NAVAL ENGINEERING YESTERYEARS

Taken from the Journal of Naval Engineering and Papers on Engineering Subjects archives, BMT Defence Services are pleased to continue this historical section of the Journal. This section will provide readers access to reference material on Past Naval Engineering processes.

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REPAIRS
H.M.S. "VANCOUVER"

(BOOK 5, PAPER 8 – JUNE 1923)

REPAIRS TO PORT SHAFTING CARRIED OUT AFTER COLLISION

During exercises off Gibraltar in February, 1922, H.M.S. "Vancouver" collided with an "H" Class submarine, the Port Propeller of the Destroyer striking the Submarine. "Vancouver" was docked at Gibraltar Dockyard for examination and it was found that all blades of Port Propeller were badly damaged and propeller shaft bent at propeller cone to an angle of approximately 20°.

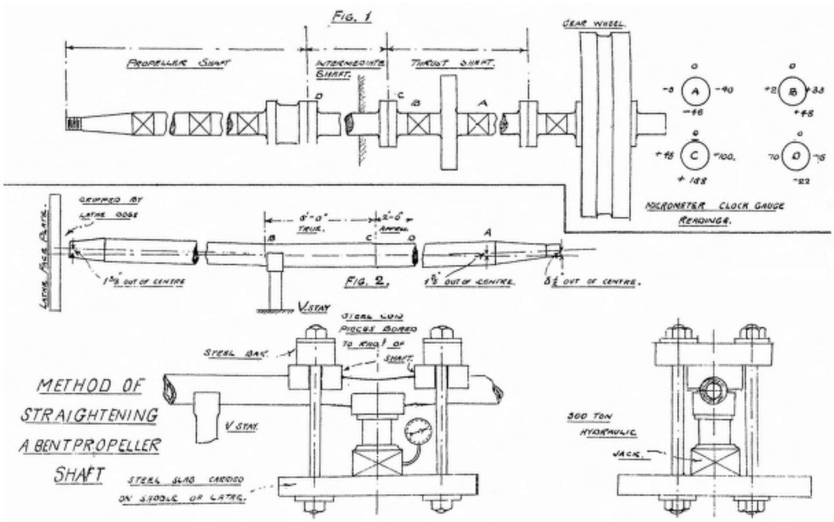
It being decided that repair of the shafting, etc., should be carried out at Portsmouth, the damaged propeller was removed while in Dock at Gibraltar, the vessel steaming to England with the Starboard Main engines only in use.

When docked at Portsmouth, Micrometer clock gauges were placed in positions A, B, C and D with the result shown in Figure 1. This gauging showed both shafts to be bent – the intermediate shaft being 0-084" out of centre, and the thrust shaft 0.023" and 0.024" out of centre respectively at the forward and after journals. Both these shafts together with the propeller shaft were then removed from the ship for straightening.

The next forward length of shaft, viz., that carrying the main gear-wheel, was also carefully checked by similar micrometer gauges. These gauges were applied at the after journal, at the periphery of distance piece between gear wheel rims and also at the face and bore of recess on coupling for spigot of the thrust shaft. These gaugings showed that the gear wheel shaft was true.

When the bent shafting was removed a wire was stretched from the aft end of gear-wheel shaft through stern tube to aft end of "A" bracket. This wire was set central at forward and aft ends of the Shipbuilders' stern tube and found to be central with bore of recess for spigot at aft coupling of the gear-wheel shaft.

From this wire, the "A" bracket was found to be slightly twisted in both the vertical and horizontal plane – the maximum amount of eccentricity being $3^3/_2$". It was decided not to reset the "A" bracket, but to correct the error by boring the "A" bracket bush to thickness gauges made from place when the shaft was placed in position after straightening.



The ship had reported that the port thrust block moved on its seating when trying engines after the collision, and the alignment of block was therefore checked. It was ascertained that the thrust block was lying outboard 3½" (full) from the centre line shown by the wire. The thrust seating was carefully examined but no signs of distortion could be found. As it was necessary to remetal the thrust shaft plummer bearings and pivot bearings of the Michel thrust owing to skimming of the journals after straightening, it was decided (as an alternative to broaching bolt holes and fitting new thrust block holding down bolts), to fit eccentric bearings to accommodate the error in athwartship position of the thrust block.

The shafts were sent to the shop for straightening. An examination there with straight edges showed that the tail shaft was bent through practically the whole length with the exception of about 6 ft. near the middle of shaft which was true, the portion immediately forward of propeller cone having the greatest angle (about 20°). The shaft was placed in the lathe, the forward end being gripped central in dogs and the forward end of straight portion placed in a "V" stay; the shaft was then revolved and it was found that the after end of straight portion was running out of truth; the portion gripped in lathe dogs was then moved out of centre until the 6 ft. straight portion was running true and it was found that the shaft was then lying in the lathe as shown in Figure 2.

Straightening of tail shaft. – The points "B" and "C" on Figure 2 are respectively the forward and after ends of the 6 ft. straight portion, and "D" is a position immediately aft of the 10½ -in steel cross beam.

The hydraulic jack was placed directly beneath "C" and shaft was revolved until bend at "D" was pointing away from jack. The top nuts were screwed down hand tight and the load put on by jack; this in the first instance raised shaft off stay and then commenced to bend shaft at "C"; the amount of set put on shaft was noted by means of scribing blocks and when slightly less than required amount, reading of pressure gauge was noted; the load was released; the top nuts eased back and cod pieces lifted clear of the shaft; shaft was then turned in lathe and amount of bend remaining at "D" was noted. An increased load indicated by the reading on pressure gauge, was then put on shaft and a further check made; this process being continued until portion "C", "D" was running true.

The slab was then moved along lathe bed by means of saddle, until jack was immediately below commencement of next bend; the foregoing process repeated and so on to the end of the shaft, new cod pieces being provided for the cone portion as necessary.

On completion of the straightening of the after end, the shaft was reversed in lathe, and straightened end being gripped in dogs and set true and position "B" resting in "V" stay. The straightening operation was then repeated on the forward end of shaft.

On completion of this, shaft was centred at each end true to the cones and then run on these centres while supported at "B" by a stay; a complete check was taken of variations from the truth, the greatest error being found to be 3½" approx. on the "A" bracket bearing section, partly caused by shaft being out of round due to initial bend.

The inner bush end "A" bracket bearing journals were skimmed to remove these slight errors, while the outer bush bearing journal was polished only.

It was found that a load of 230-250 tons was sufficient to straighten shaft cold with the exception of portion "A" at the forward end of propeller cone. This part was beyond capacity of hydraulic jack to deal with when cold, owing to the large angle of bend, and it was therefore heated to a dull red by paraffin blow lamps and could then be straightened with a pressure load of 280-290 tons. The diameter of shaft was 12¼ in.

After straightening in the lathe the shafting was machined as follows:

(a) Propeller shaft - Journals for Inner stern bush and "A" bracket bush skimmed.

(b) Intermediate shaft - There are no supporting bearings to this shaft – 0.016 in. was machined from face of forward coupling and 0.004 in. from face of aft coupling.

(c) Thrust shaft - Journals reduced forward 0.025 in. and aft 0.034 in. on diameter. Thrust collar reduced 0.011 in. in width, forward coupling 0.008 in., aft coupling 0.016 in.

After replacing in the ship, the shafting was aligned by the couplings and it was noted that thrust block was considerably low - a check was also made by coupling up shafts and allowing the line of shafting to sag. Shafting was then lifted in centre of length until it just left the bearings at after end of gear case and forward end of stern tube. The thrust block was set up one-half the amount shafting was lifted and a taper steel liner fitted under each of the two fore and aft bottom feet of thrust block. Dimensions of these liners were - length, 5 feet, thickness 0.140 in. at aft end, and 0.060 in. at forward end.

At this stage the gauges for use in the shop in preparing the eccentric bearing of the plummer and spherical bearings previously referred to, were made.

In view of the extensive damage to the port propeller and shafting from the collision the starboard line of shafting was also tested while vessel was in dock and found to be true.

On completion of the repairs a two hours' full power trial of machinery was run during which no undue vibration was observed.

REPAIRS TO MICHELL THRUST BLOCK

The following repair affords an excellent example of what can be achieved with elementary means on board, and, in particular, of a demonstration of the value of expert craftsmanship.

A modern Geared Turbine Destroyer came into port reporting that its Port Main Thrust had become excessively heated and that the whitemetal had run from the pads. On examination it was found that the metal had run from the Thrust Pads on the Ahead Side, choking the lubricating oil pipes, etc. The Ahead face of the collar was deeply grooved over its entire surface but not regularly, one groove extending around nearly the complete circle and reaching a depth of $^{30}/_{1000}$ in. at its maximum.

The Astern face was found undamaged and true, and after consideration it was decided to refit the thrust in position instead of incurring the considerable expense of removing the shaft to the Shop to be dealt with in a lathe. To remove the shaft it would have been necessary to open up the deck and displace many machinery details. The work on board could only be undertaken by a mechanic possessing exceptional skill in using the file, and fortunately such a mechanic was available.

The details of the Thrust Block were removed and the Astern face of the Collar used as a base for trueing the damaged surface.

The damaged surface was first divided into eight sectors as indicated in Figure 1, and grooves $1^{1}/_{8}$ in. wide filed so as to get below the scored surface. By repeated trials it was ascertained that $^{30}/_{1000}$ in. would need to be removed from the entire face in order to obtain an acceptable working surface.

