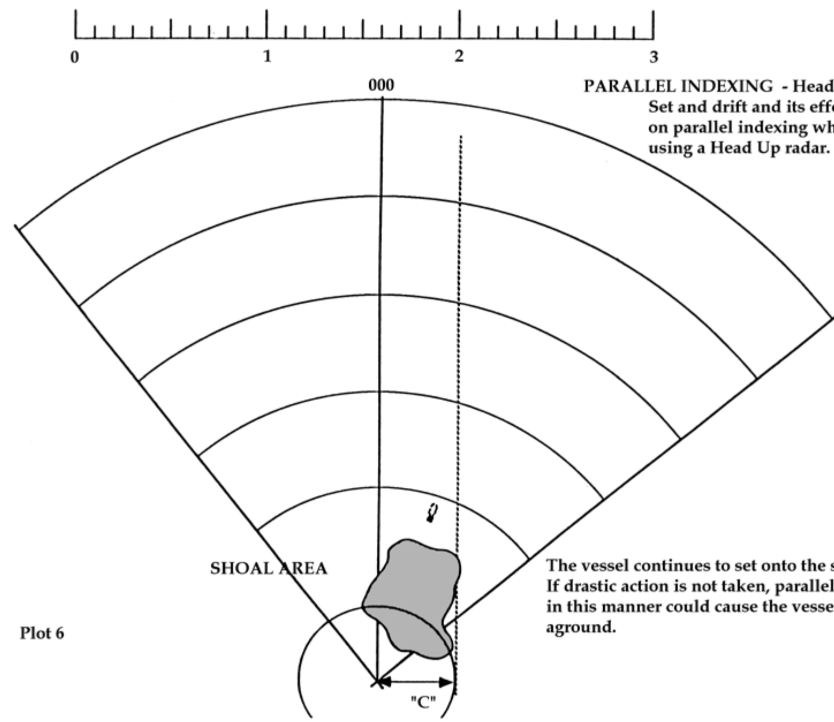
Plot 4



PARALLEL INDEXING - Head Up
Set and drift and its effect on parallel indexing when using a Head Up radar.

The vessel changes course again to place the nav. aid on the parallel line. The shoal is now well inside the original 0.5 nm safety clearance even though the nav. aid is at the predetermined 0.5 nm range.

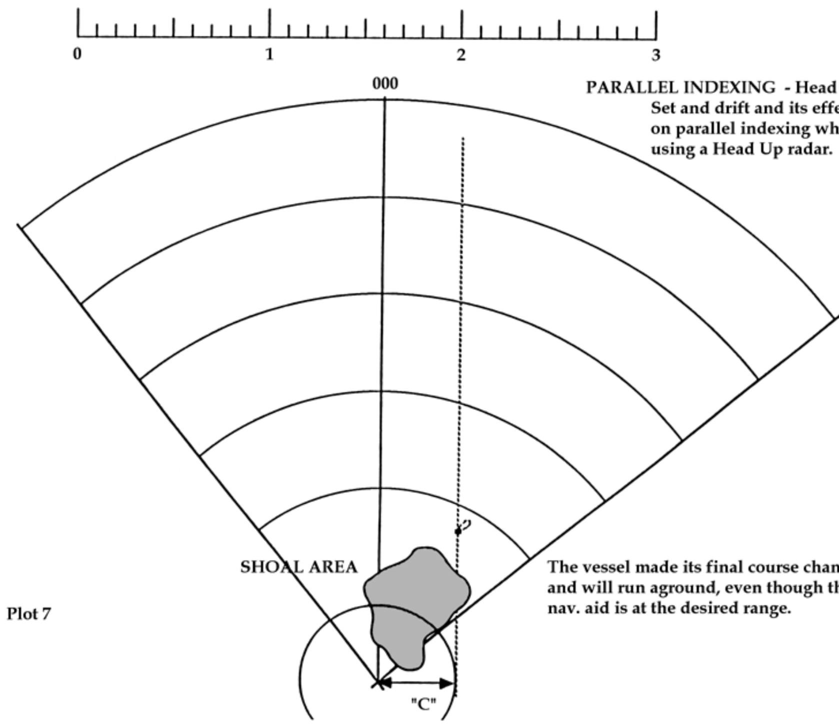
Plot 5



PARALLEL INDEXING - Head Up
Set and drift and its effect on parallel indexing when using a Head Up radar.

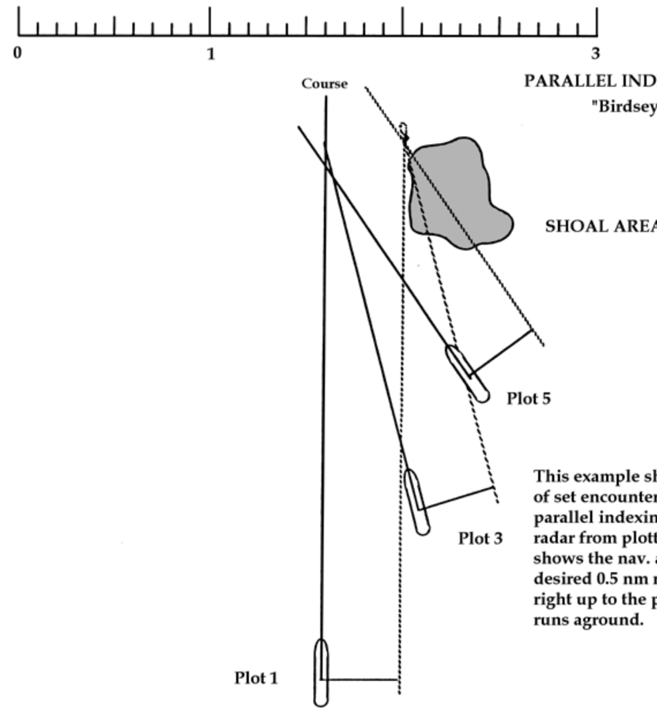
The vessel continues to set onto the shoal. If drastic action is not taken, parallel indexing in this manner could cause the vessel to run aground.

