DIESELS FOR HIGH POWER

A COMPARISON WITH STEAM

BY

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Machinery Fitted to Merchant Ships

In 1958, seven out of every eight merchant ships of over 2,000 tons completed in the world had Diesel engines, and the proportion is increasing. The use of steam is now largely restricted to big ships; the building of marine steam turbines slowly but steadily shrinking as larger Diesels become available. In this country we are lagging a little behind other major shipbuilders in changing over to Diesel machinery, but 61 per cent of our tonnage built in 1958 had Diesels and the proportion has increased by 3 per cent since 1956.

Diesel Machinery Development for Merchant Ships

The complete success of Diesel machinery up to about 8,000 s.h.p. was apparent several years ago, and the designers of large Diesel engines determined to capture the market for higher powers. In the last year BMW, MAN, Gotaverken, Fiat and Sulzer have all offered engines of between 20,000 and 24,000 horse power (Doxfords have one of 17,000 in development). These engines have not of course been put into ships yet, and therefore are not reflected in the shipbuilding returns. It would appear that they will sweep the field, though the only country for which figures are available is Japan. Her 14th post-war shipbuilding programme, just being put in hand[1], is for 25 ships of 382,000 tons deadweight capacity. All but one are motor ships, including three tankers, of 33,800, 34,800 and 46,700 tons. It will be appreciated that as the Merchant Navy abandons steam propulsion the facilities necessary for the production of naval steam machinery will tend to wither away. There will be fewer designers available, and firms will not maintain the necessary plant or the technical know how.

Steam Machinery Development for Merchant Ships

High temperature and high pressure steam machinery has not been favoured by ship owners to any significant extent. A fuel rate of 0·55 lb/h.p. hour is available from turbine machinery using steam at 750 degrees F. and 500 lb/sq in. To get below 0·5 lb/s.h.p. with machinery of about 15,000 h.p. rather exotic steam conditions[2] are required, and only in a few vessels—such as the *American Seaman*—has the attempt been made.

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[1] *The Motor Ship*, February, 1959.

[2] *The Engineer*, 20.3.59.

Choice of Merchant Ship Machinery

The factors of course are entirely economic. The development of special oils like Shell Alexia, the availability of reliable turbo chargers, and such features as chromium plated piston rings and modern filtration have greatly reduced the maintenance required by large Diesels. It has proved possible to build engines of lower specific weight and far greater power without increasing the number of working parts. None of the very powerful engines now available has more than twelve pistons. An analysis of last year's figures for breakdown at sea shows that turbine tankers broke down slightly more often than Diesel tankers.

The ship owner is vitally interested in the total weight and the space occupied by machinery and fuel, in the initial cost and the fuel bills. So are we in the Royal Navy.

Naval Logistics Affecting Choice of Machinery

In war-time there is a considerable advantage in cutting down Fleet bunkering requirements. Steam machinery is more affected than Diesel by running at other than optimum load, and it requires almost twice as much fuel in practice.

It also happens—though this need not be so in the future—that the components of reasonably modern Diesel engines, such as the A.S.R.1., actually are interchangeable, whereas many of the components of the latest steam frigate machinery are not. The effect of this on maintenance will be obvious.

Safety in Action

A Diesel ship with her water compensated fuel is inherently more stable. Advantage can be taken of this either to mount a really heavy armament, as the Germans did in their pocket battleships, or in any other way which the Staff Requirements suggest.

If the ship should be hit, Diesel machinery is comparatively difficult to disable, and damage in a machinery space is far less likely to kill the engine room complement.

Recent Naval Diesel Development

Two Diesel frigates, *Salisbury* and *Leopard*, were included in the 1945 programme, and the major features of the design were frozen at that time. There has been no new naval Diesel development in the last few years in this country, but both the Germans and Italians are now building Diesel frigates of their own design. Naturally these vessels are far more up to date than our own could hope to be, and both of them are fitting engines of considerably higher power per cylinder. The German frigates have gas turbine boost for high powers.

