MODERN METHODS OF OVERHAULING INTERNAL COMBUSTION ENGINES

by

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From the date of the introduction of the internal combustion engine until a few years ago the jobbing method of overhaul was used almost exclusively. This is the method of the local garage where engines of all types are overhauled simultaneously in a single shop, with general purpose tools and equipment, and where each engine is treated as a separate job. The work to be done is assessed on the apparent condition of each engine on arrival. Standards of workmanship vary widely from shop to shop, and the potential life of each completed engine varies equally widely while the absence of set standards leads to lack of interchangeability between the parts of engines overhauled in different shops, and even between those emanating from the same shop. To attain even reasonably good results by this method it is necessary to use a high proportion of skilled mechanics, and there is a tendency for these mechanics to become Jacks of all engines and masters of none. Perhaps the greatest disadvantage of this method lies in the fact that proper planning and organisation are almost impossible, as is witnessed by the dirt and confusion met in most jobbing shops. To a lesser extent the work is handicapped by the unavoidable use of general purpose tools and equipment. The cost is kept high by the use of skilled labour and by the individual treatment of each engine.

It is not surprising that those in charge of the maintenance of large numbers of similar engines, in the first place bus and haulage companies, began to develop more efficient methods. Early efforts in this direction were largely ineffective because the engines were not, at that time, built to sufficiently accurate standards. The introduction of mass production methods in the makers' factories led, automatically, to a high degree of standardisation in the engines built. Certain engine builders started schemes for reconditioning their engines in their own factories and this led to an appreciation, at the design stage, of the requirements at the overhaul stage. When this point had been reached the way was open for an entirely new conception of the overhauling process. Taking British-built engines only into consideration, it can be said that most of the petrol engines have reached this point in evolution but that only relatively few compression ignition engines have done so. This is, of course, because most petrol engine makers have a high production of a small number of models, whereas, until very recently, the reverse has been the case with the majority of Diesel makers.

This article describes a modern commercial overhaul plant and discusses the extent to which similar methods can be applied to the overhaul of naval engines. It is, however, important to realise, at the outset, that the naval problem is more complex and far less amenable to a simple solution. Firstly, a commercial organisation can usually confine its activities to a small number of roughly similar engine types whereas the naval requirement covers a very large number of types of all sizes and powers. Secondly, these methods can only be applied *in toto* to engines which can be transported to a central repair shop. Many naval engines cannot be removed because of their size or position in the ship. Thirdly, commercial plants usually have to cater for a small geographical area only instead of the Navy's world-wide needs.

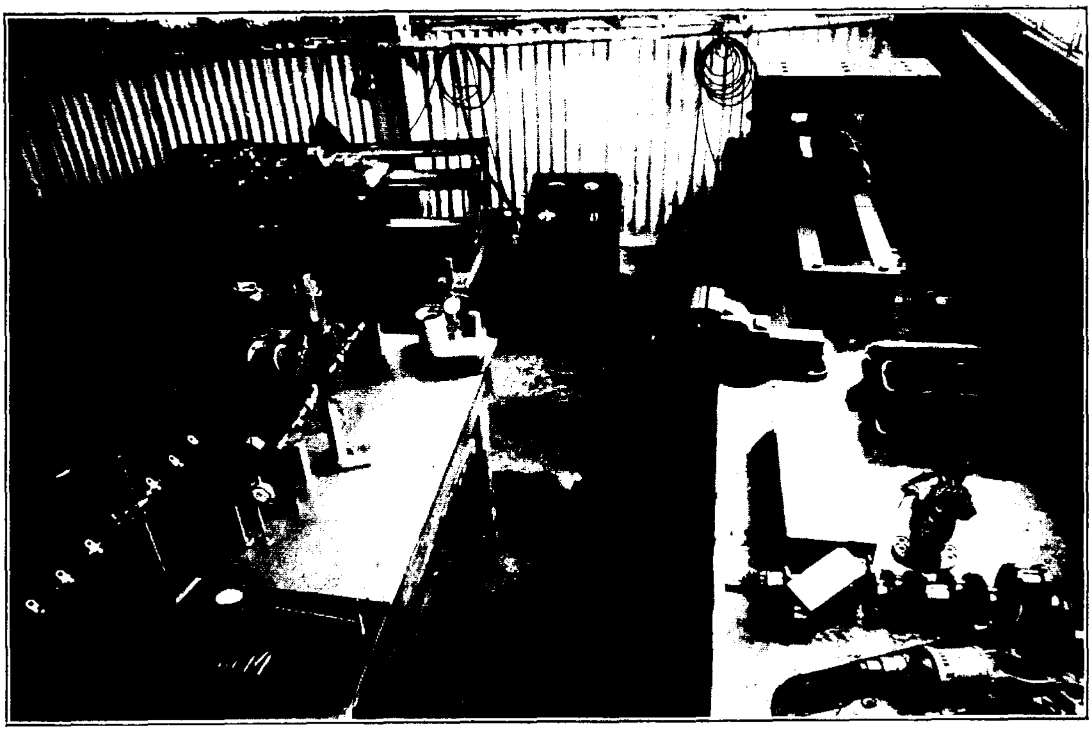

FIG. 2.—WOULDHAM (M.E.D. CHATHAM)—SHOWING CRACK DETECTOR, DEMAGNETISER AND SURFACE TABLES

REQUIREMENTS OF A MODERN OVERHAUL SCHEME

The over-riding requirement is reliability in the overhauled engines. With engines of modern design, it is possible to achieve reliability equal to that of the new engine for a period equal to that of a new engine before its first overhaul, and the aim should be nothing less than this. Of equal importance is the requirement that all the parts of the overhauled engines should be of standard sizes so that spare parts kept in stock can be guaranteed to fit. In naval service, just as in commercial service, the operational availability of the machinery depends mainly upon these two points. Fortunately, most of the factors which make for efficiency in an overhaul organisation tend to promote interchangeability of parts as well as improving the prospect of reliability.

Engines eventually reach a stage when this degree of reliability cannot be guaranteed. When this stage is reached they should be completely rebuilt, or scrapped ; the retention of such engines is both unfair to the user and uneconomical. In the type of overhaul organisation particularly described in this article, this stage is never reached because the engines lose their identity, being broken down to component parts which are either discarded or rebuilt at random into engines at the overhaul plant. This type of overhaul is, unfortunately, not practicable for all engines.

Time spent at the overhaul depot is time wasted as far as the utility of the engine is concerned, and the number of spare engines required in the pool depends upon the average time spent on overhaul. Speed is, therefore, another requirement.

