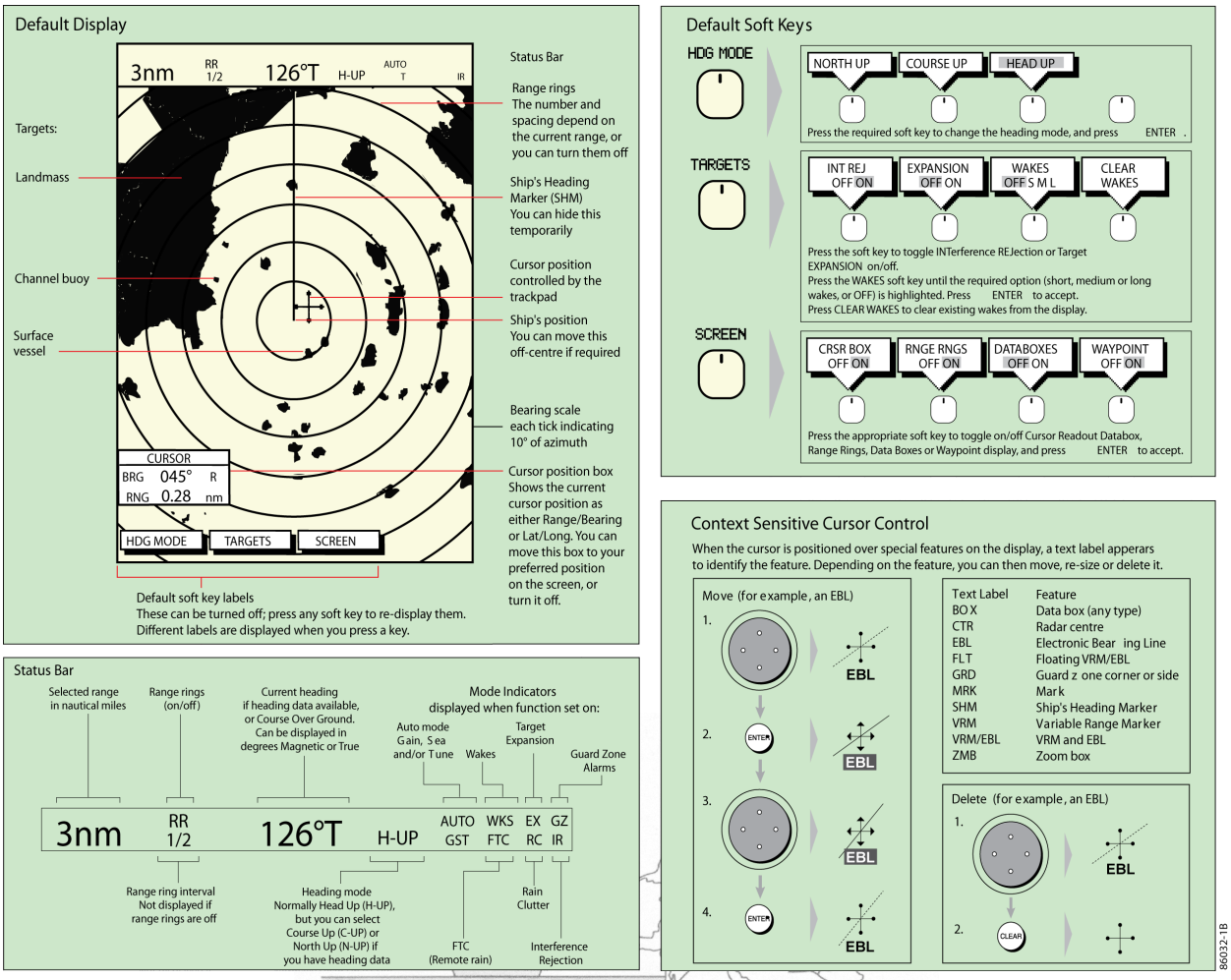
