assume in clear weather). He will therefore take the seamanlike precaution of reducing the risk by a reduction in speed or by a course alteration before a close quarter situation has had a chance to develop. Likewise when danger threatens and he uses the trial steering facility, to pre-test the effect of a contemplated collision avoidance alteration, he will not plan to produce a CPA distance which is still so small that the new situation created by his alteration may not be clearly seen to be safe by the ship to which he is giving way. Such an action would introduce the risk of that ship being caused mistakenly to manœuvre in an unforeseeable manner when the resultant close quarter situation was being reached. Admittedly it is not always possible to manœuvre to increase the CPA distance as much as one would like, but we do not recommend that Predictor's trial course facility be used to plan close shaves.

Four-Point Mooring

Lt.-Commander K. G. Lees, R.N.

H.M.S. *Reclaim* was built in 1948 by Simons & Co. of Renfrew as a salvage ship of the *King Salvor* class but altered before completion for her role as a deep diving vessel. She established world deep diving records in 1948 (536 ft., 163 m.) in Loch Fyne, the diver wearing a standard diving dress and breathing a mixture of oxygen and helium, and in 1956 (600 ft., 183 m.) off Norway. In 1964 she carried out a series of dives to 600 ft. for one hour, off Toulon, the divers wearing lightweight self-contained equipment. In 1950 she located the sunk submarine *Truculent* in the Thames estuary and in 1964 the submarine *Affray*, when underwater television was used for the first time. In 1966 she recovered a crashed Viscount aircraft in the Irish Sea. *Reclaim* is now engaged in trials which will eventually permit diving for prolonged periods to 1000 ft., and therefore anywhere on the Continental Shelf.

Two divers are lowered to the sea-bed in a submersible compression chamber equipped with underwater lighting and television and in telephonic communication with the ship. While one diver swims out of the chamber to undertake the required task the other acts as attendant. The chamber when hoisted aboard under pressure is locked on to another chamber in the ship's hold, where the divers carry out the process of decompression which may take several hours.

H.M.S. *Reclaim* encounters some unique navigation and seamanship problems when engaged in deep diving. To place the divers on a particular job the ship has to be held stationary above the position; and this is accomplished by carrying out a four-point moor whereby the ship is anchored by each bow and quarter. In order to moor in this way *Reclaim* is fitted with two 2½-ton bower anchors each connected to fifteen 15-fathom shackles of 1½ in. chain cable; on the stern are carried two 1½-ton Danforth anchors each connected to 270 fathoms of 5 in. wire. The disparity between the weight of the anchors and cable forward and the anchors and wire aft means that more wire has to be let out aft than cable forward. This equipment enables the ship to be moored in depths of water down to 600 ft.

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The required position of the ship is usually directly above an object on the seabed, the position of which has to be known accurately and is preferably marked. The object can be located by echo sounder or sonar, which may well have been done by another ship before *Reclaim* arrives on the scene or it could have been snagged by a search vessel. Having decided the final position it is necessary to consider the heading of the ship; generally it is better to have the ship's head pointing into the prevailing weather so that the heavy bower anchors take the strain. It is also preferable to have the ship lie along the line of the tide so that two anchors take the strain and the force exerted on the ship's hull is the minimum. The resultant heading may well be a compromise between the two requirements. Having plotted the required diving position and decided which way the ship will lie when moored, the positions of the bower anchors are plotted 200 yards on each bow and the stern anchors 300 yards on each quarter. The length of the ship is disregarded as this gives a safety factor against coming up 'all standing' during the mooring operation.

The methods available to navigate into the moor are by visual bearings from convenient navigation marks, by radar parallel index ranges on convenient land, by Decca, by visual bearings and distance meter ranges of the datum mark, or by eye on the datum mark. All except the last require initial preparation and close collaboration between the navigator and Captain to carry it out. A moor carried out by visual bearings from convenient navigation marks close by requires each let go position to be plotted with a lattice of bearings for each one. Two continuous bearing readings allow the ship's track to be plotted and the turn adjusted as necessary. This system is cumbersome and more suitable for a slow moor than a fast moor. The use of radar parallel index ranges on a convenient point of land allows the picture to be drawn on the face of the radar PPI. The circle of the turn can be added and any deviation from the plan is immediately apparent. This is the usual system if the geographical position allows. The use of Decca when too far from land for either of the above methods is quite convenient, the final required position and each anchor position are transposed from the chart to a blown-up, large-scale Decca lattice plot. Continuous readings from the Decca QM12 receiver allow the ship's position to be plotted as the moor is carried out and the turn adjusted as necessary. Using the datum mark previously laid in the final diving position depends on the estimated accuracy of the lay, the scope of the buoy wire and the tidal conditions. Where these are satisfactory, mooring by visual bearings and distance meter ranges, or completely by eye, is relatively simple.