The cost of an overhaul, both in money and in manpower, is always of importance. Apart from overheads, the main costs are for labour and for the provision of replace parts. To reduce labour costs, the organisation must be designed to use the minimum total manpower with the maximum of semi-skilled and unskilled dilution. This can best be achieved by sub-division and specialisation in the shop, and by the use of special tools and fixtures on an extensive scale. Material costs can be kept low by the elimination of special machining and hand fitting, by ample use of mass-produced replace parts, and by reclaiming as much discarded material as possible. An overhaul plant should not undertake any work which can be obtained more cheaply elsewhere. In particular, the " special part," which is so expensive to make, should have no place in the scheme.

Cleanliness is of vital importance. The mixing up of dirty parts with the parts ready for re-assembly, so often found in jobbing shops, must be an impossibility. The swarf and dust of machining operations must be kept out of the assembly area.

Given a reasonable layout, and adequate tooling, all these requirements can be met with the help of careful organisation, but final success will depend upon effective inspection. Everyone engaged in the work must be trained to have the outlook of an inspector for the particular parts he handles. Independent inspection must also be used, and it is most desirable that this inspection should be entirely divorced from production responsibility ; it is too easy to compromise on quality in order to avoid failing in quantity.

LAYOUT AND OPERATION

The layout of a modern *line overhaul* plant is shown diagrammatically in Fig. 1, which is a combination of what seem to be the best points of a number of such plants operating in this country. The term *line overhaul* is used to describe a system of overhauling one type of engine in set stages with conveyor belt, or roller rail, movement between the stages. *Line-batch overhaul*, which is more common, is a line system adapted to handle three or four roughly similar types of engine which go through the plant in batches. These two systems are used for the smaller petrol and Diesel engines, about 200 H.P. is usually considered to be the limit for Diesels, but weight and bulk are the limiting factors. Above the limiting size, fixed or moving engine stands are generally used in place of belts or rails. The basic methods are the same in all cases when engines can be overhauled in a central shop. In batch systems, time is lost on the change-over from one engine to another due to the necessity for re-tooling and for clearing the line. It is important, therefore, to keep the numbers in a batch as high as outside conditions will allow.

SALIENT FEATURES

The plant is divided, geographically, into five main processes—stripping and cleaning, refitting and inspection of parts and sub-assemblies, erection, testing, and preservation and packing. Ancillary processes consist of :—spare parts storage and recording, reclamation of discarded parts, and a separate bay for dealing with crankshafts and cylinder blocks. Dirty parts, which are handled only in the stripping and cleaning area, have to pass a cleanliness inspection point before entering any other area in the plant.

With the use of special tools and labour-saving devices, stripping can be reduced to a very rapid operation ; a team of three men can completely strip a 50 H.P. engine in less than half an hour.

All parts, except injection and electrical equipment, are cleaned by immersion in chemical tanks. Hand spray guns are also used in some plants.

After cleaning, parts are segregated to separate sections for inspection and overhaul. In most of these sections, the parts move along benches as the various operations are performed, finishing as a completed sub-assembly at the end of the bench adjacent to the point on the erection line where it will be required. Injection and electrical equipments are handled in enclosed dust-proof shops, and both crankshafts and cylinder blocks, which generally need machining, go to a separate bay. The procedure in all sections is basically

