STEERING GEAR

BY

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This article has been written with a view to promoting discussion on a subject which, in the Author's opinion, has long been neglected. The idea originated in a question which seems pertinent. ' Has the method of control and steering of naval ships been properly developed in view of the technical advances in the fields of engineering—both mechanical and electrical—of this century ?' After some thought it appears that the answer to this must be an emphatic NO ! It is hoped to show here that our present steering arrangements are needlessly cumbersome and could be simplified considerably. Furthermore, the proposals could be incorporated into present ships with saving in weight and maintenance effort.

Consider the present system as fitted to the 1942 Class aircraft carriers (*Eagle*), which is a twin-rudder installation.

The helmsman operates a wheel in the lower steering position (L.S.P.) which is situated nine decks below the bridge. By telemotor system, the wheel controls the output of two turbo driven Hele Shaw pumps fitted in the starboard forward and port after engine rooms respectively. These pumps operate their respective rudders by piped hydraulic power. Because of the great distances between pumps and tiller flats, the hunting gear has also to be telemotor operated. In addition to these turbo driven pumps, each rudder has its own electric driven pump in its tiller flat. In the event of turbo driven pump failure the corresponding electric pump operates the rudder by ' following ' the opposite rudder—this is effected by direct linkage from the hunting gear of one rudder to the output control of the opposite electric pump. This case of single turbo driven pump failure does not affect the helmsman's control. Complete turbo driven pump failure puts the L.S.P. out of action and emergency Diesel pumps are fitted adjacent to the tiller flats to enable a modified form of steering to be used in the event of failure of turbo and electric pumps.

The complicated nature of such an arrangement is obvious, although no doubt the reaction of some people would be ' so what—it works '. This is agreed, but although a steam hammer will crack a nut, the same object can be achieved by using the rather more simple nut-cracker. Examination of this system shows that present day designers consider that, to steer a large carrier, no less than six pumps and miles of heavy piping and valves are necessary if a certain degree of damage control and reliability is to be achieved. However, by examining the requirements it seems that all concerned have allowed matters to get out of hand.

Consider reliability. Experience has shown that a rugged, simple piece of functional machinery is more reliable than a complicated jungle of alternatives. Turbo driven auxiliaries are reliable ; despite a certain prejudice which exists, so are electric prime-movers ; and, to a lesser degree, so are Diesels. However, any system which links all three introduces complications of large and long pipe runs which require maintenance effort and which make fault-finding more difficult.

From the damage control aspect it is even more difficult to justify the existing system. A ship can only be steered if the rudders are intact and there is

machinery available to operate them. There seems little object in putting the helmsman, turbo driven pumps, telemotor systems and other items under armour when the rudder and tiller flats are out on a limb. One torpedo hit aft (possibly an acoustic torpedo would 'home' here) would leave the ship out of control although some eighty per cent of the present layout would be intact. On the score of heavy damage remote from the tiller flats, it is hoped to show that complete integrity of steering arrangements can be simply achieved, although, under existing systems, such damage would certainly cause at least partial failure.

This leads to the main point of the article—it is considered that the present steering gear layout has not evolved forwards from the direct operated rudder of the sailing ship, but rather developed into a competition to produce a workable monstrosity. Obviously, some mechanical force is required to operate ships' rudders and hydraulic power is a convenient method of doing this. The present system indicates a complete mistrust of mechanical reliability which hardly does credit to the present age. The number of occasions when a prime-mover failure is responsible for steering breakdown are few indeed, so it would seem reasonable to instal one complete stand-by unit (in the case of twin-rudder installations) which would be capable of operating either rudder at full power or both at half power. Provided the power supply to the main and stand-by units was of high integrity, this should reduce the numbers of hydraulic units from six to three.

Some twenty years ago, the helmsman was moved from the bridge because of the vulnerability of that position. Since he is too far away for direct communication, the obvious step is to position him in, or adjacent to, the tiller flat and extend the present line of communication from the bridge to the new position. The result of this would be to minimize the risk of damage to the steering control telemotor system by reducing the distance between the wheel and the rudder from some 600 to less than 50 feet. The question of communication between bridge and helmsman can best be solved by using electric or electronic equipment. Such equipment is light and easily installed and is easily designed to provide a large number of alternative channels of communication. The sort of communication that springs to mind is a series of sound powered lines connecting bridge and steering position with small amplifiers at each end. These amplifiers could possibly use transistors instead of valves and be powered normally from ships supply with a stand-by supply by nickel-iron cell batteries —such a system would be more shock resistant and less vulnerable than the present telemotor pipes, and the total weight of even a fifty channel set would be considerably less than one run of telemotor pipes.

One possible drawback to siting the steering compartment right aft is the question of vibration, but this could be reduced by improved compartment design and the effect alleviated by shorter tricks at the wheel.

The hydraulic pump installation could well consist of three (in twin-rudder ships) electric driven pumps, this provides a fifty per cent safety factor against breakdown.