Plot 6



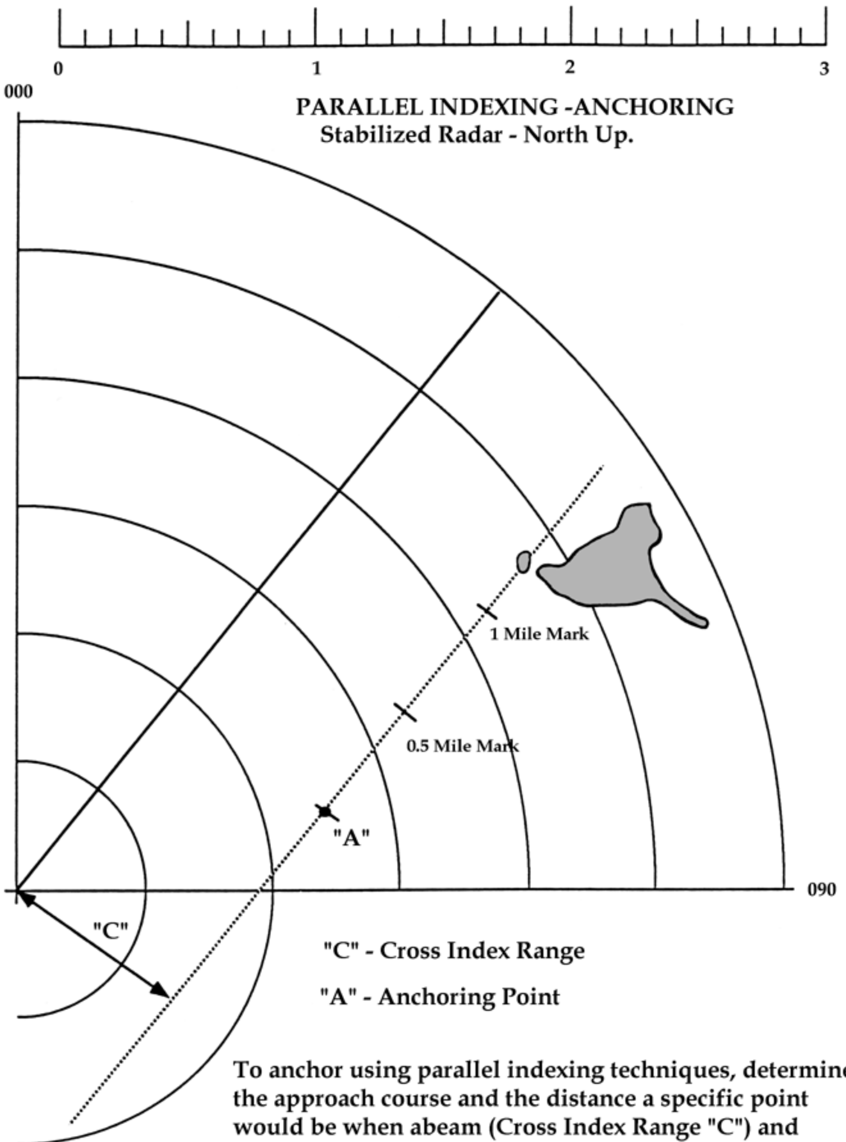
PARALLEL INDEXING - Head Up
Set and drift and its effect on parallel indexing when using a Head Up radar.

The vessel made its final course change and will run aground, even though the nav. aid is at the desired range.



PARALLEL INDEXING - Head Up
"Birdseye plot".

This example shows the amount of set encountered and its effect on parallel indexing with a Head Up radar from plotted positions. This shows the nav. aid being kept at the desired 0.5 nm range at all times right up to the point when the vessel runs aground.

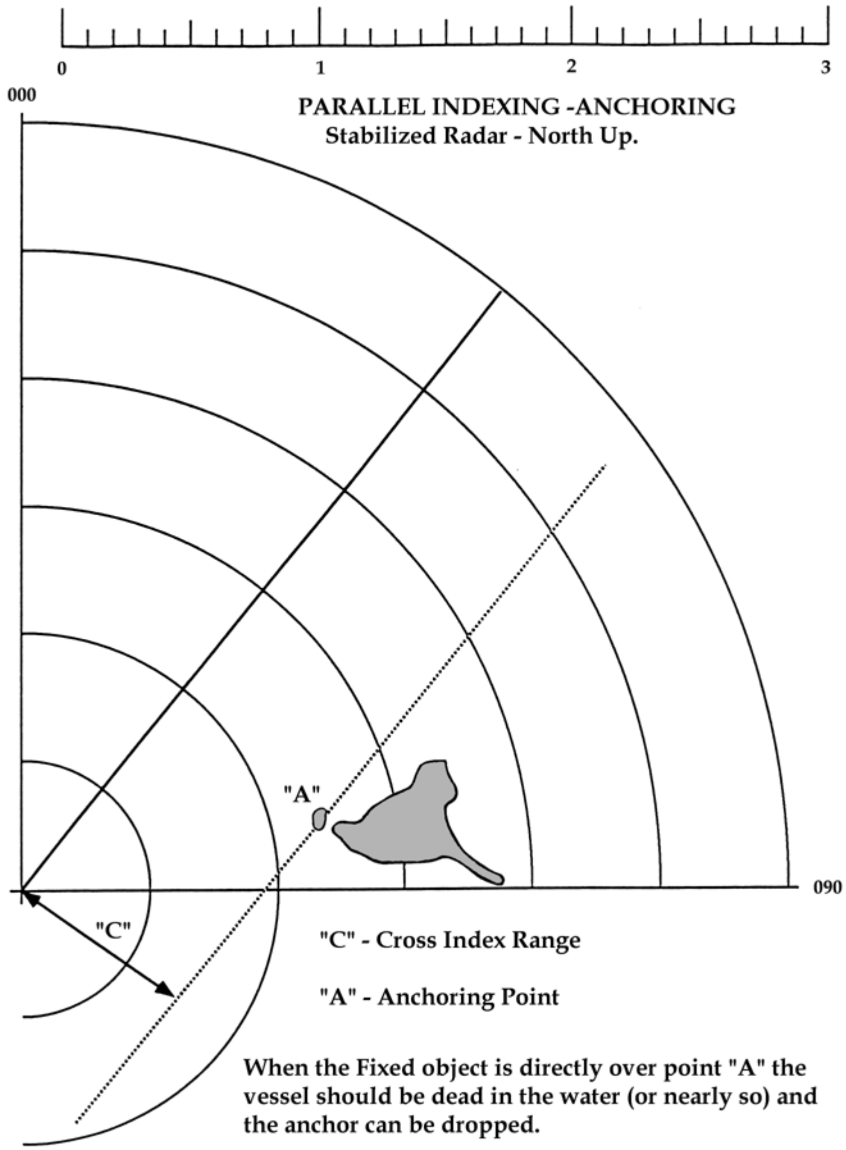


PARALLEL INDEXING -ANCHORING
Stabilized Radar - North Up.

"C" - Cross Index Range

"A" - Anchoring Point

To anchor using parallel indexing techniques, determine the approach course and the distance a specific point would be when abeam (Cross Index Range "C") and draw a line on the screen that parallels the approach course at the desired perpendicular distance.