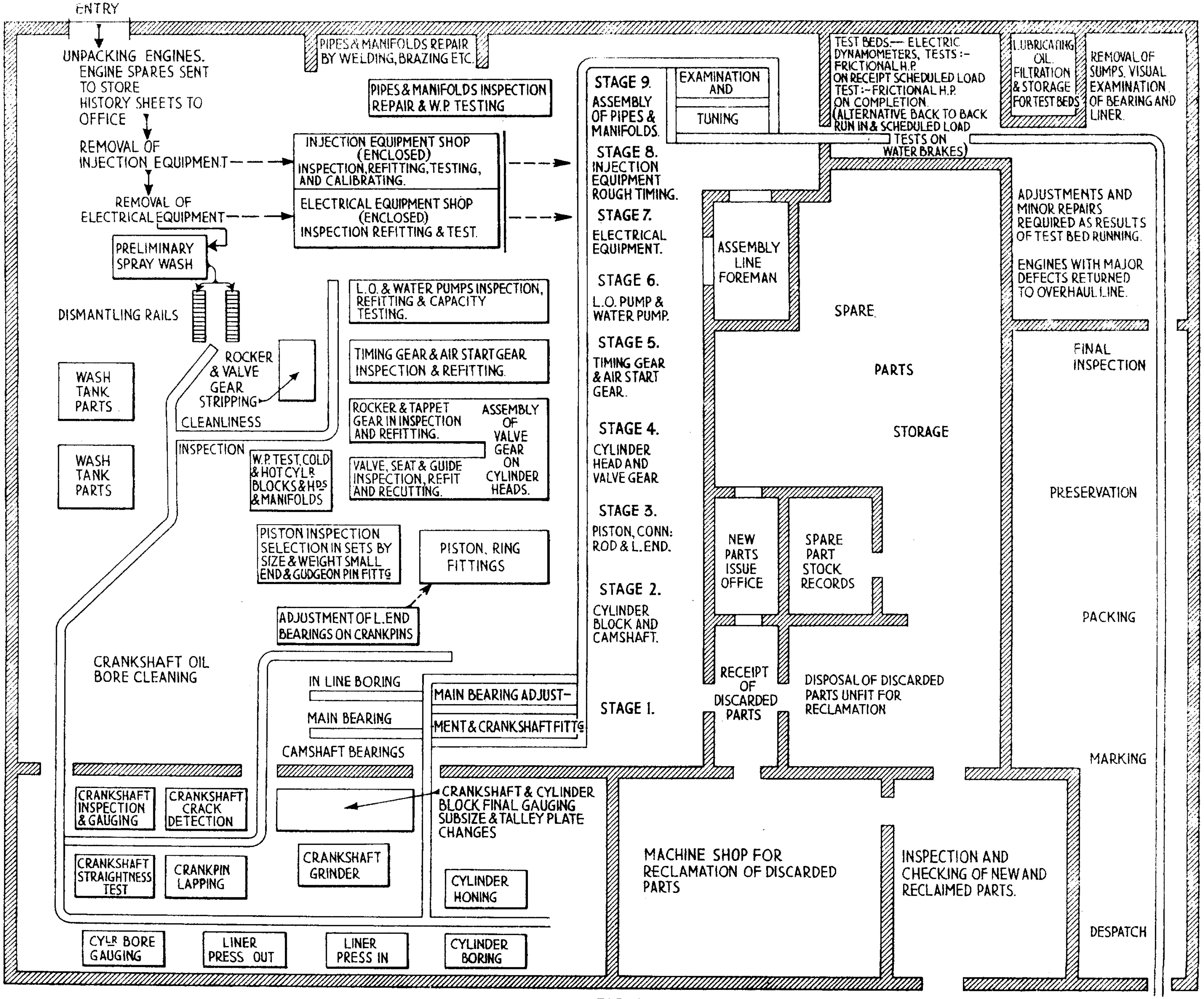
ENTRY
UNPACKING ENGINES.
ENGINE SPARES SENT TO STORE
HISTORY SHEETS TO OFFICE
REMOVAL OF INJECTION EQUIPMENT
REMOVAL OF ELECTRICAL EQUIPMENT
PRELIMINARY SPRAY WASH
DISMANTLING RAILS
WASH TANK PARTS
WASH TANK PARTS
ROCKER & VALVE GEAR STRIPPING
CLEANLINESS
INSPECTION
PIPES & MANIFOLDS REPAIR BY WELDING, BRAZING ETC.
PIPES & MANIFOLDS INSPECTION REPAIR & W.P. TESTING
INJECTION EQUIPMENT SHOP (ENCLOSED) INSPECTION, REFITTING, TESTING, AND CALIBRATING.
ELECTRICAL EQUIPMENT SHOP (ENCLOSED) INSPECTION REFITTING & TEST.
L.O. & WATER PUMPS INSPECTION, REFITTING & CAPACITY TESTING.
TIMING GEAR & AIR START GEAR INSPECTION & REFITTING.
ROCKER & TAPPET GEAR IN INSPECTION AND REFITTING.
ASSEMBLY OF VALVE GEAR ON CYLINDER HEADS.
VALVE, SEAT & GUIDE INSPECTION, REFIT AND RECUTTING.
W.P. TEST, COLD & HOT CYLR BLOCKS & HDS & MANIFOLDS
PISTON INSPECTION SELECTION IN SETS BY SIZE & WEIGHT SMALL END & GUDGEON PIN FITTG
PISTON, RING FITTINGS
ADJUSTMENT OF L. END BEARINGS ON CRANKPINS
CRANKSHAFT OIL BORE CLEANING
IN LINE BORING
MAIN BEARING
CAMSHAFT BEARINGS
MAIN BEARING ADJUSTMENT & CRANKSHAFT FITTG
CRANKSHAFT INSPECTION & GAUGING
CRANKSHAFT CRACK DETECTION
CRANKSHAFT & CYLINDER BLOCK FINAL GAUGING SUBSIZE & TALLEY PLATE CHANGES
CRANKSHAFT STRAIGHTNESS TEST
CRANKPIN LAPPING
CRANKSHAFT GRINDER
CYLINDER HONING
CYLR BORE GAUGING
LINER PRESS OUT
LINER PRESS IN
CYLINDER BORING
STAGE 9. ASSEMBLY OF PIPES & MANIFOLDS.
EXAMINATION AND
TUNING
STAGE 8. INJECTION EQUIPMENT ROUGH TIMING.
STAGE 7. ELECTRICAL EQUIPMENT.
STAGE 6. L.O. PUMP & WATER PUMP.
STAGE 5. TIMING GEAR & AIR START GEAR.
STAGE 4. CYLINDER HEAD AND VALVE GEAR
STAGE 3. PISTON, CONN: ROD & L. END.
STAGE 2. CYLINDER BLOCK AND CAMSHAFT.
STAGE 1.
ASSEMBLY LINE FOREMAN
SPARE PARTS STORAGE
NEW PARTS ISSUE OFFICE
SPARE PART STOCK RECORDS
RECEIPT OF DISCARDED PARTS
DISPOSAL OF DISCARDED PARTS UNFIT FOR RECLAMATION
MACHINE SHOP FOR RECLAMATION OF DISCARDED PARTS
INSPECTION AND CHECKING OF NEW AND RECLAIMED PARTS.
TEST BEDS:— ELECTRIC DYNAMOMETERS, TESTS :— FRICTIONAL H.P. ON RECEIPT SCHEDULED LOAD TEST :— FRICTIONAL H.P. ON COMPLETION. (ALTERNATIVE BACK TO BACK RUN IN & SCHEDULED LOAD TESTS ON WATER BRAKES)
LUBRICATING OIL FILTRATION & STORAGE FOR TEST BEDS
REMOVAL OF SUMPS. VISUAL EXAMINATION OF BEARING AND LINER.
ADJUSTMENTS AND MINOR REPAIRS REQUIRED AS RESULTS OF TEST BED RUNNING.
ENGINES WITH MAJOR DEFECTS RETURNED TO OVERHAUL LINE.
FINAL INSPECTION
PRESERVATION
PACKING
MARKING
DESPATCH