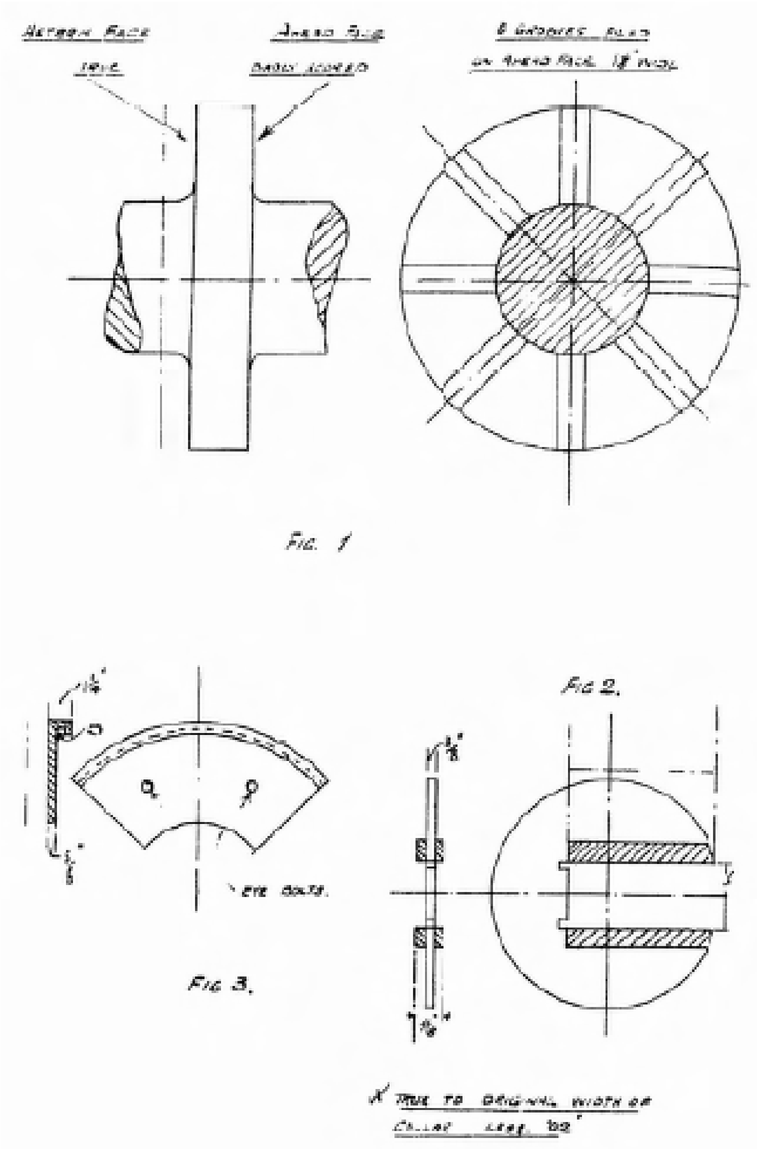
A gauge of horse-shoe type was made as indicated in Figure 2, and used with a feeler to ensure that the field grooves were true to each other as far as practicable. Truth having thus been obtained, the material between the sectors was removed by rough and smooth files. For final trueing, a special surface plate, shown in Figure 3 was used – the portion "B" working around the edge of the Collar and the surface marked forming the face plate; by constant use of the horse-shoe gauge and feelers, the face was trued, scraped and oil stoned.

All the scores were removed with the exception of the deep one which could not be entirely erased.

The Thrust Pads were remetalled, faced and scraped at both leading and trailing edges to designed dimensions with a final allowance of $^{47}/_{1000}$ in. oil clearance. The Thrust block was completely reassembled, pipes cleared and replaced.

Work afloat was carried out by one fitter and his assistant, in 16 working days of 8 hours each, i.e., 128 working hours at small cost and, I urgently necessary, the work could have been completed by working continuously in one working week presuming that mechanics of equal skill were available.

The vessel afterwards carried out a Basin Trial and a Full Power Trial at sea with entirely satisfactory results.

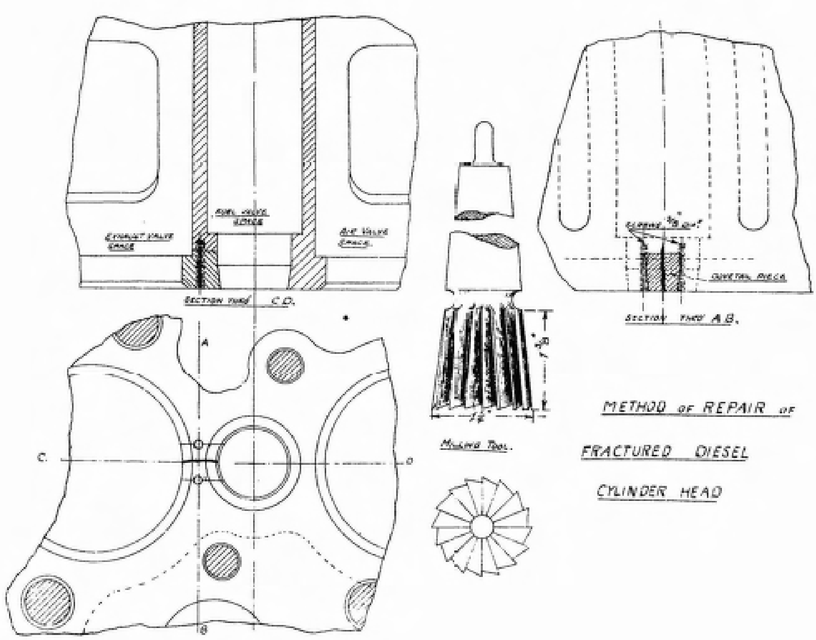


CRACKS IN CYLINDER HEADS OF DIESEL ENGINES

In the Diesel Electric Generating Machinery of a Capital vessel, the frequent development of cracks in the cylinder heads in the metal of the region bounding the exhaust valve spaces on the under side, permitted the exhaust gases to pass through the crack into the space between the exhaust valve cover and the cylinder head, thus leading to erosion of the seating between them, and ultimately to erosion of the exhaust valve itself, and so to loss of compression and misfiring. In some cased cracks also appeared in the metal between the air inlet space and fuel valve space, but this was a development following the growth of the crack in the exhaust space. The circumstances being such that a sufficiency of spares could not be assured, the following method of lengthening the life of the defective heads was followed with success.

As soon as a crack became evident, the head was removed and the material in way of the crack removed for a depth extending to about $^{1}/_{8}$ in. beyond the seating of the exhaust valve cover. The machining was commenced with a 1-10. drill and finished with a bevelled milling tool. A piece of cast iron of dovetailed shape was then fitted carefully in the milled groove, and secured from movement by two in number $^{3}/_{8}$ in. grub screws about 1 $^{3}/_{8}$ in. in length. The cast iron stop piece was then filed to the circular form of the pocket, and the exhaust valve cover seating was trued up with a morse cutter, which as in the case of the milling cutter was made on board.

The drawing shows the details of the method and the milling tool.



PROPELLER TURBINES SOME HANDLING AND CONTROL PROBLEMS

by

LIEUTENANT-COMMANDER (E) COLIN RAWDEN, B.ENG., R.N

Acknowledgement is made to the Editors of "Flight" and "The Aeroplane" for permission to reproduce some of the illustrations in this article.

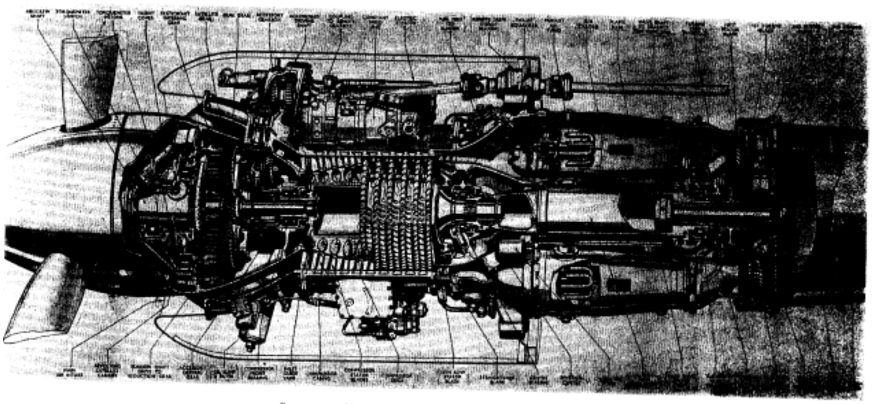
(VOL 5, BOOK 4, PAPER 1 - JAN 1952)

Integral Type Propeller Turbines

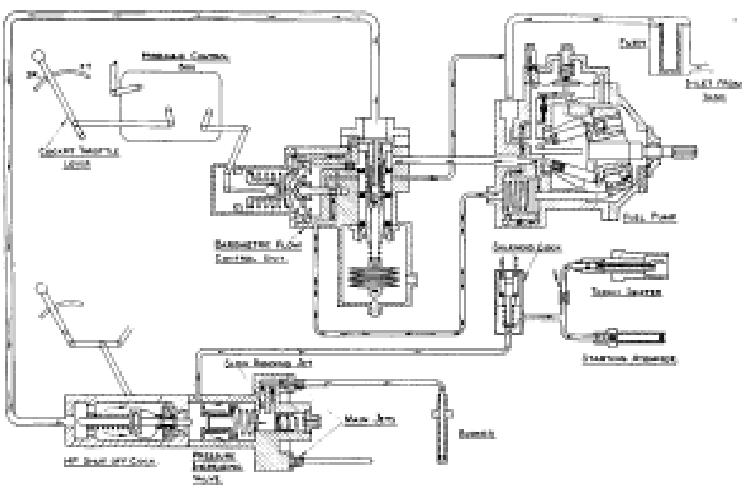
The Python and Mamba propeller turbines coming into the service in the Navy are of the integral type. That is to say the turbine and compressor are mounted on a common shaft, and this is directly coupled through the reduction gear to the propeller. The remarks in the following article, particularly as far as control is concerned, apply only to this type of engine. In the propeller turbine the amount of energy absorbed by the turbine is a very high percentage of the total energy in the jet stream from the combustion chambers, and the residual jet stream thrust is comparatively small. At a given speed the power produced by the turbine can vary within fairly wide limits, since a variable pitch propeller is fitted which can absorb varying power in accordance with blade pitch. Fuel flow varies accordingly and in fact defines the total power available. The proportion of turbine power absorbed by the compressor is very high and generally exceeds half the total, the remainder only being available to produce useful work via the propeller.