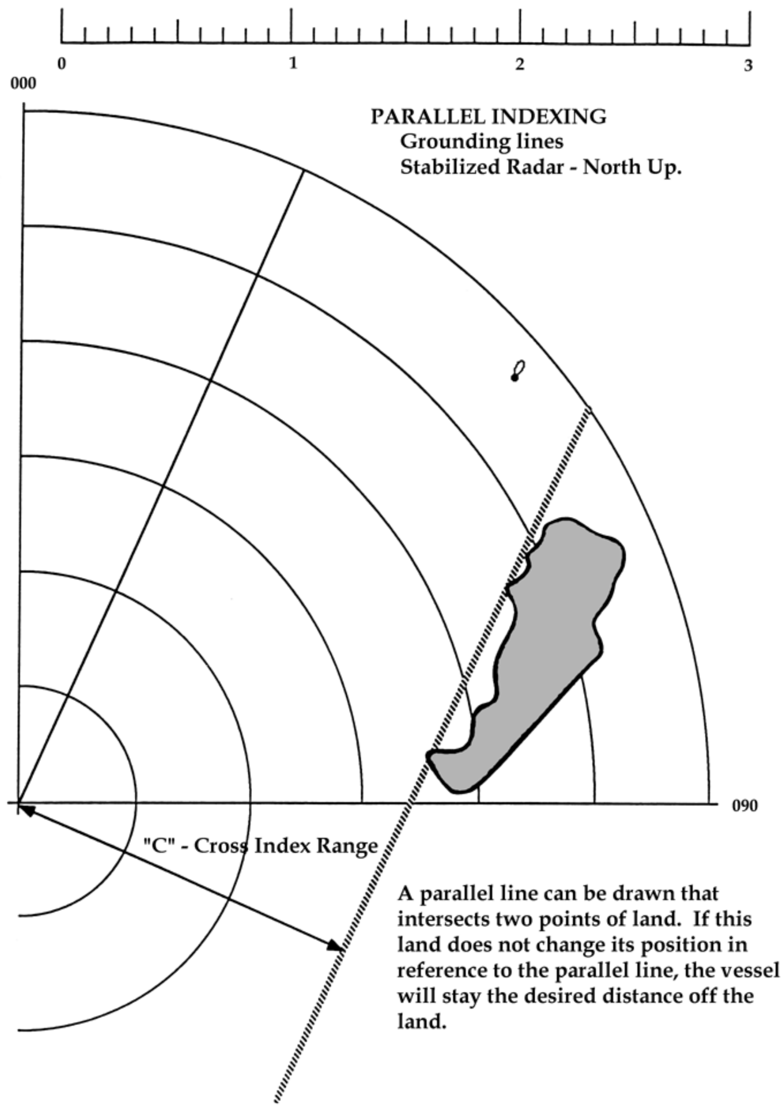


PARALLEL INDEXING -ANCHORING
Stabilized Radar - North Up.

