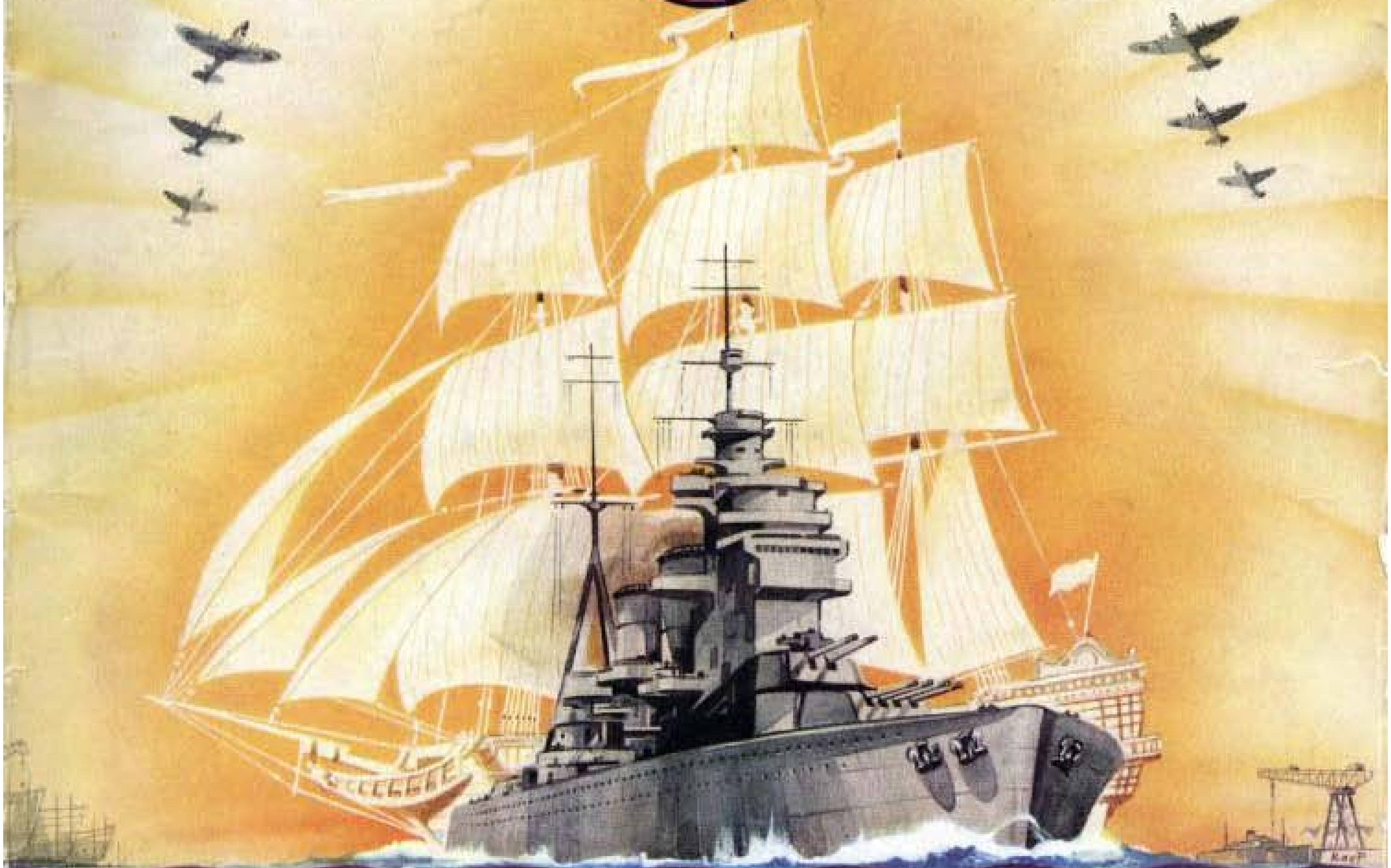
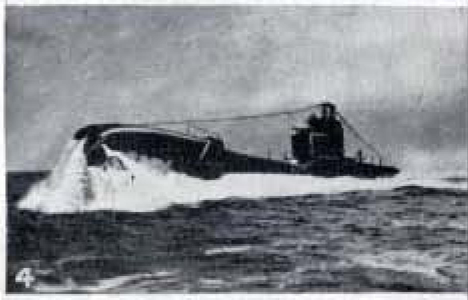
"The royal navy of England hath ever been its greatest defence and ornament"



ENGINEERING IN THE ROYAL NAVY

WARSHIPS OF H.M. NAVY



THESE ILLUSTRATIONS are typical of the many types of warships in which the machinery is run and maintained by personnel of the Engineering Branch

1 Ocean-going tug
2 Motor torpedo boat
3 Anti-submarine trawler
4 Submarine
5 Fleet destroyer
6 "Dido" class cruiser
7 "Tribal" class destroyer
8 Fast minelayer
9 "Fiji" class cruiser
10 "Nelson" class battleship
11 "King George V" class battleship
12 Escort aircraft carrier
13 "County" class cruiser
14 Fleet aircraft carrier

ENGINEERING IN THE ROYAL NAVY

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The ENGINEER-IN-CHIEF OF THE FLEET WRITES THE FOREWORD

IT IS with great pleasure that I accept the opportunity offered by the Editor of writing a foreword to this issue, since it gives me a chance to pay tribute in the technical Press to the work of the Engineering Branch of H.M. Navy.

The article which appears in this issue gives some idea of the training and duties of engineer officers and ratings who number about 25 per cent. of the whole of the man-power of the Navy. These men serve wherever the White Ensign flies, in ships varying in size from large battleships and aircraft carriers down to submarines, minesweepers, trawlers and the small craft of the Coastal and Amphibious Forces, in shore bases and establishments and on air stations operating naval aircraft.

Their work is not spectacular and is seldom referred to in the Press, but whenever one reads of a fleet action, the safe arrival of an important convoy, a landing on a hostile coast, or an air strike by naval aircraft, it can be accepted that the engineering personnel have played their part towards the success achieved.

Engineer Vice-Admiral Sir John Kingcome, K.C.B. M.I.Mech.E., M.I.Mar.E.

under sail may be said to have come to an end with the action of the "Arethusa" against the forts of Odessa in 1854.

For many years we clung to masts and yards but for all practical purposes the knell of the wooden ship and the sailing ship as engines of war was sounded in the Russian War. From that time some of the sailors began to be displaced by stokers and 50 years later engine-room complements accounted for a third of the men in the Navy. In 1900 there were some 970 engineer officers and 24,000 men employed; in 1910 1,460 officers and 37,000 men; during the 1914-18 war the Engineer-in-Chief had under him a body of officers and men exceeding 80,000. While it is not possible to give actual figures at this time it can be said that the number of officers and ratings employed in the Engineering Branch in this war is far greater than ever before.

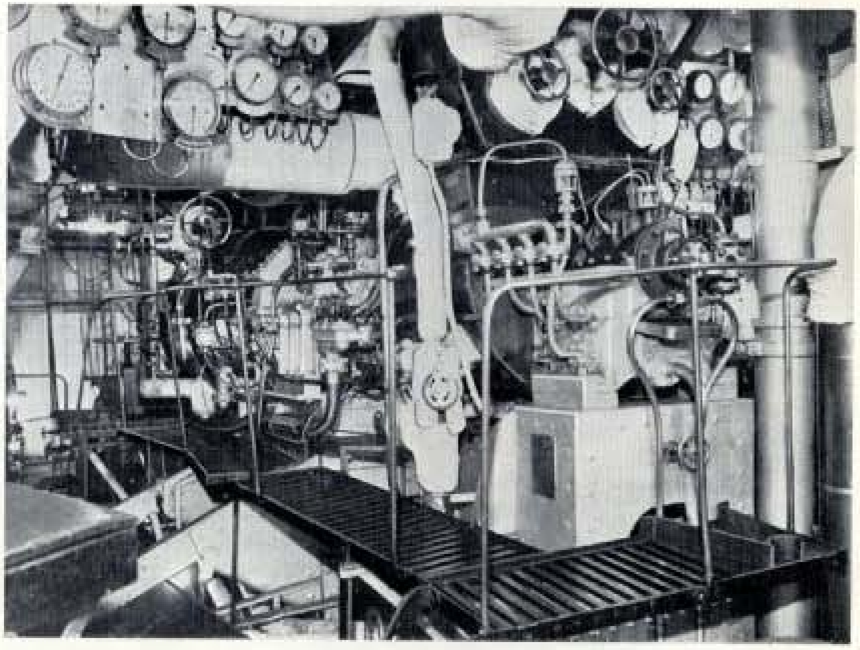


Fig. 2—The cruising and high pressure turbines in the aft engine room of the cruiser H.M.S. Sheffield.

The Engineer-in-Chief of the Fleet

How the department of the Engineer-in-Chief of the Fleet at the Admiralty came into existence has already been shown and a list has been made of the officers who have been at its head. The Engineer-in-Chief's staff comprises two groups of officers, those at the Admiralty and those serving as overseers in the various ship-building and engineering centres.

The design of new machinery, the preparation of specifications, the production, inspection and testing of main and auxiliary machinery driven by steam and oil, are all dealt with by these officers.

Similar work in connection with the armament of the Navy is carried out by engineer officers under the Director of Naval Ordnance and the Director of Torpedoes & Mining.

The engineering work done under the Director of Dockyards is only second in importance to that done under the Engineer-in-Chief. Just as the office of Engineer-in-Chief in 1887 was filled by a naval engineer, so the appointments in the Yards had gradually ceased to be held by civilians, the much esteemed John Dinnen being the first naval engineer to hold such a post of Engineer Manager. At each Yard will be found drawing and estimating offices, foundries, smitheries, boiler shops, fitting and machine shops, each Dockyard constituting an engineering concern comparable with the largest of industrial establishments. The principal duties of the engineer officers consist of directing the fitting of new machinery aboard ships, the repair of the machinery, including gunnery equipment of ships in commission, and the general over-sight of Yard machinery.

Naval Engineers and the Fleet

Having thus briefly reviewed the work of the Engineering Branch of the Navy at the Admiralty and in the Dockyards, we now turn to consider more fully first the history of the Branch and then its work in the Fleet.

When the naval engineer first made his appearance he was a mechanic straight from bench and forge. Millwrights, black-smiths and such all found their way into

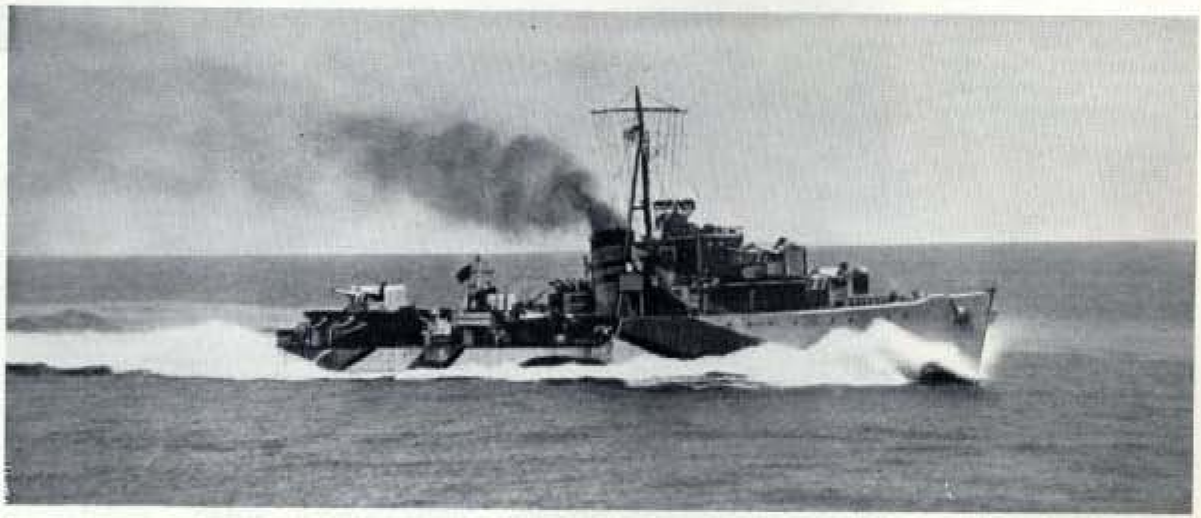


Fig. 3—A Fleet destroyer; one of the small ships which have done such great work in protecting our ships from submarine attack.

the early steamers. These pioneers matriculated in the same school as George Stephenson. From 1821 to 1837 they were just enginemen and came and went as they chose.

In 1837 things underwent a great change. The engineers were made Warrant Officers, First, Second and Third Class. Records began to be kept and a system of training inaugurated. In 1841 the engineers were granted a gold band on the cap, and steam engine buttons on the coat and collar. Next year, to stimulate them to higher things, the grant of a silver medal "For ability and good conduct" was inaugurated. In 1847 an Order in Council created the ranks of Inspector of Machinery, Chief Engineer, and Engineer First, Second and Third Class, ranking with the Masters and Assistant Masters. Chief Engineers were commissioned officers, had entrance to the ward-room and a year or two later appeared in the Navy List.

As might be expected the Crimean War led to a great development in the Engineering branch of the Navy. Of the new entrants, many were undesirable and soon disappeared. A shortage of likely men led Chief Engineer Murdoch in 1859 to tour the shops of Newcastle, Leith and Glasgow, his recruits being known as "Murdochites." In the "60's" the engineer boys became engineer students and some gained admission to the Royal School of Naval Architecture and Marine Engineering at South Kensington. Such well known men as Seaton, Sennett, Corner, Chilcott, Durston, Milton and Morcon were graduates of the School, the activities of which in 1873 were transferred to Greenwich College.

In 1868 the new class of Petty Officer Engine-Room Artificers had been established and in 1875 a Committee was set up to enquire into the best means of securing the higher mechanical skill and scientific knowledge for the Engineering Branch. Through the recommendations of the Committee, separate messes for engineers were abolished. H.M.S. Marlborough was allocated as a home for Engineer Students and plans for the R.N. Engineering College, Keyham, were laid down. In 1880 a training school for engineer students was constituted at Keyham College and in 1888 H.M.S. Marlborough paid off and all her students were transferred to the College. Since that date the R.N. Engineering College, Keyham has been in continuous use for training officers in engineering, with the exception of the years 1914-1919 when it was taken over for training special entry Cadets. The College is now being moved to a new site at Manadon, Plymouth, where extensive instructional buildings are already built. The syllabus covered at Keyham compares favourably with honours degree standards and officers who complete the course are exempted from all sections of the Institution of Mechanical Engineers examinations.

The Engineering Branch of the Navy to-day has a personnel greater than at any previous time in its history, its officers ranging in rank from Vice-Admiral to Warrant Engineer. These officers have come from many sources, some having passed through the R.N.E.C. Keyham, a large number of temporary officers having joined the R.N., R.N.R., and R.N.V.R. from civilian engineering, others are officers promoted from the ranks of the engine-room artificers, while there is a group of officers who have risen from the stokers mess deck through the grade of mechanician.

The horse-power of a modern battleship is in the region of 150,000, cruisers have engines of 80,000, while destroyers are of 50,000 h.p. Taking the combined fleets the total horse-power runs into several millions. The source of nearly all power in a ship lies in her boilers, but her machinery spaces contain not only boilers and main steam turbines with their associated pumps and steam and water systems, but also all the auxiliary machinery necessary for satisfactorily running and fighting.

It should be remembered that a modern warship is more self-contained than a big hotel. It has to generate and distribute all its own electrical power for operating machinery and guns and for lighting throughout the ship. It has to distil all water used for boilers and domestic purposes. In addition a great amount of refrigerating machinery is required to store provisions for large numbers of men, often in hot climates. The galleys and steam cooking arrangements, together with ventilation and heating of the living spaces also come under the engineers. Then too, there are the water-tight doors and arrangements for pumping, flooding and draining the multitude of water-tight compartments which have to be maintained in good order so that the ship can be maintained in a seaworthy condition in the event of damage.

The order of priorities for the functions of a warship is "to float, to move, to fight" in that no ship can fight effectively under modern conditions unless she maintains a reasonable manoeuverability. By virtue of their normal duties, the engineering personnel are concerned with pumping

Fig. 4—H.M.S. Implacable; one of the Fleet carriers which have reduced the dangers of air attack to the Navy.

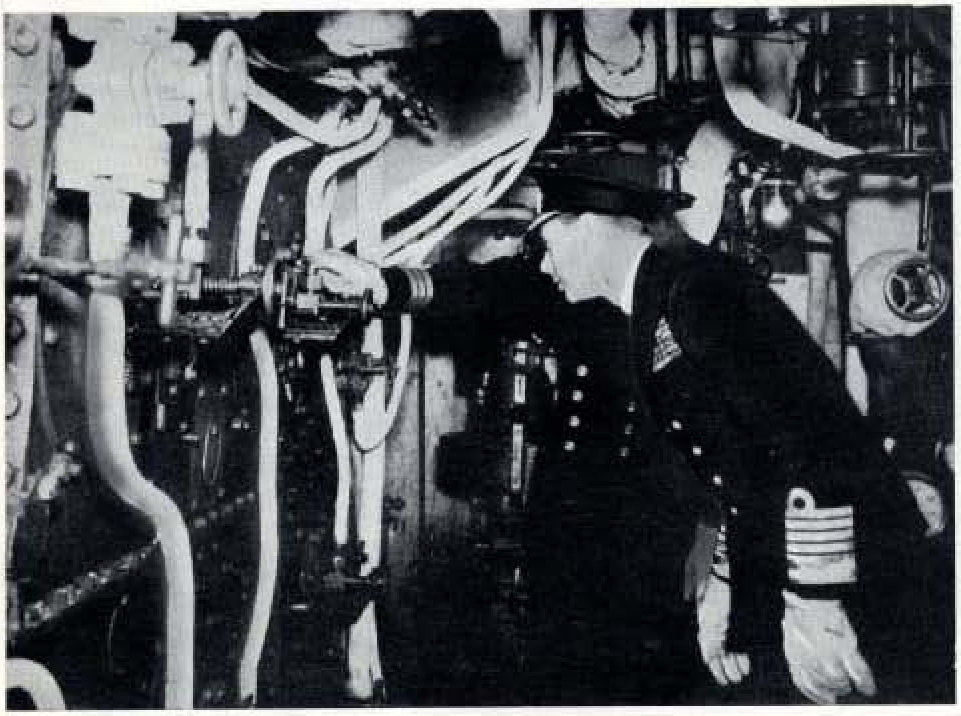


Fig. 5—The King looking into one of the oil-fired furnaces in a boiler room of H.M.S. Duke of York.

and counterflooding to maintain stability, and the maintenance and operation of fire fighting equipment. These are major factors in the control of damage which are essential to enable a damaged ship to play her part in battle or, as a last resource, to return to harbour.

The care and maintenance of the great mass of machinery in a warship calls for a large and competent staff. A battleship carries some eight or nine engineer officers, a cruiser four or five and the destroyers and submarines one each. There are about four times as many artificers and twenty times as many stokers. The engine room artificers are highly skilled as fitters and turners, boilermakers, coppersmiths and engine smiths and form the nucleus of the maintenance staff together with mechanicians promoted and trained from stokers, while every member of the stoker complement from chief stoker to the newly joined 2nd class stokers have their jobs to do both at sea and in harbour.

At sea, the staff of a ship is divided into three watches, each watch doing four hours duty in the machinery spaces out of every twelve. In addition, portions of the engine-room personnel are required to keep watches for damage control purposes, while all members of the ship's company are required for duty during periods of action and at dawn and dusk each day whilst at sea in dangerous waters. When in port there are periodical surveys and defects, large and small, have to be made good.

Now, with the increasing activities of our ships in the wide expanse of the Pacific, a further demand has been made on existing maintenance resources. This has brought into being numbers of large mobile repair ships manned partly by engineering branch personnel and partly by the new Naval Branch named Special Repair Ratings (Dockyard) recruited from trained tradesmen. These repair ships, forming part of the Fleet Train, are in addition to the submarine and destroyer repair ships which have long been a feature of repair facilities.

Engineer officers of high rank serve on the staff of Commanders-in-Chief and Flag Officers of Squadrons and Flotillas.

Maintenance of Naval Aircraft

During the war of 1914-1918 a very small force known as the Royal Naval Air Service, started before the war, was expanded into a large efficient corps to carry out the duties of what is now known as Coastal Command of the R.A.F. and engineer officers were attached to the R.N.A.S. for the prodection and maintenance of aircraft and air ships.

In 1917 the Royal Flying Corps and The Royal Naval Air Service were merged to form the Royal Air Force and nearly all the officers and men of the R.N.A.S. transferred to the R.A.F.

In 1924 the Fleet Air Arm was formed by the R.A.F. to operate aircraft which were ship-borne since by this time the Navy had developed a practical form of aircraft carrier. The Navy was given operational control of these ship-borne aircraft and many naval officers were attached to the F.A.A. as pilots and observers.

In 1937 the Navy was given further control of ship-borne aircraft which became an integral part of the Navy, who then became responsible for the administration of naval aircraft except as regards design and supply.

In 1939 some three months before war broke out, the transfer of control of naval aircraft to the Navy, in accordance with the 1937 agreement, was finally made. From this date the Navy has been responsible for the maintenance and repair of its own aircraft.

At the beginning of war the Navy owned only a few hundred aircraft of which about half were employed for training purposes. Now it has as many thousands of aircraft as prior to the war it had hundreds.

Permanent naval engineer officers who specialise in aviation not only have to possess the equivalent of an honours degree in Aeronautical Engineering but in addition learn to fly service aircraft, have a short period of operational flying and thereafter be responsible for the repair and maintenance of naval aircraft.

During the war the numbers of these officers have been augmented by the recruitment of a very large body of aeronautical engineers. The day to day servicing of aircraft is the responsibility of air mechanics and the repair is carried out by air artificers. For the purpose of maintenance and repair these ratings are divided into the trades of (A) airframes, (E) engines, (L) electrical, (O) ordnance.

The Navy is a world wide organisation and it is necessary therefore that the facilities for the operation, repair and maintenance of naval aircraft should be built up on a sound basis of world wide facilities so that ships carrying aircraft can operate speedily in all the oceans. At the present time many thousands of naval officers and men are employed on aircraft maintenance duties from the British Islands to the Pacific.

Probably few of the major forces of the armed services of the British Empire have expanded so rapidly from small beginnings as the air organisation of the Navy has done in this war. To-day it forms one of the main offensive weapons of the Fleet.

Having thus outlined the history, development and duties of the Engineering Branch we now proceed to deal in detail with many of its activities, from training to operational work on land, sea and in the air. In order to define the marine and aeronautical subjects we have grouped these into two main sections, the second section appearing under the title of "The Maintenance and Repair of Naval Aircraft." Further sub-divisions separate the many subjects covered in our story; a full list of these is given in the detailed index at the end.

The Technical Training of Stoker Ratings

Fig. 6—A battleship of the King George V class, one of the types of ships in which a stoker may be called upon to serve on completion of his training.

BEHIND the many told and untold deeds of gallantry and devotion to duty of "the men who go down to the sea in ships" lies another story which, if more prosaic, concerns the foundation stone of all that goes to build up and maintain the magnificent traditions of the Royal Navy. This is the story of training, and, although we are confining our subject matter to the engineering branches, the inside picture covers such a wide range and has so many aspects, that we must of necessity give but little more than a framework coverage, in the form of a cross section of some of the activities involved.

As our first section, it seems fitting that we should commence with the training of stokers, the men whose main duties keep them down out of the limelight, in the machinery spaces of a ship, although their work to-day is less arduous than that of many years ago (see Figs. 7 and 8).

To give a sort of background course before going to sea, the Admiralty has allocated two old battleships as a Stokers Training Establishment, these ships at present being situated off Plymouth, under the title of H.M.S. *Imperieuse*.

To digress for a moment, it is rather interesting to recall briefly the history of the four previous ships of the same name, as follows:—

Imperieuse (1) A 38-gun frigate captured from the French off Spezia on October 11th, 1793. Renamed "Unite" about 1803/4 and used as a convict ship in 1840.

Imperieuse (2) Another 38-gun frigate captured from the Spaniards on October 5th, 1804 and renamed. In action between 1807 and 1809 making many small captures and landings on the French coast. Was off Italian coast 1811-1813 and took part in landing operations at Anzio in October 1813.

Imperieuse (3) A 50-gun ship, designed as sail but completed as screw steamer. Launched Deptford 1852 and was in the Baltic 1854/5, Peiho in August 1859 and China 1862.

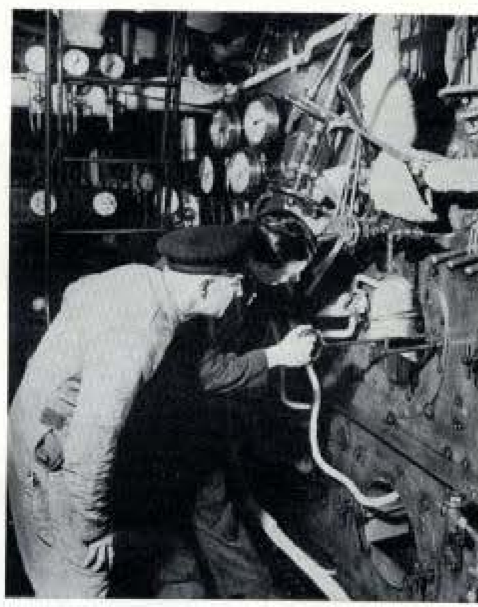


Fig. 7—The work in the boiler room of a modern warship is less arduous than in the earlier types; this view is taken on board H.M.S. Garth, a Hunt class destroyer, famous for its E-boat activities.

Imperieuse (4). Twin screw armoured cruiser, 8,400 tons, launched Portsmouth 1883; had four 9.2" and 6.6" guns, and would do $16\frac{3}{4}$ knots. Originally brig-rigged, but completed with single mast amidships.

Fig. 8 (Left)—In the days of the early coal-fired battleships, a stoker's work in the boiler room was an arduous job. Contrast this view with the one in Fig. 7.

Fig. 9—A new draft of stoker ratings arrive on board to commence their twelve weeks training course

Returning to our story of stoker training, we commence with details of—

The Daily Routine

After a new draft of stoker ratings has arrived on board as featured in Fig. 9, it settles down to a daily routine of which we give an abbreviated winter time table as follows:—

a.m.

6.00	Call the hands
6.30	Hands to breakfast and clean into the rig of day.
7.20	All Divisions fall in for P.T. (A view of a division stripped off for P.T. on the quarterdeck is given in Fig. 10.)
7.45	Finish P.T. Classes under instruction fall in on quarterdeck.
8.55	Divisions and Prayers.
10.00	Stand easy.
10.10	Out pipes (i.e. end of stand easy). Hands carry on with their work.
11.40	Classes under instruction muster on forecastle; cooks to the galley.
11.50	Secure (i.e. dismiss).
12.00	Dinner.
p.m.	
1.15	Hands fall in.
2.30	Stand easy.
2.40	Out pipes; hands carry on with their work.
3.50	Secure.
4.00	Cooks to the galley.
4.10	Tea. Liberty men to clean. Shift change into evening rig.
4.30	Liberty men fall in (a view of men embarking on the liberty boat is given in Fig. 18; these boats also leave at 5.30 p.m. and 6.45 p.m.).
5.00	Evening Quarters.
6.30	Supper
8.00	Stand by hammocks.
8.45	First post.
9.00	Last post.
10.00	Pipe down.

All stokers under training have one organised afternoon's recreation per week when they land from 1.30 till 3.30 p.m. for games, swimming or route march.

THE SYLLABUS OF INSTRUCTION

The syllabus of instruction as now laid down for Stokers 2nd Class (who must be $17\frac{1}{2}$ years old), calls for a twelve weeks course, the first four of which are employed generally in getting used to the layout of the ships and during this time the routine duties are such as carried out by seamen in normal warships.

The Fifth and Sixth Weeks

—of the syllabus commence with the ratings being grouped into classes, after which an introductory lecture is given by the Engineer Officer A very comprehensive Machinery Handbook is then issued which contains a wealth of information and illustrations on the design, function and operation of all types of ship's machinery; it includes a chapter on ferrous and non-ferrous metals, their uses in a ship, also tables of carbon steels and copper zinc alloys. This is issued free of charge to each rating, together with a Stokers' Lecture Book giving details for the course.

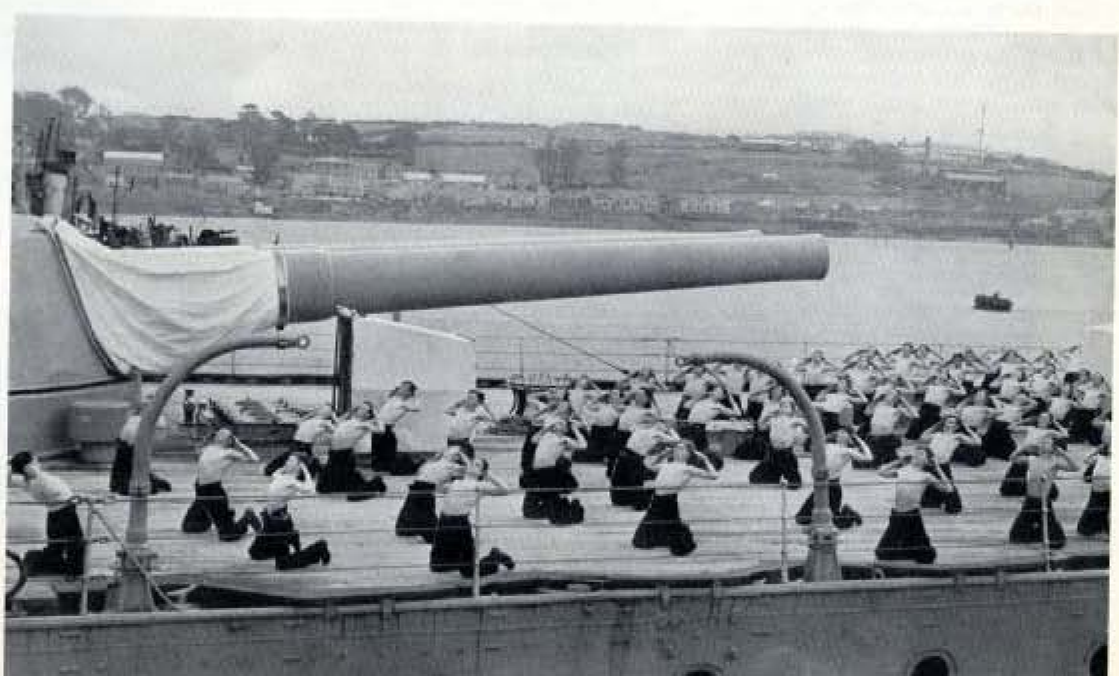


Fig. 10 — Physical training is carried out daily as part of the syllabus of the Training Course on H.M.S. Imperieuse. This view shows a Division stripped off for P.T. on the quarterdeck.

The classroom lectures for the period deal with the following subjects:—

The most usual types of boilers met with in the Service, i.e. the cylindrical return tube, the Babcock & Wilcox, Yarrow and Admiralty 3-drum water tube boilers, their differences, together with advantages and disadvantages.

Boiler mountings are described and their uses demonstrated by means of models. The theory of combustion of fuel is coupled with the methods of stoking and raising of steam, the fire irons and their uses, how fires are cleaned in a water tube boiler, etc.

The maintenance of boilers is an important subject and includes the methods to be adopted to prevent internal corrosion when not in use.

Furnace details, boiler and funnel casings uptakes (i.e. casings between funnel and boiler) and funnel guys also form the subject of lectures during the fifth week.

Fig. 11—This, of course, is an old hand at the job and not a stoker under training, nevertheless cleaning the inside of the funnel is all part of a stoker's routine work.

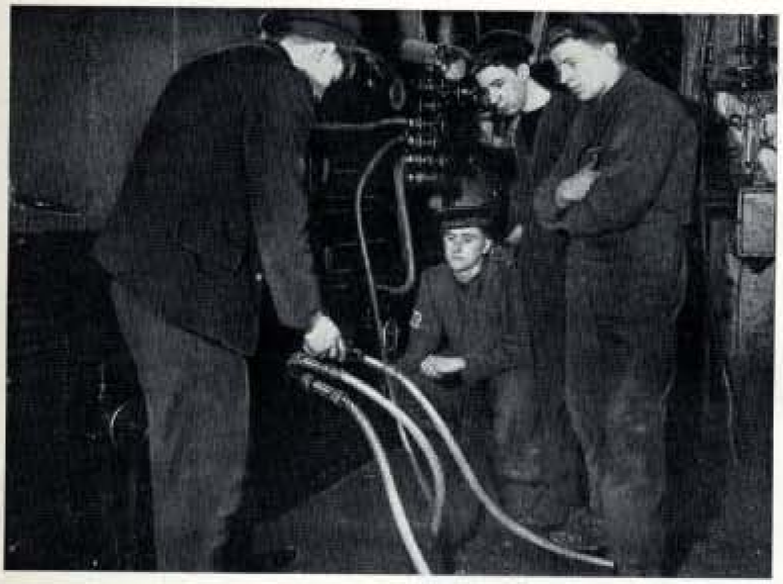


Fig. 12—Receiving instruction in the method of flashing up an oil-fired boiler from cold, using a U-tube.

At least one day of the week is spent on practical instruction on the subjects previously covered in the classroom, thus linking theory and practice. Boilers are cleaned internally and externally (see Fig. 11) and the ratings have the job of cleaning up the room, after being impressed with the necessity of cleanliness in this part of the ship.

The Seventh Week

—of the syllabus covers the following classroom subjects:—

The purity of boiler feed water and the necessity of using only pure distilled water for this purpose to avoid scale-forming substances also solids in solution which will cause a rise of density; the apparatus used for testing feed water.

The exclusion of air in feed water, to prevent corrosion, by pumping up with de-aerated water.

The necessity of using feed heaters whereby a great saving of fuel is effected by using the latent heat in the exhaust steam.

Automatic feed regulators and boiler superheaters.

The storage of oil fuel, its course from the tank to sprayer and the sprayer details (with models).

Raising steam from cold in oil fuel boilers, using the "U" tube and hand pump; the burning of oil fuel, with smoke making and prevention—its causes and remedies.

The cleaning of oil fuel filters and the testing of a gauge glass are also included.

During this week, the classroom lectures are followed up by practical instruction on the same subjects in the boiler room. Boilers are connected up and blown down, tests are made on a gauge glass and boiler water is tested for density; the oil fuel system is demonstrated and filters cleaned and ratings have to light up a boiler from cold using a U-tube.

The method of flashing up from cold when no steam is available is illustrated in Fig. 12 and the line drawing Fig. 13. One of the normal oil fuel sprayers is removed from the boiler and a special lighting up sprayer of small output is fitted in its place. Oily waste is packed round the U-tube which is then placed through one of the air doors into the combustion tube (or

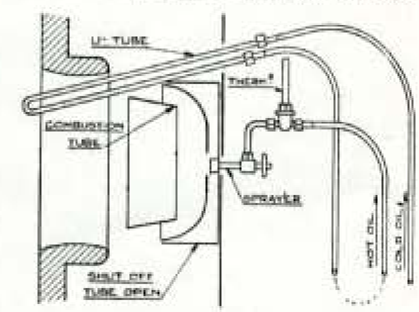


Fig. 13—Shows how a U-tube is used for lighting-up.

above it if the boiler has a closed front as in the line drawing).

As will be seen, one flexible hose from the U-tube connects with the sprayer, whilst the other is connected to the control valve box through which the cold oil fuel is provided by means of a hand operated pump. The oily waste, together with a further supply in the combustion tube, is ignited, and in this way the fuel is heated to between 170 and 210 degrees Fah., according to the type of oil used, on its way to the sprayer in the front of the boiler. As soon as the sprayer is flashed up, the temperature is controlled by adjusting the amount of U-tube exposed to the cone of flame produced from the sprayer.

When sufficient steam pressure has been raised, the oil fuel heater can be used, and the steam oil fuel pump started; the U-tube and lighting-up sprayer are then disconnected and the normal sprayer and its pipe replaced. While this is being done, another sprayer can be used.

A general view in a typical oil-fired boiler room of a cruiser (H.M.S. *Sheffield*) is given in Fig. 14.

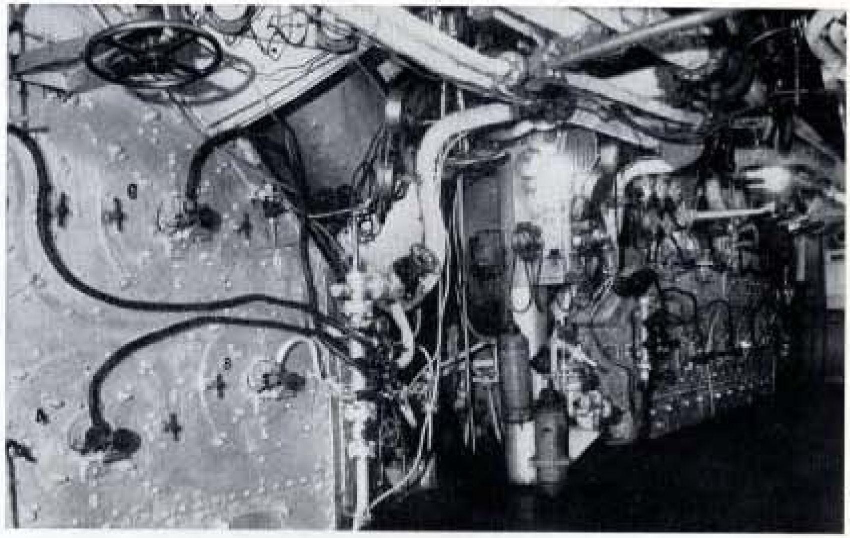
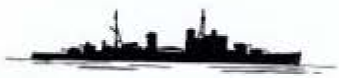


Fig. 14—This general view, taken on board the cruiser H.M.S. Sheffield, shows a typical oil-fired boiler room.



The Eighth and Ninth Weeks

—of classroom instruction are partly devoted to brief descriptions of the action and uses of some of the auxiliary machinery generally fitted in turbine driven warships. This covers boiler room auxiliaries such as feed pumps for supplying water to the boilers, forced draught fan engines for providing the air for the combustion of the fuel in the boiler furnace and oil fuel pumps for supplying the fuel to the sprayers.

The engine room auxiliaries dealt with include the air pumps and extraction pumps for removing the condensate and air from the condensers, main circulating pumps for circulating sea water through the main condensers, also supplying cooling water for lubricating oil and drain coolers, and forced lubrication pumps for the bearings of the main engines.

Other subjects in the weeks' syllabus include the evaporator for providing distilled water for the boiler feed and for domestic use, the condensers for condensing the exhaust steam to maintain the supply of feed water, and the various dynamo engines, which, in a battleship may be up to eight in number. In addition, forced and drip lubrication is explained as well as the different lubricating oils.

The practical boiler and engine room instruction follows closely on the classroom work; the turbine drainage system for preventing water from accumulating in the turbines is explained together with the gear used for turning a reciprocating engine to the starting position.

Fig. 15—A view in the Centre Engine Room of one of the ships, looking between the main low pressure turbines. In the foreground a rating is logging a gauge reading, whilst in the rear the Chief Stoker is taking a silver nitrate test of feed water.

A view in the centre of an engine room is given in Fig. 15 and is taken from a point looking between the main low pressure turbines. The rating in the foreground is logging a gauge reading, whilst in the rear, the Chief Stoker is taking a silver nitrate test of feed water.

This test is to detect any salt in the feed water and is carried out by allowing one or two drops of silver nitrate to drop into a sample of water held in a test tube; i salt is present a milky looking cloud will appear. On testing water from boilers or reserve feed tanks, where lime may be present, a few drops of nitric acid are added first to prevent the formation of a cloud due to the lime.

The work of the eighth and ninth weeks includes the cleaning of the evaporator, the engine room, the engine room bilges, also other maintenance work.

The Tenth Week

—of the training syllabus covers the following classroom subjects:—

A description of some of the various types of reciprocating engines and steam turbines, the latter including the Parson's reaction type and the Brown Curtis multistage impulse type. A Machinery Demonstration Room is fitted up where various equipment of this kind, both in actual and model form, can be better explained and demonstrated. The view Fig. 16 features part of this room and shows small compound reciprocating engines, whilst on the wall are various types of thermometers and pressure and vacuum type gauges. In the left hand corner, part of a drain cooler can be seen; the opposite side of the room is devoted mainly to reaction and impulse turbine models.

The starting of main and auxiliary machinery is dealt with, as well as the

Fig. 16—Small compound reciprocating engines together with various types of thermometers, pressure and vacuum gauges in the Machinery Demonstration Room.

question of bearing and lubricating oil temperatures and the ratings have to acquire a knowledge of some of the tools and materials of the engineering department, and their uses.

Visual aid working models, made from plywood by the ships staff, are used to assist in explaining the operation of various components; those we have photographed in Fig. 17 show, from left to right, the closed feed controller, the boiler automatic feed regulator and the oil relay dynamo governor gear.

Practical instruction takes the ratings into the engine room, where they follow the layout of steam, water, lubrication, closed exhaust and other systems; warm through and start up the auxiliary engines and on the main engines check up bearings and lubrication, operate the turr ing gear, drains and valves. Maintenance work including the cleaning of engine room and bilges, also forms part of the week's work.

The Eleventh and Twelfth Weeks —in the classroom mainly deal with the various precautionary methods to be adopted on board ship. For instance there are many parts of a ship in which there is little or no ventilation and the bottled up air becomes foul or stagnant and, under certain conditions, explosive. These comprise double bottom compartments, bunkers, boilers, condensers, distillers, evaporators, wing spaces, store rooms, main and reserve feed tanks, oil tanks and petrol compartments.

The methods of testing for foul and explosive gases are explained including the construction of the safety lamp and its uses.

A brief outline is given of the equipment for pumping, flooding, draining and oiling ship, also the methods of cleaning oil fuel tanks, watertight compartments, feed and fresh water tanks. The necessity for maintaining the plating surfaces in a clean condition to avoid corrosion is stressed. The arrangement of watertight sub-divisions of the ship is dealt with including watertight doors, hatches and scuttles.

For the practical work of this section, the ratings are given a tour of instruction in the ship, where, in the different departments they put into practice the classroom subjects.

Damage Control

A fighting ship expects to suffer damage in the normal course of events at sea in wartime and therefore has an organisation covering the broad aspects of self-defence in every portion. This organisation is known as damage control.

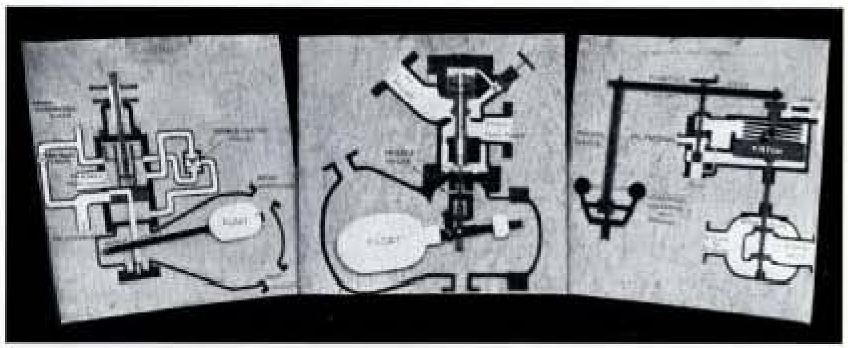


Fig. 17—Visual aid working models made by the ship's staff from plywood, assist in explaining the operation of various components; left to right—the closed feed controller, the boiler automatic feed regulator, and the oil relay dynamo governor gear.

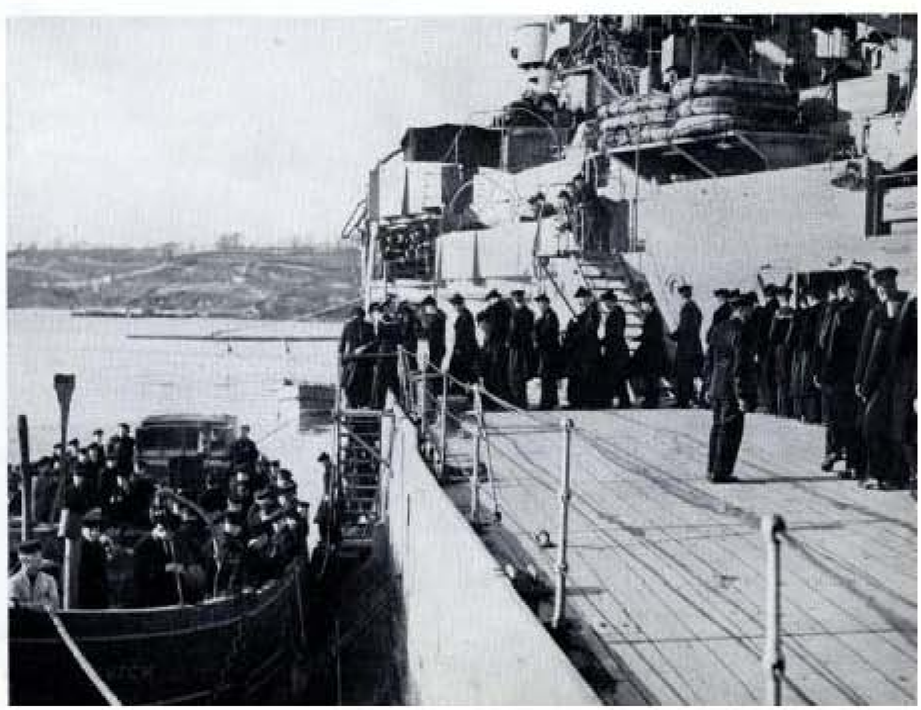


Fig. 18 (Right)—Liberty men going ashore on the 4.30 p.m. liberty boat.

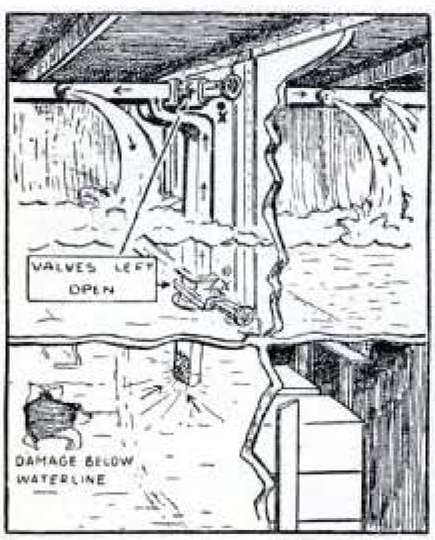


Fig. 19—Open ventilation valves can spread flooding.

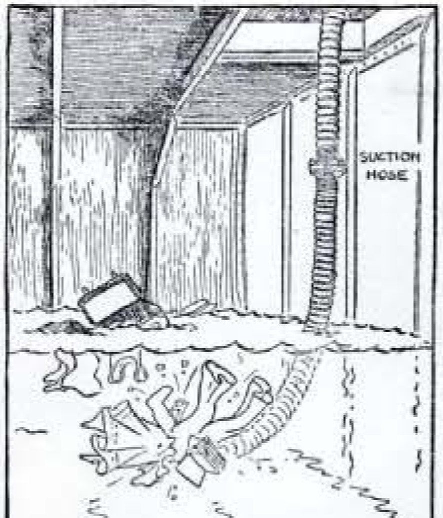


Fig. 20—Personal gear left about chokes suction hose.

The damage which a ship can receive is very varied and complex, the main types being flooding, fire, damage to machinery and equipment and damage to personnel. The objects of ship safety are to reduce the effects so that she can continue to fight with the utmost vigour in spite of any damage; if, however, one individual fails in carrying out a ship's safety rules, the result may be disastrous.

All ratings throughout their twelve weeks course receive a grounding in the methods of combating damage and each is given a little booklet on the subject entitled "Ship Safety". Two illustrations from this booklet are reproduced herewith; the first, Fig. 19, shows how the effects of flooding can spread through neglect in carrying out watertight discipline by leaving ventilation valves open, the second, Fig. 20, illustrates how suction hose can be choked by personal gear, either left about instead of in lockers, or throuth the opening of badly secured locker doors following an explosion.

Fire is one of the most common and one of the most dangerous forms of damage which a ship sustains, because of the amount of inflammable material carried such as petrol, oil, paint, explosives, cleaning gear, bedding, etc. In view of this, everyone in a ship's company must be

a potential fire-fighter and the principal rules of extinction cover two methods, "cooling down"—where water sprays cool the surfaces of burning matter, bulkheads, etc., below the point of combustion, and the fire goes out, and "smothering"—where an agent is used to blot out the oxygen so that the fire cannot burn.

The illustration Fig. 21 shows a squad of stoker ratings staging a fire fighting demonstration, although, for the purpose of the photograph, they are not wearing their anti-flash gear, which is always worn during battle to protect those parts of the body not covered by clothing, that is the head, neck, hands and wrists.

Commencing with the equipment in the centre of the picture we have the Damage Control Officer standing by a diesel portable pump which will draw water from the sea at the rate of 70 tons per hour and deliver it to the branch pipes held by the two centre ratings wearing "fearnought" suits, smoke helmets and anti-flash gloves.

The left branch is known as a "Fyrex" and by turning the head to the left will produce (*a*) a jet 30 ft. long at 25/30 lb. per sq. inch (*b*) a spray which gets wider the further the head is turned until it assumes (*c*) a solid wall of water. The "Oilfire" branch (right) gives the water a whirling motion as it leaves the nozzle producing a spray which can be used on oil fires, as the name suggests. If the spray is directed so as to cover gradually the area of burning oil, an emulsion is formed which effectively smothers the fire.

The ratings stationed by the two scuttles (commonly called "port holes" by those not acquainted with ship's terms) are ensuring that the breathing pipes from the smoke helmets can only take in fresh air; each also holds a "life-line" attached to the fire fighters' waists.

The machine to the left of the picture is a foam generator for big oil fires and holds 20 gallons of special compound which, mixed with either fresh or sea water, produces 680 to 900 gallons of foam per minute at 35 lb. per sq. inch pressure; this foam is light, non-injurious and non-corrosive and is effective for 36 to 48 hours after discharge, and has the great advantage that it can be poured into compartments which cannot be entered due to heat and smoke.

The machine in the right foreground of the illustration is a portable Drysdale Snorer salvage pump which is used to reduce flooding by pumping water back into the sea, through a fitting in the scuttles which is blanked off when not required, at a rate of 70 tons per hour. The electric starter for the pump stands on the floor in the centre foreground.

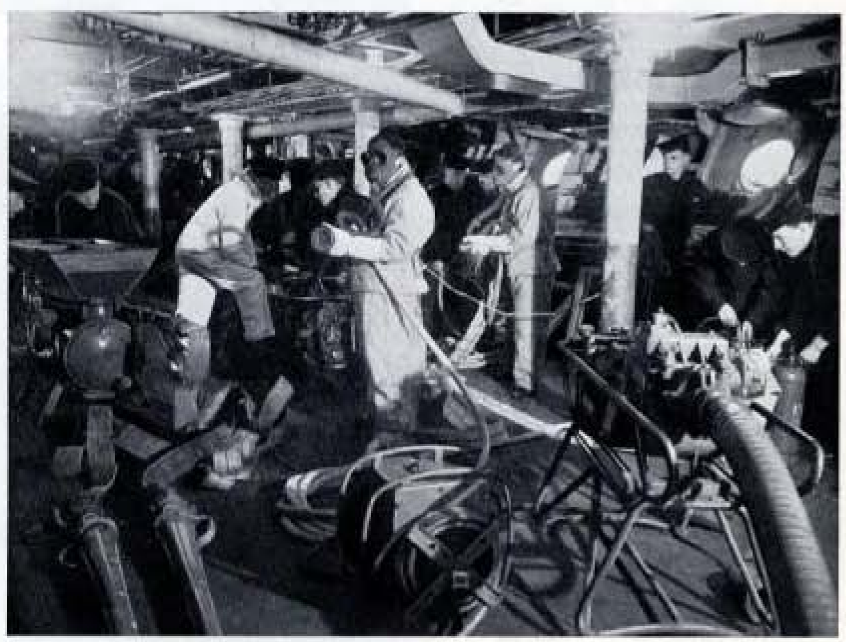


Fig. 21—All ratings take a course in Damage Control; here is a fire fighting demonstration with water and foam equipment (for the purpose of the photograph the ratings are not wearing the usual anti-flash gear).

THE TECHNICAL TRAINING OF STOKER RATINGS

The two ratings on the right are "standing by" with two-gallon Nu-Swift and Foamite generators. The jet from the former is used for small fires of wood, fibre, rope and bedding, etc., whilst the spray is directed against incendiary bombs and oil fires. The Foamite is principally used for small oil fires or any fire except where electrical apparatus is concerned.

Instructional Films
—form a regular feature of training and are of considerable assistance in "putting over" the actual procedure to be adopted in carrying out certain jobs. For instance, there is one called "Ship Safety" which deals with many aspects of damage control; others are entitled "Boiler Cleaning", "Lubrication," etc. and a film called "Meet the Ship" is shown at the commencement of the instructional period.

The Information Room
—is another very important feature on board H.M.S. *Imperieuse* and in which every facility is provided for stokers under training to broaden their general and technical knowledge, and study various aspects of naval and land wartare. This is located in what was the Ward Room and is used by 150 to 200 ratings each day, including watchkeepers when off duty, the normal times being from 12.15 to 1.15 p.m. and 5.15 to 9.0 p.m.

The room is divided into sections comprising the Western, Eastern and Far Eastern war fronts, the home front and Empire section and a local section, the latter covering entertainments and activities ashore from symphony to Ensa concerts, cinemas and theatres, etc.

A view of one part of the room is reproduced in Fig. 22, the far wall being devoted to a summary of the daily wireless bulletins as affecting the theatres of war, the place names being linked up from the bulletin boards by red tapes to their geographical situation on the large map.

Fig. 22—A view in the Information Room where every facility is provided for stokers under training to broaden their general and technical knowledge, and study various aspects of naval and land warfare.

Fig. 23—A Handicraft Section for woodworking and cartooning encourages ratings to develop an interesting hobby during off-duty hours; a good selection of tools is covered by an Admiralty grant.

The books on the table (and they are arranged like this after each "sitting") are displayed in groups such as Army, R.A.F., Navy, biography, Empire, aspects of British life, national and international affairs and post war planning. To show the freedom of thought encouraged we made a note of the following books as representative of the general display, "British Trade Unions," "Liberty versus Equality," "What

Fig. 24 (Left)—A corner of the Information Room devoted to photographs and displays concerning the Pacific theatre of war; the subject matter is changed every fortnight.

Fig. 25—A Dutch division of stoker ratings under instruction marches off after Sunday morning divisions.

about India," "Agenda for a Post War World," and "The Means to full Employment."

A view of a section featuring the Pacific theatre of war is given in Fig. 24. The photograph display stands are changed every fortnight and comprise up-to-date views of war operations in all spheres, not merely from the naval aspect but rather a preponderance of Army and R.A.F.

As all ratings are lectured for one hour a week on adult education and current affairs (usually Saturday morning), this Information Room affords an excellent way of following up such instruction by means of the periodicals, books, maps and photographs, etc. Visiting lecturers have included a Reader of Law from Birmingham University, B.B.C. officials on discussion groups, members of social and health services, etc. During our stay aboard, a Dutch naval officer lectured on the war in the Far East. Three evenings a week are also arranged for voluntary educational classes.

The maintenance of the room is made possible by utilising the rebate allowed on N.A.A.F.I. (Canteen) purchases, the modifications and setting out of the displays are, however, all carried out by the stokers themselves.

A Handicrafts Section

—for woodworking and cartooning encourages ratings to develop an interesting hobby during off-duty hours. The men work under the instruction of a rating who has served his time as a joiner in civil life, the good selection of tools provided being covered by an Admiralty grant.

The articles produced include stools, trays, lamp standards, photo frames, dolls' houses, toys, etc., an illustration of a typical selection being featured in Fig. 23. Many items are made from odd wood from stores packing cases, etc., such as the bottom of the castle held in the rating's hand on which we can read "selected compressed cooked corn beef." A small fee, with a maximum of 5s. per article, is charged, to enable a stock of good wood to be maintained; a small model boat for instance would cost about 1s. 6d.

The Entertainment Side

—is not neglected and frequent concerts are arranged through the generosity of visiting artistes who give their services free. We had the opportunity of being present at one of these given by the Plymouth City Police Male Voice Choir, 35 strong, in the starboard battery.

Their rendering of the Lost Chord, The Holy City, Fishermen of England, and many other well-known favourites, was received with enthusiastic applause, as were the variety turns by the other artistes.

On the following occasion the B.B.C. arranged for a Brains Trust to be held on board comprising Dr. C. E. M. Joad, Mr. Quintin Hogg, Miss Barbara Ward, and Mr. Donald McCullough.

For our last illustrations we feature a Dutch Royal Naval section of stokers under instruction marching off after Divisions in Fig. 25 and in Fig. 26 we see a kit muster for Captain's inspection.

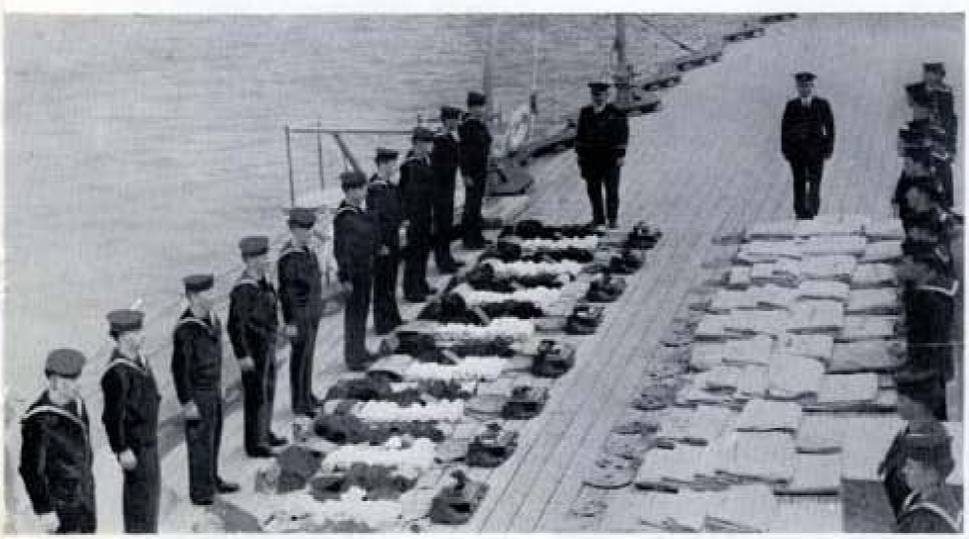


Fig. 26—The stoker ratings muster their kit on the quarterdeck of H.M.S. Imperieuse ready for the Captain's inspection.

This brings us to the end of our story of the technical training of stokers, with the draft leaving the ship during their twelfth week on board, the first part of which has been given over to general revision of instruction.

As a fitting conclusion to this section we quote an extract from Lord Jellicoe's despatches after the Battle of Jutland, May 1916.

"It must never be forgotten that the prelude to action is the work of the Engine Room Department and that, during action, the officers and men of that Department perform their most important duties without the incentive which knowledge of the course of the action gives to those on deck. The qualities of discipline and endurance are taxed to the utmost under these conditions and they were, as always, most fully maintained throughout the operations under review. Many ships attained speeds that had never before been reached, thus showing very clearly their high state of steaming efficiency. Failures in material were conspicuous by their absence and many instances are recorded of magnificent work on the part of the Engine Room Departments of injured ships."

STOKER RATINGS WHO SHOW EXCEPTIONAL ABILITY MAY BE PROMOTED DIRECT TO COMMISSIONED RANK AS SHOWN BELOW

STOKER II .. .. .. (*12 months*)	17½ Exceptional ratings may be rated at 9 months. Must serve 12 months as Stoker II.
STOKER I .. .. .. (*2 years*)	Must be under 18½ years of age.
LEADING STOKERS COURSE (*3 months*)	Duration 3 months. May be taken 2 years from the date of being rated Stoker I.
PROVISIONAL MECHANICIAN CANDIDATE (*1 year*)	Must have attained necessary standard on completion of Leading Stoker's Course. Drafted to sea as Acting S.P.O.
MECHANICIAN CANDIDATE (*2 years*)	Must serve 1 year at sea as Acting Stoker Petty Officer (above). Commences Professional Course lasting 2 years.
MECHANICIAN II .. .. (*18 months*)	Must pass successful Professional and Educational Exams. at conclusion of above course.
ACTING SUB-LIEUT. (E) ..	Specially selected 18 months after conclusion of Mechanician's Course. Maximum age 28½ years. Courses at Greenwich lasting 12 months and confirmed as Sub-Lieut. (E) and sent to sea.
LIEUTENANT (E) .. .. (*8 years*)	Must have served 16 months as Sub-Lieut. (E) and have obtained Engine Room Watchkeeping Certificate.
LIEUT. COMMANDER (E) ..	Must have served 8 years as Lieutenant (E).
COMMANDER (E)	Selected from Lieutenant-Commanders (E).
CAPTAIN (E)	Selected from Commanders (E).

THE NORMAL AVENUE OF ADVANCEMENT OPEN TO STOKER RATINGS

ABBREVIATIONS

M.T.E.—Mechanical Training Establishment.
S.P.O.—Stoker Petty Officer.
Roman Figures—Class.
Ldg. Sto.—Leading Stoker.

STOKER II — Must be 17½ years old.

STOKER I — Must serve one year as Stoker II. Must be 18½ years of age. Exceptional ratings may be rated earlier.

LEADING STOKER — Must serve 2 years as Stoker I. Must possess an Auxiliary Watchkeeping Certificate. Must pass a preliminary educational examination. Must pass a successful examination at the end of a 3 months Training Course at M.T.E.

S.P.O.
Must have qualified for S.P.O. at conclusion of Ldg. Sto's. Course at M.T.E. Must have served 2 years as Leading Stoker.

CHIEF STOKER
Must pass an examination. Candidates for exam. must have served 2 years as S.P.O. and possess a Boiler Room Certificate.

MECHANICIAN CANDIDATE
Must be under 29½ years of age. Must obtain necessary standard of marks at conclusion of Leading Stoker's Course at M.T.E. Sent to sea for 1 year as Acting S.P.O.

MECHANICIAN 2nd CLASS
Must pass a successful examination at the conclusion of a 2 years Professional Course at M.T.E. Must be under 32 years of age.

MECHANICIAN 1st CLASS
Must have served 18 months as Mechn II. Exceptional ratings may be advanced from 6 to 12 months after being rated Mechn. II. Must pass a professional examination.

WARRANT MECHANICIAN
Must pass professional and educational examinations. Candidates to have served 2 years as Mechn I and II. Professional Examination is competitive.

CHIEF MECHANICIAN
Must have served 6 years as Mechanician I and II.

LIEUTENANT (E)
Promoted by selection. Must be under 35 years of age.

LIEUTENANT COMMANDER (E)
Promoted after 8 years service as Lieutenant (E). Half time as Wt. Mechn. to count.

COMMANDER (E)
Promoted by selection from Lieutenant Commander (E).

COMMISSIONED MECHANICIAN
Must have served from 8 to 12 years as Warrant Mechanician

LIEUTENANT (E)
Promoted by selection after 5 years as Comd. Mechn. Must be under 49 years of age.

THE TRAINING OF NAVAL ARTIFICERS

Following the subject of stoker training in our first section, the story now broadens out into the wider field of training Naval Artificer Apprentices and, as an introduction, we propose to give a brief outline of the methods of entry, the instruction curriculum and the opportunities of advancement to officer rank.

The Methods of Entry

In peacetime, there are two methods of entry as an Artificer in the Royal Navy. The first is to commence as an Artificer Apprentice, and this constitutes the greater proportion of the total entry; the second method is to join direct as a 5th or Acting 4th Class Artificer, this being determined by age after serving a recognised apprenticeship in an outside engineering firm. It is with the Apprentice entry that this section is concerned.

Naval Apprentices must be British subjects and are entered between the ages of 15 and 16 years by examinations held twice yearly, one in the Spring, in open competition conducted by the Civil Service Commissioners, and the other in the Autumn by an Admiralty examination on the recommendation of Education and other authorities. A number of these boys have previously passed the School Certificate examination.

Prior to joining the Service the boys are allowed to choose the branch they prefer, that is, Engine Room, Air, Electrical or Ordnance and the successful candidates, if medically fit, join either at Rosyth or Torpoint, with the exception of Air Apprentices who join at Lee-on-Solent for kitting up and three weeks training and then move on to one or other of the establishments mentioned.

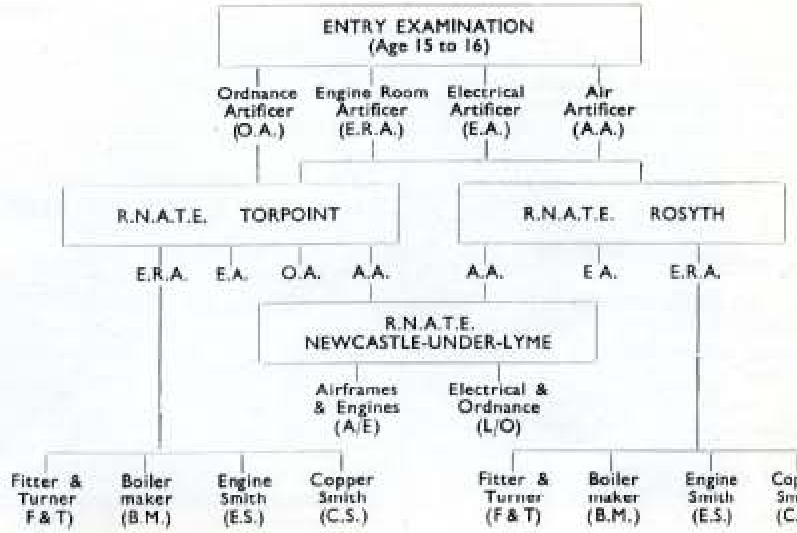
The R.N. Artificer Training Establishments

The three R.N.A.T.E.s are situated at Torpoint, Cornwall, at Rosyth, Fife, and at Newcastle-under-Lyme, Staffordshire.

Torpoint and Rosyth are sister establishments, the training being identical throughout. One small difference is that all the O.A. Apprentices are trained at Torpoint. Apart from this, E.R.A., E.A. and A.A. apprentices are split between the two establishments. This fact should be borne in mind as the reader follows the training at Rosyth which is shown in detail in the following pages.

The establishment at Newcastle-under-Lyme takes all the A.A. apprentices after the completion of their first year's basic training at Torpoint and Rosyth. Here the apprentices are given the specialised trade and technical training required to fit them to become Air Artificers.

The diagram above shows the distribution of apprentices of the various branches and trades throughout the R.N.A.T.E.s.



The Instruction Curriculum

At present the course for Artificer Apprentices i.e., E.R.A. (Engine Room Artificers) E.A. (Electrical Artificers) or O.A. (Ordnance Artificers) lasts four years, divided into eight terms of 6 months, with leave periods of 2 weeks at Easter and Christmas and 3 weeks in August. If successful in their final examination, they then go to sea as Artificers 5th Class and complete their training in sea-going ships in 6 to 12 months. When passed as competent they are rated Acting Artificers 4th Class with the status of petty officer and can then advance progressively to 1st Class Artificer.

The majority of E.R.A.s eventually pass the examination for Chief E.R.A. and become rated as such after a few years when they have obtained a certificate stating they are in all respects capable of taking charge of the engines of a small ship. Similar advancements to Chief Electrical Artificer and Chief Ordnance Artificer are available for E.A.s and O.A.s.

All the apprentices at the Training Establishments do similar work for the first 4 months, learning to drill holes and to chip, file and scrape at the bench. At the end of this period they are allocated to their different trades after carrying out a practical test. The full list of trades is as follows:—

E.R.A. Fitter and Turner, Boilermaker, Enginesmith or Coppersmith (marine engineering).

E.A. Fitter and Turner (electrical engineering).

O.A. Fitter and Turner (ordnance).

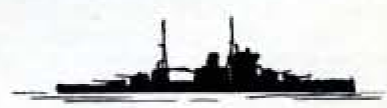
For the next year all the Fitters and Turners continue to improve their skill at the bench, whilst the Boilermakers, Enginesmiths and Coppersmiths learn their trades.

After 18 months the Fitters and Turners change from bench to lathe instruction and all apprentices have short periods in trades other than their own so that when their training is completed they will be capable of tackling simple jobs of any trade. Progressive trade tests are carried out at the end of each 6 month term and apprentices must obtain the required passing standard before going on to further instruction.

For the third year, the Fitters and Turners lathe instruction is supplemented by work on other machines, such as milling, boring and grinding, etc., whilst the outside trades (i.e. B.M., E.S. and C.S.) are mainly engaged on welding practice. During this year all apprentices receive instruction in internal combustion engines and practical electricity. In addition, Coppersmiths do some pattern-making and foundry work.

Fitters and Turners in their fourth year go back to the bench for a period and all apprentices spend a few weeks working aboard ships undergoing refit and repair in the Dockyard; this gives them an insight into conditions afloat.

Towards the end of their time each apprentice has to take the Admiralty passing out test job which decides his final position as a competent craftsman.



Opportunities of Advancement to Rank of Officer

Cadet (E) A limited number of D Class Artificer Apprentices who have distinguished themselves in work and recreation and are likely to make good officers are selected each half year for entrance to the Royal Naval Engineering College, Keyham as Cadet (E) (See the following section entitled "The Training of Engineer and Air Engineer Officers").

THE TRAINING OF NAVAL ARTIFICERS

Fig. 27.—The new entry Artificer Apprentices arrive in their civilian clothes at the Rosyth Training Establishment and parade for the Engineer Captain's inspection.

Warrant Rank Artificers can become Warrant Engineers, Warrant Electricians and Warrant Ordnance Officers after 6 to 7 years service, of which 3½ years must have been at sea, on passing an Admiralty examination. There are two alternative methods of promotion from Warrant rank. The first is that confirmed Warrant Officers under the age of 36 are eligible for direct promotion to Lieutenant (E). The second is they are advanced to Commissioned Officers from Warrant rank by selection from a zone of 8 to 12 years seniority as Warrant Officer. These officers generally attain Lieutenant's rank and can reach the rank of Lieutenant Commander before retirement.

Sub-Lieutenant (E) E.R.A.s at sea are allowed to sit for an examination before they are 24½ years of age which qualifies them for a one year's course of study at the R.N. College, Greenwich, passing out as a Sub-Lieutenant (E).

All the ranks just mentioned become eligible for advancement to higher ranks under the usual Service conditions. (One or two have reached the rank of Rear Admiral (E).)

The training details, as summarised in this very condensed form, enable a broad picture to be obtained of the apprenticeship scheme and the future prospects of the boy who has the ability and determination to make good.

THE ROYAL NAVAL ARTIFICER TRAINING ESTABLISHMENT, ROSYTH

We now propose to follow the training of E.R.A. and E.A. apprentices in some detail and for this purpose we spent some time at the Rosyth Establishment to obtain the following description and photographs which cover all phases of an apprentice's life from entry to passing out.

For the commencement of our story we start with the boys who, having been accepted as Artificer Apprentices, are provided with rail warrants and travel on the appointed day, in civilian clothes, to join their establishment. Arriving at the local railway station they are met by their Divisional Petty Officer Instructor who will be waiting with motor transport to convey each group of boys without delay to their new home.

A brief parade at the Training Establishment for the Engineer Captain's inspection (see Fig. 27) is immediately followed by a hot meal and once this important preliminary has been completed, the new entries are shown their dormitory in which a single bed and clothes locker is allotted to each apprentice and blankets, towels and all necessary items of gear supplied.

At Rosyth each dormitory is centrally heated and has within the same building its own lavatories, wash places and hot and cold showers. The view featured in Fig. 28 is of a typical dormitory which accommodates 33 apprentices and a petty officer apprentice.

During the next few days each boy is fitted out with complete uniform, is shown the routine of the establishment and gets acquainted with the other 60 or so boys who joined at the same time.

Each new group of apprentices forms a Division called after famous Admirals, namely, Rodney, Anson, Collingwood, Hawke, Howe, Duncan, Benbow, Grenville, Keppel, Cochrane, Jervis, Drake, Hood, Raleigh and Effingham, only two of the last seven divisions are at Rosyth at any one time, being composed of Air Apprentices.

Fig. 28 (Left)—This view is taken in a typical dormitory, which is centrally heated and accomodates 33 apprentices and a petty officer apprentice.

