PROPULSIVE MACHINERY FOR SURVEYING VESSELS

by

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The diversity in the types of machinery employed in existing vessels and the fact that construction will be started shortly on a surveying vessel for our own Navy, has prompted this brief investigation.

Hydrography, being an applied science, having as its mission the determination of the data relative to the configuration of the earth, in so far as concerns navigation, the measurement of the depths of all the navigable waters, surveys of the coasts, the observation and study of the tides, the undertaking of magnetic and astronomic observations, and even oceanographic research, in so far as these are of importance for the elaboration of marine charts and sailing directions, is always obliged to make use of surveying ships. These vessels, depending upon whether they are to be utilised as a working base for the personnel and material, for the transport of the necessary material, or simultaneously as a working base and transport, must satisfy certain predetermined criteria.

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Without taking time to consider the station ship, — to satisfy the exigencies of which it will suffice to have propulsive machinery to enable it to proceed from the base of supplies to the region in which it is to operate and to maintain itself there for a greater or lesser period of time — we shall pass at once to the question of two other types ; that is, the ship as the working vessel and the ship as base and working vessel. These two types require propulsive machinery which have the characteristics of mobility (facility of manœuvring, rapidity of starting), serviceability and economy.

Mobility is an essential feature for hydrographic work. Depending upon the meteorological contingencies, the propulsive machinery must be able to insure that the vessel can get underway as quickly as possible, in order to take advantage of the favourable weather, and which will permit flexibility of manœuvring in accordance with the plan for sounding operations.

The strains to which the machines are subjected each day in the field, with the constant reversals and continuous changes in speed, necessitate a certain robustness of construction which will permit these operations to be carried out without undue stress to the machinery, so that it may remain for long periods of time without appreciable overhaul, which is often difficult if not impossible to provide.

The economical operation of the machinery evidently provides an opportunity for operations at some distance from the base of supplies, assuring a greater output of work, due to an increased radius of action.

The choice of propulsive machinery for surveying vessels then falls upon three different groups: electric, internal combustion or steam (rotating or reciprocating).

It will suffice to outline the advantages offered by each of the three groups ; advantages which are contingent upon the conditions in the zone where the vessel is to be stationed or in the field of operations and with relation to the base of supplies : a condition which will define the nature of the field work.

The type which seems to combine, at first glance, the greater number of qualities, and to which preference should be given for this reason, is the electric motor. It offers — viz —

Facility of control since the manœuvre is extremely simple, as well with regard to reversal, change of speed and stopping. A commutating machine will provide this.

Economy — since all of the power may be transmitted to the shaft turning at a minimum number of revolutions. The electric propulsion is also efficient as well at the half load as at full load. The principal generator revolves at a constant speed, the consumption of steam per H.P. being about the same no matter what the speed ; it is not necessary to reverse the direction of rotation of the generator to back the ship.

Reliability — in view of the fact that the energy may be supplied by an installation comprising a number of small generators, a fact which insures propulsion, even though at reduced speed, when one generator is under repair or needs attention. There is also the possibility of employing one of these generators for lighting while at anchor, for the windlass and the refrigerating machinery. The motors may be driven by rotating steam engines, or internal combustion engines, depending upon which is the most suitable installation, and may employ either alternating or direct current.

However, in view of the high cost of such installations, they have not been generally adopted, except perhaps in the services which are well endowed financially, such as the Coast and Geodetic Survey of the U.S.A. Its surveying ship, *the Hydrogapher,* designed for surveys along and off the coast and in regions where the meteorological conditions are rather good and the bases of supply located at moderate distances, is electrically propelled by a motor supplied from two groups of Diesel generators. The flexibility and the economy of operation, as well as the elimination of large reserve feed tanks for the boilers, determined this choice of machinery. Her displacement is 760 tons.

Internal Combustion Engines are :

Economical, as a result of their high compression, their fuel consumption being less than that of the straight steam installations of the same power.

They require a smaller personnel for operating and manœuvring since there are no boilers and no apparatus for the condensation of the steam.

They are quickly put in operation.

On the other hand, they have the disadvantage of less flexibility, and since the power varies within narrow limits, they are not suitable for frequent changes in speed, because the ignition of the fuel being produced by the heat of compression, only an initial speed which is rather high is susceptible of maintaining it. When the machine is fitted for reversing externally, it necessitates a special mechanism, either mechanical, electrical or hydraulic, to change the direction underway; when it has the internal reversing device, it must be fitted with mechanical devices controlled by hand or by compressed air. It is also difficult to attenuate the synchronism of the vibrations, because the machines cannot always be located in the most suitable place to insure a reduction or elimination of these detrimental effects.