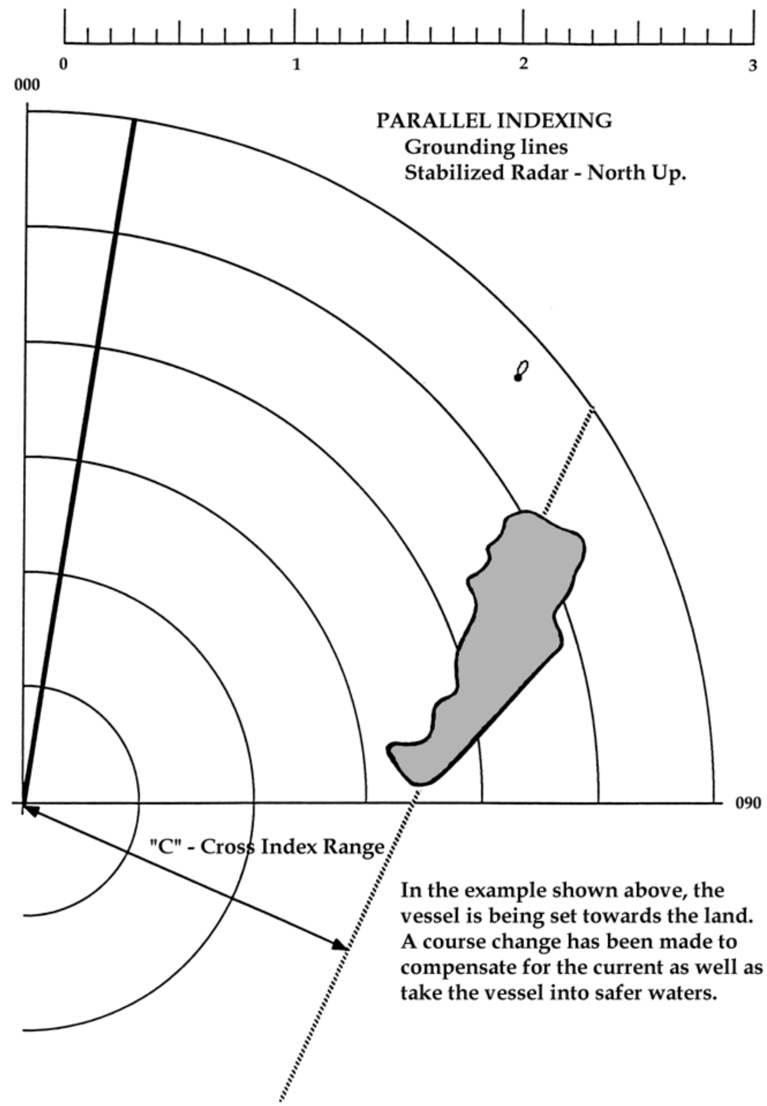
"C" - Cross Index Range

"A" - Anchoring Point

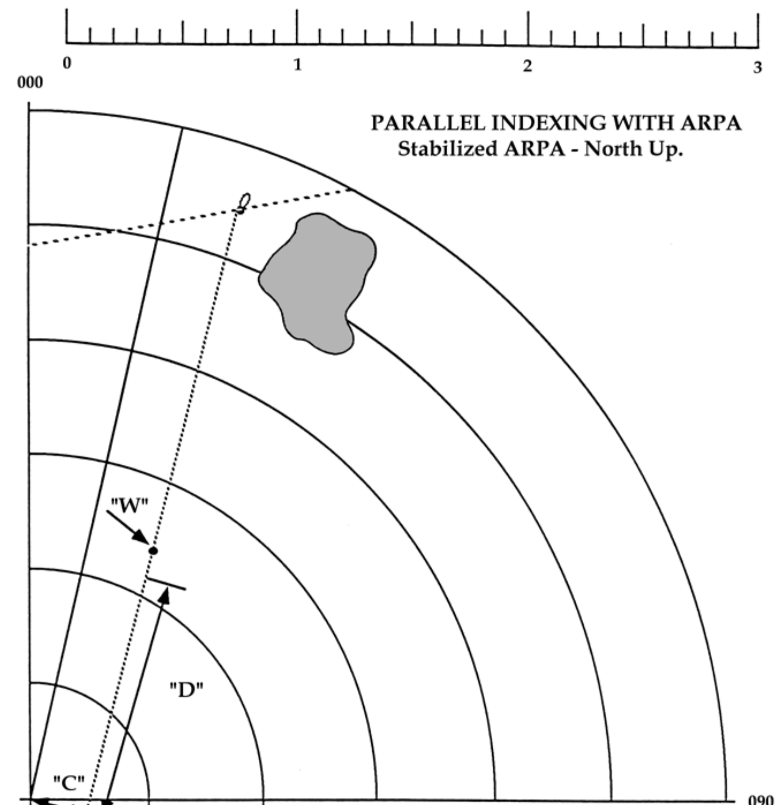
When the Fixed object is directly over point "A" the vessel should be dead in the water (or nearly so) and the anchor can be dropped.



A parallel line can be drawn that intersects two points of land. If this land does not change its position in reference to the parallel line, the vessel will stay the desired distance off the land.



In the example shown above, the vessel is being set towards the land. A course change has been made to compensate for the current as well as take the vessel into safer waters.



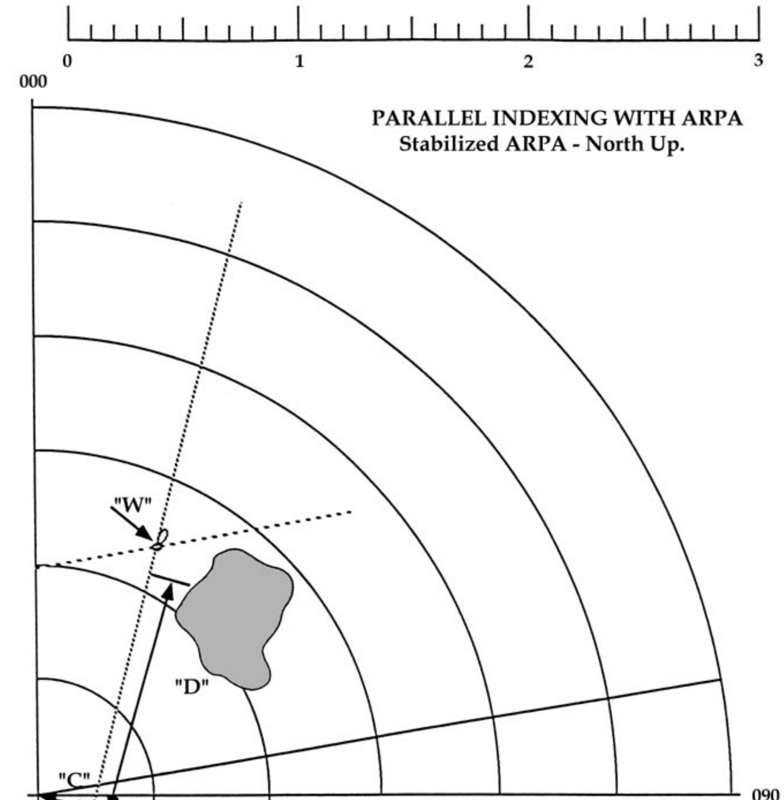
"C" - Cross Index Range

"D" - Dead Range

"W" - Wheel Over Point

Plot 1

When using an ARPA, it may be possible to use an EBL (Electronic Bearing Line) that can be moved or offset from the origin of the display. This line can be set at a specific range and bearing from the origin of the display and rotated to the desired bearing. The course can then be adjusted to bring the desired fixed navigation aid on a parallel course. If navigation lines are available and an accurate speed is in use, navigation lines can be used as well. Set the nav line on the fixed aid in the direction of the new course. When the nav. line tracks to the Wheel Over Point, the course change should be made.



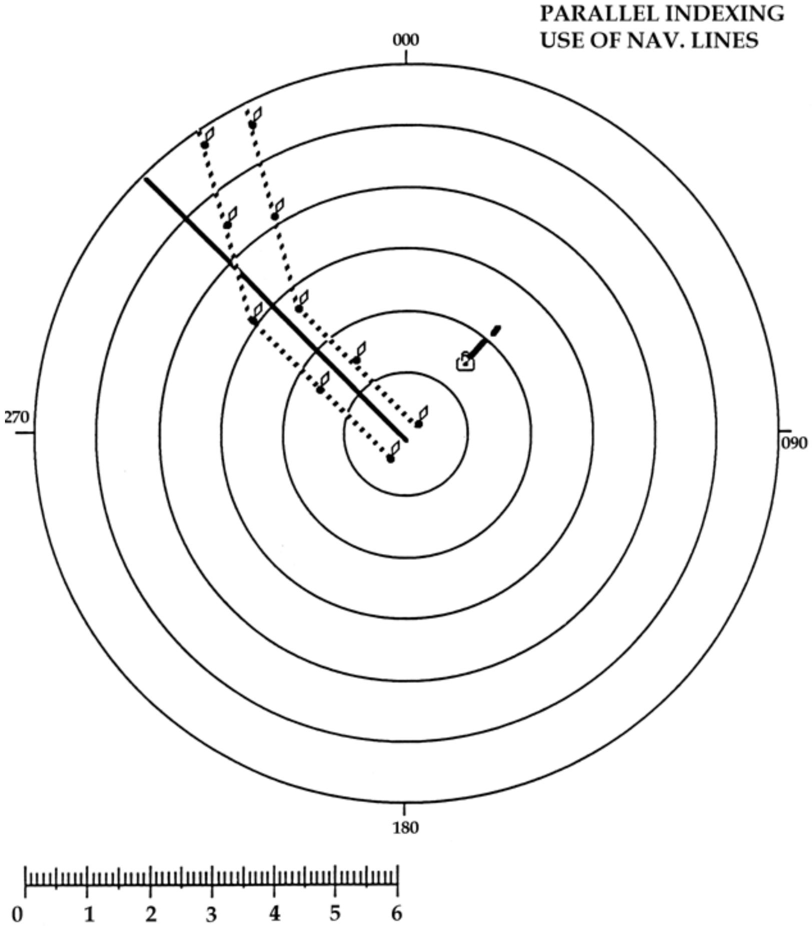
When the course change is made, the fixed nav aid should track down the nav line on the screen. If the nav line moves off the fixed nav. aid, there is probably an error in the course or speed that is being used by the ARPA to move the nav line.

