The complete action of steering will now be considered. When the ship's head swings off course, say to starboard, the quartermaster applies port helm to bring the ship's head back towards the course. As the ship's head starts to swing back the amount of port helm is decreased and then the helm, perhaps, put to midships when the ship's head is back on course or, if need be, counter helm to starboard is applied to check the ship's head and prevent it swinging on past the course to port.

At the end of his trick on the wheel the quartermaster states the course and usually gives some guidance to his relief. For example, he might say " She's swinging about two degrees on each side of the course and taking about three-quarters of a turn to starboard and half a turn to port ". Perhaps, instead of giving the number of turns of the wheel each side he may give the actual rudder angles, for example, 10° to starboard and 7° to port.

In more technical terms it could be said that the ship was carrying 3° starboard helm or rudder (10°–7°) and yawing 4° (that is, two degrees each side).

The helm may be carried either because of transverse thrust from the ship's propellor(s) or because of a combination of transverse thrust and weather conditions. With a single right hand screw propellor a ship's head tends to turn to port when going ahead. When the wind is on the port bow of a ship with a large forecastle head and " flying light " the ship's head tends to fall to starboard away from the wind. On the other hand, a ship with a high superstructure aft tends to head up into the wind. Thus the amount of weather helm carried depends on individual ship characteristics and the prevailing weather conditions.

Yaw is caused mainly by *swell*. The amount of yaw experienced depends on the amplitude of the swell and, more important, the direction of the swell in relation to the ship's head. For instance, a heavy head swell should hardly cause a vessel to yaw at all, although she may pitch a good deal. Similarly, a heavy beam swell should not cause the vessel to yaw although she will probably roll heavily. On the other hand, a moderate swell which approaches the vessel on either bow or quarter will probably cause the vessel to yaw on either side of her course no matter how skilled the quartermaster. In fact, the over-zealous quartermaster who attempts to prevent yaw is generally putting unnecessary wear and tear on the steering gear.

In general ships tend to yaw most when the swell is approaching from about four points abaft the beam. The action when a swell approaches from abaft the starboard beam is first for the swell to catch the stern and throw it upwards to port thus swinging the bow to starboard; as the swell overtakes the vessel the stern falls down into the following trough and the bow is lifted and thrown back to port. The cycle is then repeated. If the vessel's

speed and course are such that the crest of the swell catches the stern at the same time as when the bow is in the trough the ship will yaw considerably —a synchronism being established between the period of yaw and the apparent period, i.e. the period of encounter, of the swell. There could also be a synchronism between the natural period of the ship's roll and the time between successive wave encounters of the swell. This would cause the ship to roll violently and could be dangerous. This latter type of synchronism should be avoided whenever possible and can be broken by an alteration of course and/or speed in order to change the period between successive wave encounters.

The sensitivity of a quartermaster's steering is inversely proportional to the amount of yaw, that is the greater the yaw the less sensitive the steering. If, for example, a ship is yawing two degrees (one degree on each side of the course) the quartermaster will only change the amount of helm he is carrying when the ship moves more than one degree off course.

In general, in calm weather or with wind, sea and swell ahead it is usually found that a vessel is best steered with small, sensitive helm applications and with little, if any, weather helm being carried. In heavy weather with the vessel yawing it is found that larger, less sensitive helm applications are required. The amount of weather helm, as mentioned earlier, depends on the characteristics of the ship and the directions of the wind, sea and swell.

Automatic helmsmen are provided with controls for adjusting the amount of rudder, yaw (sensitivity) and the amount of weather helm carried. The degree of success of the automatic steering depends on how well the officer on watch can make these adjustments according to the prevailing weather conditions and the characteristics of the ship.

The automatic helmsman receives information about the direction of the ship's head from the transmitting system of a gyro compass or, in some cases lately, from a transmitting magnetic compass. This generally means that an actual alteration of course has to occur before rudder is applied or removed. A human quartermaster can often harmonize himself with the helm in such a way that he can anticipate the moment when the ship is about to fall off course and thus apply helm in anticipation of this movement. Some later types of automatic helmsmen have a time adjustment fitted which enables the rudder to be applied or removed before the ship's head actually moves and can thus " anticipate " movement—compare Figs. 1 b and 1 c. The setting of this adjustment is again the responsibility of the officer on watch because it depends on the prevailing conditions.

One of the main objects of this volume, besides providing an explanation of the working and information about the maintenance of various types of auto-pilots, is to assist the officer in making the above important adjustments.