WARTIME DEVELOPMENT OF INTERNAL COMBUSTION ENGINES FOR SMALL CRAFT.

Prior to the war, boats and small craft had not been used in very large numbers in the Navy. The only types of small craft in general use were the boats carried in H.M. ships and a certain number of harbour craft used at bases and in dockyards. The annual building programme was therefore very small, being confined to the boats needed to equip ships building plus a small allowance for replacements.

Boats carried in ships were divided into two distinct categories:—

(*a*) Slow boats (Round chine).

(*b*) Fast boats (Hard chine).

The first category consisted of types of boat which had been used with comparatively little variation ever since motor boats were first introduced into the Service. They were fitted with comparatively heavy slow-running engines using petrol, paraffin or diesel fuel which were intended to be serviced without removal from the boat. Fast boats were introduced in 1935 and this necessitated the use of light weight fast-running engines. The obvious solution to this problem lay in the adaptation of motor vehicle engines and this course was followed. Adaptation, or ' marine conversion ' as it is usually termed, was generally carried out by some firm other than the actual engine builder.

As a result of the comparatively small number of new engines required, firms manufacturing on a large scale were less attracted by the business than small firms dealing exclusively with the small boat engine trade. For many years most of the engines fitted in ' slow ' boats were manufactured by the smaller firms and the ' marine conversion ' of motor vehicle engines for fast boats was placed in their hands. The position at the outbreak of hostilities, therefore, was that the comparatively modest requirements of I.C. engines for propulsion of boats and small Naval craft were being met by a section of industry having limited technical resources and a very small reserve of manufacturing capacity.

Wartime requirements for small craft have fallen into four main groupings—

(*a*) Increased numbers of ships boats.

(*b*) Greatly increased programme of harbour craft.

(*c*) Landing craft.

(*d*) Coastal Forces craft.

The latter requirement has presented a somewhat different problem from that of the other three categories, and is not included in the scope of this article.

Requirement (*a*) developed comparatively slowly and reflected the increase in the Naval building programme. It was possible to provide the number of engines required from the resources of the firms who had been dealing with the peace time requirement and no major problem was involved.

In the case of (*b*) the problem was tackled initially by requisitioning large numbers of privately owned craft (yachts, fishing vessels, etc.), and new construction was not required. In due course, however, the great difficulties associated with the operation and maintenance of a large fleet of miscellaneous and relatively unsuitable craft rendered a new construction programme essential. This programme started modestly and engine requirements were at

first met by obtaining engines of the commercial types used for fishing vessels; but later on the expansion of the programme became so rapid that it was necessary to utilise all available British capacity supplemented by supplies from the U.S.A. This has resulted in certain classes of boat being fitted with engines having less satisfactory characteristics than would normally be accepted.

Requirement (*c*) expanded very rapidly from 1940 onwards and at a very early stage it was found necessary to draw on U.S.A. manufacturers for all the engines required for the minor craft, high speed petrol engines similar to those formerly fitted in ship's fast motor boats being used. In the case of major landing craft a suitable British diesel engine was available and it was found possible to expand manufacturing capacity at a rate commensurate with the requirements of the building programme.

From the foregoing remarks it will be seen that war requirements for small craft have unavoidably brought about the following position:—

(1) A very large number of engines have been brought into service.

(2) An undesirably large number of different types of engine of both British and American origin are in use.

(3) The technical characteristics of many of these types are far from ideal for the services on which they have to be employed.

The necessity for operating very large numbers of I.C. engines of diverse types has introduced a problem of the first magnitude and one which the Navy has never previously had to face on anything approaching this scale, although comparable problems are of course dealt with by the R.A.F. and the Army on a very much larger scale.

In view of the important operational uses for which they are required, the foregoing problem has received much more attention in connection with landing craft than in the case of the other categories of craft dealt with in this article. As the lessons learnt in this connection will materially influence future Admiralty policy in dealing with the smaller classes of I.C. engines, a brief outline of the principal problems encountered and the measures taken to deal with them is given below.