Throttle Response

One of the main fundamental differences between the propeller turbine and the piston engine is the greatly increased rotational inertia of the turbine. This is due partly to the greater mass of the moving parts but mainly to the much higher speed of rotation. Cruising revs. for Mamba are 14,500 r.p.m. and 7,800 for Python. The problem of power response to throttle immediately presented itself. In the case of engine acceleration a considerable delay resulted, because as engine revs increased most of the engine power was absorbed in accelerating the engine compressor and turbine rotor, and relatively little power became quickly available as propeller thrust. Conversely on sudden closing of the throttle deceleration of the engine rotor threw up power to be absorbed by the propeller, and in fact response was initially in the opposite sense. It was apparent that unless some new method of engine control were adopted, the degree of throttle response necessary for deck landing approach, and in particular the rapid power response in acceleration for the re-take off or wave off case, could not possibly be met. The important decision was therefore made to run the engine at constant r.p.m. throughout the power range except at the lower end for ground idling, and a small increase at the top end for take off or combat power. Engines of this type are known as "Constant Speeding Engines."



SECTIONED VIEW OF ARMSTRONG SIDDELEY "MAMBA"



PYTHON FUEL SYSTEM

Single Lever Control

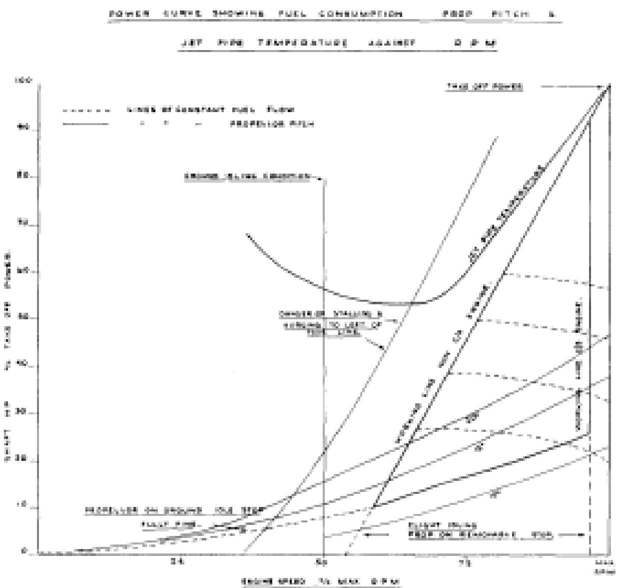
It had previously been decided to utilize the normal piston engine type of constant speed unit for controlling engine speed, in conjunction with the type of altitude compensated fuel control unit normally used on pure jet engines. Both of these units had already been subject to considerable development, and providing they could be made to work satisfactorily together a suitable method of control should result. The remaining major decision was that control should be effected by a single lever only.

Constant Speeding and Fuel Control

Now the term Constant Speeding Engine is something of a misnomer, since variations of power are still absorbed by changes of propeller pitch setting, which in turn are governed by fluctuations of speed of the C.S.U. To increase the power setting by movement of the control lever, it is not sufficient merely to increase the fuel flow. One has to coarsen the propeller pitch at the same time, and this is achieved by increasing the speed setting on the C.S.U., the immediate effect of which is to increase the revs. slightly, which is only permitted by an initial fining off of propeller pitch. Then the C.S.U. takes over and coarsens the pitch until the new increased power setting is absorbed. This cycle of events is unfortunate, since the first response to throttle movement is in the wrong sense, then there is a time lag before any increase of actual thrust is obtained, and a period of hunting takes place before the engine settles down to the new power setting. These undesirable effects are reduced if the throttle is moved very slowly, but this is incompatible with deck landing requirements. The solution to this problem was found as follows. Instead of directly linking the throttle lever both to the F.C.U. and the C.S.U. a device embodying a hydraulically operated delay mechanism was incorporated in the E.C.U. or Engine Control Unit and hydraulic pressure is supplied from the engine oil feed. The effects of its operation are twofold. Firstly it reduces the C.S.U. setting below the actual speed of the engine, when increased power is demanded, and hence ensures that the immediate response is to coarsen the pitch, followed by a steady coarsening during power increase. Conversely a steady fining off of pitch takes place during shut down. Secondly, during increase of power the E.C.U. ensures that the fuel flow always lags slightly behind the demand, and during shut down, the decrease of fuel flow is slightly ahead of the instantaneous requirement. This ensures that any given instant during change of power, the fuel supply is never sufficiently excessive to cause increase of working temperatures in the turbine above those permissible. As a result of fitting the E.C.U. surging is almost entirely eliminated, rapid throttle movements can be permitted and quick transitions from thrust to drag conditions can be obtained. Tests with this system have shown results compatible with the most favourable piston engines. A slight penalty has been paid in that higher capacity C.S.Us. than normal have been found necessary to provide the high rates and wider ranges of pitch change.

Power-R.P.M.-Compressor Stalling and Jet Pipe Temperature

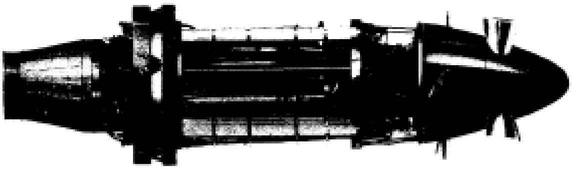
Let us now turn to some general considerations of propeller turbine characteristics based on a typical power curve shown opposite. Neglecting for the moment what has been said previously about constant speeding engines, it will be seen that owing to the fitting of the variable pitch propeller the speed of the engine could be varied independently of fuel supply, and in fact for any given power setting an infinite number of fuel delivery to engine speed relationships could be adopted. Furthermore, the specific fuel consumption remains practically constant at constant power, over a fairly wide range. The full power operating conditions are limited by the maximum turbine temperature, which in turn is defined by the mechanical properties of the blading under load at temperature, and of the turbine disc under heavy centrifugal loads. Turbine temperature is not easily measured under practical running conditions. However the temperature of the jet flow at any given point down stream of the turbine is always in constant relation to the turbine temperature and it has been found more convenient to measure the temperature of the jet stream by thermocouples, and relay this signal to an indicator in the cockpit. Hence the operating conditions of the engine are observed from this jet pipe temperature gauge. At the lower end of the speed range there is a minimum idling speed, below which the engine will not run properly. This speed is approximately half the maximum, and below these r.p.m. not only is the compression ratio of the axial compressor insufficient to produce any appreciable power, but there is danger of the compressor stalling or surging and in general working in an unstable and unsatisfactory fashion. Now the effect of stalling is very important. When the compressor stalls the mass flow of air through the engine is suddenly and drastically reduced. But the same amount of fuel continues to be fed in, temporarily at any rate, and the effect of this is to increase the working temperature very seriously. In extreme cases we are faced with the dismal and expensive prospect of distorted or molten turbine blades issuing from the jet pipe orifice. This phenomenon of stalling is a fundamental characteristic of the axial compressor, and may continue above idling speed some way into the lower end of the operating power range of the engine, especially when power demand is high in relation to r.p.m. Hence for any given shaft horse power developed, an operating speed is chosen which is well in excess of the possible stalling revs. This gives a safe margin for engine handling (or mishandling). Happily in the case of constant speeding engines, the high revs at the lower end of the power range, with the propeller in very fine pitch, and a low fuel setting, produce a safe condition, from the point of view of stalling and overheating. Before leaving this question, it may be pointed out that the danger of compressor stalling is of course greater at low air speeds, and particularly when starting up on the ground.



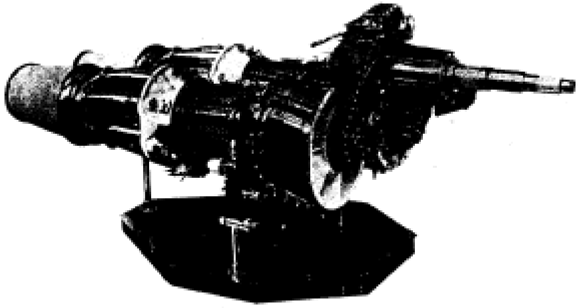
Power Curve

Torquemeter Gauge

In a propeller turbine aircraft there is little indication of the precise value of the power output at any moment, especially when the engine is of the constant speeding variety. Jet pipe temperature does give an indication, but this is not very accurate since power varies fairly widely with J.P.T. near the top end of the scale. Hence the torquemeter gauge is provided as a standard fitting instrument. This is operated from oil-filled statimeter cylinders, which actually react the torque in the reduction gear casing. The gauge gives a direct indication of shaft horsepower, and may be calibrated in torquemeter pressure, pounds per square inch, or in actual S.H.P. This is the instrument which corresponds most nearly to the boost gauge for a piston engine.