FIG. 1

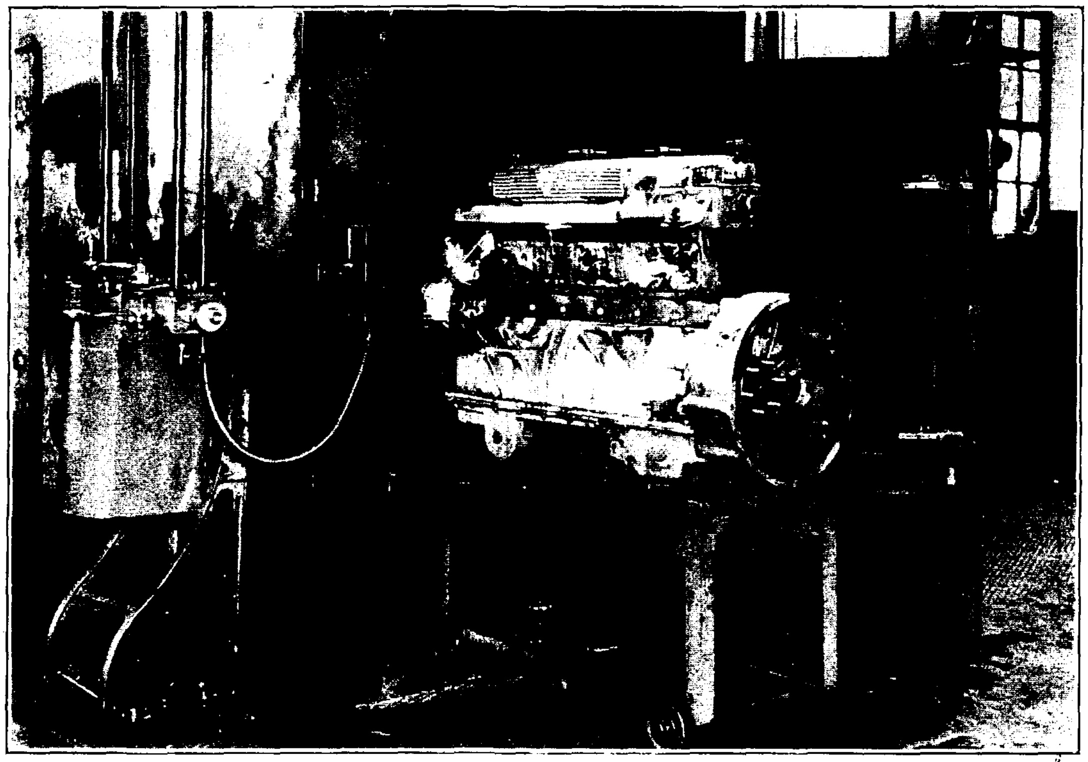

FIG. 3.—LONDON PASSENGER TRANSPORT BOARD (L.P.T.B.)—ENGINE LEAVING PRELIMINARY WASHING PLANT

the same. All parts lose identity, which means that a completed engine may have no two parts which were in the same engine when received for overhaul. All sections work to the schedule of dimensions which lays down the limiting sizes allowed to be rebuilt into an engine.

Inspection

The first operation is inspection, where all parts damaged, or worn beyond schedule limits, are placed in discard bins. The parts remaining, being suitable for re-use, are passed down the bench for minor refitting and adjustment and finish up in the sub-assembly parts bins. New parts are fed into these bins, in numbers equal to those discarded, from the spare parts store. Sub-assemblies are then built up at the end of the bench using parts indiscriminately in the knowledge that all are within acceptable dimensions. Sub-assemblies are then inspected before going to the erection line. In the case of injection equipment, electrical equipment, and all pumps, inspection at this point includes calibration and output tests. The indiscriminate use of parts is modified for crankshafts and pistons where mated sets are built up and used together.

Crankshafts

All crankshafts go through the following processes :—Cleaning of oil bores, check for distortion, straightening (if distortion is within defined limits), crack detection, gauging, grinding to standard undersize (if required), lapping (if called for in the schedule), and final gauging and inspection.

Cylinder Heads and Cylinder Blocks

Cylinder heads and cylinder blocks are first de-scaled and then water pressure tested (both hot and cold water tests are advisable). Cylinder blocks then go for gauging, re-boring to standard undersize, honing (if required by the

FIG. 4.—L.P.T.B.—REBORING AND HONING BAY FOR CYLINDER BLOCKS

schedule), and final inspection ; alternatively, they may go for pressing out of old and pressing in of new liners.

Pistons

Methods of dealing with pistons vary widely ; sometimes new pistons only are fitted, sometimes old pistons are retained without any machining if within certain dimensions, and in some cases ring grooves are machined for over-width rings. As in the case of all sub-size parts, which of the above methods is adopted rests on a compromise between obtaining the longest service out of each part and simplifying the provision of spares. A typical example when pistons machining is not accepted is as follows :

Pistons are discarded or retained according to head, skirt, and ring groove wear. They are then arranged into three groups according to skirt diameters and marked with an indicating colour. Gudgeon pins and connecting rods are then fitted and checked parallel, after which the rods and pistons together are weighed and again grouped into engine sets with the same indicator colour and within certain limits of weight difference. These engine sets thereafter remain as a " mated set." The mated sets go to the large end fitting bench where the large ends are fitted to a crankshaft and the set of pistons and crankshaft are marked as a mated set. Cylinder bores are marked at the final gauging, as upper tolerance, mid tolerance, and low tolerance using the same indicating colours as in the case of the pistons. Pistons and blocks of similar colour are fitted at the erecting stage ; some adjustment in boring or honing may be necessary at the end of a run of engines to keep pistons and bores in step. After large end fitting, the pistons return to their original bench for ring fitting and final inspection.

Bearing clearances

Due to slight distortion of the castings in service it is seldom that the main and camshaft bearing housings are truly in line when an engine comes in for overhaul.

To overcome serious distortion bearing shells and camshaft bushes are fitted slightly undersize in internal diameter and are then " in line " bored or reamered to size in position. In the majority of cases, however, a little scraping in of a standard bored bearing is sufficient to overcome this distortion.

To measure bearing clearances the most satisfactory method appears to be as follows :—A strip or strips of suitable thickness cellophane paper, about ½ in. wide, are inserted in the cap and the cap tightened down and the effect on the freeness of the bearing felt. Cellophane is added until the crankshaft or rod is just nipped.

Undersize shells are, of course, used to correspond with ground crankshafts. In order to lessen spares complication, all crankpins—and similarly all main journals—are reduced to the same undersize even when only one pin needs reducing.

Erection and Test

Erection is carried out in stages using parts at random. Details of all sub-size parts used are recorded, for each engine, at each stage.

Every engine is run in to a definite schedule before starting its bench test. The run-in performance is almost as important as the test performance, but this is not realised in all plants. The best method is to use electric motors, or reversible electric dynamometers, to drive the engines while running in because the frictional horse power can be plotted. The frictional H.P. gives a clear indication of the state of the engine when received from the erection