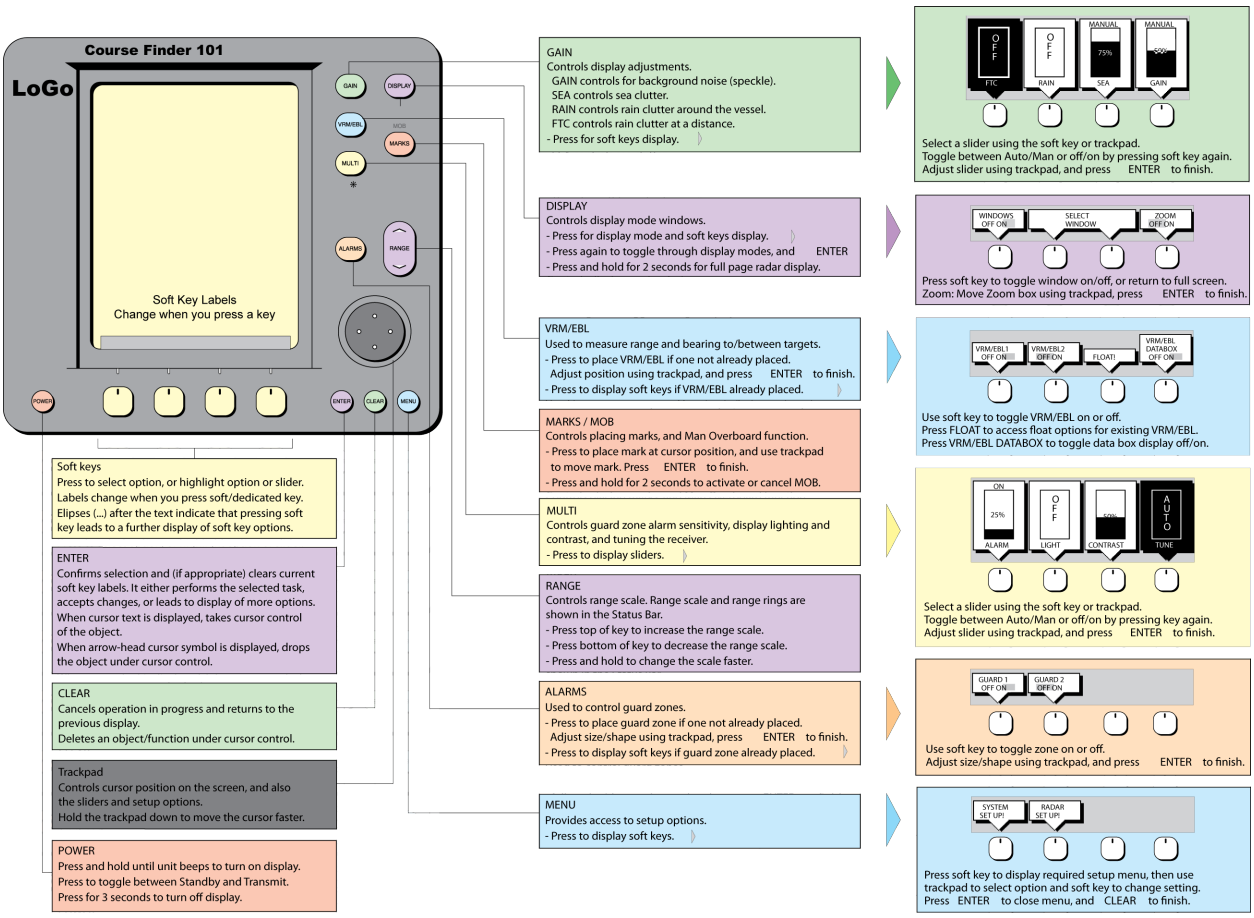
5.0 Operating the Radar