These reasons certainly have much to do with the fact that this type is not in more general use. Only a very few vessels are fitted with internal combustion engines, and these are generally those which are designed more for oceanographic service. They are :

The *Meteor,* of the German Navy, constructed between 1915 and 1935, displacing 1200 tons, speed about 12 knots, propelled originally by two triple expansion engines developing 650 H.P., but now by internal combustion engines.

The *Tydeman,* Netherlands, constructed in 1916, displacing 1600 tons, speed 10 knots, two machines developing 700 H.P.

The *San Juan* and the *San Luiz,* of the Argentine, became the *Commodore Rivadavia* and the *Bahia Blanca.* By their original names, they were designed to be new torpedo-destroyers of 979 tons with engines developing 700 H.P. and a speed of 12 knots.

The *Amiral Mouchez,* of the French Navy, constructed in 1937, displacing 719 tons, with a machine giving a speed of 12 knots.

The *Kang Lu,* Chinese, constructed in 1903 and refitted in 1925. Her displacement is 2130 tons ; she is equipped with a machine developing 500 H. P. to produce a speed of 10.5 knots.

The *Capitan Mairanda,* Uruguayan, constructed in 1930, displacement 516 tons, equipped with one machine of 500 H.P. for speed of 10.5 knots.

Let us now study the types of steam machinery, comprising the reciprocating engines and turbines :

In the rotating machines, as we know, there is no need for an intervening mechanism for the transmission of power to the shaft, provided the steam acts directly on the motor. There results, therefore, a reduction in the number of moving parts, from which we obtain a higher mechanical efficiency because the action of the inertia in opposing changes of speed and direction of rotation is not so great. In the absence of articulating parts, there is not so much friction to be eliminated and consequently less necessity for adjustments. The weight per H.P. is less, as well as the space occupied.

On the other hand, these machines have a smaller range of economical operation, since the steam consumption changes but slightly, because the speed is maintained constant while the load varies. Further, these machines are not reversible and one is obliged to resort to a supplementary reversing turbine for backing. These drawbacks may be the cause of the rareness of their adoption.

We cite below the three examples of vessels equipped with turbines :

The *Stork*, of the British Navy, sloop of the *Bittern* type, built in 1936, displacing 1.180 tons, speed 18 knots and 3.300 H.P.

The *Ypres* and the *Reims*, French dispatch boats, constructed in 1918 and 1919, displacing respectively 655 and 644 tons, twin screw, driven by two turbines developing 5,000 H.P. at a speed of 19/20 knots, the steam being provided by water-tube boilers burning heavy fuel-oil.

The reciprocating engine is still given the preference to-day. It still exceeds the other types by a considerable percentage. The favour and the sympathy which it has gained is not surprising because it is the traditional equipment and the only one which was employed in field work for a long period.

Its disadvantages are the space requirements, the weight, the great number of moving parts with the resultant inertia ; the frictional effects contributing to a reduction in mechanical efficiency are compensated by a greater flexibility of manœuvering, which permits great and sudden changes in speed compatible with the power available. The possibility of it being maintained with excentrics on center or even in the reversing position makes it possible to propel the vessel in either direction very rapidly and perfectly, depending upon the skill of the operating personnel.

Equipped with appropriate servo-motors, it is the type which is most suitable for surveying work on account of the resultant increased efficiency ; it further acts to reduce the operating costs, which in the nature of things are rather high.

The present state of development of these reciprocating engines offers several interesting solutions, which give the possibility of choosing the one offering the greater advantages. The predominance of this type is confirmed by the long list of vessels equipped with such propulsive machinery. In the great majority of cases, these are vessels which have been adapted to this service after having been withdrawn from the military service, because they had lost some of their military value, but had retained other values which made them better adapted to this special service.

The following vessels are in service in our Navy :

The *Berrio*, former tug constructed in 1897 and adapted in 1930 ; displacement 424 tons, equipped with two compound engines of 550 H.P., giving a speed of 10 knots, the steam being supplied by two coal-burning Scotch boilers.

The *Beira*, gunboat constructed in 1936, displacing 451 tons, equipped with two triple-expansion engines of 500 H.P., giving a speed of 10 knots, the steam being supplied by two coal-burning Scotch boilers.