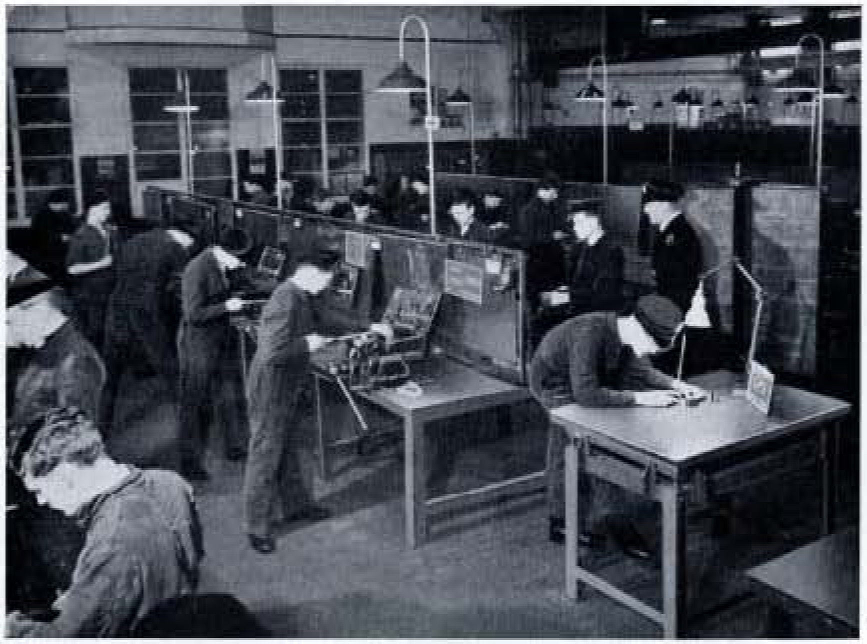


Fig. 29—The new entry apprentices are first taught the use of hand tools at the bench, including chipping, filing, hacksawing, preliminary marking off and simple fitting.

These divisional titles are retained during their entire stay, arising from which a keen inter-divisional spirit is to be found in all activities.

Every Division has a divisional officer, a divisional instructor who will be a Chief or Petty Officer, and two petty officer apprentices who are selected from the senior apprentices. The selection of petty officer apprentices by the Captain of the establishment is the result of three years observation and a boy needs to be above the average in all respects to be considered; in the last term a few are rated C.P.O. apprentices. These lads play an important part in the routines of the establishment and have ample opportunity to develop their power of command and leadership. By their example they exert a great influence, especially with the younger apprentices.

As previously mentioned we are confining our story to the training of E.R.A. and E.A. Apprentices, but we would interpose a few remarks about the other branches. The Air Apprentices, for instance, spend one year on the fitting bench in addition to school instruction and at the end of this period they produce a test job and sit a school examination. Those successful pass on to the Royal Naval Artificer Training Establishment at Newcastle-under-Lyme for specialised instruction in aero engineering.

The Electrical and Ordnance Atificer Apprentices complete a course similar to that of the Engine Room branch except that they are all fitters and turners and take electrical engineering and ordnance respectively instead of marine engineering as a technical subject.

A Class (New Entry) Artificers (0 to 6th month)

When a new class has settled down, a start is made on training. After breakfast, which is taken at 6.55 a.m., the factory classes fall in at 7.30 a.m. for the morning instruction which lasts until the dinner break from 11.45 a.m. until 1.20 p.m., afternoon work then continuing until the tea interval at 4.40 p.m. and two or three evenings a week resume for the evening period of school instruction from 5.45 p.m. until 7.45 p.m. Two intervals of "stand easy" are given from 10.0 a.m. to 10.15 a.m. and 2.50 p.m. to 3.0 p.m., soup, during the winter months, being served at the morning stand easy.

As mentioned earlier in the curriculum summary, all apprentices do similar work during their first term, this period being spent on the bench where they learn how to use hand tools correctly, their work consisting of chipping, fling, hacksawing, preliminary marking off and simple fitting (see Fig. 29).

To add a touch of human interest we had a chat with one of the new entry apprentices, a Rodney Division lad named R. A. Edmonds (see Fig. 30) and obtained a cross section of his life story. Born in Shirley, Birmingham, on 25th August 1929, he, as an only child, follows two generations of engine drivers, his father being employed on the L.M.S. Railway, as was his grandfather before him.

The father's ambition had always been to enter the Navy and he passed the necessary examinations when a boy, but objections from his mother prevented him from fulfilling his ambition. He now sees his son taking the first steps in working out the life he wanted.

From the age of 11 to 13 years, young Edmonds attended Sharmans Cross Senior School in Shirley, from which he passed to Bordesley Green Junior Technical School for a two years course, having secured one of the 30 places available, out of the 300 or so who sat for the examination. During this period the war came close to his home, for his family were bombed out by a land mine in 1940 and moved to Satley, Birmingham.

In October 1944, Edmonds sat for the Naval Artificers Apprentice Examination and was one of three who passed, out of eight Birmingham boys who entered. In this examination a total of 1,000 marks are awarded, i.e. 500 for mathematics and 500 for science, a pass requiring a minimum of 400 marks. Edmonds' result was 364 for maths. and 157 for science and he explains his low percentage on the science side by the fact that the examination covered mainly physics whereas, having attended an engineering school, his knowledge gained was mostly applied mechanics.

This boy's story must be typical of the many thousands who have passed through the Training Establishments and although his travels have so far only taken him to Denmark and Germany (a holiday in June 1939) his future will no doubt open up a broader sphere of activities in company with his fellow artificers. (This lad is further featured on the extreme right of the front row in Fig. 27 and later in the Junior Recreation Room at Rosyth (Fig. 89) again on the extreme right).

Fig. 30—R. A. Edmonds, a new entry apprentice from Birmingham, commences work at his allotted bench position on a simple chipping operation; his issued kit of tools stands open at the rear of the vice.

To return to the work of the A Class apprentices, their practice jobs during the term consist of the following:—

1. Chip a hexagon out of mild steel bar piece, $2\frac{1}{4}$" diameter by $2\frac{1}{2}$" long. No definite finished size is required and no time limit is fixed.
2. Make two pairs of outside and one pair of inside calipers also one pair of "oddlegs".
3. File the chipped hexagon (1) to a true hexagon, but to no definite size.
4. Make a spanner from forging supplied, in a time limit of approximately 7 hours.
5. Tongue and groove the hexagon (3) and fit with a key. Time allowed 45 hours.
6. Make a tool clamp, the spindles of of which must be filed from $\frac{5}{8}$" rough bar and screwed $\frac{5}{16}$" with stocks and dies

The Trade Allocation Test Job which follows is the plate and cube illustrated in Fig. 33 for which a time of $27\frac{1}{2}$ hours is allowed, marks being forfeited for excess time. As a result of this, and a school examination, the E.R.A. apprentices are selected for the trades of Fitter and Turner, Boilermaker, Enginesmith or Coppersmith. These trades are allocated in the following percentages—Fitter and Turner 73, Boilermaker 16, Enginesmith 4, Coppersmith 7—the first 30 per cent. of apprentices in order of merit being allowed their own choice, the remainder being allocated by the Instructional Officer.

It should be understood at this point that these trades are concerned with maintenance work done in harbour and that all Engine Room Artificers must be competent to supervise running machinery in ships at sea, irrespective of their trades.

Fig. 31—A general view in the Factory Machine Shop; a Churchill Piston Ring and Surface Grinder will be seen at work in the foreground.

The Factory Machine Shop

Before proceeding with the work of the B Class Apprentices we show one or two general views of the factory Machine Shop, Fig. 31 showing the grinding section in the foreground, the machine nearest the camera being a Churchill Piston Ring and Surface Grinder. The next view Fig. 32 features a row of Lang 13" swing Junior Lathes in the foreground, whilst to the left can be seen the end machine of a row of Ward No. 2A Capstan Lathes fitted with air chucks.

The equipment installed in the Machine Shop covers a very wide range and comprises 160 lathes from 3" to 16" centres, 14 shapers from 12" to 16" stroke, 12 milling machines (horizontal and vertical), 2 horizontal borers, 5 cylindrical grinders, 1 Churchill Piston Ring Grinder, 4 Ward Capstan Lathes, 10 drilling machines (sensitives and radials), 2 openside planers, 1 bevel gear generator, 1 worm gear generator, 1 Kendall & Gent Bolt Threader, 1 tool grinder and a variety of cold saws.

Throughout all shops a low pressure (100 lb.) air system is installed for pneumatic

Fig. 32—Another view in the extensive Machine Shop featuring a row of Lang 13" Junior Lathes in the foreground; several Ward 2A Capstan Lathes with air chucks are installed, one of which can be seen to the left of the picture.

tools, gas blow torches and the air chucks on the Ward Capstans.

When entering the Workshops, the apprentices leave their overcoats or raincoats in a dressing room where they don overalls; washrooms of the type depicted in Fig. 35 are provided for cleaning up after the workshop period.

B Class E.R.A. (F and T's) and E.A. Apprentices (6th to 12th month)

The practice work to be carried out during the second term by both E.R.A. and E.A. Fitters and Turners consists of the following jobs:—

1. Make a hexagon block and plate, with two keys and keyways—time allowed 45 hours.
2. Make a hexagon plate gauge.
3. Fit two keys, using an A Class cube and plate test job—10 hours.
4. Using Exercise (3), increase size of centre by filing to form a double rectangle and make three blocks to fit in several positions—40 hours.
5. Make keyed cube, with two keyways and keys—40 hours.
6. Make a small vice using screwed spindle supplied from D Class practice work—20 hours.

The keyed L block (see Fig. 33) is the test job for this period (time—45 hours), the term ending with a certain amount of productive work.

During the first twelve months covering the A and B Class periods, the apprentices after spending a three week disciplinary course spend 36 weeks on the bench, one week on the marking-off table and two weeks on the drilling machine.

C Class E.R.A. (F & T.s) and E.A. Apprentices (1 to 1½ year period)

It is during this term that the E.R.A.s and E.A.s practice work commences to differ in some respects so that it is more suited to the class of job appropriate to the branch in which they will ultimately be employed. Where the differences occur will be noted from the following:—

1. Make a hexagon T block—time allowed 35 hours.
2. Make a cottered sleeve, certain machining being done on the shaper (E.A.s make one to a smaller scale) —time 35 hours.
3. Make a small T block.
4. Dewrance cocks to be packed, baked and tested (E.R.A.s only).
   Make a base for a small scribing block (E.A.s only).
5. Make a small male and female hexagon —35 hours.

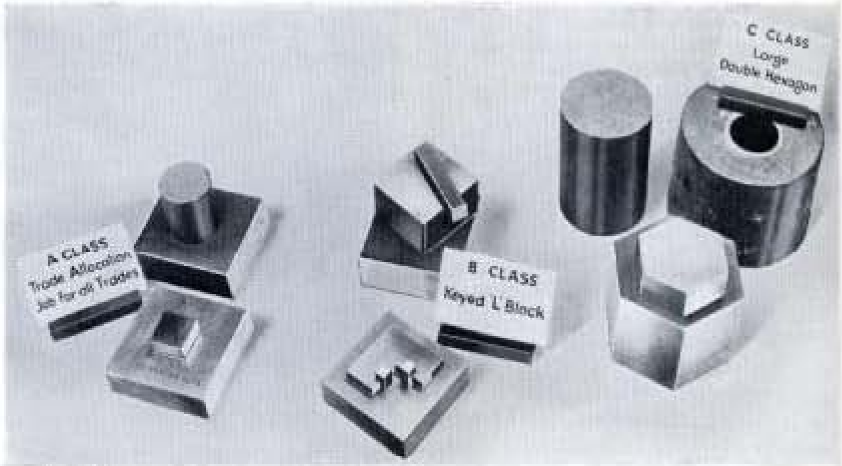


Fig. 33—Fitters and Turners and Electrical Artificers Test Jobs. Left—plate and cube (A Class) the Trade allocation job for all trades; centre—keyed L block (B Class, 6th to 12th month); right—large double hexagon (C Class, 1 to 1½ year period).

Fig. 34—Fitters and Turners (D Class, 1½ to 2 year period) forging a hexagon headed bolt as practice work during their 4 weeks Enginesmithing Course.

Fig. 35 (Left)—Overalls are donned when entering the Workshops, overcoats or raincoats being left in a dressing room; washrooms of the type depicted are provided for cleaning up after the workshop period.

Fig. 36—In the D Class period, Fitters and Turners also spend 2 weeks in the Boiler Shop and 4 weeks Coppersmithing; practice work in the latter course is here depicted, the apprentice brazing flanges and unions to a copper pipe.

6. Make a circular T block—25 hours. Make block for large surface gauge (roughing done in shaping machine) (E.A.s only).
7. Productive work for advanced E.R.A.s further exercises for backward ones. Small V blocks to be shaped (later hardened and ground in F Class) (E.A.s only).

The test job for the period is the large double hexagon shown in Fig. 33, time—40 hours. During this term both E.R.A.s and E.A.s have spent 21 weeks on the bench and 2 weeks on the shaping machine.

D Class E.R.A. (F & T.s) and E.A. Apprentices (1½ to 2 year period)

The apprentices now commence a comprehensive course on machine tools, and it is during this term that they spend a short time in each of the other "outside trades" as mentioned previously, the distribution of practical work being as follows:—

	E.R.A.	E.A.
Lathes	10 weeks	12 weeks
Boiler Shop ...	2 ,,	—
Smith's Shop ...	4 ,,	4 weeks
Coppersmithing	4 ,,	4 ,,
Revision ...	2 ,,	2 ,,

The following is the E.R.A. lathe and machine syllabus of practice work:—

1. Parallel turning, turning to size, V thread cutting and bolt head machining.
2. Turn medium sized Whitworth nut.
3. Turn standard Whitworth bolt and nut using forged bolt made as the test job in the Smith's Shop (see Fig. 34).
4. Make threaded and knurled spindle used for B Class vice practice job.
5. Make a "brazing—metal" boss or connection.
6. Make a screw jack—time allowed 35 hours.

The term test job is the ½" union (see Fig. 37) done after 8 weeks lathe instruction (time—10 hours).

The lathe and machine syllabus, for E.A.s is as follows:—

1. Make small screw jack, incorporating parallel turning and turning to size.
2. Turn standard B.A. bolt and nut.
3. Make adjustable tap wrench.
4. Make small scribing block and fittings.
5. Make threaded and screwed spindle used for B Class vice practice job.

The test job is the ½" union as for the E.R.A. Apprentices.

For their "outside trades" work, the 2 weeks spent by the apprentices on boiler-making, is devoted to belling and rolling boiler tubes, followed by cutting and driving them out, also light plate work, including riveting, and making a section of stove piping. For the 4 weeks engine-smithing they have to forge and temper a set of chisels and lathe tools, make and temper a coil spring (1" approx.) forge a ¾" bolt with welded head, also forge and temper a flat ratchet drill. The test job consists of forging a hexagon headed bolt by swaging down and knocking up the head as illustrated in Fig. 34. The coppersmithing

Fig. 37—Here are the next progressive test jobs covering lathe practice which follow the bench test jobs in Fig. 33; left—½" union and nut (D Class, Fitters and Turners and Electrical Artificers); centre—screwed spindle (E Class, 2 to 2½ year period, Electrical Artificers); right—oil fuel sprayer (E Class, Fitters and Turners).

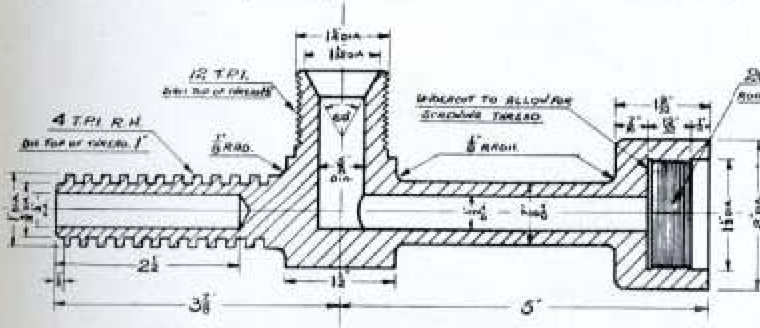


Fig. 38—A line drawing of the oil fuel sprayer body; details of the handwheel and nut, also sprayer cap are omitted to conserve space.

period of 4 weeks covers tinning, soft soldering and the use of a soldering iron, brazing over a fire and with a blow lamp, socketing a pipe and brazing on flanges or unions (see Fig. 36) and remetalling a pair of brasses. The test job is a copper pipe with brazed flange, union, saddle piece and socketed joint.

E Class E.R.A. (F & T.s) and E.A. Apprentices (2 to 2½ year period)

For most of this term the apprentices spend their time on lathe work as indicated in the following distribution of practical work:—

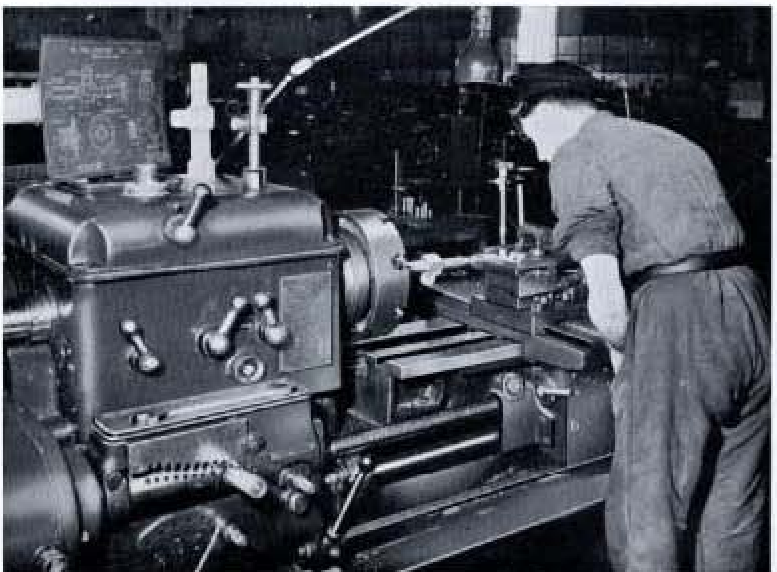


Fig. 39—An E Class Fitter and Turner at work on the oil fuel sprayer test job at the end of his 2½ year period of training.

This term's test job is the oil fuel sprayer shown in Fig. 37 and the line drawing Fig. 38, the time allowed for this being 45 hours. A view of one of the apprentices in the early stages of turning the body is given in the views Figs. 39 and 40. Incidentally this boy's father is an Engineer Lieutenant now serving as the Engineer Officer of a destroyer.

A certain amount of productive turning is also done during the term.

The E.A.s Class E, lathe and machine practice syllabus is as follows:—

1. Square thread and multiple start spindles and nuts (R and L hand).
2. Slotting and keyway cutting practice.
3. Lapping exercise.
4. Turn springs for surface gauge and automatic centre punch.
5. Make surface gauge fittings.
6. Make automatic centre punch.

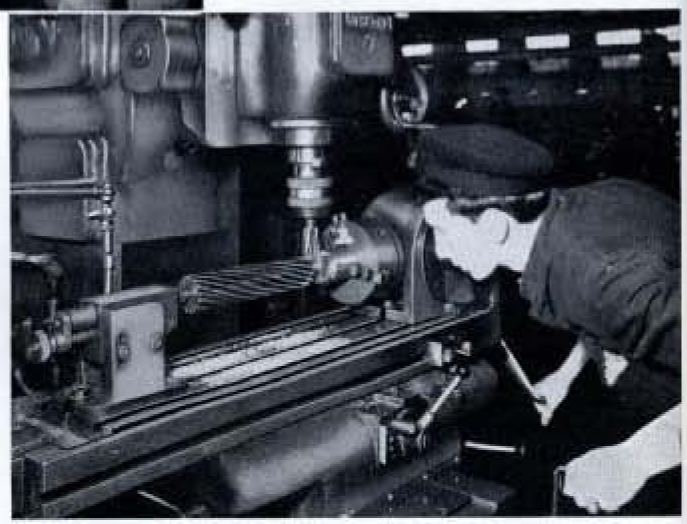


Fig. 41—F Class (2½ to 3 year period) Fitters and Turners and Electrical Artificers spend 2 weeks on milling practice; here a square is being milled on a helical toothed pinion.

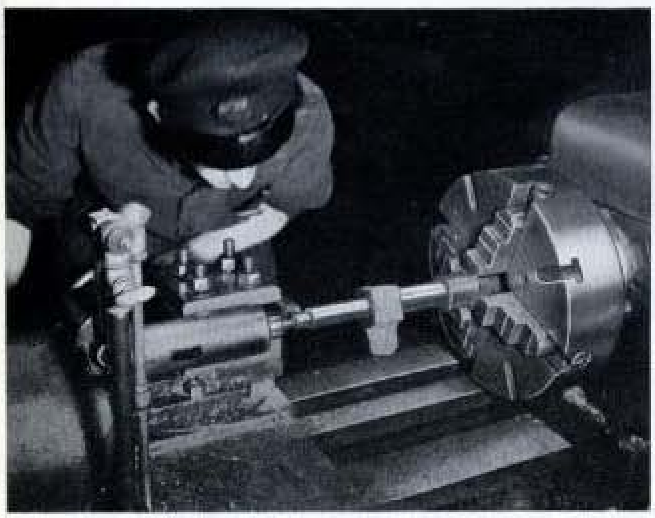


Fig. 40—A close-up view of the turning operation on the oil fuel sprayer body.

	E.R.A.	E.A.
Lathes	18 weeks	20 weeks
Toolroom ...	2 ,,	2 ,,
Erection and lining up of marine machinery	3 ,,	—
Electrical (school)	—	1 week

The lathe and machine practice syllabus for the E.R.A.s covers the following:—

1. Make square thread spindle (R and L hand threads) with corresponding nuts.
2. Turn plain taper plugged cock and shell from castings.
3. Practice multiple start spindles and nuts.
4. Turn Dewrance packed cock and plug from castings.

Fig. 42 (Right) — The apprentice in the early stages of turning the main circulating pump shaft.

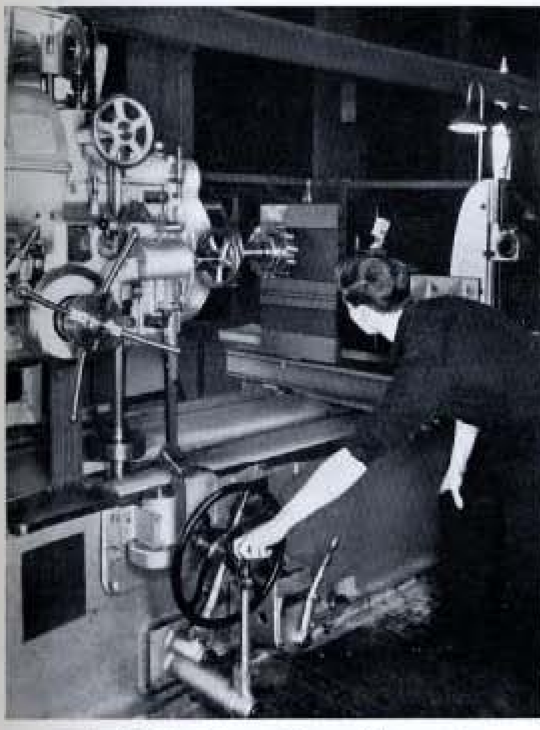


Fig. 43—An F Class Fitter and Turner facing a cast iron angle bracket on a horizontal boring machine; this is a maintenance job for the Machine Shop

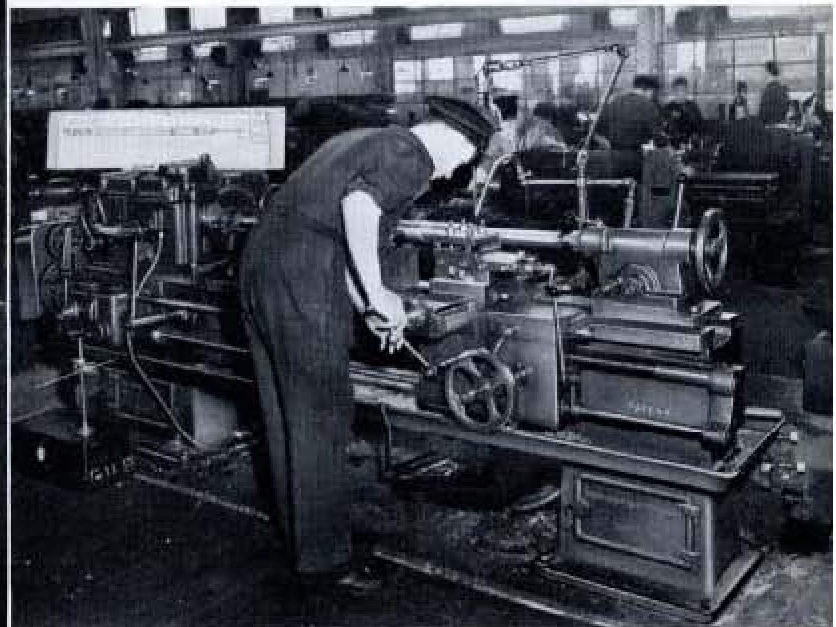


Fig. 44—A Fitter and Turner on production work in his third year (F Class) of training. Here he is turning up a main circulating pump shaft for replacement on an American type destroyer.

7. Make double handled stocks for B.A. dies.
   Production work.

The end of term test job is the screwed spindle illustrated in Fig. 37, time allowed —40 hours.

F Class E.R.A. (F & T.s) and E.A. Apprentices (2½ to 3 year period)

During this term the apprentices take courses in electrical maintenance and internal combustion engines in addition to continuing their machine shop practice as will be seen from the following:—

	E.R.A.	E.A.
Lathes and other machines ...	10 weeks	13 weeks
Milling	2 ,,	2 ,,
Grinding ...	1 ,,	1 ,,
Electrical (Factory	3 ,,	4 ,,
Electrical (School)	1 ,,	—
I.C. Engines (petrol) ...	5 ,,	2 weeks

The E.R.A.s lathe practice work includes turning a threaded spindle with nuts, sliding sleeve and taper pin, for which they are allowed 15 hours. Practice work on milling and boring machines is featured in Figs. 41 and 43 respectively; in the first a square is being milled on a helical toothed pinion and in the second a cast iron angle bracket is being faced on a horizontal boring machine; this is a maintenance job for the Machine Shop.

Fig. 46 (Right)—Fitters and Turners, whilst in the F and G Classes, receive 3 and 4 weeks electrical instruction respectively in this Electrical Demonstration Room; they have to strip, reassemble and rectify faults on compound, shunt and series wound motors, also fans and motor generators.

Fig. 45—A line drawing of the main circulating pump shaft which is machined all over from steel bar (see Figs. 42 and 44).

Another production job, one of many done in the lathe during this term, is illustrated in Figs. 42 and 44; this is a new shaft for a main circulating pump on an American type destroyer, the drawing for which is reproduced in Fig. 45. There is no test job for this term.

The practical electrical instruction for the E.R.A.s is carried out in the Electrical Demonstration Room in the Factory (see Fig. 46). Here they have to strip, reassemble and rectify faults on compound, shunt and series wound motors, also fans and motor generators.

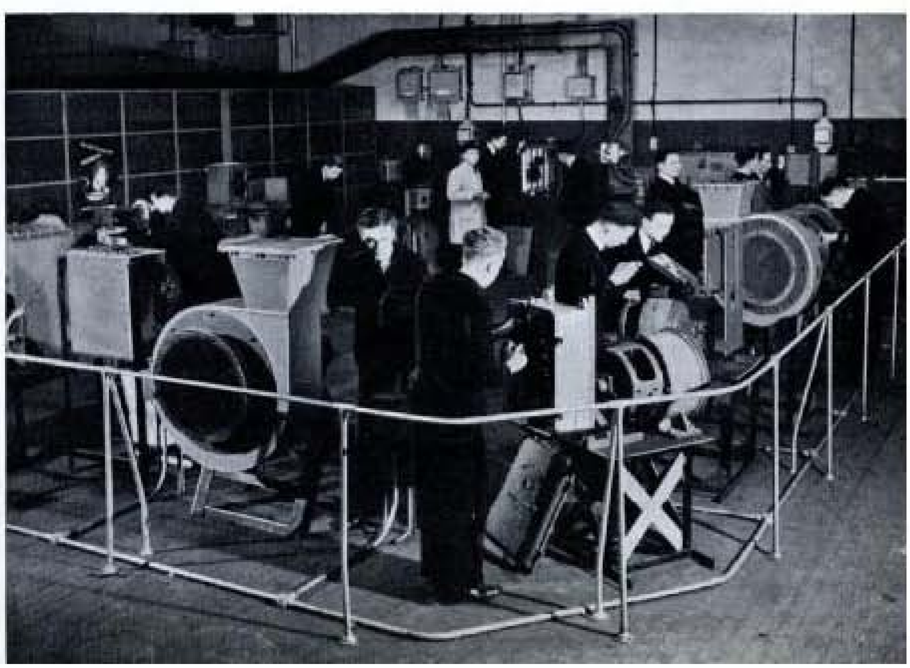


Fig. 47—Electrical Artificers spend 4 and 6 weeks respectively, during their F and G Class periods, in the Electrical Demonstration Room; here they are shown carrying out tests on a ring main breaker which is part of a ship's electrical installation.

Fig. 48—G Class (3 to 3½ year period) Fitters and Turners stripping a Dorman diesel engine. When reassembled after inspecting for wear or breakage, the engine must be run by them in the next shop (See Fig. 49)

The lathe practice work for the E.A.s covers the turning of a vice spindle and a small taper shank three-jawed chuck; production turning is also carried out as well as milling and grinding practice. There is no test job. The illustration Fig. 47 shows E.A.s in the Electrical Demonstration Room in the Factory carrying out tests on a ring main breaker which is part of a ship's ring main electrical installation.

G Class E.R.A. (F & T.s) and E.A. Apprentices (3 to 3½ year period)

It is during this and Class H terms that the apprentices spend a few weeks assisting in repair work, under an instructor, aboard ships undergoing refit and repair in the Dockyard as will be understood from the term "afloat" in the following distribution of practical work:—

	E.R.A.	E.A.
Bench	7 weeks	13 weeks
"Afloat" ...	4 "	4 "
I.C. Engines (diesel) ...	5 "	—
Electrical (Factory) ...	4 "	6 weeks
Erection and lining up of marine machinery	3 "	—

The bench practice work for E.R.A.s during the period under review covers the following:—

1. Grind in and complete the Dewrance cock turned in E Class.
2. Fit two keys and taper pin to sliding sleeve turned in F Class—time 35 hours.
3. Make circular H block—time allowed 40 hours. (This job is shown being marked up by the instructor in Fig. 50 and in the drawing Fig. 51.)
4. Pack the Dewrance cock (2), turned in E Class.

No test job is set for the bench work.

As seen from the details above the E.R.A.s spend 5 weeks in instruction on internal combustion engines (diesel) following 5 weeks on petrol engines in the previous term. In Fig. 48 we see some of them stripping a Dorman diesel engine, after which they check up on all clearances, test for wear on cylinders, inspect every part for breakages, etc., and then reassemble, replacing any defective part. The functioning of all components such as oil pumps, etc., is explained, injectors are tested, and the apprentices must run the engines in the adjoining shop after reassembly.

In the view Fig. 49 we have part of the Engine Test shop, the apprentice on the right being in the process of transferring an engine from the next shop after reassembly.

During the engine test, faults are laid on by the instructor and the apprentices have to find and rectify them.

The petrol engines seen in the illustration include a 110 h.p. Chrysler, 95 h.p. Ford V8, and a 100 h.p. Power Meadows, the diesels being a 90 h.p. Perkins, 40 h.p. Gardner and 160 h.p. Gray Marine (American).

The E.A. Apprentices G Class bench practice work is as follows:—

1. Make a toolmaker's vice using the spindle turned in E Class.
2. Make a hexagon block with tongue

Fig. 49 (Right)—I.C.E. instruction for Fitters and Turners covers 10 weeks training (5 weeks F Class, petrol and paraffin engines, and 5 weeks G Class diesel engines). In this running shop, faults are laid on and have to be traced and rectified.

piece and two keys—time allowed 35 hours.

3. Complete the surface gauge, the fittings for which were made in E Class.
4. Make small double cube and split plate—25 hours.
5. Make strap, block, gib and cotter.

There is no test job for the bench work.

H Class E.R.A. (F & T.s) and E.A. Apprentices (3½ to 4 year period)

The distribution of practical work for this last term is as follows:—

	E.R.A.	E.A.
Bench	5 weeks	5 weeks
Lathes	4 ,,	4 ,,
Marking off ...	1 ,,	1 ,,
I.C.E. (revision)	1 ,,	—
Gunnery (Fire Control) ...	—	1 week
"Afloat" ...	2 weeks	2 weeks
School Revision & Examination	2 ,,	2 ,,
Admiralty Test Job	4 ,,	4 ,,
Disciplinary Course ...	3 ,,	3 ,,

For the E.R.A.s practice bench work they have to make a 1½" large double cube and split plate in 45 hours, the E.A.s job being to make a square block with two plates and two keys in 48 hours. Both branches undertake revision turning in the lathe.

Before we proceed to describe the Admiralty passing out test jobs we give an illustration of the Test and Practice Job Marking Room in Fig. 52 whilst in Fig. 50 we have a close-up of an instructor marking up a circular H block, one of the practice jobs for Class G Fitters and Turners (E.R.A.s). To show the accuracy demanded on this job, which is typical of all other work, we reproduce details of the marking sheet as follows and this should be read in conjunction with the drawing Fig. 51. The error allowed on the drawing dimensions mentioned is − .005" for dimensions and ±.003" for fits.

Fig. 50—Here, an instructor is marking up a circular H block, a Class G Fitters and Turners practice job, details of which are shown in the drawing Fig. 51. The system of marking is described in the text.

"G" Class

Circular H Block Standard Time 35 hours
Maximum Marks 100

A **Dimensions** Deduct 1 mark for every 5/1000" error.

		Drawing Dimensions
1.	Length of male.	1.875"
2.	Length of female (2 in no.)	1.4375"
3.	Difference between sides of slots and circumference of female blocks (2 places)	1.00"
4.	Thickness of the two arms of male (2 places)	1.00"
5.	Thickness of reduced part	.500"
6.	Length of 2 arms (2 places)	.500"
7.	End of slot to end of blocks (females) (2 places) ...	.500"

B **Fits** Try feelers between male and female blocks on each side and between butts of blocks—total 29 places. Add total feelers that will enter ½" and deduct 1 mark for every 3/1000" clearance.

C **Reverse** Deduct up to 5 marks for reversibility.

D **Angles** Deduct up to 5 marks for truth of angles and alignment.

E **Finish** Deduct up to 10 marks for finish of filed surfaces, corners, general finish by sighting.

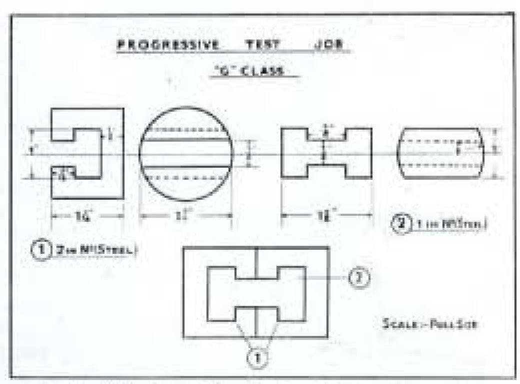


Fig. 51—A drawing of the circular H block, the practice job which is being marked up by the instructor in Fig. 50.

Fig. 52 (Left)—A view in the Test and Practice Job Marking Room, where certain practice and all test and Admiralty passing out jobs are marked.

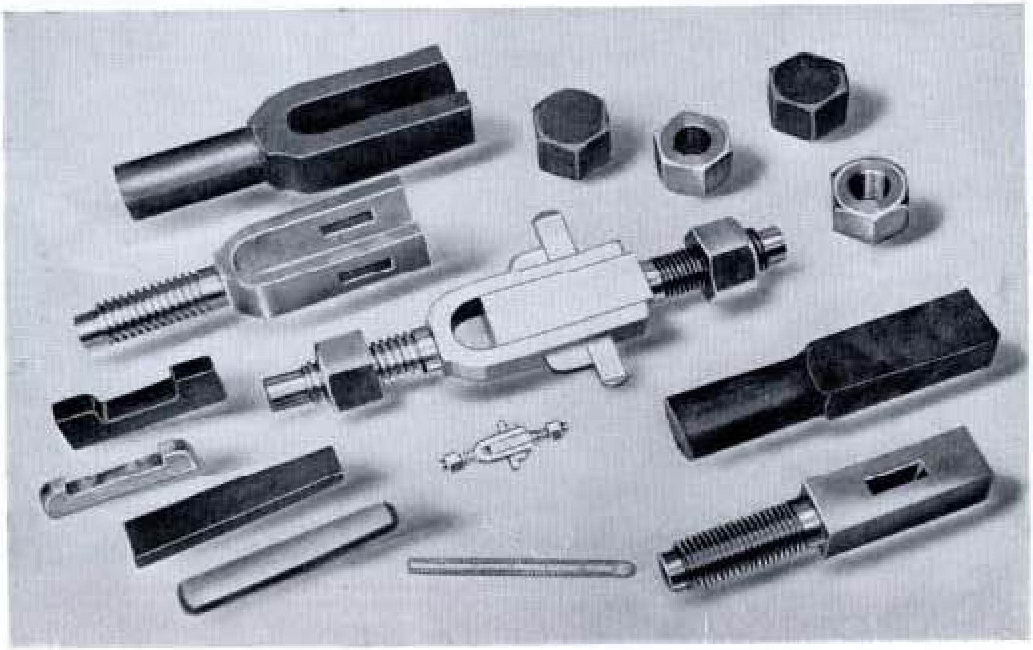


Fig. 53—The large block, strap, gib and cotter, one of four Admiralty passing out test jobs for Fitters and Turners. The small replica was a former passing out job for Electrical Artificers.

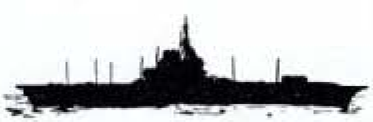
Final Percentage

(*a*) Jobs completed in a time in excess of standard time:—
Percentage obtained minus

$$\frac{\text{Excess Time}}{\text{Standard Time}} \times \frac{100}{2}$$

(*b*) Jobs completed in standard time or under:—
No penalty.

The final or passing out test is an Admiralty set test job together with an Admiralty Part II examination in technical subjects and it is the result of these, combined with the result of the Admiralty Part I school examination held at the end of D Class, which decides an apprentice's final position as a competent craftsman. Four test jobs are standardised for each of the two branches i.e. E.R.A. (Fitters and Turners) and E.A. Apprentices (we deal with those for the "outside trades" later) and every half-year the Admiralty select one E.R.A. and one E.A. job as the test jobs to be set.



E.R.A. (Fitters and Turners) Admiralty Passing out Test Jobs

In the illustration Fig. 53 we feature—

The Block, Strap, Gib and Cotter

—in its assembled and exploded states together with the rough material and forgings (supplied) from which each part is made. (The small replica was a former passing out job for E.A.s.)

In the making of this, and the other three test jobs, milling and slotting machines are not allowed and slotting must not be done in the lathe; chasers, taps, stocks and dies are also forbidden. The internal faces of the strap and the two fitting faces of the block must be hand worked and the one a push fit in the other, excess metal elsewhere can be removed by machining. The screwed spindles (square and Whitworth threads), must be in alignment with the rest of the job and the machined finish nuts have to be finger tight.

When marking the job great importance is attached to the fitting of the block in the strap, the fit of the gib and cotter in the block and strap, the fit and excellence of the threads and to the accuracy of all dimensions. When turned surfaces are finished with a file or emery cloth they are penalised.

In addition to fits and finishes, there are 50 dimensions to be marked and to show the accuracy demanded we give a very brief selection:—

	Drawing Dimensions	Error allowed without penalty
Length of block ...	5.062″	.008″
Width of block ...	1.75″	.002″
Depth of block ...	1.75″	.002″
Difference in dimensions at each end of block (1)		.002″
(2)		.002″
Length of slot in block	1.75″	.005″
Alignment of screwed spindle with block (1)		.004″
(2)		.004″
Dimensions across flats of nuts ...	2.375″	.003″

The standard working time is 75 hours; no allowance is made for completing in a shorter time, but marks are deducted if exceeded.

The Claw Coupling

—is featured in Fig. 54 and here again the accuracy of all dimensions is important; in addition the sleeve had to be a push fit in the half coupling (.002″ clearance allowed and 5 marks deducted for every additional .001″), the keys must be a push fit in sleeve and coupling (.002″ average clearance allowed and 3 marks deducted for each additional .001″ average), the spindle has to be a sliding fit in the square half coupling, and all couplings must be capable of being rotated so as to engage in all three positions when the square thread nut is tight. (The nuts have to be workable by hand.)

Important points noted in marking are the fit of the coupling halves at butts and faces, the fit of the square and bearing parts of the spindle, the fit of sleeve and keys and the general reversibility of parts except keys and keyways.

The general method of obtaining deductions is given in the following example:—For a dimension of $1\frac{1}{2}$″ the allowance is .003″ and one mark is deducted for each subsequent error of that amount, so that an error of .012″ will be penalised by 3 marks. Failure to obtain 40 per cent. in any section (and there are eight marking sections for the claw coupling) may mean total failure.

The standard time for the job is 90 hours.

The Gudgeon End

—Fig. 55 is the third of the E.R.A. (Fitters and Turners) Admiralty passing out test jobs to be featured. Like the others in this series it is a combined machining and fitting job, i.e. lathe, shaper and bench.

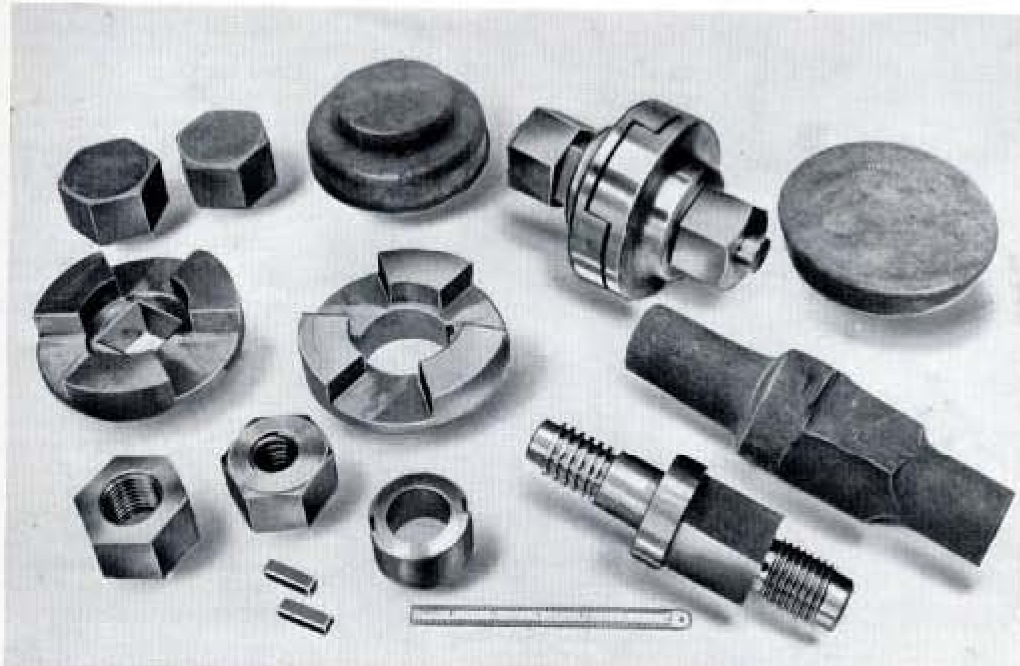


Fig. 54—The claw coupling, which is the second Fitters and Turners Admiralty passing out test job we illustrate: all these jobs are shown in their rough, machined, and assembled states, the forgings in each instance being supplied.

When completed the brasses and liners must be a push fit in the block (9 marks deducted for every additional .001" above .002" average clearance allowed), the pin a working fit in the bushes and the assembled pin to be free to revolve when in position.

In common with all the test jobs, marks are deducted for any new part required to be supplied as a result of carelessness or bad judgment. For the gudgeon end this means a penalty of 16 marks for a new block, 6 each for brasses, 8 each for pins, 6 for liner and 10 for nut.

For the marking of the job, importance is attached to the fitting of the brasses and bearing pin, the correct position of the pin and brasses in the gudgeon, and the fit and excellence of the threads.

The standard time for the test is 85 hours.

Fig. 55—The third example of Admiralty passing out test jobs for Fitters and Turners here features the gudgeon end. On all four tests, milling and slotting machines are not allowed and slotting must not be done in the lathe; chasers, taps, stocks and dies are also forbidden.

Fig. 56—This locomotive end is the last of the Admiralty passing out test jobs for Fitters and Turners; for all examples machining is done and certain excess metal removed on the lathe and shaper only, other parts have to be hand worked.

The Locomotive End

—illustrated in Fig. 56 is the last of the E.R.A. (Fitters and Turners) Admiralty passing out test jobs. Any machine except a slotter or miller may be used for all parts except the inside of the strap, which must be hand worked throughout. As an exception to the general rule, the ½" Whitworth thread on the cotter can be cut with dies, and taps can be used for the corresponding nuts, but a deduction up to 5 marks is made for a slack nut.

Brasses and blocks have to be a push fit in the strap, an average clearance (arrived at from a total taken at 16 places) of .002" being allowed, 6 marks being deducted for every additional .001" clearance. The pin must also be a working fit in the brasses, and reversible, the total clearance being taken at 8 places and subject to the same allowance and deduction as for the brasses and blocks.

When marking, great importance is attached to the fitting of the brasses and blocks in the strap, the fit of the gib and cotter in both block and strap, the fit and excellence of the threads and the fit and position of the pin.

The standard time for the job is 95 hours.

E.A. Apprentices Admiralty Passing Out Test Jobs

Our story now deals with the four test jobs for the Electrical Artificer Apprentices, the general rules for which lay down that only a lathe and a drilling machine may be used but chasers are permitted, slotting and shaping operations can also be done in the lathe. Turned surfaces which have been finished with a file or emery cloth are penalised.

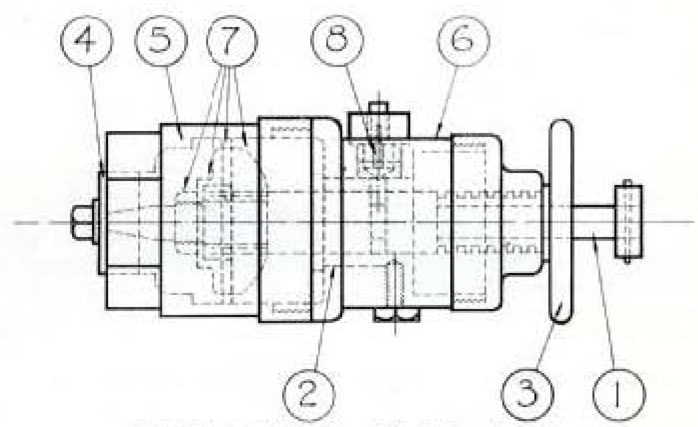


Fig. 57—A detailed drawing of the Dashpot Mechanism.

The Dashpot Mechanism is the first to be illustrated (Fig. 58), the materials used being brass, mild steel, cast iron and spring steel. The principal fits required are as follows (see drawing Fig. 57)—

Spindle (1)—to be a lap fit in bush (2)—clearance allowed .0002", 8 marks deducted for each additional .0001".
—to be a sliding fit in handwheel (3)
—to be a taper fit in the guide block (4)
—up to 5 marks deducted for badly fitting taper.

Guide Block (4)—to be a sliding fit in the female body (5) and reversible.

Bush (2)—to be a push fit in the male body (6).

Plunger and Nut (7)—to be a sliding fit in the female body (5).

In marking the job, great importance is attached to the fits as detailed above, all dimensions given to four places of decimals (totalling 31), the finish of threads, the sharpness of all square corners and the

Fig. 58—This dashpot mechanism is one of the four Admiralty passing out test jobs for Electrical Artificers. For all these jobs chasers are permitted, but only a lathe or drilling machine may be used although shaping and slotting can be done in the lathe.

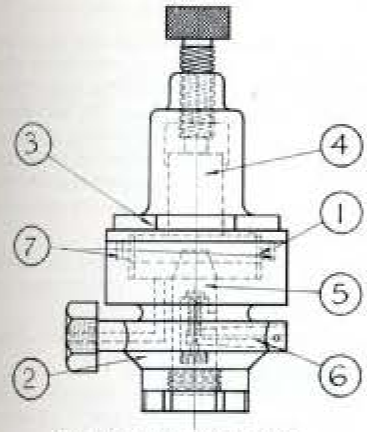


Fig. 59—Drawing of Gas Valve.

finish of lapped surfaces. The small spring (8) by the way, which is made in the lathe, has 12 coils, is .0937" diameter and $\frac{1}{16}$" long, .030" error in length being allowed and .005" on diameter.

The standard time for the job is 120 hours.

The Gas Valve is featured in Fig. 60 and for this the materials comprise cast brass, high tensile brass, mild steel and spring steel the fits required on the various parts being as follows (see drawing Fig. 59).

Sleeve (1)—push fit in valve box (2) and valve box cover (3)—maximum deductions 10 marks each.

Adjusting Plunger (4)—lap fit in valve box cover (3)—maximum deductions 20 marks.

—sliding and reversible fit in sleeve (1)—maximum deductions 20 marks.

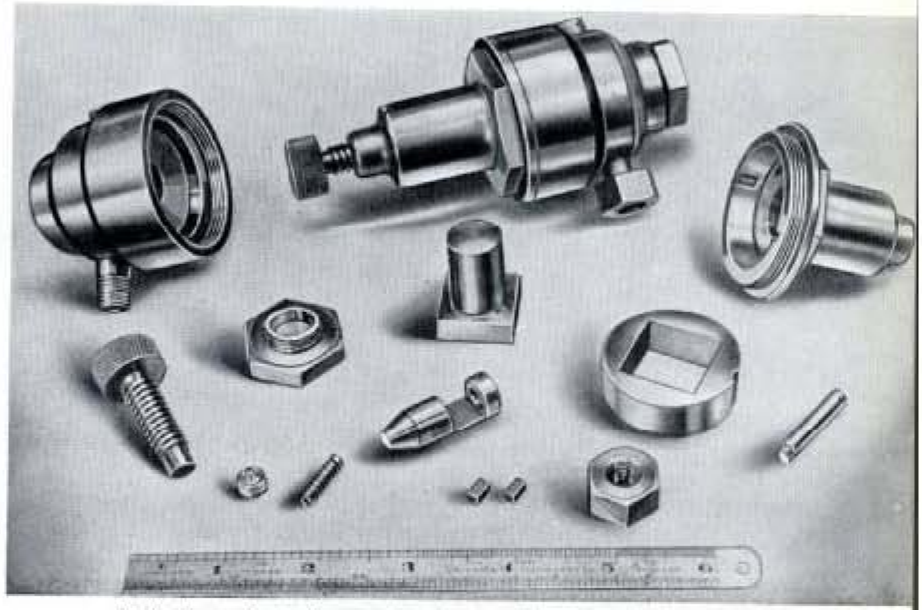


Fig. 60—Here we feature the gas valve as the second of the Electrical Artificers Admiralty passing out test jobs. Push, sliding, lapped and tapered fits are called for and certain parts have to be reversible.

Shuttle (5)—push fit in valve box (2)—maximum deductions 5 marks.

Bye-Pass (6)—tapered fit in valve box (2)—maximum deductions 5 marks.

Keys (7)—sliding fit, and reversible, in valve box cover (3) and sleeve (1)—maximum deductions 20 marks.

All screws have to be a hand fit in their threads and reamers are allowed for the tapered holes; the small B.A. threaded holes are tapped. The points of importance in marking are the same as for the dashpot mechanism. The standard time allowed is 80 hours.

The Reciprocating Oil Pump is shown in Fig. 62, the various components being made from cast iron, brass, copper, steel and spring steel. Referring to the drawing Fig. 61 the various fits required are as follows:—

The pump plunger (1) and the cam (2) to be sliding fits in the guide bush (3) and fit all ways.

The spindle (4) to be a taper fit in coupling (5).

The key (6) to be a push fit into the spindle (4) and when assembled together to be a push fit into the cam (2) and reversible.

The pump plunger (1) to be a lap fit in the pump barrel (7).

The spindle (4) to be a working fit in the spindle bush (8) and the cam bearing body (9).

The guide (10) to be a push fit in the pump barrel (7).

When completed, the job is not accepted until assembled in the position as indicated

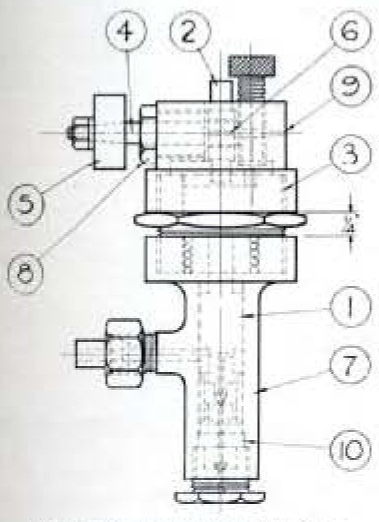


Fig. 61—The Reciprocating Oil Pump.

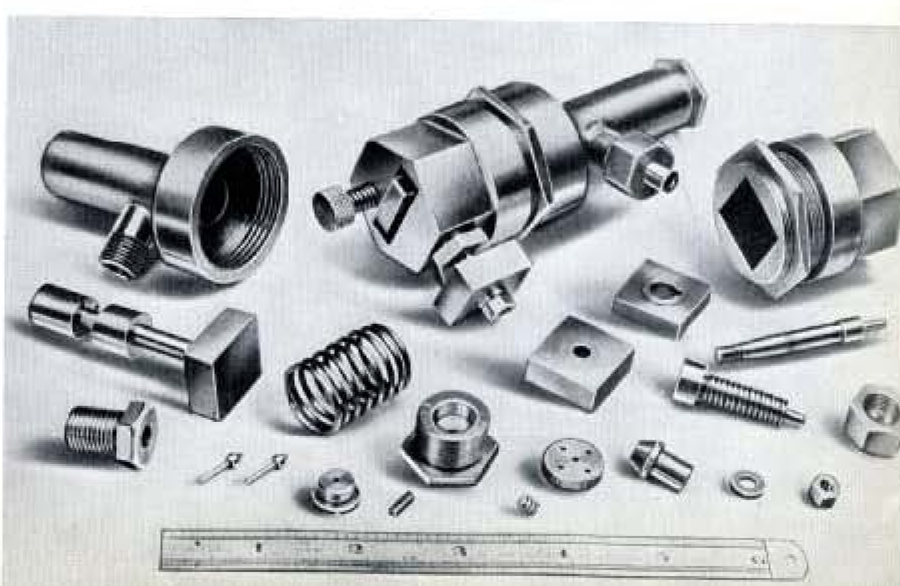


Fig. 62 (Right)—This reciprocating oil pump is the third of the Admiralty passing out test jobs for Electrical Artificers to be illustrated; great importance is attached to fits, all dimensions which are given to four places of decimals, finish of threads and lapped surfaces.

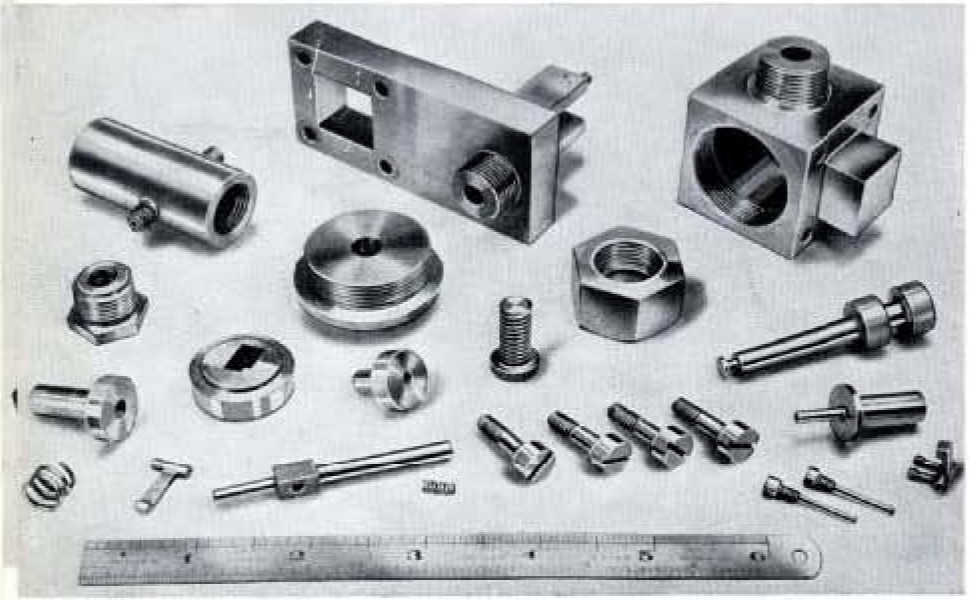


Fig 63—The fourth Admiralty passing out test job for Electrical Artificers is this trip governor servo valve. This illustration only shows the exploded parts, the assembled component being featured second from the left in Fig. 64.

in the drawing, that is, the top and bottom faces of the guide bush (3) are to be screwed hard home by hand in the pump barrel (7) and the cam bearing body (9), when the dimension of ¼" shown between adjacent faces of (7) and (9) should be obtained. Two sides of the square in the guide bush (3) are to be parallel to the axis of the discharge orifice in the pump barrel (7), the axis of the cam spindle is likewise to be parallel to it and the coupling is to be on the same side as the discharge orifice.

The standard time for the job is 105 hours.

The last of the Electrical Artificers Admiralty passing out test jobs is—

The Trip Governor Servo Valve featured in Figs. 63 and 64 which is made up of gunmetal, high tensile brass, cast iron, mild steel and spring steel components.

This test job when completed must be assembled in the position shown in the drawing Fig. 65, that is with the axis of the inlet and discharge orifices (7) at right angles to the axis of the driving spindle, the governor valve chest is also to be at the right hand side when looking on the driving end of the spindle. The various fits required are as follows:—

The governor body (2) has to be a sliding fit in the bedplate (1) and fit all ways.

The tappet (3) to be a working fit in the governor body (2).

The driving spindle (4) to be a sliding fit in the operating cam (5) and fit all ways.

The piston (6) to be a lap fit in the cylinder (7).

The lever bearing screws (8) to be a working fit in the bell-crank lever (9) and pawl (10) of the trip assembly.

The driving spindle (4) to be a working fit in the spindle bushes (11 and 12).

Fig. 64—A group of the four Admiralty passing out test jobs for Electrical Artificers, taken particularly to show the trip governor servo valve (second from left) seen exploded in Fig. 63.

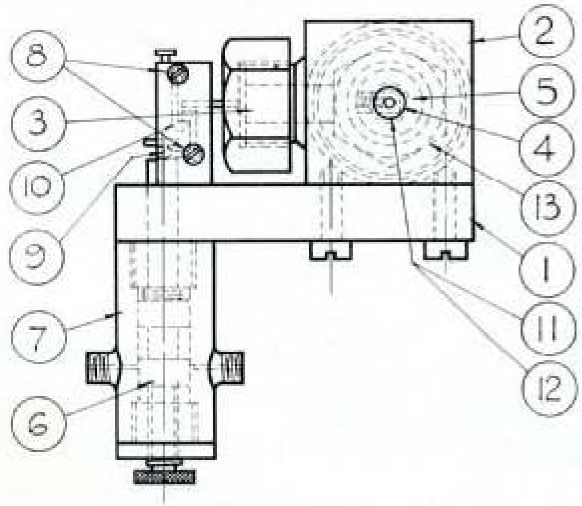


Fig 65—Details of the Trip Governor Servo Valve.

One spindle bush (11) to be a push fit into the governor body plug (13) and the other bush (12) a similar fit into the governor body (2).

The standard time for this test job is 100 hours.

The "Outside Trades"— B.M., E.S. and C.S.

Earlier in this section we mentioned that in addition to Fitters and Turners, Engine Room Artificer Apprentices cover the three other trades of Boilermaker, Enginesmith and Coppersmith. As we have already dealt very fully with the practical training of Fitters and Turners, both E.R.A.

Fig. 66—Standard half yearly test jobs for Boilermakers, Enginesmiths and Coppersmiths. (The lettered references are given in the text below).

and E.A. branches, we now propose to touch, only very lightly, the work of the "outside trades" apprentices.

Broadly speaking the Boilermakers undergo a course of rolling and bending plates, riveting, fitting boiler tubes and a long course in all forms of electric arc and oxy-acetylene welding, whilst the Enginesmith's course covers forging, spring making, tool making and welding. The Coppersmiths are trained in pipe bending, fitting and brazing and spend a short time in pattern making, moulding and foundry work; they also do a considerable amount of electric and gas welding.

The types of work undertaken by these apprentices is first exampled in Fig. 66 which shows the standard term (half yearly) test jobs, indicated by the lettered items, as follows:—,

Enginesmiths: A (Class B) Wheel spanners; B (Class C) Eccentric rod; C (Class B) Tongs with welded shank; D (Class D) High tensile brass forging; G (Class E) Welded 4-way piece.

Coppersmiths: E (Class B) Copper pipe reduced and tapered, with flanges and branches; F (Class C) steel feed pipe, for water or steam, bent to template; G (Class E) Welded 4-way piece.

Boilermaker: H (Class B) Water tight bucket, riveted and rimmed; I (Class C) Square to round, formed from one flat plate; J (Class D) Joggle patch. This is fitted over fracture at butt strap on boiler drum and after water pressure testing is removed for examination of rivets and its fit; G (Class E) Welded 4-way piece.

The Distribution of Practical Work for the "Outside Trades"
—is as follows:—

A and B Classes (0 to 12 months)

	B.M. weeks	E.S. weeks	C.S. weeks
Fitters bench ...	17	17	17
Boiler Shop ...	21	—	—
Enginesmithing	—	21	—
Coppersmithing	—	—	21
Drilling machine	1	1	1

C Class (1 to 1½ year period)

Boiler Shop ...	23	—	—
Enginesmithing	—	23	—
Coppersmithing	—	—	16
Foundry ...	—	—	7

A general view of Coppersmiths at work on test jobs and repair work for ships is given in Fig. 67 an example of ship's work being the evaporator coil on the foremost forge, this coil being featured again in the Oxy-acetylene Welding Shop in Fig. 71.

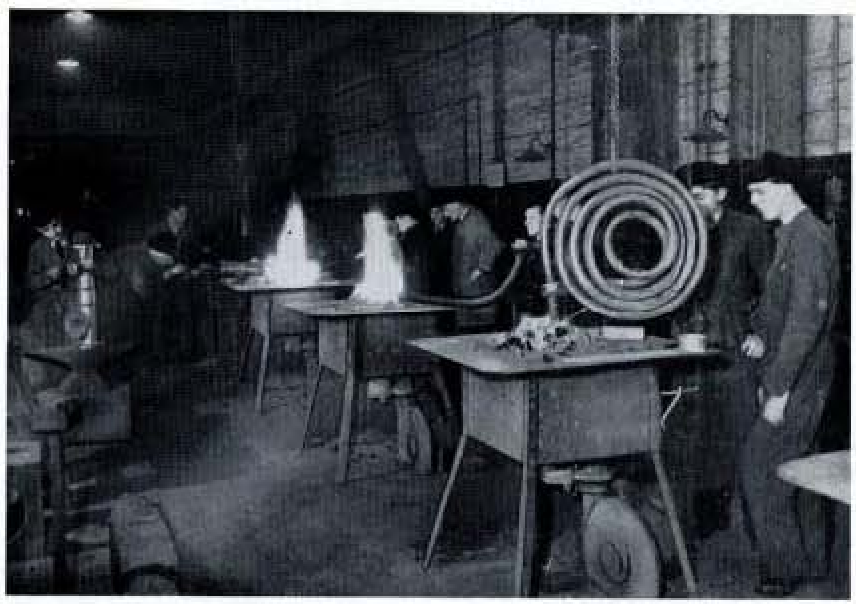


Fig. 67—A general view of Coppersmiths on test jobs and repair work for ships. On the foremost forge will be seen the evaporator coil featured in the Oxy-acetylene Welding Shop in Fig. 71.

The nearer view Fig. 68 shows on the front forge, the C Class test job (see F. Fig 66) whilst the apprentice at the anvil is finishing one of his Admiralty passing out test jobs (see C Fig. 79). On the rear table a B Class test job is being built up as E Fig. 66.

Fig. 68—Coppersmiths at work. On the front forge is the C Class test job (see F, Fig. 66) whilst the apprentice at the anvil is finishing one of his Admiralty passing out test jobs (see C, Fig. 79). On the rear table a B Class test job is being built up as E, Fig. 66.

D Class ($1\frac{1}{2}$ to 2 year period)

	B.M. weeks	E.S. weeks	C.S. weeks
Boiler Shop ...	12	4	4
Enginesmithing	4	12	4
Coppersmithing	4	4	12
Revision ...	2	2	2

E Class (2 to $2\frac{1}{2}$ year period)

	B.M. weeks	E.S. weeks	C.S. weeks
Welding ...	18	18	18
Boiler Shop ...	2	—	—
Enginesmithing	—	2	—
Coppersmithing	—	—	2
Erection and lining up of marine machinery	3	3	3

Fig. 69—Boilermaker apprentices reinforcing the worn bore of a worm wheel for the steering gear of a destroyer by oxy-acetylene welding.

As will be seen from the above all the E.R.A. "outside trades" spend 18 weeks in the Welding Shop (i.e. 9 weeks on oxy-acetylene and 9 on electric arc) and the illustration Fig. 71 shows work proceeding in the Oxy-acetylene Shop. On the foremost bench is the evaporator coil previously depicted in Fig. 67, whilst on the second bench, seaming straight runs is being practised. Production work is being done on the end bench by reinforcing the bore of a worm wheel for the steering gear of a destroyer. As a result of wear, the bore was $\frac{1}{8}$" oversize, so it was bored out a further $\frac{1}{4}$" in diameter and is now being built up to machine to 3.47" diameter. A better view of the operation is given in Fig. 69.

In one of the ten electric arc welding booths (Fig. 70) an H Class Enginesmith Apprentice is at work on one of the Admiralty passing out test jobs. Here he is building up a $1\frac{1}{2}$" diameter mild steel shaft to $2\frac{3}{4}$" diameter, after which it must clean up by machining to $2\frac{1}{2}$" diameter and be screwcut with a vee thread (see J, Fig. 78).

Fig. 70—An Enginesmith (H Class) at work on one of the Admiralty passing out test jobs.

F Class ($2\frac{1}{2}$ to 3 year period)

	B.M. weeks	E.S. weeks	C.S. weeks
Lathes and other machines ...	3	3	3
Boiler Shop ...	9	—	—
Enginesmithing	—	9	—
Pattern making	—	—	1
Foundry ...	—	—	4
Coppersmithing	—	—	5
Fitting bench ...	3	3	2
Electrical (Factory)	2	2	2
I.C. Engines (petrol) ...	5	5	5

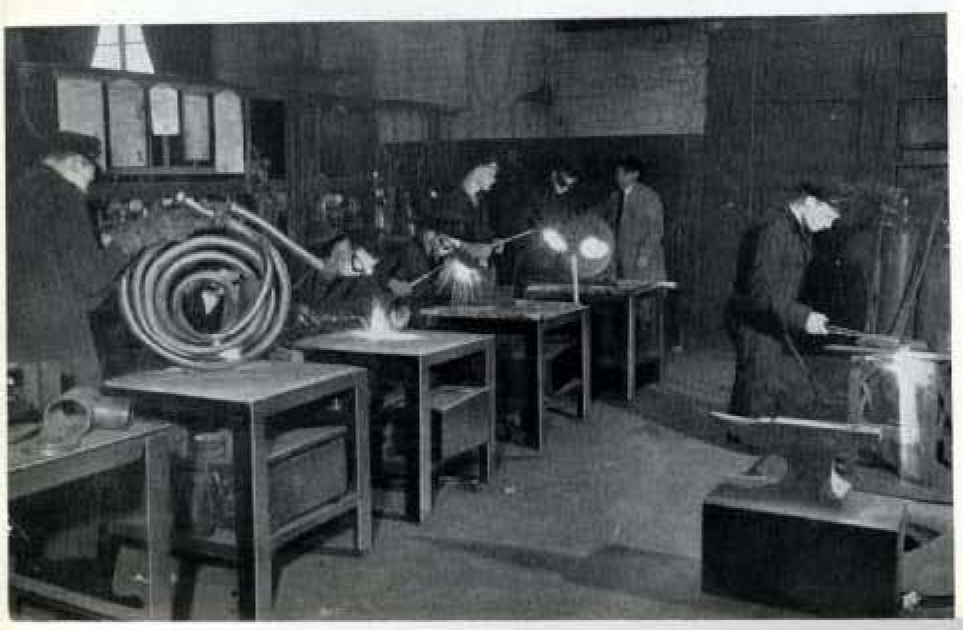


Fig. 71 (Left)—Here Boilermaker apprentices are at work in the Oxy-acetylene Shop.

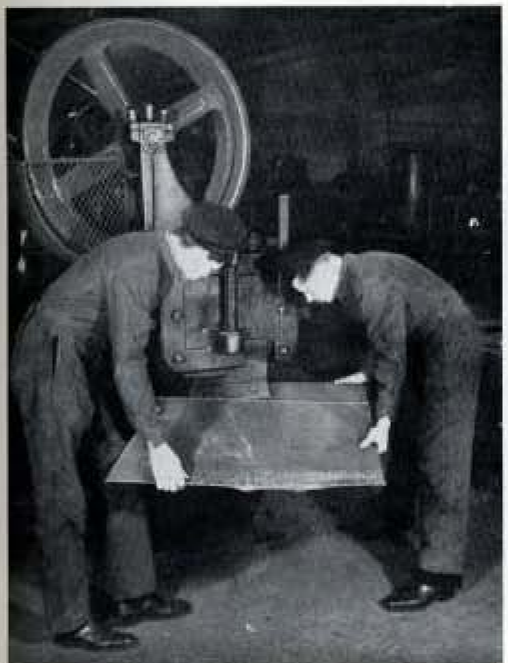


Fig. 72—F Class (2½ to 3 year period) Boilermakers cutting out ¼" plate for production work.

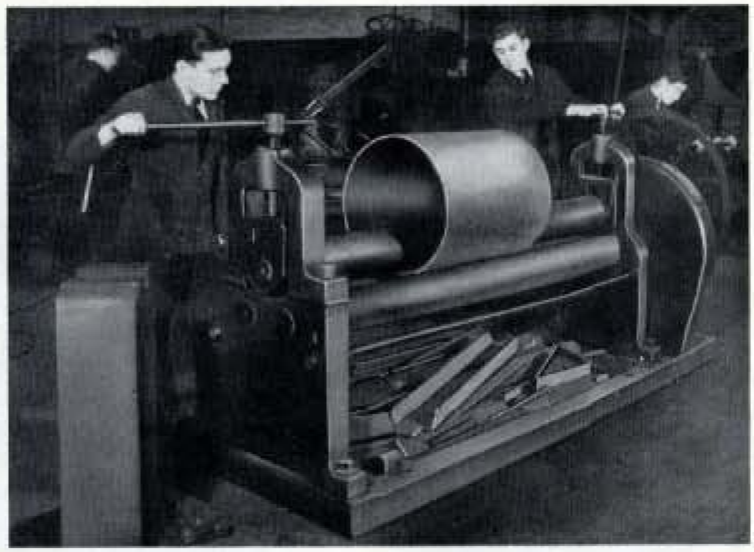


Fig. 73—Boilermakers (F Class) rolling a 22" diameter by 2' 6" long steel cylinder from ⅜" plate for production work on a battleship.

The photographs we took to illustrate the above work are as follows:—

Fig. 72. Boilermakers cutting out ¼" plate for production work.

Fig. 73. Boilermakers rolling a 22" diameter by 2' 6" long steel cylinder from ⅜" plate for production work on a battleship. These bending rolls take up to 6 ft. long; a larger machine, taking up to 8 ft., was used by the apprentices for making the 8 ft. by 2' 10" diameter boiler drum, from ½" plate, used for patching practice.

Fig. 74 shows Coppersmith Apprentices in the Foundry pouring gunmetal into a mould they have made for a quill for piston rings.

Fig. 74 (Above)—Coppersmith Apprentices (F Class, 2½ to 3 year period) spend 4 weeks in the Foundry. Here we see them pouring gunmetal into a mould for a quill for piston rings.

Fig. 75 (Left)—Boilermaker apprentices (G Class, 3 to 3½ year period) tubing up a new boiler which will be used for test work in passing out.

