CHAPTER 7

SCOPE INTERPRETATION

LEARNING OBJECTIVES

After you finish this chapter , you should be able to do the following:

1. Explain the four main PPI PIP characteristics.
2. Discuss two methods of tracking a contact on a radar scope.
3. Explain the techniques for identifying land, ship, and air contacts.
4. Recognize weather conditions on a radar scope.
5. Explain the various false contacts and other miscellaneous contacts.
6. Evaluate scope presentations.

INTRODUCTION

Scope interpretation is the studying of radar echoes for characteristics that will reveal the identification, character, and intent of targets. Target characteristics include the number of contacts (composition), bearing, range, altitude, course, and speed. Since the survival of the ship depends on its crew knowing the intent of nearby aircraft, accuracy in interpreting echoes is vital. As a member of the ship's early warning system, you should consider being able to perform in-depth scope interpretations as your primary fundamental skill.

The amount of reliable information that CIC can obtain from any radar depends, to a great extent, on the skill of the operator. An operator must have intelligence, imagination, skill, great concentration, and an intense interest in his work to provide maximum results. To become proficient, you must practice continually. The more you understand about the capabilities and limitations of your equipment, the better you will be able to apply your skill and knowledge to the tactical situation at hand.

You will often see strange looking contacts on the radar scope. Because their appearance is so difficult to describe, they are given names such as phantoms, pixies, gremlins, and the like. If you thoroughly understand the radar and know the positions of nearby ships, you should be able to recognize many types of false targets.

As you gain experience, you will notice many qualities in an echo that a less experienced operator will likely miss. Experience will enable you to judge more accurately the size and type of object causing an echo. For example, a skilled operator can usually distinguish the pip made by several planes in a group from the pip of a single plane. An unskilled operator, on the other hand, may be able to determine only the range and bearing. Even those may be unreliable at times. A proficient operator sees much more than just the position of a target.

A skilled operator can usually detect a target at a greater distance than an unskilled operator can. This ability results from his close observation of the scope and his "feeling" for the appearance of echoes that a less skilled operator might lose in the "grass."

A properly trained operator measures each range in exactly the same way so that his personal error is small and constant. As a result, these ranges and bearings are more consistent and reliable than those obtained by an unskilled operator. The skill you develop through constant practice will also enable you to measure ranges and bearing more quickly.

It is important that you recognize a target in the shortest possible time. Indecision creates costly delays, particularly if the target is a high-speed air contact. Your speed in recognizing targets aids the plotters in assembling information, speeds evaluations and decisions, gives weapons personnel more time to react to a threat, and adds to the overall efficiency of the radar watch.

PPI PIP CHARACTERISTICS

There are four main pip characteristics you must consider in echo interpretation and evaluation. These are **shape**, **size, fluctuation,** and **motion**.

PIP SHAPE

The shape of a target pip on a PPI is very distinct. The use of a rotating beam makes this distinctness possible. As we discussed earlier, the target pip begins to appear when the edge of the lobe strikes the target. The pip strength gradually increases, reaching the maximum when the center of the beam is pointing directly at the target. The strength decreases as the remaining half of the beam moves across the target. Finally, after the beam has passed the target, the pip disappears. As a result, the pip presentation has a shape similar to that of a banana. For radars that do not use a rotating beam or display targets with computer-generated video, PIP shape probably will not change but PIP strength and size may vary, depending on the radar.

The pip is always displayed perpendicular to the PPI sweep. If you see a pip that is not at a right angle to the sweep, the pip is not a target echo. Dismiss it as a false target.

False targets are common. They can be caused by several types of interference, such as interference in the ship's power line, large variations in receiver noise level (static), interference from another radar operating in the same frequency band ("running rabbits"), atmospheric phenomena caused by electrical storms, and electronic jamming.

You will see ship and aircraft target echoes as sharp, well-defined pips. Land appears as a large, sometimes blotchy pip; while weather creates a very fuzzy or hazy pip. The quality of a pip is based on the amount of energy reflected back to the antenna by the target and how well the radar is tuned.

PIP SIZE

Earlier we discussed the effects that radar beamwidth and pulsewidth have on the size of a pip. We determined that the width of the pip is equal to the horizontal beamwidth of the radar plus the width of the target. Also, we said that the depth of the pip is equal to the minimum range of the radar (PW X 164 yards) plus the depth of the target. If a radar that has a horizontal beamwidth of 10° and a pulsewidth of 1 μs, every pip on the scope will be at least 10° wide and 164 yards deep.

Unfortunately, the PPI scope adds distortion to the depth of the pip. This distortion is the result of limitations in the minimum dimensions of each spot of light. Distortion is greatest on the longer range scales and almost nonexistent on shorter range scales. To minimize the effects of distortion, the range scale is seldom changed on repeaters that are used to search for or track targets. As a result, the long-range surface search operator becomes accustomed to a constant range environment discrepancy and knows exactly how much distortion to expect. The short-range surface search operator, on the other hand, will have very little distortion. Therefore, if each radar operator sets the repeater to a certain range scale, the distortion that a particular operator sees will be constant. The objective of this procedure is to ensure that the difference in size between the pips of two different targets is based upon the actual size of each target. For example, if an aircraft carrier and a destroyer are observed at about the same range, even an untrained operator can see that one pip is larger than the other. With more experience, you will be able to see the difference between the pips of an oiler and a destroyer.

A well-trained operator without the ability to make comparisons can still obtain a good estimate of target size. One of the best ways of judging the size of a target is to note the range at which it is first detected. At a given range, an object must be a certain size before it will return an echo that can be seen on the scope. In other words, the size of a ship or an aircraft determines when it will first become visible on the scope at a definite range. With aircraft, this initial pickup range will vary with the altitude of the aircraft (assuming that you and your equipment are operating at top efficiency).

You must also be aware that as ranges increase, you will have more difficulty in initially distinguishing between ship and land contacts. This problem occurs because a land target may initially appear as a single pip. As the range decreases, more and more pips appear in the same area. Finally, when the range is short enough, the number of pips is so great that they seem to merge into one solid, slightly distorted mass, having the general shape of a coastline, peninsula, or island.

On the other hand, when you initially detect a ship it will appear as a very weak pip. As the distance decreases, the pip will gradually become brighter. This increase in intensity is the result of echoes coming first from the ship's masts and superstructure and later from the ship's hull as well. The size of an echo will be about the same, regardless of the ship's course. However, as the range decreases or a change in course resulting in a beam aspect occurs, the ship will reflect increased amounts of energy and cause the pip shape and intensity to increase.