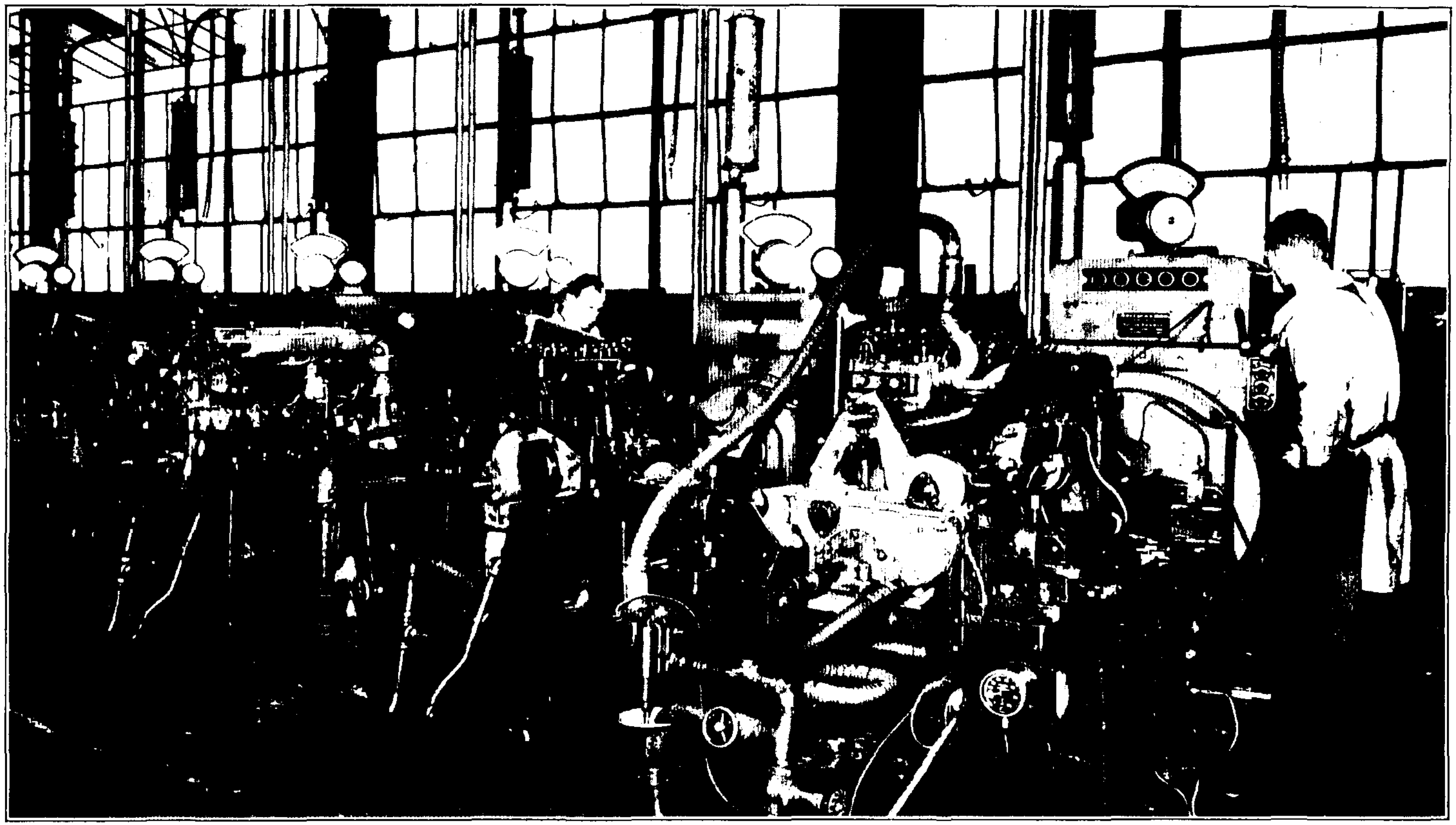

Fig. 5.—L.P.T.B.—ENGINES UNDER TEST AFTER OVERHAUL. ELECTRICAL DYNAMOMETER USED FOR "MOTORING IN" AFTER TESTING

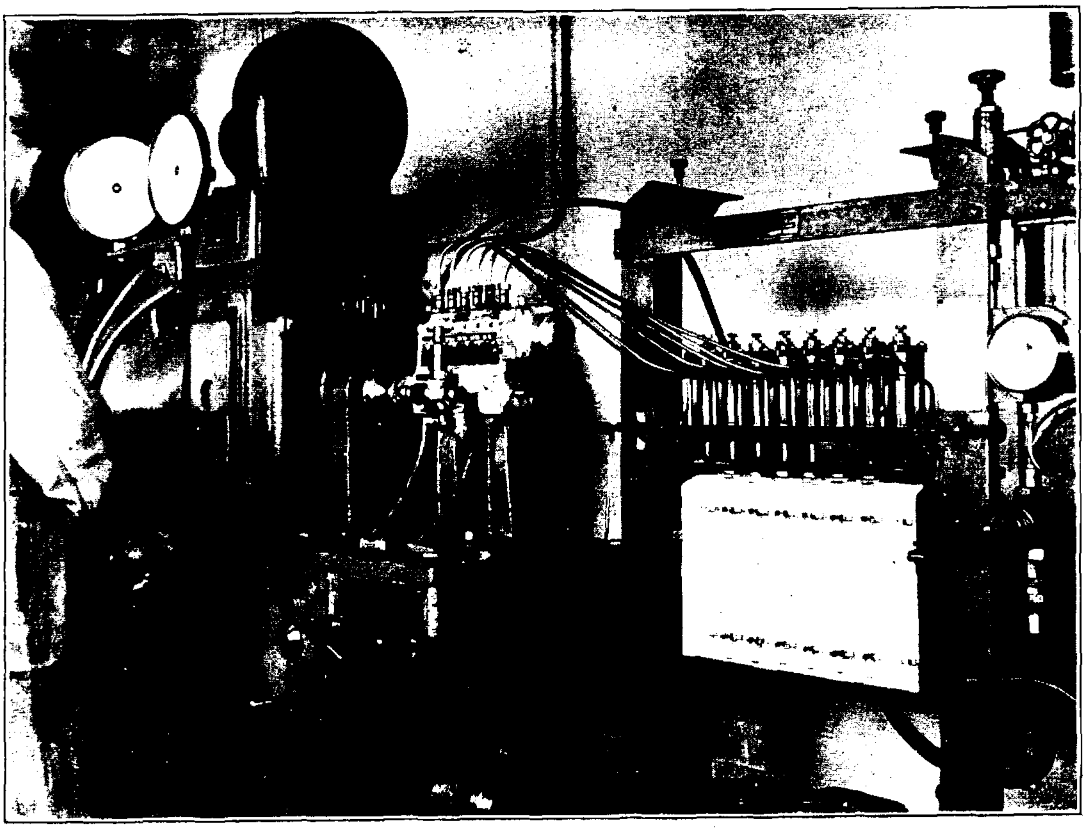

FIG. 6.—L.P.T.B.—INJECTION EQUIPMENT SHOP—CALIBRATING A FUEL PUMP ON A HARTRIDGE TESTING MACHINE

line and can be used to ensure that engines are not put on test with incipient defects in the running gear.