"C" - Cross Index Range

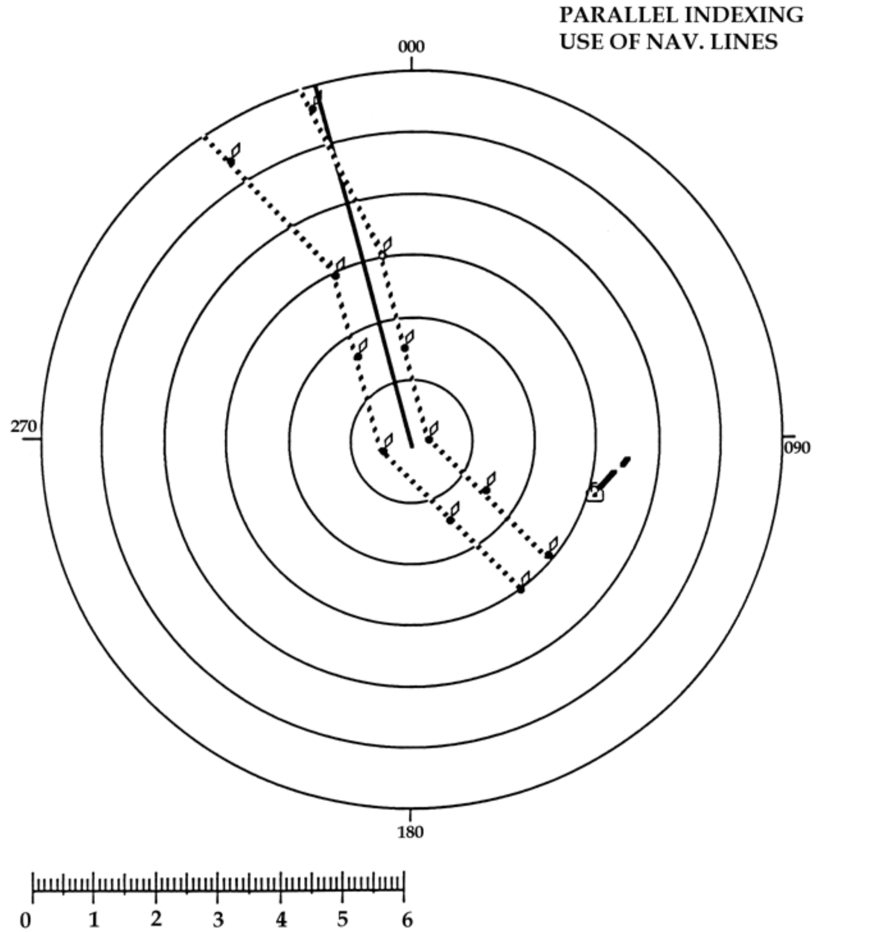
"D" - Dead Range

"W" - Wheel Over Point

Plot 2



An indexing technique that can be used with an ARPA is the use of nav. lines in channel keeping. In the example above, the operator has selected a fixed nav. aid to ground reference the ARPA. The nav lines were then drawn in. The operator can then determine what part of the channel the vessel is in and prepare for the course change. There is a possibility that the ARPA might try to track the Racon on the reference target. If that happens the nav. lines could move off the channel markers. If this occurs, remove the nav. lines, choose another nav aid to reference on and reconstruct the nav. lines.



Additional nav lines can be placed at a later time on some units and the channel keeping value of the nav lines can continue. The nav lines track based on the vessel's course and speed. On some units, it is possible to fix the position of these lines with respect to the vessel and use these lines in a more traditional parallel indexing manner.

THE FRANKLIN CONTINUOUS RADAR PLOT TECHNIQUE

The Franklin Continuous Radar Plot technique provides means for continuous correlation of a small fixed, radar-conspicuous object with own ship's position and movement relative to a planned track. The technique, as developed by Master Chief Quartermaster Byron E. Franklin, U.S. Navy, while serving aboard USS INTREPID (CVS-11), is a refinement of the parallel-cursor (parallel-index) techniques used as a means for keeping own ship on a planned track or for avoiding navigational hazards.

Ranges and bearings of the conspicuous object from various points, including turning points, on the planned track are transferred from the chart to the reflection plotter mounted on a stabilized relative motion indicator. On plotting the ranges and bearings and connecting them with line segments, the navigator has a visual display of the position of the conspicuous object relative to the path it should follow on the PPI (see figure 4.26).

If the pip of the conspicuous object is painted successively on the constructed path (planned relative movement line or series of such lines), the navigator knows that, within the limits of accuracy of the plot and the radar display, his ship is on the planned track. With the plot labeled with respect to time, he knows whether he is ahead or behind his planned schedule. If the pips are painted to the left or right of the RML, action required to return to the planned track is readily apparent. However, either of the following rules of thumb may be used: (1) Using the DRM as the reference direction for any offsets of the pips, the ship is to the left of the planned track if the pips are painted to the left of the planned RML; the ship is to the right of the planned track if the pips are painted to the right of the planned RML. (2) While facing in the direction of travel of the conspicuous object on the PPI, the ship is to the left or right of the planned track if the pips are painted left or right of the planned RML, respectively.

Through taking such corrective action as is necessary to keep the conspicuous object pip on the RML in accordance with the planned time schedule, continuous radar fixing is, in effect, accomplished. This fixing has the limitation of being based upon the range and bearing method, more subject to identification mistakes than the method using three or more intersecting range arcs.

Except for the limitations of being restricted with respect to the range scale setting and some PPI clutter produced by the construction of the planned RML, the technique does not interfere with the use of the PPI for fixing by other means. Preferably, the technique should be used in conjunction with either visual fixing or fixing by means of three or more intersecting range arcs. Fixing by either means should establish whether the radar-conspicuous object has been identified correctly. With verification that the radar-conspicuous object has been identified correctly, requirements for frequent visual fixes or fixes by range measurements are less critical.

Because of the normal time lag in the latest radar fix plotted on the chart, inspection of the position of the pip of the radar-conspicuous object relative to the planned RML should provide a more timely indication as to whether the ship is to the left or right of the planned track or whether the ship has turned too early or too late according to plan.