Echoes returned from air targets are generally smaller than those returned from ships. However, aircraft are usually detected at far greater ranges because of their altitude. An aircraft flying at 20,000 feet should be detectable at about 185 nautical miles by an air search radar. The pip seen for a single aircraft at long range is normally very weak.

Each radar has its own characteristic range at which a target of a certain type (air or surface) will appear. Because large ships generally have tall masts and superstructures, they will be detected at greater ranges than smaller, low-lying vessels, such as surfaced submarines and fishing boats. Once you learn the capabilities of a given radar, you will be able to estimate the approximate a target's size by its echo strength and range.

PIP FLUCTUATION

You can obtain valuable information by observing a target pip closely. Variation in signal strength can indicate the character of the target. These variations appear as changes in the brightness or size of the pip. Two aircraft flying together, for example, will usually produce a fluctuating pip. This happens because on one sweep of the radar beam a strong echo is returned from each aircraft. This causes a large, bright pip to appear. Then, possibly on the next sweep, an echo will be received from only one of the aircraft. This pip will be dimmer.

A change in target aspect can also cause a change in pip brightness. A single jet aircraft flying toward your ship presents a very small reflecting surface. The pip will be very weak or barely discernible. However, if the aircraft goes into a banking turn, it will display a larger reflecting surface and the pip will become much brighter. Consequently, you will usually observe a contact's change of direction long before the change is apparent on the plot. Whenever you observe a sudden change in the size of a pip, it indicates that the target has probably changed course.

Target Composition

You must watch every radar pip closely to obtain maximum information from its shape, movement, and size. Any variations from the normal—erratic fluctuations in brightness, abnormal size, or abnormal shape—will usually give you some indication of the number of targets contained in a pip. You should also be aware of the normal pip width and depth, which is based on the beamwidth and range resolution of the radar. If the pip is wider than the width you expect or deeper than the depth you expect, the echo is being returned from more than one contact. The presence of bumps on the top or sides of a pip may also indicate more than one target.

Fade Areas

Most radars have certain areas where contacts cannot be detected. These areas are predictable and are called *fade areas*.

As a radar transmits, some of the energy strikes the surface of the sea and is reflected upward. This upward traveling energy tends to have a cancellation effect at certain points on the energy traveling in a major lobe. This can result in many fade areas occurring within a radar lobe. Long-range air search radars have many large fade areas. These areas occur because of their lower frequencies. Higher frequency radars produce fewer and smaller fade areas. Figure 7-1 shows a fade chart for a typical air search radar. The figure illustrates a side view of a major lobe of the radar. The shaded portions are the fade areas. The radar will not detect an aircraft located in any of the fade areas.

Fade charts for all the radars installed aboard your ship are always available for your use. These charts provide valuable altitude information. Let's say you detect an air contact initially at 100 nautical miles. By referring to the fade chart in figure 7-1, you can see that the contact can be at any of several altitudes. However, if the aircraft maintains a constant altitude, it will fade and reappear at definite ranges. For purposes of illustration, assume that it fades at 40 nautical miles and reappears at 28 nautical miles. Entering the fade chart with this information, you can see that the aircraft's altitude is about 5,000 feet.

If the aircraft had been flying at a higher altitude, it would probably have been detected much sooner; however, its pattern would have been similar. Your skill

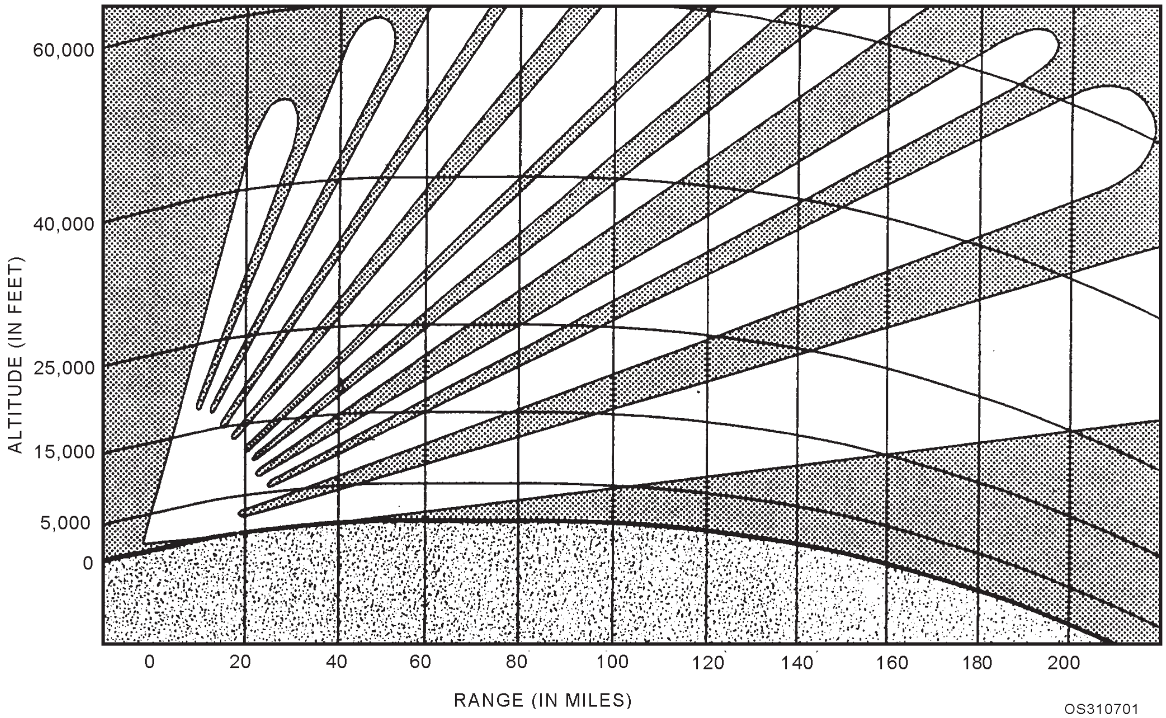

Figure 7-1.—Typical fade chart.

in using fade charts can serve you well when you are assigned to operate an air search radar—particularly if no height-finding radar is available.

PIP MOTION

The speed of movement tells you a lot about the probable nature of a target. An aircraft carrier can't make 100 knots, nor will most airplanes fly at 20 knots. The motion of a target often indicates that the target requires special attention. If an air contact is traveling at 1,800 knots, you should certainly give it more attention than you would give one traveling at 250 knots. Targets that you detect at short ranges, as well as those that will pass near your ship, also require your immediate attention. You must obtain as much information as rapidly as possible on any potential threat target to ensure that your ship will have sufficient time to react.