Test procedure varies greatly. Comprehensive tests add appreciably to the overhaul cost, but it is noticeable that transport companies usually find that it pays to spend money on this item. With this type of overhaul stringent tests are really essential, as with any other, and a study of performance on test is just as important as the matter of " getting the engine through." It is good practice to remove any engine exhibiting abnormal behaviour to an examination bay. If the trouble cannot be diagnosed and remedied at this point, the engine is returned to the start of the overhaul line for complete stripping and re-building.

The filtration arrangements for both fuel and lubricating oil must be the best obtainable.

After Bench Test

Examination after bench testing is usually confined to visual examination of the bearings and bottom ends of the liners, but pistons are drawn if there is any doubt as to their condition.

After preservation, every item that should be packed is checked into the case on a card and the engine is not released until this card has been received in the record office.

Reclaimed Parts

This method of overhaul would be most uneconomical if the parts discarded at the various inspection points were to be thrown away or sold at scrap price. Each such part passes to a special section for decision whether, and by what

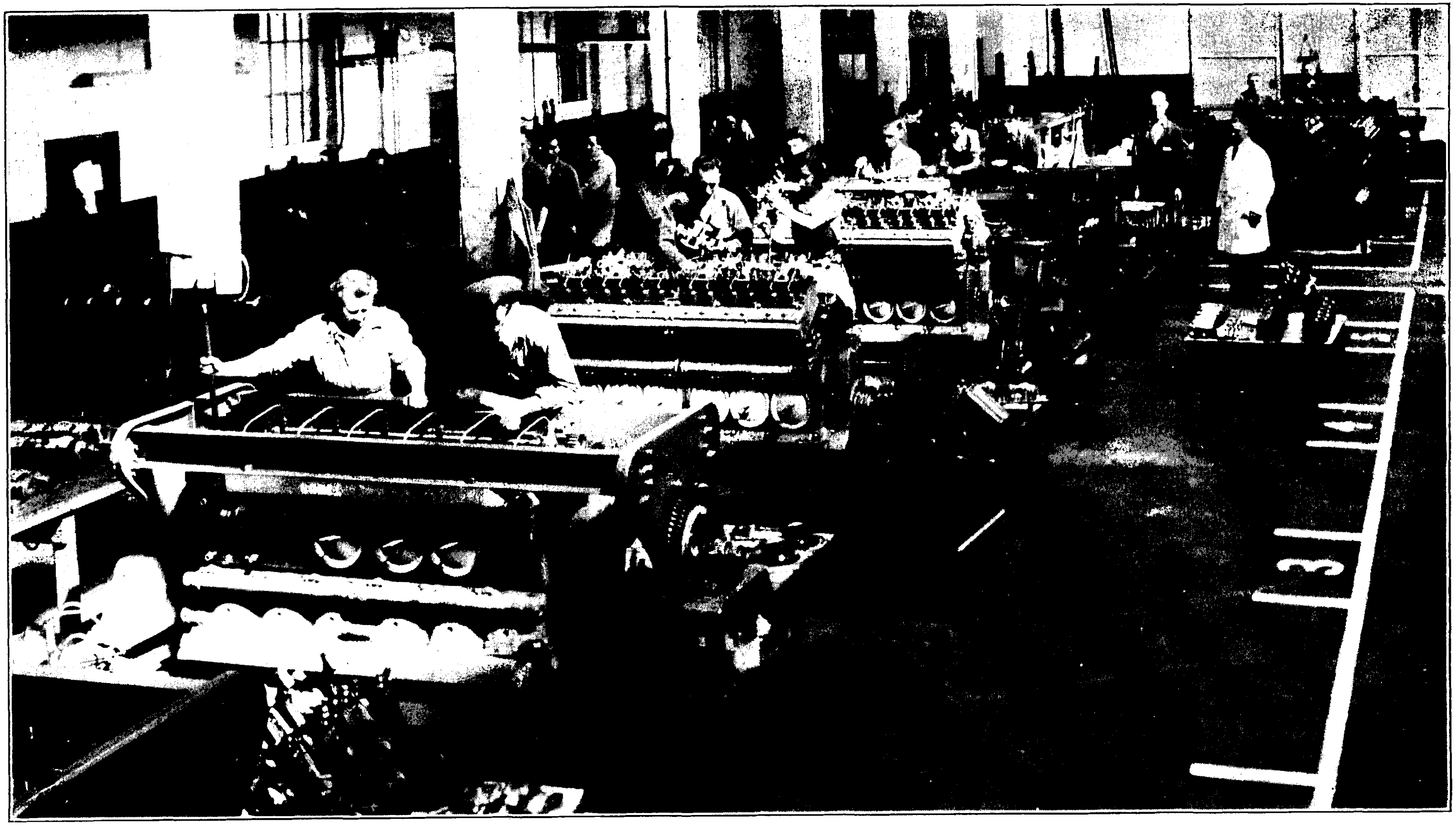

FIG. 7.—SPECIALISED OVERHAUL OF PAXMAN T.P.M.12 (500 B.H.P.) ENGINES AT BRITANNIA WORKS DURING THE WAR

FIG. 8.—PAXMAN T.P.M.12 ENGINES ON BENCH TRIAL AFTER OVERHAUL, SHOWING ACOUSTIC HOODS

means, it is reclaimable. Since reclaimed parts are absorbed in the general stock, only approved methods are allowed in this shop which operates quite independently of the overhauling side of the plant. Reclaiming processes for each part tend to become largely standardised, and semi-mass production methods can be used in many cases.

The following examples give some idea of the work done: crankshafts metal sprayed or plated, backs of worn bearing shells metal sprayed, worn oversize pistons machined to standard size, bearing shells relined (this work is usually sent out to the specialist firms), stellite deposit on exhaust valve seats renewed, cam followers and pump parts built up, cracked cylinder blocks and heads welded, etc.

Much depends upon the development of sound and economical technique in this shop.

Recording methods in the spare parts store have to be on modern lines to maintain a constant balance between discards from the plant on one hand and the inflow of reclaimed parts and purchases on the other. Shortage of any one part will hold up the entire overhaul line.

THE APPLICATION OF MODERN OVERHAUL METHODS TO NAVAL I.C. ENGINES

Though the Navy operates more than sufficient engines to make the introduction of modern methods worth while, the problem is complicated by a number of factors not met with in the commercial world. The engines requiring overhaul must be divided into " fixed " and " removable " classes. All engines too large to be transported conveniently to a central depot fall in the fixed class. There are, however, many others, such as destroyers' generators, which are eminently suitable for central overhaul, but which can only be removed from their ships at prohibitive cost. Any overhaul scheme must, therefore, cater for a large number of fixed engines as well as for the removable ones. In the removable class there is a great diversity of engine types and sizes which limits the degree of specialisation attainable, and this state of affairs can only be improved by standardisation of engine designs.