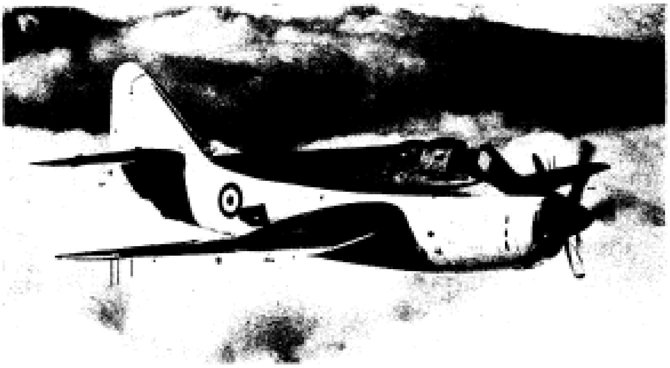
" Python "—External View



" Double Mamba "—External View

Starting

Starting is at present achieved by a displacement motor driven by compressed air, though in production aircraft the energy will be produced by an explosive cartridge. The amount of energy involved in starting is very considerable, and in order to keep the size of the motor and the period of acceleration within reasonable bounds, the engine speed is not taken up to the full stable ground idling r.p.m. by external source of power. Hence after lighting up there is a period of acceleration of the engine to the idling speed, and this is obviously a period of danger from compressor stalling, especially if the throttle is opened too quickly, or if starting power is on the low side giving too low initial revs. The jet pipe temperature must be watched carefully at this stage and fuel supply cut off if the temperature shows signs of going too high. The problem of re-lighting in the air is less critical owing to the forward speed of the aircraft.



Fairey Gannet in flight, with one engine stopped. Tail of Jet Pipe can be seen aft of wing root

Jet Pipe Temperature Control

It may be asked why, in view of the danger of stalling, and the disastrous effects of turbine overheating, no safety device has been evolved. A system could be produced, interconnected with fuel flow so that whenever the temperature showed signs of exceeding safe limits, the fuel delivery would be reduced sufficiently to prevent damage. Development of such a device has been attempted, the principle adopted being the electrical amplification of a signal from the jet pipe thermocouple operating a servo in the fuel system. However, to date this method has proved somewhat unreliable, and in practice the apparatus evolved has been too heavy to be readily acceptable by the aircraft designers. A palliative measure has been the fitting of a very readily recognized warning device, in the shape of a loudly ringing bell or flashing light operated by a signal relayed from the thermocouple.

Stopping

Stopping the engine presents a slight problem since the friction forces are negligible, and the inertia of the moving parts is high. Furthermore, even the lightest of breezes is sufficient to windmill the propeller quite fast. This is unacceptable for the carrier operations of ranging and striking down, hence to avoid decapitation of members of the flight deck party, propeller brakes will be fitted and housed in the reduction gear. The brake will also be used to keep one engine stationary when single engine cruising with the Double-Mamba.

Engine or C.S.U. Failure

Propeller Discing and Feathering Reverse Torque Switch

Owing to the very high ground idling speed which is forced upon us by the characteristics of the engine, obviously a corresponding fine propeller pitch is required to keep the power output sufficiently low when ground running and taxi-ing, and in fact this pitch needs to be as low as 8 to 12 degrees. Now this is all very well on the ground, but consider the case of an engine or C.S.U. failure in flight. The centrifugal twisting moments on the propeller blades, caused by their shape, forces them into the finest pitch they can assume. This is a condition known as discing and the associated dangers are all too apparent. Firstly, if it happens to take place at high speed the drag is very high and sufficiently serious to cause a grave handling problem owing to change of trim and deceleration of the aircraft. There is also a danger of drag torque seriously overspeeding the engine. The answer to this part of the problem is fairly simple, and comprises the fitting of an electric switch in the reduction gear which overrides the C.S.U. selecting positive coarse, and at the same time operating the feathering pump, which coarsens the propeller pitch, and if necessary doing so to the fully feathered position. This switch is known as the "reverse" torque switch, and operates automatically whenever a condition of reverse torque exists, i.e., when the propeller is creating back torque on the engine. There is an important exception to this, however, during starting, when the reverse torque switch is automatically isolated to prevent the propeller coarsening off during the starting cycle.

WYVERN PROPELLER IN FINE PITCH SHOWING LARGE BLADE FRONTAL AREA

WYVERN PROPELLER SHOWING VERY FINE BASIC PITCH SETTING

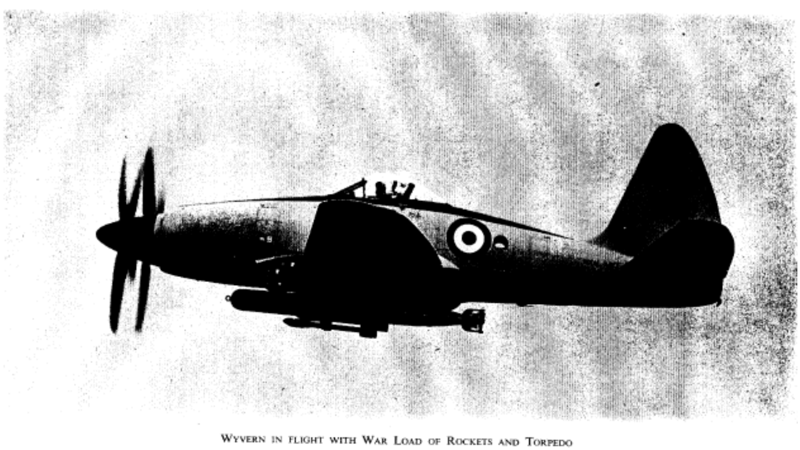
WYVERN PROPELLER "FEATHERED" SHOWING REDUCED FRONTAL AREA AND CONSEQUENT DRAG REDUCTION

Flight Fine Pitch Stop

Now supposing the engine is still running but the C.S.U. has failed. We can continue to fly, but only with the propeller at very fine fixed pitch. In the case of a heavily loaded aircraft the power developed will almost certainly be insufficient to maintain flying speed and altitude, and in any case reduction of range due to increased specific fuel consumption would make it impossible to return any distance to base. Clearly a safety device must be provided to prevent the propeller blades assuming this very fine pitch angle, and this has been achieved by fitting a removable stop known as the " flight fine pitch stop." This was electrically operated on earlier engines and is now operated from the engine oil feed. The stop is set at some 25 degrees, which figure has been worked out as a compromise, giving reasonable range, yet fine enough to allow emergency handling at low speeds and landing. The stop must be withdrawn, of course, for satisfactory engine handling, preventing compressor stalling and turbine overheating during normal landing, and particularly for deck landing. This is done by fitting an extra catch on the throttle lever to control the stop, so that it is automatically tripped at a position near throttle full closure. Alternatively the stop may be interconnected with the undercarriage retraction so that the stop is withdrawn on lowering the undercarriage. In this case the interconnection is over-ridden when take-off power is selected, in order to give protection against C.S.U. failure during take-off.

Influence of Ambient Air Temperature

There is a characteristic of the propeller-turbine which should be mentioned although it is a performance feature rather than one of control, and that is the reduction of power output with increase of ambient air temperature. Fuel settings are made on individual engines to give a definite power output at both take off and cruising r.p.m. Neglecting the effect of altitude, speed and intake ram effect on mass flow, the fuel flow settings will determine the steady operating conditions and jet-pipe temperatures at the two powers setting. As we have seen previously at take off power the turbine will be operating at the maximum safe temperature for a short period. Consider now an increase of ambient air temperature. The effect in increasing jet-pipe temperature is more drastic than appears at first sight, since the fuel flow and its thermal content remain unchanged, and absolute temperatures are to be considered in the relationship between the increments of ambient and jet-pipe temperatures. Both experiments and calculation show that an increase of one degree centigrade of the ambient air temperature will cause a rise of approximately three degrees of jet-pipe temperature. This could be disastrous to the turbine in the case of fuel setting in a cold climate, then moving to a hot climate and continuing to operate there without reduction of maximum fuel flow. Conversely, maximum fuel flow can be set down to prevent jet-pipe temperatures exceeding the safe limits. When this is done the loss of take-off power is in the order of seven per cent per ten degrees centigrade of ambient air temperature. This loss of take-off power must be accepted in tropical climates.



WYVERN IN FLIGHT WITH WAR LOAD OF ROCKETS AND TORPEDO

Future of the Propeller Turbine

The propeller jet is going to be with us for a long time in the Navy, certainly in the case of the anti-submarine aircraft, and probably in the case of a strike or escort fighter aircraft in which the specification calls for long range. New techniques will have to be learned, both of engine handling by pilots, and of maintenance by technical personnel. So perhaps it is as well if we try and understand the first principles of operation.

SHIPS' BOATS

by

COMMANDER (E) A. E. HOLLAMBY, M.I.Mar.E., R.N.

(VOL 6, BOOK 1, PAPER 11 – JAN 1953)

The mere mention of this form of maritime transport still tends to give an Engineer Officer and an Engine Room Artificer that sinking feeling! What has been, is being, and could be done to make the subject of ships' boats happily suggestive of runs ashore and picnic parties, rather than the breakdowns, which when not actually occurring, tend to hang over the Engine Room Department like the sword of Damocles?.

The older engineers still remember the effort which had to be put into the petrol/paraffin* engines to keep them running, their organizations to try to get a boat away to time, the starting difficulties in the morning due usually to the electric leads getting damp, or in very cold weather the very poor starting qualities of those engines.

The abandonment of petrol/paraffin engines for purely petrol engines was in those days considered a great advance, but ignition troubles still persisted. After a period at sea in rough weather, more especially in destroyers and below, it was a major operation to get the boat running on arrival in harbour due principally to damp electrical equipment.