Once the radar-conspicuous object has been identified correctly, the planned RML enables rapid re-identification in those situations where the radarscope cannot be observed continuously. Also, this identification of the conspicuous object with respect to its movement along the planned RML provides means for more certain identification of other radar targets.

While the planned RML can be constructed through use of the bearing cursor and the variable range marker (range strobe), the use of plastic templates provides greater flexibility in the use of the technique, particularly when there are requirements for use of more than one range scale setting or a need for shifting to a different radar-conspicuous object during a passage through restricted waters. With a planned RML for a specific radar-conspicuous object cut in a plastic template for a specific range scale setting available, the planned RML can be traced rapidly on the PPI. With availability of other templates prepared for different range scale settings or different objects and associated range scale settings, the planned RML as needed can be traced rapidly on the PPI. Other templates can be prepared for alternative planned tracks.

If the range scale setting is continuously adjustable or "rubberized it may be possible to construct the template by tracing the planned track on a chart having a scale which can be duplicated on the PPI. Because the planned RML is opposite to the planned track, the track cut in the template must be rotated 180˚ prior to tracing the planned RML on the PPI.

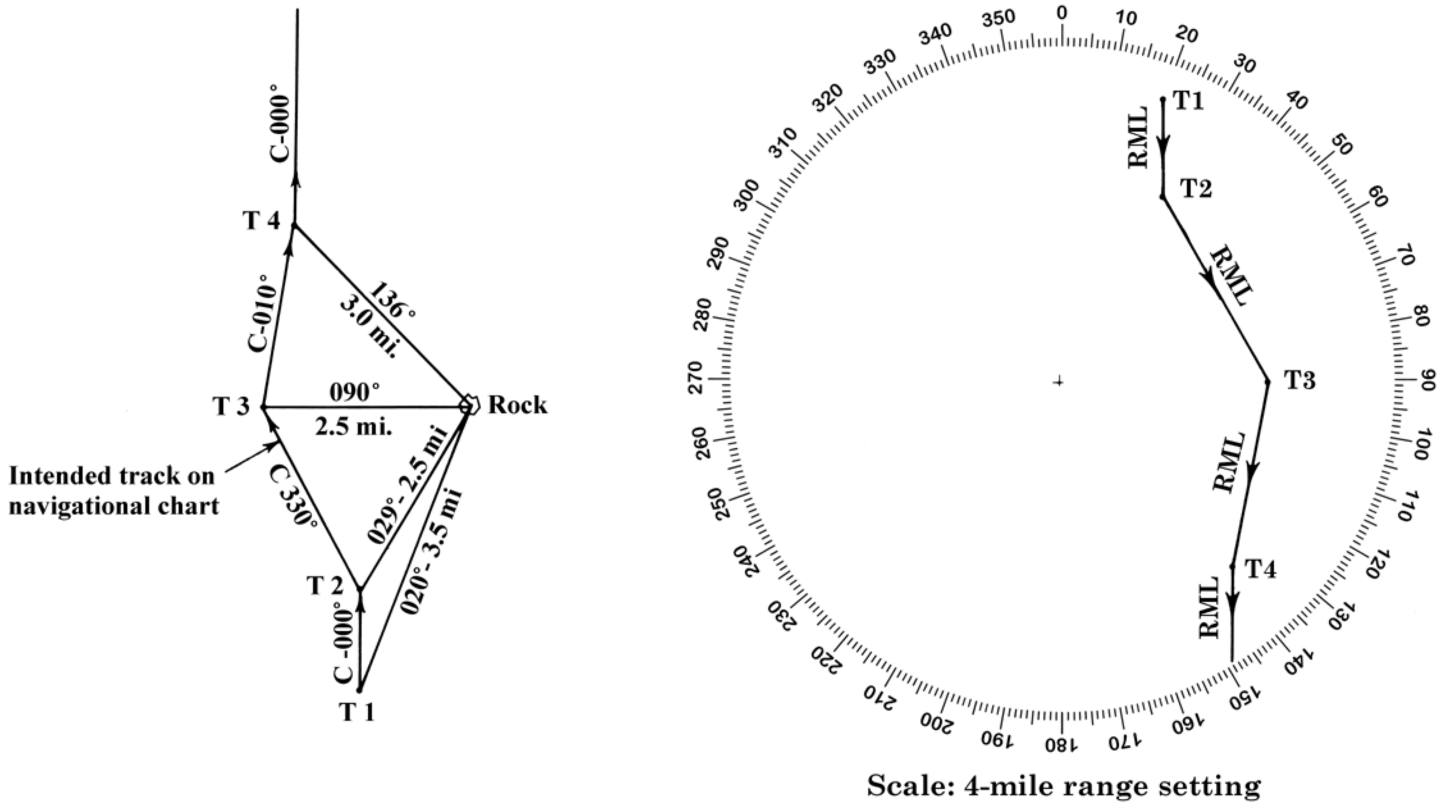


Figure 4.26 - The Franklin continuous radar plot technique.

TRUE MOTION RADAR RESET IN RESTRICTED WATERS

When using true motion displays, the navigator should exercise care in deciding when and where to reset own ship's position on the PPI. While navigating in restricted waters, he must insure that he has adequate warning ahead; through sound planning, he must avoid any need for resetting the display at critical times.

The following is an example of resetting a true motion display for a ship entering the River Tyne. The speed made good is 6 knots. The navigator desires to maintain a warning ahead of at least 1 mile (see figure 4.27).

At 1000
Own ship is reset to the south on the 3-mile range scale to display area A so that Tynemouth is just showing and sufficient warning to the north is obtained for the turn at about 1030.

At 1024
Own ship is reset to the southeast on the 1.5-mile range scale to display area B before the turn at 1030.

At 1040
Own ship is reset to the east to display area C. The reset has been carried out early to avoid a reset in the entrance and to show all traffic up to South Shields.

At 1055
Own ship is reset to the northeast to display area D. The reset has been carried out early before the bend of the river at South Shields and to place the bend at Tyne Dock near the center of the display.

At 1117
Own ship is reset to the east to display area E.

At 1133
Own ship is reset to the northeast to display area F. The reset has been carried out before the bend at Hebburn and up to the northeast because the ship is making good a southwest direction.

At 1200
Own ship is reset to the southeast to display area G.