Shrewd operators can extract maximum accurate information by recognizing when the radar set is performing to its specifications, and when it is not. The key to obtaining and maintaining a “good picture” is to understand what a good picture should look like. How to duplicate it on one’s own display is explained next.

5.1 Radar operation

The RayMarine Corporation has published a two page Radar Quick Reference Card for the owners of their radars, which is reproduced as Figure 5.1. This is an excellent cross reference for the following paragraphs which introduce a number of controls, some of which have the inevitable acronyms associated with their function. One of the things you will notice is the number of controls that the operator can adjust on this relatively unsophisticated, small marine radar set. Each one of these many settings can have an effect upon the value of the radar picture to the navigator.





Radar Quick Reference card

Page Two

Figure 5.1 Radar quick reference card (2 pages)
(Reproduced courtesy Canadian Marconi.)

5.1.1 Automatic controls

The latest recreational radar sets, called " Mini-" or " Micro-" radar by some manufacturers, have " auto" selections on most of their controls. They can come with Auto-Tune, Auto-Gain, Auto-Sea Clutter, and Auto-Rain Clutter options on the control panel. These features allow novice operators to switch on and start using their equipment "out-of-the-box", without any introduction as to what it is they should be seeing. Unfortunately, after quite limited experience, many of these operators assume that they are now expert. Worse, they may not be getting the maximum benefit for safe operation from their equipment!

It is necessary to consider that these Auto settings are either a production line standard setting, or they have been adjusted to an arbitrary level by a technician who may, or may not, have ever set foot aboard a boat.

5.1.2 "Grass"

A radar receiver is an extremely sensitive device which must amplify tiny echoes to a usable level for display. These tiny echoes are surrounded by the natural background noises that are always present in the ether (static). There is usually man-made interference from other radars and/or electronic devices close by as well. Even in the receiver circuits themselves there is noise created by the electrons banging about within.

Professional radar people usually refer to all this background noise as grass. The name comes from the appearance of the atmospheric noise on an oscilloscope, or "A" scan Cathode Ray Tube (CRT), where it looks just like grass sparkling on the bottom of the trace (see Figure 5.2 below). When you look at this illustration, you should imagine that the radar antenna is stopped, pointing in one direction. Therefore, it is possible to study the echoes from the reflecting objects along that particular azimuth. If the antenna was rotating, the objects along its azimuth would only register on the trace of the oscilloscope for the split second that the radar was sweeping past the object itself.

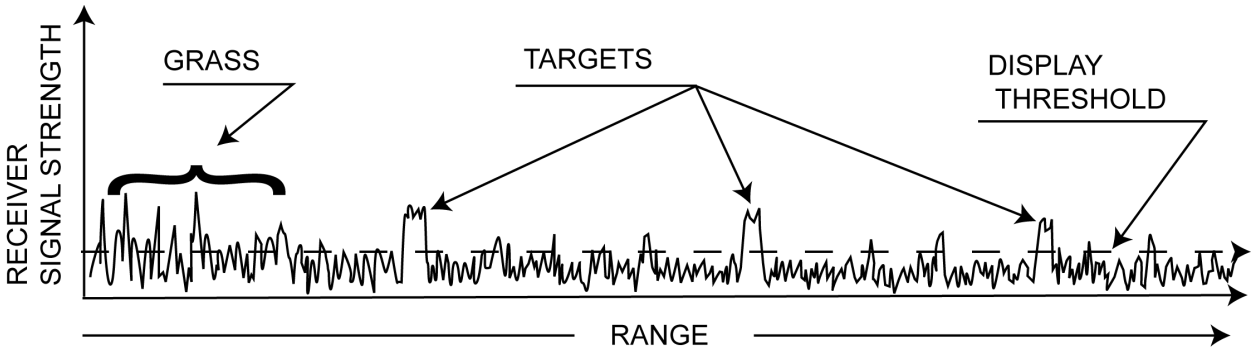


Figure 5.2 Oscillograph view of a Radar trace.

5.1.3 Tweaking the display

Two of the controls can be used to affect the "grass level" itself, the Tune control and the Gain control. A perfectly tuned receiver will detect the maximum size of echoes among the background grass level. The Gain control increases or decreases the overall amplitude of both the displayed grass and the echo paints, like the volume control on a radio increases both the music and the background clicks and pops of static. A very weak signal may just "peak" over the top of the grass level. Turning the Gain down too far can drop the weak signal below the display threshold and it will no longer paint on your display. Turning the Gain up too high can make it very difficult to recognize a steady, but weak signal among the strong sparkling noise around it on the display.

As noted earlier, most of the small radars on the market today have automatic (Auto) positions on individual control knobs of the display console. This can be advantageous to the new operator. However, these automatic settings are a compromise and do not always fully adjust for difficult conditions. It is a good idea to understand what each control knob does and how to use it to "tweak" the display picture, extracting the maximum useful information from it.