As and when they became available, diesels were introduced and compared with petrol engines they were a godsend, but the war put an end to the steady progress being made in step with commercial progress. During the war there was a tremendous requirement for ships' boats, and all the available engines (including petrol engines) of suitable powers from various manufacturers up to the limit of their production capacity, had to be obtained to satisfy naval requirements.

This brought about a recession instead of progression which had to be accepted. The result was that at the end of the war there was a motley collection of between 80 and 90 varieties of propulsion units with infinite combinations of engines plus installation equipment plus type of boat. For example, the 36 ft. boats had Kelvin, Ford (14 conversions by various firms), Chrysler, Perkins, Ferry, Parsons, Thornycroft and Dorman engines. Efficient maintenance of the machinery and installation equipment was an impossible task: the positioning of spare gear in the various theatres of war hopeless. But at the expense of many sleepless nights on the part of the Boat E.R.A.s the boats were kept running to the credit of those who burnt the midnight oil.

* **Editor's Note** – it is now a historical fact, that in the days referred to, we used to talk about petrol and paraffin instead of gasoline and kerosene as in modern parlance.

Those conditions had to be accepted during the war, but what has happened since? Let us deal with the problems separately.

Engines

Taking into account the fundamental requirements of the maximum horse power in the minimum space and for the minimum weight, and the necessity for the maximum reliability consistent with these limitations, it was evident that petrol engines, except for the very small horse powers such as outboard motors, were out. The best of the diesel engines, as found on service functioning under sea-going conditions were selected, a re-engining programme within the financial allocations has been progressed and now the number of types of engines has been reduced to 18 instead of 80 in 90% of our boats. As time goes on there will be a further reduction in the number of types. The preparation and promulgation of Maintenance Schedules by Fleet Orders had given the sea-going engineers information about particular engines, guidance as to the frequency of examinations of the various parts, and has stressed the necessity for routine overhauls. All new type engines intended for boats will be thoroughly type tested ashore before release for prototype trials under service conditions in a boat. The expenditure entailed and time taken for these trials should pay dividends in subsequent reliability. The progress of development in the gas-turbine field is being actively followed and reference has been made to this aspect in the article on 'The Rover Gas-Turbine Engined Launch' in the April 1951 issue of the *Journal of Naval Engineering*. One of the Rover Gas-Turbines had been fitted to a harbour launch at Portsmouth Dockyard for assessment of the installation under service conditions.

Installation Equipment

To reduce maintenance problems to the minimum so far as replace parts are concerned, orders have already been issued to standardize shafts, stern tube bushes and fuel tanks for all ships' boats up to 100 h.p. In other words a 25 h.p. boat will have the same equipment as a 100 h.p. Similar action is being taken to cover the 100 h.p. to 200 h.p. range, so that in the near future whatever the power of the boat, whatever the engine and whoever the builder, the Engineer Officer can demand on the S.P.D.C. replace installation parts with the certain knowledge he will get the particular piece designed for his particular boat without delay.

Circulating Water

"Something in the inlet!", "Air lock!" – we have all heard the old familiar cries, but it all boils down (or up!) to the same thing: no circulating water suction. Salt water cooling causes choking of the cylinder head cooling spaces by deposits at the hot spots, but if fresh water is used and is cooled in a heat exchanger, we are still dependent on a sea water suction and therefore the source of trouble from the installation angle is still present. What can we do about it? We can do away with circulating water for engine cooling by the use of Keep Coolers. This practice has been adopted by the River Police, who were always in trouble with sea weed or flotsam blocking the circulating water inlets. Here then we have a closed fresh water circuit, the fresh water pipes being snugged in against the keel for protection and cooling. The other purposes for which we need circulating water are stern tube and exhaust. Can we do away with this requirement? From the engineer's point of view, grease-packed stern tube glands and underwater or dry exhaust will, in addition to keep cooling, eliminate entirely the necessity for circulating water inlets; but structural and executive requirements for certain boats may preclude this advance. Air-cooled engines are only available in the very small horse power ranges and in this respect a single cylinder and twin cylinder engine are being tried on service.

Gear Boxes and Clutches

The mechanically operated gear-boxes, although designed by gear-box experts, have never given the required satisfactory service. The pipe "Boat E.R.A. required on the Quarter Deck!" has often been due to slipping clutches. It has always been apparent that experienced coxswains need the boat E.R.A. less than inexperienced and more particularly untrained coxswains, in boats with manually-operated gears and clutches. In this respect the boats with Kitchen rudders have always needed less maintenance as the clutches are usually left permanently 'In'. To cut out the human element, and in an attempt to reduce the breakdowns, hydraulically-operated gears and clutches have been installed in some boats and are at present being tested under service conditions. Only time can tell whether it is the answer to our prayers, or from the frying pan into the fire so far as breakdowns and maintenance is concerned.

Controls

Who has not extended a hand of sympathy – usually towards the gangway as it flashes by – to an inexperienced coxswain of, say, a two-engined fast motor boat as he tries to get alongside. He has two gear levers, two throttles and the wheel to contend with, *all hand operated*. A human octopus would be in his element, as he could find a use for all his tentacles. Naturally a tremendous amount of thought has been given to this problem. It has been suggested that the throttle should be foot operated as in a car, but this would be absolutely hopeless due to the bumping and pounding you get in a boat. So what can we do about this problem?

If the hydraulic gear box is a success, and it is hoped that it will be, we have a simple means of reducing the number of controls – and that is by a *Single Lever Control* for each engine.

This device is designed to work with hydraulic mechanisms linked up to throttles, and is fitted in some R.A.F. tenders and commercial craft. The single lever can be so arranged to work each side of quadrant. In the central position the gears are disengaged with the engine at idling revolutions; the first movement of this lever engages either the ahead or astern gears, dependent on which way it is moved, and any further movement increases the power. A boat fitted with single lever control is now on trial.

Other Considerations

In the face of these major problems there is little opportunity for considering refinements, but one at least is being investigated and that is vibration. So far, a lack of vibration in a ship's boat has been merely an indication that the engine has again broken down, and the consternation of the passengers has prevented their appreciation of the peace and comfort which they might enjoy with vibration permanently eliminated. To achieve this we have fitted sound proof mountings in a survey boat recently completed within isolates the structure borne vibration and noise. This fitting imposes its penalties in the necessity for a flexible coupling in the transmission system and flexible pipes. Trials are being carried out.

Policy

In addition to the detailed considerations by technical departments of the problems concerned with ship's boats, all the present design new construction boats are given careful consideration by a Boat Panel under the Chairmanship of the Director of Naval Equipment. Taking the subject a stage further there is an Inter-Service Marine Craft Committee which meets regularly to discuss various designs with a view to standardization where possible of craft, machinery and equipment.

Conclusion

The foregoing paragraphs are merely an attempt at describing what is being, or could be done, to soothe the nerves of all those duties bring them into contact with ships' boats. It is impossible to predict absolute success in the future, but readers can draw their own conclusions as to whether the various problems are being given due consideration.

SHIPS THAT SERVE SHIPS

by

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The author relates in some detail the special features incorporated in the design of light vessels and lighthouse tenders, which are maintained for the service of the mariner by the Corporation of Trinity House as the General Lighthouse Authority for England and Wales. Some details of the pilot cutters maintained by the Corporation of Trinity House are also described. Opportunity has been taken to include a short history of Trinity House as a Corporation since the grant of the first Charter.

INTRODUCTION

In 1514 Henry VIII granted its first Charter to a Guild of mariners or "Pilots" of the Trinity which had already been in existence for some time with functions of a semi-religious and charitable nature. The petition for the grant had pointed out that many unqualified young men and foreigners were setting up as pilots or lodesmen in the River Thames and the Charter, among other things, gave power and authority to the Guild of the Trinity to make ordinances for the relief, increase and augmentation of shipping and to enforce these ordinances by penalties.

This Charter was renewed by each Sovereign in succession, with or without variations, that of James I (1604) laying it down specifically that no persons should take upon them to be Pilots in the Thames unless they were so appointed by the Corporation.

The amplified Charter of James II was granted in 1685, thanks largely to the influence of Samuel Pepys, that indefatigable Secretary to the Navy, who twice served as Master of the Corporation, and, so far as pilotage in the Thames was concerned, laid down that pilotage of foreign ships was compulsory and gave to the Corporation the exclusive right to licence pilots.

The whole question of pilotage was made the subject of an enquiry early in this century and the Pilotage Act 1913 provided for the reorganization of this important service with a view to securing uniformity of administration so far as practicable.

Today, Trinity House is the Pilotage Authority for the London District, an area which extends from London and Rochester Bridges to the Sunk Sand off Felixstowe in the north and to Dungeness in the south, as well as for some forty ports in various parts of England and Wales, including Southampton (these Out-ports having been created in 1808). Its duties comprise:-

(a) the examination and licensing of pilots

(b) the granting of pilotage certificates to masters and mates of British ships; and

(c) the provision of a sufficient supply of licensed pilots for the ports concerned.

There are nearly six hundred pilots licensed by Trinity House but it must be understood that they are not the servants of the Corporation. The Pilotage Service is administered through the London Pilotage Committee on which the ship owners and pilots have a representative, so far as concerns the London District, and through sub-commissioners at the other ports. Certain ports, including Liverpool, have pilotage authorities independent of Trinity House.

PILOT CUTTERS

The term "Pilot Cutter" is, of course, a heritage from the days of sail. Many of the vessels which today bear the name are over 140 feet in length and a few are over 150 feet in length.