Your own ship's course and speed will affect the motion of surface contacts on a radarscope. During normal operations, the surface search operator has the PPI sweep fixed in the center of the scope, and all contact motion is relative to own ship's motion. If your ship is heading toward land, the range to the land will decrease at a rate equal to your ship's speed. Thus, you will see the land target moving toward the center of the scope at a speed equal to your ship's speed.

Now suppose your ship is heading east at 20 knots and another ship located 10 nautical miles due east of you is also heading east at 20 knots. The other ship will appear on the scope as a stationary pip 10 nautical miles to the east. As long as both ships maintain their course and speed, the pip will indicate no motion. However, if the contact decreases its speed from 20 knots to 15 knots while your speed remains at 20 knots, your ship will overtake the contact at the rate of 5 knots. At first, it appeared as though you were watching a stationary contact 10 nautical miles to the east. However, when the change in speed occurred, the contact suddenly started moving slowly toward the center of the scope. In other words, the contact appeared to be heading west at 5 knots.

Q1. What are the four main PIP characteristics?

Q2. Large fade areas are predominately associated with what type of radars?

INDICATOR TRACKING

A major problem that you may encounter is keeping an up-to-date reference on the locations and designations of targets. By using a reflector plotter and a grease pencil on a conventional radar repeater, you can keep this information accurately. By placing a series of marks on the face of the plotting device, you can establish a track on a target. There are two recommended methods for marking a track—(1) the continuous line method and (2) the dot method.

CONTINUOUS LINE

The continuous line method consists of placing a grease pencil mark at the inside center of the pip and drawing back a short line. On each successive sweep, repeat your marking on the new pip. You must be sure to start at the new position of the target, then draw the line back and connect it with the last position. If you keep a sharp point on your grease pencil, you will produce a light, narrow, continuous line. This line will depict the track of the target clearly.

DOT METHOD

The dot method of tracking is the more widely used of the two methods. The procedure is very similar to that of the continuous line, except that you do not connect the positions of the target. As a result, the track will appear as a line of dots. The dot method has the distinct advantage of showing changes in the target's speed. A disadvantage is that course changes are less apparent than with the continuous line method.

EVALUATION OF SCOPE INDICATIONS

The indications that appear on a radarscope are quite varied. These indications include

1. natural targets (land, ships, and aircraft);
2. weather;
3. false targets; and
4. miscellaneous targets.

You, as the radar operator, will perform the initial evaluation of all targets.

HINTS ON IDENTIFYING NATURAL TARGETS

The primary types of natural targets are land, ships, and aircraft. Although there are other types of natural targets, a working knowledge of the primary types coupled with actual operating experience will enable you to evaluate all targets.

A well-trained CIC radar operator should never have trouble recognizing land targets. When you pick up a target, you should ensure that it is be plotted on a chart. This will help with final target evaluation.

Land Targets

You can usually identify objects as land targets by using the following information:

1. Land does NOT move on geographic plots; however, the it does move on the radarscope because of ownship's motion.
2. The pip usually remains at the same brightness.
3. Land will be at expected positions.
4. Land usually covers a greater area on the screen than other targets.
5. Separate pips caused by two land masses do not move relative to one another.
6. Sandspits and smooth, clear beaches do not show up on radar at ranges greater than a few nautical miles. The reason is that these targets have almost no area that will reflect energy back to the radar. Ranges determined from these targets are not reliable, because ranging may be to the surf rather than to the beach. If waves are breaking over a sandbar on the beach, echoes may be returned from the surf. Waves may break well out from the actual shore; therefore, ranging on the surf may be misleading when a radar position is being determined relative to the beach.
7. Mud flats and marshes normally reflect radar pulses only slightly better than sandspits do. 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 may, therefore, return either strong or weak echoes, depending on the density and size of the vegetation growing in that area.
8. When sand dunes are located well back from a low, smooth beach, the apparent shoreline appearing on radar is the line of dunes rather than the true shoreline.
9. Lagoons and inland lakes usually appear as blanks on a PPI scope because the smooth water surface reflects no energy to the radar antenna. In some instances, the sandbar or reef surrounding the lagoon may not appear on the radar either, because it lies too low in the water.
10. Coral atolls and long chains of islands may produce long lines of echoes when the radar beam is directed perpendicular to them. This is

especially true for islands that are closely spaced. The reason is that spreading, created by the radar's beamwidth, causes the echoes to blend into continuous lines. However, when the chain of islands is viewed lengthwise or obliquely, each island may produce a separate pip. Surf breaking on a reef around an atoll produces a ragged, variable line of echoes.

11. Submerged objects do not produce radar echoes. But, rocks projecting above the surface of the water, or waves breaking over a reef will appear on the radarscope. When an object is entirely submerged and the sea is smooth, you will see no indication on the scope.

12. If land rises gradually from the shoreline, no part of the terrain will produce an echo that is stronger than the echo from any other part. As a result, a general haze of signals will appear on the scope. This makes it difficult to determine the range to any particular part of the land. In fact, if the antenna is held still and the ship is not rolling, the apparent range to a shore of this sort may vary as much as 1,000 yards. This variation may be caused by slight changes in propagation conditions, which cause the beam to be moved up and down the slope.

As mentioned above, you can recognize land by plotting the contact. You must use care, though, because as a ship approaches or goes away from a shore behind which the land rises gradually, a plot of the ranges and bearings may indicate an apparent course and speed. You can understand this situation by referring to figure 7-2. In view A, the ship is 50 nautical miles from the land, but because the radar beam strikes at point 1, well up on the slope, the indicated range is 60 nautical miles. Later, in view B, when the ship has moved 10 nautical miles closer to land, the indicated range is 46 nautical miles because the radar echo is now returned from point 2. In view C, when the ship has moved another 10 nautical miles, the radar beam strikes even lower on the slope. Now the indicated range is 32 nautical miles. If you plot these ranges, the land appears to be coming toward the ship at a speed of 8 knots, as shown in view D.

