usefulness—the range of knots which André Pires tabulates covered latitudes only from 10° to 24°—and laborious although it was, the meridian observation of the Sun, used with the four-year declination tables, was a sounder practice.

The sections of this manuscript (which has an English *Introduction* by Armando Cortesão) include the Regiment of the Sun, the Regiment of the Pole, the Regiment of the Southern Cross, the Length of an Arc of the Meridian and the Variation of the Compass. Its publication is an important addition to the source material for the History of Navigation. It is of interest, too, as having come into the possession of the French Minister Colbert as a gift from the French Ambassador to Lisbon.

REFERENCE

1 Luis Mendonça de Albuquerque, *O Livro de Marinharia de André Pires*, Junta de Investigações do Ultramar, Lisboa, 1963.

Radar Practice in Fairly Dense Traffic

from Commander P. Clissold

THERE are occasions when, because of the density of shipping and/or lack of sea room, ships navigating by radar in thick weather cannot avoid passing within a distance of two miles, the least distance usually considered desirable. In such a situation a simple plan of procedure and of avoiding action, if possible to devise, should greatly reduce strain on the navigator and so increase the safety of navigation generally. Also, if such a plan came to be generally followed, safety would be further enhanced, because each navigator would know what the others were likely to do.

The plan described supposes that a ship has a relative display radar with a not less than 12-inch screen, fitted with a reflection plotter.

The aim is to keep the procedure as simple and straightforward as possible, with the minimum amount of plotting. The method employed is as follows:

(*a*) Watch kept on 6-mile scale.

(*b*) Range marker kept at 5 miles range.

(*c*) Echoes are marked on the reflection plotter on appearance and periodically until the 5-mile ring is reached.

(*d*) The distance of nearest approach is then estimated by laying a straight-edge along the line of the echo's advance.

(*e*) If the distance of the nearest approach is less than one mile, course is altered in accordance with Hollingdale's rules (rounded), which are based upon the bearing of the threat (Fig. 1). If this rule cannot be safely applied because of, for example, the presence of another ship, engines are stopped. There are thus two simple actions open to the navigator: the first, usually taken, is to alter

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course a given amount, and the second, if this does not seem advisable, to stop engines.

'Stop Engines' was chosen as the simplest way of quickly reducing speed, not of stopping the ship. It is possible that 'Dead Slow Ahead' would be almost as efficient and more convenient to engineers. Of course, there is nothing to prevent the navigator from going astern on his engines and stopping his ship, but in the tests which were made it did not prove necessary to do so.

The plan was tested on a simulator with 'own ship's' speed at 12 knots and an appropriate loss of speed when 'engines' were 'rung to stop'. Twenty degrees of helm were used, also with an appropriate reduction in speed and time lag when altering course.

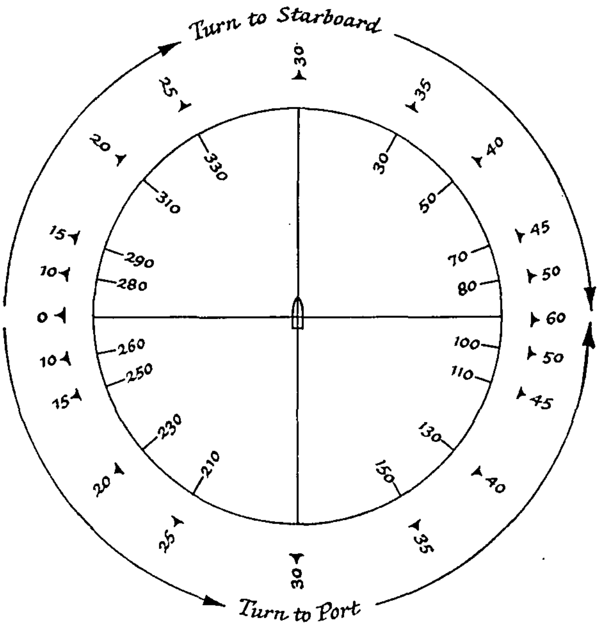

FIG. 1. Hollingdale's rules (rounded). If both ships alter as shown, nearest approach is half the range at which action is taken

During the first half of the test the radar was gyro-stabilized and for the second half it was unstabilized with a yaw of 3° on either side of the mean course introduced. Eighteen encounters were made with ships on varying courses, crossing, meeting end-on, passing or overtaking at speeds between 6 and 15 knots. The targets were introduced more or less at random, there being one, two or three visible on the screen together.

Engines were stopped and speed run down to 'steerage way' on four occasions. Owing to the successive appearance of targets, alterations had occasionally to be made while still to starboard of the original course, but the largest alteration was 60° to starboard and this was made only once; the usual amount altered was 30° to starboard.

If the ships were on a collision course and both followed Hollingdale's rules at a range of 5 miles, assuming that alteration occurred without delay, the nearest

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approach would be 2·5 miles. The smallest nearest-approach experienced was 0·75 miles on three occasions. The average miss distance was 1·1 miles. Of course, the nearest approach was estimated much more accurately when the display was stabilized and no difficulty was experienced in deciding whether risk of collision existed. With an unstabilized display and a rather quick (but regular) yaw the prediction of the echo's movement was less certain and on one occasion a collision course was predicted, and avoiding action taken when in fact the ships would have passed clear if both had maintained course and speed. The error was, however, quickly detected, engines were stopped and the position clarified while still at a safe distance.

The results seem to be satisfactory, but more tests are certainly necessary before the plan could be confidently recommended. Such tests would be better carried out by different people on different simulators. Questions which need answers are:

(1) Up to what speed could this procedure be used safely? Other ships may, of course, be going faster than 'own ship'.

(2) Is 5 miles the best range to choose for taking avoiding action?

(3) Is 'stop engines' the best engine movement?

(4) Is the plan suitable for use with true-motion radar? On a 6-mile range scale an off-centre ship has a longer warning range, but the nearest approach cannot be directly observed.

If some such plan as outlined can be demonstrated as suitable, a considerable step forward will have been taken in showing the navigator how to be happy in fog.