G Class (3 to 3½ year period)

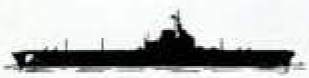
	B.M. weeks	E.S. weeks	C.S. weeks
Boiler Shop ...	11	—	—
Enginesmithing	—	11	—
Coppersmithing	—	—	11
"Afloat" ...	4	4	4
I.C. Engines (diesel) ...	5	5	5
Erection and lining up of marine machinery	3	3	3

The illustration Fig. 75 shows G Class Boilermaker Apprentices tubing up a new boiler which will be used for their passing out test work, part of which consists of putting in six complete tubes, water testing them and then removing by cutting out (see E, Fig. 76).

H Class ($3\frac{1}{2}$ to 4 year period)

	B.M. weeks	E.S. weeks	C.S. weeks
Boiler Shop ...	10	—	—
Enginesmithing	—	10	—
Coppersmithing	—	—	8
Foundry ...	—	—	2
I.C.E. (revision)	1	1	1
"Afloat" ...	2	2	2
School Revision and Exam. ...	2	2	2
Admiralty test job	4	4	4
Disciplinary course ...	3	3	3

In the illustration Fig. 77 we see H Class Enginesmiths using a 5 cwt power hammer on the first stages of forging the connecting rod (see L Fig. 78) which is one of their passing out test jobs. An apprentice in C Class controls the hammer.



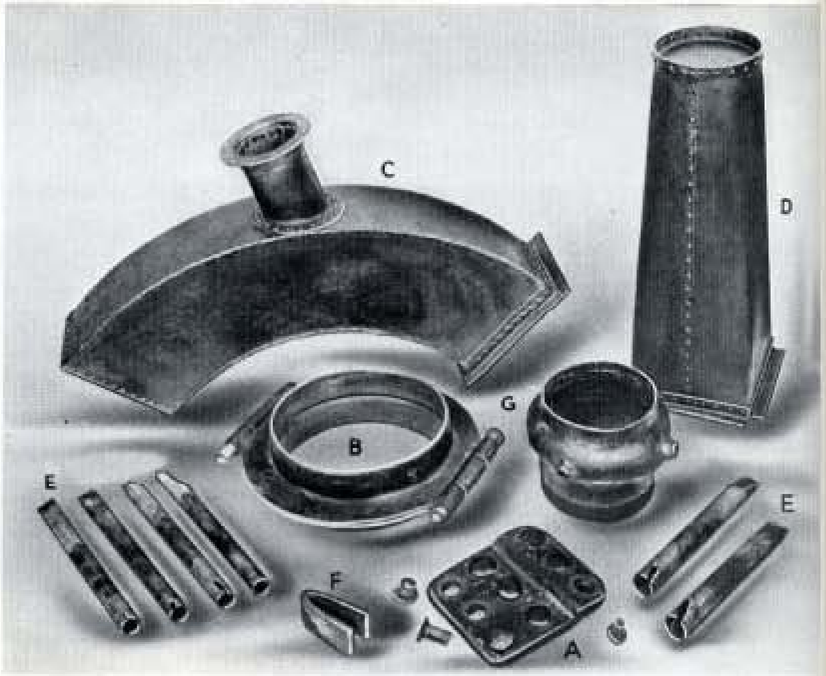


Fig. 76—Boilermakers Admiralty passing out test jobs:—
A, Joggle patch for a boiler drum. B, Double funnel ring and hinges. C, Air trunk with branch pipe. D, Stove trunk (to pass water test). E, Boiler tubes after cutting out from drum. F, Arc welded test piece. G—Double welded (oxy-acetylene and metallic arc) 'Sulzer' joint.

The B.M., E.S. and C.S. Admiralty Passing Out Test Jobs

The Admiralty passing out test jobs, for the three "outside trades" are as follows:—

Boilermakers. The illustration Fig. 76 features examples of the various jobs, details of which are enumerated below.

1. Make and rivet a joggle patch (A) on a boiler drum. After drilling, the patch is examined and then bolted to drum and the clearance checked, following which, it is riveted, caulked and water pressure tested to 200 lbs. per sq. in. and then the rivets are cut out for examination. Each candidate is allowed the assistance of two mates (E.R.A. apprentices) who work in the capacity of skilled labourers. The standard time allowed is $11\frac{1}{2}$ hours.

2. Make a double funnel ring and hinges (B) to drawing supplied. The material is cut from $\frac{1}{4}$" plate and the two pins are forged. Time allowed—15 hours.

3. Make an air trunk (C) with branch pipe, to drawing. No paper to be used in joints and job to be oxy-acetylene and arc welded where indicated. This is water tested when completed. Time allowed—30 hours.

3a. Alternatively, make a stove trunk (D) to drawing. No jointing material of any kind to be used and job is water tested on completion. Time allowed—26 hours.

4. Make a double welded (oxy-acetylene and arc) "Sulzer" joint (G) out of $\frac{1}{8}$" mild steel plate using a jig and fuller. Two screwed water connections to be positioned in drilled holes in corrugated sleeve and welded joints are tested to 650 lb. per sq. in. Time allowed—20 hours.

5. Roll and bell-mouth one row (11 generator and 2 fre row) of boiler tubes into Admiralty pattern boiler drum and water pressure test to 300 lbs. per sq. in. After test, tubes to be cut out (as "E") and removed by splitting internally, closing in and driving out. Time allowed—6 hours.

5a. Alternatively roll and bell-mouth 4 generator tubes and 2 fire row tubes into steam and water drums of Admiralty pattern boiler. Work involved is similar to (5).

6. Arc weld a test piece (F) using bevelled edged pieces of plate. After welding, the test piece to be ground to dimensions on drawing supplied and weld surfaces cleaned by filing; the job is then subjected to a tensile or bending test. Time allowed—2 hours.

Enginesmiths. The passing out test jobs for this trade, as illustrated in Fig. 78 are as follows:—

1. Forge distiller pump crosshead (E) to drawing supplied. Forging to be one piece from 4" square steel and power hammer used. Finished job to be such that it is necessary to remove $\frac{1}{8}$" of metal from the entire surface to produce to drawing dimensions. Time allowed—14 hours.

1a. Alternatively, forge connecting rod (L) for reciprocating engine; procedure as (1) and time the same. (See Fig. 77).

Fig. 77 (Left)—Enginesmiths (H Class) on a 5 cwt. power hammer, in the first stages of forging a connecting rod from $3\frac{1}{2}$" square steel. This is one of their Admiralty passing out test jobs and is depicted at L in Fig. 78. An apprentice in C Class controls the hammer.

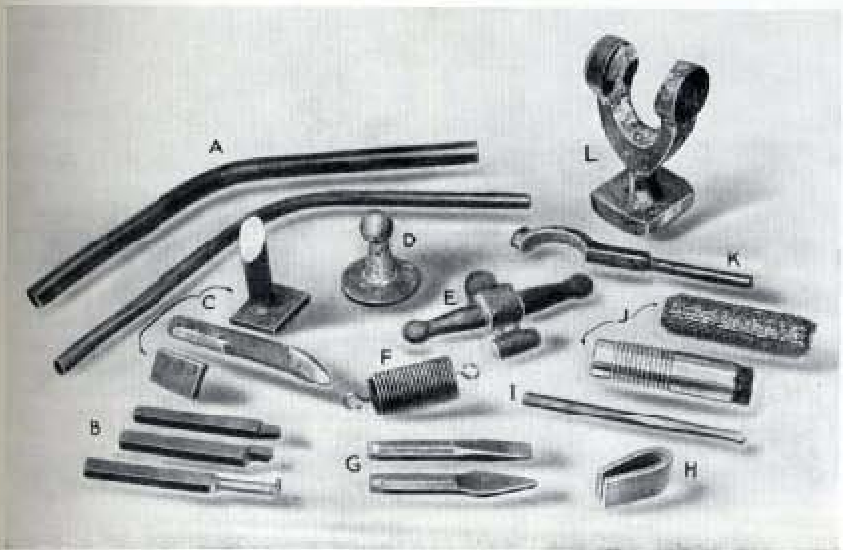


Fig. 78—Enginesmiths Admiralty passing out test jobs:—
A, Forged welds (each piece is made from two lengths hand forged together); B, Three lathe tools; C, Oxy-acetylene welded stanchion piece with base plate and lug; D, Forged brass handrail stanchion; E, Forged distiller pump crosshead; F, Steel spring made to drawing; G, Hand forged and tempered cold chisels; H, Arc welded test piece; I, $\frac{3}{8}$" clearing tool to drill 3" deep; J, Arc welded engine shaft and its machined counterpart; K, Forged brass hydrant "C" Spanner; L, Forged connecting rod for reciprocating engine.

2. Forge brass handrail stanchion (D) to drawing supplied. Here again the procedure is as (1). Time allowed—5 hours.

2a. Alternatively forge brass hydrant "C" spanner (K) from $1\frac{1}{2}$" diameter high tensile brass to drawing supplied. The job is to be in one piece and no allowance is made for machining. Time allowed—5 hours.

3. Forged welds (A), using two pieces of 1" diameter and two pieces of $1\frac{1}{2}$" diameter steel bar to length of 18" between marks. The marks must be made to coincide with a trammel supplied, by lengthening or shortening, as necessary. Time allowed—2 hours.

4. Make a steel spring (F) to drawing supplied. The spring is tested by suspending from it a 50 lb. weight on a 3ft. long wire and then dropping a 2 lb. weight on to the 50 lb. weight from a height of 3 ft. to produce a shock whilst the spring is in tension. The large weight is then oscillated up and down and then removed, and the spring should return to its original length. 20 marks are deducted for every $\frac{1}{4}$" difference in length, before and after test, over an allowance of $\frac{1}{8}$".

5. Make the following set of tools to drawing supplied and temper same—cross cut and flat chisels (G); right hand side cutting tool, roughing and boring tools (B), and $\frac{3}{8}$" clearing tool to drill 3" deep (I). Time allowed—2 hours. The tools are to be finished by fitters and tested for temper as considered necessary by the Engineer Officer.

6. Weld by oxy-acetylene process, a stanchion piece (C) with base plate and lug, to drawing supplied. The steel parts are supplied in the required sizes but the edges to be welded are to be prepared to drawing, by the candidate. Time allowed —$5\frac{1}{2}$ hours.

7. Reinforce by metallic arc welding, an engine shaft to dimensions on drawing. After welding, shaft will be machined (not by welder) for inspection of welding. Built up and machined pieces are shown at (J) (see also Fig. 70). Time allowed—5 hours.

8. Arc weld a test piece (H) as described under item (6) of Boilermakers test jobs.

Coppersmiths. The passing out test jobs for Coppersmiths, as illustrated in Fig. 79, are as follows:—

1. Make a socketed pipe (C) with saddle throat branch and inlet pipe branch. Two circular pipes are made up from copper sheet and joined with a socket. The saddle throat branch is made from copper sheet and fitted, leaving the crown in the branch. Fit inlet pipe branch and three drilled flanges, all seams and flanges being brazed with spelter. The seams of the two circular pipes are to be on the opposite side to the axial centre line of saddle and branch. The completed job is water pressure tested to 200 lbs. per sq. in. Time allowed—50 hours. (See also Fig. 68).

1a. Alternatively, make solid drawn copper pipe (D) with saddle branch, two bosses and pig's ear. Of the two bosses, one must be brazed internally and the other externally and two drain pipes must connect bosses to pig's ear which is to be made from sheet copper. Three drilled flanges to be fitted and the complete job water pressure tested to 300 lbs. per sq. inch. Time allowed—30 hours.

2. Mould and cast 1" bore valve box (F) from pattern and core supplied. The metal for this box is to be mixed and melted by candidate and finished casting is water pressure tested to 650 lbs. per sq. inch. Time allowed—$5\frac{1}{2}$ hours.

3. Re-metal a small pair of brasses (E) about 4" diameter, after running out old metal. Time allowed—$1\frac{1}{4}$ hours.

4. Bend and flange a $4\frac{1}{2}$" external diameter lap welded steel water cooled exhaust pipe (A) to drawing from material

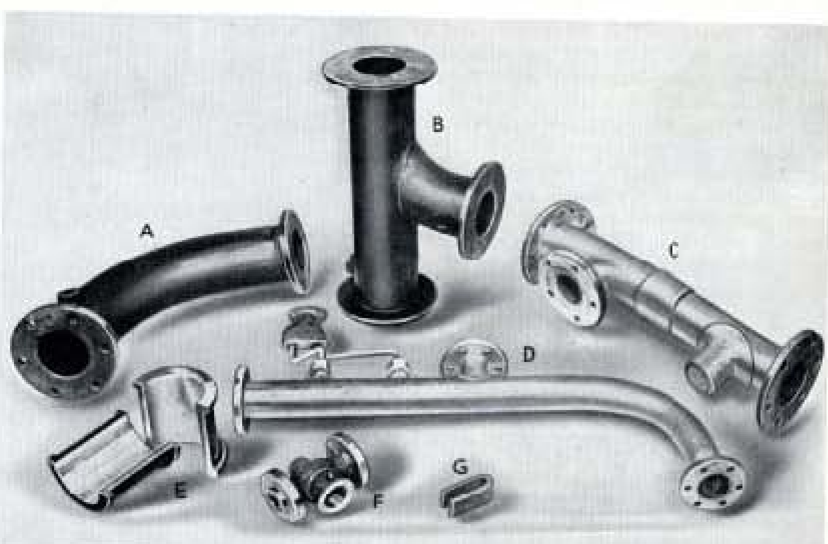


Fig. 79—Coppersmiths Admiralty passing out test jobs:—
A, Steel water cooled exhaust pipe; B, Steel water cooled tee piece; C, Copper socketed pipe with saddle throat branch and inlet pipe branch; D, Solid drawn copper pipe with saddle branch, two bosses, and pigs ear; E, Re-metalling small pair of brasses; F, Mould and cast 1" bore valve box; G, Arc welded test piece.

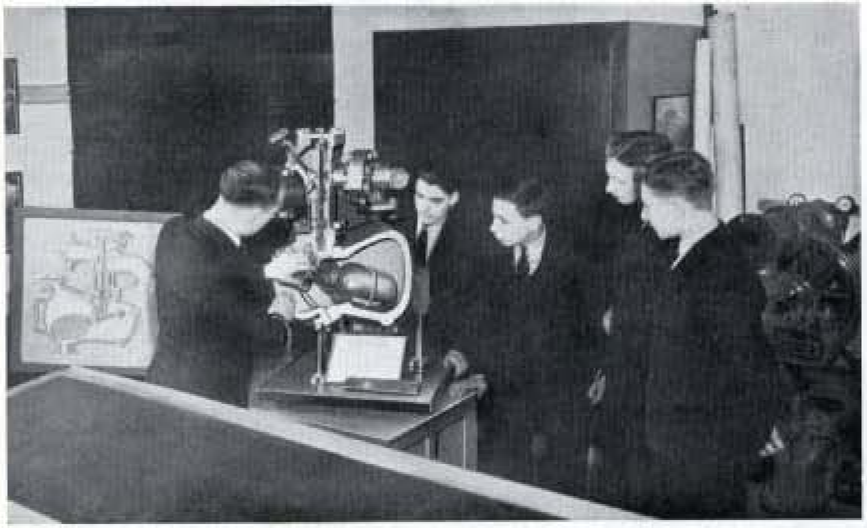


Fig. 80—In the Marine Engineering Demonstration Room where the technical aspects of reciprocating machinery, boilers, turbines and marine auxiliaries are taught. The senior apprentices are being shown the functions of a boiler feed regulator.

supplied. All drilled flanges to be welded; the jacket to be made in halves with seams along centre line of inside and outside of bend, seams of jacket to be oxy-acetylene welded and joint of jacket to flange, arc welded. The pipe before jacketing is tested to 300 lb. per sq. in. and the jacket tested to 50 lbs. per sq. inch. Time allowed—52 hours.

4a. Alternatively, make a water cooled T piece (B) from 4½" external diameter lap welded pipe to drawing from material supplied. Three drilled flanges to be welded to pipe and all seams welded. The pressure tests are the same as for (4). Time allowed—60 hours.

5. Arc weld a test piece (G) as described under item (6) of Boilermakers test jobs.

Rosyth Apprentices Aid the War Effort

This brings us to the end of our story of the practical training instruction for E.R.A. and E.A. apprentices at the Rosyth Establishment and at this point we could not add a better testimonial as to their ability and quality of work than to state that for the first three years of this war they made good over 4,000 defects for the Rosyth escort vessels, from skimming a valve to a complete refit of auxiliary machinery.

SCHOOL AND TECHNICAL INSTRUCTION

Whilst the major part of the apprentices' time is spent on trade training, a proportion is devoted to school and technical instruction. This is divided into two sections, the school subjects, mainly maths., mechanics, heat and electricity, being taken in the first two years of training. The technical subjects are taken in the final two years and include marine engineering, engineering drawing and more advanced mechanics and electricity, together with a course on workshop practice.

For this side of training at Rosyth, a well equipped instructional block is provided comprising some 17 classrooms, demonstration rooms and three drawing offices; this building also contains an information room complete with photographs, journals and pamphlets of topical interest. In this connection it is interesting to note that all apprentices devote one hour each week to current affairs and adult education.

Junior Apprentices attend school for about seven hours per week where they receive instruction from a staff of qualified schoolmasters. Part of this instruction is given in working hours. Local examinations are set for A. B. and C. Classes, and all junior apprentices are required to pass an Admiralty Examination in School subjects in D. Class before commencing technical instruction as senior apprentices. Most of the senior instruction is given in evening periods of two hours a week per subject; one of these two hour periods is devoted to:—

Mechanical Drawing, which briefly, covers the following for all apprentices:—

E Class: simple geometric constructions, Watt parallel motion, orthographic projection, simple drawings, intersections, developments and projections. Length of course—18 weeks.

F Class: involutes, cycloids and helices, etc., gear teeth, cams, drawing office practice, conventional representation of screw threads, nuts, bolts, keys, keyways, etc. Length of course—17 weeks.

G Class: correct methods of sectioning machinery details, construction of additional views, etc., free hand sketching of machine parts and production of full working drawings from sketches, isometric projection as applied to pictorial freehand sketching, production of freehand pictorial sketches on isometric principle from simple machine components, making pictorial sketches from orthographic blueprints. Length of course—18 weeks.

H Class: sketching of details of a small assembly, followed by assembly drawings, sectioned as necessary. Length of course—14 weeks.

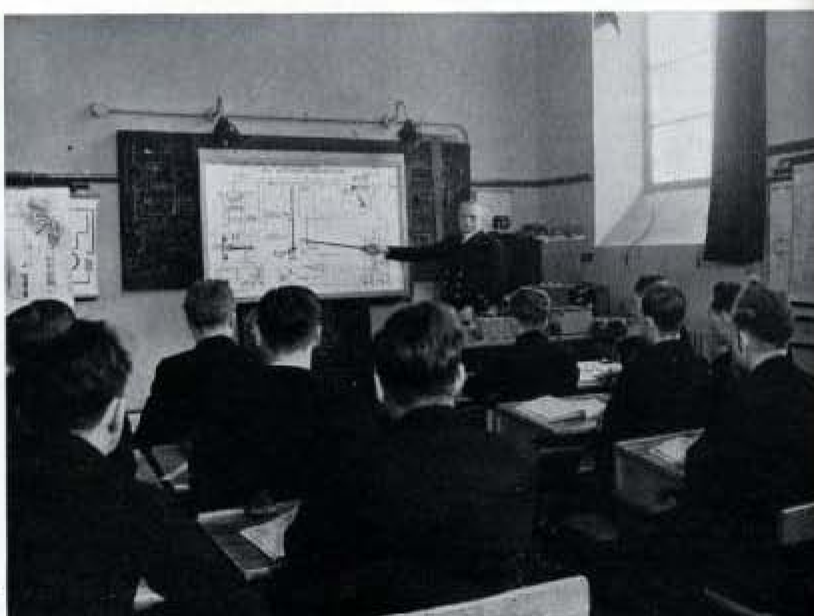


Fig. 81—H Class Electrical Artificer apprentices in a classroom, learning the functions of an oil fuel pump motor, starter and automatic controller.

The Marine Engineering Syllabus
—is for the E.R.A.s only and is also taken during two hourly evening periods per week for apprentices when in their E, F, G and H Classes, the length of each term's course being approximately 16 weeks. The subject matter is too lengthy to detail in this article, but it is sufficient to say that it covers all the technical aspects of running, maintenance and repair of reciprocating machinery, boilers, turbines, and marine auxiliaries, the latter including evaporators, refrigerators, air compressors, variable speed gears, catapults, and internal combustion engines.

A view in the Marine Engineering Demonstration Room is given in Fig. 80 and here we see apprentices receiving instruction in the operation of the Weir "Robot" Boiler Feed Regulator by means of a sectioned regulator and the adjacent diagram.

The Electrical Practice Syllabus
—for the E.A. apprentices in their E, F, G and H Classes is also taken in evening periods of two hours each, with each term's course lasting approximately 16 weeks. The very detailed subject matter is broadly classed under the headings of magnetism, electro-magnetism, current electricity, instruments and electrical machines.

In addition to the evening work, all E.R.A. and E.A. apprentices receive practical and technical day time instruction in the Factory, in their F and G Class terms (see distribution of practical work for these classes given earlier). The associated lecture rooms in the Factory contain sectional models and instructional data and in Fig. 81 we see a class of senior E.A. apprentices learning the layout and functions of an oil fuel pump motor, starter and automatic controller. It is interesting to note that the Chief Electrical Artificer taking the lecture has over 30 years continuous service in the Navy and was in the Collingwood with the present King in the Battle of Jutland. He has five sons in the Navy, one of them being in the class photographed.

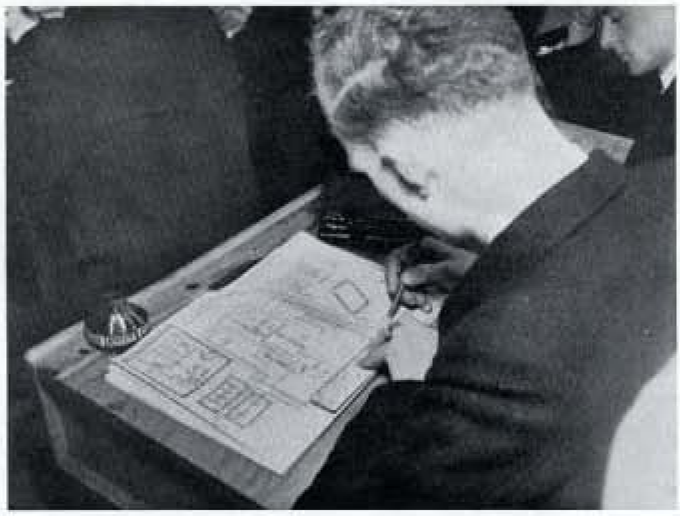


Fig. 82—An Electrical Artificer apprentice in the classroom puts the finishing touches in his notebook to an excellent diagram, in colour of a 3 ton winch motor and controller.

The next illustration, Fig. 82 shows one of the E.A. apprentices putting the finishing touches in his notebook to an excellent diagram, in colour, of a 3 ton winch motor and controller.

The Workshop Practice Syllabus
—for all E.R.A. and E.A. apprentices covers instruction periods of one hour per week whilst in A Class, and two hours per week in E and F Classes, and includes the following:—

- Production of ferrous and non-ferrous metals.
- Cutting tools and cutting speeds for various materials.
- Heat treatment of tool steels.
- The various general types of machine tools, including punching and shearing machines.
- Gauges, micrometers, etc.
- Flanging, caulking, ferruling, jointing and packing.
- Galvanising, tinning, soldering and brazing.
- All the principal processes in turning and fitting, marking off and erection of machinery; enginesmithing, coppersmithing and boilermaking, also iron and brass foundries.
- Workshop repairs to worn and defective machinery.

An Instructional Film Hut
—is attached to the Workshops so that film and "still" demonstrations can be interwoven with practical training. Here, 16 mm. talkie equipment is installed for showing internal combustion engine, marine engineering and workshop practice films, also documentary films supplied by the Admiralty for adult educational purposes. In addition still projectors are available for use in lecture work, a typical "shot" describing the action of a geared oil pump being featured in Fig. 83. The still projectors are also used in the classrooms; the operating of the equipment in the Film Hut is done by a Wren cinema projectionist.

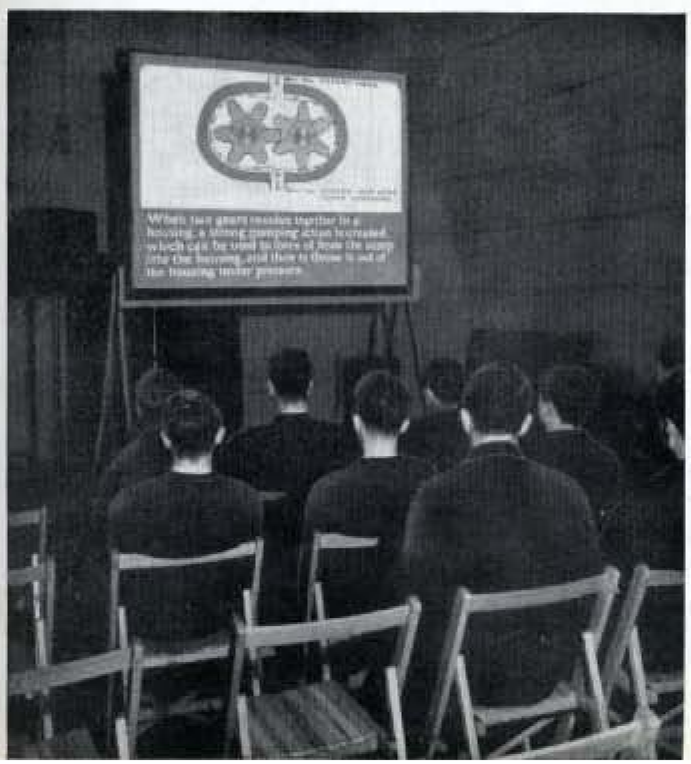


Fig. 83 (Left)—In the Instructional Film Hut the action of a geared pump is thrown on the screen by a still projector. Technical instruction is aided by the extensive use of a 16 mm. film projector and sound unit.

Up to this point in our article we have considered the workmanship and technical training at some length. It is however part of the scheme that a healthy responsible artificer should be trained who will make a good Chief Petty Officer, for it must be remembered that an artificer reaches C.P.O.s rate within 18 to 24 months of leaving his training establishment. Turning therefore to the apprentices' other activities we deal with them broadly under the heading of—

Fig. 84—A view in the Main Galley showing steam cookers in the foreground with domestic ovens in the rear.

MESSING, RECREATION AND PHYSICAL TRAINING

The provision of good feeding facilities is essential in establishing the basis of a sound constitution and the Galley at Rosyth maintains a high standard in this respect. The view reproduced in Fig. 84 shows some of the equipment installed which includes four steam Jackson boilers, six steam ovens, five domestic type gas ovens, six range ovens with hot plates, one gas grill, a three-pan gas fish fryer, five steam jacketted coppers, two long counter hot plates, an electric mincing and mixing machine and an electric potato peeler.

850 persons are victualed from this galley daily and all sit down to their meals at the same time. The reproduction in Fig. 85 of part of a typical General Mess Menu shows the variety of food provided; the additional items per day, not listed, include tea, sugar, milk, bread and butter.

S.—109. T.S.—7c. (Established—March, 1911.) (Revised—November, 1927.) H.M.S. M.T.E., ROSYTH.

GENERAL MESS MENU.

For week ending 3rd February, 1945.

Day and Date	Breakfast	Dinner	Tea	Supper
Sunday, 28th Jan.	Bacon & Egg	Potato Soup Roast Pork Stuffing, Apple Sauce Runner Beans Roast Potatoes Queen Pudding	Bakewell Tarts & Jam	Soup Pressed Brisket & Pickles.
Monday, 29th Jan.	Porridge Grilled Sausages	Pea Soup Beef Pies & Puddings Carrots Boiled Potatoes Cremola Pudding	Sardines	Beans & Chips.
Tuesday, 30th Jan.	Corn flakes Smoked Haddock	Scotch Broth Roast Lamb Cabbage Mashed Potatoes Apple Tart & Custard	Chocolate Cake	Rissoles & Peas.
Wednesday, 31st Jan.	Fried Bread & Beans	Gravy Soup Roast Beef Cauliflower Boiled Potatoes College Pudding & Sauce	Lemon Curd Cakes	Welsh Rarebit.
Thursday, 1st Feb.	Bacon & Egg Omelette	Vegetable Soup Ragout of Beef Haricot Beans Boiled Potatoes Nelson Tart	Cookies	Sausage en Casserole.
Friday, 2nd Feb.	Wheat Flakes Liver & Saute Potatoes	Valetta Soup Roast Lamb Cabbage Mashed Potatoes Monmouth Pudding & Sauce	Syrup	Fried Fish & Potatoes
Saturday, 3rd Feb.	Sausage & Scrambled Egg	Mulligatawny Soup Stewed Steak Marrowfat Peas	Marmalade	Soup

Fig. 85—This reproduction of part of a General Mess Menu shows the variety of food provided; the additional items per day, not listed, include tea, sugar, milk, bread and butter.

The Junior and Senior Apprentices Dining Halls are situated one on either side of the Galley; the view in Fig. 87 is taken looking towards the entrance doors to the Senior's hall, the six range ovens being on the left. As the boys come in they line up at the hot plate under their respective Division notices, i.e. Grenville, Benbow, Duncan, Howe, Hawke and Keppel. The Senior Dining Hall, having a seating capacity for 360, is featured in Fig. 86 the Wrens having just completed the laying of the tables.

The Canteen (Fig. 88) is a favourite rendezvous for the apprentices off duty and is administered by N.A.A.F.I. The C.P.O. Canteen Manager, seen behind the counter, maintains an extremely wide range of goods. N.A.A.F.I. also supplies part of the victualling and sports requirements of the establishment.

The Junior Recreation Room (Fig. 89) provides ample room for leisure activities; the tables and periodical stands look rather bare in the illustration, but this was due to the late arrival of papers on the Sunday morning the photograph was taken. The new entry Rodney Division apprentices, featured in the early part of our training story, will be seen in civilian clothes in the foreground (R. A. Edmonds being on the extreme right); Air Apprentices of the Keppel Division are at the rear.

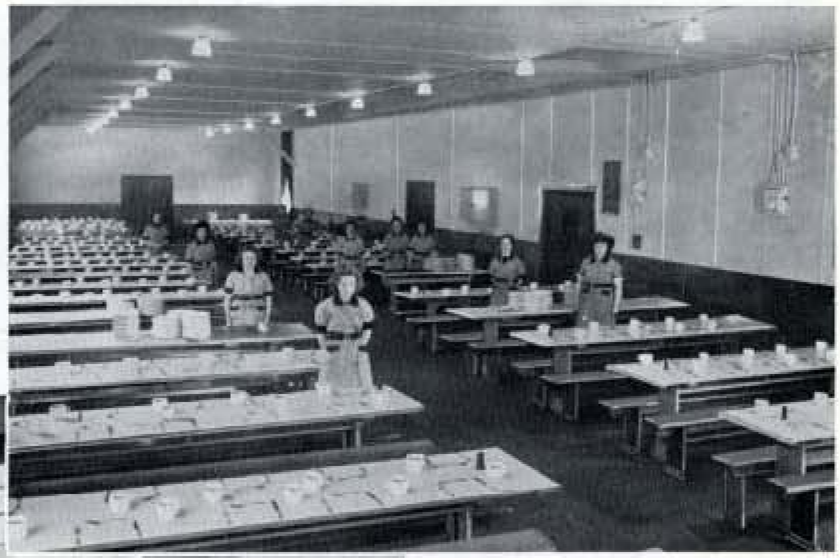


Fig. 86 (Above)—This Senior Dining Hall has a seating capacity of 360, and is the same size as the Junior Dining Hall on the other side of the Galley.

Fig. 87 (Above)—Another view in the Galley looking towards the entrance doors to the Senior Dining Hall; the boys line up at the hot plate under their respective Division notices, i.e. Grenville, Benbow, Duncan, Howe, Hawke and Keppel.

★

Fig. 88 (Below)—The Canteen carries an extremely wide range of goods from cakes and coffee to lighters, fountain pens, ink, etc.

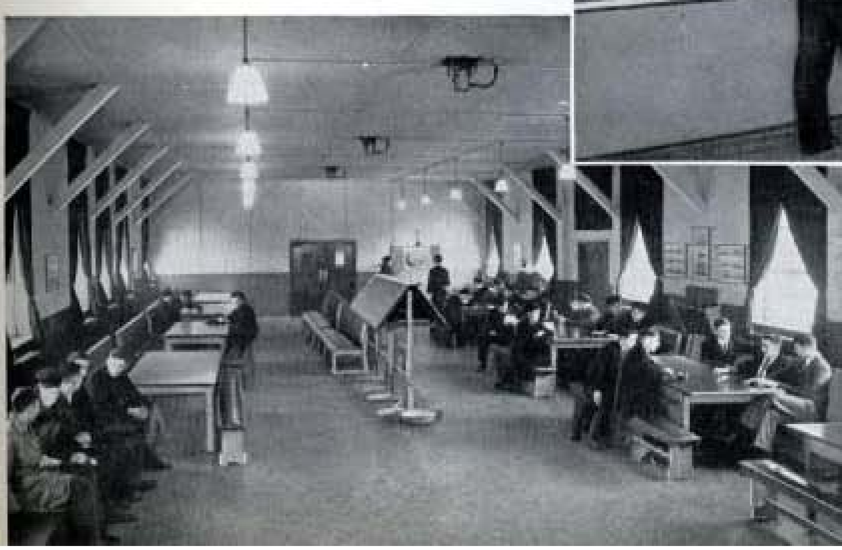


Fig. 89 (Left)—A view in the Junior Recreation Room; absence of reading matter was due to the late arrival of daily papers. The new entry Rodney apprentices, featured in the early part of this section, will be seen in the foreground (in civilian clothes); Air Apprentices of the Keppel Division are at the rear.

Fig. 90—A corner of the Reading Room and Library for the use of all apprentices. On the wall is the ensign of H.M.S. Penelope, still black with smoke from the smoke screen put up during her exploit in helping to save a Malta convoy.

The Reading Room and Library for all apprentices contains fiction and reference books, including general knowledge and technical subjects. One of the Schoolmasters (R.N.) of Warrant Officer rank is detailed as librarian and is assisted by apprentices who volunteer for the job.

A corner of the room is illustrated in Fig. 90 and on the wall will be seen a tattered ensign which has an interesting history. This ensign was flown by the cruiser H.M.S. Penelope whilst escorting a convoy to Malta under Admiral Vian, when the Italian battle fleet came out to prevent our much needed supplies from getting through. Manoeuvring into the right wind quarter the British cruisers were ordered to lay a smoke screen which so effectively concealed our movements that our escorting craft, light in comparison with the Italian ships, were able to dash backwards and forwards through the screen to deliver crippling blows on the enemy fleet. Still black with the acrid oily smoke, the ensign was presented to the R.N.A.T.E. Rosyth where it hangs to-day as illustrated. (The story of this famous action is admirably told by C. S. Forester in his book "The Ship.").

The System of Physical Training

One feature of our visit to Rosyth was to note the lavish facilities available for physical and recreational training, including a well equipped gymnasium, one of the finest swimming baths in the country and extensive playing fields complete with athletic arena. All types of games are played from rugger, soccer, hockey, cricket, etc., down to table-tennis, chess and draughts; all kinds of athletics are also encouraged including field events such as javelin-throwing, discus, putting the shot, etc.

Physical Training is divided into two groups, compulsory and voluntary. Under the former, the Junior Divisions (i.e. A, B, C and D Classes) are given two periods of 50 minutes P.T. per week and the Senior Divisions (i.e. E, F, G and H Classes) one period of approximately one hour. Before leaving the Junior section, D Class is examined in a physical training table laid down by the P. and R.T. School and Admiralty prizes are awarded to the two outstanding performers. Admiralty prizes are also awarded to the best performer and runner-up in the Senior and Junior vaulting and agility competitions which are held towards the close of the Easter term.

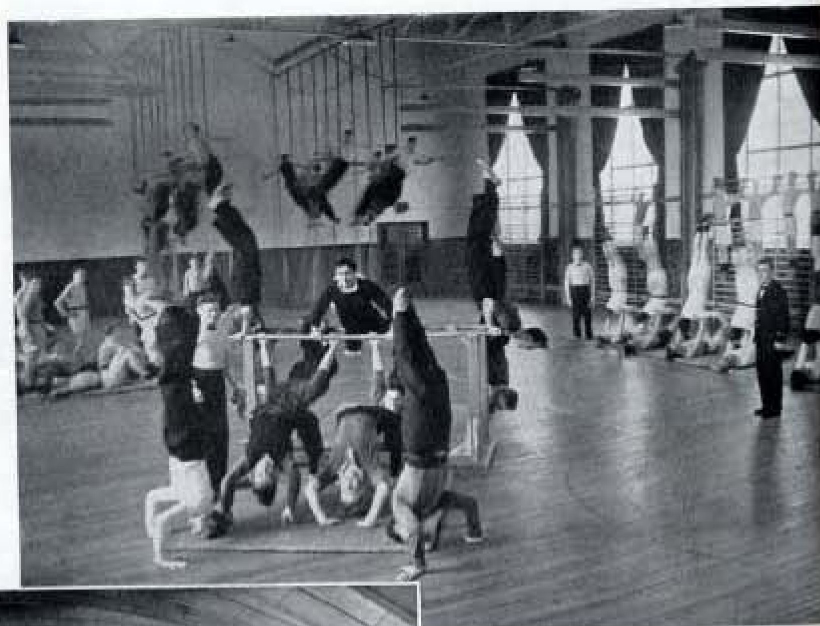


Fig. 91—Senior apprentices preparing for a physical training display in the well equipped gymnasium.

Fig. 92 (Left)—At the Rosyth Training Establishment is one of the finest indoor swimming baths in the country; 100 ft. long by 50 ft. wide, and with both air and water temperature thermostatically controlled, it offers excellent facilities for recreation and swimming instruction.

The illustration Fig. 91 shows Senior apprentices preparing for a physical training display in the gymnasium.

For voluntary physical training the gymnasium is open every evening for practice in vaulting, agility, parallel and horizontal bar work, boxing and fencing, for which a staff of expert instructors is always present. Boxing is a popular sport at Rosyth and several apprentices have been successful in local amateur competitions.

Swimming. All apprentices, on joining, are tested in the Admiralty Provisional Swimming Test. Those who fail are graded backward swimmers and put in two special practices a week, in their own time, until proficient. The bath which, as previously stated, is one of the finest in the country, (see Fig. 92) is available every evening for free practice in swimming, diving, life saving and water polo, and instructors are always on duty for the purpose of coaching. Incidentally, a very strong representative team can be raised to challenge local Public schools and Universities.

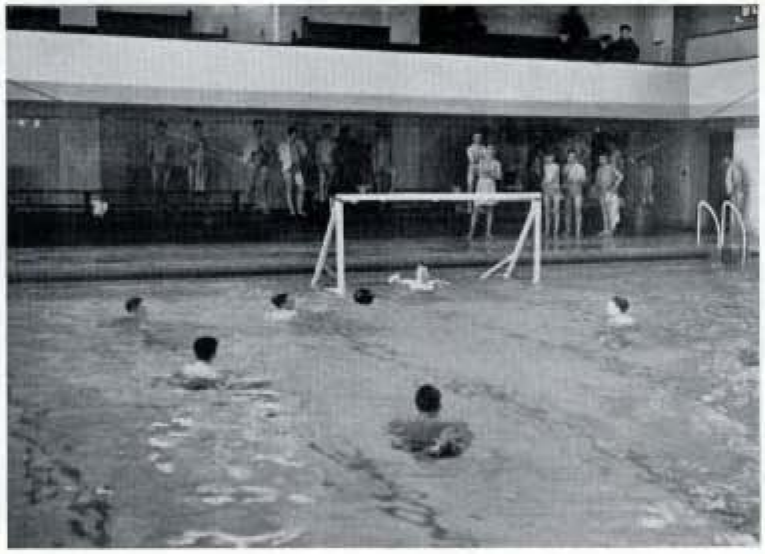


Fig. 93—A game of water polo in the Swimming Baths; facilities are afforded for practising diving, life-saving and water polo in free practice periods

Fig. 94—A game of Rugby football in progress on one of the Rugby pitches laid out on the Training Establishment Recreation Grounds.

A view of a game of water polo in progress is given in Fig. 93; the bath, being 100ft. long by 50 ft. wide and 12 ft. at the deep end (with both air and water temperature thermostatically controlled) provides ample scope for this sport.

Organised Recreation is one of the compulsory features of training, and all Divisions take part in this from 1.30 p.m. to 4.30 p.m. one afternoon a week. During this period, games are organised so that everyone takes part in some form of recreation. The system is arranged on inter-divisional lines between the Senior and Junior sections, the competitions in which the Divisional teams compete being as follows, and in the order mentioned:—

Winter—Rugby, soccer, boxing, hockey, cross country and P. and R.T.

Summer—Athletics, cricket, boat pulling, water polo and swimming.

Saturday afternoon is always devoted to voluntary recreation but every effort is made to provide as many different types of games, etc., as possible; as an encouragement, apprentices taking part in organised games on Saturdays are granted an extension of leave of one hour, except H Class which normally has late leave.

The next series of pictures show various sports in progress. Fig. 94 for instance features an inter-divisional league rugger

Fig. 95—The Recreation Grounds offer every facility for outdoor sports and recreational displays in suitable weather. Here we see rope climbing as part of an obstacle race.

match, whilst Fig. 95 shows rope climbing as part of an obstacle race, the final of which is the climbing up and over an inclined board made slippery with soft soap (see Fig. 96). A typical P.T. tableau is given in Fig. 97.

The Boat Pulling Regatta on the River Forth is one of the annual events of the Training Establishment and in Fig. 99 we show a typical start, the cutter crews getting well under way in Fig. 98; part of the Forth Bridge can be seen in the background.

In addition to these sporting activities there are other forms of recreation. The apprentices run their own brass band which plays at all parades (see Fig. 103), they also have a dance band composed entirely of apprentices, which provides the music at their own socials and dances.

There are two cinema shows in the large hall every week and in addition various Divisions form their own concert parties. A music club is in being and has a fine selection of gramophone records from which recitals are given several evenings a week. Billiard rooms for the Senior and Junior apprentices are being constructed and will shortly be available.

Fig. 96—Competitors in an obstacle race climb up and over an inclined greasy board as one of the features of an athletic sports occasion.

Fig. 97—A typical tableau in one of the outdoor physical training displays.

A well illustrated and topical magazine entitled "Artifex" which deals in a light vein with the activities of the Establishment is produced twice a year and is very popular with apprentices and ex-apprentices.

Apprentices Welfare

Included in the facilities available for the general welfare of the apprentices is a barber, bootmaker and tailor, whilst in Fig. 100 we show a Surgeon Lieutenant (D), known throughout the Navy as "Toothy", busy on a job of work in his well-equipped Dental Surgery.

The view in the Sick Bay, Fig. 101, which is under the control of a Surgeon

Fig. 98—Cutter crews well under way in the annual regatta; part of the Forth Bridge can be seen in the background.

Fig. 99—The Boat Pulling Regatta on the River Forth is one of the annual events of the Training Establishment; here is a typical start.

Fig. 100—A Surgeon Lieutenant (D) (known throughout the Navy as "Toothy") finds a job of work to do in his well-equipped Dental Surgery at the Training Establishment.

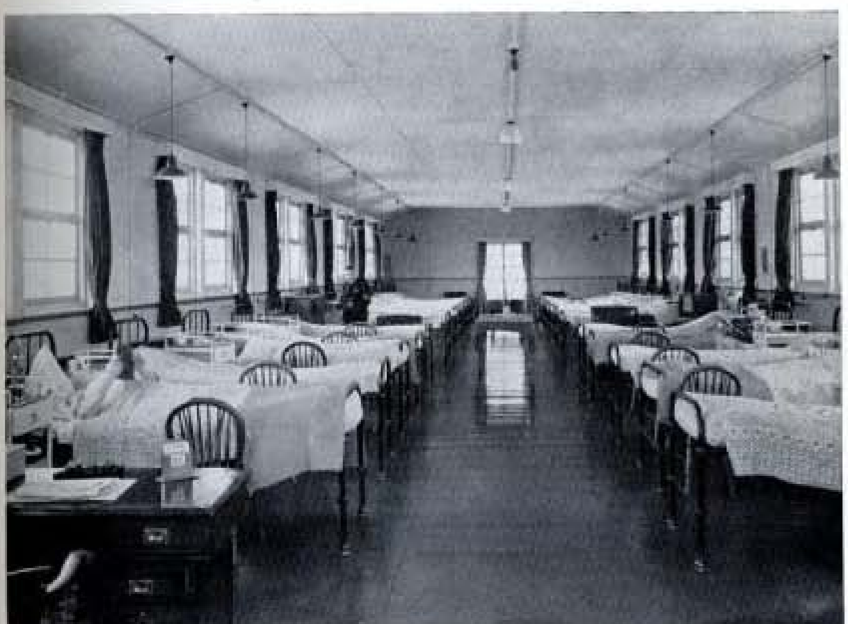


Fig. 101—The empty beds in the spotless Sick Bay speak well for the general health of the apprentices under training.

Commander, speaks well for the general health of the apprentices under training.

The spiritual welfare of the boys is looked after by the Chaplain, who arranges that the Chapel is always open for prayer, meditation, Bible reading or the perusal of the books and pamphlets in the bookcase. Religious instruction is given once a week for 35 minutes and about 85 per cent. of the C. of E. apprentices are confirmed before leaving the establishment (some, of course, are confirmed before joining).

We chose a non-service time to get the best view of the interior of the Chapel. (Fig. 102).

Our concluding feature concerns—

The Divisional Officer Period, an allocation of 35 minutes a week during the first year of instruction, in which talks are given on Service life and matters generally. On these occasions apprentices have opportunities to ask questions on any subject they like and not necessarily concerned with their training. The boys come to look upon the D.O. as "father", they go to him about clothing, with requests for leave, in fact his assistance is sought for everything they want.

On the other hand the Divisional Officer is expected to know every apprentice and issues a report on individuals when requested; such reports carry a lot of weight when a selection for promotion to Cadet (E) is made.

Fig. 102 (Right)—The Chapel is always open for prayer, meditation, Bible reading or the perusal of the books and pamphlets in the bookcase; we chose a non-service time to get the best view of the interior.

Fig. 103—For our last picture at the Rosyth Training Establishment we show Sunday morning Divisions, with band, on the Parade Ground; as will be seen, wintry conditions prevail, with snow on the ground.

As we take our leave of Rosyth, with the view of Sunday morning Divisions on the Parade Ground (Fig. 103), we trust that this detailed story has given a comprehensive insight into the thoroughness and scope of the training of Naval Artificers.

E.R.A.s at Sea

The last three photographs in this section are included to show the type of equipment the E.R.A.s training enables them to handle at sea. In Fig. 104 we see E.R.A.s at the throttles of a recoprocating engine on board a frigate. In Fig. 105 the E.R.A. on watch in a corvette is receiving a message from the bridge via the voice pipe, while Fig. 106 depicts the engine room of a submarine used for instructional purposes.

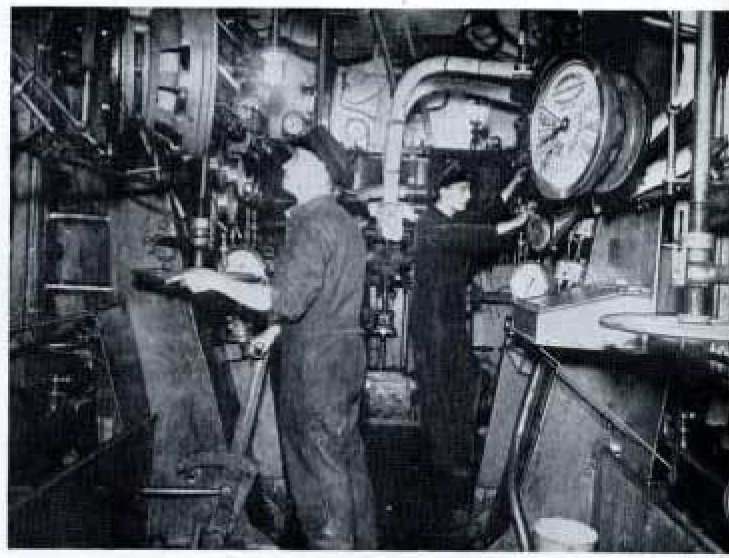


Fig. 104 (Right)—E.R.A.s at the throttles of a reciprocating engine on board a frigate.

Fig. 105 (Below)—The E.R.A. on watch in a corvette receiving a message from the bridge via the voice pipe.

Fig. 106 (Below)—A view in the engine room of a submarine used for instructional purposes.

The Training of Engineer and Air Engineer Officers

To attempt to deal in detail with the syllabus of instruction, for what is virtually a university course, for the training of commissioned officers of the Engineering Branch of the Royal Navy, would develop the training angle to such an extent as to outweigh the broader sphere of activities of the Branch, which is the main theme of this article. We propose therefore to touch this subject lightly, but at the same time to endeavour to convey, by means of a variety of photographs, some of the fundamentals involved.

Except for a brief mention of the training of Air Artificers in the previous section, our story has so far been concerned with personnel engaged on the marine engineering side, this section however, gives the first link with the aeronautical engineering field which forms the subject matter of the latter sections in this issue.

To obtain the information and photographs now given we visited—

The Royal Naval Engineering College, Keyham

—the purpose of which is to give a sound basic training in Engineering so that officers may later specialise in the many forms of engineering in the Royal Navy. Although specialisation is taken up at a later date, *all* Engineer Officers are given basic training in Aeronautical Engineering.

Among the positions held at present by Keyham trained officers are those of the Engineer-in-Chief of the Fleet, the Director of Aircraft Maintenance & Repair, the Deputy Director of Dockyards, and the Chief Inspector of Gun Mountings.

To this end the College has served continuously—except for one short interruption during the war of 1914/18—since it was established in 1880 in the buildings which it still occupies at Keyham, adjoining the Devonport Dockyard. Prior to 1880, Naval Engineer Officers were trained in the Royal Dockyards under a system of apprenticeship, but subsequently the majority of them received their professional education 'at Keyham'.

The College is under the charge of a Captain of the Engineering Branch, assisted by two Commanders from the same branch of the Service, one for Administrative duties and the other as Director of Studies. The teaching staff is composed almost entirely of naval officers, the engineering and instructor sections being represented in approximately equal proportions.

The Course of Training, which occupied six years in 1880, has been repeatedly made shorter and more intense; under present war-time conditions it is limited to just under four years, including a period of about eight months in the middle of the course which is spent on active service at sea. Most of the officers joining the College now, do so with the rank of Cadet, at an average age of about 18 years, shortly after their entry into the Navy (these include a selected number of Artificer Apprentices as mentioned at the commencement of the artificers training section); other officers join the College at about the same age, after several years training as Cadets at the Royal Naval College, Dartmouth.

The first year of the College course is devoted mainly to continuing the general education of officers under instruction, with the object of laying, in classroom and laboratory, a firm foundation of mathematical and scientific method in preparation for later technical studies; a short time is also spent on history, English and a foreign language.

After the first year, technical education gradually dominates the course. A thorough theoretical training in marine and electrical engineering is supplemented by practical work in the Engine Test Shop and Electrical Workshops of the College, whilst instruction in thermo-dynamics and metallurgy enables officers to master the physical properties of the materials with which they will spend their time in the Service.

The College has its own Fitting Shop which plays an important part in the course and other trades are studied in the Dockyard, so that Engineer Officers may have the varied knowledge necessary to direct the labours of the many skilled ratings found in a modern warship. Wider interests are served by the study of ship construction, machine design, mechanical drawing and the economics of engineering; a short course in aero-engines has also recently been added to the curriculum. The satisfactory completion of the College course is accepted by the Institution of Mechanical Engineers as a qualification for Associate Membership.

Engineering skill is, however, only one of the two main objects, and the highest importance is attached to the development of officer like qualities. On the parade ground, in the administration of the College, and in all recreational activities, officers under instruction are given the opportunity to acquire those powers of command and that understanding of men which will be so essential to them in the Fleet, whilst special lectures are provided to equip them for the duties of Divisional Officers.

For many years the College has trained Engineer Officers for the naval forces of the Dominions and India, and during the present war officers of several Allied navies have received instruction. The war has also brought other tasks, including the engineering training of a large number of officers of the Air Branch of the Royal Naval Volunteer Reserve, and the establishment of a Fire-fighting School. Young officers of the Royal Corps of Naval Constructors have also been accommodated at the College during their first year of training.

The New College Buildings at Manadon

Even before the War, it had become apparent that the College needed larger and more modern premises with better educational environment, and the site shown in the aerial view Fig. 107 has been acquired at Manadon, on the outskirts of

Fig. 107 (Right)—An aerial view of the new Royal Naval Engineering College buildings at Manadon, on the outskirts of Plymouth.

Fig. 108—A general view in the new Drawing Office at Manadon, showing a class of newly joined Cadets receiving preliminary instruction in mechanical drawing; the room has accommodation for 50 at a time and the equipment includes six drafting machines seen at the far end.

Plymouth. Many instructional buildings, including three hangars, an aero-engine test bench and engine repair shop for training in aero-engineering, are already in use, and in due course, whilst preserving its traditional connection with Devonport Dockyard, the College will be transferred to Manadon entirely.

The foregoing details, having served as an introduction to this section, we now propose to give a little more detailed information concerning the syllabus of instruction and in particular to the portions we illustrate with photographs. For this purpose we have divided the story into two sub-sections comprising the marine and aeronautical branches respectively, the first being dealt with under the title of—

THE TRAINING OF ENGINEER OFFICERS

Officers qualifying in Engineering undergo a course of training which is divided into three periods (1) comprising four terms (I—IV) of fourteen weeks each, (2) a period of eight months at sea, and (3) five terms (V—IX) of fourteen weeks each. The subjects taken are collated into five groups, but as it will be impossible for us to touch on all of them, we list them at the outset to show the range covered:—

Group 1

- Workshop Appliances I and II
- Mechanical Drawing
- Ship Construction
- Marine Engines and Boilers
- Electrical Engineering I

Group 2

- Electricity and Physics
- Mathematics I
- Mechanics I and II
- Thermodynamics I
- Chemistry and Metallurgy
- History
- English
- Foreign Language

Group 3

- Workshop Practice
- Care and Operation of Machinery
- Testing of Engines and Boilers
- Aero Engines—theory and practice
- Aeronautical Workshop Practice

Group 4

- Marine Engineering
- Machine Design
- Mathematics II
- Thermodynamics II
- Mechanics III

Group 5

- Electrical Engineering II
- Electrical H.P. Distribution and Service Electrical Gear
- Care and Operation of Electrical Machinery, and Electrical Workshop Practice
- Economics of Engineering
- Chemistry and Metallurgy

Our first illustration Fig. 108 introduces the subject of—

Mechanical Drawing and depicts a general view in the Drawing Office at Manadon showing a class of newly joined Cadets receiving preliminary instruction in the use of instruments. The room has accommodation for 50 at a time and the equipment includes the six Mavitta drafting machines seen at the far end.

This subject is divided under two headings (*a*) mechanical drawing and (*b*) free hand drawing. Having mastered the preliminary technique in (*a*) the instruction develops up to the drawing of machinery items, to various scales, from freehand sketches, without further reference to the originals; certain drawings are also finished and tinted in conventional colours. The syllabus under (*b*) concludes with the making of fully dimensioned freehand sketches of engine parts, giving all the necessary views and information for the completion of a finished drawing.

Workshop Appliances and Practice are the next subjects we deal with and these are considered under two sub-headings (*a*) Fitting Shop and (*b*) Dockyard Shops. Instruction in these shops is arranged to ensure that officers obtain an adequate knowledge of workshop methods, the work undertaken being calculated not only to stimulate interest, but to produce a high standard of practical workmanship. Repetition jobs are avoided, those selected being

Fig. 109 (Right)—Engineer Officers in the new Fitting and Machine Shop at Manadon. Here they acquire a thorough knowledge of elementary fitting work and the ability to use all the hand tools and workshop machines usually fitted on board H.M. ships.

with a view to encouraging ingenuity in devising methods of carrying out repairs on board, and to provide as thorough an understanding as possible of the diversity of uses of the machines and tools available.

During the Fitting Shop periods the instruction consists almost entirely of practical work under the supervision of competent instructors, supplemented by amplifying lectures. Commencing with elementary bench and machine work the course progresses through various machining processes in the making of such things as square thread bolts, three-start threaded spindles, double turned stepped piston rings and oil fuel sprayer components etc., up to advanced machining calculated to show the variety of ways of doing both simple and awkward jobs. At this stage general toolroom practice is undertaken including the grinding of limit gauges to various fits and the heat treatment of tool steels and springs etc.

The illustration Fig. 109 shows officers under instruction in the new Fitting and Machine Shop at Manadon.

After the sixth term the instruction becomes more general and concentrates mainly on general refitting of ships machinery, including adjustment, overhaul, examination and maintenance of reciprocating steam engines, diesel engines, condensers, air compressors, turbo-fans and turbo-dynamos, manoeuvring and safety valves etc. More specialised machine work is also undertaken such as helical gear cutting.

In the view reproduced in Fig. 110 we see seventh and ninth term officers undertaking top overhauls on various motor boat engines on which they check plugs, tappet clearances, oil pump, filters etc. and adjust the clutch and ignition settings,

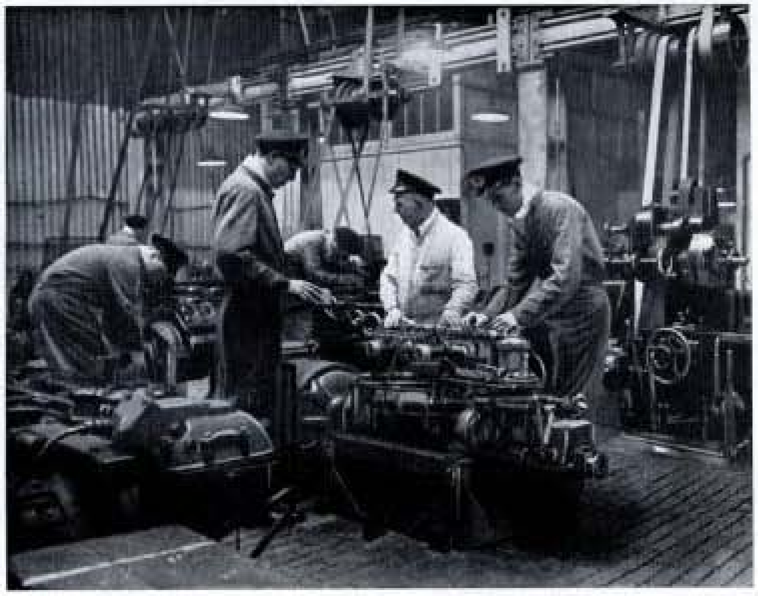


Fig. 110—As part of the general refitting instruction given to officers during their seventh and ninth terms in Workshop Practice, they have to strip down and refit various reciprocating engines.

It is interesting to note that almost all the instruction in this shop is carried out by active service or retired Chief E.R.A.s.

In the Dockyard Shops the instructors are skilled dockyard tradesmen and here the officers carry out practical work in the Pattern Shop, Foundry, Boiler Shop, Engine Smithery and Coppersmith's Shop. As far as possible, all raw materials required for the Fitting Shop are prepared by the officers under instruction in the appropriate Yard Shops.

For our next practical subject we have—**The Testing of Engines and Boilers** which is undertaken in the Engine Test Shop by officers in their seventh, eighth and ninth terms. Trials are carried out on the various machines and equipment, instruction being given in starting, stripping and watchkeeping; opportunity is also taken during the trials for co-ordinating the thermodynamics learnt in earlier terms.

The I.C.E. section of the shop is equipped with test benches fitted up with modern high speed petrol and diesel engines on which the trials are run to ascertain specific consumption, coupled with which fuel loops are plotted at various loads and speeds. The effects on performance of altering the times of ignition or injection are also observed and exhaust gases are analysed for various running conditions.

The working of a modern jerk pump for compression ignition engines is examined and pumps and injectors are stripped, cleaned and re-assembled. Other equipment installed includes a Farnborough indicator and a cathode ray oscillograph for observing the various working conditions of high speed petrol engines.

The type of engine on the test benches is typified by the 1,200 h.p. Sterling Admiral motor torpedo boat engine shown in Fig. 111 beyond which is a 750 h.p. (520 K.W.) General Motors diesel engine. The centre officer in the illustration is in the Royal Canadian Navy.

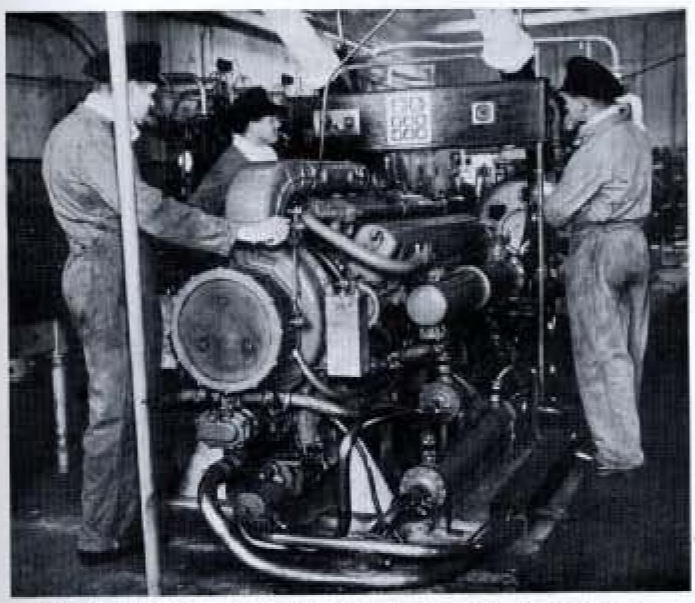


Fig. 111—This 1,200 h.p. Sterling Admiral motor torpedo boat engine is one of several internal combustion engines installed in the Test Shop on which officers in their seventh and eighth terms can apply thermodynamics to practice.

In the next picture Fig. 112 we show a Ford V8 spark ignition engine, of 95 b.h.p. at 3,600 r.p.m., coupled up to a Heenan & Froude hydraulic brake and wired to a cathode ray oscillograph from which a pressure curve from any cylinder can be obtained and thus the timing of the engine checked and the performance estimated. The curve seen on the indicator rises uniformly from the base line to maximum compression pressure, then sharply up to maximum firing pressure, falling away on the exhaust stroke down to the base line again. The glasses on the wall are for measuring the petrol consumption (note the striped background which is converted to horizontal lines when looking through the liquid and so shows the level at a glance).

Located in the same section is a 32,000 B.T.U.s CO_2 refrigerating plant with pre-cooler (Fig. 113) which is the same as fitted to all ships of the cruiser class and larger. Trials are run under varying conditions of brine and circulating water temperatures to observe the effect on output and co-efficient of performance.

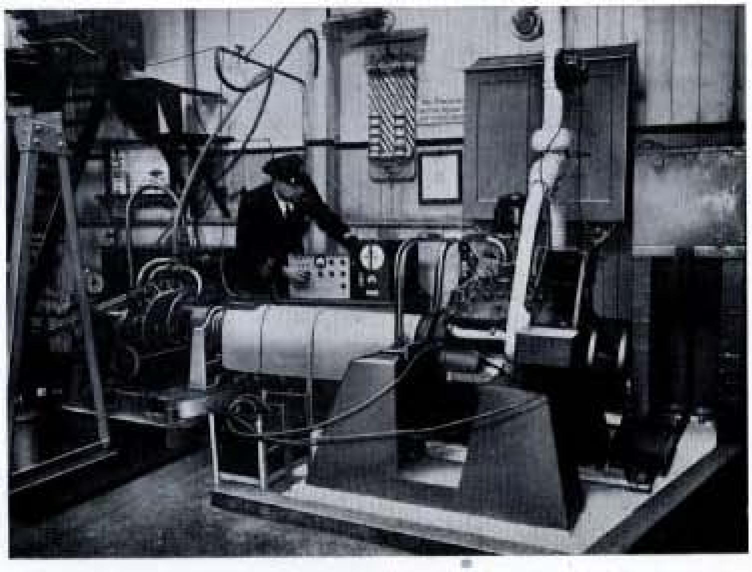


Fig. 112—This Ford V8 engine, which develops 95 b.h.p. at 3,600 r.p.m. is coupled up to a Heenan & Froude hydraulic brake as well as to a cathode ray oscillograph on which the effect of ignition timing is demonstrated.

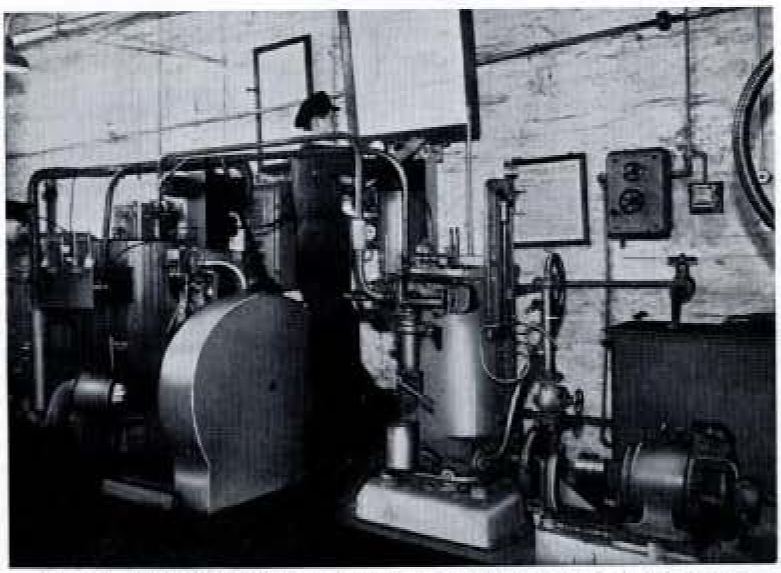


Fig. 113—This refrigerating plant in the Engine Test Shop is the same as fitted to all ships of the cruiser class and larger. Running under varying conditions of brine and circulating water temperatures, tropical region results can be simulated.

On the wall above, is the heat-entropy chart (right) for CO_2 gas, on which is shown the refrigerating cycle; the left chart is a diagrammatic layout of the pre-cooler, a fitting brought into use for tropical service.

With his head just visible on the left of the photograph is a Polish Sub-Lieutenant reading the temperature of the gas inlet to the evaporator, the centre officer, an acting Lieutenant in the Royal Canadian Navy, is standing at the rear of the pump, adjusting the precooler inlet valve to give correct pressure; the condenser is situated to the right.

The Steam Section of the Engine Test Shop comprises a range of equipment including boilers of the small tube Yarrow and oil burning Babcock & Wilcox types, on which furnace temperatures can be observed by optical pyrometers and boiler efficiencies deduced. There is also an evaporating plant for distilling boiler feed water from sea water, optical and electrical torsionmeters from which can be calculated crank effort diagrams and the torque of a reciprocating engine and its BHP.

The B.T.H. turbo-dynamo, Fig. 114 is used for demonstrating the water consumption and thermal and overall efficiency of a turbine of this type. In the illustration, the Royal Canadian Navy Sub-Lieutenant on the left is reading the absolute vacuum in the Kenotometer situated above the condenser, whilst at the turbo generator on the right an acting Lieutenant of the Royal Indian Navy is noting the readings of the steam receiver and stage pressures.

Fig. 114 (Right)—A Royal Canadian Navy Sub-Lieutenant (E) (left) and a Royal Indian Navy Acting Lieutenant (E) are respectively reading the absolute vacuum in the Kenotometer and noting the readings of steam receiver and stage pressures on the B.T.H. Turbo-Dynamo in the Engine Test Shop.

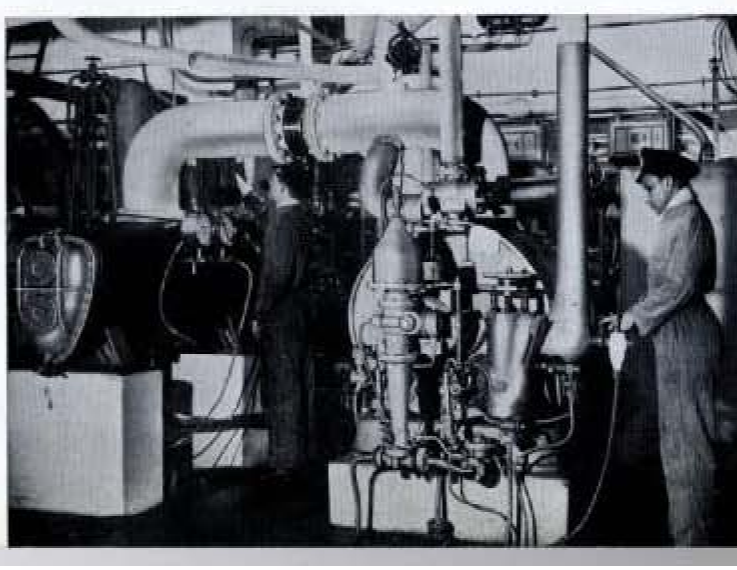


Fig. 115—The testing of boiler and feed water is done in the Engine Test Shop. By means of this equipment it is possible to determine the quantative alkalinity and salinity of the water used.

Fig. 116—Two Lieutenants (E) in their passing out terms (9th) calibrating an ammeter by means of a Crompton potentionmeter under the eye of their lecturer in the Low Power Electrical Laboratory.

A modern Drysdale pump is also installed and trials are made to find out the impeller, pump and pipe characteristics.

The testing of boiler and feed water is carried out by means of the apparatus illustrated in Fig. 115 by which it is possible to determine the quantative alkalinity and salinity of the water used. Owing to the ever present problem of corrosion in boilers, great importance is attached to these tests in which nitric acid and silver nitrate are used for titration and phenol phthalein and potassium chromate are used as indicators.

A rough titration can also be produced by the use of the standard drop bottle which gives .07 millilitres per drop. The number of drops when a brick red precipitate persists throughout the water in the tube enables the grains per gallon of chlorine (and therefore of salt) in the water to be calculated. (A more elementary description of this test is given in the section dealing with the training of stoker ratings).

We next turn our attention to—

The Electrical Engineering Group in which the training is designed to give officers a sufficient knowledge of theory and workshop practice to enable them to deal with problems of maintenance and repair of the electrical machinery which will be under their supervision. This consists of a lecture course under the title 'Electrical Engineering', practical work in the Electrical Test Shop and Electrical Workshops and instruction in Electrical High Power Distribution and Service Electrical Gear.

The illustration Fig. 116 is taken in the Low Power Electrical Laboratory where modern galvanometers and requisite instruments are available for the testing of instruments, the use of potentiometers, the determination of B/H curves by the ring method and Hysteresis losses in samples of iron by Hopkinson permeameter, using a fluxmeter. Two large 500 ampere-hour batteries are installed for supplying the low voltage required. In the photograph to which we refer, two ninth term Lieutenants are calibrating an ammeter by means of a Crompton potentiometer, under the eye of their lecturer.

The next illustration, Fig. 117 gives us a view in the High Power Electrical Laboratory where the equipment includes all types of motors and generators, both A.C. and D.C. The current as received from the

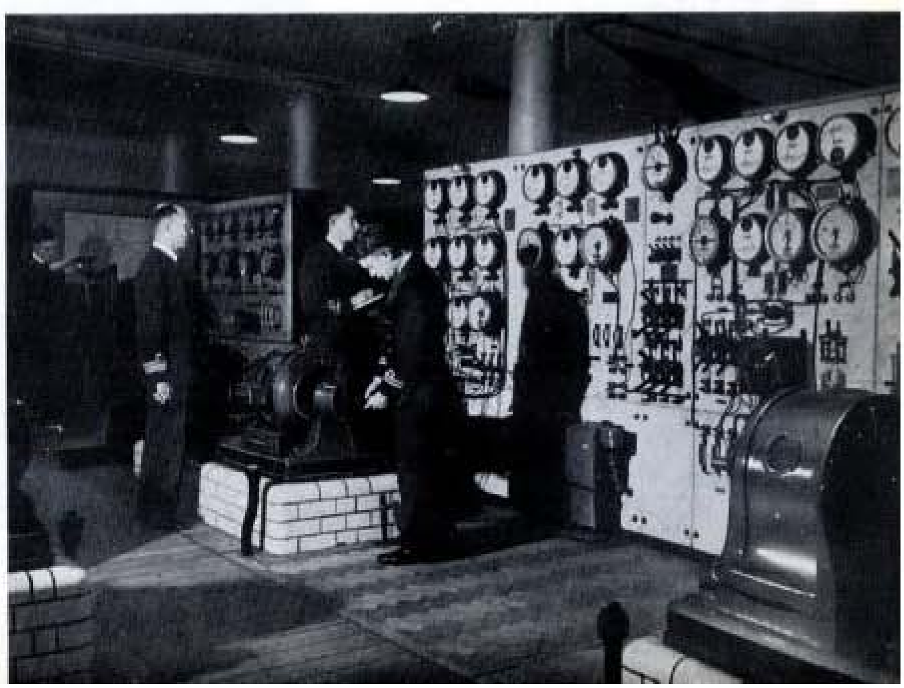


Fig. 117 (Right)—Three ninth term Lieutenants (E) with their Instructor Commander in the High Power Electrical Laboratory carrying out a brake test on 3-phase induction motors; the electrical input is measured on the panel, whilst the output is ascertained from the Heenan & Froude hydraulic brake.