Our own Diesel frigates are justly criticized as requiring too much maintenance and the type has gone out of production for this reason. Their maintenance load has been assesssed as double that of a *Whitby*, four times as much per horsepower, but recent experience in refitting *Lynx* at Portsmouth[3] shows that this assessment should be revised, and that the maintenance load is likely to be about 125 per cent of the *Whitby's*. This lower figure will be taken when considering the possibility of modern Diesel designs later in this article. It is undoubtedly the case that the vast number of working parts in the frigates is the cause of the formidable maintenance bill. The frigates have 128 main engine pistons. A merchant ship of the same power would have twelve.

The multiple engine installation in the Type 41 and 61's is flexible in operation, as was expected, but it is felt that in practice nearly the same flexibility would have resulted from fitting two larger engines per shaft. The Diesel frigates spend nearly all their time at sea with half their engines running.

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[3] Portsmouth Yard Letter 1457 of 2.4.59.

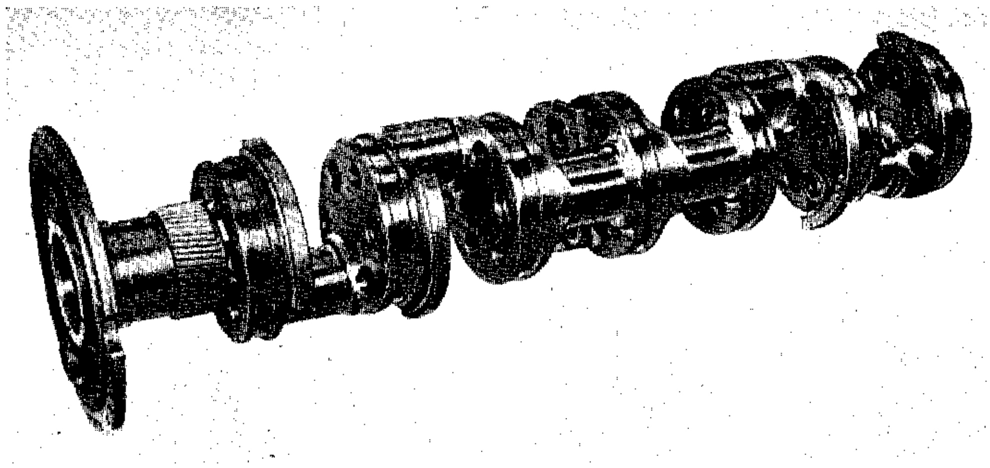

FIG. 1—DISC WEBBED, CRANKSHAFT
(Bristol Siddeley Engines Ltd.)

Diesel Design in 1959

The advantages of Diesel propulsion are so obvious to the world's ship owners that it is worth while examining what is immediately possible to see if we could profit by renewed attention to Diesel propulsion.

We could press A.S.R.1. development a little further, and while the gains from this would not be spectacular, the reduction in maintenance load is likely to be considerable. It is very probable that with very slight modifications to the engines, maintenance in Type 41 frigates will work out at about equal to the *Whitby* estimate, (twice as much per horse-power).

It is not possible to use even the most highly developed merchant service Diesels in the R.N. ; like merchant service steam machinery, they take up too much room and weigh too much. It is possible however to produce more attractive engines than A.S.R.1. This is the normal result of the passage of time, and is certainly not intended to reflect on the A.S.R.1. design team of ten years and more ago.

By using a crankshaft with disc webs (see Fig 1.), the main bearings being on the periphery of the disc, it is possible to increase the ratio of cylinder bore to cylinder centres distance substantially without increasing bearing loadings. A.S.R.1. engines have their cylinder centres 17 inches apart with a cylinder bore of $9\frac{3}{4}$ inches. With a disc web crankshaft the cylinder centres could be reduced to $12\frac{1}{4}$ inches apart, or alternatively the bore can be increased to $13\frac{1}{2}$ inches on the original 17 inch centres.

It is also now possible to design cylinder heads with better breathing characteristics, so that in conjunction with the latest turbo superchargers much more air is aspirated per stroke. Higher brake mean pressures can be obtained with lower exhaust temperatures. Semi-overhead camshafts with no push rods appear necessary to avoid interference with the manifolding while allowing units to be withdrawn without disturbing the camshaft.