The duty of a modern pilot cutter is simply to act as a floating base at the approaches to ports and estuaries from which a pilot may be "picked up" or to which a pilot may be "dropped" as required.

Where there is a considerable volume of traffic provision must be made for a large number of pilots and up to thirty can be accommodated on the larger pilot cutters. A dining saloon and comfortable lounge are also provided entirely separate from the accommodation for the master, officers and crew. With modern facilities in the way of bathrooms, and washplaces and galley, it will be appreciated that the vessel, except for navigating bridge, machinery spaces and boat deck, is almost entirely sub-divided into accommodation.

Pilots generally take their turns in rotation to board incoming vessels requiring their services. Pilots of outward bound vessels are also landed by the pilot cutter. Radio-telephone communication between the pilot cutter and the shore is maintained to ensure, among other things, that pilots are available in adequate numbers for incoming vessels.

Two boarding motor boats are carried, each 18 ft long but designed for use in heavy weather to transport the pilots between the cutter and the vessels awaiting or finished with their services. These boats have to be launched in any weather and shock absorbing gear is fitted on the davits or arranged in the lead of the falls. As an additional precaution, the boat winch is of ample power to give a rapid speed of hoist.

PROPELLING MACHINERY

The variety of propelling machinery installed on the vessels ranges from a single-screw triple expansion steam reciprocating engine to twin-screw Diesel machinery of 800 collective brake horse power. One of the smaller pilot cutters, 101 feet in length overall, has a Diesel-electric installation in which power is obtained from three London 'bus type engines running at 1,650 revolutions per minute to give 255 collective shaft horse power at a single propulsion motor which is controlled from the bridge.

FIG.1 – A MODERN LIGHT VESSEL

LIGHTHOUSE SERVICE

A lighthouse is usually pictured as a lofty tower erected on a headland or isolated rock at sea. It acts as a seamark by day and displays by night a powerful light. Add to this the ability to produce the most efficient sound and wireless signals that can be devised and the result is a lighthouse of modern times in its most perfect form.

At sea it is not always possible to secure a firm foundation where, for the safety of shipping, a seamark is essential. The seabed may consist of unstable drifting sands, or the depth of water over isolated rocks may rule out any practical hope of building a permanent structure, and it is necessary to use some form of floating mark instead. Buoys of various types are used as floating marks, but the provision of a major light accompanied by a powerful fog signal is essential, in many instances, for adequate protection and this need can be met only be mooring a light vessel in the required position.

LIGHT VESSELS

Britain led the way in the use of lightships to mark sandbanks where lighthouses could not be built, the first being placed at the entrance to the Thames in 1732 to mark the Nore Sand. By 1795 four other dangerous shoals, including the Goodwin Sands, had been marked by lightships. These early vessels exhibited fixed lights from simple lanterns containing four to six candles. One, two or three lights in various combinations on separate masts enabled the particular station to be identified. Although they were strongly built, these early vessels had to ride out the winter gales on hemp cables and it was not unusual for them to break adrift. They were rigged with sails for use in emergency but an attendant vessel in the nearest port had to be maintained to supply new cables and restore the lightship to its position when necessary.

The introduction of chain cables in 1820, important as it was for shipping in general, had even greater significance for light vessels which depend so much on safe mooring. Longer vessels were built, in which greater comfort for the crew became possible, and space was made available for the development of the navigation light and fog signal equipment concurrently with the development of ship construction.

Wooden hulls gave way to composite construction, to iron and, in due course, to steel hulls. It is, however, worth pointing out that three of the later built wooden hull vessels and seven composite vessels are still in service, improved where possible to meet modern standards for accommodation.

MODERN LIGHT VESSELS

Figure 1 shows in profile a modern light vessel of which the principal particulars are as follows:-

Length overall	…	…	…	…	137 ft. 3 in.
Breadth, moulded	…	…	…	…	25 ft. 0 in.
Depth, moulded	…	…	…	…	15 ft. 8 in.
Mean draught	…	…	…	…	10 ft. 11 in.
Displacement	…	…	…	…	515 tons

It will be seen that the lantern is carried on a steel lattice tower amidships. Forward of the lantern tower a look-out shelter with all round vision is provided and on top of this shelter the diaphone fog signal is erected above all obstructions which could possibly blank the sound. The foremast and mainmast carry the radio telephone and radio-beacon aerials, and they have also been used to display daymarks, large conical or globular shapes, to assist identification in daylight. The station name is exhibited each side of the vessel in letters 6 ft. high and, as the topsides and lantern tower are painted Post Office red, the vessel can readily be identified from a distance in clear weather.

Light vessels are not self-propelling but are moored at their stations and the windlass is of necessity robust in construction. A rotary engine of 35 h.p. driven by compressed air, supplies the power required for working the windlass but hand gear is also fitted for emergency use. In addition to the main riding cable, two anchors are carried at main deck level in recesses built in the forward bulwarks (Fig 2). These anchors are arranged with special releasing gear so that one or both of them can be instantly be let go in the event of the permanent mooring carrying away in a gale. It should be said, however, that very few instances have occurred when the standby anchors have had to be brought into use.

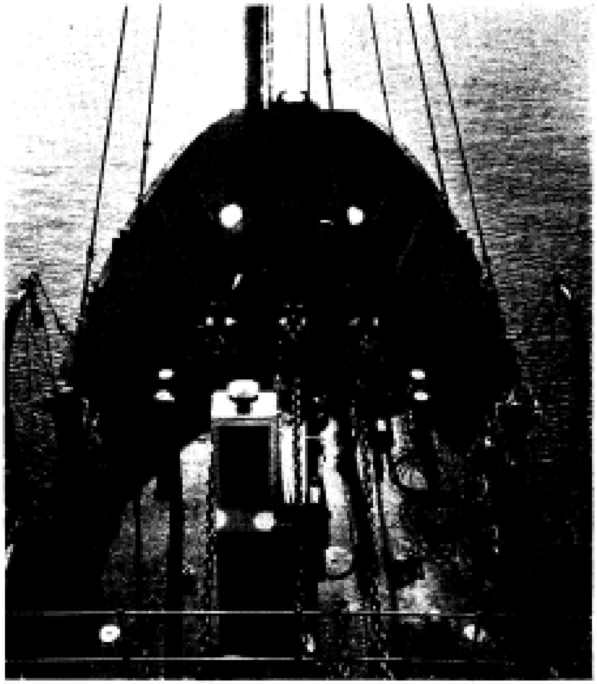

FIG.2 – FOREDECK OF A MODERN LIGHT VESSEL LOOKING FROM STEERING SHELTER

The machinery for current supply to the main navigation lantern and for ship's lighting is housed in the engine room amidships (Fig. 3). For lighting purposes four single cylinder Diesel engines directly coupled to 5½ - kW. 100-volt D.C. generators are installed; each engine develops 9½ b.h.p. at 1,000 revolutions per minute and, under normal conditions, one set is sufficient to supply the load requirements. A second set may be necessary in certain circumstances, leaving one machine available as standby, should one be dismantled for servicing.

Two fog signal sets are fitted to provide compressed air supply for the diaphone. These sets consist of a Diesel engine developing 38 b.h.p. at 1,000 revolutions per minute with a drive through flexible couplings to a 5½ - kW. generator and through a multi-groove Vee pulley and belt drive with clutch to a quadruplex air compressor. The Diesels are fresh water cooled in conjunction with a sea water circulated heat exchanger.

The quadruplex single stage air compressors have four cylinders arranged radically in a circular casing. Each cylinder is fitted with a trunk piston driven by connecting rods from a common crank pin. An annular space forming a water jacket is contained in the casing through which the cylinders pass. In effect each cylinder forms a separate single acting compressor delivering into a common passage so that at high speed a steady stream of air is discharged.

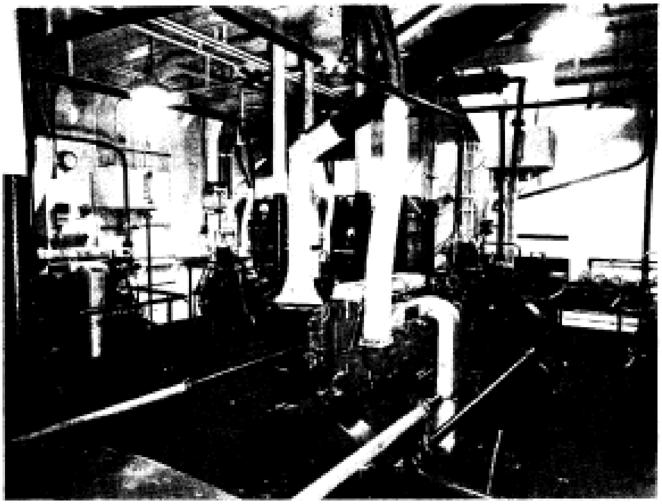

FIG.3 – LIGHTING AND FOG SIGNAL MACHINERY COMPARTMENT

The compressor has no suction valves, air being admitted to the cylinders through ports in the piston which coincide with similar ports in the top of the connecting rod during the suction stroke and at the end of the suction stroke, the piston uncovers ports cut through the cylinder wall so making direct communication between the cylinders and the suction chamber formed in the casing. Delivery valves are fitted at the outer end of each cylinder and they open during the compressing stroke when the air has reached the required pressure.

Three air receivers each of 220 cu. ft capacity are arranged in the engine room for the storage of air at a maximum pressure of 120 lbs per sq. in. This air supply is reduced in pressure to 35 lb. per sq in. for use in the fog signal diaphone and the windlass engine, the low pressure air being stored in two small receivers on the main deck.