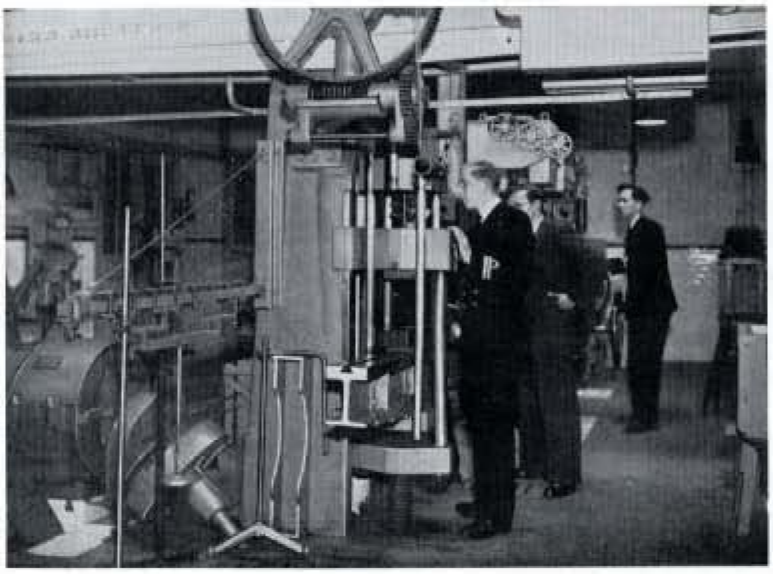


Fig. 118—A Royal Canadian Navy Lieutenant (E) taking readings on an extensometer during a tension test on a Buckton Tensile and Compression Testing Machine; the Sub-Lieutenant in the rear is working an Avery Torsion Testing Machine.

Dockyard is 440 volts D.C. and a motor generator converts it to 220 volts D.C. which is the same as the ring main of all large ships; the A.C. supply is catered for by three-phase and single phase alternators.

Referring to the illustration we see three ninth term Lieutenants with their Instructor Commander, carrying out a brake test on three-phase induction motors (nearest is a squirrel cage and the furthest a wound rotor), the electrical input being measured on the panel and the output on the Heenan & Froude hydraulic brake. These motors can be run either separately or in cascade, giving wide variations of speed.

Mechanics is our next subject which is studied under two general headings 'Mechanics'—which embraces statics, dynamics and strength of materials, and 'Fluid Mechanics'—which includes aero and hydrodynamics. The broad outline of the syllabus can be summed up as follows:—

Statics—elementary principles, including friction; general conditions of equilibrium; reactions on a beam, bending moment and shearing force; graphical statics and laboratory work.

Dynamics—elementary principles; conservation of momentum and impact; rotation of a rigid body; simple harmonic motion and easy oscillations; gyroscopic action.

Strength of Materials—stress and strain; Young's Modulus etc.; shear stress and strain; torsion and bending stresses; graphical mechanics and laboratory work; deflection of beams and struts; helical springs.

Machine Dynamics—gear teeth; balancing of rotating masses; dynamics of reciprocating engines; centrifugal governors.

Mechanics of Flight—aeroplanes in steady flight; spinning; performance of aeroplanes; stability; stresses in aeroplanes; resistance of ships, flying boat hulls.

The photograph reproduced in Fig. 118 shows part of the Mechanical Testing Laboratory in which we see, in the foreground, a Buckton tensile and compression testing machine set up for the tensile testing of a mild steel specimen. A Royal Canadian Naval Lieutenant is taking a reading on an extensometer on the specimen, this being used over the limit of proportionality, i.e. where the extension is proportional to the load.

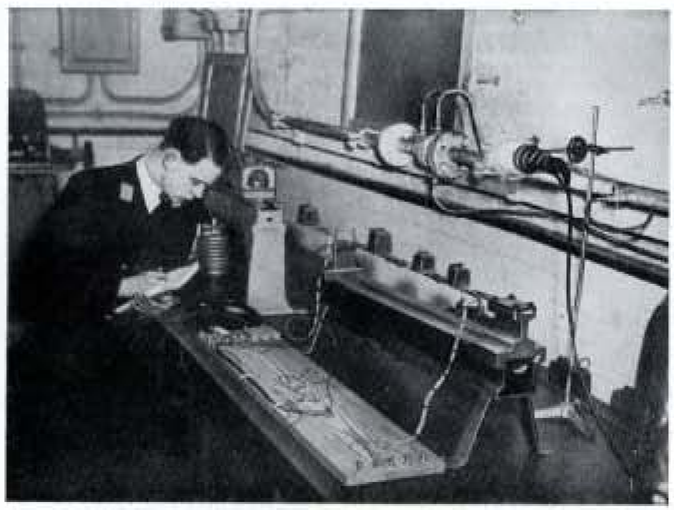


Fig. 119—Skin stresses of various materials can be determined by means of this Strain Gauge Apparatus in the Mechanical Testing Laboratory.

The Sub-Lieutenant in the rear is working an Avery torsion testing machine; other equipment installed includes two fatigue testing machines, a combined tension and torsion testing machine, a machine for experiments on oscillations, also plant for various hydraulic experiments.

In the same laboratory is the interesting Strain Gauge Apparatus featured in Fig. 119, by the means of which skin stresses of

Fig. 120—Eighth term officers in the Metallurgical Laboratory making microscopic examinations of the crystalline structure of aircraft exhaust valve steels which should be particularly resistant to corrosion.

any materials (except wood) can be determined. The apparatus consists of a number of small metal gauges, each of 120 ohms resistance, which are stuck on, in the required positions, to the upper and lower surfaces of the material to be stressed (a flat steel bar in this instance) by means of Durofix, after cleaning with fine emery paper and butyl acetate. Wires connect the gauges to a potentiometer and a 6 volt battery, and in operation, each gauge forms one arm of a Wheatstone bridge network which, before any load is applied, is adjusted by a potentiometer resistance so that no current flows through the galvanometer.

On stressing the bar to which the strain gauges are attached, by adding weights as illustrated, the resultant strain alters the resistance of the gauge and the subsequent out-of-balance current in the galvanometer is proportional to that strain. The out-of-balance measuring, by the way, is done to a hundredth part of a millionth of an amp. It can be appreciated that the possible uses of this apparatus cover a wide and important field.

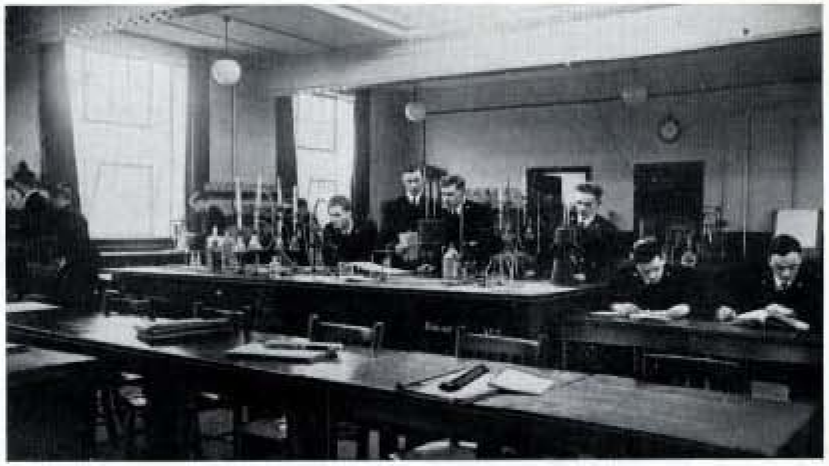


Fig. 121—A general view in the new Chemistry Laboratory at Manadon where Engineer Officers are making various tests with fuels and lubricating oils.

The last subject, we propose to illustrate, in the training syllabus for Engineer Officers comes under the heading of—

Chemistry and Metallurgy, a broad outline of features of the course of instruction being as follows:—

- Chemistry and Fuels—chemical and physical changes; plastic materials, including casein and celluloid, their manufacturing properties and uses; fuels and lubricating oils, including methods of testing oils for iodine value, viscosity-temperature curves, flash point etc.; refining and blending and physical properties of petrol and lubricating oils etc.
- Chemical Metallurgy—the manufacture of steel and cast and wrought irons, including cementation, crucible, Bessemer, open hearth, arc and induction furnace processes.
- Physical Metallurgy—preparation of metallographic specimens for examination; crystallisation; inner structures of pure metals and alloys etc.
- Ferrous Metallurgy — microstructures; hot and cold working of steel; heat treatment; casehardening etc.
- Non-Ferrous Metallurgy—copper, brass, bronze, aluminium, bearing metals, magnesium alloys, alloy steels etc.

The view Fig. 120 is taken in the Metallurgical Laboratory at Keyham, and shows microscopic examinations being made of the crystalline structure of aircraft exhaust valve steels which should be particularly resistant to corrosion. The officer at the end of the other side of the table is a Polish Sub-Lieutenant who speaks English fluently, and has now practically completed his course of instruction.

In the next illustration Fig. 121, we feature a general view in the new Chemistry Laboratory at Manadon in which various tests are being made with fuels and lubricating oils (see also details given in the Air Engineer Officers' syllabus in the next sub-section).

As will be realised from the grouped subjects, detailed earlier, which cover the scope of the Engineer Officers training, we have given only a cross section of the instruction curriculum and much of necessity has been omitted, but we trust that the information imparted conveys an impression of the high level reached.

In view of the details which follow in connection with the training of Air Engineer Officers, we have not attempted to outline the Engineer Officers aeronautical engineering instruction. We can say however that this subject is intended to supplement the normal course of instruction in a manner which will enable officers to deal with the problems of repair and maintenance of aircraft and aircraft engines which are likely to arise in their Service career. In substance the syllabus is also specially designed to form a sound basis for those who may subsequently specialise in aeronautical engineering.

Complementary to the training photographs, we now introduce three illustrations which indicate some of the activities of fully trained officers on active service. Fig. 122 for instance shows the Senior Engineer and watch-keeping officer on duty in the engine room of a cruiser, whilst in

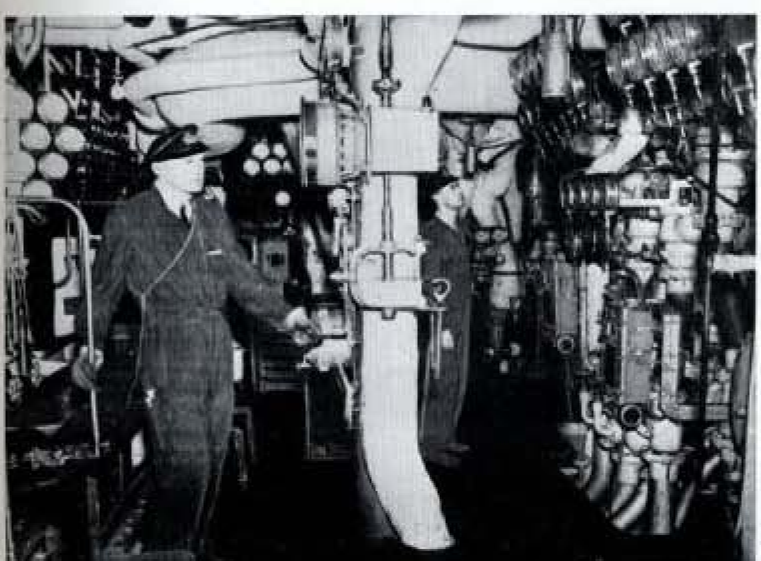


Fig. 122—A view in a cruiser's engine room showing the Senior Engineer and one of the watch-keeping officers on duty.

Fig. 123 we have a view in the engine room of the aircraft carrier *Indefatigable*. Here we see the starting platform, looking forward, showing the throttle—watch-keepers position, revolution indicators (just above the wheel) and engine room telegraph. The single wheel controls the astern manoeuvring valve, the other wheels controlling the cruising and head manoeuvring valves, respectively.

In the third illustration Fig. 124 we feature a section of the machinery control room of the *Indefatigable* where the Commander (E) would be in action; three of the four unit instrument panels are clearly shown, as well as the engine rooms and boiler room telegraphs.

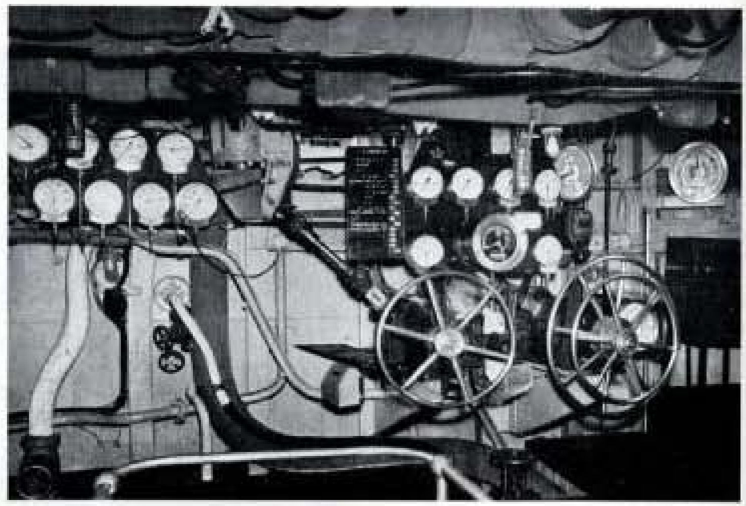


Fig. 123—A view of the starting platform in the engine room of the aircraft carrier Indefatigable.

Before passing on to the training of Air Engineer Officers we include a few further details and photographs which more particularly relate to 'E' officers activities at Keyham. For instance, in addition to the syllabus of technical instruction already outlined, the following are some of the 'external' courses carried out:—

Divisional Training. At the commencement of Term I, one 70 minutes period is devoted to R.N.E. College Standing Orders and general advice to young officers. Other Divisional subjects such as Service routine, Service letters, Naval customs and traditions, morale and esprit de corps, practical training in exercising command and taking charge etc., are embodied in a special course at the end of Term IV.

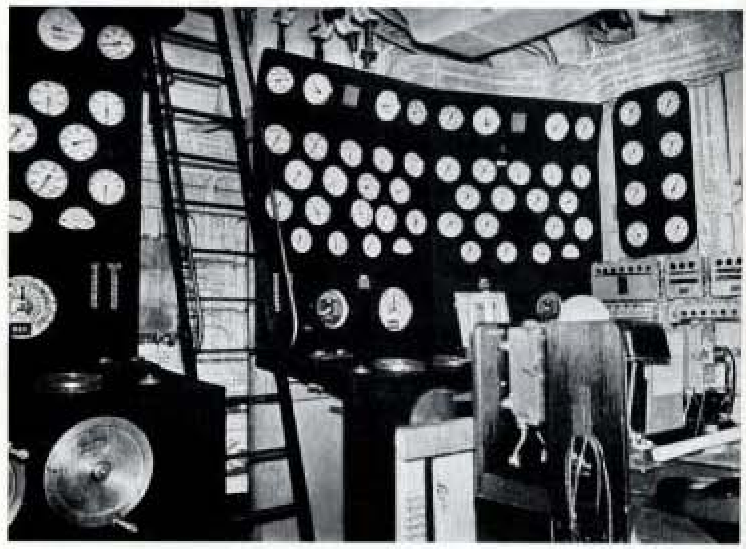


Fig. 124—Here we feature a section of the machinery control room of the Indefatigable where the Commander (E) would be in action.

Training under Arms. When practicable, all Midshipmen (E) are given instruction in the handling of weapons and in elementary field training. The miniature rifle range on part of the covered parade ground provides for recreational practice on certain evenings in the week.

Field Training. Officers undergo a refresher course comprising platoon, company and battalion work, officers sword drill and lectures on some types of light machine guns. A five days course of rifle and revolver shooting is also carried out during their first or second year.

Diving. All 'E' officers under instruction take a 2½ days diving course during their third year (see Figs. 125 and 126)

Fig. 126—On the Diving Course, service diving dress is used and practical work is carried out in 5 to 10 fathoms of water.

Fig. 125 (Left)—All 'E' Officers under instruction carry out a 2½ days Diving Course during their third year of training.

Fig. 127—A college crew sailing in their gig. Each summer, in peace time, the college crews enter for the Inter-University Races held in the 6 metre class on the Gareloch.

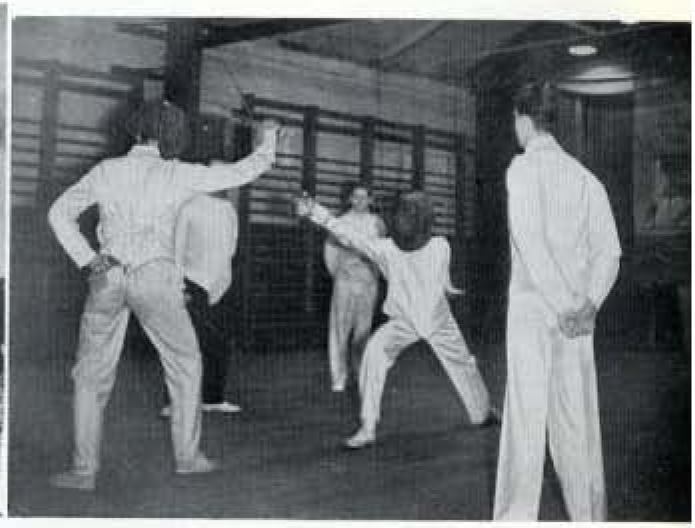


Fig. 128—Officers fencing with sabres in one of the Gymnasiums. P. and R.T. instructors attend on four evenings a week for instruction in boxing, fencing, etc

at H.M. Gunnery School, Devonport. This includes lectures on the uses of service diving dress, with practical work in 5 to 10 fathoms of water.

Physical and Recreational Training. All Midshipmen (E) and Cadets (E) are given P and R.T. instruction under the supervision of R.N.E. College Staff Officers, and P. and R.T. instructors are available on each of four mornings a week, the time being chiefly devoted to activity exercises; apparatus work is taught to the senior terms. Instructors also attend in the Gymnasiums on four evenings a week for boxing and fencing etc.; the view Fig. 128 shows officers fencing with sabres.

The full list of recreational activities at the College is a very long and comprehensive one as will be gathered from the fact that 32 separate committees for the Spring Term 1945 were necessary to cover the individual subjects. These include golf, football and all the field sports, the editing of the College magazine, the arts, play reading, theatricals, debating society, indoor games, orchestral and vocal music, and model making etc. Sailing is also a popular pastime and each summer in peace time, the College gigs (see Fig. 127) enter for the Inter-University Races held in the 6 metre class on the Gareloch. In addition they have the cruising yachts Galahad and Gauntlet for ocean racing.

The last two photographs taken at Keyham are reproduced in Figs. 129 and 130. The first shows the Dining Room for officers under instruction which, together with the annexe, has a seating capacity of 180 at a time. Provision for dining another 530 has been built temporarily at Manadon. The second illustration features a view in one of the rooms used as an officers' lounge.

Fig. 129—This Dining Room (at Keyham) for officers under instruction, together with the annexe, has a seating capicity of 180 at one time.

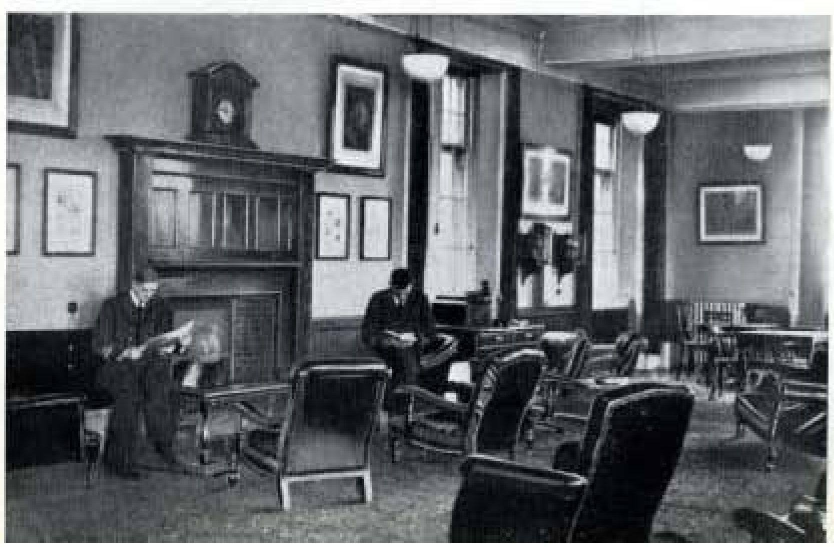


Fig 130—A view in one of the rooms at Keyham used as an officer's lounge.

THE TRAINING OF AIR ENGINEER OFFICERS

The special war-time Aeronautical Engineering Course for the training of R.N.V.R. Air Engineer Officers is carried out in the new College buildings at Manadon (see aerial view reproduced in Fig. 107 in the 'E' officers' section) and occupies a period of 23 weeks covering the following subjects—

- Aeronautics
- Electrical Engineering—Aero and Automobile
- Metallurgy, Fuels and Lubrication
- Thermodynamics
- Aero Engines and Air Frames
- Technical Organisation and Administration
- Physical Training

To give a general outline of the syllabus we briefly review these subjects in the following pages.

Aeronautics. The time allotted to this subject is 2½ periods of 70 minutes each per week and it embraces the constituent subjects of (*a*) Aerodynamics, (*b*) Dynamics of Flight and (*c*) Structures.

Taking them in this order, the details are as follows:—

(*a*) Aerodynamics, which includes the pitot tube, viscosity and streamlines; scale effect, skin friction and eddy formation; drag on solid bodies; aerofoils; high lifting devices; airscrews; aeroplane performance and aeroplanes in flight.

The view in Fig. 131 shows part of the Aerodynamics Classroom, the equipment on the lecturer's desk comprisirg, from left to right, an aeroplane model, wind generator, drag balance, pitot tube and manometer, aerofoil section and multi-manometer. It will be noted that the blackboards are illuminated by flourescent lighting.

(*b*) Dynamics of Steady Flight. This includes level flight, stalling and landing speeds; gliding and diving; climbing; turns; gusts; spinning; stability; flutter; flying boats etc.

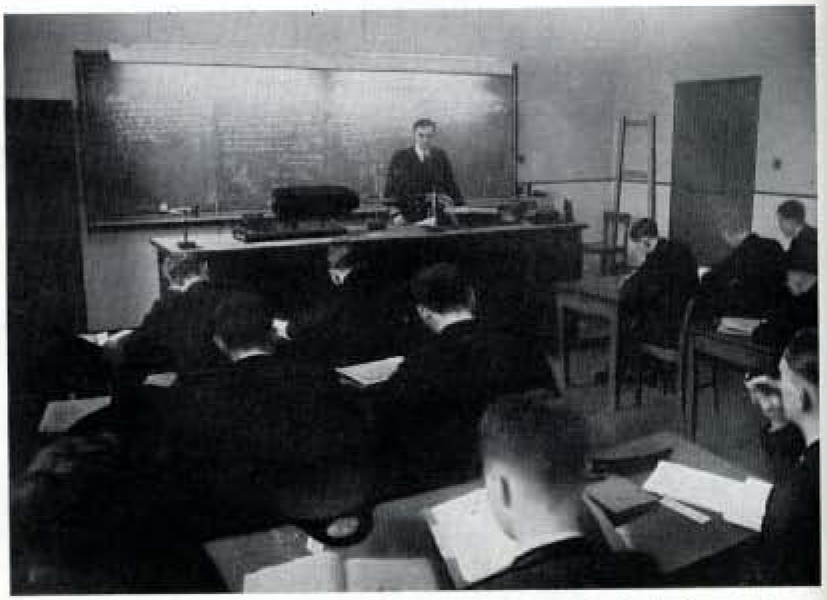


Fig. 131—Air Engineer Officers receiving instruction in the new Aerodynamics Classroom at Manadon; note the blackboards are illuminated by fluorescent lighting.

(*c*) Structures. In this group are included tensile and shear stresses and strains; torsion; bending; deflection of beams; struts; two- and three-dimensional pin-jointed frames etc.

Aircraft and Automobile Electrical Engineering. This subject is taken in the Electrical Laboratories at Manadon and in one of the hangars where three fuselages are stripped to show the complete electrical systems, the time allotted being 4 periods of 70 minutes each per week; the sub divisions are as follows:—

1. Revision — D.C. generators and motors; simple A.C. circuits.

2. Magnetos — theory of operation; types; hand and automatic timing; testing H.T. and L.T. booster coils; hand starting magnetos etc. For prictical work, various types of magnetos used in naval aircraft are stripped, assembled and tested on portable test bench.

In the photograph Fig. 132 we have a view taken in the Aero Electrical Laboratory where excellent lighting is obtained by banks of flourescent tubes. The class in session is learning the functions of the magneto also H.T. and L.T. booster coils. A lantern projector (centre) is available for illustration purposes, and on the left will be seen a layout of the Seafire electrical system.

3. Ignition—the spark discharge etc.; sparking plugs, including types, construction and tests; ignition, cable screening harness, coil ignition systems for M.T. vehicles; etc. Practical work includes cleaning and testing sparking plugs and testing ignition harness.

4. Voltage Regulation—generators and regulators; suppressers etc. Various voltage regulators are stripped, assembled and tested on generator test bench.

5. Batteries—the lead acid battery; nickel cadmium cells; metal rectifiers. Charging and testing covers the practical work.

6. Wiring Circuits—various wiring systems and miscellaneous circuits, including faults and fault finding on systems in actual aircraft.

Metallurgy, Fuels and Lubrication. The time allotted to this subject is three 70 minute periods per week and the syllabus generally covers the same ground

Fig. 132 (Left)—In this new Aircraft Electrical Laboratory excellent lighting is obtained by means of banks of fluorescent tubes. The class illustrated is learning the functions of magneto, H.T. and L.T. booster coils; note the lantern projector and the layout of Seafire electrical equipment (left).

as that detailed under the heading of Chemistry and Metallurgy in the previous sub-section devoted to the training of Engineer Officers.

The fuel and lubricating oil syllabus runs concurrently with the metallurgical course, practical work consisting of determination of calorific values of solid, liquid and gaseous fuels, viscosity, saponification value, flash point, spontaneous ignition point, demulsification value, coking value, water content and exhaust gas analysis (a view in the Chemistry Laboratory is given earlier in Fig. 121).

Practical metallurgical work follows the completion of practical fuel work and consists in the main of examination of micro-structures of the various metals in their different stages of treatment, a view in one of the new Metallurgical Laboratories being given in Fig. 133.

Fig. 133—A corner of the new Metallurgical Laboratory in which Air Engineer Officers are examining ferrous and non-ferrous material specimens under the microscope, after polishing and etching.

The Thermodynamic Syllabus is given two 80 minute periods per week and after the introductory theory goes on to deal with the practical engine cycle, combustion, engine testing, carburation, supercharging, cooling of engines, and jet propulsion.

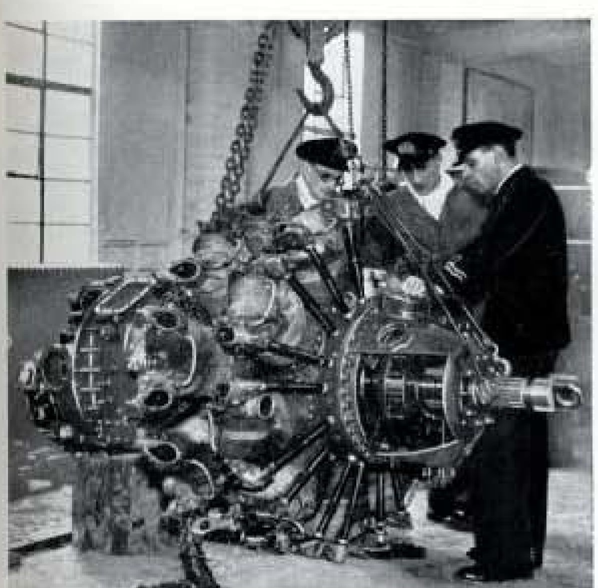


Fig. 134—A sectionalised 18 cylinder Double Wasp engine of 1,675 rated horse power for a Hellcat fighter aircraft being used for instructional purpose in the Engine Repair Section.

Aero Engines — Construction and Maintenance. The time devoted to this subject averages eight 70 minute periods per week and after the introductory lecture which deals with development and types of aircraft engines, also the use of various engine driven accessories, goes on to deal with elementary carburation, supercharging and boost control, the Stromberg carburettor and different types of starters.

The syllabus next covers the constructional details of various engines including the two-stage 18 cylinder Double Wasp and the Merlin and on each engine this is followed by stripping to unit assemblies, refitting, timing etc., and running in the test shop.

Turning to the photographs we see in Fig. 134 the sectioned Double Wasp engine of 1,675 rated horse power for a Hellcat fighter aircraft being used for instructional purposes in the Engine Repair Section at Manadon whilst in Fig. 135 we have a sectioned crankcase of a 14 cylinder Taurus engine for Albacore aircraft, the sections of which can be opened up by sliding along parallel bars in the fixture; the gears on the fore end are for driving the sleeve valve mechanism.

The next view Fig. 136 shows a Merlin engine sectioned to show the supercharger gears and wheel case, hand starter drive, camshaft drive, cylinder block and crankcase mechanisms, whilst to the left is a complete supercharger and carburettor assembly. In this picture it is interesting to see that the Lieutenant-Commander instructor has qualified as an operational pilot and an engineer in the Air Arm of the Royal Navy and consequently wears in addition to the distinguishing stripes of a Lt.Cdr.(E), the pilots wings on his sleeve. This combination of qualifications

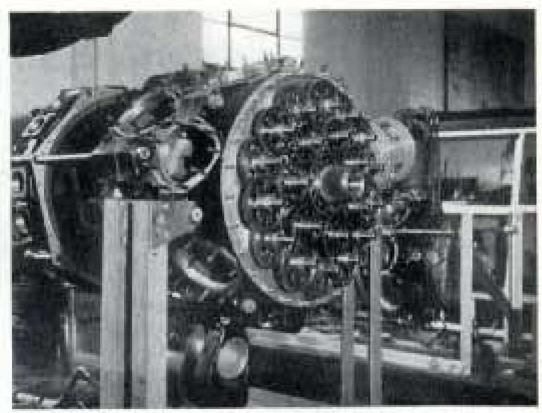


Fig. 135—This sectioned crankcase of a 14 cylinder Taurus engine for Albacore aircraft can be opened up by sliding along parallel bars. The sleeve crank drive gears can be seen on the fore end.

makes for more specialised knowledge and experience in the handling and maintenance of aircraft.

The test running of engines takes us to the Aero Engine Test Shop, a view in the Control Room of which is featured in Fig. 137. Here engines can be given one hour's test run at maximum rich cruising boost to prove new parts fitted after a major overhaul and, by means of 22 gauges, the complete performance of an engine (with exception of power output) can be recorded including oil and petrol pressures, petrol feed, engine room air temperature, engine coolant temperature etc.

The engine on test, which can just be seen through the plate glass, is a Merlin

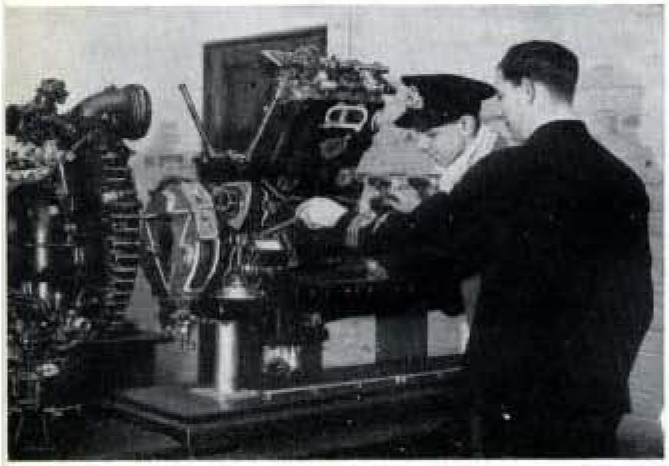


Fig. 136—A sectioned Merlin engine and complete supercharger and carburettor assembly. The Lt.-Commander instructor is both an operational pilot and an engineer in the Air Arm of the Royal Navy.

Fig. 137—A view in the control room of the new Aero Engine Test Shop. The engine on test (just seen through the plate glass) is a Merlin 30 of 1,375 rated horse power for the Barracuda I.

30, of 1,375 rated horse power for the Barracuda I, which was being run at 2,000 r.p.m. when the photograph was taken (see tachometer reading) the controls on the table including those for starter, throttle, mixture, slow running, two-speed booster and coolant and oil temperatures. Another control restricts the carburettor intake to produce conditions when flying at high altitudes, the effect being indicated on a depression gauge in which the mercury shows a drop of one inch per 1,000 feet, approximately.

A view in the Test House is given in Fig. 138 in which we see the Merlin ticking over, the 'sweep' of the test fan just being visible. The test bench here, complete with oil and coolant radiators, is designed to simulate climatic conditions an engine is likely to undergo, in fact, the engine is 'flown' on the ground.

Returning to the aero-engine syllabus we find that the next subject is propellers, which includes constructional details of Hydromatic, Rotol hydraulic and Curtiss electric types, their installation and maintenance, after which follows fuel and oil systems, engine handling and testing, also engine change and inspection, concluding with injection carburettors.

One of the three hangars at Manadon is devoted to engine and airframe inspection and in Fig. 139 we see a class of officers, having completed an engine change, including lining up of controls etc., wheeling out a Barracuda for engine ground check to prove installation.

The second hangar is used for airframe and engine dismantling and assembly and, includes metal and woodworking shops, whilst one section of the third hangar is set aside for new types of aircraft, both American and British, to ensure that officers under instruction can become familiar with the latest machines.

Airframes—Construction and Maintenance is the last technical training subject in the syllabus and covers such details as aircraft construction, control of aircraft, rigging, fabric work, alighting gear, wheel brake systems, hydraulic and vacuum systems, instruments, repairs to metal aircraft, maintenance inspections and aircraft dismantling and assembly.

This brings us to the end of the officers training section but before passing on to our next subjects, we should like to make it clear that the recreational amenities described in the Engineer Officers sub-section are available to all Air Engineer Officers, and officers under instruction in the latter branch at Manadon are represented on all the committees previously mentioned.

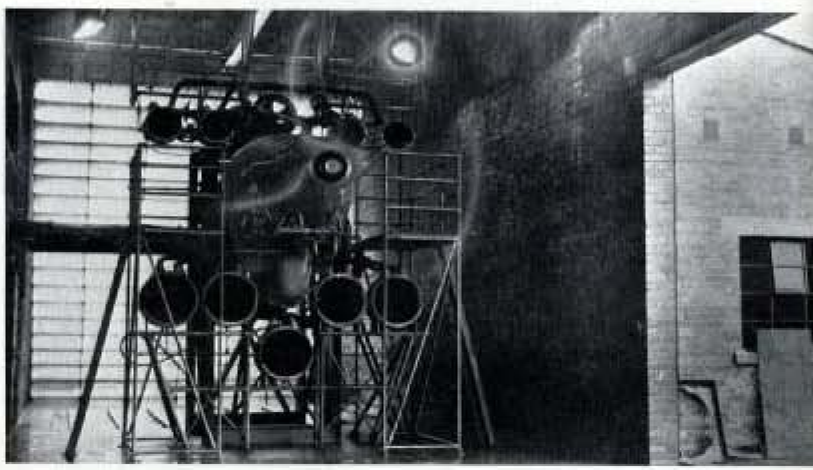


Fig. 138—A view of the Merlin on test in the Test House, complete with oil and coolant radiators. The test run is arranged to simulate all climate and altitude conditions likely to be encountered.

Fig. 139—Air Officers wheeling out a Barracuda from the new hangar at Manadon devoted to airframe and engine inspection. Having completed an engine change, including lining up of controls etc., the aircraft is now to undergo an engine ground check.

Repair Ships of the Fleet Train

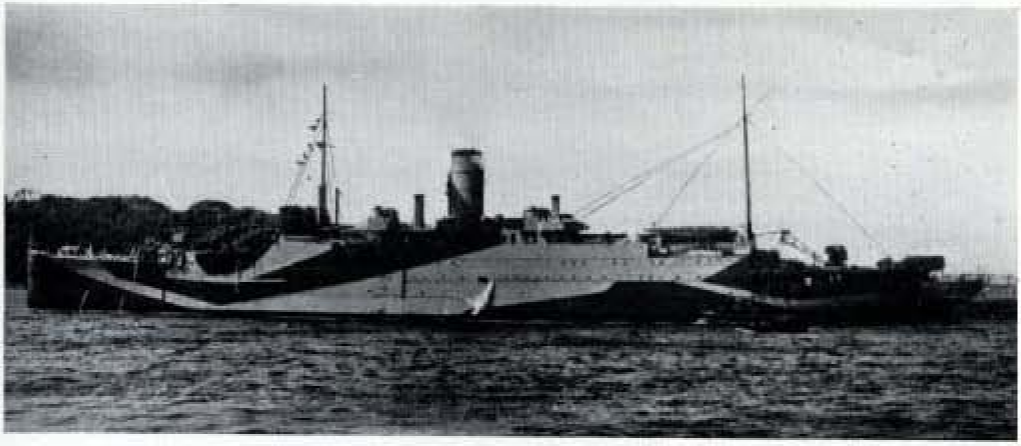


Fig. 140—A converted Repair Ship, the repair staff of which is composed of Special Repair Ratings (Dockyard).

Fig. 141—The Navy gets the job done.

OUR story up to this stage has been concerned with the training of officers and men of the Engineering Branch to fit them for their respective spheres of activities, and now, to conclude the marine section, we show how the services of some of the trades are utilised on board a naval Repair Ship.

First of all let us remember that when Japan took up arms against us, more and more ships made their way to the Indian Ocean and the China Seas. To service them, plans for fresh bases had been prepared, but new and enlarged bases and new repair ships demanded more man-power, which we could not spare.

With the fall of Hong-Kong in 1941 and Singapore early in 1942, the British Fleet had lost its two main repair bases in the Far East within the space of nine weeks. The lack of permanent bases thus became a serious problem and to meet this urgent need a scheme was put in hand for the conversion of a number of merchant ships into repair ships (see Fig. 140) and for the construction of new ones to be commenced immediately. The repair staffs for these ships have been drawn from a new naval branch known as Special Repair Ratings (Dockyard).

It will no doubt be appreciated from the nature of their duties that these Repair Ships carry all types of metal and wood-working machine tools and ancillary machinery, and have the necessary accommodation for repair parties; in fact they are fully equipped floating workshops. As part of the 'Fleet Train', they are capable of accompanying the Fleet anywhere.

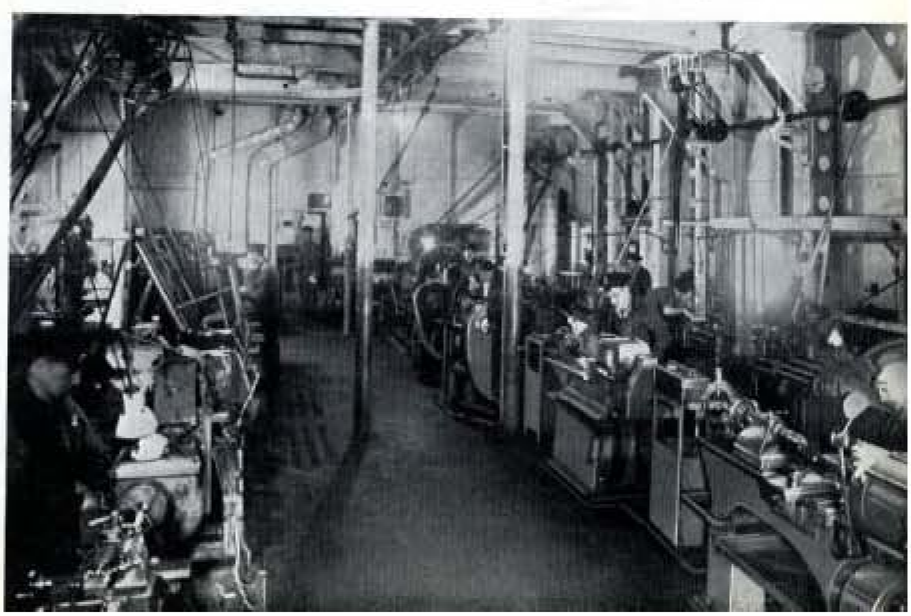


Fig. 142 (Right)—The general layout of a typical Machine Shop aboard a Repair Ship of the Fleet Train.

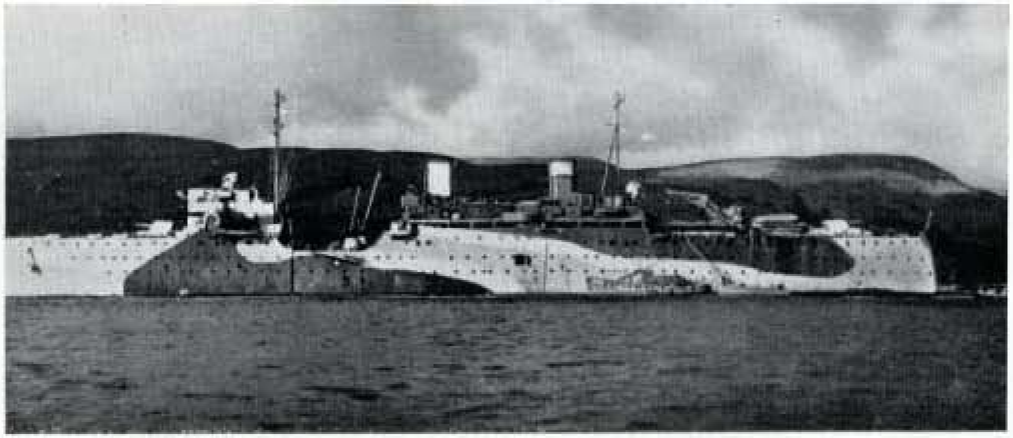


Fig. 143—A pre-war Depot Ship, the repair staff of which is drawn from normal Service branches.

The Repair Ship is no novelty in the navy: among those which have done excellent work afloat comes to the mind such names as H.M.S. *Resource*, *Medway* and *Forth*, to mention but a few of the well-known repair and depot ships for destroyers and submarines. (See Fig. 143). These ships have always been manned by naval personnel and include a large number of E.R.A.s and stokers carried for repair duties.

A tradesman not mentioned in the earlier section dealing with the training of engine room artificers will be found in these ships, that is, E.R.A. (patternmaker and moulder). These men are entered from outside sources and are not trained in the Royal Naval Artificer Training Establishments.

The photographs used to illustrate this section were taken aboard Repair Ships of the Fleet Train and our first one Fig. 141 aptly sums up the aim of the Service to get jobs done.

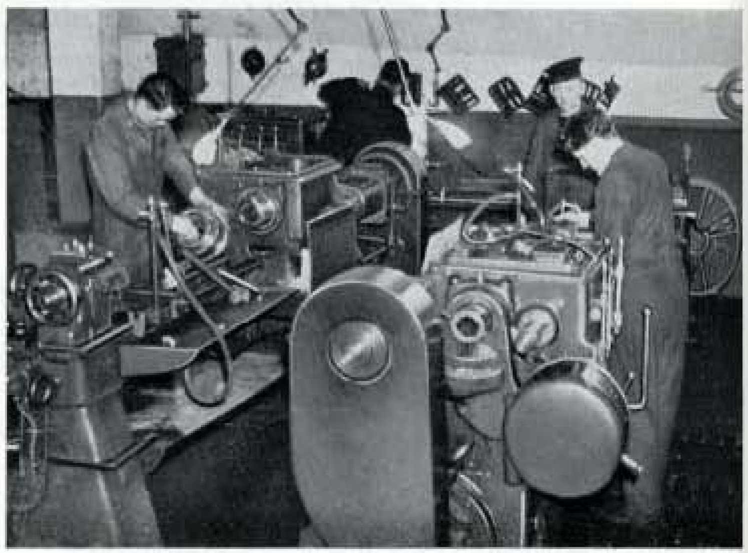


Fig. 144—A group of Lang lathes with all-geared headstocks and individual motor drive in a corner of a Repair Ship Machine Shop.

Fig. 145—Turning the propeller boss on a Lang lathe prior to the boring operation; the propeller was cast in the ship's foundry.

Fig. 146—Setting up a motor boat engine crankshaft in a Lang lathe prior to machining; note the stiffening bolts between the crank webs.

Lathe Operations

The next view, Fig. 142 shows the layout of a typical machine shop, a corner of another shop being featured in Fig. 144 and depicting some earlier types of Lang lathes with all-geared headstocks and individual motor drive. In the close-up view of one of these lathes in Fig. 145 we see a propeller for a reciprocating engine being turned up after casting in the ship's foundry.

A view of another Lang lathe in operation is given in Fig. 146. Here, an E.R.A. is setting up a motor boat engine crankshaft prior to machining; as will be observed stiffening bolts are being used between the crank webs to give added rigidity.

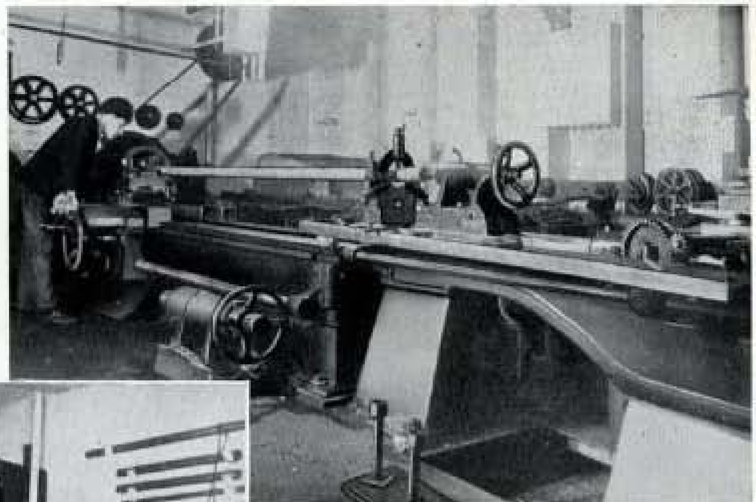


Fig. 147—An example of improvisation; the difficulty of machining a long shaft is overcome by utilising the tailstock (reversed) of an adjoining lathe.

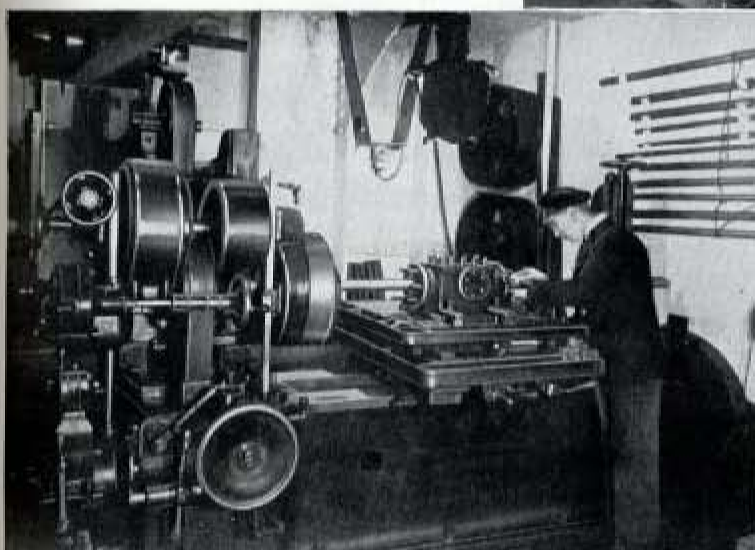


Fig. 148—A Richards Horizontal Borer at work on a Mumford steam valve chest.

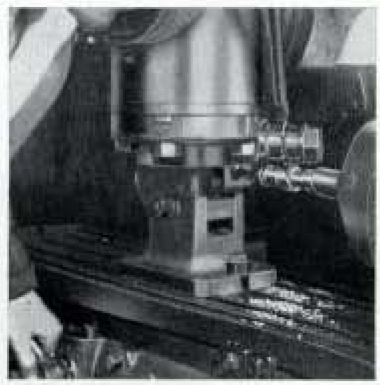


Fig. 150—Cutting the teeth of a spiral gear wheel for a battleship's radar equipment, on a Parkson IN Universal Milling Machine.

Fig. 147 is included to illustrate an example of improvisation. The oversize shaft to be machined is too long for the lathe and so the tailstock is removed and a three-point steady located at the end of the bed, centre support being provided by the tailstock of the adjoining lathe after having been turned the opposite way round on its own lathe bed.

Boring Operations

In the heavy Machine Shop we find a Richards Horizontal Borer at work on a Mumford steam valve chest, (see Fig. 148), the next illustration, Fig. 149 showing the boring of the top and bottom halves of a 9" bore main engine bearing for a cruiser. This bearing, having 'run' whilst in service, has been sent to the Repair Ship to be whitemetalled and machined to the drawing provided.

Milling Operations

Two examples of milling operations are given in Figs. 150 and 151, the first featuring a Parkson IN Universal Milling Machine with self-contained motor drive at work cutting the teeth of a spiral gear wheel required for part of the radar equipment of a battleship, whilst the second depicts the set-up of bevel milling

Fig. 149 (Below)—Boring the top and bottom halves of a 9" bore main engine bearing for a cruiser.

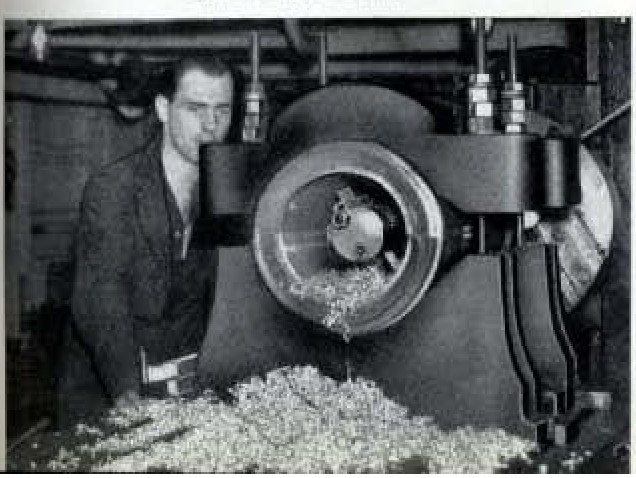


Fig. 151 (Below)—A bevel milling cutter set-up for machining the oil-way chamfer in one half of the main engine bearing shown being bored in Fig. 149.

cutters for machining the oil-way chamfer in one half of the main engine bearing previously shown on the horizontal borer in Fig. 149.

The last of our Machine Shop views shows—

A Grinding Operation in progress, the job being a governor spindle for a turbo generator and the machine, a Churchill Universal Grinder. (See Fig. 152).

The 'Outside Trades' are featured in our next series of photographs the first of which (Fig. 153) illustrates boilermakers at work in the Plate Shop cutting a large sheet of ½" mild steel plate on a shearing machine which has a capacity of ¾" thickness and will punch holes up to 1" diameter in the same plate. The wooden template to which the E.R.A.s are working is leaning against the side of the machine. In the second illustration Fig. 154 enginesmiths are reducing a steel shaft on a power hammer, the third view, Fig. 155 showing a coppersmith busy on a welding job, using oxy-acetylene equipment.

Fig. 152—Grinding a governor spindle for a turbo generator on a Churchill Universal Grinder.

Fig. 153—In the Plate Shop of a Repair Ship; boilermakers using a shearing machine for cutting ½" mild steel plate, the template for which is leaning against the machine.

We now introduce an interesting series of pictures depicting various stages in—

The Manufacture of a Washing Machine Door

A new aluminium door was required for the Baker Perkins Washing Machine in the Ship's laundry aboard one of the Repair

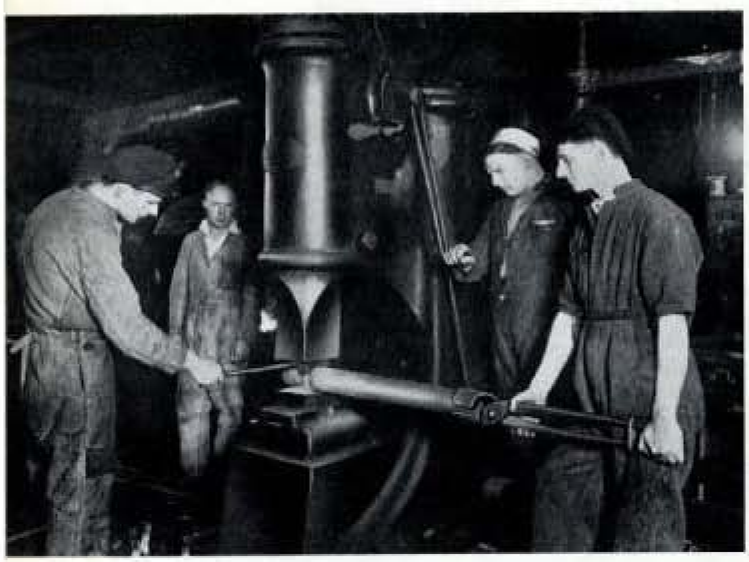


Fig. 154—Enginesmiths on board a Repair Ship using a power hammer to reduce the diameter of a steel shaft.

Fig. 155—A welding job for the coppersmith who gets to work with his oxy-acetylene equipment.

REPAIR SHIPS OF THE FLEET TRAIN

Ships and so, first of all, the E.R.A.s (pattern-makers and moulders) get to work on the new pattern which is having the finishing touches put to it in Fig. 156.

From the Pattern Shop to the Moulding Shop is the next stage as indicated in Fig. 157 which shows the two halves of the finished mould, the pouring of the aluminium being done in Fig. 158. Appropriate to this stage is the view taken in a typical Repair Ship Foundry illustrated in Fig. 159.

For our next view (Fig. 160) we show a close-up of the door being machined on a 17″ swing motor driven Lang lathe which has been adapted to take large diameter work of this nature by means of a portable extended headstock spindle with large faceplate and a special block on the saddle to raise the top slide to the required height.

Fig. 156—Putting the finishing touches to a pattern or a new door for a washing machine in the Repair Ship's laundry.

Fig. 157—Here we see the finished mould for the new washing machine door.

Fig. 159—This gives a good view in a typical Repair Ship Foundry; the cupola is nearly ready for pouring.

Fig. 158 (Left)—The next stage of pouring the aluminium into the mould for the new door.

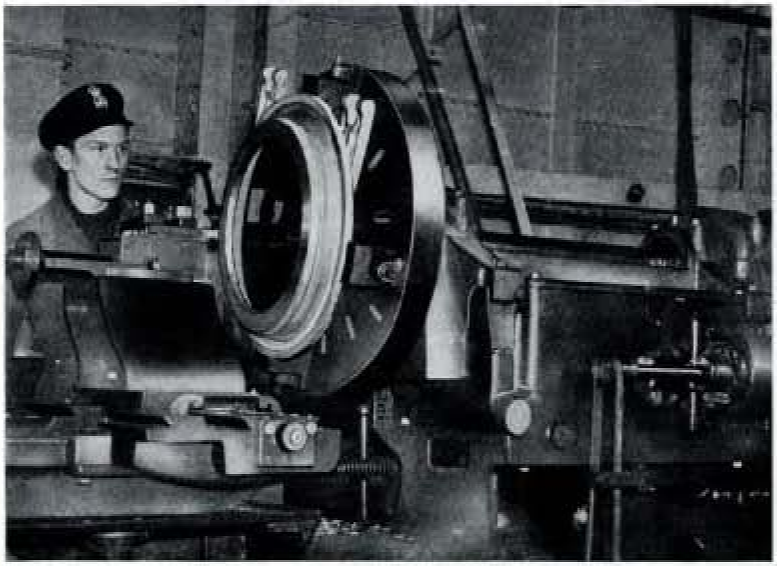


Fig. 160—Shows how a Lang lathe was adapted to machine the washing machine door by means of a portable extended headstock spindle with large faceplate, and a raised top slide on the saddle.

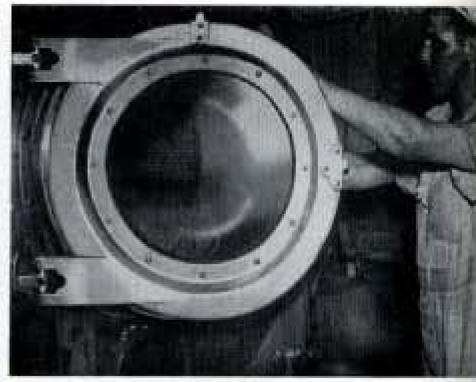


Fig. 161—The finished door fitted to the washing machine in the ship's laundry.

After various other operations including milling and drilling, the door is completed and fitted in position as depicted in Fig. 161 and the Ship's Laundry is once more back again in full working order (see Fig. 163).

Our concluding illustration Fig. 162 shows that mechanical testing of materials forms one of the duties carried out on board. Here the artificer is using a portable bench tensile testing apparatus, whilst to the right stand two types of scleroscope hardness testing machines.

Leaving the question of workshop practice we append a few remarks about the—

Special Repair Ratings (Dockyard)
—a new naval branch, known as S.R.R.(D)s, which was formed to meet the demands for repair personnel to man the new Repair Ships. For this branch, men who have had sufficient experience in a trade required for ship repairs are sent to the Naval Barracks, Chatham, as they enter the Service either as volunteers or conscripts. After a five weeks' disciplinary course they are ready for drafting to the various bases and ships as petty officers or leading-ratings according to their classification.

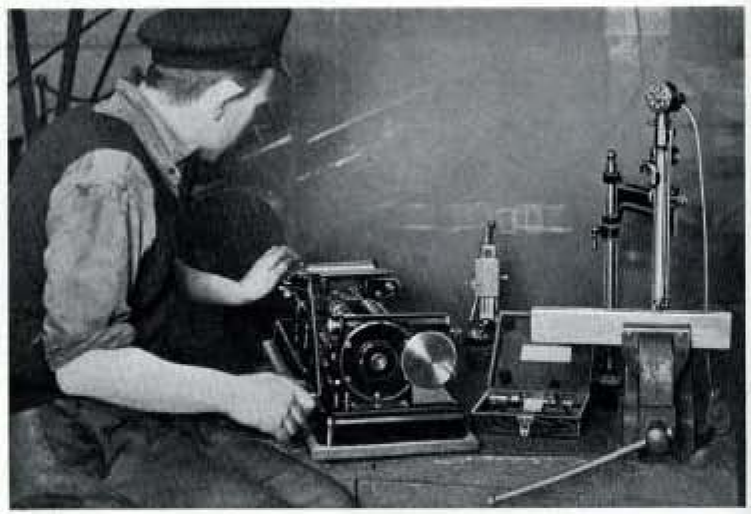


Fig. 162—Mechanical testing of materials on board a Repair Ship; the artificer is plotting a load-extension curve using an extensometer, whilst to the right stand two types of scleroscope hardness testing machines.

Every trade in the ship repair industry—and there are seventy grades in all—is represented in the four main departments of the Royal Dockyards, i.e. Captain's Department, Constructive Department, Engineering Department and Electrical Engineering Department.

Special Repair Ratings (Dockyard) have their own officers and workshops, and in all respects are completely self-contained, but subject to ordinary naval discipline. Their job in the out-of-the-way places is rarely easy and never glamorous, but there is a great demand for their services and Commanding Officers speak highly of them as a force. They are all-important and when we enter the final round with Japan they will be there to ensure that our fighting ships stay in the ring.

Fig. 163 (Left)—The washing machine is now back again in service.

THE MAINTENANCE & REPAIR OF NAVAL AIRCRAFT

FROM the battle of Taranto to the latest operations in the Pacific Ocean, naval aircraft operated from aircraft carriers have illustrated the decisive importance of Air-Sea Power.

To maintain Naval Air Squadrons in the highest possible state of operational and technical efficiency is the objective of all training and of all Royal Naval Air Stations and Establishments ashore.

In the carriers the task is to maintain the required number of aircraft in the air for protection of the Fleet or the attack on selected targets. To maintain the supply of aircraft, to fly these off and get the returning aircraft safely on board, when delay may mean their running out of fuel and when seconds may make all the difference between success or failure, provides a calling as thrilling and exacting as any to be found to-day. The maintenance personnel on board maintain and service these aircraft as quickly as possible, and effect rapid repairs to the very limited number of aircraft that can be carried in the ship. This calls for a high standard of technical organisation and skill, for limitations of weight and space in the ship for the accommodation of personnel, stores, fuel, ammunition and the thousand and one necessary items, makes things extremely complicated, and comparison between an aircraft carrier and an airfield ashore impossible. Some idea of the congestion might be obtained by visualising the compression of a whole Air Station into a space represented by less than a quarter of one runway, albeit on several decks.

The operation of naval aircraft from carriers presents many technical problems and requires the highest standard of maintenance and reliability. When single engined naval aircraft are operating at great distances over the sea from their carrier—which in itself is but a speck on the ocean and may be pitching and rolling to a degree—there is no alternative in case of mechanical failure to the loss of the aircraft and serious risk to the aircrews, and above all, the loss of essential air cover to the Fleet in circumstances when replacement by reserves cannot readily be provided.

During the interval between the two wars, the Navy did not maintain its own aircraft; and the opening of hostilities in 1939 found Naval Aviation as it is understood to-day in its infancy. The necessity for very rapid expansion at a time when competition for personnel and equipment was particularly keen presented many problems, and improvised solutions have had to be accepted in a number of cases.

That solutions have been possible at all is due in very large measure to the keenness and devotion to duty of many thousands of officers of the R.N.V.R., of the W.R.N.S., of personnel entered for hostilities only, and of the unstinting assistance given by the R.A.F.

DIRECTOR OF AIRCRAFT MAINTENANCE AND REPAIR

Rear-Admiral (E) C. P. Berthon, C.B.E.

It is fitting that acknowledgement should be made here of the services rendered not only by the above, but also by all those who in industry or in a civilian capacity have contributed to the remarkable achievement of the British Naval Air power now being deployed against the Japanese.

In the public press, the air achievements of the Royal Navy are often published under the heading "Fleet Air Arm", but the Navy itself discourages this description. Those concerned with naval aviation, although specialists in air matters, are not a separate unit, but an integral part of the Navy. Thus R.N. officers employed upon the maintenance and repair of naval aircraft are fully qualified engineers who have specialised in aeronautical engineering, and many are already fully trained pilots. In the same way, Air Artificers and Air Mechanics must feel equally at home carrying out their work upon aircraft on board ship, at a naval air station ashore, and, when required, during flight.

This blend of life and work by sea, land and air should appeal to all who feel the call of adventure and variety combined with high professional standing as aeronautical engineers.

C. P. Berthon

IN view of the considerable amount of space devoted to the subject of training in the marine section of this article and the fact that we have already outlined the training syllabus for Air Engineer Officers, we propose to omit the curriculum of instruction for Air Apprentices (i.e. that which follows their first year's basic work at Rosyth or Torpoint, detailed in the Naval Artificers' section) and to move on to the advanced training carried out at the School of Aircraft Maintenance situated at Worthy Down.

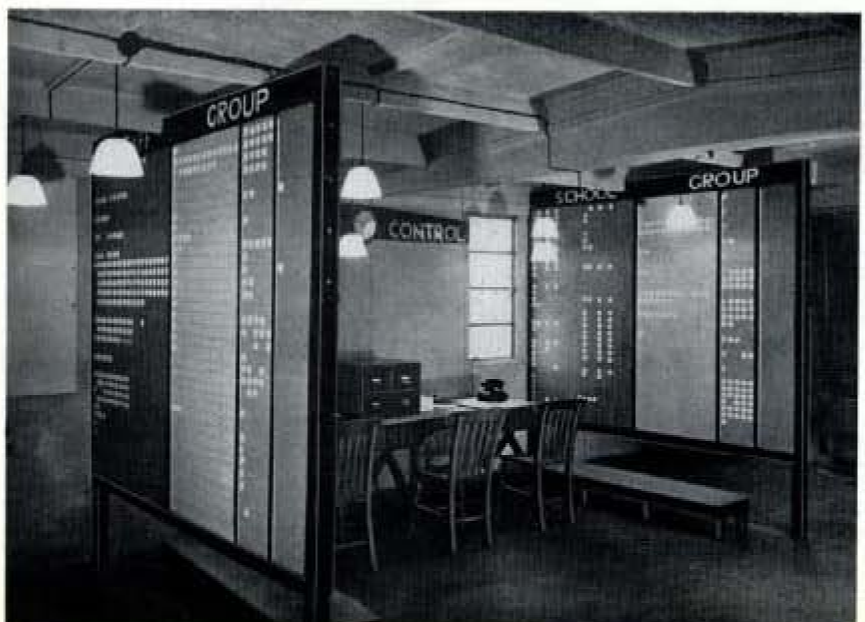
Fig. 164—A view in the Station Joining and Drafting Centre at the School of Aircraft Maintenance, Worthy Down, which bears the name of H.M.S. Kestrel.

Familiarly known in the Service as 'S.A.M.' this school started in August 1942 in a couple of blitzed hangars at Lee-on-Solent with a Walrus and an Albacore and an average of 20 pupils a week. The value of the courses inaugurated resulted in rapid development, so that to-day, at the new site, are four large hangars partitioned off into classrooms, many other instructional buildings and a weekly average of 250 pupils.

Altogether, there are approximately 30 'SAMCO' courses in operation and the wide range of subjects covered includes engine instruction, aircraft maintenance, aircraft instruments, carburettors and propellers, electrical equipment, cameras (including loading and titling), scanners, gyro gunsights, directors and D.R. compasses, rocket projectile equipment, aircraft salvage and packing etc., as well as a petty officer Air Mechanics qualifying course, an aircraft checkers course and a flight deck course etc.

All the courses mentioned are for the (A)—airframes, (E)—Engines, (O)—Ordnance and (L)—electrical ratings appropriate to the subject matter taken, the duration of each course depending on the amount of instruction necessary and ranging from as short as two days (gyro gunsights) to ten weeks for the P.O.A.M. qualifying course, the average being from one to two weeks. In addition to these, there are six courses for Air Engineer Officers of varying periods from five weeks to twenty-four weeks' duration.

So much for the outline of instruction covered. Now let us pay a visit to the, 'ship', which is known as H.M.S. *Kestrel*, where we first of all make our acquaintance with the Station Joining and Drafting Centre, a view in which is featured in Fig. 164. Here, housed in the front portion of a central hangar, are grouped all the office facilities for dealing with joining, drafting, regulating, station leave, victualling and checking, bedding etc., together with the Master at Arms office, and the arrangements run so smoothly that up to 200 personnel an hour can be dealt with.



Zoning Control

In a separate building a Zone Control Room is equipped to display a very efficient visual system recording the movements of personnel on the Station, both staff and those under instruction, and is worthy of a detailed reference. First of all we would point out that though a card index system provides an admirable record of the individual, it does not readily give a picture of the allocation of personnel as a whole. With the latter object in view, experiments were tried with various methods resulting in the system known as a Zoning Control, and which is now being applied to the whole station at R.N.A.S., Worthy Down.

For the purpose of classification, the entire station has been divided into three groups as follows:—

1. School—comprising all ratings and Wrens on, or awaiting courses in S.A.M.
2. Storage—all ratings and Wrens attached to Storage.
3. Staff—all others not included in (1) and (2) such as instructors (S.A.M.), seamen, accountant ratings, fire fighters, those attached to squadrons etc., and all remaining Wren personnel.

Three visual control panels are arranged, one for each group (see Fig. 165) as well as one board showing station accommodation. These panels provide a visual watch bill, that is, each rating is recorded according to his group indicating:—

1. (Blue) Joining and drafting routine and divisional work.
2. (Green) Working 'ship'.
3. (Yellow) Non-operative, i.e. sick, leave, etc.

Fig. 165 (Left)—A section of the Zone Control Room in which a very efficient visual system records the movements of personnel on the Station, both staff and those under instruction; the sections of each panel are in different colours.

ADVANCED TRAINING ON AIRCRAFT MAINTENANCE

Fig. 166—Sectionalised aircraft such as this Seafire is one of the features of the instructional training at Worthy Down; on these all maintenance ratings, i.e. airframe (A), engine (E), electrical (L) and ordnance (O) are taught the operations pertaining to "between flight," "daily" and "40 hour" inspections.

4. (Black) Non-operative, i.e. cells, detention, absent, etc.
5. (Red) The normal 'static' duty performed, together with a number of sub-sections of these zones indicating the precise function or duty carried out.

As will be appreciated from the foregoing details, this visual system affords the following advantages:—

a. A continuous visual watch bill indicating where a rating is at any particular time.
b. Being visual it may be kept under constant review so that surpluses and deficiencies or wastages of man power can be seen at a glance.
c. The picture of the dispersal and allocation of a group or section is immediately apparent (i.e. the formation of classes in the School of Aircraft Maintenance etc.)
d. Statistics can be compiled such as giving the personnel in S.A.M. classes etc., and with minor adaptations the strength return can be given under the headings required by FONAS Form 86 (Flag Officer Naval Air Stations).

The counterpart of the control boards is the card index. In the same way as the tallies on the board indicate the state of affairs at any given time, so the index cards show a detailed and permanent record of each rating and also provide the information required to assess the individual on his Service documents when he leaves the station.

From the question of Zoning Control, we now turn to details of some of the SAMCO courses commencing with SAMCO No. 5 which deals with—

Aircraft Maintenance

This subject covers a number of individual courses on various aircraft including Seafire, Barracuda, Wildcat, Hellcat, Avenger, Corsair, Firefly, etc., the British and American types being housed in two separate hangars.

The personnel eligible are air artificers, air fitters, and air mechanics of all trades i.e. (A), (E), (L) and (O), and from squadrons forming, re-equipping, or in anticipation of requirements, also prior to service in training squadrons.

The object of the syllabus which is of one week's duration, is to give maintenance ratings training in the details of all maintenance operations pertaining to 'between flight', 'daily' and '40 hour inspections' and of the correct methods to be employed. Lectures, practical work and demonstrations are given, together with information concerning likely sources of failures or defects.

In the Instructional hangars excellent use is made of the different types of aircraft in sectionalised stages to enable the general construction to be studied, also the location and operation of the many subsidiary components. Take the view of the Seafire in Fig. 166 for example, from which it will be appreciated how easy it is to assimilate, in a short time, a practical knowledge of those parts normally hidden from view. A corner of the Seafire class of air mechanics (A) 'in session' can be seen at the rear of the tailplane.

The next illustrations Figs. 167 and 168 are taken in the American hangar and show two views of a sectionalised Corsair, the

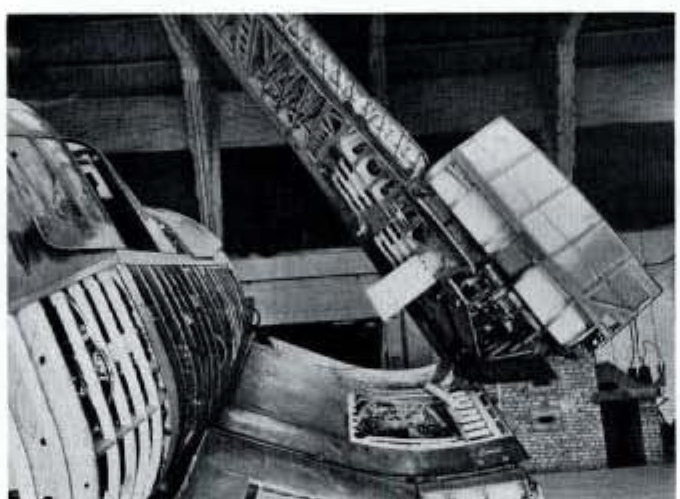


Fig. 167—This sectionalised Corsair, with its main plane folded, is in the American aircraft maintenance instruction hangar. These "inside" views enable airframe construction to be explained as well as the operation of hydraulic and electrical components.

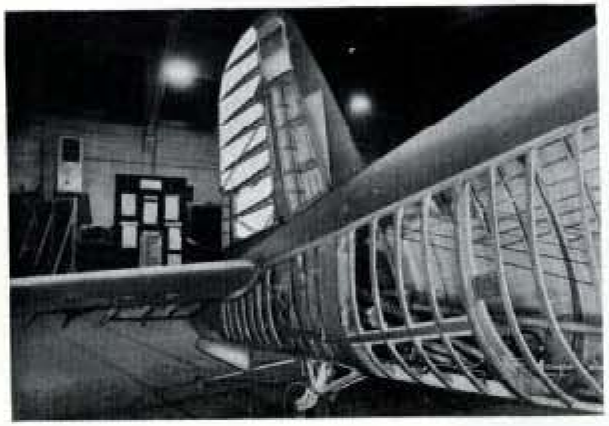


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Fig. 168 (Left)—Another view of the sectionalised Corsair looking along the rear of the fuselage and including the tail plane and rudder; the landing hook is shown extended.