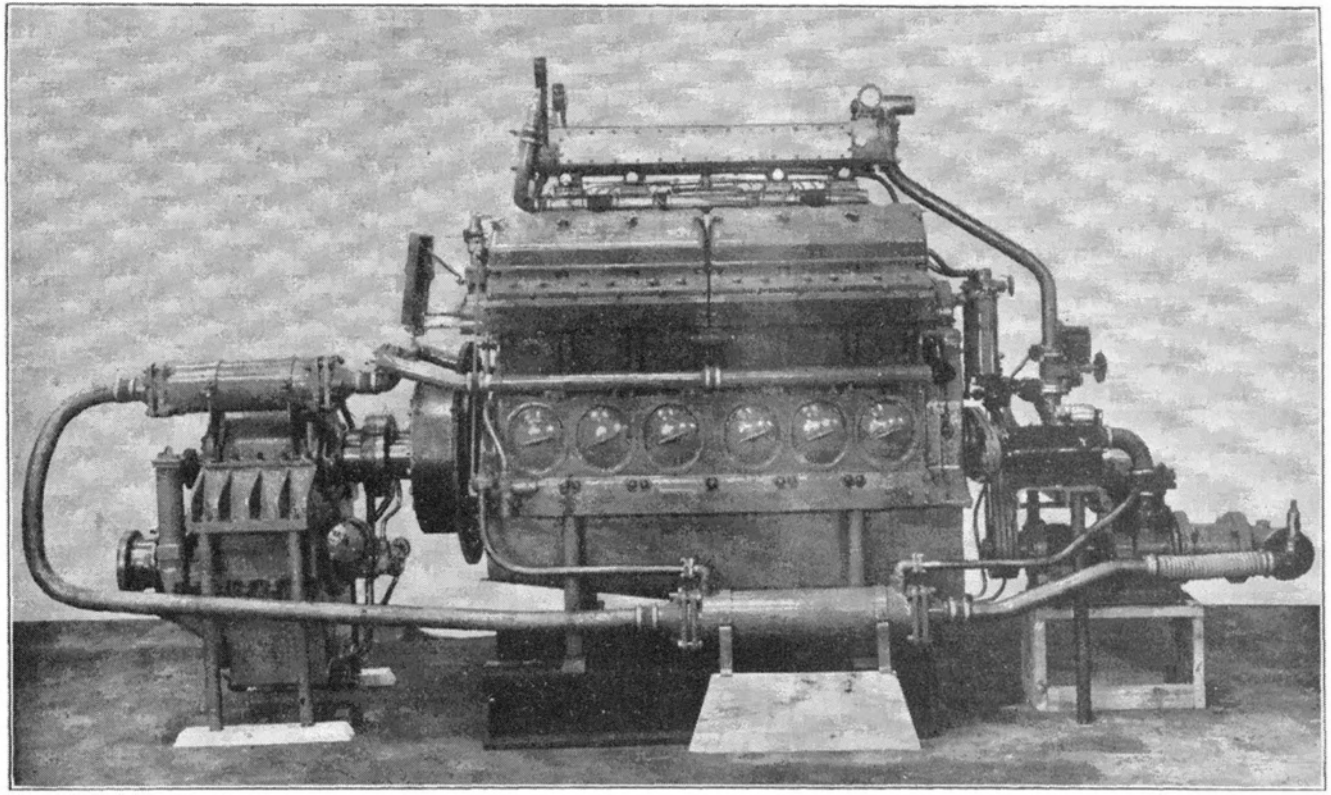
Training of Personnel.

Specialised training of personnel is the first essential for the successful operation of I.C. engines and this has probably been the biggest problem to be overcome in the landing craft organisation, due to its rapid growth. Special training schools have had to be set up dealing with the various types of engines and special establishments have dealt with training afloat.