LANTERN

The lantern, carried on a lattice tower, is a fixed structure which houses an optical system of the catoptric or mirror type. The arrangement consists of a pendulum supported on gimbals, balanced and designed so that it will have a rate of oscillation just out of step with the natural period of the ship's roll. By this means the light beams are kept horizontal although the light vessel may be riding and pitching heavily in a seaway. Above the pendulum pivot point, four groups of two focus mirrors are arranged each with its own 500-watt lamp. The mirrors can be set in various positions so that the beams from any pair are disposed in the desired relationship to the beams from the other pairs. By this means the light can be given differing characteristics and single, double, triple or quadruple flashing combinations can be produced. The advantages of this system are obvious as a lightship may have to be used first on one station and later on another station.

The optical system is revolved by a small electric motor through a shaft mounted on journal and thrust bearings and by means of change gears the speed of revolution can be made one in fifteen seconds, one in thirty seconds, one in sixty seconds, one in ninety seconds or one in 120 seconds. The current is conveyed to the lamps by slip rings. The lantern focal plane is forty feet above sea level at normal load draught and the light is visible in clear weather for a distance of approximately twelve miles.

DIAPHONE

The fog signal diaphone is operated by compressed air. A gunmetal piston is made to oscillate in a cylinder by introducing compressed air at a pressure of 35 lb. per. sq. in. to the rear chamber of the diaphone casing through an operating valve. The piston and cylinder contain a series of annular slots cut over the larger part of their length and the outer end of the piston is open to a resonator which is a trumpet mounted vertically and fitted with a large mushroom head to give all round distribution of sound. Air at the same pressure, 35 lb. per. sq. in., is introduced through a sounding valve to the front chamber of t6he casing and as the piston oscillates the annular slots on the piston and cylinder coincide, so releasing pulses of compressed air into the resonator. A large volume of sound at approximately 180 cycles per second is produced. A timing mechanism controls the sequence of the operating and sounding air valves, and the mechanism can be set to give any desired character and length of blasts.

GENERAL FEATURES AND WIRELESS AIDS

Light vessels, lying moored as they are at the converging points on busy shipping lanes, quite frequently sustain damage by collision. The point of impact in many cases is on the bow, and for this reason particularly heavy construction in this area is essential. The sloping bow and high bow bulwark, which is a feature of modern light vessels, is capable of absorbing heavy damage, thus preventing so far as possible, injury to the underwater bow plating. In case of serious damage, however, the inboard ends of the riding and anchor cables are secured on the main deck by slips which can readily be released if it is essential to let go the cables to lighten the vessel. An efficient alarm bell system is provided to warn the crew of approaching danger.

Two signal guns are carried, fired through gunports in the after main deck bulwarks. Their function is to provide visible and audible warning by the production of a large volume of smoke and sound to warn any craft approaching into danger. Explosives for the signal guns are carried in magazines built at the stern of the vessel.

Wireless aid to the navigator is given by radio-beacon transmitter which performs two functions:

(1) To transmit in clear weather a radio signal having a definite characteristic by which the light vessel can be identified and at the same time to enable a bearing to be taken.

(2) To transmit during fog or haze the radio signal which identifies the light vessel at precisely the same instant as the diaphone fog signal begins to sound. By this means the navigator is enabled to estimate his distance from the light vessel using as a basis for the estimate the know difference between the speed of sound and the speed of wireless waves. The number of seconds elapsing between the times at which the radio-beacon and sound signals are heard can be readily converted to distance from a suitable table of figures previously prepared. It is pointed out, however, that varying atmospheric conditions can alter the time taken to receive the sound signal and it is not now considered so desirable to synchronize the diaphone with the radio-beacon.

An automatic code-sender governs the Morse characters of the transmitter by operating make and break contacts to form the characteristic of the radio-beacon. The code-sender is itself controlled by a master clock which times the beginning and duration of each group of signals. The master clock and code-sender also govern the timing of the diaphone fog signal. The radio-beacon is in duplicate and in the event of failure the standby unit can be switched into circuit without interruption of transmission.

The accommodation for the Master consists of a day cabin with adjoining sleeping cabin and a separate washplace. The crew of six men is accommodated in two berth cabins with separate messroom and modern facilities are provided, including an electric refrigerator, hot and cold fresh water supplies and central heating by hot water radiator system. Steel light vessels are required to remain on station for a minimum period of three years and for this reason separate accommodation is also provided for two Trinity House workshop mechanics when on board for maintenance work.

Communication with the shore and with other light vessels is maintained by radio-telephone.

UNMANNED LIGHT VESSELS

Unmanned light vessels or light floats vary in length from about 45 feet to 65 feet. They are fully decked and suitably compartmented to give a good chance of survival in the event of being damaged by collision. An automatic acetylene light is carried on a lattice tower. An automatic bell fog signal operated by compressed CO_2 gas acting on the striker is usually fitted, sometimes with the addition of a wave operated bell signal.

Two unmanned light vessels are in service at the present time, both 65 feet long on the load waterline. They have low bulwarks forward but elsewhere the deck is open and rounded at the margin into the shell plating so that any water, which has been shipped will escape freely overside.

A watertight hatch is fitted over each compartment and ventilation is arranged by means of watertight gooseneck ventilators. At the outlet end of each gooseneck is arranged a non-return valve consisting of a light composition ball and a brass seating ring. The ball in its normal position leaves the compartment below open to atmosphere but when the ventilator mouth is submerged by a sea the ball is floated up on its seating and effectively seals the ventilator.

The light is of the open flame type in which a small pilot light burns continuously. The dissolved acetylene gas illuminant is fed to the burner by means of a flashing mechanism controlled by a diaphragm chamber into which the gas is fed at a pressure of about 450 lb. per sq in. The gas distends the diaphragm in a predetermined time and the movement of the diaphragm, magnified by suitable lever and fulcrum, opens the supply valve and admits gas to the burner, where it is at once ignited by the pilot light. The pressure in the diaphragm chamber is reduced by the release of gas to the burner and the diaphragm moving inwards closes the burner supply valve, so restarting the cycle of operations.

FIG.4 – TRINITY HOUSE TENDER *ARGUS*

LIGHTHOUSE TENDERS

Nine lighthouse tenders are stationed around the coast at six depots, from which the work of lighthouse maintenance for each of the six districts is supervised by the District Superintendent acting under the overall direction of the Chief Superintendent and the Elder Brethren of Trinity House. The lighthouse tenders are of varying length, ranging from 165 ft. 9 in. to 256 ft. overall, but are generally capable of performing the same manifold duties. T.H.V. *Argus*, a tender of modern type, is shown in Fig.4. Certain particular duties are more efficiently performed by individual vessels, natural in a fleet of vessels so diversified in type.

The propelling machinery also varies widely in character. Three twin screw tenders are fitted with triple expansion reciprocating engines supplied with steam from two Scotch boilers. Three other twin-screw tenders are fitted with triple expansion reciprocating engines supplied with steam from two oil-fired Scotch boilers. One twin-screw tender is fitted with Diesel-electric propulsion another with reciprocating engines supplied with steam from oil-fires watertube boilers and, lastly, one is single-screw with triple expansion steam engine and one large Scotch boiler of trawler type.

The diversity of propelling machinery is reflected in the auxiliary equipment and the author therefore proposes to describe some particular features of a lighthouse tender rather than attempt to describe one or all vessels in detail. It may be appropriate to digress at this stage so that something may be said of the duties which a lighthouse tender has to perform.

Maintenance work in the Lighthouse Service consists of a wide variety of operations and some of the duties carried out by the lighthouse tenders are as follows:-

(1) The relief of lighthouses and light vessels, which consists of a regular fortnightly trip on which relief crews are transported to and from their stations and supplies of oil, fresh water, coal and general stores are replenished.

(2) Maintenance of the buoyage system which demands that every buoy shall be lifted at regular intervals, cleaned, painted, equipped with fully charged gas cylinders for the light where fitted, and inspected generally to ensure that the light is efficient and that the mooring chain and sinker anchorage are satisfactory.

(3) Light vessels have also to be relived from their stations at regular intervals for repair and the lighthouse tenders, after towing the relieving vessel to her station and mooring her there, take the relieved vessel in tow to her depot for de-storing in preparation for drydocking and repair.

(4) Wrecks have to be marked as soon as possible after the occurrence.

(5) Sandbanks, suspected to be extending, must be surveyed to ensure that their limits are adequately marked.

RELIEFS

The day before the relief is due to begin the lights officers' and lightsmen's gear is loaded aboard the tender. The word "gear" in this case covers many items, food for every man to last until the next relief, sea kit of warm clothing, oilskins and seaboots, writing materials, perhaps some books and probably a half-completed mat, wool rug or ship's model on which to work as a hobby during off duty spells afloat. In the hold of the tender are separate bins for each light vessel and in each bin are stowed personal belongings and food for the men. General stores for the light vessels such as coal and anthracite, paints and cleaning materials are loaded in the hold. Diesel fuel and lantern illuminant oil in deep tanks and fresh water in the double bottom tanks, to replenish supplies on all the light vessels which are to be visited, complete the stores. The relief crews, comprising twelve lights officers and twenty-four lightsmen, are accommodated in their own separate quarters on board and the relief is ready to begin.

On arrival at the first light vessel the tender draws up and makes fast astern. Oil and water hoses are passed to the light vessel and the electric motor driven pumps on the tender which are controlled from the fore deck are set in operation. At the same time one of the two motor boats has been lowered and the relief crew with their stores are transported to the light vessel. The men who have been relieved are brought back to the tender with their belongings, after which the motor boat transports coal and other stores until all is delivered.