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first looking along the fuselage, with the wing folded and hydraulic and electrical components exposed, and the second featuring the rear of the aircraft with the arrester hook down.

Propeller bay, engine component and carburettor bays are accommodated in a nearby hangar of smaller size.

The Armament Section. Here we find an array of bombs and components is available and instruction is given in bomb and rocket projectile installations and the stripping and maintenance of Hispano 20 m.m. cannon, Browning and Vickers guns.

In Fig. 169 we feature an Ordnance class of petty officers, air fitters and air mechanics receiving instruction on the cannon and Browning guns which they strip and re-assemble and learn the different actions so that they can clear and remedy stoppages on operational aircraft. Most readers will have become acquainted from the news,

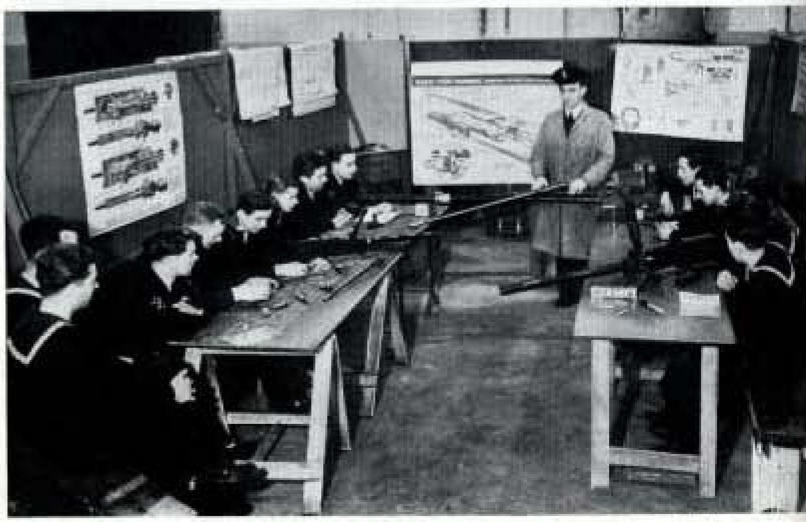

Fig. 169—An Ordnance class of petty officers, air fitters and air mechanics receiving instruction on Hispano 20 mm. cannon, .5 and .303 Browning guns, so that they can clear and remedy stoppages on operational aircraft.

Fig. 170—One of the first demonstration stands, that of Coffman Cartridge Starter tools, in the Engine Instruction School carries a board bearing a very appropriate injunction.

of the effective hitting power of the 20 mm. cannon and particularly of their good work against shipping, therefore a few details of their performance will no doubt be of interest. Using high explosive, incendiary, tracer or armour piercing ammunition, they have a muzzle velocity of 2,880 ft. per second and will fire at the rate of 720 rounds per minute. Of the Browning guns, the .5's muzzle velocity is 2,660 ft. per second and the rate of fire 800 rounds per minute, whilst the .403 has a velocity of 2,440 ft. per second and is ideal for ground strafing with a firing rate of 1,150 rounds per minute.

The Engine Instruction School is housed in a long hangar which is divided down the centre and round the sides into bays where instruction is given in the stripping and assembly of engines and components. Facing the bays are exploded engines and sectioned components of Bristol, Rolls and American engines that are in the respective bays.

As we enter the left hand aisle of this section, one of the first demonstration stands we see features Coffman cartridge starter tools (see Fig. 170) with sectioned components on the bench comprising an amal valve for governing fuel pressures, a Pesco fuel pump and a B.T.H. air compressor for brake systems, whilst overhead is a board bearing a very appropriate injunction.

A little further along we find the damaged Mercury engine depicted in Fig. 171 which demonstrates what can happen as the result of negligence in the bad fitting of the wrist pin assembly and pointing out the things to be observed to avoid similar trouble.

Walking round to one of the centre bays we see a Double Cyclone engine course (SAMCO No. 4 C2) class at work removing the reduction gear drive from the engine

Fig. 171—The notice above this damaged Mercury engine reads—"This is what can happen to an engine by negligence in bad fitting of the wrist pin assembly. Look to (a) fitting of split pin, (b) size of wrist pin and (c) securing bolt".

as shown in Fig. 172, the sectioned and stripped components being exhibited on the benches in the foreground.

This course is for air artificers, air fitters, and airmechanics (E) and is of two weeks duration to equip these ratings for squadrons or workshops. As far as possible the engine is completely stripped and assembled, using the proper tools supplied in the workshop tool kits (see Merlin example in Fig. 177) with checks and maintenance procedure explained.

As an example of the thoroughness of the training we give the syllabus of the Double Cyclone 14 cylinder engine course in detail:—,

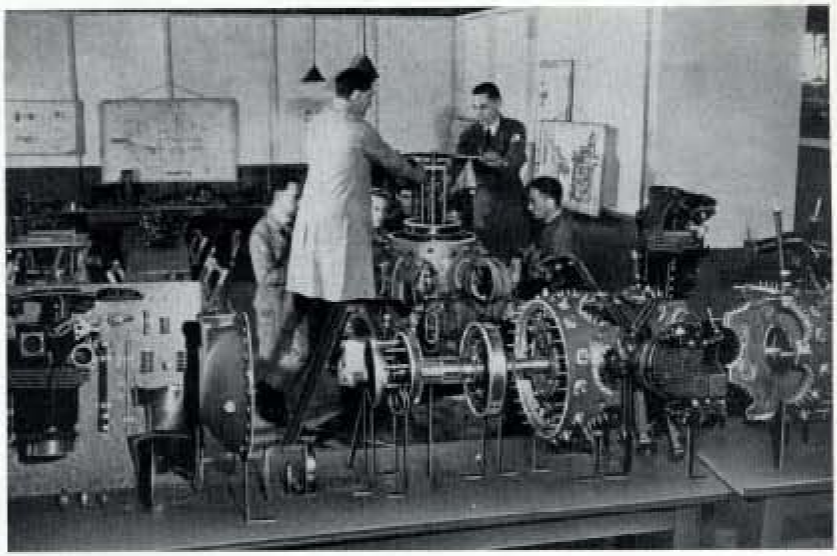

Fig. 172—A Double Cyclone 14 cylinder engine class removing the reduction gear drive; in the foreground are the complete exploded sections for instructional purposes.

First Week

Monday—General particulars of engine, method of slinging engine and securing to airframe. Detail methods of stripping engine; cleaning parts and checking.

Tuesday—Commence to strip engine into component parts. Build up cylinders, valves, rocker gear etc.; renewing of valve springs; renewing of cylinders; checks; securing and maintenance of ignition harness.

Wednesday—Tappet gear, push rods, adjustments, checks; lubrication of rockers, tappets etc.; piston ring assembly; renewing piston rings. Main crank-case description.

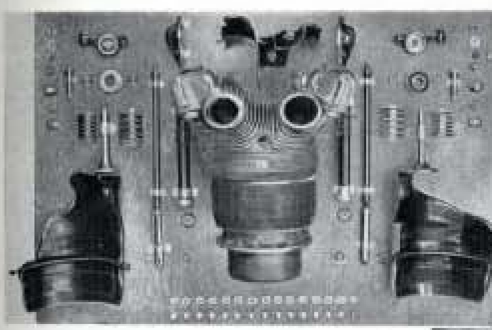

Fig. 173—The cylinder and rocker gear assembly details which commences the line of Double Wasp engine exploded sections seen in Fig. 174.

Thursday—Reduction gear, description and fitting of; checks and lubrication; detail of cover. Shock loading; cam gear and operation, fitting and checks.

Friday—Crankshaft and master rod assembly; checks and fitting of master and articulating rods; assembly of crankshaft and checks; lubrication of assemblies. Theory of Stromberg carburettor.

Saturday—Revision of week's instruction; commence to assemble engine.

Second Week

Monday—Rear cover housings; layout of gears and drives in rear cover; oil pumps and filters; maintenance of pumps and filters; stripping oil pump. Main lubrication system, pressure and scavenge; external oil system.

Tuesday—Oil priming procedure; build up of impeller drives; supercharger clutches and operation; checks. Practical valve timing and check.

Wednesday—Stromberg carburettor, maintenance, venting, priming, dehibiting renewing of carburettor. Setting of controls; fuel pump description, stripping and checks.

Thursday — Magnetos, initial point setting, maintenance. Practical timing of magneto to engine; adjustments.

Friday—Starting and stopping procedure; running faults. Revision.

Saturday—Examination.

In the next illustration Fig. 174 we see the exploded details of a Double Wasp 18 cylinder engine comprising from left to right, the nose section, the power unit, supercharger and rear covers, with a completely assembled unit at the end of the line. At the head of the line, and not included in the previous illustration, is a board carrying the cylinder and rocker gear assembly details as depicted in Fig. 173.

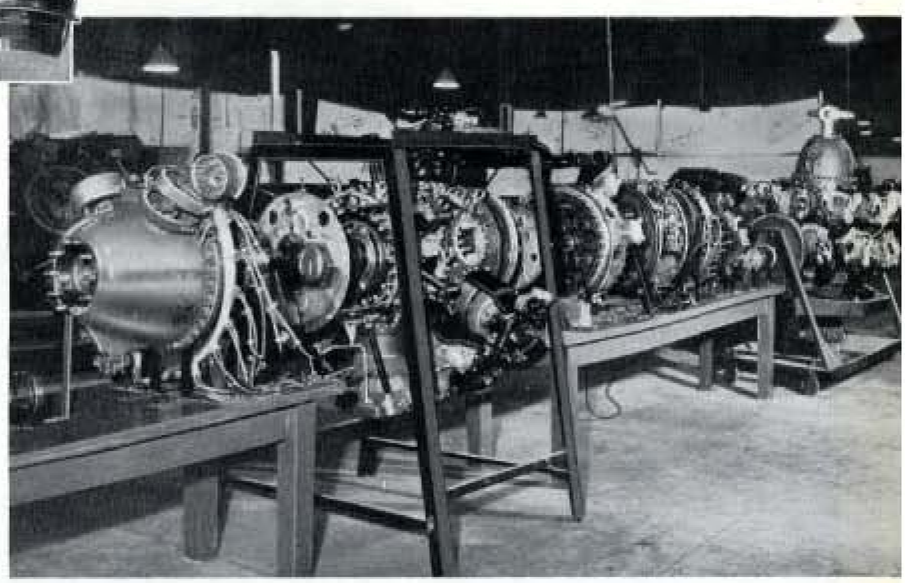

Fig. 174—Here are the exploded details of a Double Wasp 18 cylinder engine in the Engine Instruction School; the completely assembled unit is shown at the end of the line.

A little further along, part of a class of petty officer air mechanics (E) were busy mounting the power section of a Twin Wasp engine, the remainder of the class being seated in the instruction bay behind (see Fig. 175).

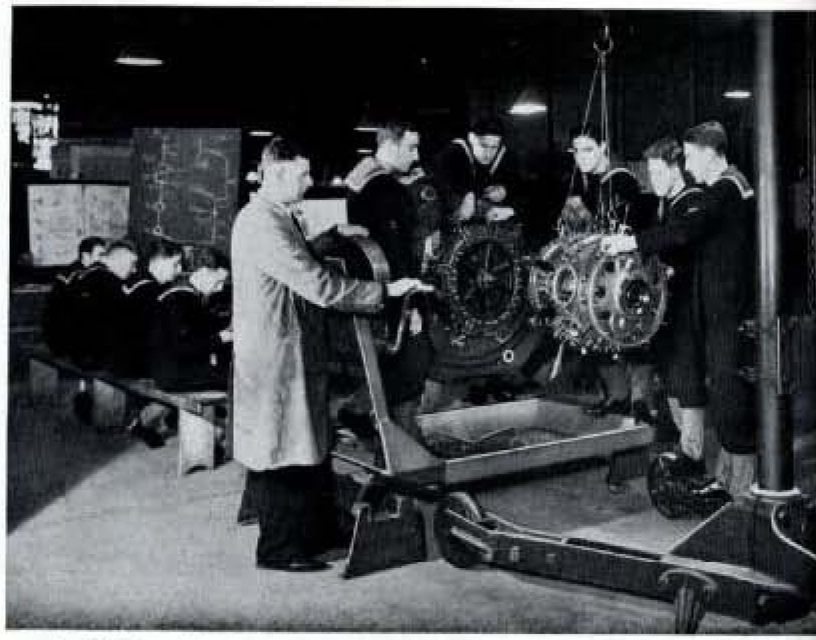

Fig. 175—Some of the class of petty officers air mechanics (E) mounting the power section of a Twin Wasp engine; the remainder of the class are in the background.

Before leaving the Engine Instruction School we will consider for a moment the—

Air Engineer Officers Training Course —which, as SAMCO 205, is designed to provide a comprehensive and complete curriculum for the conversion of officers with engineering knowledge and experience, but with no previous specialised aeronautical training, to Service Air Engineers, this course being of 25 weeks duration.

The syllabus, briefly, covers the following subjects:—

Preliminary Airframes—including theory of flight and structures, general construction, practical rigging, fabric covering and repairs.

Preliminary Engines—theory of heat engines, thermodynamics, chemistry of fuels, theory of carburation, magnetism and inductors; Otto and modified cycles; practical stripping of simple aero engines, rebuilding, valve and magneto timing; principle of lubrication, wet and dry sumps, high and low pressure systems; sparking plugs of all types, ignition and harnesses; general carburettor design from simple U tubes and Zenith to Master control and S.U. principle; supercharging, all accessories, pumps etc.; Coffman starters and inertia.

Phase 'A'—Electrics and all types of instruments; metallurgy and practical applications; hydraulics and pneumatics; propellers.

Phase 'B'—(Specialisation on engines)—Merlin and S.U. carburettor; Bristol engines and Claudel Hobson carburettor; Twin Wasp and Stromberg carburettor; viewing, engine repair section procedure.

Phase 'C'—(Specialisation on airframes) —aircraft metal repairs, dinghies etc.; Seafire, Barracuda and Corsair airframes and their respective hydraulics; procedure and administration, including all forms, publications, stores, A.R.S. storage, squadrons, centralised maintenance, carrier and flight deck procedure.

As will be appreciated from the foregoing, the officers receive much of their instruction for this course in the Engine Instruction School and in Fig. 176 we show a view taken in the officers Merlin engine lecture room which is situated at one end of the hangar. Round the walls will be seen a variety of diagrammatic drawings, as well as actual sectioned engine components, a sectioned supercharger also stands on the table at the rear. In the two weeks devoted to the Merlin engine, every part and function is dealt with thoroughly and a complete strip of the engine is undertaken during this period.

This stage provides a suitable opportunity for us to introduce an illustration of one of three cases covering the entire range of Merlin engine tools (see Fig. 177) which are used by officers and ratings taking a Merlin engine course. All tools are titled and their use briefly explained as will be apparent from the photograph; kits for other types of engines are similarly displayed for use in the Instruction School.

Other phases of the Air Engineer Officers course are featured in Figs. 178, 179 and 180 these illustrations being taken in the building devoted to hydraulics, pneumatics, metallurgy, and dinghy maintenance. In the first view, we have on the table, a working model of the Dunlop pneumatic brake system as fitted to most British aircraft, the left hand end of the table being occupied by a hydraulic test rig used for testing all types of components to 4,000 lbs. per sq. in., the components actually on test being an interlock valve and flap jack. On the wall in the rear is a sectionalised Lockheed hydraulic system for undercarriages and flaps also for wing locking on certain types of aircraft.

The board shown on the stand in Fig. 179 carries a sectionalised working model of

Fig. 176 (Left)—A view in the officers Merlin engine lecture room in the Engine Instruction School; diagrams and sectioned components are displayed on the walls, and a supercharger stands on the table at the rear.

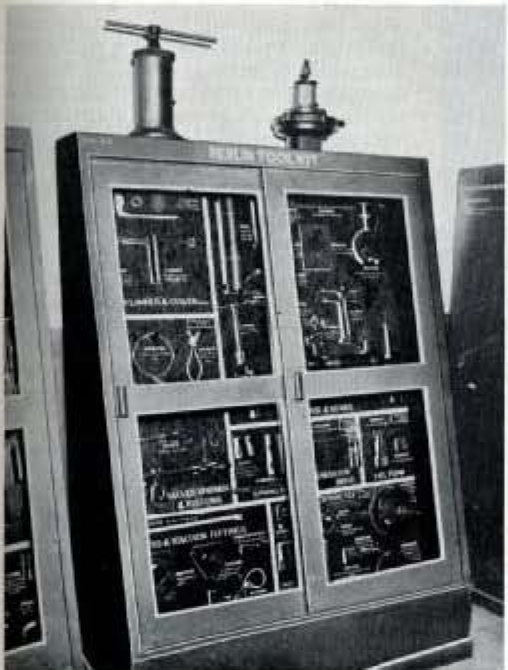

Fig. 177—This Merlin engine tool kit, one of three such cases covering the entire range, is used by officers and ratings on the Merlin engine course. Kits for other types are similarly displayed in the Instruction School.

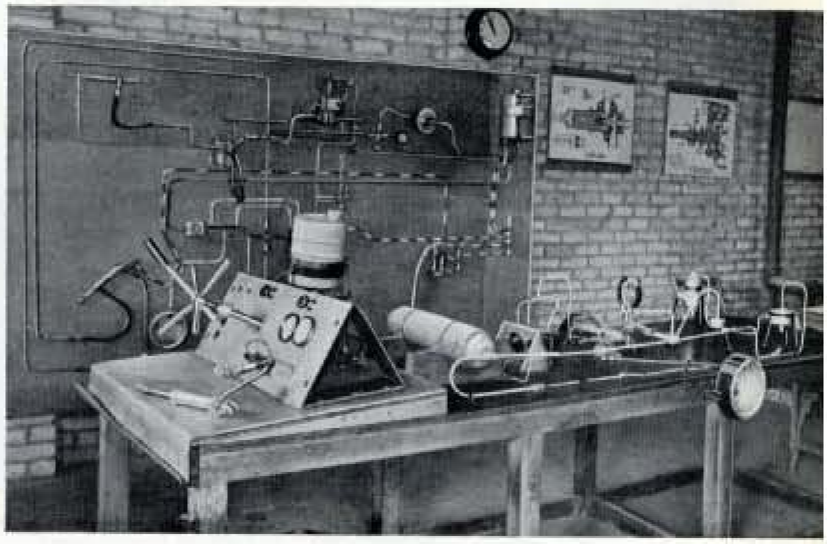

Fig. 178—Working models of the Dunlop pneumatic brake system (on table) and Lockheed hydraulic system for undercarriages and flaps (on wall) in one instruction room of the Air Engineer Officers Training Course, the object of which is to convert those with no previous specialised aeronautical knowledge to Service Air Engineers.

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the pneumatic system seen on the table in the previous illustration. The components, reading from left to right, are as follows: top line—B.T.H. air compressor; oil seal, by which the back pressure of the air carries oil back to the ball valve in compression, to provide a firm seating to the valve; oil filter, and to the right, the air bottle; centre line—'joy stick'; rudder control, and triple gauge showing air pressure in air vessel and port and starboard brakes: bottom line—brake, showing expansion chamber and brake shoes; dual relay valve, worked from rudder control also by Bowden cable from joy stick; reduction valve which reduces the pressure in the bottle to the working pressure of the brakes; air filter, and external air charging valve.

The third illustration, Fig. 180 depicts a portable testing apparatus made on the Station for diagnosing metal removed from an engine filter to assist in determining the cause of failure. Housed in a wooden box 12" by 10" by 6", the equipment consists of a magnet for testing ferrous metals, a balance for weighing small amounts for purposes of comparison, litmus paper for testing acidity, a spirit lamp for boiling certain solutions, magnifying glass for examining minute particles, tweezers, two test tubes, a burette for measuring solutions and a supply of filter papers. In the bottles are nickel spot test solutions, A and B; nitric and sulphuric acids, and caustic soda; one of the two jars contains copper sulphate and the other is used for mixing solutions. The glass plate enables work to be done on it without damaging the instructions underneath.

Typical test examples with the use of this apparatus are as follows:—To test for brass or bronze, weigh out one gramme of metal and dissolve in 20 millilitres of nitric acid; when action is finished, boil the solution for two or three minutes. If a white precipitate results, tin is present and the alloy is bronze; should no white precipitate be observed, the alloy is brass. To test for lead, in the case of lead bronze, take one millilitre of boiled solution and dilute with 10 millilitres of distilled water, add one millilitre of sulphuric acid and allow to stand. Tin is present should a white precipitate result.

Fig. 180—This portable testing apparatus was made on the Station for the Officers Conversion Course for diagnosing metal removed from an engine filter to assist in determining the cause of failure.

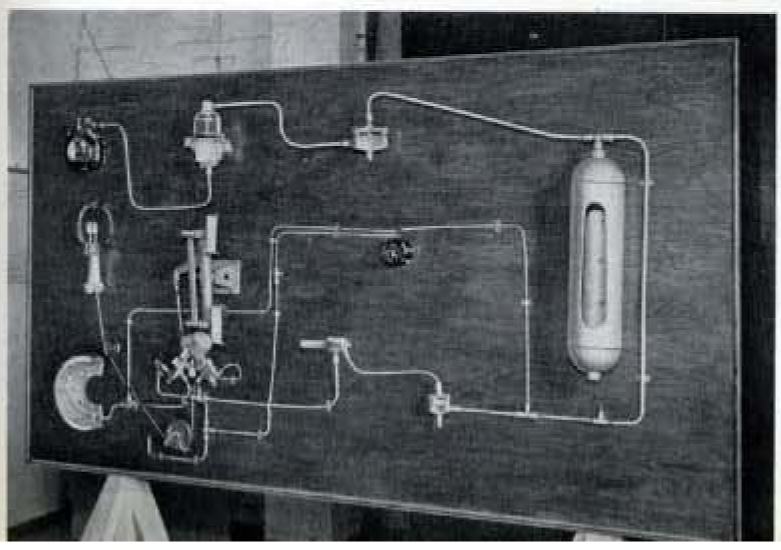


Fig. 179—(Left) This is a sectionalised working model of the Dunlop pneumatic braking system seen on the table in Fig. 178.

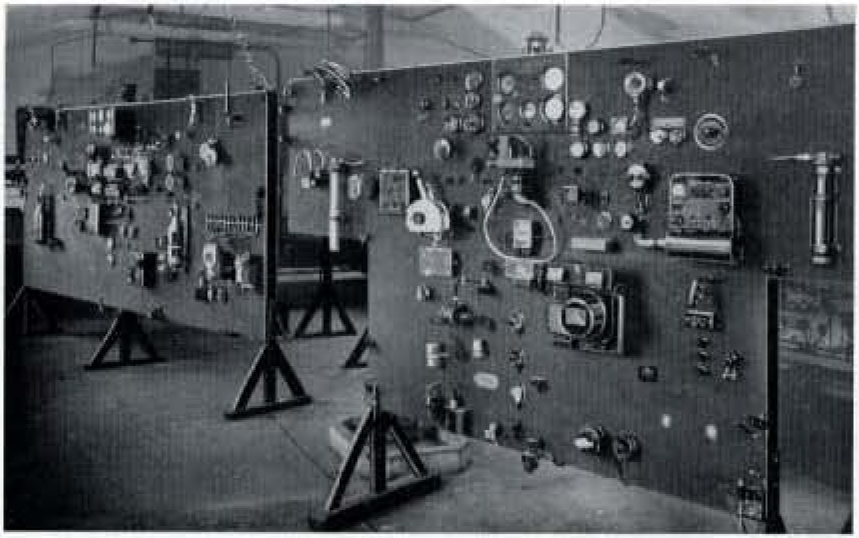


Fig. 181—Aircraft electrical circuits in full working order form part of a well-equipped section for instruction to electrical maintenance ratings. The Firefly and Barracuda panels illustrated are used for passing out petty officer air mechanics (L).

Electrical Maintenance Ratings are trained in a well equipped section where advanced instruction is given on aircraft electrical circuits, radar equipment, rocket projectiles, the gyro gun sight, distant reading compass, auto controls, instruments, cameras, etc. Much of the equipment is sectionalised and the outer casings of working models have perspex windows so that the moving parts can be observed in action.

Circuits which are the responsibility of electrical maintenance ratings are wired up on large display panels, one for each type of naval aircraft. Two of four such panels used as part of a very comprehensive syllabus for the petty officer air mechanic qualifying course (SAMCO No. 6) are illustrated in Fig. 181, the one nearest the camera being for the Firefly and the other for the Barraduca. Each of these carry complete instrument and electrical equipment wired in accordance with the actual diagrams in the aircraft handbooks.

The Barracuda Panel for instance is laid out as follows:—top right portion represents the starboard main plane and has fuel tank pressure and air temperature transmitters, together with navigation, formation and recognition lights, whilst below (bottom right) is the power plant section with magneto, booster coil, Coffman cartridge starter, oil dilution (for cold weather starting), fuel pressure transmitter, immersion switch for operating dinghy, fire extinguishers for dowsing fuel tanks, and micro switches for undercarriage indicators.

The top centre represents the pilots position and shows the flying panel with all control instruments, and underneath is the observers position with alternative bomb control, power control panel, regulator and cut out. The bomb gear in the centre is rigged up with lights representing universal carriers. The left hand side of the panel features the port main plane and carries the same equipment as the starboard side plus landing lamp, downward identity lights and flap transmitter.

Every item is in full working order, perspex covers being provided as previously explained; for passing out purposes, four faults are laid on and each petty officer rating has to locate and rectify them. The view Fig. 182 shows the rear of the Barracuda panel, the motor in the bottom left hand corner being for driving the magneto for demonstration purposes and is not part of the aircraft equipment. On the wall to the right can be seen part of a three compartment container for all gear including light bombs, smoke bombs, incendiaries, emergency supplies etc., this container being operated from the main panel.

In another building of the Electrical Section we find the working layout of—**The Bomb Installation** on a Barracuda as featured in Fig. 183. One of the large racks will be seen carrying a 100 lb. bomb, the two lower racks on the outer portions of the panel are the small bomb or flare containers that fit under the ends of the main planes. Grouped across the centre are the wiring and release controls operated from the pilots cockpit, whilst right in the centre is the nose and tail fusing switch which allows bombs to be dropped either safe or fused. The actual fusing unit is located on the rack just ahead of the bomb fins, a wire from the unit connecting with the propeller release. By the setting of the indicators, on the box below the fusing switch, is determined the order of sequence of bomb release and whether they are dropped singly or in cascade.

The D.R. Compass, or distant reading gyro-magnetic compass, to give its full title, is dealt with in yet another part of the Electrical Section and in Fig. 184 we see instruction being given on its functions and construction. This remarkable piece of mechanism, the evolution and production of which is entirely British, has proved of such navigational aid as to make possible many outstanding achievements including the blowing of the Mohne and Elder dams and the fast long distance flights of Mosquitos, not to mention its aid to naval aircraft over wide stretches of ocean.

Normal types of magnetic compasses are susceptible to acceleration and deceleration as well as to magnetic influence from the aircraft structure and equipment and consequently this makes them somewhat inaccurate. The D.R. compass however embodies two natural principles, that of the magnetic compass which endeavours to indicate magnetic north, and that of the gyroscope which possess great rigidity in space when spinning fast.

A complete D.R. compass installation consists of (1) a master compass unit, usually fitted in the tail of the fuselage so as to be remote from armour plating or electrical circuits which might cause local magnetic disturbance; (2) a series of repeater compasses for pilot, observer, navigator, bomb aimer etc. and (3) a V.S.C. unit

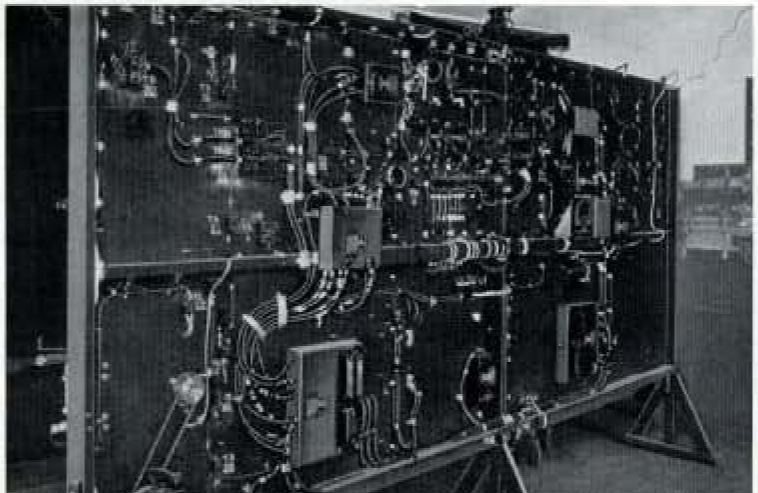


Fig. 182—(Right) A rear view of the Barracada panel seen as the furthest one in Fig. 181. From this, the multiple wiring circuits can be traced and understood.

(variation-setting corrector) which allows compensation for local variations up to 30 deg. east or west. The various components thus located at different stations throughout the aircraft are linked by electrical harness which is screened and bonded to preclude interference with radio reception.

The V.S.C. unit is incorporated between the master unit and the repeaters and it is only necessary for the navigator to set the corrector for any known local variation (marked on all aerial maps by lines called 'isogonals') for the indications of the repeaters throughout the aircraft to register a true instead of a magnetic course. An interesting point we might add is that the technique of visual bombing by means of the automatic computing bomb-sight would not have been achieved without the aid of the D.R. compass.

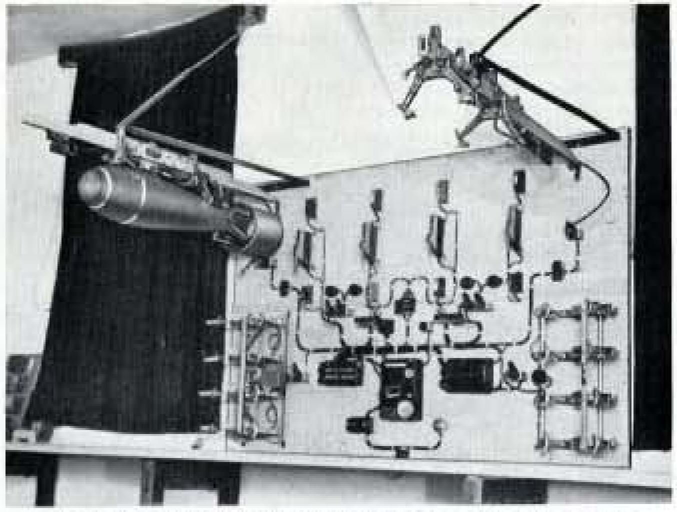


Fig. 183—A working layout of the bomb installation on a Barracuda; the large rack carries a 100 lb. bomb, the two lower racks are the small bomb containers that fit under the ends of the main planes.

The Gyro Gun Sight, instruction on which is given in the same building, features as our last illustration in this section (see Fig. 185). This is another remarkable piece of mechanism which, being harmonised with the guns on the aircraft, automatically aims them ahead of the moving enemy plane by the correct deflection angle.

Fig. 184—Here we see instruction being given to electrical maintenance ratings on the Barracuda D.R. (distant reading) Gyro-Magnetic Compass, together with the series of repeater compasses for pilot and observer.

In operation a main switch is moved to the 'on' position, which results in a six-dot circle appearing in red on the sighting screen, the initial size of the circle being set by the pilot who turns a selector to a named position, i.e. JU88, FW190 etc., immediately the target is identified. As the pilot closes on the enemy aircraft he turns a twist grip mounted on his throttle control so that the size of the six-dot circle is adjusted until it exactly encircles the target's span, when within firing range.

This brief description gives some idea of how the gyro gun sight works; we have, for obvious reasons, not attempted to explain the whole of the technique involved nor given further details of the mechanism.

To conclude our story of Advanced Training on Aircraft Maintenance, we would mention the—

Maintenance Test Flying Course, the object of which is to enable pilots who have had sufficient general flying experience to specialise in the important task of test flying of aircraft after modification and repair to ensure that they are in every way fit for operational duty.

The work of test flying demands skill as a pilot and if he is an engineer as well it saves time in diagnosing faults for the maintenance units to rectify. During the war pilots with some engineering background have been accepted, but eventually only candidates who are (E) Pilot Officers will be selected for these courses since considerable technical knowledge is required if the work is to be really well done.

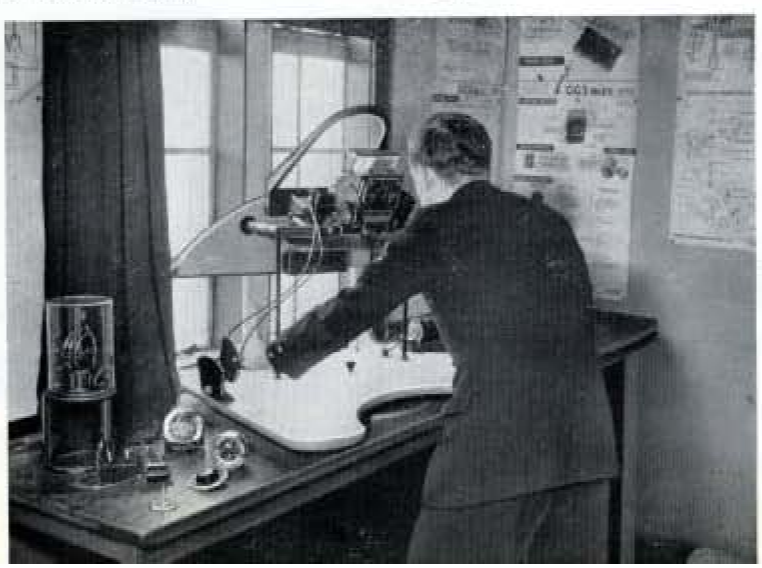


Fig. 185 (Right)—All electrical maintenance ratings have a course on the gyro gun sight which is equipped with selector settings for various named types of enemy aircraft.

THOSE who have had anything to do with instructional training schemes realise the immense value of the wall diagram or poster that can impart the theory or function of the subject matter in a clear and concise manner, whether it be the simple electrical circuit, the principle of operation of say a variable pitch propeller (see Fig. 186) or the complicated design of an intricate component.

Throughout our training sections it will be appreciated from many of the photographs reproduced that the Navy is not backward in taking advantage of the assistance of such material and in this connection it is interesting to note that the Department of Aircraft Maintenance and Repair have in being a Training Aids Production Section which has, for its central object, the simplification of instruction in relation to the maintenance and repair of aircraft.

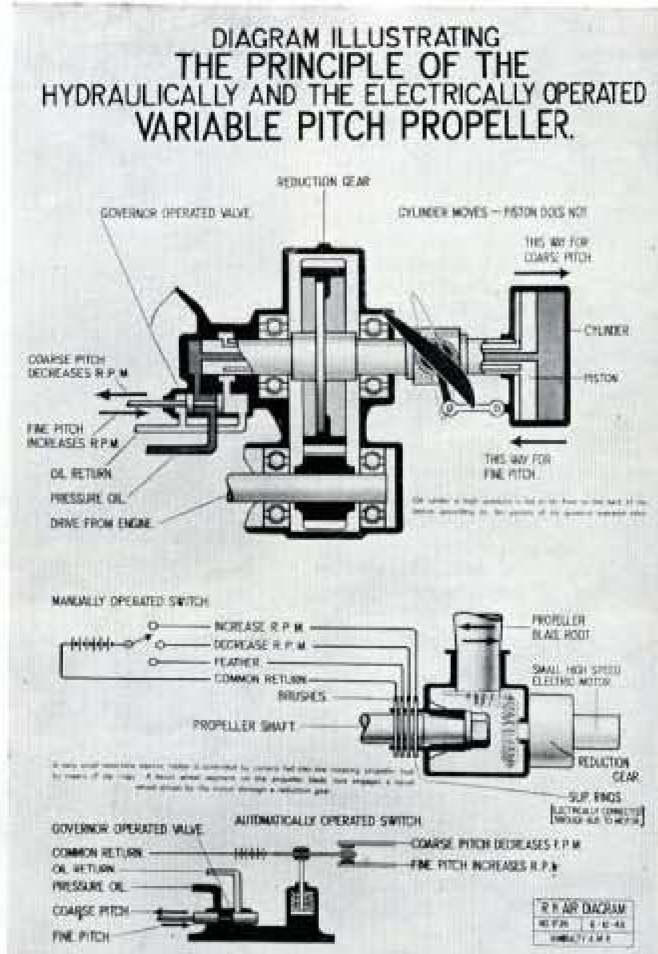


Fig. 186—A "basic" diagram of the type produced by T.A.P.S. to simplify instruction in relation to the maintenance and repair of aircraft.

Fig. 187—The centre panel of this chart for the workshop is finished in the correctly graded colours for the appropriate series of tempering temperatures.

The enormous war-time expansion of naval aviation called for intensive training on a corresponding basis and during the transition period from peace to war, first class air fitters and air mechanics were being turned out in large numbers from promising material of appropriate experience.

In course of time it became necessary to recruit men of little or no mechanical or aeronautical experience and to train these at high pressure with the help of simplified wall diagrams, posters, cinematograph films, film strips, specially written leaflets and

Fig. 188—A consultation on a point of layout of an undercarriage hydraulic braking system.

The Training Aids Production Section

Fig. 189—A view in one of the studios where designers and draughtsmen bring the wall diagrams, etc., into being.

other aids. In being primarily responsible for the production of such material for the use of Air Engineer Officers and maintenance personnel, 'T.A.P.S.' as the section is known in the Service, satisfies a very important and ever-increasing demand.

Service requirements are formulated by the School of Aircraft Maintenance, (whose work we feature in our previous section) or the Assistant Director Personnel, and in designing and producing instructional diagrams every effort is made to anticipate the type of material required. A staff of specialists, assisted by draughtsmen and colourists, is engaged in this work and the helpful ideas and suggestions which are frequently forthcoming from Air Engineer Officers and Instructors are often of great value.

As a record of some of T.A.P.S. activities, we took the photographs used to illustrate this section; Fig. 188 for instance shows a consultation on a point of layout of an undercarriage hydraulic braking system, whilst Fig. 189 takes us into one of the studios where designers and draughtsmen bring the wall diagrams etc. into being. In an adjoining studio, women artists add the colours which are such a prominent feature of the displays (See Fig. 190).

A carbon steel hardening and tempering chart which carries a centre panel finished in the correctly graded colours for the appropriate series of tempering temperatures, and reproduced in black in Fig. 187, is but one of the many workshop aids turned out.

An interesting innovation is the 'notebook diagram'. One of the major difficulties of the diagram designer is to present his subject, which is rarely simple and as previously stated may be extremely complicated, with a drastic limitation of explanatory lettering. This limitation is

Fig. 190—Women artists in another studio add the colours which are such a prominent feature of the wall displays.

Fig. 191—T.A.P.S. edit and produce the first Service publication in this country devoted exclusively to naval aircraft maintenance; the engineering leaflet is another of their many activities.

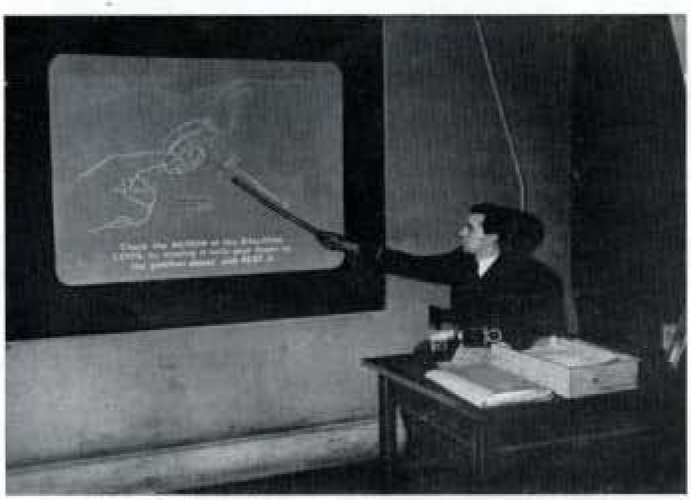


Fig. 192—A view in the Film Strip Inspection Room.

removed in the notebook diagram, a small size replica of the large lecture diagram, with additional lettering, which is designed to be pasted into the students' notebook. Instructions for colouring are provided, on the theory that in colouring the diagram himself, the trainee will absorb the lesson with greater ease.

A view in the storage, packing and despatch section is given in Fig. 193 from whence distribution of wall diagrams and posters is made based on the 'selection by user' principle which has proved sound in practice. Copies of a loose-leaf catalogue containing small reproductions of coloured naval air diagrams are also widely distributed and kept up to date so that the Station Engineer Officers, with this before them, can select and request those that suit their particular requirements.

Recently the Training Aids Production Section was entrusted with the editing and production of 'Naval Aircraft Maintenance Matters', (see Fig. 191), the first Service publication in this country devoted exclusively to naval aircraft maintenance. It is profusely illustrated and has had a good reception from the Air Engineer Officers and senior maintenance ratings to whom it is addressed. Particularly welcome to readers are the charts and coloured diagrams distributed with each issue.

The preparation of leaflets dealing with the application of engineering principles and practice to aircraft and aero engines is another of the section's activities, the one featured in Fig. 191 which gives 'notes on boost and the V.P. propeller', being a typical example.

T.A.P.S. is also responsible for viewing instructional films, and recommending them, if they are of general technical interest, to naval air engineering. Those of a more specialised instructional nature are referred to S.A.M. for report. The supervising of the production of short instructional films is another feature and two such films 'How an aircraft flies' and 'Keep 'em flying', made in collaboration with the Director of Naval Training, have recently been distributed. Film strips are also prepared in collaboration with the same department, a view in the film strip inspection room being given in Fig. 192. Recent examples deal with the daily inspection of the newer types of aircraft, the work being carried out by an Engineer Officer assisted by an ex-director of documentary films in civil life.

Fig. 193 (Right)—The storage, packing and despatch section of T.A.P.S. from whence the distribution of wall diagrams and posters is made.

Centralised Maintenance of Aircraft

AS an introduction to this section on Centralised Maintenance we propose to give an outline of the important subject of—

OPERATIONAL RESEARCH ON AIRCRAFT MAINTENANCE

—the object of which is to develop and apply the principles of Planned Flying and Planned Maintenance, whereby large economies both in aircraft and maintenance man-power have been achieved. This study has evolved during the past three years, being a direct outcome of an acute shortage, both of aircraft and men.

First of all we have the *flying plan* which is fixed for each station and lays down the flying hours to be achieved each month, dependent upon the function—operations or training,—size of station, and type of aircraft. This involves a certain daily task to be flown on 'fit-for-flying' days which must not be exceeded unless in special circumstances. The average numbers of aircraft in the various 'states' are then calculated,—net in use, backers-up, pool (some serviceable, others unserviceable and awaiting man-power), undergoing minor inspection, undergoing repair and awaiting spares (see Fig. 195).

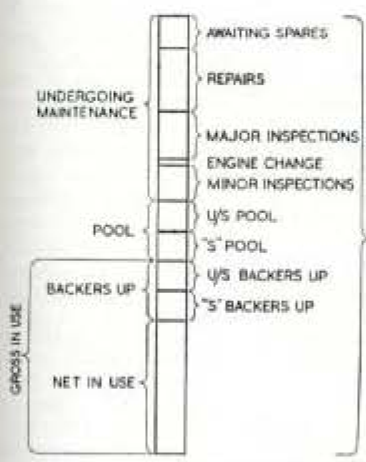


Fig. 195—The various aircraft 'states' in relation to the flying plan.

The next consideration is the *pool*, the essential 'buffer state' between the flying organisation, which constantly reduces *flying potential* by turning serviceable aircraft into unserviceable ones, and the maintenance organisation which rebuilds *potential* by reversing the process. Unless the pool always contains a certain number of aircraft 'awaiting man-power', there will be times, as after a spell of bad weather, when no aircraft are available to be worked upon and maintenance ratings will be unemployed.

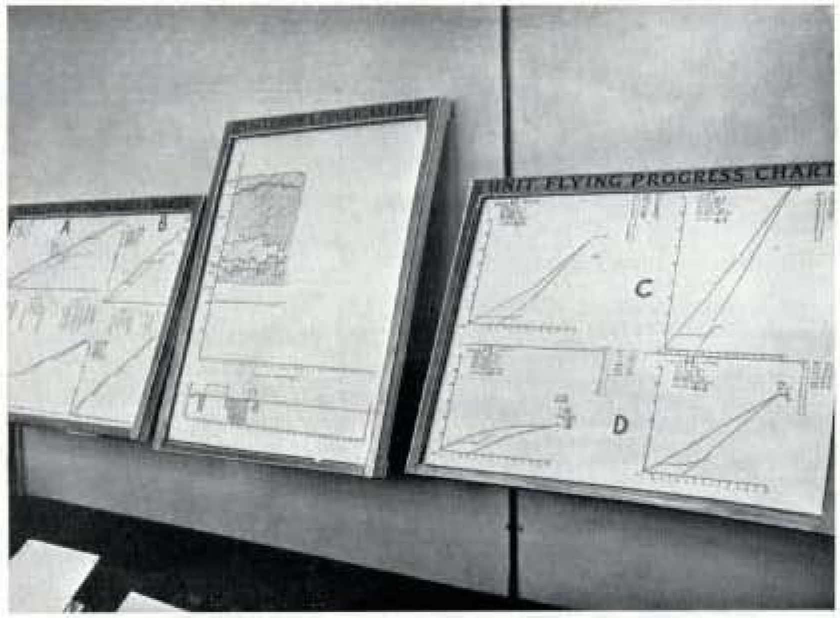


Fig. 194—The Flying and Maintenance Progress Charts kept by the Senior Engineer at the No. 1 Naval Air Fighter School, Yeovilton (H.M.S. Heron).

The *maintenance plan* follows upon the *flying plan*. Operational Research provides the necessary statistics, in the form of *total repairs arising* from 1000 hours flying by a given aircraft type, together with the man-hours required from the various trades (riggers, fitters, electricians, etc.) to rectify them. Similar figures are available for the minor inspection arisings, together with the proper gang sizes to be employed and the average times for completion. On the basis of these arisings, and with known working hours 'on the job', the flights and maintenance units may be supplied with complements of maintenance ratings in suitable proportions by trade. (The word 'arisings' is used to indicate the flow of work which results from operating aircraft over a given period of time).

Time Recording

The statistics are collected for each aircraft type by a time recording party and one experienced recorder can cover the activities of about 25 maintenance ratings, if the station is not too widely dispersed. Over a period of about a month all the repair arisings are noted and the activity of every rating is recorded at half-hourly intervals by a system of code letters. These entries, to the number of about 6,000 per day, are analysed at a central office where an over-all picture is built up and stations' efficiency compared.

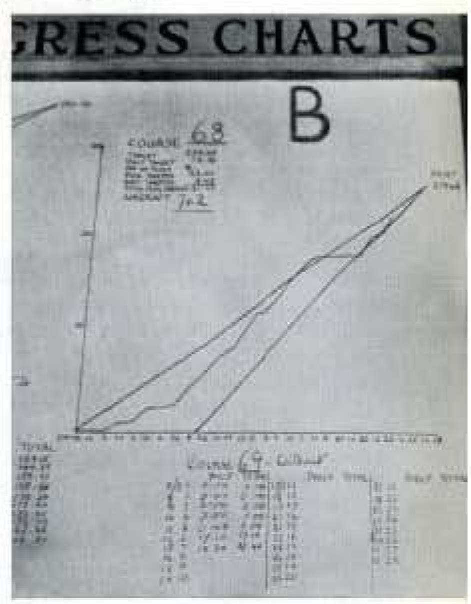


Fig. 196—A close-up view of the Flying Progress Chart for B Flight; the upper line indicates the target figure for the month, the lower line is the weather factor allowance; the aim is to keep the 'actual' flying line within this safety zone.

To take a typical example the graphs of Fig. 197 illustrate the integration of flying and maintenance for a new aircraft type which was coming into use and was still in the 'settling down' state. The five graphs illustrated are conveniently divided into three periods on a time basis, as follows:—

(1) January 9th-January 23rd. Four 'fit-flying' periods with bad weather (blacked out) in between. (Graphs 1 and 2.) Daily man-hours on minor inspections are steadily rising as new aircraft reach the first 40 hour inspection—little stagger of inspections possible yet. (Graph 3.) Man-hours on repairs fluctuating seriously, but decreasing as initial 'snags' and 'teething' troubles are overcome. (Graphs 4 and 5.)

(2) January 23rd-January 30th. A period of intensely cold weather when flying was impossible and maintenance very difficult (Graphs 1 and 2.) Employment falls off as 'awaiting man-power' aircraft are rendered serviceable, but work ceases on January 29th due to arctic conditions. (Graphs 3, 4 and 5.)

(3) January 30th-February 14th. Flying starts up again and maintenance finally begins to settle down. (Graphs 1 and 2.) Daily man-hours on minor inspections and repairs become steadier (Graph 3.) From the results of this final fortnight we conclude that for minor inspections, A and E ratings (riggers and fitters) will be needed in the proportion of about 1.7 to 1. For repairs the ratio will be about 1 to 2.5 (Graph 4) and for both combined (Graph 5) 1 to 1.1.

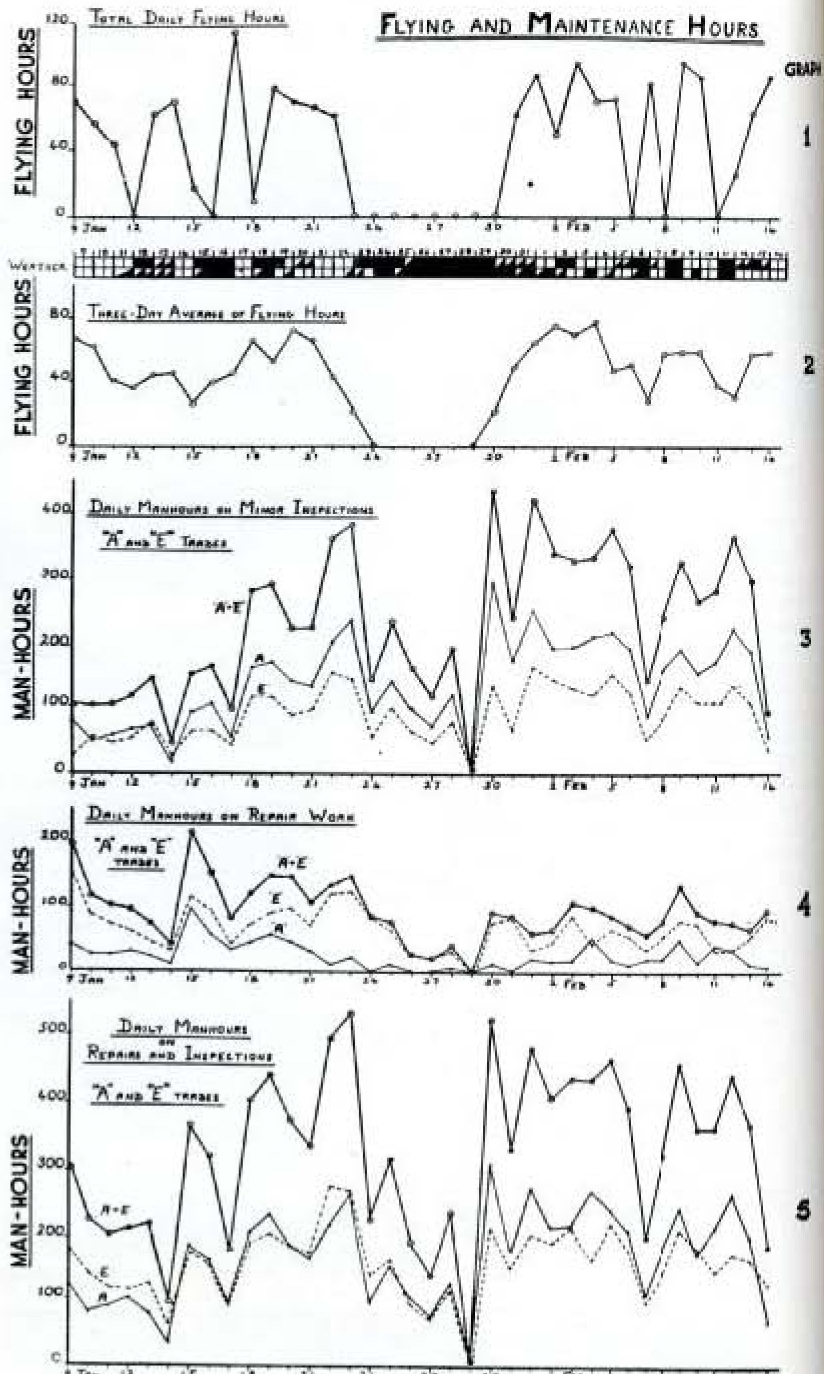


Fig. 197—These graphs show the integration of flying and maintenance for a new aircraft type which was coming into use and was still in the 'settling' down state.

Aircraft Utilisation

Given a certain target of flying hours per 'fit' day for a training station, the question arises how can the target be achieved with the greatest economy of maintenance men and aircraft at the flights? This is a complex problem depending upon the availability of pupils, the need for daily inspections of aircraft and the speed of refuelling on landing. Broadly speaking the principle followed is of flying as few aircraft as tactical requirements permit and flying them as intensively as possible.

In our next illustration Fig. 198 we show, in Graph A, the method of flying aircraft in 'blocks', with intervals between, a total of 24 hours 15 mins. flying being obtained from a gross-in-use of 12 aircraft; this leads to low flying hours per aircraft (2.2) and ground crews are irregularly employed.

Graph B in the illustration, shows the same number of flying hours achieved with half the number of aircraft at 5.5 flying hours per aircraft per day. As a result of this, the number of aircraft airborne is more nearly constant and maintenance ratings are more evenly employed.

CENTRALISED MAINTENANCE

Having outlined the principles involved, we now propose to see how the scheme is put into operation at the No. 1 Naval Air Fighter School, Yeovilton (also known in naval parlance as H.M.S. *Heron*).

The Flying Task

The task of the station is to produce operationally trained fighter pilots, at the rate of 30 a fortnight, so that after leaving Yeovilton and completing their deck landing training at sea, they will be able to take their place in the squadrons of the Fleet. The syllabus laid down takes into account and includes all forms of instructional flying, test flying, weather tests, etc., which amounts to a total target of 4,000 flying hours per month.

Operationally the fying programme is divided up into four separate Flights whose tasks are as follows:—

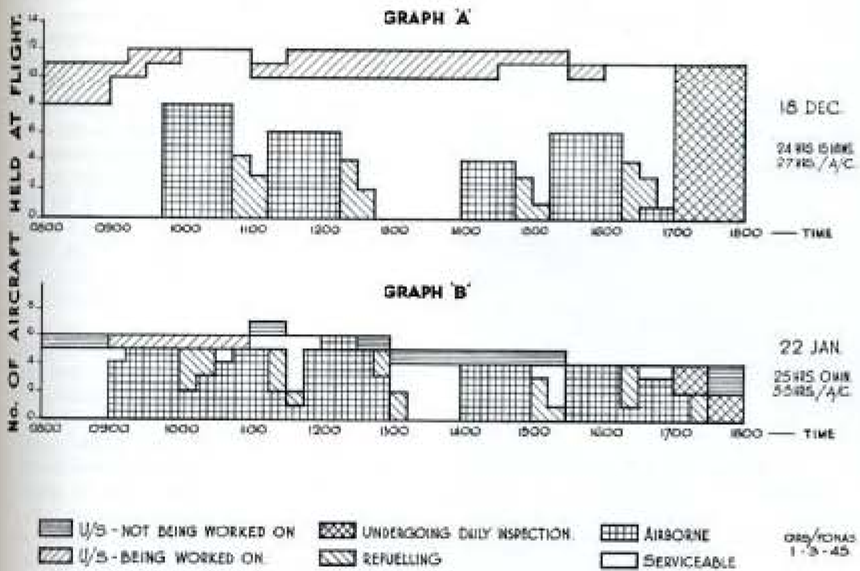


Fig. 198—Graph B shows how the same number of flying hours can be achieved with half the number of aircraft employed in graph A

'A' Flight. One month's preliminary training on Corsair aircraft.

'B' Flight. One month's preliminary training on Wildcat aircraft.

'C' Flight. A fortnight's air combat training for both Corsair and Wildcat pilots.

'D' Flight. A fortnight's aerodrome dummy deck landing and night flying training.

The Maintenance Task

The task of the maintenance organisation is to produce the correct number of serviceable aircraft to satisfy the flying task. For this purpose a flying and maintenance task chart is prepared which calculates, firstly the number of aircraft required and secondly the number of aircraft which will have to be worked on daily to complete the maintenance work for producing the necessary numbers of serviceable aircraft. To explain this procedure, it is possible to take the following simple example to indicate how many aircraft should be undergoing minor inspection at any one time.

A minor inspection is carried out on aircraft after every 40 hours flying, and it is assumed from previous experience that each minor inspection will take on an average 3 days. The arisings per month of minor inspections will be $\frac{4,000}{40}$ (the monthly target divided by 40), which equals 100 minor inspections per month. Assuming the month of 30 days, then the number of aircraft daily on minor inspections will be $\frac{100 \times 3}{30}$, which equals 10.

The same method is used to calculate the months arisings of all other types of work, but of course for repair work the figures used must of necessity be taken from statistics, such statistics being carefully prepared from figures drawn from various units operating similar types of aircraft. For a typical example it is planned that the minor repair arisings will be 35 minor repairs per 1,000 hours flying, from this it is possible to calculate the total number of aircraft which must be worked on daily on the various maintenance operations in order to produce the required number of flying hours to satisfy the flying programme.

The Numbers of aircraft required at each flight is simply calculated by assuming that each 'Net in use' aircraft will fly five hours per day, thus for 'A' Flight, whose target for Corsair aircraft is 60 hours per day, the requirement will be $\frac{60}{5}$ equalling 12 'net in use' aircraft. A percentage of reserve aircraft (known as 'backers-up') will then be allowed at the Flight to enable any 'net in use' aircraft which go unserviceable during the day, to be replaced immediately.

It is to be noted that the state of the weather is allowed for in making these calculations. The weather factor of the station is taken as being 0.65, that is to say, it is assumed that on an average 65 per cent of the days will be fully fit for flying. Thus 'A' Flight's target for instance must be reached not in 30 days but in 20 days. From this it will be seen that the total target is 60 hours on all the days which are fully fit for flying.

Flying and Maintenance Progress Charts are kept by the Senior Engineer and are illustrated in Fig. 194, a close-up view of 'B' Flight chart being given in Fig. 196. The programme of the flying is carefully watched and provided the actual line keeps within the 'safety zone', then the planned number of aircraft required remains constant. Should however the 'actual' line fall into the danger zone for any reason, (i.e. outside the target or weather allowance lines (Fig. 196)) then the Senior Engineer will order additional aircraft to be selected from the reserve pool and allotted to the Flight concerned, which will then increase their rate of flying until the safety zone is once more reached, thus returning the flying rate to normal.

The Maintenance Progress Chart (see centre chart Fig. 194) requires extremely careful watching. In theory the chart should indicate straight lines from the left to the right of the graph indicating that the correct number of maintenance operations is in progress and that these numbers are constant from day to day. The importance of this is that the man-power available to the unit is calculated briefly, by assuming an ideal gang size for the various tasks to be performed and by multiplying this

Fig. 199 (Right)—These Man-power State and Disposition boards in the Regulating Office enable the Air Engineer Officer to ensure that all units are correctly manned according to the maintenance plan.

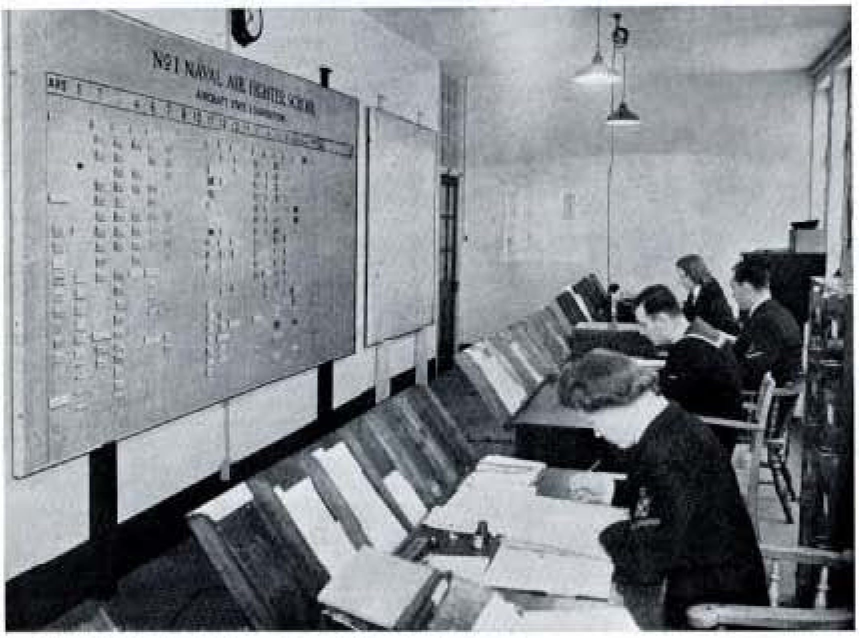


Fig. 200—A view in the Central Records Office showing the wall board on which is recorded an up-to-date picture of the state and disposition of all aircraft on the Station, both serviceable and unserviceable.

gang size (in all categories of maintenance ratings) by the number of daily maintenance arisings. Thus if these arisings are exceeded there will be insufficient men to satisfy the maintenance task. Incidentally the most economical gang size for most maintenance work, except very slight unserviceability, is five air mechanics (A) (i.e. airframes) and three air mechanics (E) (engines).

The Disposition of Man-power within the various units is the next consideration. As already explained, the maintenance arisings for the station are carefully calculated and have been split up and the work allotted to the various units. In order to keep a constant flow from all sections of the unit, it is necessary to ensure that the man-power of each section is kept constantly up to date and the men concerned are correctly fitted professionally to carry out the work they have to do.

The control of man-power is done within the Regulating Office, and the state of each section can be seen at a glance on the Man-power State and Disposition Board shown in Fig. 199. Here is indicated the location of all airframe and engine mechanics and all personnel except radio, electrical and ordnance ratings, the 'outside trades' being grouped under 'Ancillary Workshops'. The various other headings show the locations such as 'E.R.S.' (engine repair shop) 'A.R.S.' (airframe repair shop), the 'M.U.s.' (maintenance units), the Flights and various instructional courses.

As men proceed on leave from the various units or are removed from the unit for any other reason, their names are taken to the bottom of the board and they do not count as effective man-power; if the period for which they will be away is long enough to justify it, then a replacement into that unit will be provided from the reserve pool.

By this means it is possible for the Air Engineer Officer to ensure that all units are correctly manned according to the maintenance plan.

The Aircraft State and Disposition of all aircraft within the various units is displayed on a similar type of board to that which allocates man-power (see Fig. 200) the various types of aircraft being denoted by different coloured tags, i.e. red for Corsairs, white—Wildcat, yellow—Reliants and Masters, and green—Havards. From this board which is kept in the Central Records Office, it is once again possible for the Air Engineer Officer to ensure that the maintenance work is equally divided amongst the various units. Thus for example, if for any unforeseen reason the minor repair arisings on one type of aircraft build up more than that which was planned, the maintenance unit concerned will soon become 'flooded out'. When this occurs the Engineer Officer will divert the larger of the repair work to the Airframe Repair Shop and consequently any major repairs which have arisen must be diverted from the Airframe Repair Shop on the station to the main repair yard concerned, outside the station.

For convenience all technical records and returns which must be made from the station to the administrative authority will originate in the Central Records Office. These returns vary from small daily returns made by signal to the larger and more intricate returns made at specified periods to indicate the state and disposition of aircraft. The importance of accurate returns made by this office cannot be over emphasized since by this means the administrative authority is enabled to plan for the future and to control the whole disposition of aircraft throughout the command.

The Q.S. School

Before proceeding to describe the distribution of work within the units we would mention at this point that ratings drafted to the station direct from training schools are N.Q.S., which means they are not qualified to sign the Aircraft Servicing Form A700 on which every inspection and repair carried out on an aircraft is recorded. This is because they have not had direct experience on the type of aircraft concerned and will not be familiar with local organisation and maintenance orders. Hence the Q.S. School (see Fig. 201) where they qualify in a fortnight, or if they fail the first time, they are given a further fortnight's training.

The Distribution of Work within the units is briefly covered by a summary of the work undertaken by the various units as follows:—

1. **The Flight Servicing Units** which are in the charge of the Flight Commanders

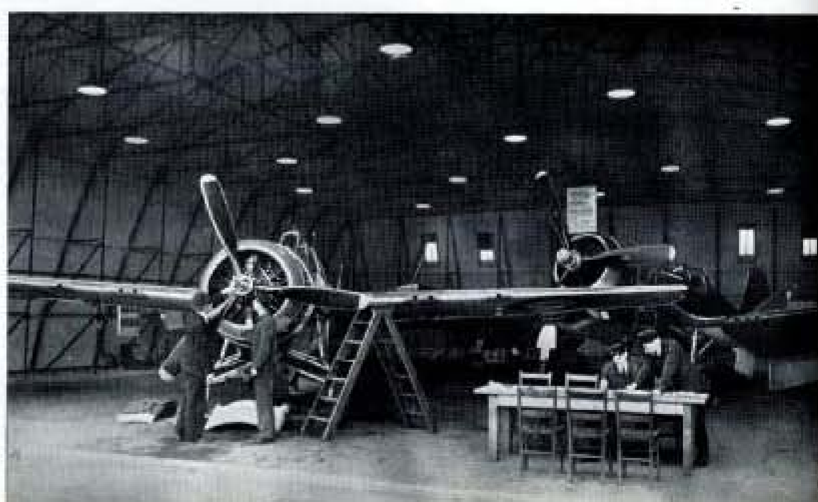


Fig. 201 (Right)—A view in the Q.S. School where ratings direct from training schools 'qualify to sign' Aircraft Servicing Form A 700 on which is recorded every inspection and repair carried out on an aircraft

and carry out Between Flight and Daily Inspections as well as the rectifying of petty unserviceabilities which can be completed within one hour. These units are accordingly responsible for the day-to-day maintenance of the aircraft which are allotted to them.

The photograph reproduced in Fig. 202 shows a line up of Corsairs outside 'A' Flight with servicing personnel at work. The pilot of the first aircraft for instance is ready to taxi off after the mechanics have finished topping up with oil; on the second machine, a radio mechanic in the cockpit is testing the W/T installation (the battery trolley in the front provides the necessary testing current) whilst the mechanics on the trestle complete adjustments to the engine; refuelling of the third aircraft is being carried out by means of a Bowser petrol pump.

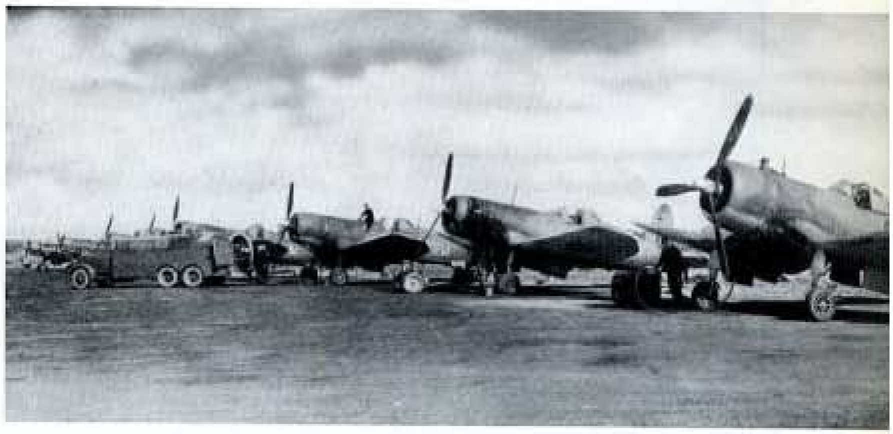


Fig. 202—A line up of A Flight Corsairs; here we have serviceable aircraft awaiting flight, aircraft being refuelled and the carrying out of between flight inspections and repair of petty unserviceability (up to one hour) by the Flight Servicing Unit.

2. **The Reserve Pool.** This unit forms a filter through which all unserviceable and serviceable aircraft are passed. For example, if an aircraft becomes unserviceable at a Flight and it is beyond the capacity of the Flight Servicing Unit to repair, then it is passed to the Reserve Pool for examination. The pool itself is capable of carrying out minor repairs which will take between one and four hours to complete and any aircraft coming within this category is dealt with by them. For repairs scheduled to take a longer time than this, the aircraft is passed to the unit concerned.

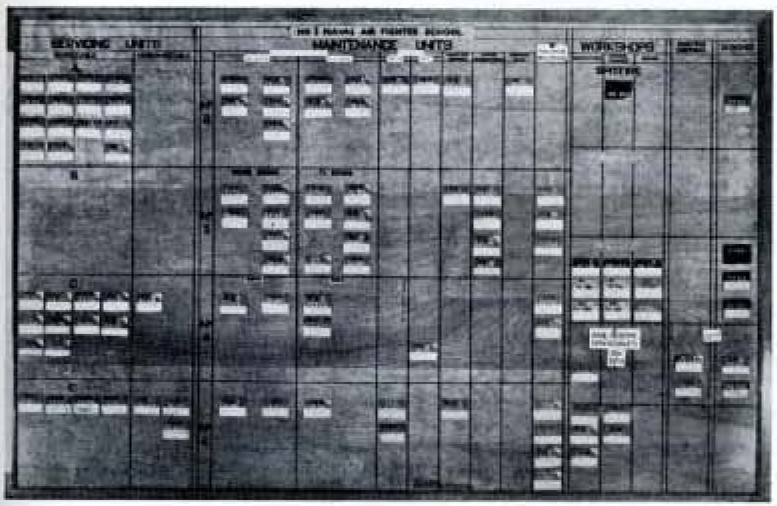


Fig. 203—The No. I Maintenance Unit State board which shows the disposition and state of every Corsair on the Station. The title 'Servicing Units' (first column) is a maintenance term and actually refers to A, B, C and D Flights.

Each of the Maintenance Units (No. I M.U. for Corsairs and No. 2 M.U. for Wildcats) has its own Reserve Pool and in Fig. 204 we see a Corsair being towed to the pool from 'A' Flight for examination.

3. **Maintenance Units.** These are divided into two units as mentioned in the previous paragraph, their work consisting of carrying out the majority of all the normal maintenance jobs including the minor inspections and minor repairs, the latter being classified as over four hours and under seven days.

Hangars are specifically set aside for this work and men are trained in special gangs for the particular maintenance operation they have to undertake.

Each Maintenance Unit has a similar 'state' board to that shown in Fig. 200 the one for No. I M.U. being illustrated in Fig. 203. This board shows the location and state of every Corsair on the Station and we give the following details to show how it operates.

The heading 'Servicing Units' is the term used from a maintenance point of view; from the flying angle it refers to the four training Flights, and here coloured tags bearing the aircraft numbers depict those serviceable or unserviceable (the repair required for the latter is indicated on the tag). The centre section headed 'Maintenance Units' show that No. I M.U. is located in hangars Nos. 2, 3, 4, and 6, No. 2 being the repair hangar and No. 3 the Reserve Pool, whilst Nos. 4 and 6 are inspection hangars.

The centre columns, reading from left to right, indicate the following:—engine repairs, airframe repairs, 40 hour inspections (two columns), awaiting spares, repair workshops, awaiting test, and awaiting man-power. The columns headed 'Workshops' show aircraft on inspection, engine change, or repair, the lower portion with the sub-heading 'Pool Reserve Serviceable Aircraft' showing those undergoing daily inspections and ready to be sent to Flights to replace any aircraft going unserviceable (i.e. beyond one hour). The last two columns are headed 'Awaiting Disposal' and 'Detached'.

Fig. 204 (Right)—A Corsair, on which the unserviceability is beyond the capacity of the Flight Servicing Unit to repair, arriving by tow at the Reserve Pool of No. I M.U. for examination.