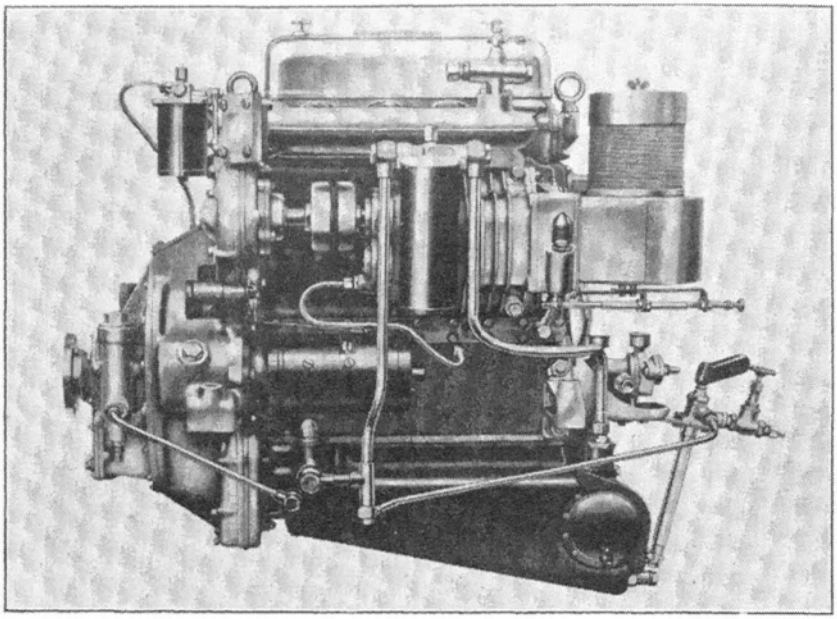
Method of Operating Engines.

The life of an I.C. engine is very closely related to the rating at which it is operated. The ratings are defined in terms of both horse power and r.p.m. and it is necessary for the designer to provide a propeller which will give the correct relationship between the two at the designed deep load draught. It then becomes the responsibility of the operating authority to ensure that the r.p.m. laid down are not exceeded and that the craft is not loaded beyond its designed deep draught. Failure to observe these conditions will lead to overloading of the engine and to unduly rapid wear or to mechanical breakdown.

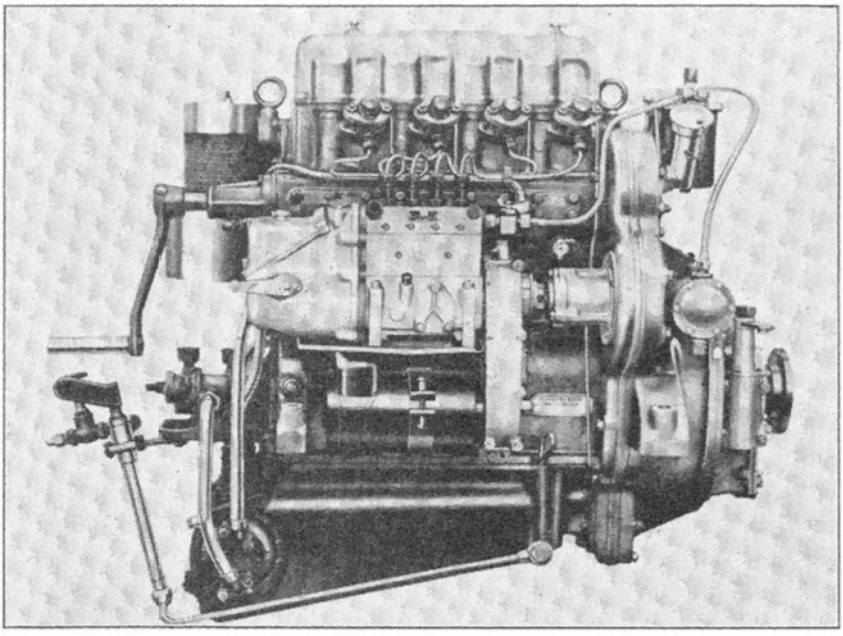
In the case of British-built engines fitted in Naval craft it has been the practice to fit a stop to limit the travel of the fuel control or throttle and thereby limit the maximum power which can be developed by the engine. Such