In the illustration, we assumed the land mass to have a smooth, gradual slope so that we could obtain a consistent plot. In practice, however, the slope of the ground is usually irregular and the plot erratic. This makes it hard to assign a definite speed to the land contact. The steeper the slope of the land, the less its apparent speed. Furthermore, since the slope of the

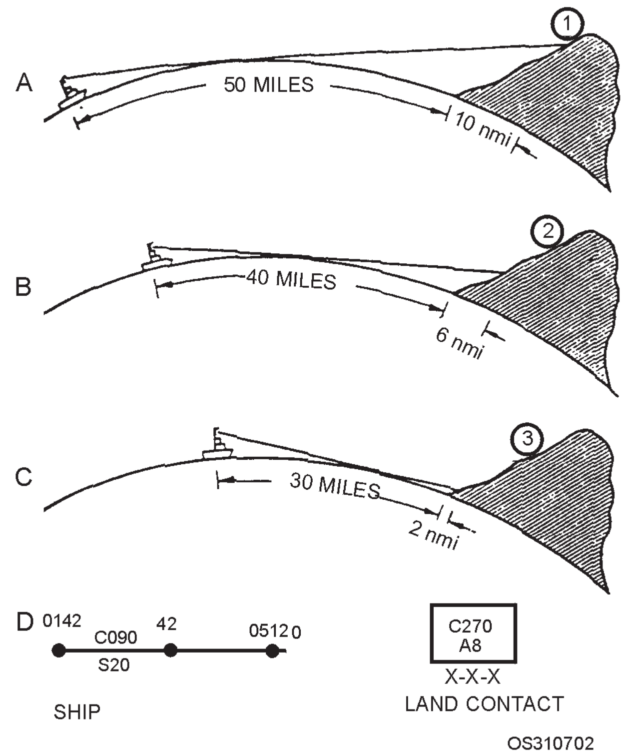

Figure 7-2.—Ship approaching land that rises back of shoreline.

land may not fall off in the direction toward which the ship is approaching, the apparent course of the contact will not be opposite the course of the ship, as we assumed in this simple illustration.

13. Blotchy signals are returned from hilly ground because the crest of each hill returns a good echo while the valley beyond it is in a shadow. If you use high receiver gain, the pattern may become solid except for the very deep valleys.

14. Low islands ordinarily produce small echoes. However, when thick palm trees or other foliage grows on the island, strong echoes are often 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 much greater ranges than barren islands.

Ship Targets

You will spend the majority of your time on watch searching out and tracking surface contacts.

You will learn to recognize a ship partly by a process of elimination. Here is an example of how this method works: First a small echo appears. A check of the target's position shows no land in that sector. Also, the echo does not have the usual massive appearance that characterizes both land and cloud echoes. You rule out aircraft because the target appears relatively stationary. Finally, the appearance of the pip clinches it. A steel ship is an excellent reflecting surface. The echo at a medium range is bright, clearly defined, and steady.

By knowing your radar and understanding how various ships appear on your scope, you can make a good estimate of the size and type of ship. Familiarity with the radar set will help you determine the maximum ranges at which you can expect to detect different types of ship targets. A target that first appears on a typical radar set at 20 nautical miles is likely to be a destroyer or similar ship. Something showing up at 10 nautical miles is likely to be a fishing boat, surfaced submarine, or other low-lying vessel. You also know that large ships will appear at greater ranges. You can improve your judgment regarding the nature of the ship considerably by knowing what is likely to be in the area.

You will detect a formation of ships at greater distances than you will a single ship because a group of ships has a larger reflecting area. At a great distance, the formation appears as a single, large target. You may mistake it for a small island. As the range closes on a formation, you will be able to distinguish individual ships. Within a range of 10 nautical miles, you will be able to determine the number of ships and their positions within the formation by the number, position, and bearing of the echoes. You can recognize the general types of ships by the appearance and strength of the echoes. Other characteristics of ship targets are:

1. The pips slowly increase and decrease in brightness.
2. Normally, there are no fade zones except at long ranges.
3. Speed is less than 50 knots.
4. Small craft or fishing boats appear at about 8 or 10 nautical miles and appear as extremely weak echoes. Plotting these contacts indicates they are moving at slow speeds.

Air Targets

The easiest way to identify an aircraft is to observe the motion of its echo on the radarscope. The echo from an aircraft will appear much the same as an echo from a small ship. However, the aircraft's echo will show rapid motion.

Another indication that a pip represents an aircraft is that the echo fades and soon reappears. This characteristic is typical of any small, weak target, but is more common with aircraft because of fade zones.

Aircraft change their aspect more rapidly than other types of targets do. Consequently, aircraft echo intensities fluctuate more rapidly than those from other types of targets. The normal echo of an aircraft on the PPI scope varies rapidly in brightness.

Helicopters are often mistaken for ships. The best recognition method is observing the speed at which the helicopters move—faster than ships but slower than fixed-wing aircraft.

Q3. Why do sandspits and smooth beaches produce a radar return that can be detected only a few miles?

Q4. How can you determine if a radar pip on your scope is a ship?

STORMS AND CLOUDS (WEATHER)

Sometimes radar is used to observe weather by detecting rain squalls, clouds, and regions of sharp temperature contrasts. Different types of weather produce various returns on the scope. For the scope to detect weather, some form of precipitation must be present—rain, snow, hail, mist, or heavy fog. Higher frequency radars give the best indication. If the precipitation is heavy enough, you may not be able to see through it on certain radars. Usually the edges of weather echoes appear fuzzy on the PPI scope.

COLD FRONTS

One of the more common weather returns is produced by a squall line accompanying a cold front. The squall line may precede the actual front by only a few nautical miles or by as much as 200 nautical miles. The line is usually well defined and quite narrow. (See figure 7-3.) Thunderstorm activity is severe in most squalls. If you are alert, you can locate severe and less active areas. If the line is solid, lowering the gain will leave only the more intense and most active areas on the scope.

WARM FRONTS

Warm fronts are usually accompanied by steady, moderate rain and an occasional thunderstorm. Their

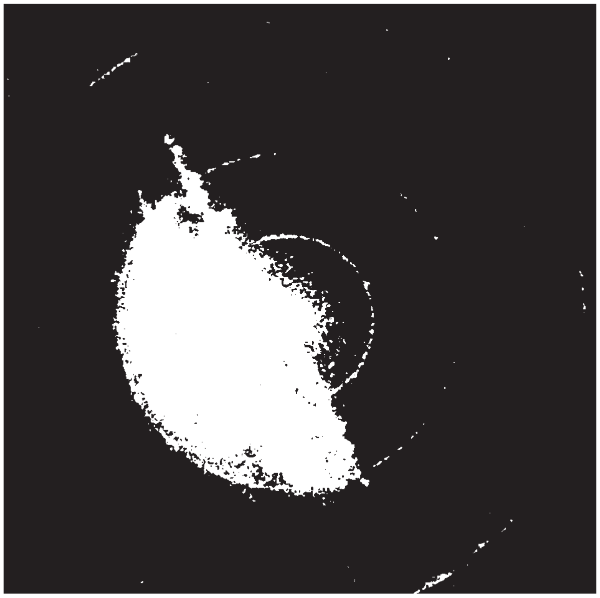

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Figure 7-3.—Cold front.

appearance on a radar is different from that of a cold front. They are much thicker and normally give a steady, solid return as opposed to groups of returns. If thunderstorm activity is present, you may locate it by reducing the gain until only the area of strongest return remains on the scope. Figure 7-4 shows a typical warm front. Compare it with the cold front in figure 7-3.