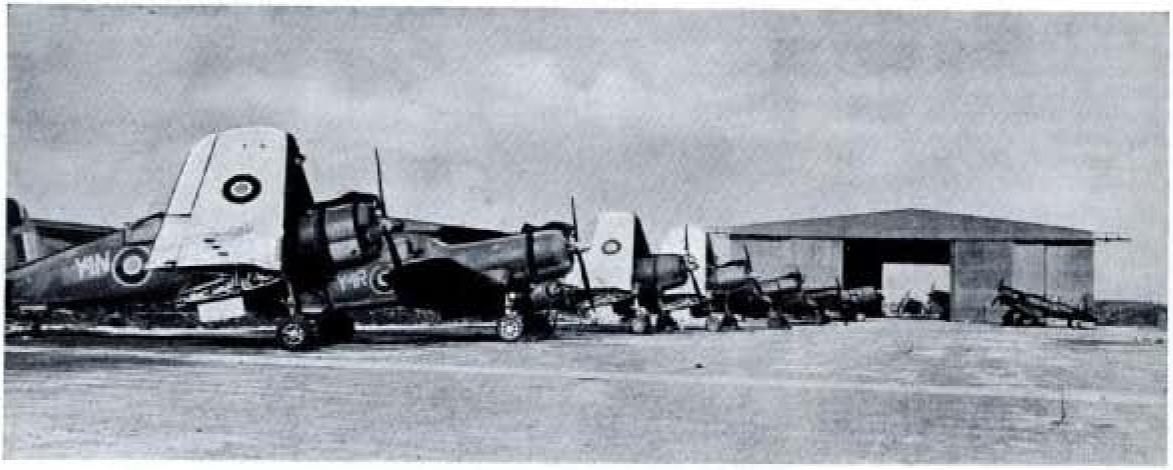


Fig. 205—Corsairs in the Reserve Pool of No. I M. U. undergoing daily inspection ready for re-allocation to Flights. These aircraft came in from Flights with some unserviceabilities which have been rectified and the D.I.s. are being carried out in the Pool to avoid this work immediately on returning to the Flights.

In the illustration Fig. 205 we see maintenance work in progress outside one of the No. I M.U. hangars, this being the normal procedure in fine weather. Another view, Fig. 206 shows an undercarriage retraction test being carried out on a Corsair inside the hangar. This aircraft made a heavy landing on the airfield, hence the retraction test for which the motor driven rig, seen to the left, is used to supply hydraulic fluid to the system, since the engine driven hydraulic pump cannot operate without the engine running. The alternative would be to use the hand pump in the cockpit, but this is a very slow method as against the outside rig which completes the test in 7 secs. and gives an even fluid pressure.

A view of maintenance parties at work on Wildcats outside the No. 2 M.U. hangars is given in Fig. 207.

Fig. 206—This Corsair made a heavy landing on the drome so it is now undergoing an undercarriage retraction test with the use of a hydraulic test rig in No. I. Maintenance Unit hangar.

4. **The Airframe Repair Shop** is responsible for the major repairs and major inspections, providing that man-power and floor space are available, such operations being designed to be completed in an average time of 14 days. If personnel and space are not available when required, then the aircraft is sent to the relevant repair yard.

In the illustration Fig. 208 we depict two engine fitters at work on a Corsair, using standard platforms supplied by the aircraft makers. The front one fits into the stub plane and nose cowling and has a series of studded steps to provide a firm horizontal foothold. The rear platform is necessary owing to the steep slope of the wing roots.

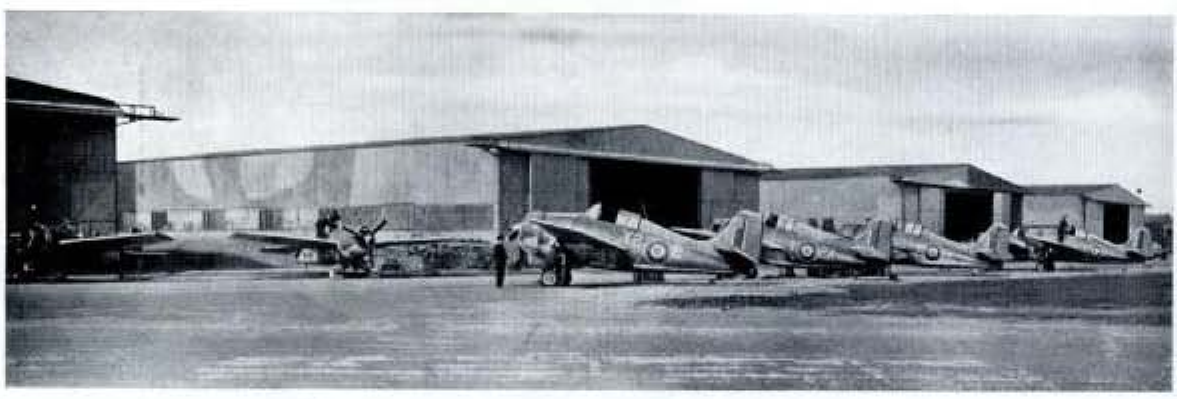


Fig. 207—Maintenance parties at work on Wildcats outside the No. 2. M.U. hangar.

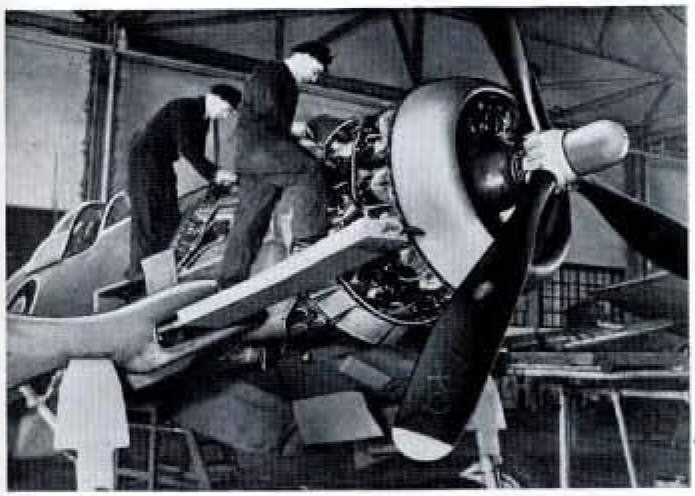


Fig. 208—Two engine fitters at work in the A.R.S. (airframe repair section) using the standard platforms provided by the manufacturers. The front one fits into the stub plane and nose cowling, the rear one is necessary owing to the steep slope of the wing roots.

The next series of pictures (not taken at Yeovilton) show a folding platform peculiar to the Royal Navy, which proves extremely useful for the maintenance of aircraft. Compactly folded for transport, the platform is wheeled to the required position as Fig. 209 with the platform to the top, and then turned on its back and the straps undone. The legs, composed of hinged telescopic struts, are raised to the vertical position and the knuckle joints (see Fig. 210) pushed fully down into their socket tubes. The corner tubes are then fixed and the telescopic diagonal braces clipped on, the result being seen in Fig. 211 which still shows the ladder in its stowed position.

Lifting the platform on to its legs, the extension feet at the wheel end are lowered to bring the wheels off the ground, and the knuckle jointed guard rail raised into its position, after which each telescopic end is adjusted alternately, by means of pins through the corner tubes, until the required height is reached (the ladder having been removed). (See Fig. 212). The completed platform with ladder in position is shown in Fig. 213, the adjustable feet giving the final levelling. To move to any position, the ladder is merely collapsed against the legs and the platform manoeuvred by lifting and wheeling from this end, after the wheel extension feet have been raised.

Fig. 209—A folding platform which proves extremely useful for the maintenance of aircraft.

Fig. 210—Shows the knuckle joint arrangement of the leg struts.

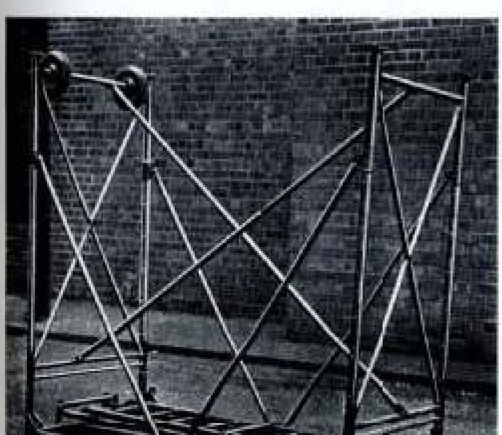


Fig. 212—Adjusting the telescopic leg struts for height.

Fig. 213—The completed platform ready for use.

Fig. 211 (Left)—The corner tubes and diagonal braces have now been secured; the ladder is still in its stowed position.

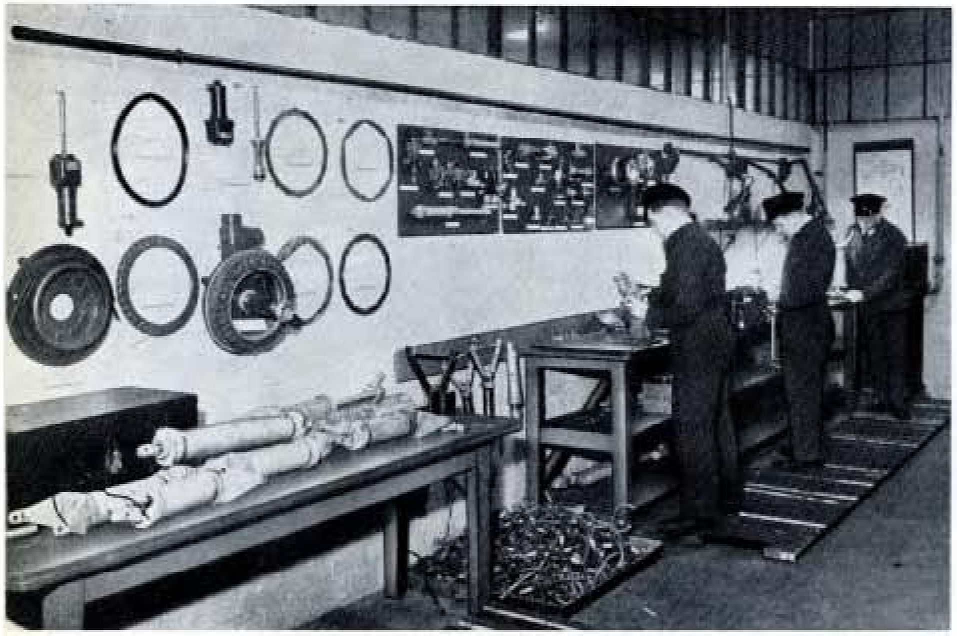


Fig. 214—A view down one side of the Hydraulic Bay, which is one of the ancillary workshops; various components are displayed so that riggers can obtain a clear understanding of the individual parts and their functions.

5. **The Engine Repair Section,** whilst carrying out major repairs to engines within the scope of the Station resources, has for its primary concern the preparation of new engines for installation into aircraft. These, together with overhauled engines, are allotted to the station reserve pool and are built up into power plants in the power plant erection shop. The object of this is to reduce the time taken to carry out an engine change on an aircraft since it is a far simpler job to instal a complete power plant that it is to instal a separate engine into the power plant structure that is already attached to the aircraft.

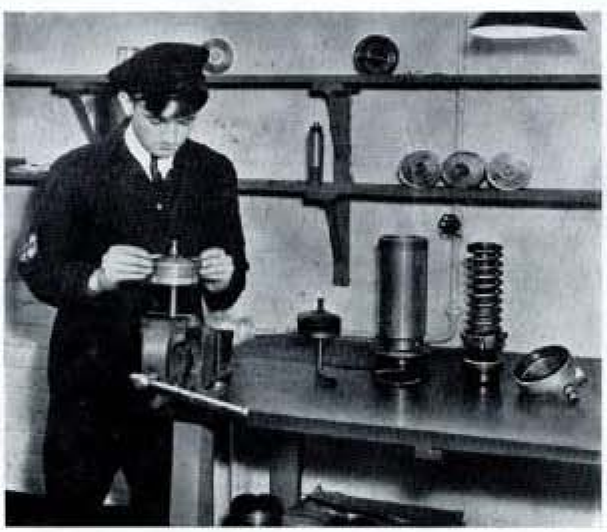


Fig. 216—The Engine Starter Repair Bay is another of the ancillary workshops. Here is a local modification being carried out to an Eclipse cartridge starter.

6. **The General Engineering Shop** embraces a number of ancillary workshops which cover in a small way all the various basic engineering traces such as coppersmiths, welders, fitters and turners, sheet metal workers, etc. They also include independent repair bays for various aircraft components such as propellers, hydraulic components, generators, etc.

In this connection a view is given of part of the Hydraulic Bay in Fig. 214. Here, various components will be seen displayed on the wall so that the riggers working in the bay can obtain a clear understanding of the individual parts and their function. In the foreground for instance is a Corsair brake assembly, beyond which are three panels displaying various hydraulic components such as manifolds, flap jack selector, engine gills jack and swivel joint for hydraulic pipe line to wing folding jack, the last panel featuring a filter, hydraulic accumulator, and unloader valves for emergency operation of the undercarriage.

On the opposite side of the bay is the special demonstration rig of the Corsair hydraulic system depicted in Fig. 215, the feed lines, etc., of which are painted in

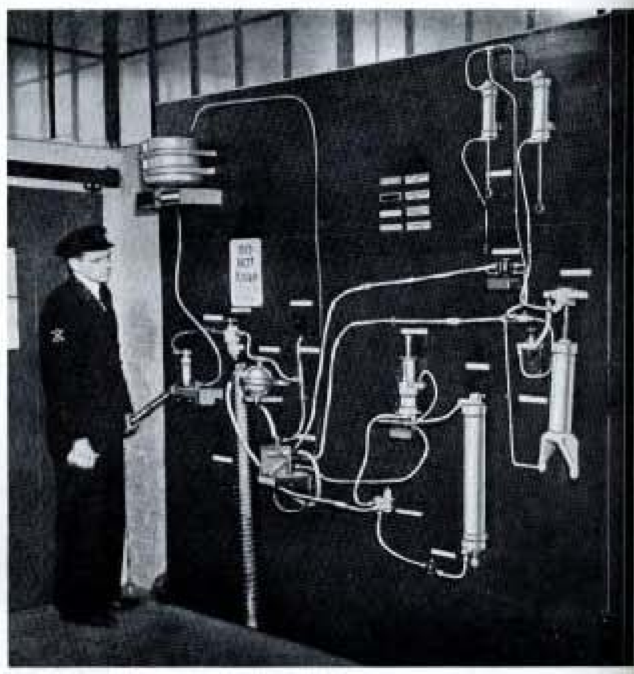


Fig. 215—This special working demonstration rig of a Corsair hydraulic system is erected in the Hydraulic Bay.

different colours to assist in understanding their functions.

Another of the ancillary workshops is the Engine Starter Repair Bay and in Fig. 216 we show a modification initiated at the Station, being carried out to an Eclipse cartridge starter as fitted to the Corsair III. On the bench stands a burnt piston

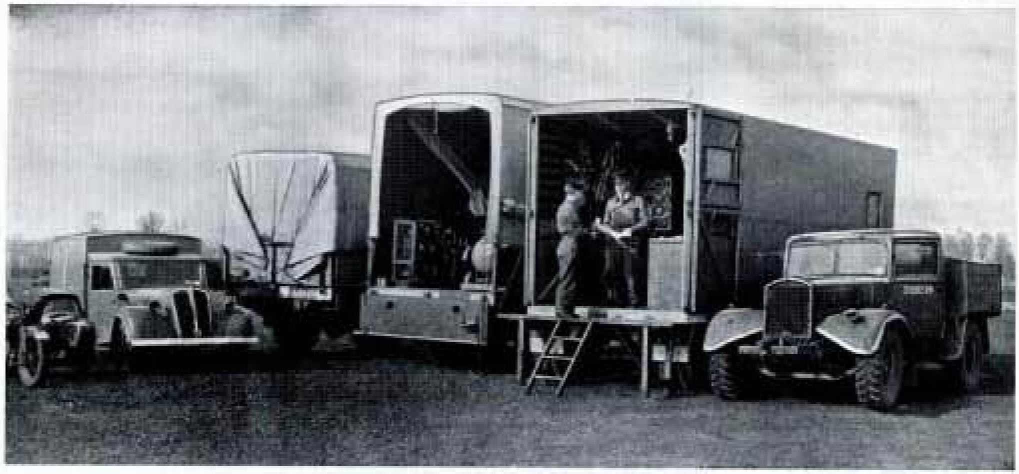


Fig. 217—Here we illustrate the equipment of a Corsair S.S.U. (squadron servicing unit). This was originally attached to the Station to supply stores during the transitionary period to Corsairs and can service a Squadron of twelve aircraft for 14 days.

of the type being replaced, next to which is the cylinder, centre assembly and cylinder head. The modification consists of turning down the diameter of the piston except for a small portion of the skirt and shrinking on a new sleeve which is complete with four piston ring grooves. The fitter at the vice is putting the new rings on the modified piston.

Fig. 218—This Curtiss electric propeller demonstration rig is situated in the Electrical Workshop; when a power unit has been stripped, serviced and re-assembled, it is mounted on the propeller boss in place of the sectioned model and given a complete functional test.

The Electrical Workshop is featured by means of the photograph reproduced in Fig. 218 which shows a Curtiss electric propeller test rig by which it is possible to simulate all flying conditions. All the aircraft controls and indicators are on the back board, together with a wiring diagram, and the propeller is sectioned to show the cam which breaks the limit switch. A brake at the top end of the motor is actuated by a solenoid which cuts out immediately to prevent over-running of the switch.

When a power unit has been stripped, serviced and re-assembled in the Electrical Workshop it is mounted on the propeller boss in place of the sectioned model and given a complete functional test.

Leaving the workshops, we now introduce three views of—

A Squadron Servicing Unit, the normal function of which is to be attached to a naval air Squadron, disembarked for a short period, to obviate taking off their own ground equipment and stores from the aircraft carrier. In this instance the unit was originally attached to the Yeovilton Air Station to supply stores during the transiartiony period to Corsairs and it carries

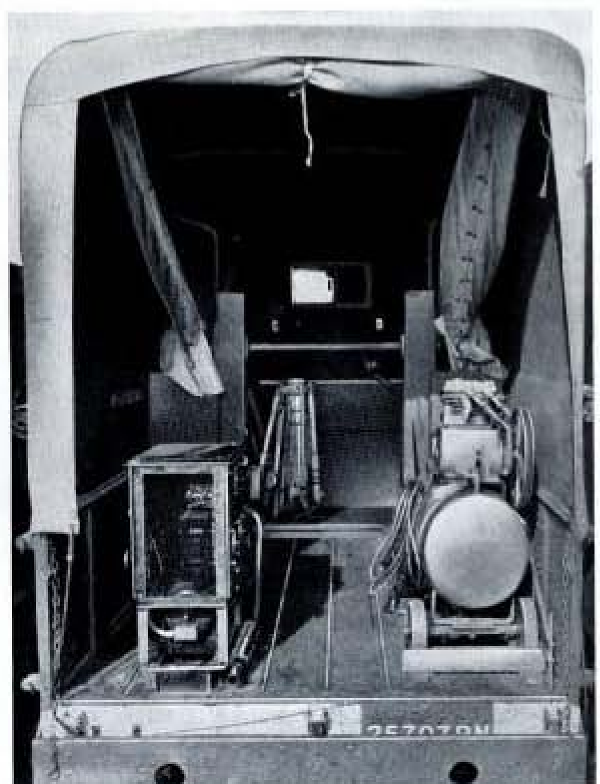


Fig. 219—The workshop lorry of the S.S.U. carries two assembled propellers, a battery charging unit, portable compressor, sparking plug cleaner, bench and vices; two let down tents at the sides provide additional working space.

enough equipment to service a squadron of twelve aircraft for 14 days.

The unit as depicted in Fig. 217, consists of a stores trailer and office, a workshop lorry, a general service lorry carrying the usual ground equipment, chocks, pickets, etc., a 10 cwt van for collecting spares, etc., a 1 ton lorry and a motor cycle combination.

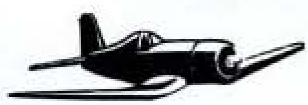
A view in the workshop lorry is given in Fig. 219 and this carries two completely assembled propellers (seen shrouded), a battery charging unit, portable air compresser, sparking plug servicing outfit, bench and vices. Two let-down tents, attached one on each side, serve as auxiliary working spaces in which two benches, secured to the sides of the lorry, are lowered into working position.

Fig. 220—Pupil pilots receiving instruction in the correct technique of handling engines under different tactical conditions, from the Senior Test Pilot, who is also a fully qualified Air Engineer Officer.

Fig. 221—This is the stores lorry of the S.S.U. which carries general aircraft and engine spares, the main control surfaces being stored in the roof.

The stores lorry featured in Fig. 221 houses general aircraft and engine spares, the main control surfaces being stowed in the roof.

These S.S.U.s., as they are known, have to hold themselves in readiness to move to a new destination at 48 hours notice.



To conclude our story of Centralised Maintenance we append a few remarks on—

Pupil Pilots Instruction

The complexities of modern aircraft make it essential that the pilots are given full instruction in the operation of their engines and particularly in the correct technique for handling them under different tactical conditions. In the lecture room shown in Fig. 220 instruction is given by the Senior Test Pilot who is also a fully qualified Air Engineer Officer. At the rear of the room will be seen a Pratt & Whitney 2,000 h.p. 18 cylinder Double Wasp engine, whilst the wall charts show functional diagrams of such components as carburettors, propellers etc.

The last illustration Fig. 222 shows a Corsair pupil pilot of D Flight practising aerodrome dummy deck landings (or A.D.D.Ls. for short) before proceeding to the real job on the deck of an aircraft carrier.

Fig. 222—A Corsair pilot of D Flight practising aerodrome dummy deck landings (A.D.D.Ls) before proceeding to the real job on the deck of an aircraft carrier.

REPAIRS AND MAINTENANCE AT A NAVAL AIRCRAFT REPAIR YARD

Fig. 223—A crashed Barracuda, after flak damage and subsequent forced landing, arrives at the Donibristle Repair Yard and is removed from the articulator by means of a mobile crane.

IN the previous section dealing with the question of Centralised Maintenance, reference was made to the transference of aircraft to relevant repair yards in the event of man-power and floor space for major repairs and inspections not being available at the air station when required. From this remark it should not be assumed that repair yards exist merely to take the overflow work from air stations, as the main considerations in their allocation of aircraft are based on the type and major extent of the maintenance and repair necessary.

Repair operations and facilities beyond air station level are divided into two groups, firstly the Maintenance Yards which undertake major inspections, medium repairs and aircraft overhauls, and are manned by Service repair ratings and secondly, Repair, Yards to which aircraft requiring the more extensive major repairs are sent. The latter operate in relation to the Naval Air Arm as the Royal Dockyards to the Fleet, and are manned by civilian repair personnel under the control and direction of naval officers.

To illustrate the work of a typical Repair Yard we visited the establishment at Donibristle, in the county of Fife, Scotland, which takes the ship's name of H.M.S. *Merlin*, also three ancillary workshops at Dundee (propellers), Dunfermline (electrical harness and sparking plugs) and Alloa (aircraft component recovery depot).

The Donibristle Repair Yard Organisation is divided into five divisions whose responsibilities are as follows:—

1. **The Storage Division** which holds all types of aircraft for allotment to Service stations and receives all machines that fly in for major inspections.

2. **The Aircraft Division,** into which is fed all crashes and storage planes for overhaul and repair, after which they are taken over by the Storage Division for despatch.

3. **The Workshops Division,** comprising the E.R.S. (engine repair section) which undertakes complete or partial overhauls of engines of certain specialised types, both English and American. For this purpose engines are received both from the Aircraft Division and direct from carriers and air stations. Repair workshops also form part of this division in which every type of accessory and component (including aerofoil but excluding electrical) is overhauled and tested.

4. **The Electrical Division** looks after all electrical matters pertaining to aircraft including Link Trainers, also connector sets and sparking plugs, etc., at Dunfermline.

5. **The Inspection Division** which is responsible for the serviceability of all aircraft, engines and components passing through the repair yard.

The Production Office is the key centre which co-ordinates the work of the organisation. It is here that the signal is received to announce that an aircraft is coming in for repair or major inspection, a Board of Survey is convened and job cards are issued and stamped after each repair section has completed its work.

Before proceeding with the illustrated story which follows, we propose to give an outline of the work progress procedure based on a crashed aircraft received at the Station and throughout this we shall give references to the appropriate numbered section in which are reproduced photographs of typical repair work in operation.

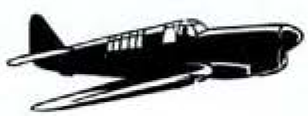
1. **The Crashed Aircraft Arrives** (see Fig. 223) and is examined by an air engineer officer to confirm that it is repairable.

2. Aircraft is allotted to hangar and a Works Order made out. As a typical example, the Works Order, after giving the aircraft number (in this instance a Barracuda), the job and engine numbers, reads as follows:—

1. Allotted to Assembly IV to prepare for Board of Survey.
2. Board to assemble at 14.00 Monday, January 29th.
3. Inspection to make report AR26B (strip report) and forward to Progress.

3. **Board of Survey** consisting of officer or civilian supervisor in charge of hangar, examiners of airframe, engine and electrical branches, a charge hand from Aerofoil Repair Shop and the Production Officer's assistant, examine aircraft internally and externally and make recommendations as to repairs required and type of routine inspection to be carried out (See Fig. 224) Next, a team of examiners compile a thorough detailed report of work required to implement the findings of the Board of Survey, whilst the office staff study the aircraft's log cards and draw up a list of all outstanding modifications to be incorporated and all special technical instructions (received from Admiralty from time to time) requiring to be satisfied.

The foregoing process takes about two days, the whole report is then vetted by the Aircraft Divisional Officer, who authorises Job Cards and History Sheets to be issued to the specialist sections to be concerned in the repair work.



4. **Work Commences,** the following proceeding simultaneously or in sequence:

(a) Propeller is removed and goes to Propeller Shop, Dundee (see Section 1).

(b) Whole power plant is taken out and transferred to P/P Bay (see Section 2).

(c) Main planes come off and go to Aerofoil Repair Shop (see Section 3).

(d) Hydraulic, pneumatic and other components go to Mechanical Workshops (see Section 7) and all instruments and electrical components to the Electrical Repair Section (see Section 6) for repair and test.

(e) Repair work on the actual fuselage starts (see Section 4). At the same time demands for spares and stores required are made out and signed by the hangar officer or civilian supervisor.

(f) Main Stores (see Section 8) supply all available items and demand those not held from a Naval Stores Depot.

(g) Modification Office obtain approval from the Admiralty for supply of modification sets required.

5. **When aircraft near completion,** and any spares are still outstanding, the following action is taken:

(a) Production Officer sends urgent hasteners to Supply Officer (Stores) who takes signal action in accordance with aircraft's priority.

R.N. AIRCRAFT REPAIR YARD,
DONIBRISTLE.

DATE 31st Jan. 1945.

AIRCRAFT REPAIR YARD - BOARD OF SURVEY REPORT.

Type and number of Aircraft : Barracuda II LS.123.
P.Plant PUB/113.

Type and number of Engine : Merlin 32.
12345/78910.

The following report of the A.R.Y. Board of Survey held on the above aircraft is submitted :

---

1. AIRSCREW ..... 2 blades broken at root ends.

2. ENGINE ..... Shock Loaded.

3. FUSELAGE:-
Engine Bay .... Severe damage.
Front ..... Slight damage by flak.
Rear ..... " " " "
Rear End ..... " " " "

4. LANDING GEAR:-
Port ..... Badly damaged.
Starboard ..... No apparent damage.
Tail ..... " " "

5. CENTRE SECTION:-
Top ..... No apparent damage.
Port ..... " " "
Starboard ..... " " "

6. FIN ..... " " "

7 RUDDER ..... Slight damage.

8. TAIL PLANE ... Damage by flak.

9. ELEVATORS:-
Port ..... Damage by flak.
Starboard ..... " " "

10. MAINPLANES:-
Port Upper ... Major damage by flak.
Port Lower ... Non-applicable.
Starboard Upper Major damage by flak.
Starboard Lower Non-applicable.

11. AILERONS:-
Port Upper ... No apparent damage.
Port Lower ... Non-applicable.
Starboard Upper No apparent damage.
Starboard Lower Non-applicable.

Recommendation:

P.Plant to be changed.
Port & Stb. M/Planes to be changed.
Major Repairs on Fuselage.
In view of general condition major insp. to be carried out concurrently with repairs.

Signed ....

Fig. 224—This shows the Board of Survey's recommendations for the repairs and inspections to be carried out on the crashed Barracuda.

(b) Copy of hasteners sent to Aircraft Component Recovery Depot, Alloa, (see main section entitled 'Aircraft Salvage and Component Recovery') who send any repairable items of the type required, which they can obtain from aircraft being broken down, to the Mechanical Workshops on a priority label for repair, test and issue to the aircraft requiring them.

(c) Any item which can be manufactured in the Workshops is put in hand.

(d) As a last resort an aircraft of the type awaiting repair is 'robbed' and the existing stores demand transferred to it.

6. During every stage of the work already described, the charge hands concerned sign that it has been correctly executed; this is countersigned by the examiners of the Inspection Division if and when approved by them.

7. **In the Power Plant Bay,** the power plant is stripped down and examined in accordance with a further Works Order which has been issued in the meantime, and the engine is transferred to the Engine Repair Section (see Section 5) for rectification, all inspections due, and test bench run. At the same time a power plant of the same type is taken from the Reserve Pool (see Section 2) and prepared for installation in the aircraft concerned.

8. **In the final stages** before test flight a very thorough independent inspection is carried out by 'finals' examiners before turning over to the test pilot. The test flight is long and severe and if, on completion the aircraft is reported satisfactory in all respects the squadron eventually receiving it can, and does, have complete confidence in its reliability.

Fig. 225—One of the first components to be removed from the aircraft is the propeller, and this is sent to the Propeller Shop, an ancillary workshop at Dundee; here is a general view in the Assembly Bay.

9. **The Dope Shop.** After test flight and before transfer to the Storage Division for disposal, the aircraft is put in the Dope Shop, thoroughly cleaned down and then given a new coat of camouflage which varies somewhat according to the duty on which the aircraft is to be engaged. Fast fighters, such as Seafires for instance, are given a very special 'high speed' finish, the perfection or otherwise of which affects their ultimate performance.

Having concluded the work procedure outline, we now commence our illustrated story of repair facilities with the view Fig. 223 of the Barracuda, which suffered a forced landing after flak damage, being removed from the articulator upon arrival at the Donibristle Repair Yard.

Following the Board of Survey report (see Fig. 224) the repair work is commenced and this introduces—

SECTION I—The Propeller Shop

—at Dundee where the damaged component is sent for complete overhaul, a new or serviceable propeller being held in readiness to replace it on the aircraft in question. (It will be appreciated that the illustrations we use do not necessarily refer to this aircraft or even to planes of the same type, but were taken during our visit to feature the many different repair operations carried out.)

The Dundee Propeller Shop started as a small section of Donibristle, repairing 15 to 20 propellers a month. When the constant speed types developed, the necessary expansion made it imperative to move to Dundee, where, commencing with dilutee labour and a few skilled men, the work has grown to the stage of employing 60 persons and an inspection staff of ten, the output having increased to 100 propellers a month and including Rotol, Curtiss and Hamilton types with a concentration on those in short supply.

A view on the Assembly Bay is given in Fig. 225, whilst Fig 226 depicts a corner of the Inspection and View Room. The girl to the left of the surface table is checking

Fig. 226—In the Inspection and View Room; at the table the track of a Rotol propeller hub is being checked with a dial gauge, the other instrument being used for checking the divide of the ports. The inspector at the rear is examining components for cracks on the electric crack detector.

A general view in the Wood Blade Propeller section is featured in Fig. 227, the carpenter on the left is cleaning the brass leading edge of a Seafire blade whilst next to him a Seafire bade is being shaped. The other two men are making scarfs for blade tip repairs on Firefly propellers, and the girl is fairing a blade cover after repair. In Fig. 228 we see a repaired Weybridge blade for a Seafire being marked off by means of the template secured to the table prior to finishing to shape.

Out in the Assembly Bay is the standard Rotol tool, Fig. 229, for fitting the bearing assembly to the blade the correct way up, with the smaller ball race at the top. This rig is adjustable for al sizes of Rotol blades.

The rig depicted in the next illustration the track of a Rotol hub with a dial gauge, the other instrument being used for checking the divide of the ports; at the rear, the spider assembly is being examined on the electric crack detector, metallic ink indicating any cracks present whilst magnetising with a current of 78 amps. For the hub assembly the chalk test is used in which the alloys are heated in oil and then dipped in chalk, the oil showing through the chalk where any cracks appear.

Fig. 227—General repairs in progress to wood propeller blades for Seafire and Firefly aircraft.

Fig. 228—Marking off a repaired wood Weybridge propeller blade for use on a Seafire; the template is secured to the table.

Fig. 229—A standard Rotol tool for fitting the bearing assembly to the blade the correct way up, with the smaller ball race at the top.

Fig. 230—The pin setting on a Rotol propeller blade being operated to provide the best geometrical position for the blade angle, which is determined by the gauge towards the tip.

Fig. 231—Testing the static balance of a 13ft. 6in diameter Hamilton Hydromatic propeller.

Fig. 232—Assembling a Rotol four-bladed propeller for a Barracuda, the woman assists by guiding the operating link through the hub shell by means of a cord.

Fig. 230 is being used for Rotol blades for operating the pin setting to provide the best geometrical position for the blade angle, which is determined by the 'home-made' adjustable gauge towards the tip.

One of the next stages in assembly brings us to the view in Fig. 232 which shows a Rotol four-bladed propeller for a Barracuda being assembled, the woman assisting by guiding the operating link through the hub shell by means of a cord.

Fig. 234—An Aircraft-Repair Inspector passing the static balance of a 10ft. 5in. diameter Rotol four-bladed propeller, which must be correct to within a 5 inch ounce.

Fig. 235—(Right) The hydromatic test rig for Hamilton propellers i.e. for internal leakage at 300 lbs. per sq. inch, external leaks at 380 lbs. per sq. inch, whilst the barrel and dome is tested to 650 lbs. per sq. in-

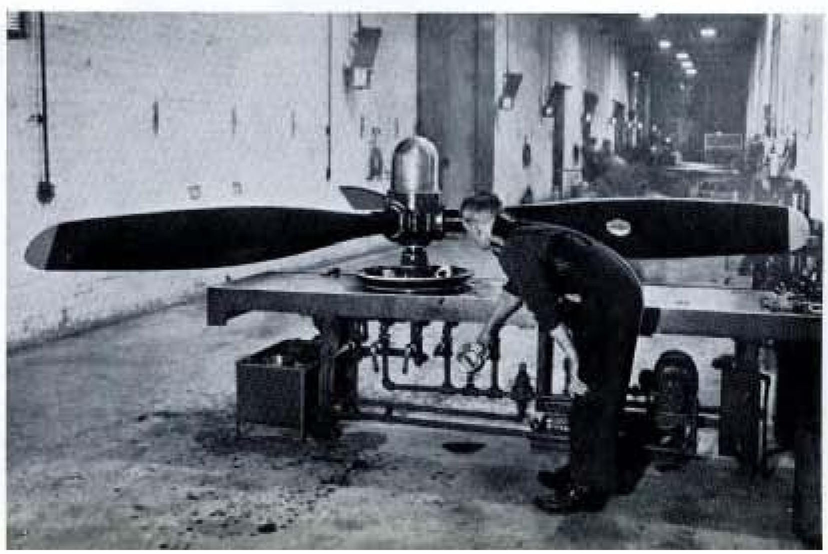
The question of balance in a propeller is a very important matter; for instance, to meet inspection requirements on this point the Hamilton Hydromatic propeller hub must be concentric within a maximum error of .004". In Fig. 233 we see this being tested by means of a dial gauge which is rotated through 360° by a revolving motion as indicated.

Fig. 233—To ensure correct balance, the concentricity of the Hamilton Hydromatic propeller hub must be within a maximum error of .004".

The static balance of the finished propeller is carried out by standard practice on the rigs featured in Figs. 231 and 234 which will take propellers up to 16 ft. in diameter. The first view shows a Rotol four-bladed propeller of 13 ft. 6 in. diameter being tested for correct balance to within a 5 inch oz. which means that at a rolling distance of 5 inches from the axis it must not be more than one ounce out of balance.

The Royal Naval Aircraft-repair Inspector in Fig. 234 is verifying the balance of a 10 ft. 5 in. diameter Rotol four-bladed propeller to the same degree of accuracy, he also satisfies himself that the balance shims or washers are correctly fitted and not in excess of the maximum permissible quantity.

The hydromatic test rig for Hamilton propellers of the non-feathering types is shown in use in Fig. 235, the pressure applied



for internal leakage being 300 lbs. per sq. inch, with 380 lbs. per sq. inch for external leaks, whilst the barrel and dome is tested to 650 lbs. per sq. inch. The changing of the blade angle is also tested to simulate operation in flight.

The rig for testing the constant speed governor unit for the Hamilton Hydromatic propeller is seen in Fig. 236, the unit being subjected to a pressure of 680 lbs. per sq. inch and checks made for internal and external leakage.

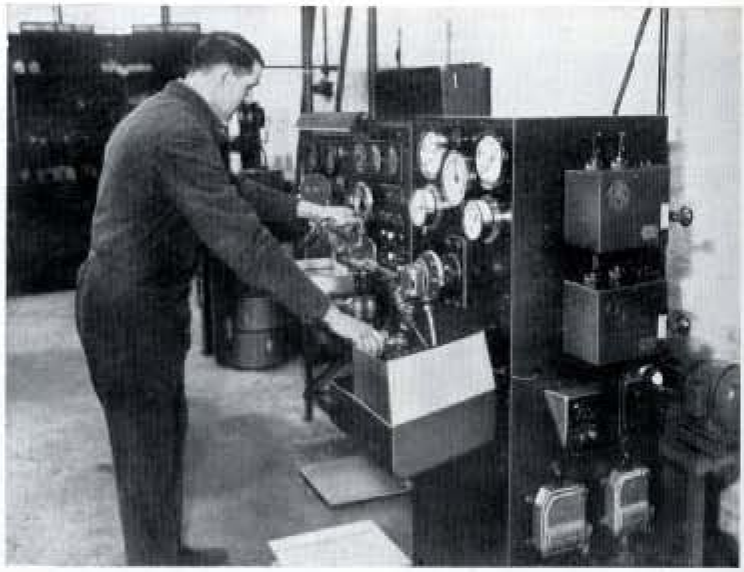


Fig. 236—Testing the constant speed governor unit for the Hamilton Hydromatic propeller. This unit controls the pitch of the blades, and through the blade pitch the revolutions of the engine.

To explain the use of the governor unit it might be interesting to see the development from the first aircraft propellers which were of the fixed pitch type, and represented a compromise between the blade angle requirements of take-off, cruising and diving. The two-position propeller, which permitted selection by the pilot of a low angle for take-off and climb and a higher angle for cruising, was next developed. This type was a definite improvement over the fixed pitch model, but it still utilised only two compromise blade angles, high or low.

To provide adequately for all conditions of aircraft operation, the governor controlled constant speed type propeller, in which the blade angle is automatically adjusted at any setting between the high and low limits, next followed.

A propeller incorporating a variable blade pitch mechanism serves the same purpose in an aircraft as the transmission in an automobile. The changing relationship between power and speed needed to meet normal operating conditions is satisfactorily accomplished in an automobile by changing the gear-ratio between the engine and the wheels. It would be impossible for the pilot to control engine output satisfactorily to meet the constantly changing requirements brought about by variations in aircraft attitude, altitude of flight, etc., and it is the constant speed propeller in which the blades automatically change pitch which becomes the aircraft equivalent of an automobile gear change.

If all other factors remain unchanged, the power required to operate a propeller at any given speed can be altered by changing the pitch of the propeller blades. It would take greater power to turn a propeller in which the blades were set at a high angle than it would if the blades were set at a lower angle. The constant speed propeller is adjusted by means of the engine driven constant speed control unit (propeller governor) to absorb more power by going to a higher blade angle when the engine tends to over-run, and to absorb less power by going to a lower blade angle when the engine tends to reduce speed.

As an example, if the pilot had set his throttle and propeller controls for 2,300 r.p.m., and then changed the attitude of the aircraft from level flight to a dive, the engine would for an instant pick up speed as a result of the increase in aircraft speed brought about by the dive. The resulting change in engine speed actuates the pitch regulating mechanism in the engine driven propeller governor, and this unit in turn supplies the required amount of oil in the Hydromatic type propeller to move the blades to a higher angle. An increase in blade angle requires an increase in engine power output, and constantly the engine (and propeller) return to the normal speed condition.

To conclude our story of propeller repair we show in Fig. 237 the racking of completed propellers ready for despatch after final inspection in the View Room. Hydromatics are sent away in an assembled condition, other types are usually dismantled and boxed. All types are treated with anti-corrosive compound.

SECTION 2—A Power Plant Bay—of the E.I.P. (i.e. Engine Installation Party) brings us back in our story to the main repair yard at Donibristle and to the general rule that it is quicker to change a complete power plant of an aircraft than individual components. In this connection it will be remembered that in the section entitled 'Centralised Maintenance of Aircraft' we stated it is far simpler to instal a complete power plant than to instal a separate engine into the power plant structure that is already attached to the aircraft.

Working parties from the E.I.P. are attached to each hangar ready to remove power plants complete and move them into the P/P Shop. A typical party of six, comprising a leading hand, two men, two women and a boy labourer have just removed the power plant (Double Wasp 18 cylinder engine) from the Hellcat seen in Fig. 238 with the aid of the 5 ton Morris crane and special lifting tackle, the plane having crashed the carrier deck on landing. (The removal of a damaged P/P and installation of a new one can be completed by two men and a boy in two days.)

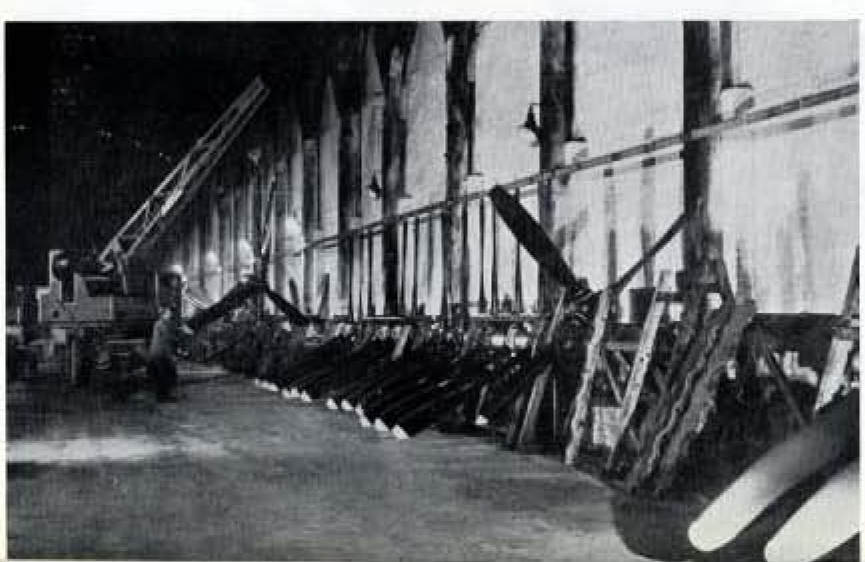


Fig. 237 (Left)—After being treated with anti-corrosive compound, propellers are racked ready to despatch to Naval Air Stations.

A NAVAL AIRCRAFT REPAIR YARD

Removing the Power Plant in the Power Plant Bay

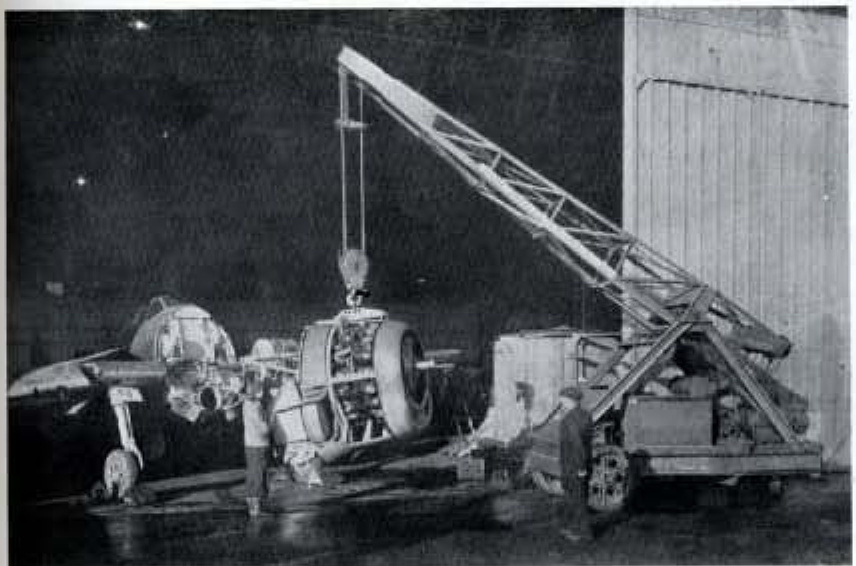


Fig. 238—The E.I.P. (engine installation party) now come into the story and here we see them removing a Pratt & Whitney 18 cylinder Double Wasp power plant from a Hellcat that crashed the deck on landing.

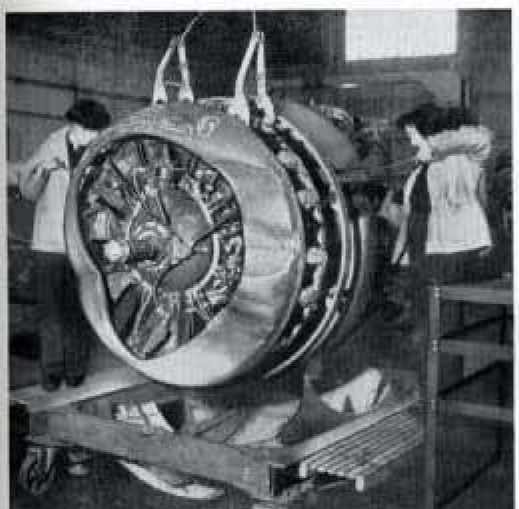


Fig. 239—In the Power Plant Bay; starting to dismantle the ancillary equipment from a Wildcat Cyclone 9 cyl. engine after a barrier crash in a carrier.

In the actual Plant Bay the plants are arranged on transportable stands in lines according to the progress of the work. Thus the first line consists of those ready for stripping after receiving their history sheet and the Board of Survey's report. Such a one is the Wildcat VI (Cyclone 9-cylinder engine) featured in Fig. 239 which has come in following a barrier crash on a carrier and on which dismantling is about to commence.

The work done in the second row consists of taking out the engine and sending it to the E.R.S. (engine repair section) after all components such as starter, generator, vacuum and fuel pumps, gun gear, etc., have been removed and placed in metal stands. The illustration Fig. 241 shows an Avenger Double Cyclone 14 cylinder engine of 1,500 rated horsepower with components stripped and engine ready for the E.R.S., whilst beyond will be seen a Double Wasp 18 cylinder engine of 1,675 r.h.p. with two-speed, two stage blower, completely assembled for installation in the airframe.

The component parts on the stands are next paraffin washed and then given an orange label unless unrepairable or requiring modification for which the label is green. New parts required are drawn from the Stores and details are given on the inspection report and afterwards added to the aircraft log.

Reserve power plants, situated in separate lines, are built up from new engines and components, received direct from manufacturers, to meet urgent demands from outside sources, the work being carried out by three skilled men, five dilutees and seventeen women. An aircraft for instance might come in, not for repair or inspection, but with an engine which is constantly giving considerable trouble; the quicker answer to this is a complete power plant change.

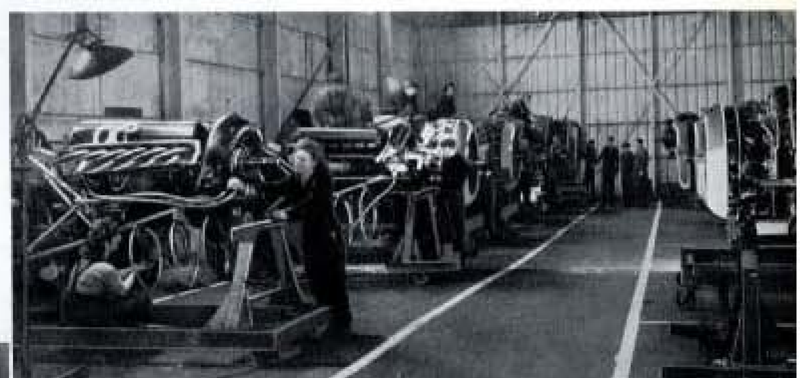


Fig. 240—The building up of new Barracuda, Wildcat, Avenger, Hellcat and Corsair power plants for the reserve pool.

The view Fig. 240 taken in the reserve pool building lines shows work in progress on Barracuda 12 cylinder Merlins, Wildcat 9 cylinder Cyclones, Avenger 14 cylinder Cyclones, and Hellcat 18 cylinder Double Wasps, whilst Fig. 242 depicts a close up of a new Wildcat Cyclone in the early stages of building up, there being 21 stages to complete.

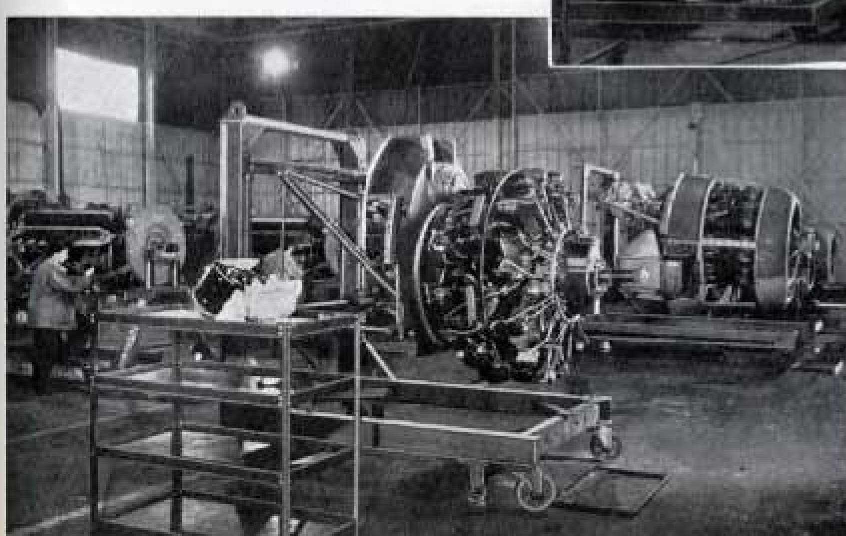


Fig. 241 (Left)—General view in the Power Plant Bay of the E.I.P.; in the foreground is an Avenger Double Cyclone 14 cylinder radial engine, of 1,500 rated horsepower, stripped of ancillary components and ready for the Engine Repair Section.

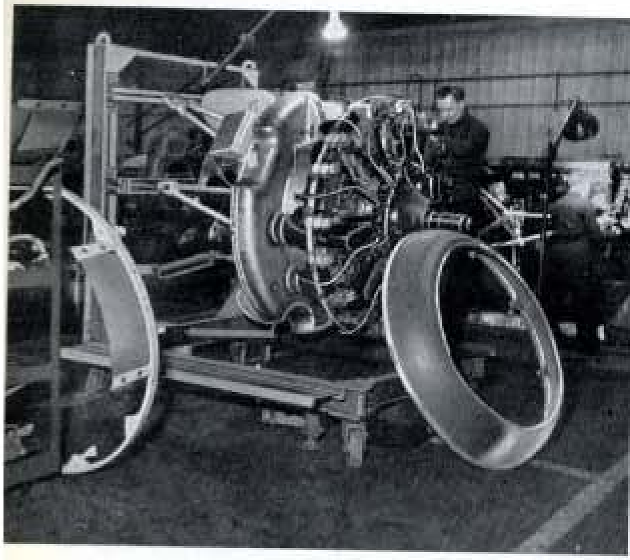


Fig. 242—In the early stages of building up a new Wildcat Cyclone 9 cylinder radial power plant for the reserve pool.

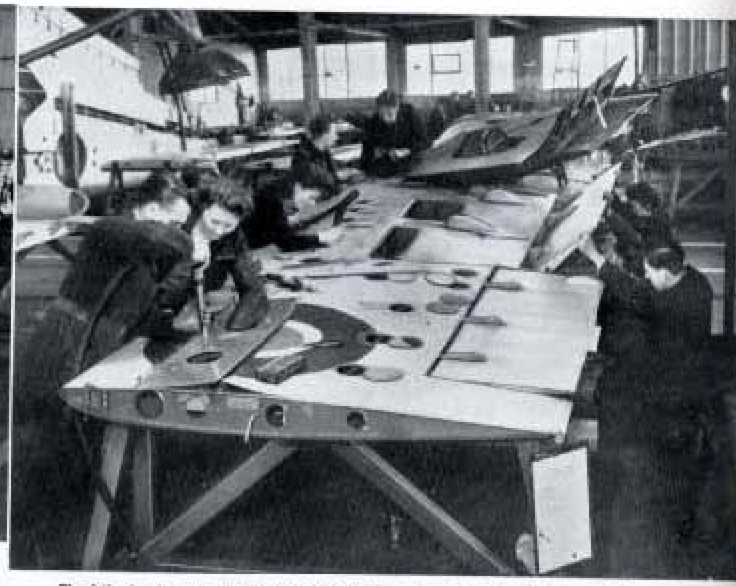


Fig. 243—In the Aerofoil Shop of Workshops Division this Wildcat main plane is being completely reconditioned and the entire electrical installation is being renewed.

After installing a power plant in an aircraft the E.I.P. give the engine a run up to see if satisfactory, which is followed by a further run by the Inspection Division. Following this the E.I.P. withdraw and examine the filters and check every detail including a flow test of the fuel by stop watch and the use of a 'slave unit' rigged up beside the aircraft to ensure that the correct amount of fuel is drawn at T.O.B. (take off boost) which represents maximum consumption. All after-flight snags are also corrected.

SECTION 3—The Aerofoil Repair Shop

The main planes, having been taken off the aircraft, are sent into the Aerofoil Repair Shop of Workshops Division and in Fig. 243 we feature a Wildcat main plane being completely reconditioned, including skin repair and replacing of cooling system, flaps and stub ailerons, etc. At the same time the electrical installation is being completely renewed including landing, navigation and formation lamps, also wireless aerials. (The two E.A.S. (electrical assembly section) ratings are at work by the stub plane at the left rear).

SECTION 4—Airframe Repair Work

The fuselage repair work and major and minor inspections have of course been proceeding in the assembly hangars and in Fig. 244 we give a general view in the No. I Hangar, which deals solely with Barracudas. A Barracuda undergoing major repairs is in the process of being stripped in Fig. 245 whilst another in Fig. 246 is having the semi-monocoque renewed from the rear bulkhead of the rear cockpit, which involves the four main longerons, dural frames, new stringers, arrester hook troughs, tail portion and the whole assembly re-aligned; the job is now ready for adding the dural stressed skin.

SECTION 5—The Engine Repair Section

—brings us to the next series of photographs and details of the work done in stripping, reconditioning and rebuilding the engines received from the Power Plant Bay.

Entering the Stripping Bay, the process of dismantling commences, the components being placed on trolleys. Two persons

Fig. 245—Here, a Barracuda undergoing major repairs is in process of being stripped in Assembly I hangar.

Fig. 244 (Left)—Minor and major inspections as well as airframe maintenance work being carried out in Assembly I hangar, devoted to Barracudas only.

are allocated per engine as will be seen in Fig. 247 which shows, in the foreground, an Avenger Double Cyclone engine, whilst to the right is a Mercury 9 cylinder engine from a Sea Otter.

The trolleys with the complete engine details are next taken to the cleaning section where the parts are degreased with cresylic acid, paraffin, etc., a trichlorethylene vapour bath being used for oil and heavy grease and an H.D.S. Metal bath for boiling to remove carbon, etc. After degreasing, the small parts are polished on a double-ended polishing machine, whilst other parts such as pistons are hand polished, including the grooves.

Still using the trollies, the complete engine components pass to the Viewing Room for careful examination, the equipment there including crack detectors, hardness and spring testers, crankshaft and master conn. rod rigs, etc. After viewing, each sub-section receives its own components, i.e. cylinders, crankshafts, crankcases, superchargers, reduction gears and carburettors for reconditioning, etc.

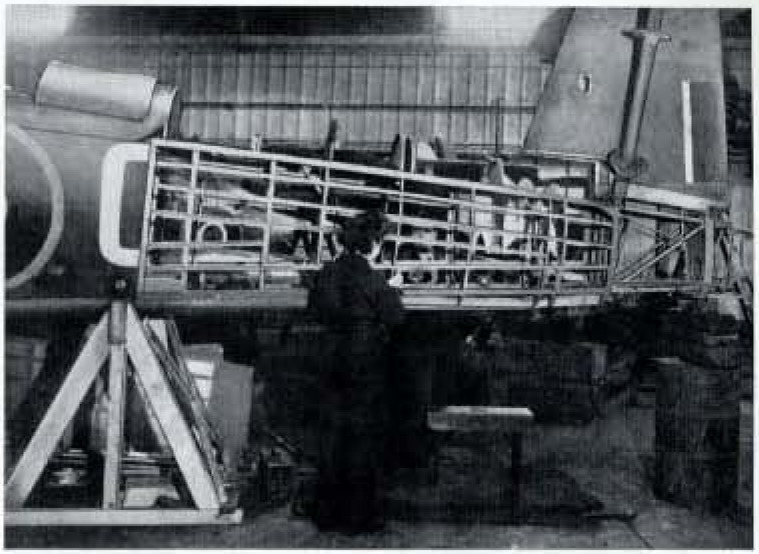


Fig. 246—In this view we show the semi-monocoque of a Barracuda being renewed from the rear bulkhead of the rear cockpit.

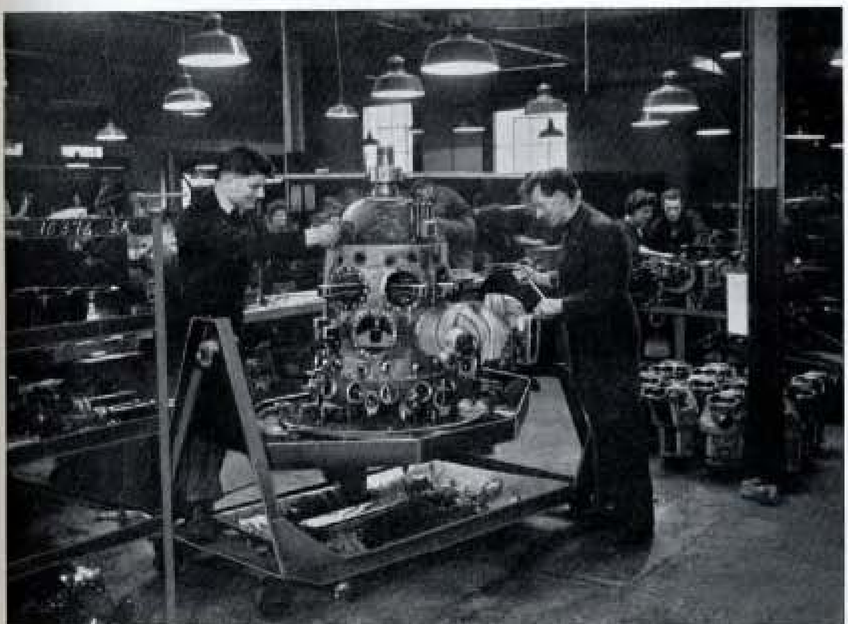


Fig. 247—In the Stripping Bay of the E.R.S. (engine repair section): a Double Cyclone 14 cylinder engine from an Avenger is in the foreground, whilst to the right is a Mercury 9 cylinder engine from a Sea Otter.

A job card is issued for each complete assembly, by which we mean such as a crankshaft assembly, or a set of cylinders. Each card itemises every operation and check necessary in building up and is used at all inspection stages when all the fits are recorded.

Looking into the Cylinder sub-section for a moment we find that here complete reconditioning takes place, involving the honing of bores if necessary, valves are refaced and seats reground and where required valve guides are rebushed.

The illustration Fig. 248 depicts the honing of Bristol Mercury engine cylinder barrels using carborundum stones held in the honing head by cellulose cement, the centre spindle, with right and left hand thread, actuating two cones to adjust the stones for diameter. The bore of these cylinders can be taken to .010″ above normal for standard pistons with new rings.

Fixed head (i.e. air cooled) cylinders should have a choke type barrel which means that the portion 2¼″ from the head is .005″ smaller in diameter than the remainder of the bore to allow for expansion under running conditions. All Bristol cylinders and some American types are lapped after honing with carborundum paste and cast iron laps to give a matt finish.

A view in the Valve and Valve Seat sub-section is given in Fig. 249 in the foreground of which is a special valve seat grinding rig for Merlin and Pegasus cylinders. For Merlins a vertical spindle with a self-contained

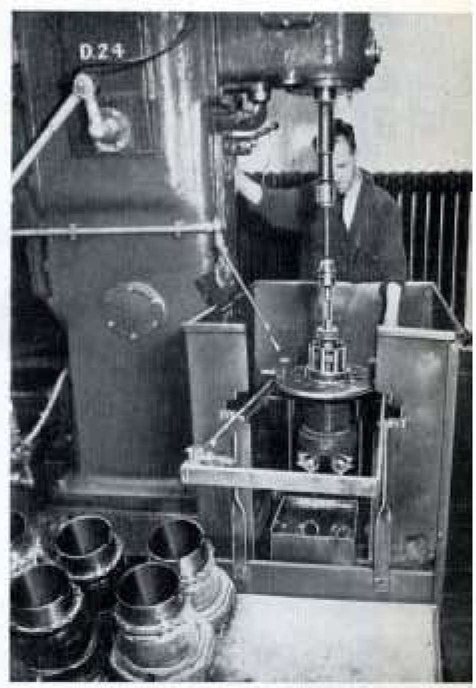


Fig. 248—Honing a worn Mercury cylinder; the bore can be taken to .010″ above normal for standard pistons with new rings.

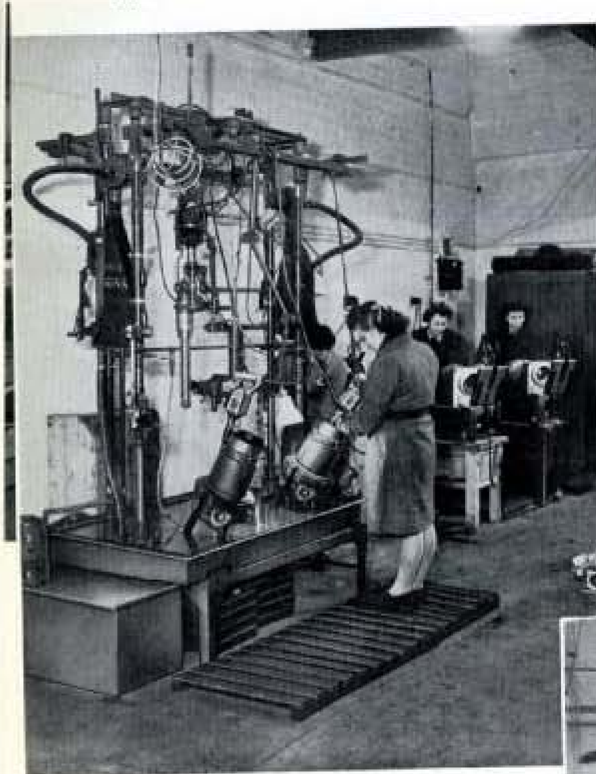


Fig. 249—The Valve and Valve Seat Section of the E.R.S. In the foreground is a special rig for Merlin and Pegasus cylinders; the two machines in the rear are Bristol valve seat grinders.

1/5 h.p. motor is used, the stone running at 10,000 r.p.m.; on the Pegasus cylinders shown in situ, Black & Decker portable valve seat grinders are used with a wet feed of paraffin and a special honing oil. The girl at the rear of the rig is using one of the grinders for dressing a stone, the vacuum cleaners being employed to remove the resultant dust.

The two machines seen in the background of this illustration are Bristol valve seat grinders on which the Mercury cylinder jigs move to stop locations for each valve head,

Fig. 250—On the Bristol valve seat grinders, the operator watches the grinding process on a Mercury cylinder in the mirror as indicated above.

the girls watching the grinding operation (done dry) in mirrors placed at the correct angles (see Fig. 250). Gauges are used to determine the width and accuracy of the surface. After trial assembly with springs in position, valves are tested by a petrol check for leaks into the cylinder bore.

All parts such as valve springs, rocker box parts, etc., are cadmium coated in the Plating Shop.

In the E.A.R.S. (i.e. Engine Accessory Repair Section of the E.R.S.) are test rigs for all types of pumps and Bristol engine rear covers (see Fig. 251). Here all components are stripped on the benches from whence they go to the cleaning section then to the Viewing Room, returning to the E.A.R.S. for re-assembly and rig tests. The Bristol rear cover carries all the engine accessories including oil, fuel and vacuum pumps, air compressor and magneto and generator drives. One of these re-assembled is now on oil pressure and flow test

Fig. 251—Components such as oil, fuel and vacuum pumps, air compressors, magneto and generator drives are repaired and tested in this Engine Accessory Repair Section, known as the E.A.R.S.

on the rig on the extreme right where it is run for 1½ hours, the dials giving pressure, temperature and revolution counter.

A corner of the Carburettor and Fuel Pump Test Room is featured in Fig. 252. On the right is a Stromberg Flow Bench (this carburettor is fitted to Cyclone and Double Wasp engines) which is a rig for simulating engine running conditions, taking right through up to full boost as well as checking the automatic mixture control. The two men are measuring the pressure difference between the two chambers, the volume of fuel being timed by a stop watch.

The girl at the left rig is checking a fuel pump from the E.A.R.S. for petrol capacity under all running conditions.

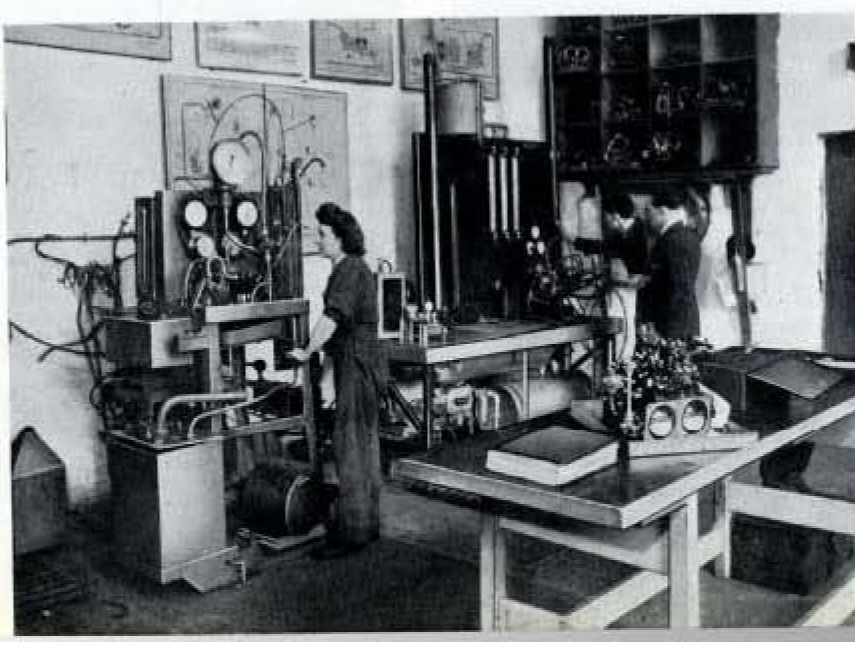


Fig. 252 (Left)—On the left is a fuel pump test rig and to the right is the Stromberg carburettor flow bench in the Carburettor and Fuel Pump Test Room.

Fig. 253—Our story of the work of the E.R.S. now brings us to the assembly of crankcases and crankshafts as illustrated.

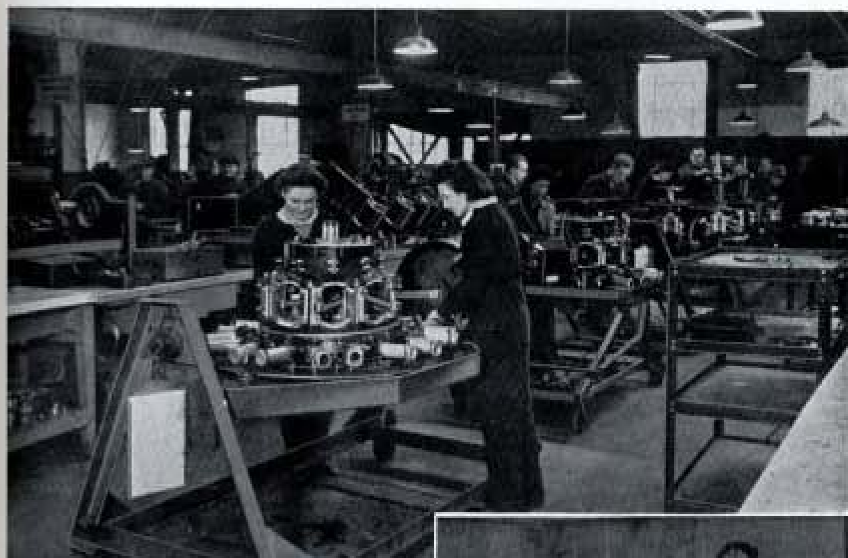


Fig. 254—This general view shows the next stages in assembly of Pegasus and Mercury engines in the E.R.S. A 12 cylinder Merlin, to the left rear, is ready for final inspection.

For the Assembly Section of the E.R.S. we now feature the part devoted to crankcases as illustrated in Fig. 253, the assembly of crankshaft units being done in the rear. Crankcases that are badly corroded are cadmium plated before coming into the section. Special rigs are provided for crankshaft assembly, for instance, those for the Mercury and Pegasus radials provide for the fitting of the conn. rods and master rod assembly to the centre shaft, after which an oil test of 60 lbs. per sq. inch at 60°F. is made through the hollow crankshaft.

A general view of the next assembly stages on Mercury and Pegasus engines is given in Fig. 254, all parts of one engine following through except cylinders, which are pooled and any set of 9, 14 or 18 being taken out and stamped with the engine number. Magnetos are fitted in the Assembly Bay, after being overhauled by the Electrical Repair Shop (see Fig. 256) the engines are tuned and finally prepared for the test bench, and then come back to the E.R.S. for final inspection.

For engines undergoing a complete overhaul, a preliminary test takes place, then a complete strip, clean and view, followed by re-assembly, final test and final inspection.

SECTION 6—The Electrical Division

As stated earlier, the Electrical Division handles all electrical matters pertaining to aircraft and the next series of photographs illustrates some of the work carried out.

The first view, Fig. 255, is taken in the Electrical Repair Shop known as the L.R.S., where engine driven generators, alternators, starters, regulators, etc. are overhauled, repaired and finally tested on the rig seen at the rear. This test bench loads the equipment exactly the same as in the aircraft and gives full performance readings. A small machine section in the same shop includes two lathes, a drilling machine, milling machine and engraving machine, etc. for the necessary repair operations.

An adjacent shop devoted to the overhaul and repair of magnetos is depicted in Fig. 256 the stripping and overhauling being done on the benches after which they are tested, six at a time, on the test bench seen on the right.

Fig. 255—The Electrical Division handles all electrical matters pertaining to aircraft. Here is part of the Repair Shop where generators, alternators, starters, regulators, etc., are overhauled, repaired and tested.

One of the Aircraft Instrument Repair Shops (see Fig. 257) deals with altimeters, rates of climb, engine speed and air speed indicators, the altimeters being tested under the bell jars on the bench, the pressure being reduced to simulate height; a mercury column at the far end of the bench is used for the pressure and vacuum testing. The girl on the extreme right is watching a test rig for oxygen equipment.

The Instrument Repair Shop devoted to gyroscope mechanisms is depicted in Fig. 259. After stripping, cleaning, overhauling and balancing on the bench they go on to the appropriate test apparatus, seen at the far end and right centre, which provide artificial horizon, direction indicator, turn and bank indicator and automatic pilot, under conditions of roll, pitch, and yaw, rotation, vibration and angle of bank. The distant reading gyro-magnetic compass,

Fig. 256—Magnetos are stripped, repaired and tested in this section of the Electrical Repair Shop.

Fig. 257—A view in the Instrument Repair Shop which deals with the maintenance and test of altimeters, air speed and engine speed indicators, rates of climb indicators, oxygen equipment, etc.

Fig. 258—An E.A.S. (electrical assembly section) mechanic tightening and checking connections on the main distribution and fuse panel in the pilot's cockpit of an Avenger.

the function of which was described in detail in the section entitled 'Advanced Training on Aircraft Maintenance' (see Fig. 184) is shown on the test rig in the right foreground.

We now consider for a moment the work of the **Electrical Assembly Section** (known as the E.A.S.) the function of which is to overhaul and repair as necessary, the electrical, instrument and special W/T installations on aircraft coming into the

Fig. 259 (Left)—The gyroscope section of the Instrument Shop. Stripping, cleaning and balancing is done on the benches; the end rig is a combined test apparatus for turn and bank instruments etc., the revolving and tilting test table, centre right, reproduces the aircraft's movements; in the right foreground is the distant reading gyro-magnetic compass.

