AXIAL VIBRATION OF SHAFTING AND ITS INFLUENCE ON THRUST BLOCK DESIGN.

In large vessels the great length of shafting between propeller and thrust block has considerable elasticity, which, with the flexibility of the high seatings inherent in such ships and that of the thrust block itself, forms a spring on which the propeller may vibrate in an axial direction. The main gearwheel becomes involved in the motion to an extent determined by the relative flexibilities of the shaft, thrust block and seating.

The exciting force for such vibration has a frequency equal to shaft revolutions per minute multiplied by the number of propeller blades and arises from a variation of water speed across the propeller disc due to the friction of the hull or other causes. The percentage variation varies according to the conditions, for instance it is about 3 times as great for the centre shaft of a triple screw vessel with a stern post as it is for a shaft in an 'A' bracket. It is also affected by turning, especially if the slip stream from the outer propeller on the outside of the turn cuts across the disc of the inner.

A critical speed is encountered when the propeller blade frequency coincides with the natural frequency of axial vibration. This critical is fairly well damped, mainly by the propeller itself, but if the thrust variation is excessive, and the critical occurs at a high power it may become serious. Cases which have overstepped the limit are: (*a*) centre shaft of triple screw vessels both on the straight and turning; (*b*) inner shafts of quadruple screw ships when turning at high powers. Borderline cases are: (*c*) inner shafts of quadruple screw ships on the straight; and (*d*) vessels with bossings instead of ' A ' brackets.

Axial vibration is objectionable for the following reasons:—

(i) Flexibility of the thrust block and seat allows the gearwheel to partake of the motion, and as the double-helical pinions are locked to it by the power torque, the flexible couplings between pinions and turbines are subjected to rapid axial sliding. This results in unduly rapid wear and, in extreme cases, in seizure with the attendant risk of damage to the gear teeth.

(ii) Large alternating forces arising on a critical speed with excessive thrust variation are found to loosen the thrust block holding down bolts and seat rivets, and have been known to start seams.

(iii) The rapid sliding causes excessive wear of stern tube and ' A ' bracket bushes, and leads to difficulty with stern tube glands. It may also cause loosening of bushes and the breaking of their securities.

(iv) It may cause excessive hull vibration and consequent vibration of important instruments but this will depend on coincidence between a natural frequency of the hull and that of the shaft system.

Action against axial vibration may be taken in new construction by locating the thrust block further aft. in the ship, thus reducing the flexibility of the system by shortening the shaft and ensuring a lower seat. This raises the natural frequency of the system and has been done where the critical speed can so be raised above full shaft revolutions. If the total length of shaft is too great to raise the critical above full power or allocation of hull space does not permit moving the block, it may be desirable to move the critical to a low power by fitting a propeller with 4 or 5 blades. The increased number of blades also reduces the thrust variation.

In existing ships the only cure is to fit a new propeller with more blades and so depress the critical r.p.m. Palliative action may be taken by imposing restrictions, the most common being an instruction to reduce the power of the outer shaft on the outside of a turn and so avoid impingement of its slip stream on to the inner propeller.

Influence on Thrust Block Design.

The desire to avoid axial vibration influences thrust block design in two ways. The first of these is that it is essential to make the block as rigid as possible and in this connection experiment has shown that the greater part of its deflection consists of a bulging out of the forward wall. This suggests that heavy horizontal ribs would be a desirable feature in new designs. Measurements have also shown that the flexibility chargeable to the seat is partly due to a deflection of the top plate allowing the block to tilt, a feature which can be mitigated by increasing the length of the block base. Welded seats have been adopted with the same object in view. The second influence on the design is the removal of the thrust block in some cases to a position remote from the machinery unit, when it becomes highly desirable for the block to be completely self contained from the aspect of lubrication.

The heat generated in a normal thrust block, with a pad pressure not exceeding 250 lb. per sq. in., is such that continuous pump circulation of cooled oil is necessary. If the pad pressure is increased to 350 lb. per sq. in., resulting in reduced pad area and shaft collar diameter, the heat generated is reduced. It has been found practicable, with the higher pad pressure quoted, to design a thrust block which is initially filled with oil and can be kept at a satisfactory running temperature by means of sea water cooling coils fitted in the top cover.

In order to reduce gland leakage to a minimum, a special design of face ring gland is being developed. With this type of gland the thrust block should be capable of running for long periods without attention and to continue so even if completely submerged.