500 H.P. PAXMAN T.P.M.12 ENGINE AND S.L.M. REVERSE/REDUCTION GEAR BOX AS FITTED IN BRITISH MAJOR LANDING CRAFT.



STARBOARD SIDE OF 50 H.P. COVENTRY DIESEL K.F. OIL ENGINE NOW BEING FITTED IN 16 FT. FAST MOTOR BOATS.



PORT SIDE OF THE COVENTRY DIESEL K.F. OIL ENGINE REFERRED TO ON PAGE 46.

a device, however, is not a complete safeguard and does not relieve the operator of the responsibility for ensuring that the permissible rating is not exceeded. Furthermore, this device takes no account of the fact that the engine should be run at a rating lower than the ' maximum continuous ' whenever possible in order to get the longest possible life from the engine.

In the case of landing craft two principal engine ratings have been defined for all types of craft, the ' maximum continuous ' rating and the ' cruising rating.' The former is intended for use when necessary for the conduct of actual operations, the latter for all other occasions. In certain cases only, a third rating, the 'emergency' rating, is defined. This rating is only intended for use in cases of the utmost emergency and then only for short periods.

The above problem is of fundamental importance for all craft propelled by I.C. engines, and is one which can only be dealt with by the operating authorities. In the landing craft organisation every endeavour has been made to impress upon the authorities concerned the importance of strict adherence to the stipulated ratings.

Engine Maintenance.

Successful operation of I.C. engines cannot be achieved without strict adherence to the recommended maintenance routine and there is probably no class of machinery to which the application of this principle is more important. Details of the routine maintenance work required are given in the engine makers' handbooks, but in order to ensure the complete standardisation of practice, charts have been published laying down the outlines of the routines to be carried out on all landing craft engines. The basis of these charts is the number of hours running to which the engines have been subjected, and it is essential that this information should be accurately recorded.

Specially trained maintenance parties organised on a flotilla basis are used in the landing craft organisation to carry out all maintenance work which lies outside the capacity of the crew. Maintenance work is here defined as all routine maintenance up to and including top overhauls which can be carried out without removing the engine from the craft.

It is intended to publish maintenance charts in respect of the engines fitted in ships' boats and harbour craft in the near future.

Engine Overhaul.

In the early days of the landing craft organisation major overhauls of engines were either carried out at the landing craft bases, or by civilian firms in the vicinity. This procedure led to many difficulties:—

(1) Overhaul practice was not standardised, different bases having their own ideas about the use of sub-standard sizes, oversizes, etc., and about the incorporation of various modifications in the engines.

(2) Stocks of spare gear were dispersed at a relatively large number of bases and were used most uneconomically, *e.g.*, there would probably be an acute shortage of spares at one base and a surplus stock undisclosed at another. There was no proper data about the rate of usage of spare gear on which to base future provision.

(3) There were no co-ordinated records of the condition of engines when taken in hand for overhaul on which future policy regarding intervals between overhauls could be based, or which would enable design changes to be initiated if required.

As a result of this unsatisfactory experience a centrally controlled engine overhaul organisation has been set up in this country at which all major over-

hauls of landing craft engines are carried out, the engines removed from craft for overhaul being replaced by spare engines. The organisation comprises a number of civilian firms each of which specialises in certain classes of engine and carries out the work under the supervision of a resident naval overseer. This arrangement has enabled very large numbers of engines to be overhauled to common standards of workmanship, and has enabled a policy of strict standardisation of component sizes to be enforced. It has also resulted in a more economical use of spare gear than would otherwise have been possible.

Spare Gear Administration.