Fig. 260—Looking through the rear fuselage door into the bomb aimer's compartment of an Avenger we see an E.A.S. mechanic adjusting the elevation, train and return to neutral relays for the gun turret.

Fig. 261—E.A.S. mechanics checking and testing the bomb installation of a Barracuda for correct firing rotation; for convenience the bomb racks are placed on top of the main planes.

Fig. 262—A general view in the Dunfermline Ancillary Repair Shop which deals with electrical harness and sparking plugs, also the complete manufacture of new connector sets.

Yard for inspection or repair. All instruments and electrical accessories found to need repair or overhaul are removed by E.A.S. personnel from the aircraft and sent to the L.R.S. workshop.

Illustrating some of the work of the E.A.S. in various hangars we show in Fig. 258 a mechanic tightening and checking connections on the main distribution and fuse panel in the pilot's cockpit of an Avenger, the next picture Fig. 260 being taken looking through the rear fuselage door into the bomb aimer's compartment of an Avenger where we see the elevation, train and return to neutral relays for the gun turret, being adjusted.

In the third illustration Fig. 261 E.A.S. mechanics are checking and testing the bomb installation of a Barracuda for correct firing rotation. (For convenience the bomb racks are placed on top of the main plane.) The girl is informing the man in the cockpit that the bomb he has selected has been released, she then recocks the mechanism for the second round. Inside the cockpit can be seen the 16-way bomb selector switch box (shown open) whilst to the left of this is the bomb jettison push button.

Electrical Harness and Sparking Plugs.

The repair of electrical harness and sparking plugs is carried out at the Dunfermline Ancillary Repair Shop which also undertakes the complete manufacture of new connector sets. In the general view Fig. 262 the intermediate assembly of harness components is proceeding on the centre benches with final assembly in the foreground; to the right the connector sets are being built up (see also Fig. 263), whilst the sparking plug benches are in the left rear.

Fig. 263 (Right)—On these benches new connector sets are in process of manufacture; the woman in the foreground is using an electric soldering iron.

Fig. 264—Electrical harness assembling and testing; the woman at the right hand metal covered round table tests each cable at a voltage varying from 10,000 to 15,000 using the wander prod as indicated.

The connector sets are made up of multi-core cables enclosed in a flexible metal casing, one such set consisting of four cables of 27, 20, 12 and 6 core leads respectively. Each operator has her particular toolbox on loan but most of the women provide additional tools of their own which is an indication of the interest they take in their work.

The equipment for repair comes into the Receiving Stores from the Donibristle despatch section and then out on to the visual inspection benches from whence it goes to the work benches for complete strip and cleaning in paraffin and petrol tanks. After detail inspection, harness components move to the assembly benches and then to the re-wiring tables seen in Fig. 264, where a definite system is followed by feeding the longest leads through first and following with the next shortest in rotation. After a further visual and check inspection they go to the final test table depicted in the right foreground, which is metal covered, to undergo a voltage test varying from 10,000 to 15,000 volts. In the centre of this table is an adjustable spark gap which should keep sparking during the test of any lead with the wander prod held by the woman in the illustration; should the spark cease, a faulty lead is indicated.

The next photograph Fig. 265 shows the three spinners for cleaning sparking plug cases, threads and electrodes respectively, after sand blasting. Each spindle has interchangeable gripping collets and runs at 1,500 r.p.m. the drive being taken from individual ¼ h.p. motors. The cleaning is done with a special type of emery cloth called Durixid, and steel brushes.

The sparking plug test rig, handling six at a time, is featured in Fig. 266. During the test each plug is subjected to an air pressure varying from 110 to 150 lbs. per sq. inch according to type; a mirror at the rear enables the operator to see that the spark travels round the four points. After this, the plugs are packed in special containers, 35 to a box; as many as 17,728 plugs have been reconditioned in one month.

When completed, all harnesses and plugs are despatched to Donibristle, unserviceable material going to salvage.

Fig. 265—Three different types of self-contained motor driven spinners running at 1,500 r.p.m. for cleaning the cases, threads and electrodes, respectively, of sparking plug components.

This ancillary workshop has been in operation over two years and employs 100 civilians, 95 per cent. of whom comprise part time female semi-skilled labour working morning and afternoon shifts of 4½ hours each. These women are entirely unskilled when engaged but are trained into proficient operators in six to eight weeks. Although only a small shop, canteen facilities

Fig. 266 (Left)—Whilst subject to an air pressure of 110 to 150 lbs. per sq. inch, British and American plugs are tested six at a time in the rig illustrated.

Fig. 267—A general view in the Component Repair Bay of the Mechanical Workshops; here are sections for the repair and test of oleo legs, cocks and filters, hydraulic and pneumatic equipment etc., a welding section is also included.

are available, providing a hot meal midday for the few full time workers and any part timers wanting to participate.

Our story now returns us to the Donibristle Repair Yard for—

SECTION 7—

The Mechanical Workshops

—which are fed from all other sections as well as from outside sources such as the Naval Air Store Depot at Perth and deal with all aircraft details (except dinghies and parachutes) including hydraulics, pneumatics, wheels, tyres, tubes, exhaust systems undercarriages, oil and petrol systems and ground equipment.

The routing procedure is for all material to come into the Mechanical Workshops Return Stores where it is sorted out for the various workshops in the Yard, who collect it as they require work. A sub-inspection first takes place to locate any major damage and to determine whether the components are worth cleaning; when cleaned the items go back to sub-inspection to assess the damage.

The Component Repair Bay is featured in the illustration Fig. 267 in which are undertaken general repairs, also repairs to specific details such as cocks and filters, hydraulics, hydraulic pumps, oleo legs and pneumatics, the various sub-sections being indicated by the hanging signs. A comprehensive test rig equipment, much of which has been designed and made in the workshops, is installed for hydraulics and pneumatics.

Twelve different types of oleo legs are dealt with and the pneumatic components include brake relay valves, pressure reducing valves, pressure regulators, etc.; oxygen and air bottles are also proof tested. A "home-made" hydraulic jack is used for giving initial test and stretch to new control cables. A gas welding section at one end of the bay is capable of welding all classes of weldable ferrous and non-ferrous metals, and produces results to A.I.D. specification standards.

Another section of the Mechanical Workshops is **The Tank Shop** for self sealing and metal tanks (see Fig. 268). The tanks are taken from the Return Stores into a ventilating shed to extract the fumes and then into the repair bay to clean and repair where necessary.

After repairing the aluminium shell of self sealing tanks, they are tested for leaks by inserting paraffin to one tenth of the tank capacity and then adding compressed air at 1½ lbs. per sq. inch. Having whitened the repaired portion to show up any leaks, the tanks are left for 20 minutes lying on each side, during which period the pressure must not drop. When satisfactory, the

Fig. 268 (Left)—This Tank Shop is another section of the Mechanical Workshops and here can be seen self-sealing and metal petrol tanks in course of repair.

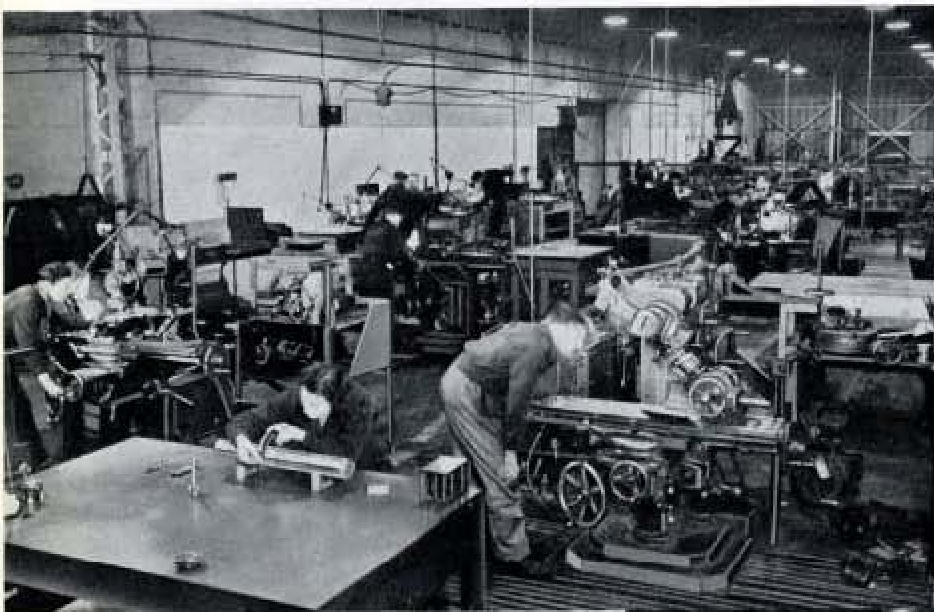


Fig. 269—A well-equipped Machine Shop forms part of the Mechanical Workshops. Two Parkson Universal Mills will be seen in the foreground, whilst elsewhere is a Churchill Internal Grinder and a Ward 2A Capstan Lathe.

The Machine Shop depicted in Fig. 269 handles most of the repair machining of the Mechanical Workshops and is equipped with two Parkson No. 2T Universal Mills (seen in foreground) one 12″ shaper, one Ward 2A Capstan Lathe, one universal grinder, one surface grinder, one Churchill Internal Grinder, five centre lathes, one engraving machine, two fly presses, two vertical drills and various tool grinders. A smaller shop has equipment for dealing with the incidental jobs for the Component Bay without bothering the main machine shop.

The close-up view Fig. 271 shows the re-grinding of the 10″ diameter by 3½″ wide Dunlop brake drums for landing wheels, on the Churchill Internal Grinder. As received, the drums were slightly out-of-round or scored, so the old liner was removed and a new one inserted, this then being ground in position to a close limit.

The next illustration Fig. 272 features a toolroom job on one of the Parkson mills, that of cutting the teeth of a high speed

outer skin of Sorbo self sealing rubber is put over to complete the repaired area.

The American metal tanks are repaired with dural plate bolted on, the bolts being inserted from inside through the inspection door. This shop deals mostly with Barracuda and Wildcat tanks to a total of approximately 160 a month. The coolers, radiators, thermostats, metal pipes and superflexit pipes (petrol and oil) are cleaned, repaired and tested in an adjoining bay.

Fig. 270—A vee pulley is required for a portable hydraulic test rig, so it is machined all over on the Ward No. 2A Capstan Lathe as illustrated.

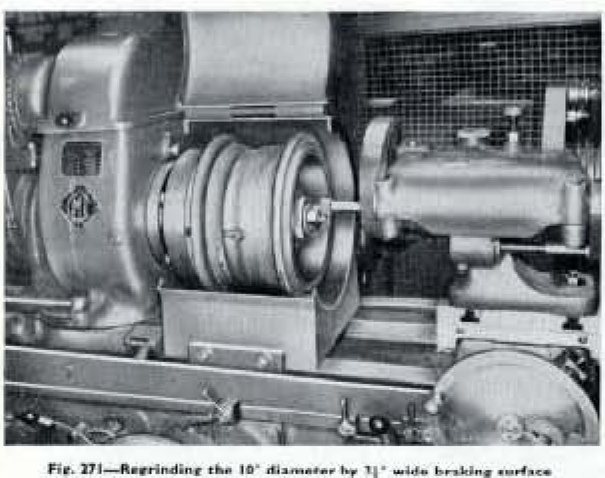


Fig. 271—Regrinding the 10″ diameter by 1½″ wide braking surface of Dunlop brake drums for landing wheels, on a Churchill Internal Grinder, the guard being raised to show the component.

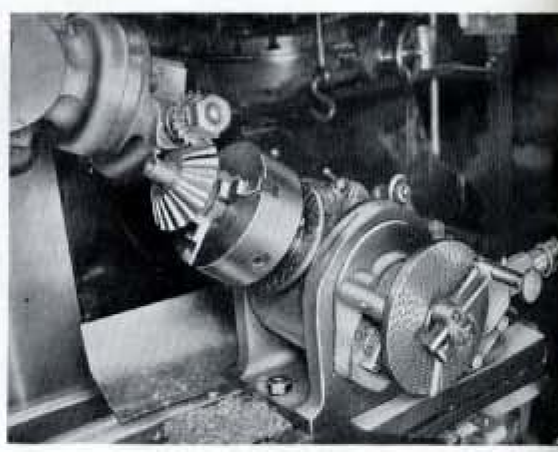


Fig. 272—Cutting the teeth of a 90° included angle cutter on one of the Parkson Universal Mills. This will be used for machining vee blocks for propeller balancing ways.

steel angle cutter of 90° including angle, 20 teeth, 4½" outside diameter which will be used for milling vee blocks for propeller balancing ways.

A vee pulley of 4" diameter by 1¾" wide with vee 1" wide by 1" deep, and the 1" diameter spindle threaded at one end, is being machined all over on the Ward 2A Capstan in Fig. 270. This pulley is required for a portable hydraulic test rig for testing all the hydraulic equipment on the aircraft in one of the assembly hangars. The pulley drives direct from the pump and runs at 2,000 r.p.m. to give the correct pressure.

Our last illustration in the Machine Shop (Fig. 273) shows the grinding of a 2 ft. 1 in. long by 3½" diameter oleo leg sustaining ram prior to hard chrome plating. These components are liable to become unserviceable by slight pitting and corrosion for which .010" is ground off the diameter and then built up .015" with hard chrome, original size being restored by removing .005" by regrinding. This method saves a complete oleo leg which otherwise would have to be returned to the makers.

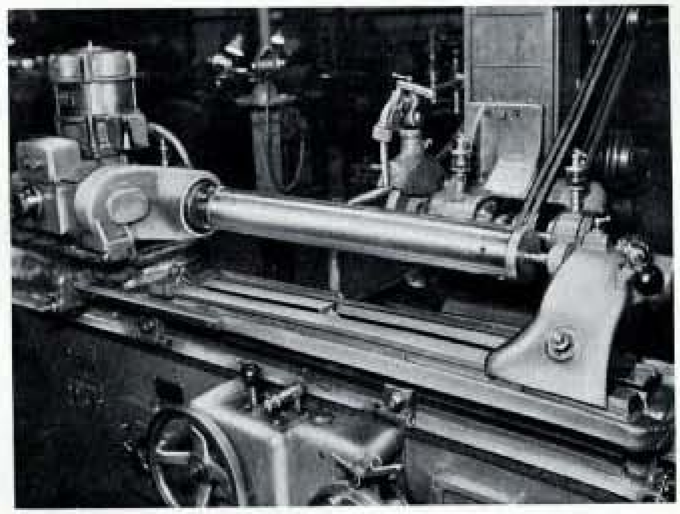


Fig. 273—Grinding a 2ft. 1in. long by 3½in. diameter oleo leg sustaining ram prior to hard chrome plating as depicted in Fig. 274.

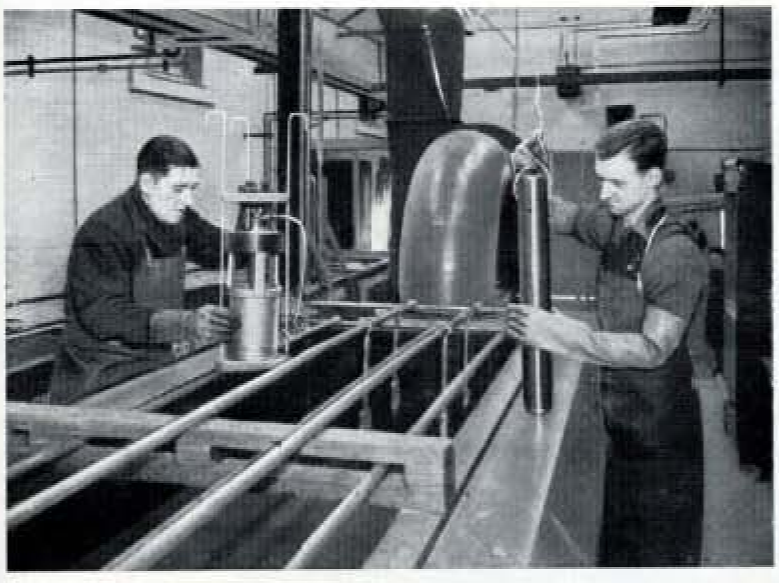


Fig. 274—This Hard Chrome Shop is another section of the Mechanical Workshops; here we see the oleo leg sustaining ram (Fig. 273) and a Merlin cylinder liner about to be inserted for chrome depositioning at the rate of .001" per hour.

We now follow the sustaining ram to **The Hard Chrome Shop** where, in Fig. 274 we see it about to be immersed in the plating tank for chrome depositioning at the rate of .001" per hour; on the opposite side a Merlin cylinder liner in its jig is about to be similarly treated. Any liner previously chromed is electrolytically stripped in a caustic soda solution, others are ground out before coming to this section.

The shop has the usual degreasing, etching, neutralizing and swilling tanks also a Seekay wax stripping off tank, the wax being removed from the portions to be plated by paring off. In this tank, wax is extracted from the fumes and reclaimed in another cabinet. Other work dealt with includes such as worn plug gauges and special milling cutters.

An adjoining shop looks after all paint and dope stripping, sulphuric acid anodizing, cadmium plating, phosphoric acid etching of Tauris cylinder liners, the sand blasting of most steel parts prior to cadmium plating, as well as the removal of corrosion from the fins of cylinders before treating with heat resisting enamel.

Next is **The Sheet Metal Shop** in which such details as panels and fairings etc. are both repaired and manufactured; modifications are also carried out on British and American aircraft. The general view in Fig. 275 shows work in progress, the foremost machine, a sheet metal former,

Fig. 275 (Right)—The Sheet Metal Shop is the last of the Mechanical Workshops we illustrate. The wide range of equipment installed is used for repairs as well as manufacture of modifications to British and American aircraft

dealing with a frame for a Barracuda monococque, whilst on the folding and forming machine (third down line) is a lower cross member frame for a Barracuda fuselage. The second man on the right bench is at work on a Barracuda navigator's sliding roof of perspex.

In the local view Fig. 276 a Morrisflex flexible shaft equipment is being used for trimming a perspex observer's window using a 'home-made' universal swivel table in the vice. On the bench are navigation and landing light covers. To form these perspex details the sheet is heated to 235°F. in an electrical oven and then formed over wooden jigs, two of which can be seen on the bench.

The adjoining **Heat Treatment Section** is for aluminium and its alloys, potassium and sodium nitrates being used as a convenient method of controlling the temperature which is very close on these materials. A handy air blast coke fire in this section for the heat treatment of tools is featured in Fig. 280.

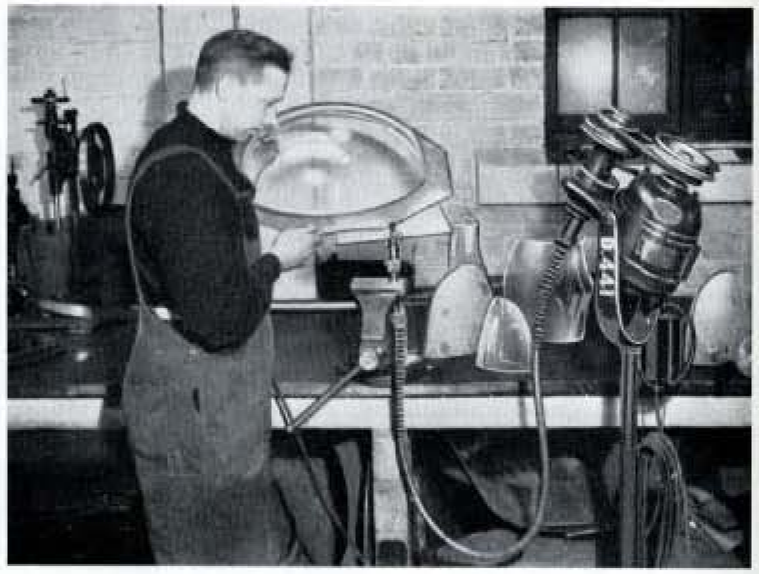


Fig. 276—Morrisflex Flexible Shaft Equipment in the Sheet Metal Shop being used for trimming a perspex observer's window; on the bench are navigation and landing light covers.

Fig. 277—A general view in the Main Stores at Donibristle where a very wide range of components is maintained and recorded for airframe, engine, electrical, wireless and instrument sections.

SECTION 8—The Main Stores

The general view Fig. 277 is taken in the Main Stores at Donibristle which supplies all available items from the smallest split pin to main planes and includes engine, electrical, wireless and instrument components together with nuts, bolts, washers, screws, etc., as well as airframe spares, all of which are recorded on the Roneodex system depicted in Fig. 278.

Re-assembly of Aircraft and Test Flight

Our story of the Repair Yard now draws to a conclusion with a return to the Assembly Hangars where, in Fg. 279 we see an Avenger two-thirds completed after a 320 hour major inspection and minor repair. In the next view Fig. 281 the assembly work on a Barracuda is also

Fig. 278 (Right)—The Roneodex equipment in the Main Stores for recording the 100,000 items in stock from the smallest split pin to main planes.

nearing completion after a 320 hour major inspection; the tail unit has still to be connected up to the main fuselage.

The last illustration Fig. 282 shows how the Barracuda, which suffered a forced landing after flak damage and which we saw being removed from the articulator in Fig. 223 will taxi out for test flight after being completely overhauled and repaired.

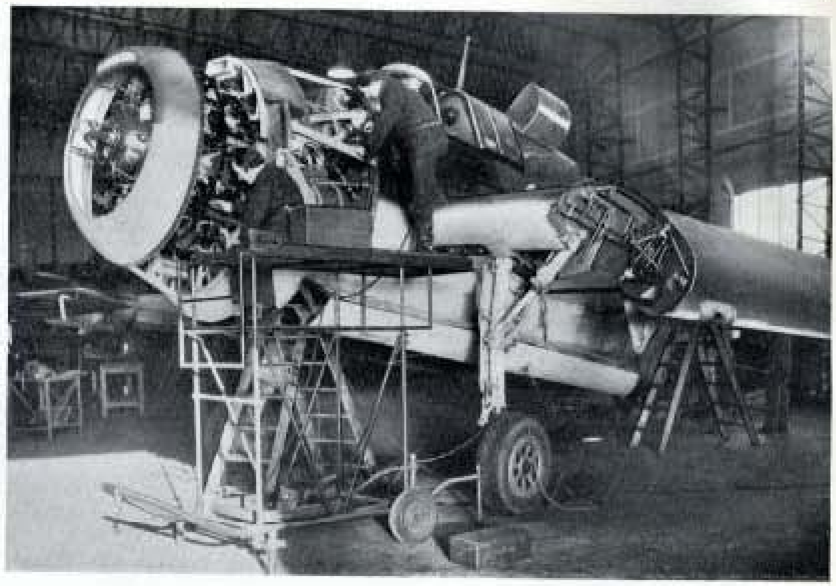


Fig. 279 (Right)—Our story of the Repair Yard is about to be concluded as we return to the Assembly hangars; in this view we show assembly of an Avenger two-thirds completed after a 320 hour major inspection and minor repair.

Fig. 280—A handy air blast coke fire for the heat treatment of tools.

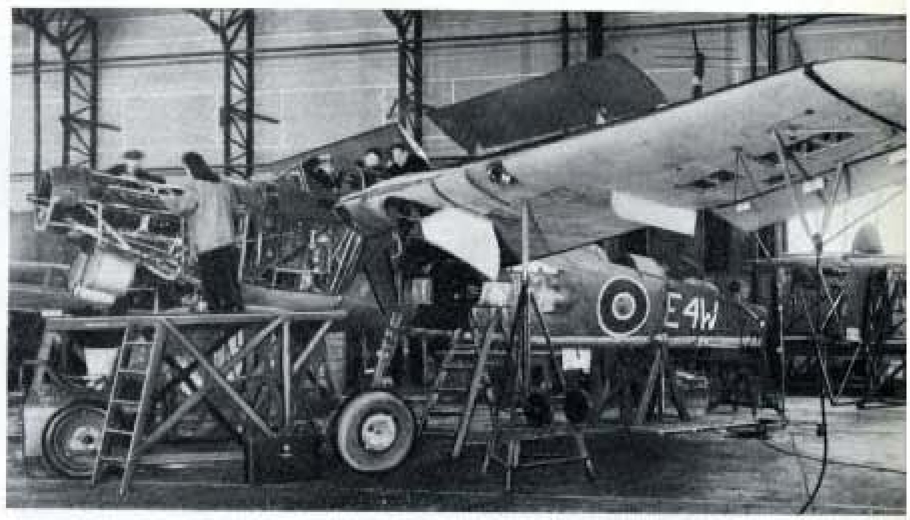


Fig. 281 (Right)—The assembly work on this Barracuda is also nearing completion after a 320 hour major inspection; the tail unit has still to be connected up with the main fuselage.

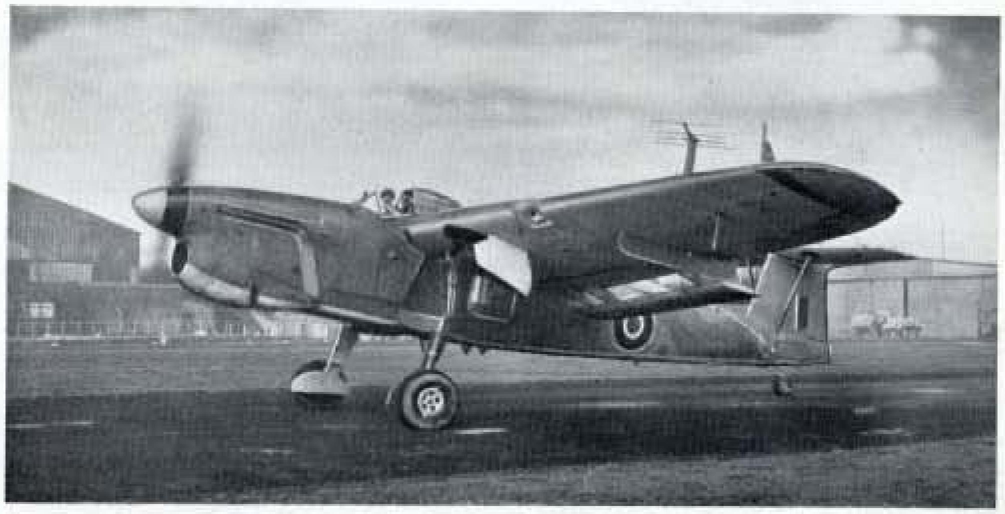


Fig. 282 (Right)—This is how the Barracuda shown in Fig. 223 will taxi out for test flight after being completely overhauled and repaired.

Fig. 283—A pupil Pilot Officer crashes this Wildcat shortly after taking off from the No. I Naval Air Fighter School at Yeovilton; after an inspection, the Aircraft Salvage Section is notified to bring in the wreck for ultimate reduction to "spares and produce."

WHEN one realises that there are something like 35,000 parts on a modern aircraft it will be appreciated that even if obsolete, time expired or damaged beyond economical repair, such an aircraft can produce many items of equipment, both serviceable and those which can be rendered serviceable after repair, that prove extremely valuable as a source of replacement on other machines.

The recovery of such components is all the more important in relieving the problem of the manufacture of new spares, and the organisation of reducing aircraft to 'spares and produce', which is the term used, is in the hands of Aircraft Component Recovery Depots situated in different parts of the country.

To illustrate a salvage and recovery sequence in this section we have drawn our story firstly from the No. I Naval Air Fighter School at Yeovilton and secondly from the A.C.R.D. at Alloa, this depot being one of the ancillary workshops of the Aircraft Repair Yard, Donibristle, as mentioned in the previous section.

Fig. 284—A Neals 3 ton crane is used to load the fuselage on to the Cat truck, the main planes and engine being removed on a Bedford prime mover lorry (sometimes referred to as a low loader articulator).

The first illustration Fig. 283 shows a wrecked Wildcat which was crashed by a pupil pilot officer shortly after taking off from the fighter school airfield. As will be seen, the power plant and one main plane have been torn away from the airframe, which, when we first arrived at the scene, was lying on its back, but has since been turned over for the purpose of dismantling.

After an inspection to determine if possible the cause of the accident, the Aircraft Salvage Section is notified to bring in the wreck for ultimate reduction to spares and produce, and in Figs. 284 and 285 we see the fuselage being loaded on to a Cat truck by means of a 3 ton Neals crane. As will be seen from Fig. 285 the Cat truck is equipped with a caterpillar track for travelling over fields, rough tracks and

Fig. 285 (Left)—This provides a better view of the Cat truck, which, with its rear wheels raised, could travel with ease on its caterpillar track over a very rough section of road across the fields.

AIRCRAFT SALVAGE AND COMPONENT RECOVERY

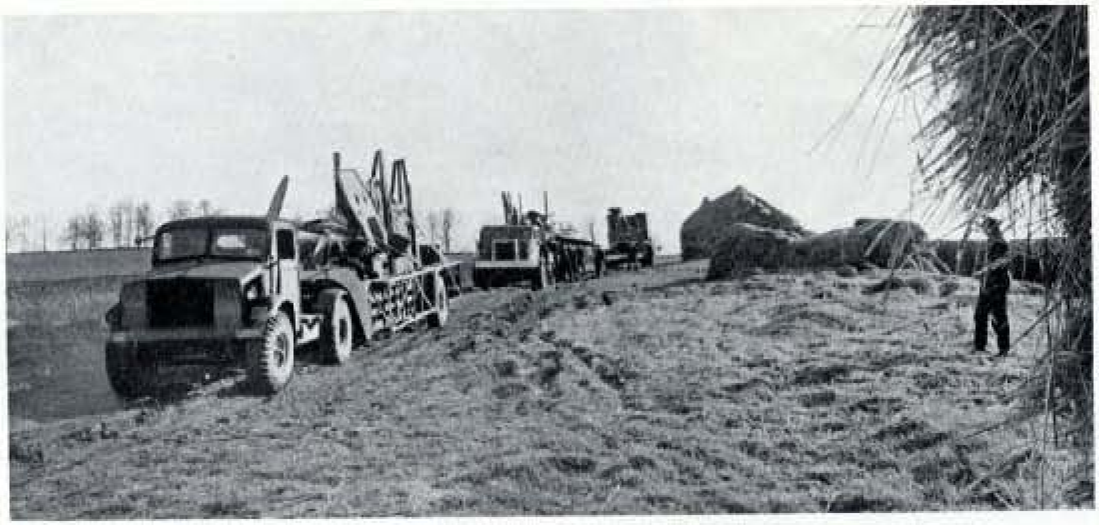


Fig. 286—The articulator with engine and main planes and the Cat truck with the fuselage, journey from the scene of the crash across the field road, the Neals crane bringing up the rear.

ditches, the rear road wheels being raised off the ground for this purpose.

Having firmly secured the fuselage and loaded the main planes and engine on to a Bedford low loader articulator, the journey to the air station commences by traversing the field road through the farm Aircraft Salvage and Component Recovery as featured in Fig. 286, the articulator leading, followed by the Cat truck and crane.

Leaving the convoy to negotiate their way through the farm gates into a narrow lane, we returned to the station to take the view outside the Aircraft Component Recovery hangar depicted in Fig. 287. Here we see obsolete Beauforts waiting to be reduced to spares and produce, whilst lining the road are some of the 27 vehicles of the Aircraft Salvage Section, the variety of types shown being listed in the caption to the photograph. Inside the hangar (see Fig. 288) early types and crashed Seafires are in the process of reduction.

Fig. 287—Obsolete Beauforts outside the Aircraft Component Recovery hangar waiting to be reduced to spares and produce. Lining the road are some of the 27 vehicles of the Aircraft Salvage Section, these, headed by a Cat truck, include a Bedford articulator low loader, a Neals crane, a P. & H. crane, an articulator high loader and another low loader in the rear.

For the next part of the story concerning the reduction procedure we visited the A.C.R.D. at Alloa, outside of which we see in Fig. 289 a Barracuda, damaged beyond economical repair, being unloaded from an articulator, whilst inside the hangar the work of dismantling other Barracudas is well under way, as illustrated in Fig. 290.

The work of reduction commences by removing the aerofoil sections, i.e., main and tail planes, fins and rudders, and dis-

Fig. 288 (Left)—Early types and crashed Seafires being reduced to spares and produce in the Aircraft Component Recovery hangar.

Fig. 289—An articulator arrives at the Aircraft Component Recovery Depot, Alloa with a Barracuda which is beyond economical repair, and the crane commences to unload.

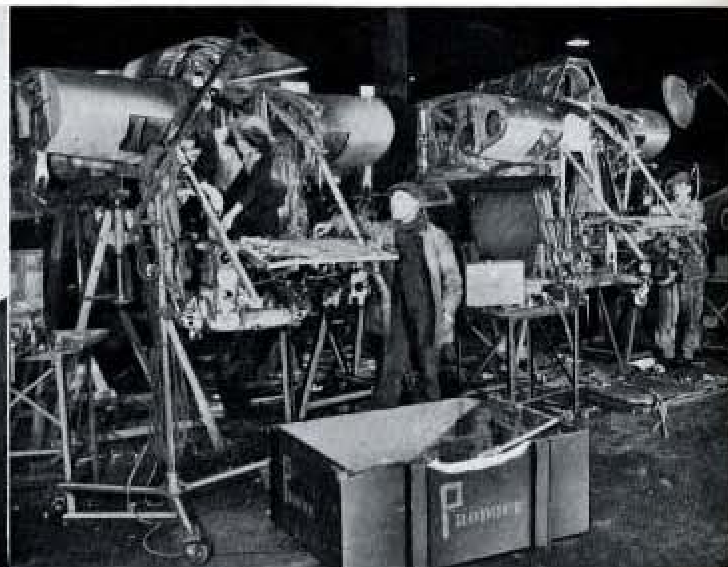


Fig. 290—Dismantling Barracudas at Alloa to obtain all the serviceable components which will be sent to Return Stores for subsequent test in the workshops and repair if necessary.

posing of them according to the category of the aircraft. If required by the Donibristle Repair Yard, then they are sent back there for repair and re-issue, alternatively they may be needed by the manufacturers or contractors. Failing this, or should a considerable degree of repair be necessary, then such components are reduced to scrap.

In dismantling the fuselage, the parts obviously of no use are put in a scrap box, whilst apparently serviceable ones are placed in a 'produce' box (see Fig. 290) and then collected for cleaning first in paraffin followed by trichlorethylene and other various cleaning and degreasing agents peculiar to aircraft engineering.

The next stage is to pass for identification by means of a photographic stores catalogue relative to the type of aircraft, a wide range of such catalogues being kept in the Publications Room at Alloa. In Fig. 291 we see serviceable Hellcat components being identified in this way, following which each part is given a job card label quoting the stores section, reference and part numbers.

After identification all parts are given a preliminary examination and then binned to await despatch to Donibristle Return Stores where, as stated in the Mechanical Workshops Section of the Repair Yard story, they are sorted out and passed to the various workshops to overhaul, test and repair if necessary.

The job card labels are divided by perforations into three sections and after repair, the appropriate inspector in the View Room will sign all three and detach the lower one marked (1). The item is then passed to the Despatch Bay who detach section (2) of the label before sending the component back to the Return Stores for forwarding to the Main Stores (Fig. 277) for stock.

As a final reference we would add that all appendix 'A' items on an aircraft, i.e. instruments, wireless, armament, etc., are treated separately at Alloa, being checked on arrival and accounted for on the airframe inventory. After identification they are sent direct to the Main Stores at Donibristle, whether serviceable or unserviceable.

Fig. 291—Identifying serviceable Hellcat components at the Alloa Recovery Depot by means of a photographic stores catalogue in which every item on the aircraft is illustrated.

AIRCRAFT EQUIPMENT MAINTENANCE

IN order to provide for the rapid servicing of operational aircraft, and to ensure that major overhauls produce the least possible loss of availability for flying, it is essential that repair organisations are able to call upon supplies of airframe and engine spares, propellers, control instruments, electrical and radio apparatus, cameras, etc., so that any part found defective may be replaced immediately by one known to be in a serviceable condition.

These spares, under the general title of Aircraft Equipment, are held in bulk at various Naval Air Store Depots, and defective items thrown up by replacement are fed back to these depots by the repairing organisations in order that, where possible, they may be reconditioned and passed into stock for further service. Working in close conjunction with each Store Depot is a Naval Aircraft Workshop whose broad functions are:—

(a) The maintenance of stores stock in a technically serviceable condition, including modification of equipment to the latest standard of operational requirement.

(b) The complete overhaul of returned unserviceable equipment within the scope of the facilities available, with particular reference to items in short supply.

(c) The dismantling and packing of aircraft propellers for overseas transit.

(d) The manufacture of items to meet emergency requirements for which no normal source of supply is available. Under war conditions the interpretation of this function has been in the tradition of Naval Engineering which postulates that no job is turned down unless its production involves the need for special equipment or machinery completely beyond the range of improvisation, or the use of unobtainable material for which there is no acceptable alternative.

Fig. 292—Splicing one of the securing strops which fits round the oleo leg of an aircraft for securing when ship borne.

A Royal Naval Aircraft Workshop

The following general description of one of these Establishments will convey an impression of the many-sided activities involved.

Apart from general executive offices there is a Drawing Office holding a very large number of drawings and a comprehensive technical library, which together cover completely and in detail, the range of equipment held by the Store Depot concerned.

The first shop visited was the **Splicing Shop.** Here the main activity is the production of cables and strops for securing aircraft when ship borre, the illustration Fig. 292 showing a workman splicing one of the securing strops which fits round the oleo leg of the aircraft and to which the quick release is attached. After splicing, the joints are covered with twine serving and then shellacked.

The next view, Fig. 293 depicts a woman worker adding the final fittings i.e. locking bolts, screw jacks and quick release, to a set of main securing cables (eight per set) prior to their final test pull of 1,200 lb., after which they are bundled for despatch. The locking bolts are added at specified distances apart, measured by a marked board on the bench; to lengthen when in use simply means altering the positions of the bolts. For securing land operated aircraft, the cables are connected to ground rods through tension springs to allow for wind conditions.

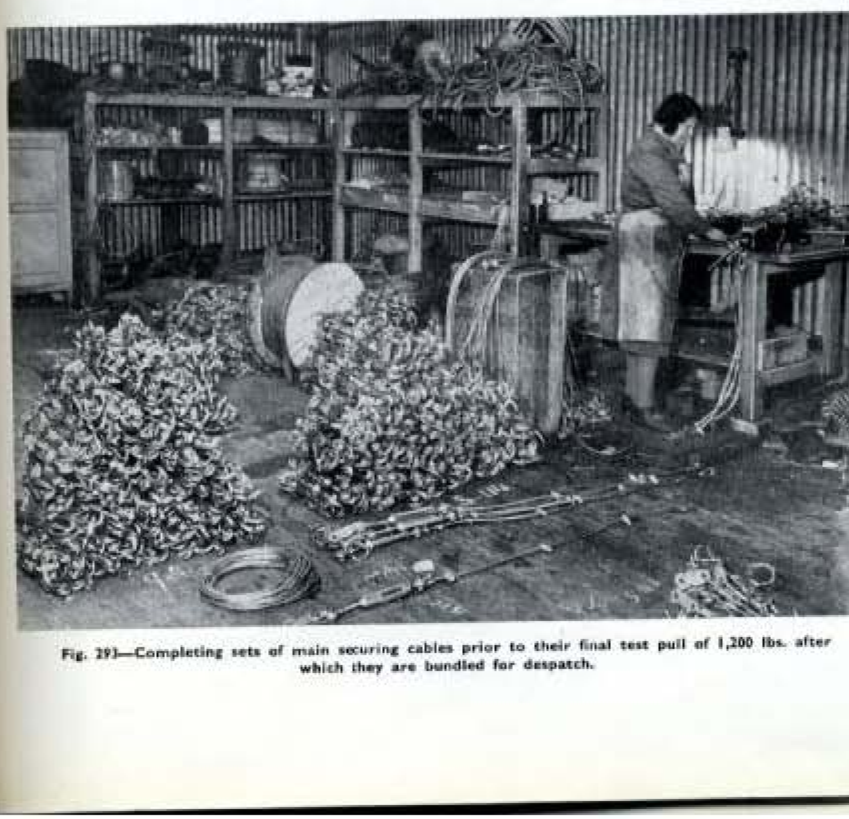
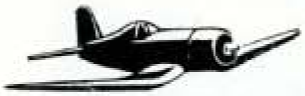


Fig. 293—Completing sets of main securing cables prior to their final test pull of 1,200 lbs. after which they are bundled for despatch.

The **Machine Shop,** which adjoins the Splicing Shop, is equipped with centre lathes, shaper, drilling machines, miller, power hacksaw, a Ward 2A Capstan Lathe and a Churchill Tool and Cutter Grinder. This shop carries out the whole of the machining required for the Establishment and the illustrations Figs. 294 and 295 show a 2½" diameter end mill being reground on the Churchill grinder and a turning operation being carried out on a test chamber for altimeters. (Two of these test chambers are later shown in use in the Instrument Shop).



The combined **Blacksmiths' and Sheet Metal Workers' Shop** is equipped with power hammer, muffle, electric heat treatment furnaces, electric and acetylene welding plants, a full range of tools for sheet metal work, including a 30 ton press, and an oxy-coal gas cutting machine. In Fig. 296 the latter is illustrated effecting a modification to an aircraft rocket projectile blast plate of ⅜" thickness, the form being controlled by the template above.

Passing to the **Electrical and Radio Shop** one finds a varied assortment of work in progress, ranging from the repair of small items such as switches, connector plugs and the like, up to the complete overhaul of electric generators and radio installations.

Fig. 294—Re-grinding a 2½" diameter end mill on a Churchill Tool and Cutter Grinder in the Machine Shop.

Fig. 295—A turning operation on an altimeter test chamber for use in the Instrument Shop (see Fig. 303).

Fig. 296 (Below)—A B.O.C. Universal Oxygen Cutting Machine effecting a modification to an aircraft rocket projectile blast plate, the form being controlled by the template above.

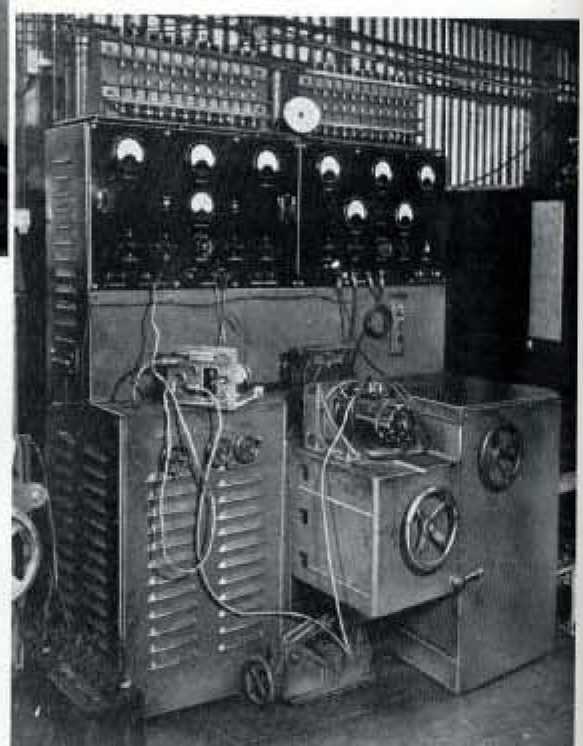


Fig. 297—A Mark VII Test Bench which will test all the electrical functions of generators and ancillary equipment such as voltage control regulators, cut outs, relays, etc.

AIRCRAFT EQUIPMENT MAINTENANCE

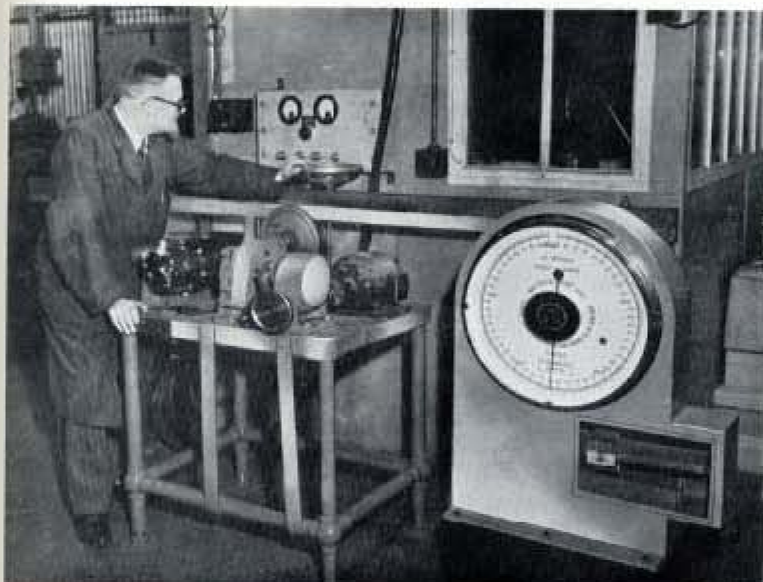


Fig. 298—A rig for testing electrically operated aero-engine starters; the torque is taken through the horizontal beam, the relative measure of its value being obtained from the scale.

As complete assemblies of generators and radio installations have to be subjected to full specification tests after overhaul, it is necessary to have a large quantity of highly specialised test equipment installed as featured in the following illustrations.

The first, Fig. 297 shows a Mark VII Test Bench which is capable of testing rotary electrical equipment used in naval aircraft such as D.C. and/or A.C. generators, either mechanically or electrically driven, or a motor requiring either type of supply. In the photograph it is shown driving a 24 volt D.C. aero-engine driven generator, which in turn is supplying power for testing a radio power pack.

The second illustration Fig. 298 shows a rig for testing electrically operated aero-engine starters, the torque of the starter being taken through the horizontal beam while a relative measure of its value is obtained from the scale of the balance on the right.

Next is a universal bomb carrier rig for testing the circuits of bomb release gear, (see Fig. 299). The bomb hook supports a weight equivalent to 550 lb. arranged by means of a smaller weight on the fulcrum lever as illustrated, the test corresponding to the use of a 500 lb. bomb. The fusing unit on each end of the carrier is first tested electrically and then the bomb gear is operated causing the weight to be released. This rig was designed and made on the premises.

Further equipment of their own design and manufacture are the meter test panels shown in Fig. 300, the left one being for avometers, the remainder being for volt meters, milliameters and ammeters respectively, the charts in the centre of each panel giving the range covered and the permissible error.

The last illustration on the electrical side is that shown in Fig. 301 which depicts the use of a lathe for winding the element for a variable resistance of approximately 150 w., to be used in a volt meter test panel for 1,000 v., A.C. or D.C. The $2\frac{1}{4}''$ diameter by 24" long steel tube covered with vitreous enamel has been painted white to show up the fine wire of 42 s.w.g. as it is being wound on, using the lathe lead screw geared to 90 t.p.i.

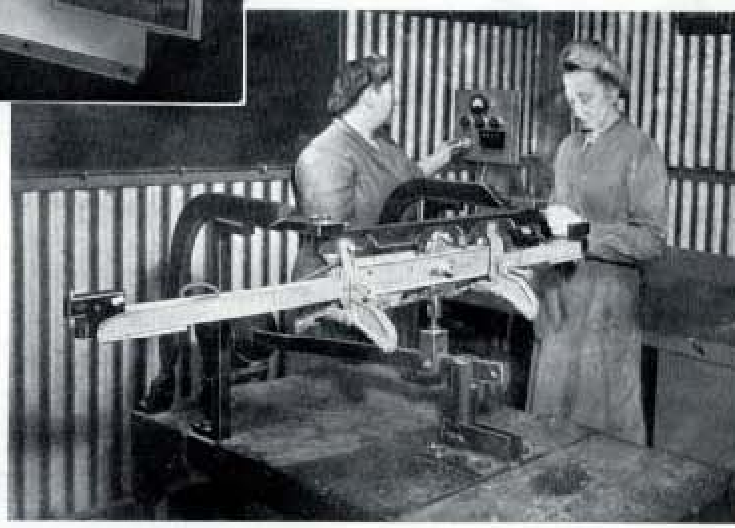


Fig. 299—A universal bomb carrier rig for testing the circuits of bomb release gear.

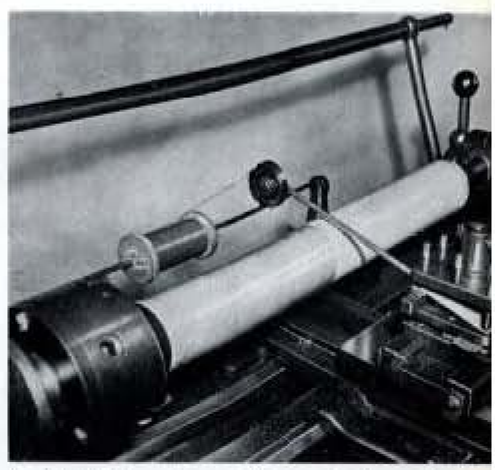


Fig. 301—This shows how a lathe is improvised to wind an element for a variable resistance, when it is too large for the standard winding machine installed.

Fig. 300 (Left)—Meter test panels in the Electrical Shop; the meters under test should normally lie flat and are only raised at an angle for the photograph.

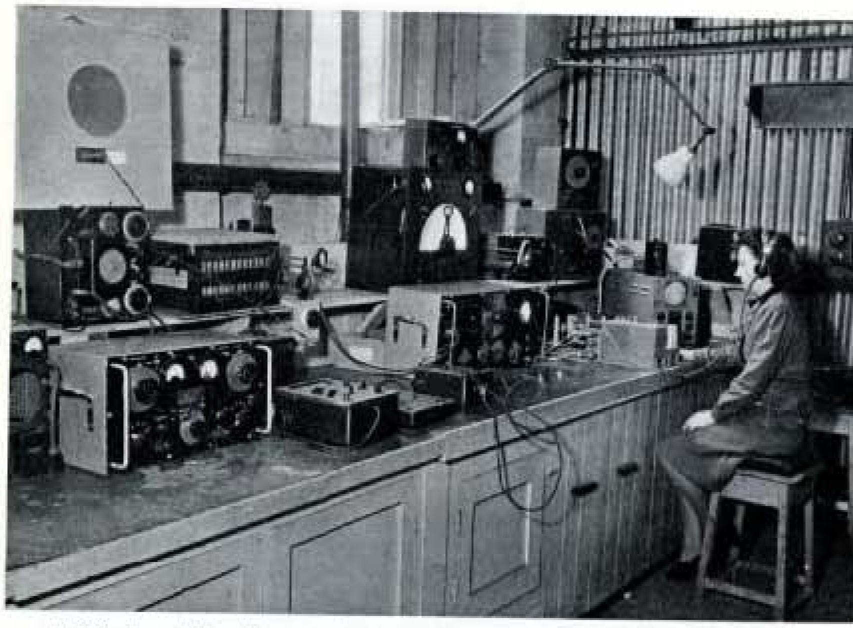


Fig. 302—Some of the radio test equipment including a transmitter-receiver undergoing final test using a cathode ray oscillograph to check the wave modulation.

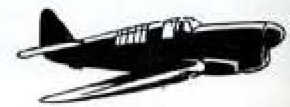
To feature the radio test equipment we took the photograph reproduced in Fig. 302 which shows an aircraft transmitter-receiver under final test using a cathode ray oscillograph to check the modulation of the wave. On the bench to the left of the set is the signal generator, with the audio-frequency oscillator above it, next to which is the power meter for output and on the right, the artificial aerial. The remote control for the set is on top of the oscillograph.

The Instrument Shop was next visited and here again repairs are carried out to a most diverse range of equipment, including engine revolution indicators, altimeters, pressure and vacuum gauges, thermometers, watches and clocks, etc.

As many instruments depend on pressure differences for their operation, the work benches are connected to vacuum and pressure lines, so that tests may be carried out during repair, without the mechanic having to leave his bench.

In the illustration Fig. 303 two of the altimeter test chambers previously seen under manufacture in the Machine Shop section (Fig. 295) are shown in use. By means of this equipment an altimeter placed in the lower chamber can be checked at all stages of repair and calibrated against a sub-standard instrument which is carried in the top chamber as illustrated. The sub-standard instrument is itself checked daily against a mercury column calibrated to give by direct reading, altitudes up to a maximum of 40,000 ft. When installed in an aircraft, the maximum permissible error of an altimeter is 400 ft. at 35,000 ft.

The final testing of instruments is carried out on highly specialised equipment, an example of which is given in Fig. 304 which shows a master calibrator for air speed indicators. In practice, the indicator on the aircraft is operated by the head wind resistance through a pitot tube; on the calibrator this pressure is supplied by compressed air and the indicator readings are checked on the large dial, in knots or m.p.h. In the illustration the top three instruments are completed and undergoing final check, the lower three still being under repair.



A further example of specialised equipment was found in the Watch Repair Shop in the form of a 'Timeograph', an electronic device by means of which the 'beat' of a timepiece is recorded graphically on a calibrated chart, so enabling rating to be carried out in a matter of minutes as compared with the very lengthy method of comparison with a chronometer.

By referring to Fig. 305 it will be seen that the watch under test is mounted on the microphone in the foreground. The beat of the watch is transmitted by the microphone to a 4-valve amplifier contained in the recorder on the right, and is thus made to operate a small hammer which causes a series of dots to be made on a

Fig. 303—Here we show in use two of the altimeter test chambers previously seen under manufacture in the Machine Shop section (Fig. 295).

Fig. 304 (Left)—A master calibrator in use for testing air speed indicators.

paper tape moving forward at constant speed. Movement of the tape is effected by means of a motor whose speed is held constant by the 15 valve crystal controlled multivibrator seen in the rear of the illustration.

The speed of the tape is so arranged that a correctly rated watch produces a series of dots in a straight line running parallel to the edge of the tape. A deviation from parallelism to left or right indicates a losing or gaining rate respectively.

A rotatable cursor above the tape on the front of the recorder is aligned with the dot track, and the error of the watch in seconds per day is read directly from a scale on the periphery of the cursor. The portion of tape reproduced in Fig. 306 showed in a few seconds that the watch on test was slow at the rate of 75 seconds per day. Every movement of the watch could be heard highly magnified in the earphones plugged in to the side of the recorder.

Fig. 305—The 'Timeograph,' an electronic device for graphically recording the 'beat' of a timepiece and reducing the work of rating to a matter of minutes instead of days.

Fig. 306—This portion of tape from the Timeograph shows that the watch on test was slow at the rate of 75 seconds per day.

The more important control instruments must be capable of telling their story to the pilot in the dark, and to effect this, dials and hands require treatment with radio-active luminising material. This process is carried out under stringent precautions, in a special room, of which Fig. 308 gives a general view, while Fig. 307 shows an operator at work with protective screen between the job and herself.

All flying instruments and engine performance indicators are treated in this way by first using an aerospray to paint white. Black is then applied by means of a rubber roller, and as the indications are engraved into the dial, this results in a black dial with white markings. The next stage of luminising is done in the cabinets behind the glass containing 80 per cent. lead to eliminate the effect of radium rays.

The paint used is made by mixing a powder, consisting of 99.95 per cent. zinc sulphide and .05 per cent. radium, or mesothorium, into a paste by the addition of a solution of gum arabic. The powder, held in a small bottle, is always kept in the heavy lead container seen in both views. When the light is switched on in the cabinet an exhaust fan comes into operation to remove any emanation from the radioactive material through the rear grill seen in Fig. 307. We would add that all the equipment was designed and made in these Workshops.

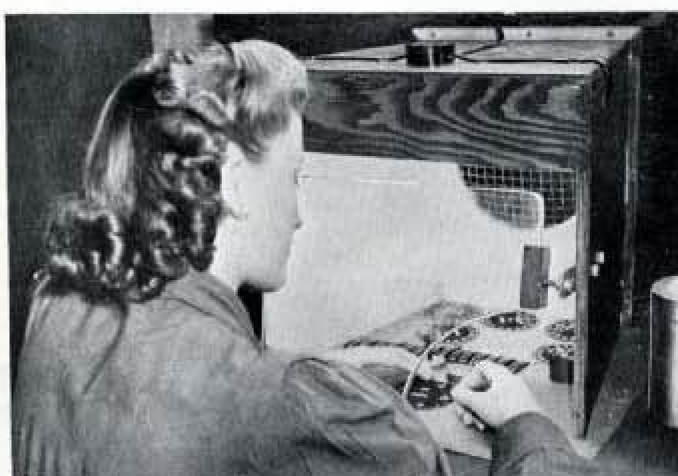


Fig. 307—A close-up of a girl at work on an air speed indicator dial.

Fig. 308 (Right)—A view in the Luminising Room where the more important control instruments have their hands and dials treated with radioactive luminising paint.

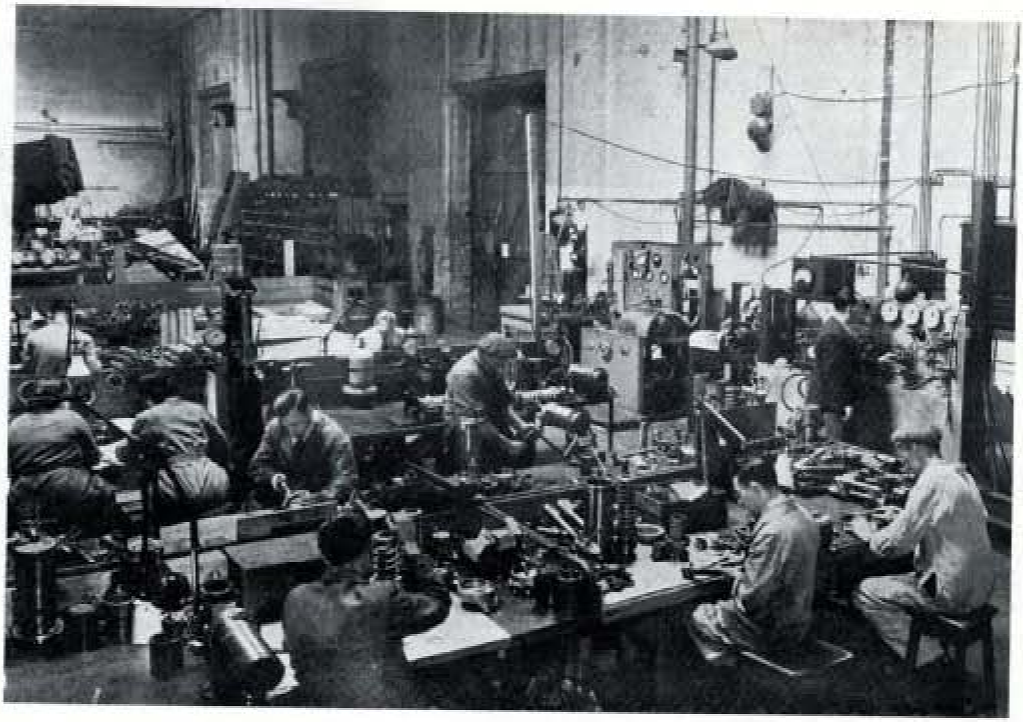


Fig. 309—This general view in the Hydraulic Shop shows some of the test equipment installed.

Although the strictest precautions are taken a further safeguard is a regular monthly examination by a doctor, including the taking of a blood test from each girl.

The Camera Repair Shop is shown in Fig. 310 with several types of aircraft cameras on view. These highly complicated pieces of mechanism are completely overhauled, modifications incorporated where necessary and tested to a most rigorous specification before being released for further service.

The camera to the left, with its magazine open in front, is used for training purposes and combat on torpedo carrying aircraft, taking a 12" by 2" picture of the actual target and indicating whether a hit has been registered. It is electrically operated, and a motor winds the film to the next position immediately after exposure. In the centre foreground is a cine gun camera as fitted to every British combat aircraft for taking actual combat records, the 16 m.m. magazine containing sufficient film for a 10 seconds burst on the aircraft's guns. The same camera is mounted on the dummy training gun at the rear to record accuracy of 'firing'.

The large camera in the centre rear is used for survey and reconnaissance and takes a $5\frac{1}{2}$" square picture, the magazine containing sufficient for 125 exposures at 2 second intervals (a larger magazine will take 250). The electrical control box to the right of it, enables either single shots or continuous running at any interval from 2 seconds to 60 seconds.

The remaining cameras right rear and front are American types for reconnaisance and gun work respectively.

Fig. 310—Some of the types of aircraft cameras which are completely overhauled and tested to a rigorous specification before releasing for further service.

In the **Hydraulic Shop** reconditioning is carried out to aircraft equipment comprising pumps, flap and undercarriage operating jacks and their control gear. A general view of this shop with some of the test equipment is shown in Fig. 309 whilst Fig. 311 depicts a test rig for engine starters of the cartridge impulse type which also are reconditioned in this particular section.

In operation on the aircraft the piston in the starter is driven forward by the explosion pressure of the operating cartridge (300 lbs per sq. in.). By means of helical splines, this forward motion is made to rotate a saw toothed clutch one complete revolution while at the same time making it protrude about $\frac{1}{16}$" to engage with its

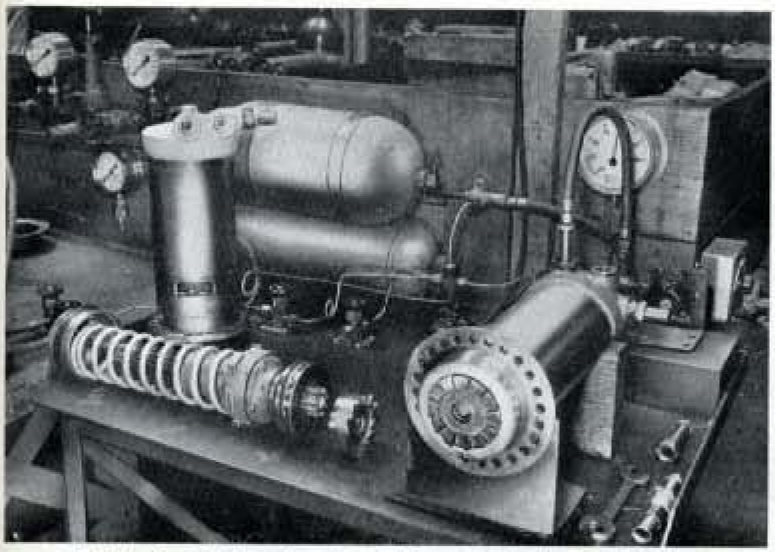


Fig. 311—A test rig for engine starters of the cartridge impulse type which are reconditioned in the Hydraulic Shop.

opposite number on the engine shaft. When the piston reaches the end of its travel an exhaust valve opens and the return stroke is effected by the compression of the main spring which also releases the clutch member from engagement.

On the test rig these motions are reproduced using air at 100 lbs. per sq. in. as the motive power. A motor driven cam-operated air supply valve is arranged so as to repeat the cycle of operations automatically four times per minute. The partially dismantled starter lying at the left front of the bench gives a view of the clutch, piston, return spring and internal mechanism.

In the **Dinghy Shop,** of which a general view is given in Fig. 312, life saving dinghies are repaired, modified, tested and finally packed into their respective containers. As the completed dinghy has to be folded into extremely small compass before it can be persuaded to enter its container, it is necessary to evacuate the air from the dinghy before commencing the folding operation. The intractability of a partially evacuated dinghy has to be experienced to be believed!

The General Engineering Shop handles repairs to ground equipment such as engine erecting stands, lifting jacks, tyre pumps etc., bomb hoists, bomb carriers, aircraft target towing winches, portable petrol driven electric generators and air compressors as well as a large range of incidental items.

Fig. 313 gives a view of gear by means of which the 7,000 foot towing wire is wound upon the replaceable drum of the target towing winch, using a modified towing winch for the purpose, on which a motor driven pulley takes the place of the windmill which can be turned into or out of the slip stream by the pilot when the winch is installed in an aircraft.

A nut engaging with a four-start, right and left hand thread on the spindle in the front, guides the wire on to the drum in

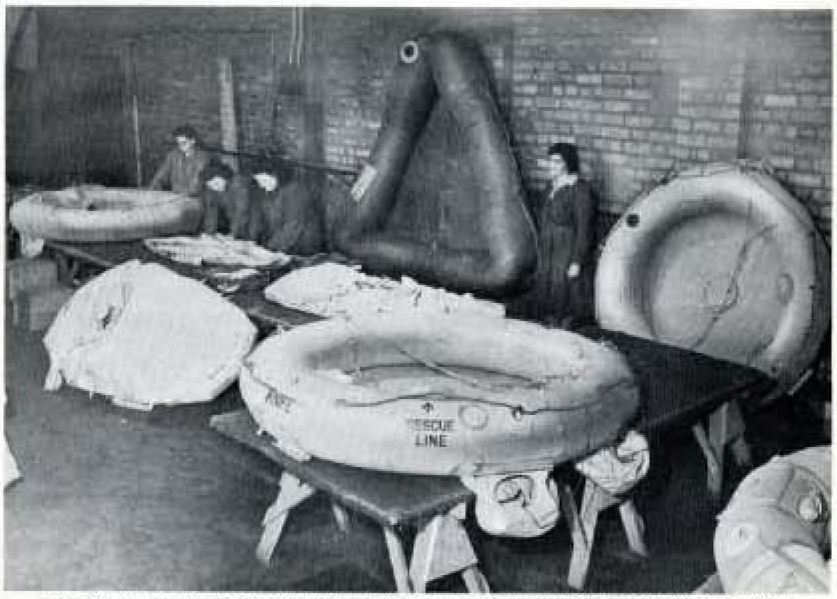


Fig. 312—In the Dinghy Shop life saving dinghies are repaired, modified, tested and finally packed into their respective containers.

even layers, the special cross handed thread providing reversal at the end of each layer. The last 200 ft. of wire is painted red as a warning to the pilot when winding in the target.

In addition to the shops illustrated there is a large Woodworking Shop in which is made a varied assortment of the special cases required for safe accommodation in storage of the many relatively fragile aircraft components.

Cleaning and electro plating plants are also installed for dealing with the many types of special finishes involved as part of the general repair work.

Fig. 313—Using a modified towing winch for winding the 7,000 ft. of target towing wire upon the replaceable drums that fit in the similar winch in the aircraft.

Fig. 314—A general view of a M.O.N.A.B. Mobile Maintenance Component comprising aircraft machine shop, two generator lorries, battery charging lorry, general purpose workshop and electrical and instrument workshop.

OUR story of aircraft maintenance and repair has so far been confined within the framework of static facilities available at air stations, repair yards and naval aircraft workshops. The war against Japan, however, has necessitated a comprehensive mobile system of land based and ship borne repair facilities which has been developed in two groups known as the Mobile Naval Airfield Organisation (or short title, M.N.A.O.) and the Fleet Aircraft Maintenance Group (F.A.M.G.) respectively.

In this section we propose to give an outline of the work of the M.N.A.O. which covers the rapid provision of the necessary equipment and personnel at airfields or air strips, for the training and maintenance of naval air squadrons disembarked from aircraft carriers operating in advance of existing bases. (The work of the F.A.M.G. is dealt with in the final section.)

The M.N.A.O. may be said to consist of two main branches:—

M.O.N.A.B.s—Mobile Operational Naval Air Bases and

T.A.M.Y.s—Transportable Air Maintenance Yards, both of these to be as flexible as possible, being broken down into a number of components which may be added to, or subtracted from, any one unit to suit local conditions and the general maintenance plan for the area.

THE M.O.N.A.B. COMPONENTS

After taking care of the requirements of command and executive, medical stores, flying control, communications, etc., from a maintenance point of view, M.O.N.A.B. components may include the following:—

(*a*) **M.S. Component** (Mobile Servicing) consisting of four lorries similar to the Squadron Servicing Unit (S.S.U.) described in the section entitled 'Centralised Maintenance of Aircraft' (see Fig. 217) fitted up as one workshop lorry, two universal stores lorries and one general purpose lorry with the usual ground equipment. These components carry sufficient stores to service 25 aircraft of a given type for 14 days but do not include the maintenance personnel.

(*b*) **M.M. Component** (Mobile Maintenance) comprising six specialized lorries, i.e. one machine shop, one electrical and instrument workshop, one general purpose workshop, one battery charging and two generator lorries, making up a self-contained mobile workshop unit (see Fig 314). Normal ground and servicing equipment together with type spares for a number of types of aircraft are carried, the unit, accompanied by the necessary personnel, being capable of servicing 50 aircraft for one month.

This component is designed to carry out minor inspection and repair by replacement of complete assemblies, two Dorland hangars being provided, in which this work is carried out (see T.A.M.Y. section).

(*c*) **M.S.M. Pack up** (Mobile Servicing and Maintenance). This covers all the machine tools, ground and servicing equipment, tool spares, generators, battery charging, etc., equivalent to one M.M. and two M.S. components. The whole is in the form of a crated pack-up for installation in existing buildings and is usually supplied to certain of the more static M.O.N.A.B.s in the rear area.

(*d*) **M.P. Component** (Mobile Personnel) which consists of only maintenance personnel with their own tool kits for one squadron and is intended for addition to a M.O.N.A.B. in an area where squadrons are expected to disembark without their maintenance ratings.

(*e*) **M.S.R. Component** (Mobile Storage Reserve). This, with necessary personnel and a range of ground handling equipment, may be added, in units, to any M.O.N.A.B. and is capable of maintaining 50 storage aircraft for which a Dorland hangar is provided.

(*f*) **M.R. Component** (Mobile Repair) consists of a pack-up of a large range of machine tools and equipment which, if attached to a M.O.N.A.B., enables that unit to carry out major inspections. The M.R. component is normally added to a unit in the rear areas when the M.S. and M.M. components are taken away for mobile use in the forward areas. The two Brook hangars with the component provide sufficient engine changing gantries for sixteen engine changes.

To provide the necessary maintenance and repair facilities for these components two types of hangar are used, the Dorland hangar for the M.M.s. and M.S.R.s and the Brook hangar for the M.R.s. these hangars being illustrated and described in the later sub-section dealing with T.A.M.Y.s.

In addition to the various vehicles designed for aircraft maintenance as mentioned, very many specialised vehicles are included in each M.O.N.A.B., the total numbers for an average unit being:—

31 specialised lorries
55 non-specialised lorries
34 trailers
36 special road-rail containers which exclude stores and spares etc.

Included in the above are the machine shops and workshops, wireless transmitting lorries and radar beacon vans, photographic tender and trailer, generator and camp lighting lorries, breakdown lorries and

The Mobile Naval Airfield Organisation

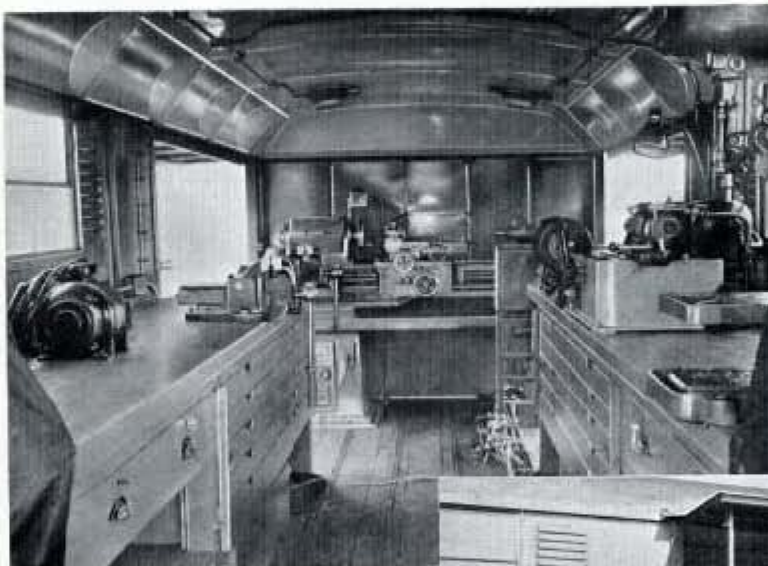


Fig. 315—An interior view of the Aircraft Machine Shop showing the centre lathe, bench drill; valve grinder, bench grinder, Morrisflex grinding equipment and vice.

crash tenders, cranes, refuellers and fuel tanker, water purification plant lorry and water trailers, office, laundry, bakery and N.A.A.F.I. trailers, a mobile dispensary, crash tenders, and many others too detailed to mention. From this list alone, it will be realised that, apart from aircraft, the maintenance problem is a big one, especially in the forward areas.

Following this general survey of M.O.N.A.B. activities, we now propose to give rather more detailed information of some of the components mentioned.

A Typical M.M. Component

—for instance is illustrated in Fig. 314, the lorries reading from left to right comprising:—

Aircraft machine shop
Two 22 k.w. Lister generator lorries (the end of one can be seen behind the aircraft machine shop)
Battery charging lorry (centre foreground)
General purpose workshop, and
Electrical and instrument workshop.

Dealing with these individually, we commence with—

The Aircraft Machine Shop

—an interior view of which we give in Fig. 315. Mounted on a Bedford 3-ton lorry chassis, the equipment consists of a 6½" centre lathe (seen at end) a ½" capacity bench drilling machine (right foreground), next to which is a valve face grinder, with a double wheel bench grinder beyond. On the left bench is a Morrisflex grinding equipment and one of the three 4½" vices supplied. Ample drawer accommodation is provided for tools and ancillary equipment.