FIG. 9.—WOULDHAM—SPARE PARTS AND STORES RECORD OFFICE

Modern methods can never be wholly successful until a considerable degree of standardisation of engines has been achieved. Every step towards such standardisation can be reflected in an increase in the efficiency of the overhaul organisation.

The twin requirements of world-wide facilities and dispersal of plant also affect the possibilities adversely. The advantages of a small number of highly specialised plants have to be balanced against the vulnerability both of the plants and of the engines in transit. These considerations lead, inevitably, to the conclusion that the most efficient methods cannot be applied in the case of the Navy. On the other hand, war experience has shown that the maintenance of complete interchangeability of spare parts, and a life-prospect in overhauled engines equal to new engines are both of paramount importance. Operational availability depends upon the extent to which these requirements can be guaranteed. It follows that naval overhaul arrangements must approach the best modern methods as closely as naval conditions allow.

Instructions for Overhaul of Naval Engines

The introduction of new methods is hampered, at the present time, both by financial stringency and by the relatively small number of engines requiring overhaul per year. The first step, which applies to both fixed and removable engines, can, however, be taken in the form of schedules of instructions for the overhauling of all types of engines. It must be stressed that the primary purpose of these schedules is to ensure complete interchangeability of parts between all engines of a type wherever overhauls may be carried out, and, equally, to ensure that all overhauled engines can be expected to run for the same period as a new engine. In the case of removable engines the schedules also serve a secondary purpose as the basis of centralised and specialised overhaul. The appropriate schedule must be followed as closely as conditions permit in every engine overhaul wherever it may take place. These schedules, which are published in A.F.O's., are compiled on service experience after full consultation with the engine designer and the overhaul authority.

The first step in the introduction of modern methods to the Navy must, therefore, be the introduction of overhaul schedules for all fixed and removable engines. It may not, however, be economical to use these schedules for certain large engines which are fitted in relatively small numbers.

Establishment of Overhaul Establishments

The second step is the establishment of specialised overhaul establishments at home and abroad. Those at home can operate a higher degree of specialisation than those abroad because each yard can concentrate on two or three engine types only, whereas foreign yards must cater for all types. The small number of coastal craft and landing craft engines in use at the present time has made it necessary to build up the specialised overhaul facilities mainly for motor boat and certain generator engines in the first instance. This will enable dockyards to gain the necessary experience, but the real aim must be to provide an organisation which can be expanded to cover the very large number of removable engines likely to be used in war.

Preparation of Wartime Procedure

The third step consists of making preparations, in time of peace, for the setting up of overhaul establishments in time of war at places other than dockyards. Existing commercial facilities would be used wherever they are available, but it must be possible to undertake overhauls in places where no such facilities exist within a few months of the outbreak of war. It is, therefore, necessary to build up and maintain a stock of those items of equipment which cannot easily be obtained ; test brakes are one example. The specialised dockyard overhaul shops should prove invaluable as a means of training men to take charge of these establishments.

These three steps in the introduction of modern methods are being progressed as finance and other facilities can be made available. The emphasis is at present being placed upon the development of really efficient methods in home waters.

An overhaul system working on the lines discussed in this article can only operate efficiently if the flow of engines approximates to the flow for which the system is designed. In other words, a greatly increased flow of engines to overhaul, due to the development of defects on service, may throw the organisation out of gear. For this reason correct operation and maintenance of the engines while on service is of the utmost importance. Furthermore, it is unlikely that any overhaul base will be able entirely to avoid errors in technique creeping in from time to time, and it is most important that engine failures suspected of being due to such errors should be reported without delay.

Adoption of Batch Overhaul

Based on the above principles the method of batch overhaul is being adopted in the Navy as far as circumstances will allow.

All removable engines of the types listed in A.F.O. 5838/45 should be returned to the appropriate centralised overhaul depot where they will be refitted in accordance with their respective major overhaul schedules of which three have been published and others are in the course of production.

These overhaul establishments are being organised at the Home Dockyards but outside the dockyard area. The staff are fully employed on I.C. engine work only and will be trained as a nucleus to enable rapid expansion to take place, in the event of war, with the minimum loss of efficiency.