HURRICANES AND TYPHOONS

Hurricanes and typhoons are dreaded weather phenomena. These storms may produce extremely high winds, which in turn produce very rough seas. Each hurricane has unique characteristics but, from studies of these storms, we can state some general rules. The average range of detection is about 200 to 250 nautical miles. The first indication on the scope is quite similar in appearance to that of a warm front. As the storm approaches, echoes from the precipitation show spiral or circular bands which grow increasingly smaller as they near the center of the storm. The rain and accompanying winds are more severe in this area. Heavy thunderstorms and hail may also be present around the outer limits of hurricanes.

If you detect a hurricane, report its position immediately. Weather-tracking aircraft, land-based radars, and satellites are always searching for these storms during storm season.

Information on these storms is vital to the safety of shipping and coastal areas. Figure 7-5 shows a hurricane as it appears on a PPI scope.

TORNADOES AND WATERSPOUTS

Tornadoes are extremely violent storms that form over land. Waterspouts resemble tornadoes but form over water and cause very little, if any, destruction.

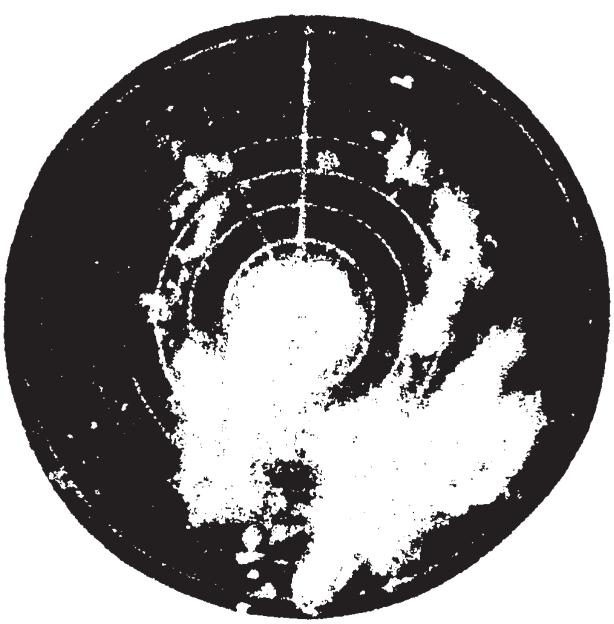

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Figure 7-4.—Warm front.

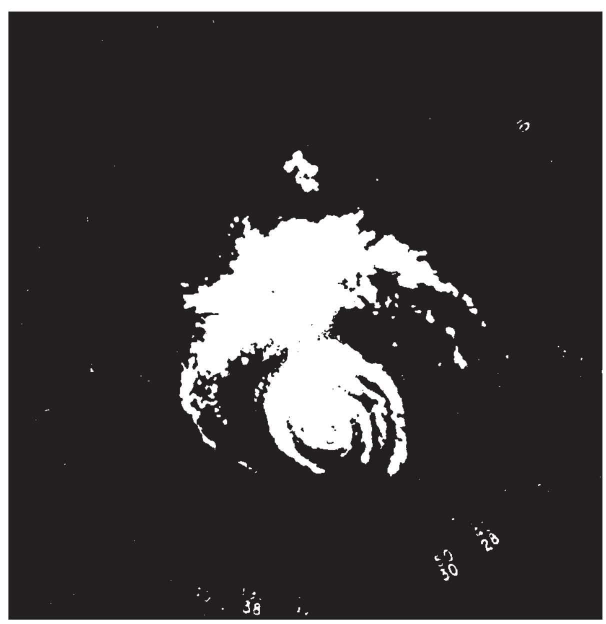

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Figure 7-5.—Hurricane (PPI scale 200 nm).

Although the exact cause of tornadoes is unknown, they appear during certain meteorological conditions and seem to move in a distinct pattern. Most tornadoes move in a northeasterly direction at a forward speed of up to about 45 knots.

On the PPI scope, a tornado or waterspout appears to be V- or hook-shaped. A very small eye or blank spot at the center is a general indication of its existence.

FALSE OR PHANTOM CONTACTS

Many pips that appear on radarscopes look like echoes given off by aircraft or ships do not, in fact, represent aircraft or ships. You need to learn what causes these pips and how they look so you can recognize them instantly.

Radar contacts made on targets that cannot be seen are often given the erroneous title “phantom” contacts. Actually, clouds, turbulence, birds, fish, weather conditions, or wakes may cause them. All of these phenomena reflect radar pulses to some extent. In general, an alert operator can recognize echoes from these sources.

MINOR LOBES

The beam of waves sent out by a radar is not shaped as perfectly as the beam of a searchlight. Actually, it appears similar to the beam shown in figure 7-6.

The main (or major) lobe radiates in the direction in which the antenna is pointing. A series of smaller lobes (unwanted but unavoidable) point in various other directions. When these minor lobes (called side lobes and back lobes) point at an object, they produce echoes if the object is large and nearby.

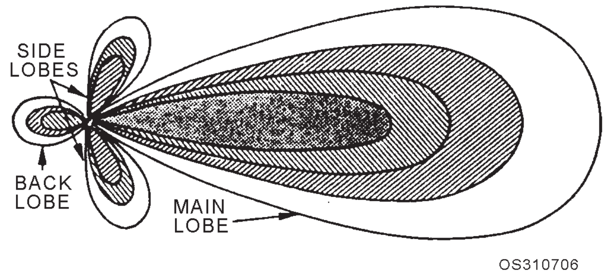

Figure 7-6.—Major (main) and minor (back and side) lobes.

Because the sweep is synchronized with the major lobe, all return will appear to be from that lobe. You can recognize minor lobe returns by their size and the fact that they are at the same range as the major lobe return. Sometimes the minor lobe returns are present through 360° of bearing. This makes it difficult to obtain an accurate bearing on the true contact. When you reduce the gain, minor lobe returns will usually disappear, leaving only the major lobe return. Some newer radars have a side lobe suppressing circuit that you may use to eliminate these undesirable minor lobe echoes.