The *Carvalho Araujo*, former English sloop *Jonquil* (of the *Flower* class), constructed in 1915, displacing 1,062.9 tons, equipped with one triple-expansion engine of 2,000 H.P.. giving a speed of 17 knots ; the steam being generated in two cylindrical boilers burning coal. Fitted out as a surveying vessel in 1937.

The adaptation to Hydrography of vessels which usually have been utilised to their limit for other service, will not satisfy the exigencies of modern hydrographic work ; their efficiency will not equal those which have been especially constructed and fitted out for this service.

The sacrifices represented by such construction in the countries which have undertaken them will certainly be more than compensated by their future utility in the performance of the indispensable work of revision, some of which has already been started, and to improve those which are comprised in the general survey plan.

The Netherlands have constructed the *Willebrord Snellius* designed for work in distant regions and in the tropics ; it has been given the necessary sea-going qualities, together with a large radius of action and does not require much upkeep at sea.

As propulsive machinery, and in order to avoid hull vibrations which otherwise might occur if internal combustion engines had been chosen, a reciprocating steam engine was selected which gives a speed of 10.5 knots. The steam is generated in oil-burning cylindrical boilers fitted with the Howden forced-draught system. It possesses a large fresh water reserve, an evaporator of high efficiency, and a refrigerating plant of great capacity. In addition, it is fitted to carry a hydroplane.

For the Canadian Hydrographic Service, there was constructed in 1933 the *Wm. J. Stewart*, designed for operating in the high seas ; it has a large radius of action under normal cruising conditions. It is supplied with two triple-expansion engines giving a speed of 12 knots, the power being transmitted to the propeller shafts through the intermediary of Mitchell thrust

bearings. The steam is furnished to the two main engines, as well as to all the auxiliary machinery, by two cylindrical coal-burning boilers, the combustion being aided by the Howden forced draught system in which the air exhausted from the engine room is heated in a multitubular heater. The grates are fitted to burn coal obtained from British Columbia. The feed-water is filtered and heated before being supplied to the boilers. A group of evaporator-distillers of great capacity, provides for all the needs aboard ship ; the ship being equipped with an extensive system of supply for hot and cold water. The refrigerating plant has a large capacity to permit the preservation of food-stuffs. A well equipped machine shop also assures the execution of overhaul and repair work of which the hydrographic service is constantly in need.

The British Admiralty, which at present is constructing several vessels for the Hydrographic Service, built in 1930-31, the *Challenger* designed especially for oceanographic research. Her displacement is 1,400 tons and she is equipped with one triple-expansion engine giving a speed of 12.5 knots. She develops 1,300 H.P. obtained from steam generated in two boilers.

In 1930, Spain constructed the *Torfiño* which was considered to be a model ship, in view of the minute consideration given every service requirement which had to be met. She displaces 1,200 tons and was designed to operate in any region whatever, but in particular to work off the coast of Sahara and the Spanish Guinea, in regions at some distance from the base of supplies.

One steam engine of two cylinders, modern Christiansen & Meyer type, of 850 H.P. gives her a speed of 12 knots and a radius of 5000 miles at 10 knots. Two water-tube boilers burning oil provide the necessary superheated steam. She carries a small hydroplane.

In 1935, there was constructed another vessel, the *Malespina* having similar characteristics, which should now be in service.

In Portugal, up to the present, we have employed adapted vessels. The survey of the coast of Portugal was accomplished, as we know, by the *Cinco de Outubro*, former royal yacht built in 1900, displacing 1,360 tons, equipped with two triple-expansion reciprocating engines developing 1800 H.P., giving the vessel a speed of 15 knots. Steam is supplied by two cylindrical boilers burning coal. The utmost service possible was obtained from this vessel and she was broken up in 1937 after a long and arduous service, having in fact accomplished all the hydrographic work along the coast of Portugal and commenced the surveying operations in the adjacent islands.

In the colony of Mozambique, the hydrographic operations are being carried out by the *Berrio* to the limit of its powers, but these are weakening year by year.

For the colony of Angola, we have finally the *Beira* which has already been renovated once.

In the Madeiras, the *Carvalho Araujo* is now operating. In carrying out the work of its second expedition, it has been able to meet the exigencies of the situation, thanks to the skill of the Commander in obtaining the best possible service from her qualities.

A New surveying vessel, ready for launching, will provide the National Hydrographic Service with an appropriate and valuable unit. Constructed especially for this service and equipped with reciprocating engines and water-tube boilers, its propulsive machinery will no doubt profit by all the advantages which modern steam machinery can offer.