The question of spare gear has proved to be one of the more difficult of those associated with the operation of large numbers of I.C. engines. The problem is divided into two parts:—

(1) Spare gear production.

(2) Administration and distribution.

It is impossible to solve the first part of this problem unless the second has been satisfactorily dealt with, since production cannot be planned unless accurate data regarding rate of usage of spares is available.

In the case of the landing craft organisation it has been found necessary to set up a central spare gear depot at which stocks of all classes of spares required by the organisation are held. Through this depot all demands for spares by the operating authorities are received. Subsidiary depots have also been established in the vicinity of the principal bases at which ready use stocks are held. The main overseas theatres of operations have also been served by setting up spare gear depots at suitable points. In this way an organisation has been established which not only enables the distribution of available spare gear to be controlled in accordance with strategic requirements, but also provides co-ordinated data about spare gear usage.

Given accurate data on which requirements can be assessed the production of spare gear would normally present no special difficulties, but under conditions such as have obtained during the war, and where data regarding future requirements of all the Ministries concerned has been sketchy and often unreliable, the problem has been difficult in the extreme. These have been further increased by the use of large numbers of American engines for which the production of spares lies outside Admiralty control.

An organisation for the administration and distribution of spare gear for the other classes of craft covered by this article is now in existence and is being developed as rapidly as possible.

Design Developments.

There have been no marked developments of design in the classes of engine under review during the war. It is not essential that the engines used for such services should have a very high performance in terms of power-weight ratio and the emphasis lies rather on obtaining the maximum of durability and reliability. The problem has therefore been one of producing as many engines as possible of types whose characteristics are known rather than experimenting with new and undeveloped types. However, the excellent performance of certain American built two stroke diesels has been a noteworthy feature of our experience in this war, and encouragement has been given to the development in this country of types having somewhat similar features. One such engine, a two stroke incorporating the Kadenacy principle, is now being fitted in ships' 16 ft. fast motor boats in place of the petrol engines which had until

recently to be used owing to the lack of any suitable diesel. This little engine is believed to represent a very promising development and if its performance on service comes up to the expectations its use is likely to be extended to other applications. The engine is illustrated on page 44.

Another line along which design development has been pursued is the marine reverse gear. The conventional form, which has for many years been fitted to a large proportion of both British and American marine engines, has many design faults and has proved very far from satisfactory on service, and other alternatives have been sought. Experience to date seems to indicate that an oil operated box is likely to provide a good solution to this problem and two types of box employing this principle are now on service. One of these has been used extensively in landing craft with excellent results, the other type is being fitted to the small diesel engine for 16 ft. fast motor boats referred to above.

For some years it has been the policy to use diesel engines in ships' motor boats instead of petrol engines and this policy has been actively pursued during the war. At the outbreak of hostilities all fast motor boats and about 50% of slow motor boats were still being fitted with petrol engines, but by 1942 nearly all slow motor boats and about 50% of fast motor boats were being fitted with diesels. The present position is that all standard types of ships' motor boats requiring engines of 10 h.p. or over (*i.e.*, about 95% of the whole programme) are now being fitted with diesel engines. In addition to this a regular programme of re-engining petrol engined boats with diesel engines is being pursued.

Future policy for engining all the classes of craft covered by this article will take full account of war experience and will incorporate the following points as far as possible:—

(1) Maximum possible use of diesel engines as opposed to petrol engines.

(2) Minimum number of different types of engine to be used.

(3) Types of engines used to be those having characteristics best suited to the classes of craft concerned.

(4) Standard methods to be employed for the maintenance and overhaul of engines.

General Conclusions.

The use of I.C. engines for the propulsion of small craft has developed during this war to an extent never previously contemplated and one which has made it an important factor in Naval operations.

The importance of the I.C. engine for this type of service is likely to increase rather than diminish, and is such as to justify a very considerable expenditure of effort in order to place this branch of Naval marine engineering on a thoroughly sound basis in the light of war experience.