DOUBLE ECHOES

You will detect double echoes most frequently when a large target is close aboard and on the beam. Such echoes are produced when the reflected beam is strong enough to make a second or third round trip, as shown in figure 7-7. Double echoes are weaker than main echoes and appear at twice the range. Triple echoes are usually so weak that they are seldom seen. Double echoes can be deceiving. If you do not recognize them instantly, you might make the mistake of reporting them as a submarine periscope contact. Used correctly, they can be useful. For example, they can indicate whether your radar is in calibration. The

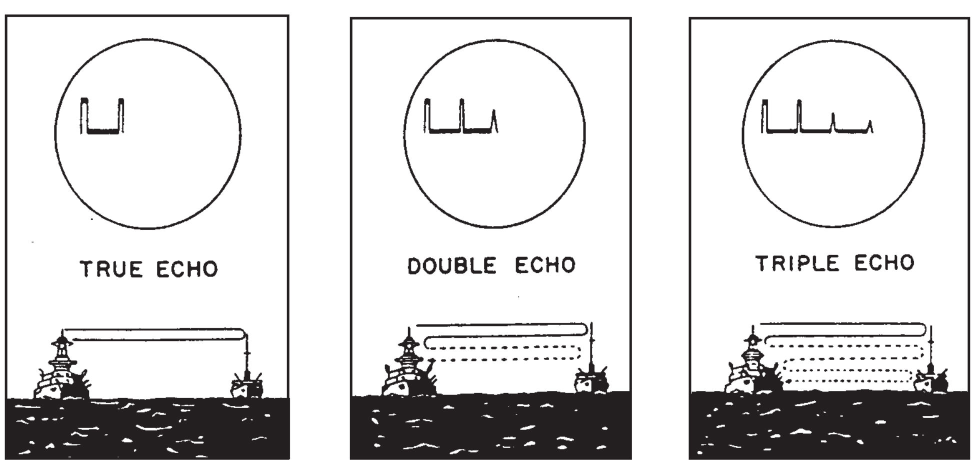

Figure 7-7.—Multiple-range echoes.

range from your ship to the target should be the same as that from the target to the second echo. One of the fleet exercises conducted aboard your ship will consist of setting up an optimum condition. The objective is to obtain these echoes for purposes of calibrating the radar.

SECOND-SWEEP ECHOES

Second-sweep echoes, seen occasionally on the scope, are returned from targets beyond the maximum theoretical range of the radar. Let's say you are operating a radar that has a maximum theoretical range of 125 nautical miles. A mountain 135 nautical miles away would be presented on the PPI at an apparent range of 10 nautical miles. This 10 nautical miles is the difference between the actual range of the mountain and the maximum range of the radar. This happens because each transmitter pulse starts the repeater timing. If the radar transmits a second pulse before an echo is returned from the previous pulse, the echo is presented in relation to the second pulse. When the PRR of the radar is varied, the apparent range of the second-sweep echo changes. Using the previous example, the maximum theoretical range of the radar is 125 nautical miles, and a target at 135 nautical miles is presented at 10 nautical miles. If the PRR is increased to the point where the maximum theoretical range becomes 120 nautical miles, the range to the second-sweep echo will increase to 15 nautical miles. Conversely, if the PRR is decreased in order to increase the maximum theoretical range to 130 nautical miles, the second-sweep echo will jump to 5 nautical miles. Varying the PRR allows you to recognize second sweep echoes immediately. The range to a true target will not vary when the PRR is changed.

RADAR INTERFERENCE

Often, you will see one or several lines that move rapidly across the screen. These lines are usually caused by another radar transmitter operating on or near your radar's frequency. They are called "running rabbits" because of their unusual appearance on the scope.

MISCELLANEOUS CONTACTS

At close range you may get some other false echoes that seem unaccountable. They may be from whitecaps (beyond sea return in the direction from which the wind is coming), from birds, or from such floating objects as large tin cans, powder cases, or even seaweed.

As a rule, echoes from birds or flying fish are faint. In addition, the behavior of birds is usually different from any other type of airborne target. Continued observation of the movement of the echoes should reveal them as birds. Because birds and fish are relatively small, they return echoes only at short ranges. A visual check by lookouts or other topside personnel will help you determine the cause of these targets.

WAKES

Occasionally, the radar will pick up reflections from the wake produced by a nearby large ship, especially during turns and high-speed running. Pips from wakes are small, have poor definition on the PPI, and are near to and astern of the echo of the ship causing them.

ATMOSPHERIC NOISE

The frequencies used by radar are so high that atmospheric noise or static has little effect on radar operation. The noise showing on an indicator is normally produced in the early stages of the receiver. Other strong pulses, similar to noise pulses, have been observed on some radar indicators as the result of nearby lightning flashes. A-band radars will sometimes encounter serious interference from St. Elmo's fire (basically, static electricity). The aurora borealis (northern lights), which interferes tremendously with most communications, has no apparent effect on radar.

Q5. What is the main cause of a contact producing a double echo?

ANALYZING DISPLAYS

Indicator presentations can be difficult to analyze. Although problems may arise on any type of target, you will encounter the greatest difficulties with land displays. When a ship operates close to land, CIC must maintain an up-to-date plot to assist in navigation. This requires a sufficient number of points of reference to establish a position. Fade zones and distortion also make identifying sufficient references difficult.

A straight shoreline often looks crescent-shaped on the PPI. This effect can be seen on any radar occasionally, but it is most pronounced on air search radar. The crescent-shaped effect is caused by beamwidth distortion. The wider the beamwidth, the greater the distortion.

Shoreline distortion is negligible at points where the shore is at right angles to your antenna. But, as the angle decreases, the shoreline distortion increases.

SIDE LOBE RINGING

At times, the crescent-shaped effect is so pronounced that when you look at the PPI, you seem to be in a land-locked harbor or lagoon. Actually, you are standing off a straight shoreline. This complete ringing effect appears mostly on air search radar. It is confusing to air intercept controllers and others concerned with controlling aircraft. Side lobe ringing is the result of a combination of beamwidth distortion and side and back lobes.

LOW LAND

Radar frequently fails to detect low-lying and gradually sloping land, especially at long range. This effect results in another distortion of the coastline.

SHIPS NEAR SHORE

Ships, rocks, and other targets close to shore may blend in with the shoreline. This mixture is caused by the spreading effect of all targets, both in range and bearing, due to the beam and pulsewidths of the radar.