During the course of the relief, which is carried on throughout the day and night, the commanding officer and chief engineer of the tender go aboard each light vessel to carry out an inspection. The hull, deck fittings and life-saving equipment are examined by the commanding officer. The machinery is inspected by the chief engineer and any essential adjustments or repairs are taken in hand.

Emergency repairs and adjustments of this kind are part of the relief work and not to be confused with routine maintenance of the fog signal machinery and electric generating plant, which is carried out by a staff of Trinity House mechanics from workshops at Blackwall, London.

BUOY WORK

Fine weather is much to be desired for buoy maintenance work and every effort is made to complete a large part of the maintenance programme during the summer months. Over 600 buoys have to be dealt with and on fine days work goes on from dawn to dusk. It is known from the records what buoys are likely to need new moorings or perhaps withdrawal for major repair and the lighthouse tender is loaded accordingly with clean buoys of the correct size and shape, each suitably painted in the colours and pattern by which it is identified in its particular position. New mooring chains are loaded through chain pipes and ranged in the bottom of the hold, ready to be quickly paid out as required, and the auxiliary equipment such as buoy lams and the wooden superstructure on which they are carried, acetylene gas cylinders, gas mantles and buoy winkers are suitably stowed. These sinkers, which provide anchorage for the buoys, are round or oval cast iron slabs weighing up to three tons and having a heavy steel eyebolt cast solid in the centre to take the mooring chain.

The lifting gear of a modern lighthouse tender consists of a steel derrick, having a safe working load of twenty tons, pivoted on a table aft of the foremast. Two hoisting engines are installed on the lower deck, one for purchase and the other for topping the derrick. Each hoisting engine consists of a 60 h.p. twin cylinder vertical steam engine driving through worm gearing a winch barrel on which 250 feet of 4½ in. circumference flexible steel wire rope is laid and unlaid by automatic spooling gear. A pull of 12 ¼ tons at 30 ft. per min. can be exerted on the first layer of rope off the barrel and by means of a single sheave purchase block 20 tons can be raised at 15 ft. per min. A volute spring shock absorber is fitted between the purchase block and the hook. The derrick guys are treble purchase blocks rove with manilla falls and operated by a 30-cwt electric capstan at each side of the hatch.

A capstan suitably positioned on the centre line is used in conjunction with the derrick to handle buoy mooring cables. This capstan has a single head on which cable lifters of various sizes can be fitted and, above the cable lifter, a warping barrel. A 60 h.p. twin cylinder steam engine fitted on the deck below drives the capstan through spur and bevel gearing. Derrick engine and capstan controls are arranged on the upper deck.

When buoy shifting is in progress the fore deck resembles a busy workshop. The tender having run a little way up tide or up wind of the buoy drops an anchor and falls back on the cable until the buoy is riding nicely placed athwart the fore deck working gangways. The derrick is swung overside and, by means of a two-legged sling hooked into the lifting lugs either side, the buoy is raised and swung inboard. The weight of the mooring cable is taken by a stopper secured on the foredeck so that the buoy can be landed.

Thereafter several operations are carried on simultaneously. The position of the buoy is checked to ensure that it has not dragged. The heavy weed and shell growths on the underwater surfaces of the buoy are removed and hosed overboard. The four apertures, each containing a cylinder of dissolved acetylene gas illuminant are opened up, cylinders removed and replaced with fully charged cylinders. Whatever is necessary to fit the buoy for at least one year's service is done, the lamps and flashing mechanism are tested, mooring cable examined and if need be lifted and replaced. Finally, when the buoy has been repainted it is lowered overside.

Buoys which carry a light are as a rule five tons in weight and with the mooring chain and other fittings the load on the derrick is about seven tons. Another class of buoy which carries a more powerful light on a lattice tower is known as a high focal plane buoy and with its fittings and mooring cable it weighs approximately twelve tons. It will be readily appreciated that the movement of a buoy and motion of the tender in even a moderate sea imposes very heavy stresses in the lifting gear.

An interesting feature of some high focal plane buoys is the long cylinder attached to the underwater body. As the buoy rises in a seaway, air is drawn into the cylinder, to be forced out at low pressure through a whistle as the buoy dips again.

LIGHT VESSEL MOORINGS

The modern gear for handling light vessel moorings consists of a triple head capstan mounted on the foredeck. The capstan heads are interchangeable and lifters can be fitted to deal with various sizes of cable. The capstan heads are driven by a 60 h.p. twin-cylinder steam engine installed on the main deck below and each head can be worked independently of the other two. Chain pipes from the lifters lead direct to the bottom of the hold where new cables are ranged and a strongly constructed roller or ramp in the bow of the lighthouse tender takes the lead of the mooring overside.

A suitable mooring for the majority of light vessels is provided by a 5-ton stockless anchor connected to 210 fathoms of $1^5/_8$-in. diameter stud link cable, but for very exposed stations 1¾-in. diameter stud link cable is used. The length of 210 fathoms, which is rather longer than that in use in merchant ships, is required to form a catenary to which the light vessel can ride easily without snatching on its mooring. It is customary to ride with 180 fathoms of cable out in bad weather.

TOWING

For towing light vessels to their stations and bringing them in when necessary for overhaul, the tenders are fitted with a towing winch of which one, an automatic veering and hauling winch, is fitted on a vessel with Diesel-electric propulsion machinery and consequently is operated by compressed air. The winch engine is of 60-h.p. built in conventional steam winch arrangement with two horizontal cylinders driving a barrel through helical gears. On the barrel 120 fathoms of 4½-in. circumference flexible steel wire is laid and unlaid by automatic spooling gear. It is customary to connect the towing hawser to one of the cables on the light vessel so that by paying out cable to suit the weather conditions a centenary is formed to ease the fluctuations of stress in the towing hawser. By this arrangement the anchor cable also takes the nip and chafe at the mooring pipe on the light vessel instead of the hawser, which is less able to sustain prolonged chafe. The lead of the hawser from the tender is taken through a towing roller consisting of one horizontal roller flanked on each side by a vertical roller.

When the tow has been set to the desired length the automatic veering and hauling gear is engaged by a clutch on the towing winch. The operation of this gear is somewhat similar to the hunting gear on a steering engine. When the pull on the towing hawser increases, the winch renders and pays out, so relieving the stress. The movement of the barrel is transmitted through gears to the control valve which is opened to admit more compressed air to the cylinders until a balance of power is reached. As soon as the pull on the hawser eases the winch engine takes charge, winding in the hawser again to the length at which it was originally set.

The remainder of the auxiliary machinery in a lighthouse tender follows generally the same lines as that in vessels of similar size, except for the workshop, wherein lathe, drilling and shaping machines, grinding machine and power saw are provided to facilitate urgent lighthouse or light vessel machinery repairs.

SPECIAL DUTIES

The Trinity House vessel *Patricia* carries out all the normal routine work of a lighthouse tender but has in addition other special duties to perform. Each year an inspection of all lighthouses, light vessels, beacons and buoys is carried out by a visiting committee of the Elder Brethren in *Patricia* which is fitted with accommodation for this purpose.

The Elder Brethren also attend in person on the Sovereign when proceeding on, or returning from, a voyage across the sea and on ceremonial occasions such as a Naval review when the Trinity House vessel *Patricia*, with the Elder Brethren on board, may be seen leading the Royal yacht.

PROPELLING MACHINERY

The propelling machinery of T.H.V. Patricia is Diesel-electric and is one of the earlier applications of this type of equipment for marine use, having been built in 1938.

Two six-cylinder four-stroke Diesel engines with mechanical injection, each of 750 b.h.p., are direct coupled to 550 volts direct current separately excited propulsion generators and a 48 kW. overhung generator supplying current, for auxiliary purposes at 220 volts d.c. The main propulsion generators are of the open self ventilated type having rotatable frames carried in cradles to provide for easy removal of the lower poles. Means are provided for measuring the wear down without dismantling the bearings.

The propulsion motors are capable of delivering 665 s.h.p. on each of the two shafts at 200 r.p.m. and are of the single armature type with separate pedestal bearings independent of the thrust shaft. Separate motor driven ventilation fans which start up automatically when current is supplied to the propulsion motors are fitted, to discharge air axially over each commutator.

CONTROL EQUIPMENT

Independent control for each propulsion motor is provided from the navigating bridge from the engine room, and electric tachometers to indicate the propulsion motor revolutions and direction are fitted at each of these control stations.

The bridge controllers are in the form of telegraphs and provide six ahead speeds and four astern speeds. Features are embodied in the control scheme which, without any interruption of power, make it impossible to overload the main generators under any conditions.

Independent control of the two propulsion motors can be maintained with one or both generators in operation. Changeover switches are provided for transferring the control from bridge to engine room and pilot lamps at each station indicate which controller is in service.

The exciter sets are in duplicate, each unit comprising a motor of 30 b.h.p., driving one main generator exciter and two propulsion motors exciters. Control of the propulsion motors is carried out by varying the fields of the generator exciter and the propulsion motor exciters.

It is interesting to note that after thirteen years in service the liner wear on the Diesel engines does not exceed 15/1,000-in., a point which indicates fairly well the advantages to be obtained with constant running Diesels as opposed to those frequently started up by compressed air for manoeuvring.

In conclusion the author realizes that, within the scope of so short a summary, it has been possible to touch only superficially on many aspects of the subject, but it would scarcely be appropriate to conclude without reference to the men who serve in the "Ships that Serve Ships." For the aids to the mariner depend ultimately on the reliability of the men at their stations and we who live by the sea know the value of their work for us and for all who navigate the sea.