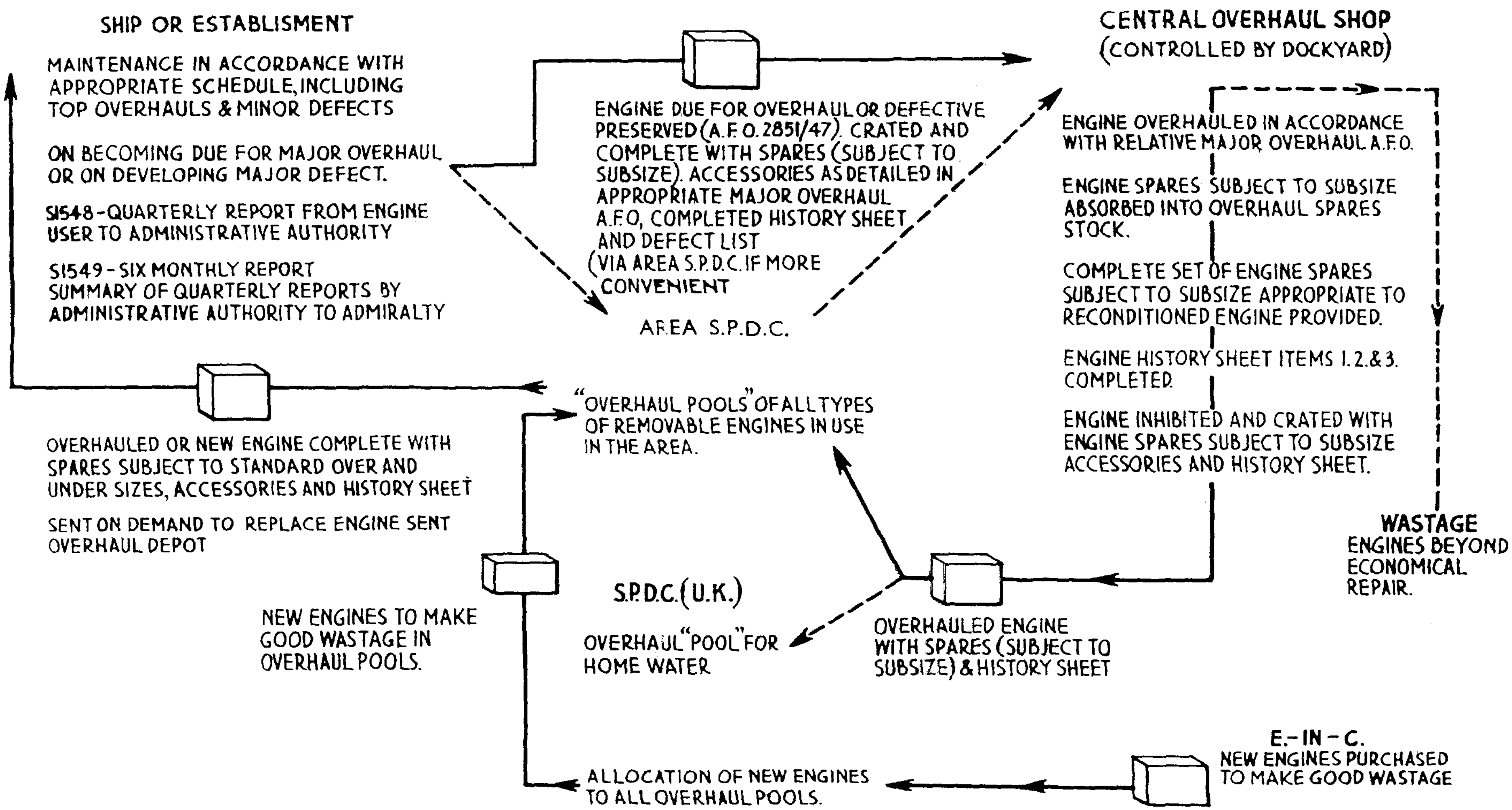

FIG. 10.—MOVEMENT OF ENGINES UNDER POOL REPLACEMENT AND CENTRALISED OVERHAUL SCHEME

Briefly then the life of an engine, as classified, will be :—

A ship demanding a replacement engine in accordance with A.F.O. 5838/45, or the overhaul A.F.O. modifying it, will receive a packing case in which will be enclosed a re-conditioned engine which has been overhauled in accordance with the appropriate overhaul schedule, has been subjected to maker's acceptance trials, or the equivalent thereof, and preserved. Also enclosed will be the engine spare parts which are subject to standard over and under sizes. The history sheet with Items 1, 2, and 3 completed, will be forwarded under separate cover.

The engine which has completed its running hours should be preserved, as far as the ship's facilities will allow, in accordance with A.F.O. 2851/47, and returned in the same packing case complete with all accessories and spare parts subject to standard over and under sizes.

The case is then forwarded to the appropriate Dockyard where the engine will receive a complete overhaul.

The period between leaving the ship and the major overhaul taking place is indefinite and so it is essential that every effort should be made to preserve the engine efficiently.

The history sheet with items 4-13 completed should be forwarded with the engine. A defect list should be forwarded to the Dockyard concerned to cover reconditioning of the returned engine.

On completion of overhaul, test, preservation, and packing, the engine is despatched to an engine pool.

The above is a brief outline of the organisation which is being set up and is already functioning in the U.K. and which will be extended to bases abroad in the near future.

The overhaul establishments abroad will be brought into the scheme as soon as spare engine pools can be established at figures adequate to cover the longer delay periods inevitable on foreign stations. This position can almost be met by Perkins P.6M and Ford V.8 engine pools.

Also, the establishments abroad will not be set up until the difficulties encountered at home have been satisfactorily overcome. At bases abroad, however, each dockyard will deal with all types of engines on the station, but the method of overhaul will be based upon the same principles.

The main overhaul depots and the engines at present allocated to them for overhaul are :—

Chatham	Perkins	P 6 M
	Perkins	S 6 M
	Scammel	R N 2
Portsmouth	Paxman	T P M 12
	Paxman	4 R Q
	Ford	V 8
	Kelvin	F 4
	Anzani	Outboard
	S.L.M.	Gear boxes
Devonport	Dorman	2 D S M
	Dorman	4 D S M
	Dorman	4 D W D M
	Dorman	8 V R M
	Gardner	4 L 2
	Gardner	4 L W
	Gardner	6 L W

Rosyth	Fowler 2 D Y
	Stuart Turner P 5
	Stuart Turner P 5 M C
	Stuart Turner P 55 M
	Stuart Turner P 55 M R
Sheerness	Coventry K F 4
	Coventry Cub
	Austin lifeboat engine

From the ship's point of view the replacement engine can be accepted with confidence.

Maintenance

The behaviour of the engine then depends to a large extent on a high standard of maintenance towards which end the maintenance schedules are published as a guide. These schedules are at present published in A.F.O. 5973/45, A.F.O. Diagrams 374/45, but in order to assist distribution and availability they are being revised and republished as S and D forms, a copy of which will be issued with each reconditioned engine, additional copies being obtainable on demand.

A motor boat engine maintenance log is being edited in order to assist in keeping a record of running hours, maintenance routines, and defects, etc., and as a carrier for the maintenance schedule.

In order to enable the Admiralty and administrative authorities to collate information, Form S1548—Internal combustion engine quarterly report, which is rendered by users to the administrative authority, and Form S1549—Internal combustion engine half-yearly report, which is a summary of the quarterly reports and is rendered by the administrative authorities to Admiralty, have been introduced. (A.F.O. 3887/47)

The Engineer Officer's Point of View

Well-organised maintenance routines, using the maintenance schedules as a guidance, supported where possible, by well-trained and enthusiastic stoker mechanics should lead to trouble free running in most cases. Where, however, serious trouble is experienced the Engineer Officer must decide on one of two courses.

Firstly, whether the defect is within the capacity of ship's staff or secondly, whether it should be handled by the overhaul depot.

On this particular point it is not desired to take the initiative away from the Engineer Officer but it is important that when any large scale stripping down is involved, a replacement engine should be obtained and the defective engine returned.

With respect to spare parts subject to standard over and under sizes it is important that these be returned with each engine, for it is highly probable that the replacement engine will be fitted with a crankshaft, or pistons, of different dimensions.

Such then is the organisation that is being built up. The motor boat engine overhaul scheme, however, is but the foundation of the scheme to cover all removable internal combustion engines in time of war.

Boat engines were selected as the building-up material because they alone can give an adequate flow in peace-time. To assist in this direction it is essential that all users should refrain from carrying out engine overhaul on board except in very exceptional circumstances.