SUMMARY OF DISTORTIONS

The various distortions we have been discussing are summarized in figure 7-8. View A shows the actual shape of the shoreline and the land behind it. Notice the radio tower on the low sandy beach, the two ships at anchor close to shore, and the lighthouse. The heavy line in view B shows how the land looks on the PPI. The dotted lines represent the actual position and the shape of all targets. Notice in particular the following conditions:

1. The low sandy beach is not normally detected by the radar.
2. 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 radio tower could not be seen without reducing receiver gain.
3. The radar shadow behind both mountains increases. Distortion due to radar shadows is responsible for more confusion than is caused by any other condition. Radar-shadow distortion prevents the small island from showing.
4. The land spreads in bearing because of beamwidth 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.
5. Ship No. 1 appears as a small peninsula. The contact has merged with the land because of beamwidth distortion. If the land had been a much better target than the ship, the ship would have been wiped out completely.

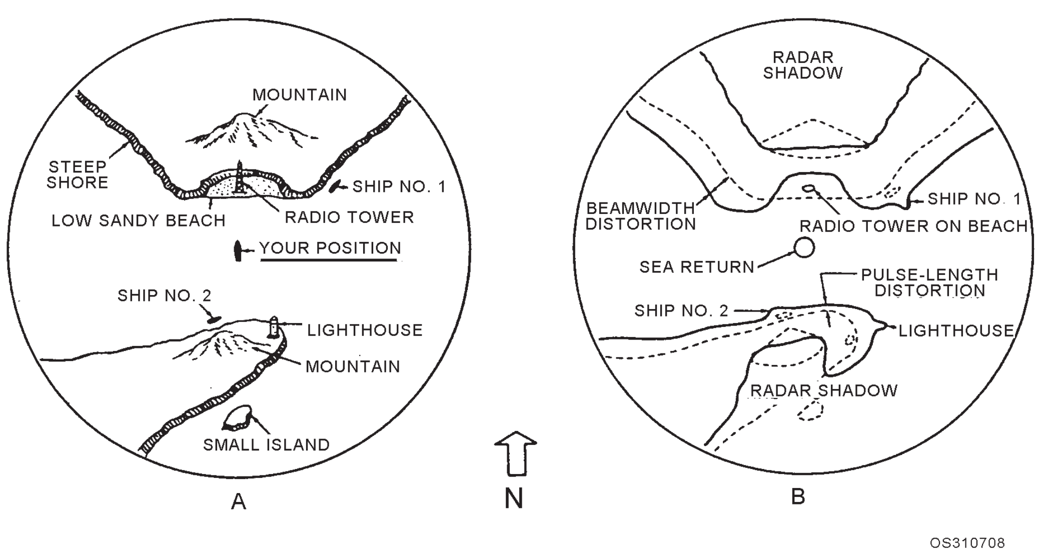

Figure 7-8.—The effect of beamwidth distortion and pulse-length distortion.

6. Ship No. 2 also merges with the shoreline and forms a bump. This display is caused by pulse-length distortion. Reducing receiver gain might cause the ship to separate from the land, provided it is not too close to the shore.
7. The lighthouse also looks like a peninsula because of beamwidth distortion.

Q6. What causes the radar return of a ship near the shoreline to blend in with the land return?

SCOPE EVALUATIONS

Surface search presentations are relatively easy to evaluate. Figure 7-9 shows a photograph of a surface search radarscope taken during a snowstorm. You can see the falling snow to the west, southwest, and south. The northern part of the scope is covered with land return. There are several surface contacts present to the east, northeast, and northwest. Note the surface contact partially merged with the snow at 160°. (Range rings are 1 mile apart.) Your ship appears to be heading 085° because the blank area at 265° is probably a stern shadow caused by a mast or other structure on the ship.

Evaluating air search radar presentations can be a little more difficult. Figure 7-10 shows an air search radarscope with the range rings 10 nautical miles apart. Let's discuss each contact individually.

1. The pips northwest at about 20 nautical miles appear to be two aircraft.

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Figure 7-9.—Land, surface contacts, and a snowstorm on a PPI.

2. The pip northeast at 5 nautical miles is very large and is probably more than one aircraft. It may be a ship.
3. The pip to the east at 21 nautical miles is probably two or more aircraft flying close together.
4. The pip to the south at 24 nautical miles appears to be two aircraft because two separate pips are distinguishable.
5. The pip to the west at 42 nautical miles appears to be a single aircraft.
6. The pip to the southwest at 51 nautical miles is probably a minor lobe echo from the land to the west.
7. Another large land area can be seen to the southeast. The pips in that vicinity are either land echoes or minor lobe echoes from the land.

Figure 7-11 shows the same radar, the same scope, with the same range scale setting, taken about 30 seconds later. Let's see how good our evaluations were.

1. The pips northwest at about 20 nautical miles have weakened considerably. It will be necessary to wait at least another sweep for a good evaluation.
2. The pip northeast at about 5 nautical miles is now spreading out and certainly is at least two aircraft.
3. The pip to the east at 24 nautical miles appears to be two aircraft because of the two separate bumps.
4. The pips to the south have separated and are definitely two aircraft, one heading north and one heading south.
5. The pip to the west at 44 nautical miles is an aircraft heading west.
6. The pip to the southwest at 53 nautical miles is an aircraft rather than a minor lobe echo, because it has moved 2 nautical miles in 30 seconds.
7. The pip at 159°, 40 nautical miles is an aircraft rather than a minor lobe echo. Refer back to figure 7-10. You can see this same contact at 163°, 42 nautical miles. The contact is definitely an aircraft heading northeast.