The next paragraph explains how to set up your radar for optimal performance. It is necessary to adjust each of the controls separately. In doing this, one learns the function of each of the controls. Note that manufacturers may use slightly different names for some of these controls, but there should be little difficulty recognizing the effect they have on your radar picture.

***Note*:** Before starting to set up your radar, **always** turn the clutter circuit controls off or to their minimum settings.

5.2 Manual tuning

5.2.1 Tune

The physical dimensions of the magnetron tube in the transmitter dictate the precise transmitter output frequency of the particular set. The Tune control fine-tunes the receiver circuits to match their maximum sensitivity to that transmitted signal.

Most new radars have a bar-type display which responds to the Tune control. When the adjustment has reached the maximum reading on the bar display, the receiver is tuned to the transmitter.

There is another excellent cross-check to ensure that your set has actually peaked. If you have a reasonably strong and steady echo from a target (preferably not moving), halfway out on your displayed range, turn down the Gain control until the return is weak, but still easily seen.

Adjust the Tune control to obtain the maximum possible strength (brightness) from that particular return. If the blip increases its displayed brightness dramatically, turn the Gain down again, and repeat the process. When the maximum possible strength from the echo has been established, the best possible tuning has been achieved. You should then readjust the Gain back to your personal comfort setting.

Note: As the transmitter magnetron's metal case heats up it will expand, thus its frequency is likely to drift a little. Watch for this drift (degrading picture) and re-tune from time to time, if necessary.

5.2.2 Gain

The Gain control adjusts the overall amplification boost within the receiver. It is possible to turn up the receiver Gain until the display becomes an ugly mass of strong returns from both noise and legitimate targets. Conversely, it is also possible to turn the Gain down until all of the noise disappears, and with it many legitimate targets. The ideal Gain setting is, of course, the choice of the operator.

The generally accepted rule-of-thumb is that the noise, or grass level, should be as high as the operator can "comfortably" tolerate, but beware of the consequences of either extreme setting.

Grass is generated by any natural static noise or random echo which is strong enough to exceed the minimum threshold for it to be displayed on the radar screen. Random echoes are mainly caused by reflections of radar energy from the face of waves close to the vessel. Therefore, there will be many more of these "sea returns" on a rough day than in calm conditions. Because the faces of waves change quickly these sea returns are very random and the grass seems to scintillate or sparkle in the area close around the vessel. By keeping an eye on this grass area one can very often find a return that seems to stay in one place rather than in the indiscriminate sparkling around it. This is the signature of a possible target, weak and small, but persistent. In a clutter situation this may be the buoy you have been trying to find.

5.2.3 Sea clutter or Slow Time Constant (STC)

Land-based radars have permanent echoes (PEs). Marine radars have sea clutter. PEs are the reflections from nearby objects: an aircraft hanger, a building, a microwave tower, a hilltop, etc. Except on sophisticated commercial and military radars, there is nothing one can do with them except become familiar with these patterns.

On a calm day, the marine radar is almost totally devoid of this interference. The calm water surrounding the vessel provides a flat unobstructed plane. However, when the wind blows up and seas start to build, things change. As the faces of the waves grow steeper and start to break, some of the energy transmitted from the antenna is scattered back towards the ship. This random reflection shows itself by an increasing amount of displayed noise, usually toward the direction of the approaching swell.

A high mounted antenna will show "sea return" noise over a greater range, but the strength of this is quite weak. A low mounted antenna shows the interference over a smaller range, close in, but with strong echoes. The Sea Clutter control uses a special circuit to alter the receiver gain close to the ship, in such a manner that the intensity of the clutter is reduced. This makes it possible to work through the sea clutter; however, as the overall effect is to reduce the sensitivity of the radar receiver close to the vessel, weak returns from legitimate objects are likely to be weakened or completely suppressed. This control should be set to the least (brightest) amount that can be tolerated. Always remember to zero the sea clutter control when the need for it has passed.

5.2.4 Rain clutter or Fast Time Constant (FTC)

Shorter wavelength radar is more susceptible to rain or snow interference than are its longer wavelength cousins. A squall within your radar range can blanket the area of heavy rain with strong returns, twinkling somewhat like grass, but tending to obscure all other usable data in the vicinity. The Rain Clutter control will reduce the effect somewhat, allowing some ability to see targets within the area. However, like other clutter reducing circuits, this control also lowers the overall sensitivity of the radar.