The moor can be done as a fast moor or a slow moor. For a fast moor (Fig. 1) the ship should run in on the approach course for the first anchor position for at least half a mile in order to steady up. A speed of 10 knots is maintained until just before the last anchor is let go. On reaching the first anchor position (A) the inner stern anchor is let go and 20 degrees of appropriate wheel applied. As the stern swings over the second anchor position (B) the outer stern anchor is let go, both stern wires being allowed to run out freely. The swing is continued, being adjusted according to the navigation system in use, until the third anchor position is reached. At this stage the ship should be pointing roughly in the direction of the fourth anchor with a fast swing being maintained. As soon as the heavy outer bower anchor (C) is let go the swing will be retarded. The limit of stern wire available is also being reached at this stage and it is imperative to have continuous reports from aft of the amount of wire out, so that the final part of

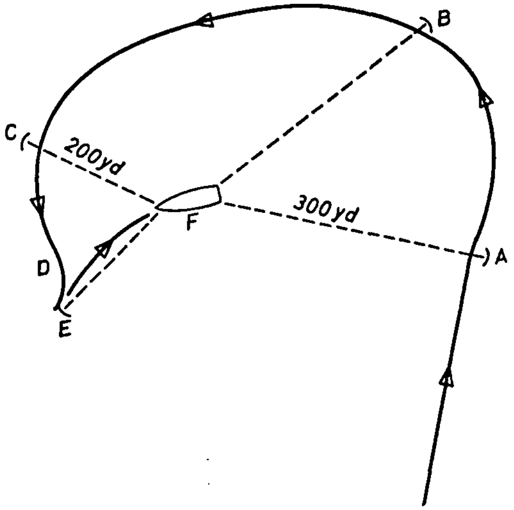

FIG. 1

the turn can be tightened if necessary. The ship is driven to the position of the fourth anchor, the inner bower. Just before reaching the let-go position the engines are stopped (D), the drag of the stern wires and the outer cable will reverse the swing and spin the ship out of the mooring turn. On letting go the last anchor (E) the ship is driven astern into the centre of the moor and middled up in the required position (F). The cables and wires can be heaved and veered as necessary to carry out an underwater television search and the diving position of the submersible compression chamber can be adjusted as required.

A slow moor (Fig. 2) makes use of tide and weather to assist in getting the ship to the fourth anchor position against the drag of the cable and wires already out. The stern wires are let go and the turn commenced as before, but at lower speed.

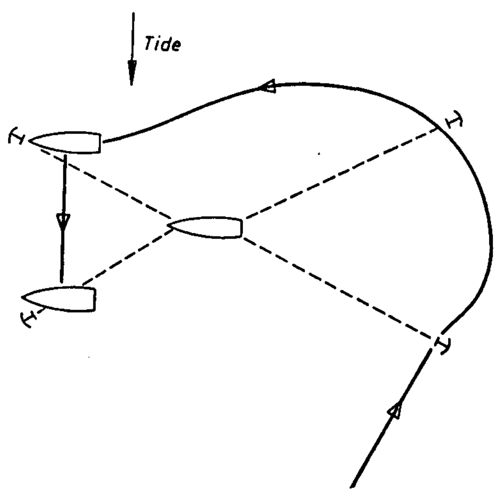

FIG. 2

The ship is driven to the let-go position of the third anchor, the outer bower, and stopped. The tide and wind are then allowed to take the ship across to the position of the fourth anchor, assisted by engine movements if appropriate. This method may not however be compatible with the direction in which the ship is required when moored.

The operation of unmooring depends on the tide and weather at the time. The lee bower anchor is usually weighed first, paying out the weather cable and stern wires as necessary. This is followed by the weather bower anchor. The ship is then driven astern to recover the stern anchors in the appropriate sequence. In conclusion it must be pointed out that each operation has some unique feature. There is no such thing as a standard method of mooring; variations on the methods described above are possible and may be appropriate in a particular instance.

Operational Aspects of Ships' Bridge Design

A seminar on the operational aspects of ships' bridge design was organized in Liverpool on 18 January 1973 by the North West Branch of the Nautical Institute and the Merseyside Branch of the Royal Institute of Navigation. Points from some of the papers presented at the seminar are summarized below.

THE CONTRIBUTION OF ERGONOMICS. Mr. Malcolm Hatfield (P. & O. Steam Navigation Co., Ltd.) tentatively defines ergonomics as the optimal fitting together of the requirements of work and the abilities of people, based on controlled experiments in anatomy, physiology and psychology; it is more than 'the science of good seating'. In general the design of ships' bridges does not reflect the necessary coordination of these basic disciplines and, while manning scales must affect bridge design, the bridge layout also affects operational practices. A bridge is the working area for a variable number of people depending on the conditions in which the ship must operate. The present deployment of manpower is however largely based on traditional practices and, for example, lookouts as at present employed may contribute little to the safe navigation of a vessel; legal restrictions and levels of ability, as well as an innate conservatism, are bars to progress.

Turning to the overall shape of the bridge structure, the poor visibility from many wheelhouses is due to insufficient attention to the design of the bridge in relation to the rest of the ship particularly in VLCC's, where communication is also a problem; the bridge wings may themselves obstruct visibility. A primary concept in ergonomics is the work station, which is the man-machine interface for any particular operation with its associated controls and displays. The number and disposition of work stations should be based on an analysis of functions; one criterion of good design is how little the bridge personnel have to move about.

It is often stated that most accidents at sea are attributable to human error, but the ergonomic approach is to analyse the overall system performance to discover and remove the weak links in that system. Because men are involved in the system an engineering solution may be inadequate or inappropriate and a vital element will be the proper allocation of functions between man and machines. The navigator himself may not be the most appropriate person to conduct