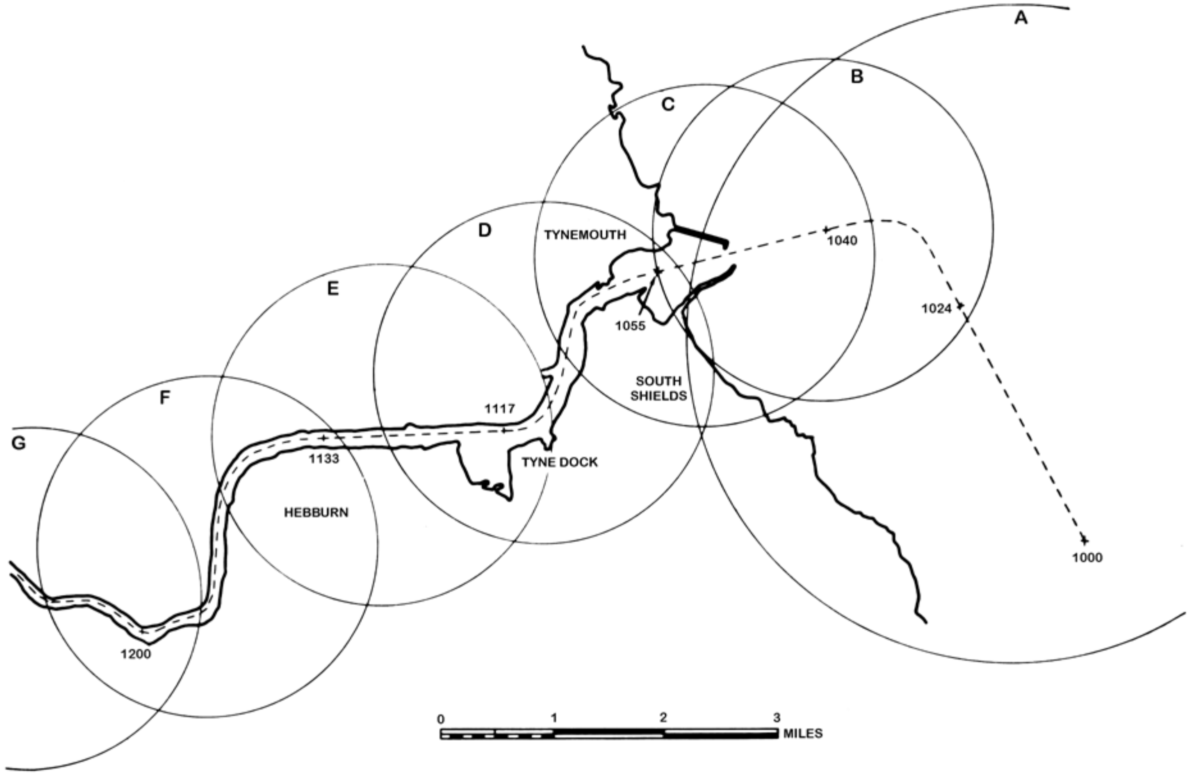


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Figure 4.27 - Resetting a true motion display.

RADAR DETECTION OF ICE

Radar can be an invaluable aid in the detection of ice if used wisely by the radar observer having knowledge of the characteristics of radar propagation and the capabilities of his radar set. The radar observer must have good appreciation of the fact that ice capable of causing damage to a ship may not be detected even when the observer is maintaining a continuous watch of the radarscope and is using operating controls expertly.

When navigating in the vicinity of ice during low visibility, a continuous watch of the radarscope is a necessity. For reasonably early warning of the presence of ice, range scale settings of about 6 or 12 miles are probably those most suitable. Such settings should provide ample time for evasive action after detection. Because any ice detected by radar may be lost subsequently in sea clutter, it may be advisable to maintain a geographical plot. The latter plot can aid in differentiating between ice aground or drifting and ship targets. If an ice contact is evaluated as an iceberg, it should be given a wide berth because of the probability of growlers in its vicinity. If ice contacts are evaluated as bergy bits or growlers, the radar observer should be alert for the presence of an iceberg. Because the smaller ice may have calved recently from an iceberg, the radar observer should maintain a particularly close watch to windward of the smaller ice.

ICEBERGS

While large icebergs may be detected initially at ranges of 15 to 20 miles in a calm sea, the strengths of echoes returned from icebergs are only about $^1/_{60}$ of the strengths of echoes which would be returned from a steel ship of equivalent size.

Because of the shape of the iceberg, the strengths of echoes returned may have wide variation with change in aspect. Also, because of shape and aspect, the iceberg may appear on the radarscope as separate echoes. Tabular icebergs, having flat tops and nearly vertical sides which may rise as much as 100 feet above the sea surface, are comparatively good radar targets.

Generally, icebergs will be detected at ranges not less than 3 miles because of irregularities in the sloping faces.

BERGY BITS

Bergy bits, extending at most about 15 feet above the sea surface, usually cannot be detected by radar at ranges greater than 3 miles. However, they may be detected at ranges as great as 6 miles. Because their echoes are generally weak and may be lost in sea clutter, bergy bits weighing several hundred or a few thousand tons can impose considerable hazard to a ship.

GROWLERS

Growlers, extending at most about 6 feet above the sea surface, are extremely poor radar targets. Being smooth and round because of wave action, as well as small, growlers are recognized as the most dangerous type of ice that can be encountered.

In a rough sea and with sea clutter extending beyond 1 mile, growlers large enough to cause damage to a ship may not be detected by radar. Even with expert use of receiver gain, pulse length, and anti-clutter controls, dangerous growlers in waves over 4 feet in height may not be detected.

In a calm sea growlers are not likely to be detected at a range exceeding 2 miles.

RADAR SETTINGS FOR RADARSCOPE PHOTOGRAPHY

Radar settings are an important factor in preparing good quality radarscope photography. A natural tendency is to adjust the radar image so that it presents a suitable visual display, but this, almost invariably, produces poor photographic results. Usually the resulting photograph is badly overexposed and lacking in detail. Another tendency is to try to record too much information on one photograph such that the clutter of background returns actually obscures the target images. In both cases, the basic problem is a combination of gain and intensity control. A basic rule of thumb is if imagery looks right to visual inspection, it will probably overexpose the recording film. As a rule of thumb, if the image intensity is adjusted so that weak returns are just visible, then a one sweep exposure should produce a reasonably good photograph.

The following list of effects associated with various radar settings can be used as an aid in avoiding improper settings for radarscope photography:

(1) Excessive brightness produces an overall milky or intensely bright appearance of the images. Individual returns will bloom excessively and appear unfocused. It becomes difficult to distinguish the division between land and water, and ground and cultural returns.

(2) Improper contrast results in a lack of balance in the grey tonal gradations on the scope, greatly degrading the interpretive quality.

(3) High gain results in "blooming" of all bright returns adversely affecting the image resolution. High gain also causes the formation of a "hot spot" at the sweep origin.