Rain may be heavy on one azimuth arc only, and non-existent around the rest of the swept area. If the squall is not in an area of primary concern, leave the clutter control at its minimum setting. Again, all anti-clutter controls reduce the overall sensitivity of radar. Be in the habit of turning them off first, then adding back only the least amount needed to achieve a comfortable display viewing level. In addition to the Rain control, some radars have a separate FTC control. This adjusts a circuit optimized for the reduction of precipitation interference at longer ranges.

5.2.5 Interference rejection

When this control is present, it works to reduce the effects that other sources of RF signals may have on your display. The most common interference that is likely to be experienced is caused by other active marine radars in the vicinity. All of the 3 cm radars in the Marine Band operate at frequencies very close to one another. They also have similar PRF selections and this causes the "listening" receiver to pick up the pulses being transmitted from other operating radars. The pulses of energy sweep across the receiver leaving a pattern on the display called running rabbits, for their unique pattern. Figure 5.3 illustrates this phenomenon.

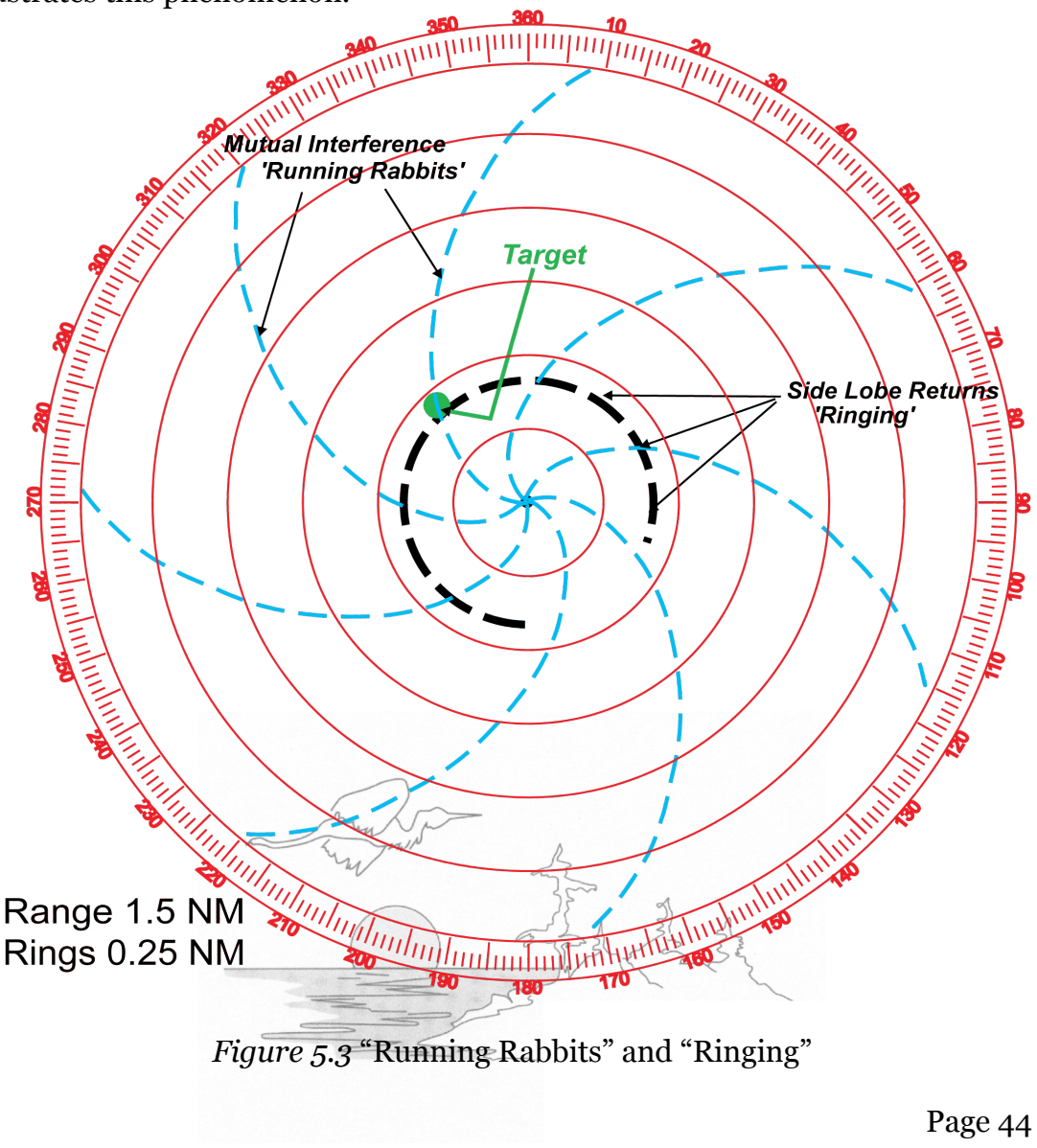


Figure 5.3 "Running Rabbits" and "Ringing"

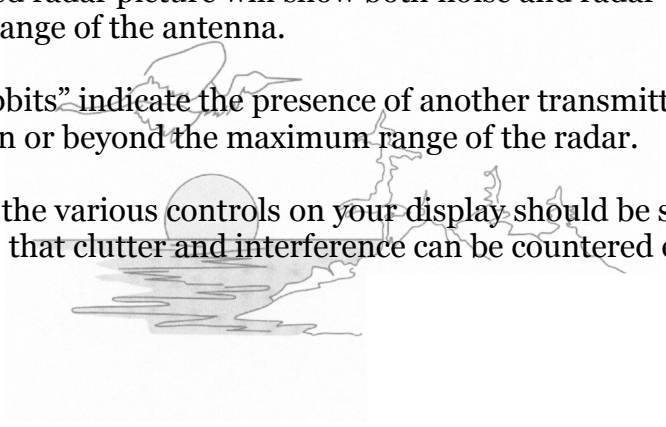
Also shown in Figure 5.3 is the ringing effect caused when a large target, such as a supertanker, passes close aboard the boat. In addition to the very strong echoes from the main beam, the size and proximity of the target will allow echoes to be displayed from weak transmitted pulses in the side lobe "scatter" of the antenna pattern. Side lobes are shown in Figure 3.5 in Section 3.0. These weak echoes are strong enough to be processed by the receiver, but they will paint on the display at the current angle the antenna is pointing, well before and well after, the actual bearing toward the target. The arcs painting on either side of the main target return show the location of these side lobes in relation to the main beam.