Combining the features mentioned above, a 20-cylinder ' V ' engine of $9\frac{3}{4}$ in. and $10\frac{1}{2}$ in. stroke should produce 3,750 b.h.p., its maintenance load being no heavier than that of the A.S.R.1. despite the large increase in power, due to simplification of the fuel system and valve gear. It could fit on the existing A.S.R.1. engine beds in frigates, for example, putting these ships on a par with the *Whitby's* for power and speed. Maintenance costs can be taken as remaining at about 125 per cent of the *Whitby* figure, and might well be justified in view of the reduced fuel requirements and other fundamental advantages of Diesel propulsion.

Larger Engines

In view of successful merchant practice it is felt that, despite the possibilities mentioned above, simpler installations with smaller numbers of larger engines would be far preferable. Using the basis drawings prepared for the $9\frac{3}{4} \times 10\frac{1}{2}$ in. engine a series of larger engines have been scaled up. These become progressively less attractive on a power/weight basis but offer cheaper maintenance per horsepower as the size increases.

A convenient size for manufacture at Chatham without departing from A.S.R.1. practice in machining would be a 20-cylinder ' V ', 12 in. bore $\times$ 12 in. stroke. The engine would be 17 ft $1\frac{1}{2}$ in long, 6 ft 5 in. wide and 8 ft 6 in. high (all dimensions $\pm$ about 3 in., depending on detail drawings). It should weigh not more than 31 tons at the most, and develop 6,200 b.h.p. at 1,000 r.p.m. and 180 b.m.e.p. The height quoted is without turbo-blowers, which it might be convenient to mount off the engine, but they are included in the weight. The engine would have its heat exchanger mounted between the ' V ' banks, carry its oil and oil cooler in the sump, and have fuel and oil filters mounted on the frame to reduce installation pipework. One of these on each shaft in conjunction with gas turbine boost would give Diesel propulsion at 0·39 lb/s.h.p. up to about 22 knots in a large frigate, the gas turbines coming in above that figure. If the turbine could be persuaded to run on marine Diesel fuel instead of pool gas oil (dieso) the Diesels could use this fuel also, given suitable arrangements to prepare it.

Very Large Engines

There are no very large 4-stroke ' V ' engines in existence, but by adopting some features from submarine practice and others from the merchant service it is probable that they could be built with confidence if need be. Two engines have been scaled up from those mentioned previously, for comparative purposes, but no details have been worked out:

(1) 20-cyl. ' V ' 24 in. bore $\times$ 24 in. stroke, length 34 ft, width 13 ft, height 17 ft, weight 240 tons, output 21,600 h.p. at 500 r.p.m. and 160 b.m.e.p.

(2) 20-cyl. ' V ' $19\frac{1}{2}$ in. bore $\times$ 21 in stroke, length 30 ft 6 in., width 10 ft 8 in., height 14 ft, weight 144 tons, output 15,000 h.p. at 550 r.p.m.

Either of these would quite probably require no more maintenance than the latest steam machinery and possibly much less, but in this case the proof of the pudding would have to be in the eating—one cannot be certain.

Development Times and Costs

For the $9\frac{3}{4} \times 10\frac{1}{2}$ in. and 12 in. $\times$ 12 in. engines, two years should suffice if a really determined effort were made, ten draughtsmen being required on the job for that time. The aim would be to have a unit running in six months and the multi-cylinder prototype in two years, at a cost of about £75,000. The very large engines mentioned offer more difficult problems and no doubt would take longer, perhaps twice as long, and cost a lot more. They should have the advantage of burning lower grades of fuel, and also require slightly less of it, about 0·36 lb/b.h.p.hr against 0·375 for the smaller engines.

Employment Afloat

In a few years time no doubt we shall have atomic power plants for the major warships we must build if we are to remain a considerable naval power. It seems likely from published data[4], however, that atomic power may not be economically superior to other prime movers, even for the largest shore generating stations, for quite some time, and in that event it quite probably will not pay us to develop it for small warships for many years to come. It is suggested that turbo charged Diesels might well take over from conventional steam plants during this period, with gas turbine boost where appropriate.

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[4] *The Nuclear Engineer*, May, 1959.