(4) Low gain results in a loss of weak to medium returns. The result will be poor interpretive quality where there are few bright targets illuminated due to absence of definitive target patterns on the scope.

(5) Excessively bright bearing cursors, heading flashes, and range markers result in wide cursors, flashes, and markers which may obscure significant images.

(6) Improper radarscope or camera focus will result in extremely fuzzy or blurred imagery.

NAVIGATIONAL PLANNING

Before transiting hazardous waters, the prudent navigator should develop a feasible plan for deriving maximum benefit from available navigational means. In developing his plan, the navigator should study the capabilities and limitations of each means according to the navigational situation. He should determine how one means, such as cross-bearing fixing, can best be supported by another means, such as fixing by radar-range measurements.

The navigator must be prepared for the unexpected, including the possibility that at some point during the transit it may be necessary to direct the movements of the vessel primarily by means of radar observations because of a sudden obscurity of charted features. Without adequate planning for the use of radar as the primary means for insuring the safety of the vessel, considerable difficulty and delay may be incurred before the navigator is able to obtain reliable fixes by means of radar following a sudden loss of visibility.

An intended track which may be ideal for visual observations may impose severe limitations on radar observations. In some cases a modification of this intended track can afford increased capability for reliable radar observations without unduly degrading the reliability of the visual observations or increasing the length of the transit by a significant amount. In that the navigator of a radar-equipped vessel always must be prepared to use radar as the primary means of navigating his vessel while in pilot waters, the navigator should effect a reasonable compromise between the requirements for visual and radar fixing while determining the intended track for the transit.

The value of radar for navigation in pilot waters is largely lost when it is not manned continuously by a competent observer. Without continuous manning the problems associated with reliable radarscope interpretation are too great, usually, for prompt and effective use of the radar as the primary means of insuring the safety of the vessel. The continuous manning of the radar is also required for obtaining the best radarscope presentation through proper adjustments of the operating controls as the navigational situation changes or as there is a need to make adjustments to identify specific features.

With radar being used to support visual fixing during a transit of hazardous waters, visual observations can be used as an aid in the identification of radar observations. Through comparing the radar plot with the visual plot, the navigator can evaluate the accuracies of the radar observations. With radar actually being used to support visual fixing, the transition to the use of radar as the primary means can be effected with lesser difficulty and with greater safety than would be the case if the radar were not continuously manned and used to support visual fixing.

While the navigational plan must be prepared in accordance with the manning level and individual skills as well as the navigational situation, characteristics of navigational aids or equipment, characteristics of radar propagation, etc., the navigator should recognize the navigational limitations imposed by lack of provision for continuous manning of the radar. A transit, which may be effected with a reasonable margin of safety if the radar is manned continuously by a competent observer, may impose too much risk if provision is not made for the continuous manning of the radar.

The provision for continuous manning of the radar by a designated and competent observer does not necessarily mean that other responsible navigational personnel should not observe the radarscope from time to time. In fact the observations by other navigational personnel are highly desirable. According to the navigational plan, the designated observer may be relieved by a more experienced and proficient observer in the event that radar must be used as the primary means of insuring the safety of the vessel at some point during the transit. In such event the observer who has been manning the radar should be able to brief his relief rapidly and reliably with respect to the radar situation. Assuming that the previous observer has made optimum range settings according to plan at various points on the track, the new observer should be able to make effective use of the radar almost immediately. If this more proficient observer has been making frequent observations of the radarscope, aided by comment of the observer continuously manning the radar, any briefing requirements on actually relieving the other observer should be minimal.

If radar is to be used effectively in hazardous waters, it is essential that provisions be made for the radar observer and other responsible navigational personnel to be able to inspect the chart in the immediate vicinity of the radar indicator. The practice of leaving a radar indicator installed in the wheelhouse to inspect the chart in the chartroom is highly unsatisfactory in situations requiring prompt and reliable radarscope interpretation. The radar observer must be able to make frequent inspections of the chart without undue delays between such inspections and subsequent radar observations. A continuous correlation of the chart and the PPI display is required for reliable radarscope interpretation.

If the navigational plot is maintained on a chart other than that used by the radar observer for radarscope interpretation, the observer's chart should include the basic planning data, such as the intended track, turning bearings, danger bearings, turning ranges, etc.

In planning for the effective use of radar, it is advisable to have a definite procedure and standardized terminology for making verbal reports of radar and visual observations. At points on the track where simultaneous visual and radar observations are to be made, the lack of an adequate reporting procedure will make the required coordination unduly difficult. Reports of radar observations can be simplified through the use of appropriate annotations on the chart and PPI. For example, a charted rock which is identified on the PPI can be designated as “A”; another radar-conspicuous object can be designated as “B,” etc. With the chart similarly annotated, the various objects can be reported in accordance with their letter designations.

SPECIAL TECHNIQUES

In that the navigator of a radar-equipped vessel always must be prepared to use radar as his primary means of navigation in pilot waters, during the planning for a transit of these waters it behooves him to study the navigational situation with respect to any special techniques which can be employed to enhance the use of radar. The effectiveness of such techniques usually is dependent upon adequate preparation for their use, including special constructions on the chart or the preparation of transparent chart overlays.

The correlation of the chart and the PPI display during a transit of confined waters frequently can be aided through the use of a transparent chart overlay on which properly scaled concentric circles are inscribed as a means of simulating the fixed range rings on the PPI. By placing the center of the concentric circles at appropriate positions on the chart, the navigator is able to determine by rapid inspection, and with close approximation, just where the pips of certain charted features should appear with respect to the fixed range rings on the PPI when the vessel is at those positions. This technique compensates for the difficulty imposed by viewing the PPI at one scale and the chart at another scale. Through study of the positions of various charted features with respect to the simulated fixed range rings on the transparency as the center of the simulated rings is moved along the intended track, certain possibilities for unique observations may be revealed.

Identifying Echoes

By placing the center of the properly scaled simulated range ring transparency over the observer’s most probable position on the chart, the identification of echoes is aided. The positions of the range rings relative to the more conspicuous objects aid in establishing the most probable position. With better positioning of the center of the simulated rings, more reliable identification is obtained.

Fixing

By placing the simulated range ring transparency over the chart so that the simulated rings have the same relationship to charted objects as the actual range rings have to the corresponding echoes, the observer’s position is found at the center of the simulated range rings.

Under some conditions, there may be not be enough suitable objects and corresponding echoes to correlate with the range rings to obtain the desired accuracy.

This method of fixing should be particularly useful aboard small craft with limited navigational personnel, equipment, and plotting facilities. This method should serve to overcome difficulties associated with unstabilized displays and lack of a variable range marker.