These pumps would be supplied from the ship's ring main with automatic change-over switches and starters which would ensure that failure of normal supply would entail only a brief interruption of normal steering. For the extreme action case, where the risk of damage to the ship's ring main is high, small, short life, gas turbine generators, capable of supplying full load for all units, could be installed adjacent to the tiller flats.

This proposed system does not entail any great departure from existing practice but would represent a real saving in weight and maintenance effort. Basically, the actual rudder operation would remain the same. Some design

study would be necessary to develop the automatic change-over switches ; the automatic starters are already a practical proposition.

The logical step beyond this is the automatic pilot, which would maintain any predetermined course without the aid of the helmsman ; such a system with mechanical ' take-out ' for harbour manœuvring appears to offer real advantages.

A certain amount of prejudice against electrical control systems as opposed to mechanical ones exists, but a well designed electric system is just as reliable as a mechanical one, and, considering the distances involved, much lighter.

COMMENT BY E.-IN-C.

This article comes quite near to expressing E.-in-C.'s present policy on steering gear for big ships but it should be made quite clear that the answer to the Author's query at the beginning of the article is, in fact, an emphatic YES. Some of the ideas which are put forward are being built into *Hermes* now, but unfortunately, because most of the compartments had already been laid out, it has not been possible to go as far as we should have liked along the path of simplification.

It must be remembered that *Eagle* is by no means a new ship as far as the design of such equipment as the steering gear is concerned, but it may be as well to try and see how this gear came about.

Steam pumps were included because they were considered, at that time, to be more reliable than electric and because they will continue to run when submerged. Even today it is difficult to produce an electric motor suitable for this duty which will run both dry and submerged, but in the *Hermes* the steam pumps are being replaced by electric. The automatic change-over from the steam pumps to the electric was included to meet the staff requirement that steering should continue from the primary steering position for as long as possible after action damage. Hydraulics were used for the automatic change-over equipment because they were considered, at that time, to be more reliable than electrics. In *Hermes* electrics will be used and it should be emphasized here that there is in fact no prejudice against electrics. It is agreed that damage in the tiller flat could put the ship out of control with 80 per cent of the present layout intact but it is remarkable how seldom anything of this sort did, in fact, happen in the last war, although control was frequently lost through action damage interrupting electric supplies or cutting telemotor leads.

With regard to the primary steering position, it was put under the bridge to enable voice-pipe communication to be used. Inter-communication is now essential so any position in the ship can be chosen. In the *Hermes*, and probably in future big ships, the primary steering position will be between the engine room and the tiller flat ; this gives the shortest lead of telemotor piping and the shortest lead of telegraph shafting (telegraphs will probably be all electric in future ships). D.N.D., quite reasonably, does not agree to the tiller flat being used as the primary steering position because he wants the telegraphsmen and quartermaster to be together ; if they were both in the tiller flat the telegraph leads would be extremely long. Also, although a space in the tiller flat could be made sound and vibration proof it would still be very uncomfortable because the extremities of a ship the size of the *Eagle* rise and fall a considerable distance.

The Author has not suggested, at least not in so many words, that the effort to operate the wheel is too high, but there is no doubt that we have now got beyond the limit where we can use direct operation of pump-stroke through the telemotor transmitter and receiver. The present intention is to provide an

additional hydraulic power link to reduce very greatly wheel effort and make them largely independent of pump size and stroke efforts. The use of an electric link has not been rejected purely out of prejudice. It has been suggested that hunting gear might be abolished altogether and a sort of joy-stick control adopted. This would mean providing an efficient rudder indicator either electric, hydraulic or mechanical. If a rudder indicator has to be provided it might just as well do something other than indicate, for example, take off stroke at the correct rudder angle. This is, of course, just what the hunting gear does and it is intended to retain it. An electric transmitter receiver and hunting gear could, of course, be used, but at present the general consensus of opinion is that the hydraulic gear is more likely to be able to withstand the effects of action damage and to continue to operate under water.

Automatic pilots have been fitted for various trials and there is no difficulty in providing them, but they mean more weight and space, more maintenance effort, and no saving in man-power. However, they would be fitted where they were a requirement.

These comments have not yet dealt with the question of stand-by pump capacity and the positioning of these pumps ; the present line of thought is very similar to the Author's.

In conclusion, it must be said that we are very fortunate in having a number of steering gear specialists in this country who supply gear to many nations both for naval and commercial use. These firms cannot afford to be, and indeed are not, out of date in their approach to the problem, so that the Admiralty gets the benefit of these experts' trials, tribulations and successes, in literally hundreds of modern installations throughout the world. Although we are now aiming at greater simplicity as well as reliability in our steering gear, we must remember that many of the features built into the *Eagle* were included as a result of seagoing war-time experience and cannot now be lightly discarded. Furthermore it is a remarkably fine gear and what is more, it works very well.

It is hoped that these comments will satisfy the Author that, in fact, the subject of big ship steering gear has not ' been long neglected '.