This ringing effect can be reduced, or removed, by turning down the Gain control. However, the standard caution applies: any major adjustment of the Gain control will adversely affect the overall radar picture. Be sure it is returned to its previous setting as soon as you are finished.

The reader is encouraged to experiment with setting up his or her own display manually. It will be a pleasant surprise how much more can be seen. He/she will then know the range of the settings and become more comfortable with interpreting the displayed picture.

5.3 Summary

- Auto settings on the radar display console controls are optimized for average conditions and are seldom able to fully compensate for unusual weather or atmospheric conditions.
- Manual adjustment of the receiver circuits may permit the operator to see targets that would otherwise be hidden in noise or masked behind interference close to the radar.
- A "too clean" radar picture is, more than likely not displaying legitimate weak target paints.
- A "too dirty" radar picture is most likely to be blocking out many legitimate target paints, both weak and nominal.
- Any circuit control that can clean up clutter and interference can also mask good echoes when over-adjusted or switched on when not required (even Auto).
- A well-adjusted radar picture will show both noise and radar blips over the entire line-of-sight range of the antenna.
- "Running Rabbits" indicate the presence of another transmitting radar in the vicinity, within or beyond the maximum range of the radar.
- The affects of the various controls on your display should be studied in good conditions, so that clutter and interference can be countered effectively in poor conditions.



Next - The radar display

All of the controls that have been discussed are mounted on the Control Display Console. These are the operators' means of inputting their commands and adjustments to the radar set to obtain the information display which best meets their immediate navigational requirements. In the next segment the man-machine interface will be examined revealing how radar is used to navigate.