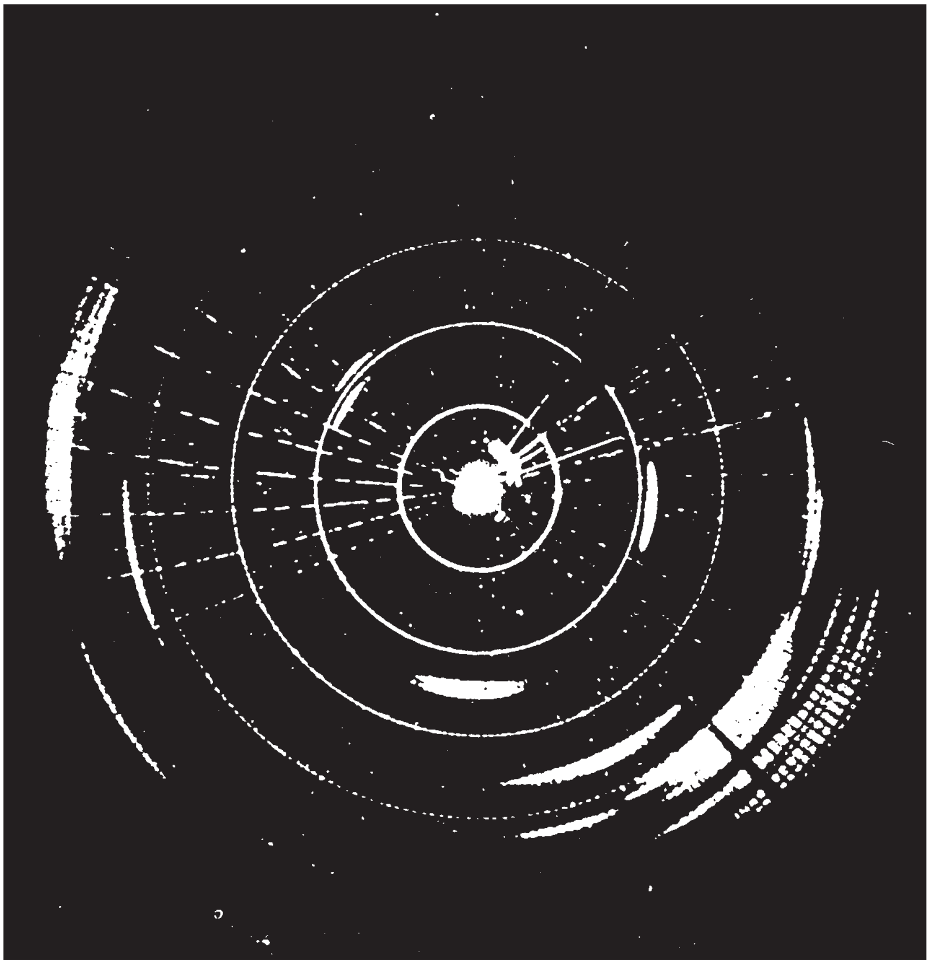

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Figure 7-10.—Air search radar presentation.

8. A new pip has appeared to the northeast at 50 nautical miles. It could be an aircraft or a minor lobe echo. We will have to wait at least one more sweep to be sure.
9. Another new pip has appeared to the northeast at 30 nautical miles. This contact is probably an aircraft that was in a fade zone on the previous sweep. The possibility of its being a minor lobe echo is eliminated because minor lobe echoes are always presented at the same range as the land target that produces them. Since there is no land on the scope at 30 nautical miles, this pip cannot be a minor lobe echo.

Notice the lines of interference to the west and northeast. These are probably caused by interference from other friendly radars in the area operating in the same frequency range.

The more you operate or stand watch on the scopes, the more proficient you will become. This skill, in turn, saves time in your evaluation of what appears on your scope.

You know now, for instance, that radar shadows exist behind objects that reflect radar energy. If the antenna for your radar is not mounted higher than everything else on the ship, a blind sector may exist. Such objects as masts, superstructures, and other antennas can cause radar blind sectors. Most ships have prepared charts showing the blind sectors. Know the blind sectors on the radar you are operating.

ANSWERS TO CHAPTER QUESTIONS

A1. Shape, Size, Fluctuation, and Motion.

A2. Low frequency radars.

A3. These targets have almost no area that will reflect energy back to the radar. Ranges determined from these targets are not reliable, because ranging may be to the surf rather than to the beach.

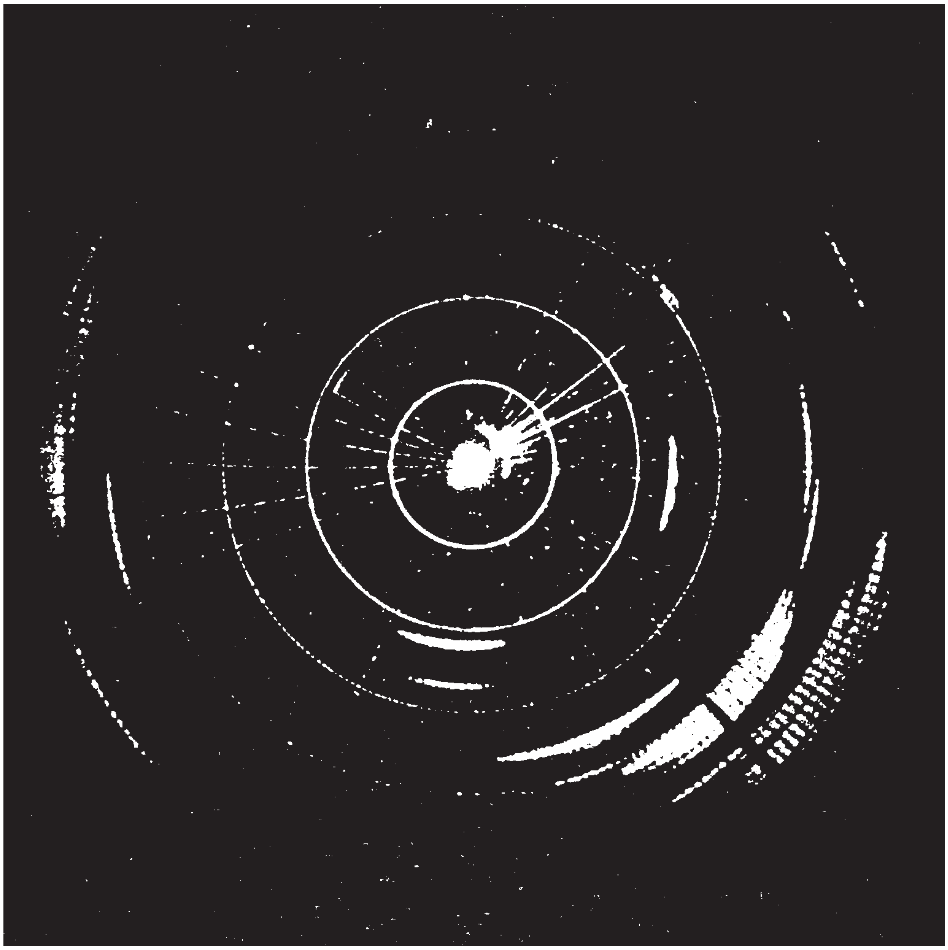

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Figure 7-11.—Air search presentation 30 seconds later.

A4. By a process of elimination. First, check the navigational position for the possibility of land in that sector. Next, if the target appears relatively stationary, rule out aircraft. Finally, look at the appearance of the pip. A steel ship is an excellent reflecting surface. The echo at a medium range is bright, clearly defined, and steady.

A5. A large target is close aboard and on the beam. Such echoes are produced when the reflected beam is strong enough to make a second or third round trip.

A6. The spreading effect of all targets, both in range and bearing, due to the beam and pulse widths of the radar.