Fig. 316—This view, taken from the right hand side of the Aircraft Machine Shop, shows how the side doors let down offering extra work benches if required, as well as cooler working conditions in hot climates.

Both sides of the lorry open up as shown in Fig. 316, the lower doors offering extra work benches if required and cooler working conditions in hot climates. Additional covered in outside working space can be erected by means of the canvas, poles and pegs provided.

22 K.W. Generator Sets

One of the 22 K.W. generator lorries is depicted in Fig. 317, the tarpaulin canopy having been undone and thrown back to show the equipment better.

Fig. 317 (Left)—One of the two 22 k.w. Lister Generator Lorries included in the M.M. Component; the tarpaulin canopy is usually kept in position.

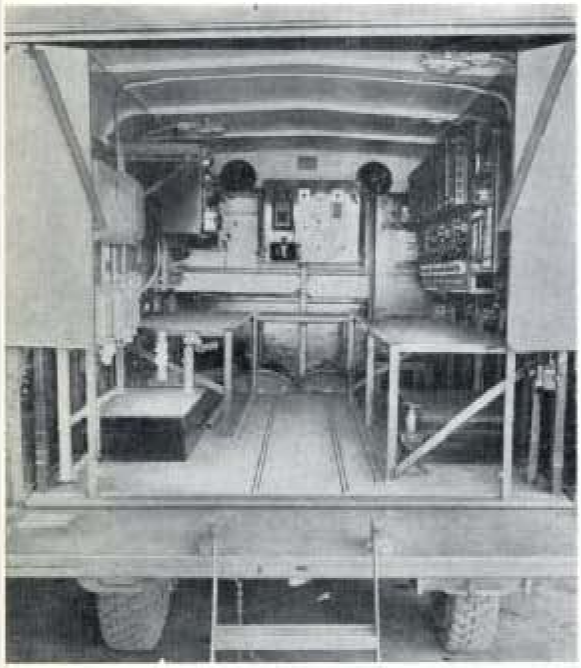


Fig. 318—An interior view of the Mobile Maintenance Battery Charging Lorry.

Fig. 319—This view shows the interior of the General Purpose Workshop which is another of the M.M. Component units.

The interior of—

The Battery Charging Lorry

—is featured in Fig. 318. On the left side are the mains input panel and two mains rectifiers (230 v. A.C. to 36 v. D.C.), the other equipment including four charging panels and four rectifiers, an accumulator capacity test panel and a rack of hydrometers. Each rectifier when switched on brings a cooling fan into operation. This lorry carries sufficient equipment to satisfy the servicing and maintaining of 100 aircraft.

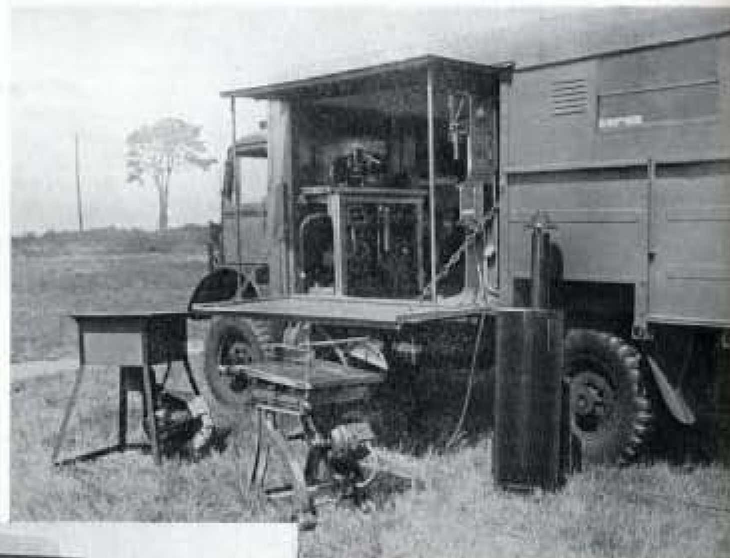


Fig. 320—The General Purpose Workshop taken from the exterior; the equipment standing outside comprises a brazing hearth, portable saw bench and salt bath.

Fig. 321—This Electrical and Instrument Workshop completes the M.O.N.A.B. Mobile Maintenance Component. In the foreground will be seen a portable petrol driven generator test set and sparking plug servicing unit.

The General Purpose Workshop

—equipment consists of a portable motor driven saw bench, brazing hearth (with electrically driven fan), and quench tank, double wheel bench grinder, 1" pillar drilling machine, a tube bending machine, hand rotary shearing machine, 6" hand guillotine (up to ⅛" plate) universal swaging machine, 30" bench folding machine, bench nibbler, salt bath (with paraffin burners) for annealing and normalising, air compressor, three bench vices, aerospray dope spraying equipment, oxy-acetylene cutting and welding equipment, and a 40 lb. anvil. (See interior view Fig. 319). Hoses and guns and a portable electrically driven inhibiting machine for aero engines are also included.

A view of this lorry with the sides let down is given in Fig. 320, and inside can be seen the guillotine on the bench, with

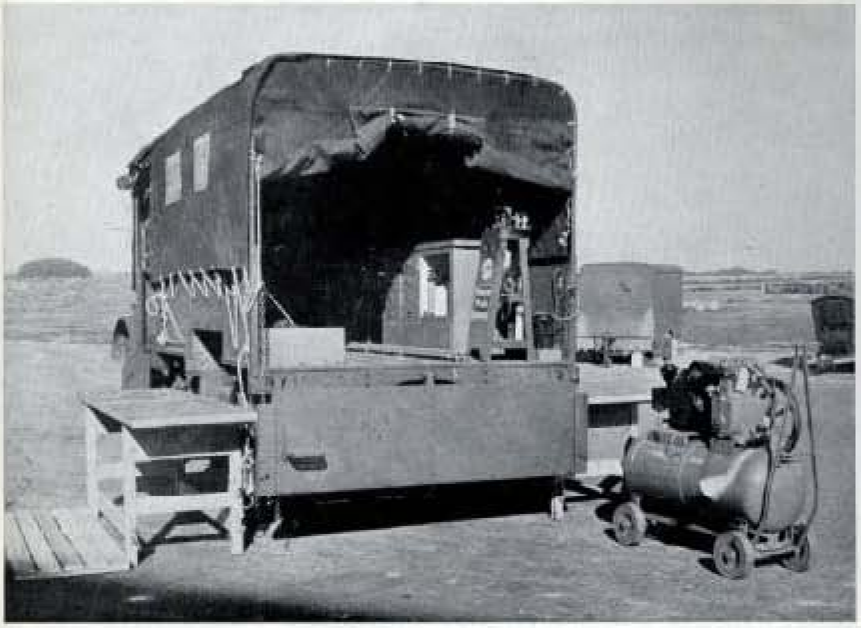


Fig. 322—The workshop lorry of a M.O.N.A.B. Mobile Servicing Component with the portable air compressor outside as well as two of the three portable fitters benches.

Fig. 323—An interior view of a M.S. Universal Store Lorry showing the stowage arrangements for all types of aircraft stores.

the air compressor underneath, whilst to the right is the pillar drill; outside is the brazing hearth (with fan wrapped up) saw bench and salt bath.

The last lorry of the M.M. component is—

The Electrical and Instrument Workshop

—a view from the outside being featured in Fig. 321. This lorry is fitted out with a 3½" bench lathe, ⅜" capacity bench drilling machine, double wheel bench grinder, generator test bench, portable petrol driven generator test set with control panel (seen outside) a sparking plug cleaning and servicing unit (also standing outside) three test panels and two resistance units, an instrument tester, four portable fitters benches and a 4½" bench vice. Both this and the G.P. workshop have canvas awnings for additional working space outside.

Two of the four lorries which go to make up—

A Mobile Servicing (M.S.) Component

—are illustrated in Figs. 322 and 323 the first showing the workshop lorry equipped with battery charging set, sparking plug cleaning and servicing unit, portable petrol driven air compressor (seen outside) bench drilling machine, bench vice, drawers for equipment etc., and three portable fitters benches, two of which are shown erected outside.

The second illustration shows the interior of the universal stores lorry in which will be seen the stowage arrangements for all types of aircraft stores. The lorries are so constructed that any one of seven types of aircraft stores may be carried in them by the use of adjustable stowages.

Another section of M.O.N.A.B. activities consists of an—

M.A.R. Component

(Mobile Air Radio maintenance unit)

—which comprises three radio and four radar workshops, two stores and two 22 k.w. generator lorries of the same type as featured in the M.M. Component (Fig. 317). A general layout of the unit is given in Fig. 324 from which it will be seen that the workshops and stores are housed in standard road-rail containers, these normally being mounted on 3 ton Bedford chassis and each equipped with a pair of steps for entry. (See Fig. 327).

Fig. 324 (Right)—This Mobile Air Radio Maintenance Unit has its radio and radar workshops and stores housed in road-rail containers which normally would be mounted on 3 ton Bedford chassis.

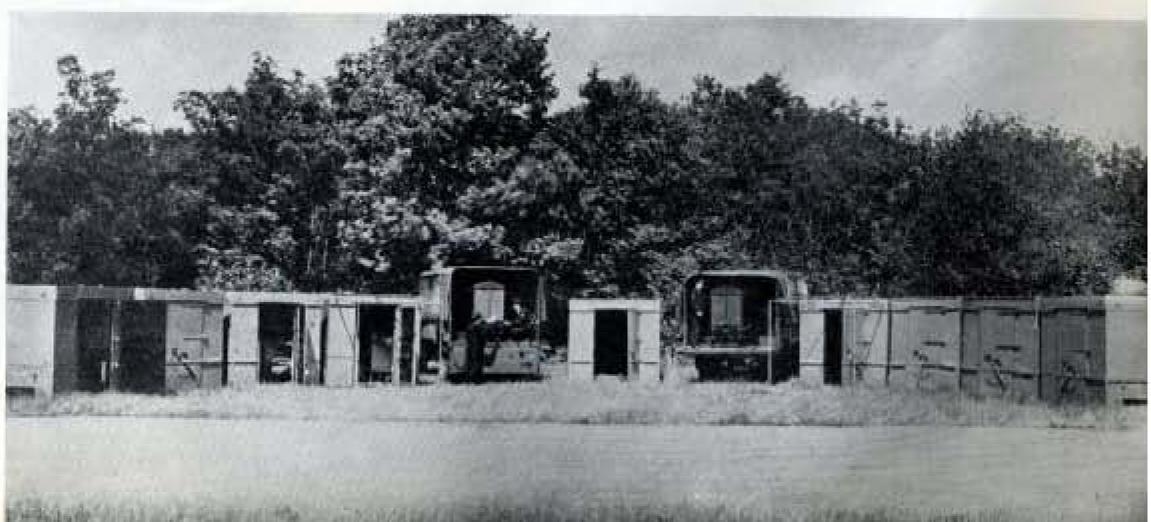


Fig. 325—Erecting the black-out entrance to one of the workshop stores of the M.A.R. Component. This enables night work to be carried out in the forward areas.

Fig. 326—A radio mechanic lifts the black-out to emerge from the stores with an item of electrical equipment; a generator set suitably earthed, will be seen adjacent.

Each container is provided with a black-out entrance for working at night in forward areas, the view Fig. 325 showing this being erected to one of the workshop stores, whilst Fig. 326 depicts it in use. The amount of canvas lying on the grass provides for the additional height when mounted on the lorry chassis.

An interior view of one of the radar workshops, cleared of equipment to be tested, is depicted in Fig. 327, the close-up illustration Fig. 328 showing the power supply panel on the wall and the voltage control panel which is located under the bench, a portion of the top and side having been removed to show it. A 400 volt, 3-phase input is supplied to each wokshop which contains motor generators to provide the various voltages required to the power supply panel. On the bench and connected to this panel in the illustration, is a communication set in course of being serviced.

Our concluding illustration, Fig. 329 shows but one of the many other specialised vehicles which go to make up a M.O.N.A.B. unit. This is—

A Bakery Trailer

—which has an oil-fired steam oven, 11 ft. 3 in. long and 4 ft. 9 in. wide, divided into two decks each capable of handling 144 2 lb. loaves in a baking cycle of 70 minutes.

TRANSPORTABLE AIR MAINTENANCE YARDS (T.A.M.Y.s.)

As mentioned at the commencement of this section, the T.A.M.Y.s. form the second of the two main branches of the M.N.A.O. and their function is to carry out the maintenance and repair of aircraft on the same lines as a maintenance yard located on a permanent site.

As with the M.O.N.A.B.s the number of components constituting a T.A.M.Y. may

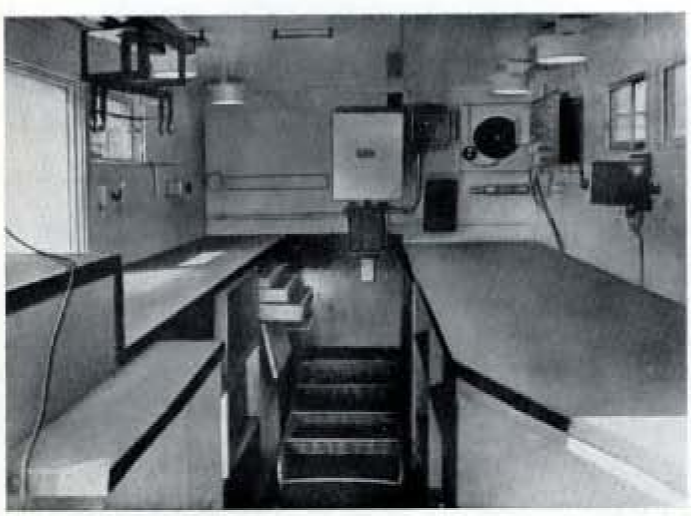


Fig. 327—An interior view of one of the Radar Workshops of the M.A.R. Component; the metal steps used for entering the workshop when mounted on the lorry chassis, can be seen lying on the floor.

Fig. 328—A close-up view in the Radar Workshop showing a communicaion set in course of being serviced.

vary according to local conditions but some idea of the work undertaken can be gathered from the fact that a normal sized T.A.M.Y. will be capable of handling 15 major inspections or medium repairs, 25 minor repairs and 25 complete engine overhauls per month, the latter item including the repair of components.

From these remarks it will be appreciated that a T.A.M.Y. may work in close co-operation with the Fleet Air Maintenance Group (F.A.M.G.) particularly as some of its constituent sections, have definite functions to perform, working with the F.A.M.G. (For instance, an M.R. component in conjunction with a Component Repair Ship and Engine Repair Ship would be capable of supporting a large number of aircraft).

The seven components which go to make up a normal T.A.M.Y. cover the provision of hangars or buildings, equipment and personnel for a technical office and administration, large aircraft workshops, engine overhaul and repairs, ancillary workshops, propeller repairs, dope and paint shop and workshops for breaking down aircraft to spares and produce.

Fig. 329—This Bakery Trailer, with a capacity for 144 2 lb. loaves in a baking cycle of 70 minutes, is but one of the many specialised vehicles which go to make up a M.O.N.A.B. unit.

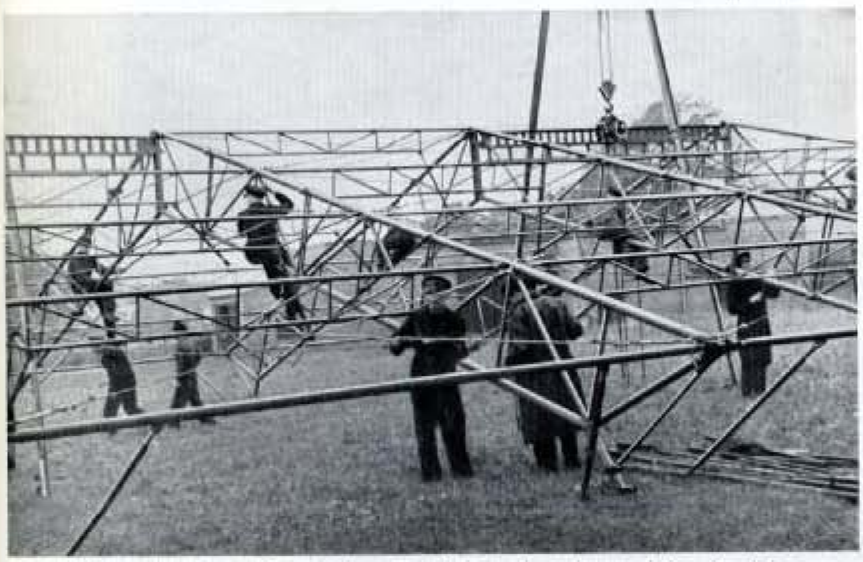


Fig. 330—The roof span of a Dorland transportable hangar is nearing completion, the tubular sections being rapidly assembled in 'meccano' fashion.

being for the M.R. component, as well as for the T.A.M.Y. workshops requirements.

In point of fact, the principle of construction of both types of hangar is identical the main difference being that the Brook is equivalent to two Dorland hangars with an additional span joining them together.

As will be seen from the illustrations, the hangars are of tubular construction throughout, the sections being built up rapidly on 'meccano' lines. In Fig. 330 the roof span of a Dorland is well under way, being supported at both ends by the two sets of tackle blocks on their own girder runways which will be turned over, for use as lifting mediums inside, when the hangar is completed.

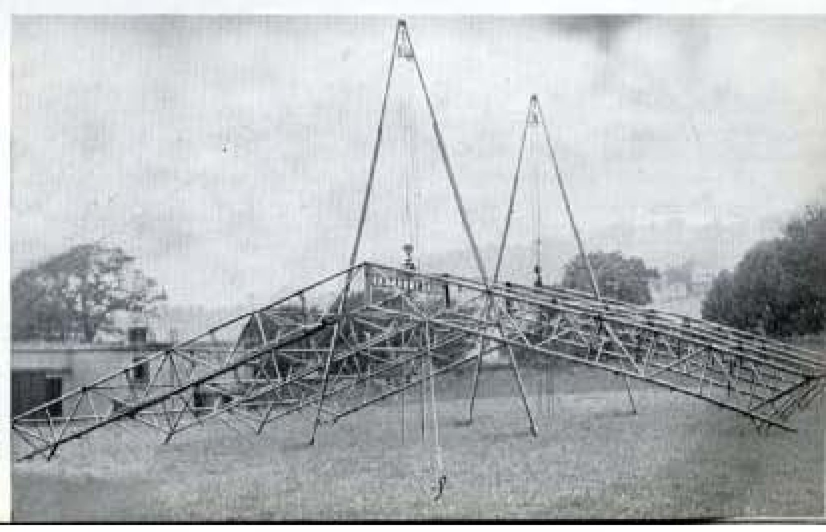
The next view Fig. 331 shows the roof completed ready for the addition of the side supports and as soon as these are attached, the whole structure is hoisted higher as in Fig. 332 until they are in the vertical position when each is secured to its corresponding roof section.

Armament and radio etc. are treated as separate components and in addition such components as command and executive, flying control, medical etc. are required in the same way as for a M.O.N.A.B.

The only views we propose to use to illustrate the equipment of this branch are of—

The Transportable Hangars
—of the Dorland and Brook type, the first, as previously mentioned in the M.O.N.A.B. section being used for the maintenance of aircraft to which the M.M. and M.S.R. components are attached, the Brook type

Fig. 331—Here we see the roof span of the Dorland hangar completed ready for the addition of the side supports.



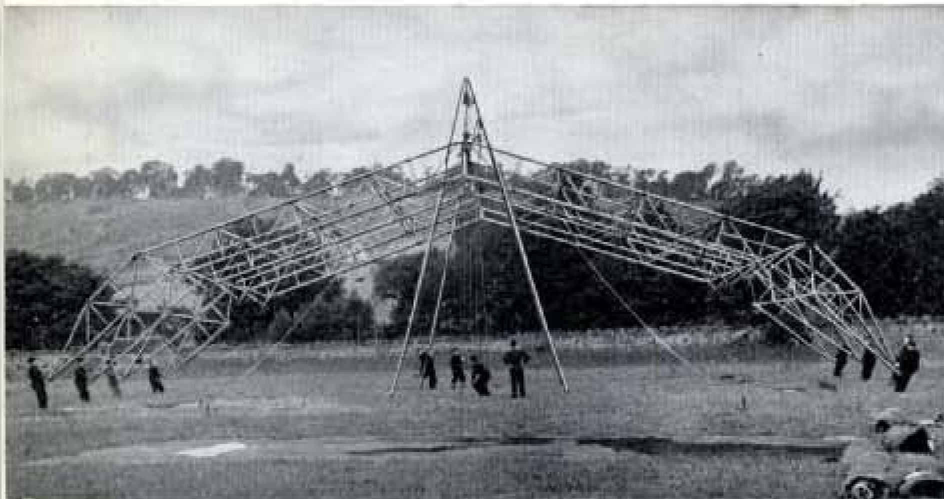


Fig. 332—The side supports have now been secured to the roof span and the structure is being raised to bring them into the vertical position

In the normal course of events the tarpaulin roofing and the end walls would be added before raising into position, but these were omitted for the purpose of the photographs. The next view however (Fig. 333) shows how the end walls are attached to runways with heavy roller type curtain fittings; by this means the hangar can be open or closed at both ends at will.

The last two illustrations Figs. 334 and 335 show the Brook hangar construction in its semi-finished and finished states, the latter being completed with camouflage netting (note the size from the men on the roof).

We would like to add that none of the erecting equipment is surplus to the finished hangar as all such parts are used in the framework, the sectioned shear legs for instance being dismantled and used as connecting and strengthening ties between each side support at the ground ends, and the blocks and tacking providing the lifting mediums inside as previously mentioned.

One important feature of the construction is that the hangars can be erected on ground of practically any unevenness if required, as the hangars are fully articulating during erection, thus obviating the necessity of levelling the ground beforehand.

Fig. 333 (Above)—The tarpaulin enc walls of the hangar are attached to runways with heavy roller type curtain fittings.

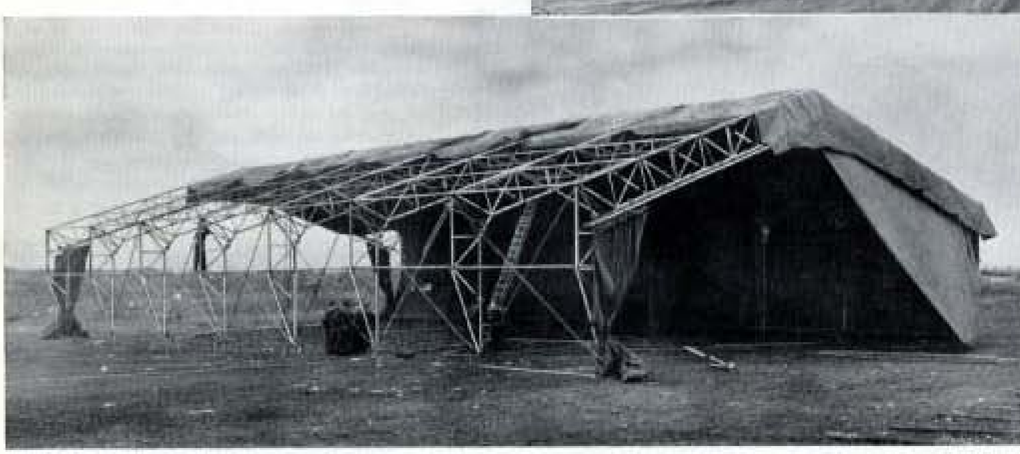


Fig. 334 (Left)—This illustration shows the larger Brook hangar construction in its semi-finished state.

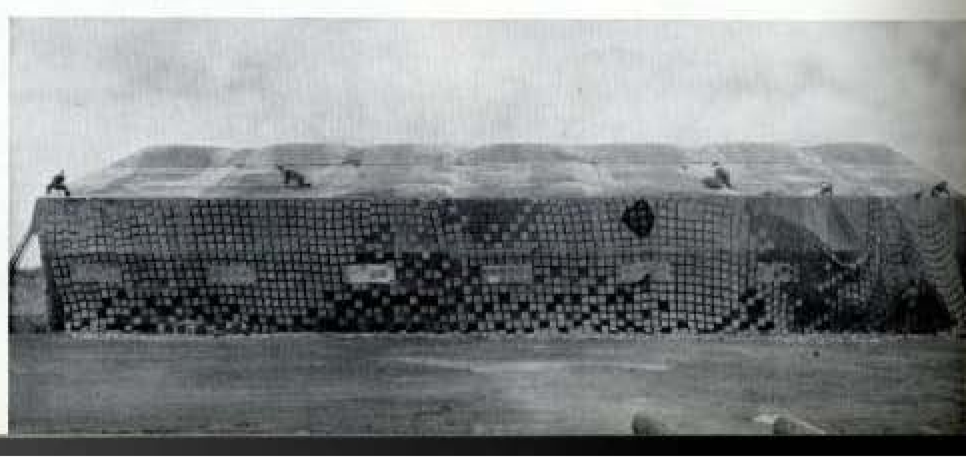


Fig. 335 (Right)—Here the Brook hangar is being completed by the addition of its camouflage netting. The men on the roof give some idea of its size.

Aircraft Maintenance and Repair in Aircraft Carriers

Fig. 336—A view of H.M.S. Indefatigable, one of Britain's modern aircraft carriers.

WHILST the aircraft carrier is the floating airfield from which operational sorties are launched against the enemy, the number of aircraft which can be carried is strictly limited by the space available for stowing them and the space required for accommodating the squadron personnel. An airfield ashore can usually find elbow room for reserve aircraft over and above those actually required for daily flying; but in a carrier, where aircraft have to be packed within a few inches of each other, spare aircraft cannot normally be accommodated.

It follows, therefore, that the aircraft embarked must be brought abroad in first class fighting condition and thereafter maintained and repaired by the maintenance personnel and facilities which are embarked. The aim is to be able to fly 100 per cent of the aircraft in a 100 per cent operationally equipped state.

The extent of the maintenance and repair work carried out afloat is governed to a certain degree by the strength of the supply chain providing replenishment aircraft, that is, supply of new aircraft to the carrier from an external source. But it is also governed by the number of maintenance personnel, the maintenance equipment and the repair workshops which can be provided in the carrier, after the basic demands on space made by stowed aircraft and the ship as a sea going vessel, have been satisfied.

Routine servicing and maintenance, comprising daily and between flight inspections and periodical inspections at a predetermined number of flying hours, represent the minimum amount of work required to ensure operational efficiency and airworthiness. In consequence, this routine work decides the minimum facilities (men and material) for which provision must be made. In addition, further facilities must be embarked in order to cope with unserviceability, whether it arises from operational and accidental damage or from defective aircraft design and material. It is neither desirable nor economical to disembark aircraft on account of some minor damage such as a buckled wing tip.

These further facilities can be roughly divided into two categories—provision of aircraft spares and provision of essential aircraft repair workshops and repair materials.

The range of spares provided comprises major airframe assemblies excluding fuselages but including spare main planes, tail

Fig. 337—A Hellcat comes up to the flight deck of an escort carrier after servicing in the hangar below.

planes, rudders, propellers, control surfaces, undercarriages, engines and power plants, and a complete outfit of smaller spare parts appropriate to the types of aircraft carried, with a foundation of Aircraft General Stores common to all aircraft. The allowances of such spares are limited (once again) by the available space for stowing them.

Fig. 338—Seafires being brought up from the hangar for ranging on the flight deck of an aircraft carrier.

Very often, in order to replace damaged portions of an aircraft, special equipment is required; this equipment is still another liability to the account of space for stowage. It follows, therefore, that the repair workshops are provided for two functions; firstly, the repair of damaged assemblies and components which have been replaced on the aircraft by serviceable spares, and secondly, the routine servicing and maintenance. Both functions tend in the right direction of minimising the number of large and small spares required. If, for instance, a damaged main plane panel can be repaired by metal working, the space which would have been allocated for complete main planes can be reduced by the size of one and used instead for important expendable items like petrol drop tanks.

Fig. 339—Aircraft being ranged for attack: Corsairs are in the foreground and Barracudas in the rear.

In aircraft carriers of modern construction it has been found desirable to allocate parts of the hangar area as Aircraft Repair Spaces. (See Fig. 341.) The location of these spaces is usually immediately forward to aft of the lifts—the hangar between the lifts being regarded as the main aircraft stowage. (See Fig. 340.) Various aircraft repair shops open off the Aircraft Repair Spaces.

One of these is the Engine Repair Shop, part of which is illustrated in Fig. 342. Here there are fitted racks for engine parts, low pressure air for pneumatic tools, bench space and engine cleaning equipment. The amount of engine work undertaken is not extensive under normal conditions, being limited to replacements of accessories cylinders, pistons, etc. The personnel from this shop also assist the squadron ratings to change engines and power plants and themselves build up spare power plants ready for installation. Running faults, which cannot be solved by the maintenance crews, are investigated and rectified so long as major engine stripping operations are not required.

The second shop in this area is the Metal Workers Shop. A lathe, drilling machine, bending rolls, sheet metal guillotine, small salt bath, tube bending machine and throatless shears are the principal machines fitted in this shop. Adequate benches, a hard wood hammering block and a screened off welding bag are also provided.

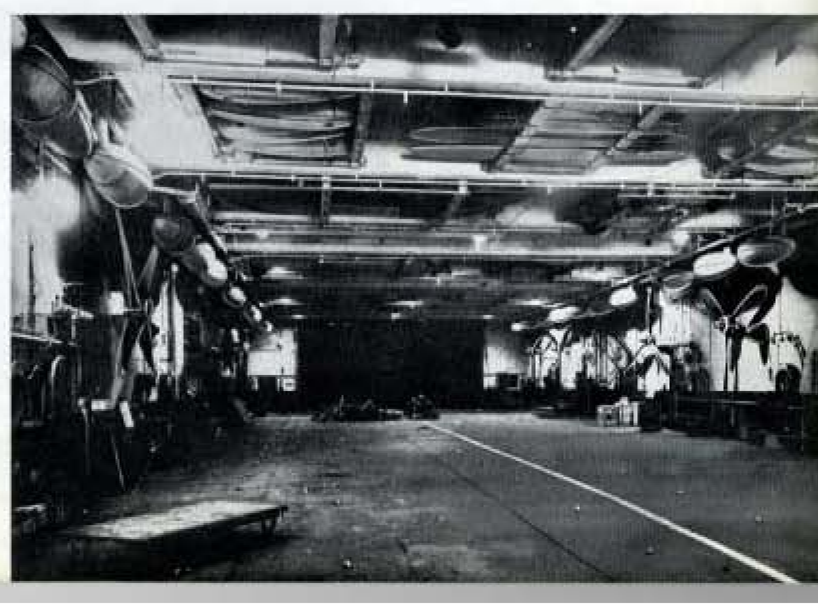


Fig. 340 (Right)—In the hangar of a modern carrier: note overload drop tanks in roof, also main and tail plane stowages. The space at the end is the lift well.

MAINTENANCE AND REPAIR IN AIRCRAFT CARRIERS

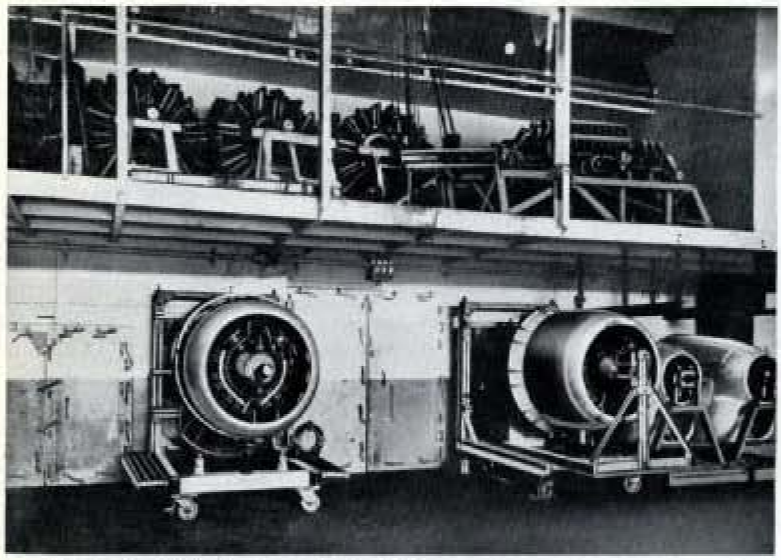


Fig. 341—One of the aircraft repair spaces showing power plants and a shelf for stowage of engines and equipment.

A limited amount of panel work on unstressed parts of the airframe and the repair of ailerons, flaps, elevators, rudders, wing ribs and formers, the repair of wing tips and cowlings, the replacement of perspex and repair of damaged pipe lines, worn control cables, etc., indicate the maximum extent of the work undertaken by the ratings in this shop. During action, it will frequently be necessary to carry out rapid "patching" of flak holes and bullet damage with sheet metal.

The Sparking Plug Servicing Space is only a small compartment but is very important. Plugs can be stripped, cleaned and tested, the air under pressure being supplied by pipe line. In this connection it might be added that low pressure air is lead into all the aircraft repair shops and supplied at selected positions along both sides of the hangar, and forward and aft on the flight deck; high pressure air up to 4,000 lbs. is also supplied at points in the hangar and on the flight deck.

The Aircraft Electrical Repair Shop and the Aircraft Instrument Repair Shop are situated adjacent to each other. The work undertaken in the former includes the repair of electrical equipment, generator and magneto testing, repair and testing of ignition harness and electric motors used in aircraft; in the latter, aircraft instruments can be tested, and repaired to a limited extent. There are electric power points in these shops and the low pressure air is delivered through air dryers.

Another electrical shop close to the hangar is the Aircraft Battery Charging Shop. Its use is self evident.

The Aircraft Oxygen Charging Shop is usually situated lower down in the carrier. Oxygen storage cylinders are secured in racks and a suitable system of pipe lines enables the small aircraft oxygen bottles to be charged. A number of fully charged aircraft bottles are kept in ready-use racks here and also on or near the flight deck.

Apart from ready-use storerooms and headquarters offices this completes the aircraft maintenance facilities afloat. To put the value of these facilities into proper perspective it is necessary to outline what happens during operations. Let us assume that the carrier's air force will be required at dawn to attack an enemy target.

During the preceding night parties of maintenance ratings will have been completing periodical inspections and each aircraft will have had its daily inspection. Petrol tanks, and probably overload drop tanks on the fighters, will have been filled; oil levels checked; bombs, rockets and other armament provided and loaded on to the aircraft. Some time before the strike is due to fly off, the aircraft will be

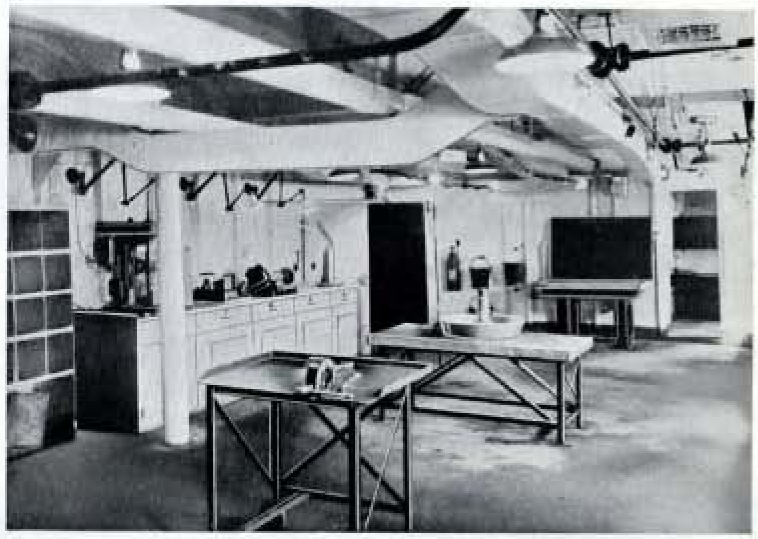


Fig. 342—A view of part of the Engine Repair Shop on board a modern aircraft carrier.

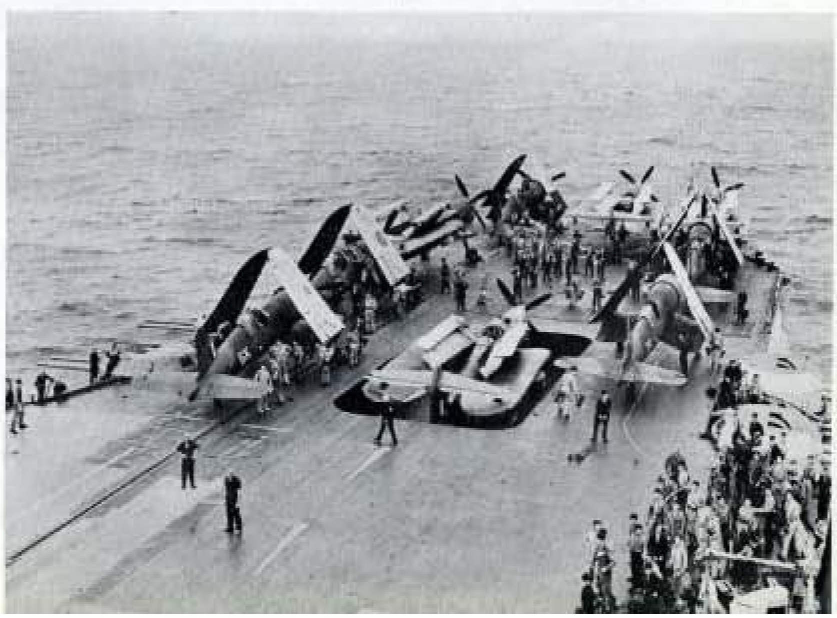


Fig. 343 (Right)—Striking Barracudas and Corsairs down to hangar for maintenance and refuelling, etc., after an attack on Port Blair.

Fig. 344—Aircraft carriers in Eastern waters; this view from the flight deck shows an escort carrier in company.

ranged, that is they will be brought up from the hangar by the lifts and accurately packed at the after end of the flight decl in readiness for the take off. (See Fig. 339.) Engines can now be run up and tested. It is probable that some minor unserviceability will occur; for instance an electric starter may refuse to fenction. If there is time, the 'snags' party change the defective starter for a serviceable one tested by the electrical workshop. (This particular snag can also be overcome in practice by swinging the propeller with a makeshift tackle known as a 'bungee' starter—from the electric rope used in its construction.)

If the ranging parties are unlucky (there is often a thirty to forty knot gale over the flight deck) or careless, an aileron or rudder may be damaged. Depending on the extent of the damage the aircraft will be temporarily patched with dope and fabric or struck down to the hangar where it can be repaired during the time the first strike is away.

After the aircraft have flown off nothing much can be done in the carrier except wait. The crash party and fire parties prepare methodically to deal with any accident during the landing on. Some aircraft may have been partially disabled by enemy action and find difficulty in landing on without further damage. During the interval between one strike and the next, whether it is one hour, four days or even a month, all maintenance personnel and the ships aircraft workshops are devoted to servicing and repairing the aircraft so that once more the maximum number will be available for operations.

Fig. 345 (above)—Under the bombed bastions of the entrance to Grand Harbour, Malta; an escort carrier arrives with her deck loaded with Seafire IIIs. This much published photo is included in commemoration of the epic of Malta.

Fig. 346 (Left)—The aircraft carrier H.M.S. Victorious off Honolulu.

The Fleet Aircraft Maintenance Group

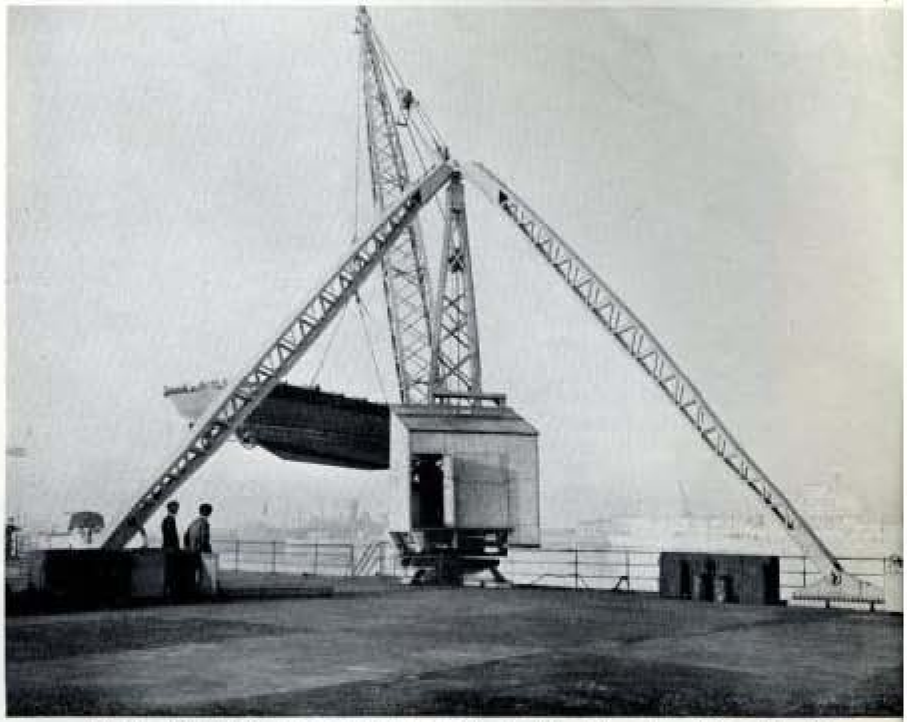


Fig. 347—Aircraft lighters having a flat deck 48 ft. long by 12 ft. wide, and powered by two V8 petrol engines of 30/40 h.p., are used to ferry unserviceable aircraft from the carrier to the Maintenance Ship. When the Maintenance Ship is on the move, the lighters are hoisted aboard and secured in cradles on the 'flight' deck.

IN this section we conclude our story of mobile maintenance and repair facilities by dealing with the functions of the Fleet Aircraft Maintenance Group (F.A.M.G.) the constituent ships of which provide these facilities afloat for carrier borne aircraft in areas such as the Far Eastern zone where strategic conditions make this necessary.

The three types of ships which go to make up the F.A.M.G. are known as Aircraft Maintenance Ships, Component Repair Ships and Engine Repair Ships, a broad outline of their individual responsibilities being as follows:—

1. Aircraft Maintenance Ships

—on which the work undertaken is similar to that carried out in the Airframe Repair Shops (A.R.S.) of a large naval air station and comprises:—

Minor and medium repairs, chiefly by replacement.

Major inspection and modification of aircraft.

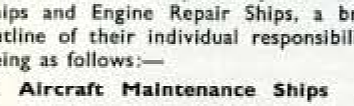
Medium repairs to fuselages.

Minor repairs and rectifications to power plant assemblies.

Functional tests of completed aircraft and their installations such as hydraulic systems, guns, radio sets, etc.

All ground tests other than compass swinging and flight testing.

As aircraft cannot land on or take off from these ships, flight testing is done from shore bases and when pier and road facilities to an air strip are not available the aircraft is transferred by aircraft lighter to an available carrier from which it is flown off to the air strip.



2. Component Repair Ships

The primary function of these ships is to keep the Maintenance Ships supplied with serviceable and tested components. In addition, they hold themselves available for meeting similar requirements in carriers and air stations and for the manufacture of simple modification parts.

The work is equivalent to that carried out by the various shops (other than A.R.S. and E.R.S.) of a naval aircraft maintenance yard and comprises all repair work on components and accessories, particularly those known to be in short supply. Some extent of the field covered will be gathered from the following list of workshops aboard:—

Radar repair and test; metal workers; coppersmiths and welding; woodworkers; fabric workers; propeller; propeller balancing; dope; oxygen and CO_2 bottle charging and test; machine shop; battery and accumulator repair; electrical repair; instrument repair; oleo and hydraulic; main plane control surface and empannage shop.

3. Engine Repair Ships

—undertake work similar to that carried out by the Engine Repair Shop (E.R.S.) of a naval aircraft maintenance yard including:—

Complete overhauls, rectifications and modifications to engines and their accessories, other than work on power plant structures or major salvage work or engine components.

Bench testing of engines after completing.

Storage and preservation of a certain number of serviceable spare engines.

For this work the Engine Repair Ships are equipped with the following shops:—

Engine receipt and unserviceable engine store; engine stripping; engine cleaning; engine viewing; engine accessory; carburettor and petrol test; engine component rectification and assembly; engine final assembly; electrical repair; engine test; test fan erection and stowage; engine despatch and serviceable engine store; woodworkers; metal workers; machine shop; plating; battery charging; oxy-acetylene and electric welding; impregnating shop.

The brief story of the maintenance and repair process is that all unserviceable engines received in the Engine Repair Ships direct from the carriers or from the Maintenance Ships, or possibly a shore service, are taken into the Engine Receipt Store, from whence they go to the Stripping Shop where they are reduced to their component parts which are then taken into the Cleaning Bay for thorough cleaning before visual and magnetic inspection in the Viewing Shop.

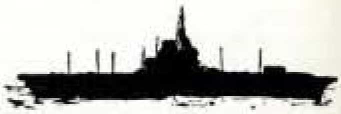
Various components are next dealt with in the Accessory Shops such as the Cylinder Bay, Valve Servicing Bay, Crankshaft Bay, etc., the parts found unserviceable in the Viewing Shop being rectified where possible, or replaced by serviceable components. The components are assembled in the Engine Component Rectification and Assembly Bay and then the engines are built up in two final assembly lines that run either side of the ship, meeting together in the Electrical Repair Shop where, by the ignition system, the engine is completed.

Fig. 348—From this angle one of the lighter cradles on the 'flight' deck is shown more clearly; in this view and in Fig. 347, the new aircraft carrier Implacable will be seen lying at anchor in the background.

Finally the engine goes on to one of the two test benches for its trial runs, after which it is put in a state of preservation internally and externally and either issued as a serviceable engine to the Maintenance Ship or carrier or stored in the Engine Despatch Store

The three types of ships are complementary to each other but to avoid delay in dealing with minor defects small workshops are provided in the Maintenance Ships (see later description). Ships accept unserviceable components and engines from any available source such as M.O.N.A.B.s or stores carriers as well as from the carrier force they are supporting. To facilitate the necessary contacts, the ships of the F.A.M.G. normally operate in close proximity to each other, the control being centralised in a Group Staff Office in one of the ships.

We might mention here that one ship operating with the Fleet is unique in as much that she combines the functions of all three ships and is known as a Naval Aircraft Repair Ship.



A NAVAL AIRCRAFT MAINTENANCE SHIP

Having given a broad outline of the F.A.M.G. activities we now deal in greater detail with one of the latest of the Maintenance Ships which we visited for the purpose of obtaining the following information and photographs.

In general appearance this ship resembles an aircraft carrier, having a 'flight' deck (which however does not function as such as aircraft do not alight on or take off from it) from which a lift connects with the hangar below. On this top deck is

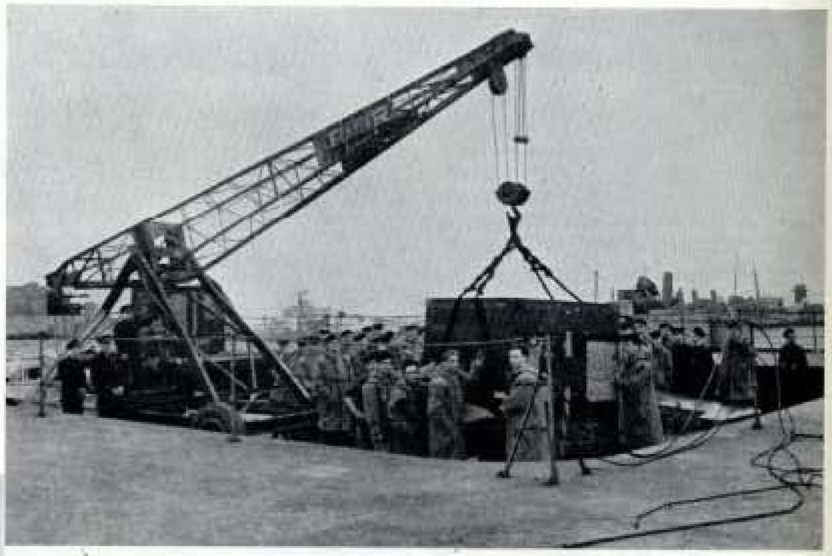


Fig. 349—A view taken on the 'flight' deck showing a mobile crane taking a new crated engine down the lift to the hangar deck.

Fig. 350—Before the Board of Survey make their inspection of the aircraft on the flight deck, the guns are removed together with the wireless, safety and other equipment; here will be seen an Air Mechanic (O) from the Air Ordnance Workshops, removing the .3 Browning turret gun from an Avenger.

Fig. 351 (Right)—In the Air Ordnance Workshops the guns are stripped and cleaned, and any modifications required are carried out; in this view the mechanics are at work on the Avenger turret gun, whilst in the racks are the six .5 Brownings from the main planes of a Corsair.

the 'island' housing the air offices, ground equipment store and recreation space, whilst at the aft end is a building containing the oxygen producing plant and aero engine and power plant stowage.

Surrounding the hangar and extending the full length of the ship are two decks, the first being known as the gallery deck and the second, the hangar deck, this one being at the same floor level as the hangar itself and into which are several entrance doors.

Each of these decks is divided into various compartments, the gallery deck for instance housing the radar and electrical offices and repair shops, the R.U. (ready use) stores, the instrument repair shop, the sparking plug servicing shop, woodworkers shop, dope store and blacksmiths and welders shop. On the hangar deck is located the ground equipment and tool stores, the fabric workers shop, hydraulic and oleo leg shop, dope shop, E.R.S. and fuel pump shop, armament offices and workshops, aircraft offices (maintenance etc.), metal workers shop, machine shop, propeller shop and parachute hanging room.

Fig. 352—A view in the Electrical Repair Shop on the gallery deck, showing an Octopus generator testing machine in use ; on the bench is an Octopus armature drop tester and a bomb release test panel.

Fig. 353—This Battery Charging Room on the gallery deck has 26 panels, with meters, for aircraft batteries (including heavy duty type such as starter batteries) as well as those for use in the motor boats.

The main and lower decks, extending the full width and length of the ship are, in turn, situated below the hangar deck and house the living, sleeping and messing quarters for the maintenance personnel as well as the ship's machinery rooms.

As mentioned earlier, the 'flight' deck is not used for aircraft flying on or taking off, the method used for bringing aboard unserviceable aircraft or despatching serviceable ones being by means of two aircraft lighters, which, when the maintenance ship is on the move, are hoisted aboard and secured in cradles on the 'flight' deck (see Figs. 347 and 348).

These lighters, each having a flat deck 48 ft. long by 12 ft. wide, and powered by two V8 petrol engines of 30/40 h.p., ferry the aircraft to and from its destination, whether it be carrier or shore based maintenance.

The other craft carried by the ship are all diesel engine powered and comprise two 23 knot skimmers (45 h.p. 2-stroke diesels) two fast motor-boats, one motor cutter and one pinnace.

Mobile cranes assist in the rapid movement of stores and equipment to any part of the 'flight' deck or hangar; in Fig. 349 we see one in use taking a new crated engine down the lift to the hangar below.

The Repair Procedure

We now follow the general procedure adopted for the maintenance and repair of aircraft sent to the Maintenance Ship, the first consideration being that such work should be of a character involving not more than 1,000 man-hours to complete.

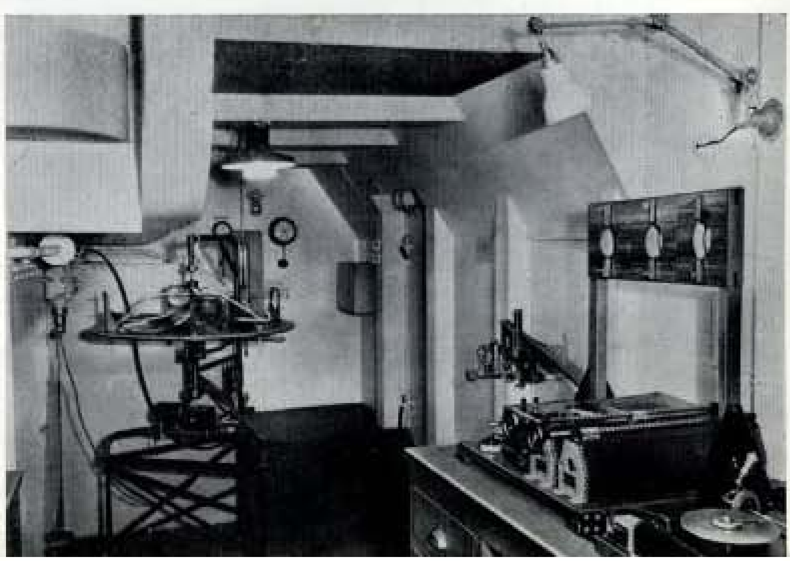


Fig. 354 (Right)—In this temperature controlled Instrument Test Shop will be seen (left) a gyroscope revolving and tilting test table and (right) an electrical engine speed indicator test rig (without indicators). In the right foreground is a corner of a mechanical engine speed indicator test rig.

Fig. 355—The Hydraulic and Oleo Leg Repair Shop is situated on the hangar deck and here we show mechanics at work on oleo components; a Lockheed static hydraulic test rig will be seen on the left.

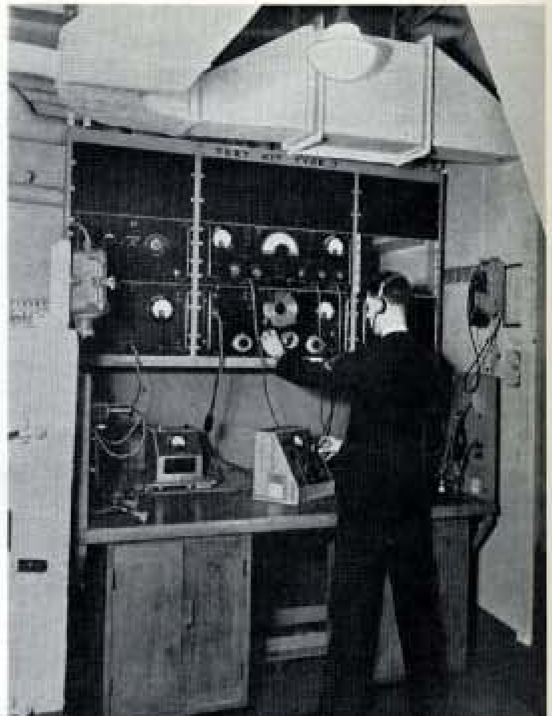


Fig. 356—Artificial aerials being used in the Wireless Test Room and Stores for the calibration of a wireless set on the bench behind the petty officer mechanic.

As soon as an aircraft arrives on board it is in charge of the Receipt and Despatch section until it reaches the hangar. Aftre the R and D has informed all relevant sections, the guns are made safe and bombs and pyrotechnics (if any) removed, the log books are checked, to be followed in turn by the removal of appendix 'A' equipment, i.e. instruments, wireless, safety equipment and the aircraft's armament.

A view of an air mechanic (O) removing the .5 Browning turret gun from an Avenger is given in Fig. 350, and in Fig. 351 we see it in the process of being stripped, cleaned and re-assembled ready for testing in the aircraft from the 'flight' deck when it later returns there from the hangar after repair. The six .5 Brownings in the rack have been removed from the main planes of a Corsair.

Still on the 'flight' deck the aircraft undergoes preliminary inspection to decide whether or not it is worth repairing; if the former, then a Board of Survey follows, to provide a complete assessment of the damage etc., a functional test of the electrical and hydraulic equipment being given and an engine run made if in sufficiently fit condition.

After a detailed inspection to decide what work is to be done in the ship and removal of those components requiring repair in the Component Repair Ship, the aircraft goes below to the hangar where the A.R.S. takes over until the plane returns to the 'flight' deck on completion.

The main hangar has an aircraft space for maintenance and repair, including the dope and propeller shops, and as the work of airframe repairing proceeds, together with the removal of components for repair in the ship's workshops, the aircraft moves progressively along the hangar until it reaches the re-assembly stages.

The Maintenance Ships Workshops

Our remaining illustrations in this section feature some of the workshops on board the Maintenance Ship, the first, Fig. 352, giving a view in the Electrical Repair Shop on the gallery deck where the equipment is stripped, cleaned, defective parts replaced, 'surface' repairs are carried out and general insulation tests given. Here, a generator testing machine is seen in use, whilst on the bench is an armature drop tester and a bomb release test panel.

Two other shops coming under the control of the Electrical Section are illustrated in Figs. 353 and 354. Fig. 353 shows one end of the Battery Charging Room in which are 26 panels with meters for aircraft batteries, including heavy duty starter type, as well as those for use in the motor boats. Two motor generators, driven from the ship's ring main, supply current up to 40 volts D.C.

The second view Fig. 354 is taken in the Instrument Test Room, the gyroscope test equipment on the left being of the same type as illustrated in Fig. 259 ('Repairs and Maintenance at a Naval Aircraft Repair Yard'). In the right foreground can be seen the corner of a mechanical engine speed indicator test rig, next to which is its electrical counterpart, minus indicators which, when on test, would be held in the holes provided in the top panel. On the wall beyond this rig is a pressure

Fig. 357 (Left)—The Aircraft Metal Repair Shop which extends beyond the Propeller Shop on the hangar deck.

THE FLEET AIRCRAFT MAINTENANCE GROUP

Fig. 358—A view in the Smiths and Welders Shop for the aircraft and engine room departments; the two oxy-acetylene and arc welding booths are located at the opposite end.

Fig. 359—These mechanics in the Fabric Workers Shop are at work on canvas lifting strops for stowing aircraft main planes. This shop deals with all aircraft fabric repairs.

gauge tester for large gauges up to 6,000 lbs. per sq. inch. The far bulkhead carries a temperature gauge controlling the amount of outside air passing into the room through the electric heaters.

For our next subject we feature a corner of the Wireless Test Room and Stores (Fig 356) showing artificial aerials being used in connection with the calibration of a wireless set on the bench behind the petty officer mechanic. Most of the fault location is done on this test kit, the stripping and rectification being done on the bench (not shown).

Part of the Hydraulic and Oleo Leg Repair Shop on the hangar deck is depicted in Fig. 355 where all hydraulic equipment including jacks, relief valves, etc., are stripped and repaired by replacement parts and finally tested on the rigs provided; a Lockheed hydraulic static rig will be seen on the left.

The Aircraft Metal Repair Shop Fig. 357 extends beyond the Propeller Shop on the hangar deck and is equipped with guillotine, wheeling and raising machine, bending machine and rolls, metal nibbler, bench drill and the necessary work tables. The repair of damaged trimming tabs for elevators is being carried out on the centre table.

The next illustration Fig. 358 features part of the Smiths and Welders Shop which handles work for both the aircraft and engine room departments. In the foreground is a coppersmith's hearth, with a blacksmith's forge and anvil in the rear. At the opposite end of the shop are two booths housing oxy-acetylene and electric arc welding equipment. The Plumbers Shop containing another blacksmith's hearth and a small pot fire is situated next door.

Our description of repair work on board the Maintenance Ship is brought to a close with a view in Fig. 359 which shows mechanics busy on the sewing machines in the Fabric Workers Shop, putting the finishing touches to the aircraft main plane canvas lifting strops used for stowage purposes. As the name suggests, this shop deals with all aircraft fabric repairs.

Although not necessarily in the fighting zone a Maintenance Ship must have protection from air attack and consequently carries various types of anti-aircraft guns. As a fitting conclusion to this section we reproduce in Fig. 360 an effective 'shot' of one of the multiple batteries on board.

Those of our readers who have followed the story of Engineering in the Royal Navy from the beginning will appreciate that we set ourselves a formidable task in tackling such a comprehensive subject. There is much, of course, that has not been told, but we trust that the field covered has been the means of putting on record, in an interesting and informative manner, some of the activities of the Engineering Branch of the Senior Service, which, before this article was published, had not been given (or sought) a high spot in the public limelight.

Fig. 360 (Left)—As a protection from air attack, this Maintenance Ship carries various types of anti-aircraft guns; here is an effective 'shot' of one of the multiple batteries.

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Glossary of Abbreviations used in this Issue

A.A.	Air Artificer
A.C.R.D.	Aircraft Component Recovery Depot
A.D.D.L.s.	Aerodrome Dummy Deck Landings
Air Mechanics (day to day servicing) and Air Artificers (repairs) trades:—	
(A)	Airframes
(E)	Engines
(L)	Electrical
(O)	Ordnance
A.R.S.	Airframe Repair Shop (or Section)
C.P.O.	Chief Petty Officer
D.I.	Daily Inspection (of aircraft)
D.R. Compass	Distant Reading Gyro-magnetic Compass
E.A.	Electrical Artificer
E.A.R.S.	Engine Accessory Repair Section (of E.R.S.)
E.A.S.	Electrical Assembly Section
E.I.P.	Engine Installation Party
E.R.A.	Engine Room Artificer
E.R.A. (B.M.)	Engine Room Artificer (Boilermaker)
E.R.A. (C.S.)	Engine Room Artificer (Coppersmith)
E.R.A. (E.S.)	Engine Room Artificer (Enginesmith)
E.R.A. (F. & T.)	Engine Room Artificer (Fitter & Turner)
E.R.S.	Engine Repair Shop (or Section)
F.A.M.G.	Fleet Aircraft Maintenance Group
I.C.E.	Internal Combustion Engine
Lieutenant (E)	An Engineer Officer (applies to all Commissioned Ranks)
L.R.S.	Electrical Repair Shop
M.A.R. Component	Mobile Air Radio Maintenance Unit (M.O.N.A.B.)
M.M. Component	Mobile Maintenance (M.O.N.A.B.)
M.N.A.O.	Mobile Naval Airfield Organisation
M.O.N.A.B.	Mobile Operational Naval Air Base
M.P. Component	Mobile Personnel (M.O.N.A.B.)
M.R. Component	Mobile Repair (M.O.N.A.B.)
M.S. Component	Mobile Servicing (M.O.N.A.B.)
M.S.M. Pack up	Mobile Servicing and Maintenance (M.O.N.A.B.)
M.S.R. Component	Mobile Storage Reserve (M.O.N.A.B.)
M.U.	Maintenance Unit
O.A.	Ordnance Artificer
P.O.A.M.	Petty Officer Air Mechanic
P/P	Power Plant
Q.S. School	'Qualify to Sign' School (for Aircraft Servicing Form A700)
R.N.A.T.E.	Royal Naval Artificer Training Establishment
R.U. Stores	Ready Use Stores
S.A.M.	School of Aircraft Maintenance
S.S.U.	Squadron Servicing Unit
S.T.E.	Stoker Training Establishment
T.A.M.Y.	Transportable Air Maintenance Yard
T.A.P.S.	Training Aids Production Section
V.S.C. Unit	Variation Setting Corrector (D.R. Compass)

Engineering in the Royal Navy as a Career

NOW that the Reader has completed this survey of the engineering activities of the Royal Navy, he may wish to know of the standards required and the procedure to be adopted in order to join.

The categories available to anyone so inclined are as follows:—

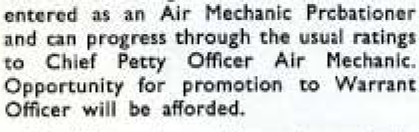
(a) Stoker or Air Mechanic,
(b) Artificer, or
(c) Cadet.

The introduction of conscription has of course greatly affected the entry into the Navy of young men over the age of 18, and for this reason very brief details are given for Stoker, Air Mechanic and Direct Entry Artificers. Conditions and methods of entry for Artificer Apprentices and Cadets are given in greater detail.

(1) **Stoker:** Normal age of entry for Stokers is from 17½—23 years and no previous experience is required. The prospect of advancements for Stokers is shown on page 15 of this issue.

(2) **Air Mechanics:** Candidates must be between the ages of 17½ and 23 and will be required to pass an educational examination consisting of simple arithmetic, dictation and reading. The Air Mechanic is entered as an Air Mechanic Probationer and can progress through the usual ratings to Chief Petty Officer Air Mechanic. Opportunity for promotion to Warrant Officer will be afforded.

Candidates who qualify undergo a technical course in the maintenance of aero engines, air frames, armament and electrical equipment.



(3) **The Direct Entry Artificer:** Candidates will be accepted between the ages of 19½ and 28 and are expected to be well trained in their trade. In addition, they will be required to take an educational examination in English and Arithmetic, to answer questions on their trade and to complete a test job before being accepted. They will be entered as Artificers 5th Class if under the age of 21, and as Acting 4th Class Artificers if above that age.

Entry as Stoker, Air Mechanic or Direct Entry Artificer is effected by direct application to the nearest Recruiting Office.

All candidates must pass a medical examination, including eyesight tests, and must be of British Nationality. All recruits are required to be of very good character and must supply references.

(4) **Artificer Apprentices:** Candidates are entered under the following systems:—

(a) *Spring Examination—Entry by Open Competition*

Candidates must be not less than 15 years of age on the 1st May following the date of the examination and must not have attained their 16th birthday on the 1st May.

An open competitive examination is normally held during the Spring of each year (for entry in the August following), and is conducted by the Civil Service Commissioners at the same time and in the same manner as the examination for Dockyard Apprentices. Prospective candidates should apply to the Secretary, Civil Service Commission, Burlington Gardens, London, W.1, for application forms which must be returned between the 15th November and 15th January preceding the Examination. The Examination usually takes place in London, Leeds, Edinburgh, Glasgow, Belfast, Cardiff, Ipswich, Portsmouth, Devonport, Chatham, Pembroke, Sheerness, Chester, Durham, Lancaster and Salisbury. A fee of 5s. will be required from each candidate attending the examination or 7s. 6d. if the candidate wishes to compete also for a Dockyard Apprenticeship.

The subjects of examination are Arithmetic, Mathematics, English, History, Geography and Science.

Specimens of the question papers set at examinations when available, may be obtained either directly or through any bookseller, from H.M. Stationery Office.

(b) *Autumn Examination*

For this examination the age limits are as follows:—

Candidates must be between the ages of 15 and 16 years on the 1st January following the date of the examination.

Boys who wish to compete at the Autumn examination should apply for recommendation to one of the following authorities:—

(i) Local Education Authorities in Great Britain and Northern Ireland.
(ii) Advisory Committees for Juvenile Employment under the Ministry of Labour.
(iii) The Governing Body of a Secondary School not provided by the Local Education Authority, but recognised by the Ministry of Education, (including Northern Ireland) or Scottish Education Department.
(iv) The Superintendent, Royal Hospital School, Holbrook.
(v) The Superintendents of the Training Ships *Arethusa*, *Exmouth*, *Indefatigable*, *Mercury* and of the Lancashire and National Sea Training Home and Watts' Naval Training School.
(vi) Boys who are not entitled to a recommendation from one of the above authorities may be allowed to take the examination at the discretion of the Admiralty.

Candidates are expected to have educational attainments at least equal to those boys who enter by open competition. They should have spent at east one year in a School providing education of a Secondary or Higher Grade Elementary type; but if in any case the recommending Authority is fully satisfied that the Candidate, although he may not satisfy the above condition, has the necessary educational attainments as a result of attendance at an Evening Continuation School offering higher instrurtion, or otherwise, special application may be made to the Admiralty for this condition to be waived.

Recommendations should be made on the appropriate form, which will be supplied only to the Authority concerned, on application to the Secretary of the Admiralty, London, S.W.1, and must be forwarded so as to reach the Admiralty not later than 1st October.

The examination will be held locally on the third Tuesday in October each year. The examination papers, which will be set by the Admiralty, will be the same for all candidates and will be supplied to the Education Authority, Governing Body or Superintendent of the School or Establishment by whom all arrangements for holding the examination will be made.

The examination will be completed in one day and will consist of two papers:—

(*a*) Practical Mathematics (to be taken in the morning) and (*b*) Elementary Science (to be taken in the afternoon). The standard of the papers is similar to that required for the Spring Examination.

Candidates successful at Spring and Autumn will be required to pass a medical examination as soon as possible. Medical standard requires that candidates should be in good health and free from any disease or serious defect of vision or hearing. The standard of height and chest measurement has been fixed at, Height 5 ft. 1 in., Chest 31 ins.

Successful candidates are allowed to state the order in which they prefer the Engine-room, Electrical, Ordnance and Air Branches. So far as possible they will be entered according to the order of their preference. No guarantee can be given, however, that this will always be possible.

The Apprentices' life in the Navy and prospects of promotion are shown on page 16 of this issue.

Applications for entry should be addressed to: The Recruiting Staff Officer, Royal Navy and Royal Marines:—

London: 28 Charing Cross Road, London, W.C.2.
Birmingham: Crown Buildings, James Watt Street, Birmingham.
Bristol: 121 Victoria Street, Bristol 1.
Derby: 96 Green Lane, Derby.
Glasgow: 300 Bath Street, Glasgow.
Liverpool: 7 St. John's Lane, Liverpool, 1.
Manchester: Lloyd's House, Albert Square, Manchester, 2.
Newcastle-on-Tyne: 184 Westmorland Road, Newcastle-on-Tyne.
Southampton: 6 Orchard Place, Queen's Park, Southampton.
or to The Director of Naval Recruiting, Admiralty, S.W.1; or to the nearest Combined Recruiting Centre, the address of which can be obtained from any Ministry of Labour Employment Exchange.

(5) Cadets:

Entry into the Royal Navy as a commissioned officer is possible in two ways, first by entry as a Cadet into the Royal Naval College Dartmouth at about 13 years of age, or later as a Special Entry Cadet at the approximate age of 18 years.

Candidates for joining Dartmouth must reach the necessary educational standard and be interviewed by a Committee appointed for that purpose.

The educational test undertaken by candidates is the 'Common Examination for Entrance to Public Schools and the Royal Naval College'. This examination will begin on the fourth Monday in February, the third Monday in June and the Second Monday in November. The fee for the examination will be £2 10s. which will be payable in advance on demand to the Director of Navy Accounts, Admiralty, S.W.1. Candidates must offer the following subjects at the educational examination:

English, History, Geography, Latin or Science, Mathematics and French.

Medical standard requires that candidates should be in good health and free from any disease or serious defect of vision or hearing.

The College terms begin approximately on the 16th January, 6th May, and 22nd September. Candidates must take the Common Entrance Examination immediately preceding the term of entry. Candidates for entry in—

(*a*) January—must be more than 13 years and 4 months, but not more than 13 years and 8 months of age on the preceding 1st December.

(*b*) May—must be more than 13 years and 4 months, but not more than 13 years and 8 months of age on the preceding 1st April.

(*c*) September—must be more than 13 years and 4 months, but not more than 13 years and 8 months of age on the preceding 1st August.

Candidates must be British subjects and are allowed only one attempt to enter the R.N. College.

A nomination is not required by a candidate for a Naval Cadetship. All that is necessary is to apply to the Secretary of the Admiralty, (C.W. Branch). Applications should not be made until the Candidate has reached 12½ years of age.

Ten Cadet Scholarships to the College will be offered for competition at each entry to Candidates from grant-aided Secondary Schools—that is to say, thirty scholarships a year. In addition, further scholarships to a number of not more than 10 at each entry will be given to boys not coming from grant-aided Secondary Schools who show themselves to be equal or superior in ability to the boys who have been given Scholarships from the grant-aided Secondary Schools.

On leaving Dartmouth, cadets make their choice of Executive, Engineering and Supply and Secretariat Branches and join up with the Special Entry Cadets.

(6) Special Entry Cadets:

An examination for appointments to Naval Cadetships (Special Entry) is held by the Civil Service Commission three times a year, in January, May and October. The examinations at which candidates may compete, subject to their satisfying the necessary conditions as to age, etc., are for appointments as Naval Cadets (Executive), Naval Cadets (Engineering), Naval Cadets (Supply and Secretariat Branch) and Cadets in the Royal Indian Navy (subject to vacancies). At the May and October examinations candidates may compete also for First Appointments in the Royal Marines. The number of Cadetships offered for competition under the special entry scheme is notified in the Press from time to time, or may be ascertained on application to the Secretary of the Admiralty (C.W. Branch).

Applicants, before being admitted to the examination, must satisfy the Civil Service Commissioners that they are eligible in respect of character and record, and must produce a School Certificate or equivalent, or have passed the Matriculation Examination of the London University or any other examination which, in the opinion of the Civil Service Commissioners, is of equivalent or higher standard.

In order to be eligible for examination as a Cadet (Special Entry) a candidate must have attained the age of 17 and must not have attained the age of 18 years on the undermentioned date:—

For the January exam., 1st May following.
For the May exam., 1st September following.
For the October exam., 1st Jany. following.

Subjects for examination are:—

(1) English	Compulsory
(2) Lower Mathematics	Compulsory
(3) Physics plus Chemistry	Compulsory for Executive and Engineering
(4) Latin	Two subjects only to be chosen from this group.
(5) French	
(6) German	
(7) Modern History	
(8) Higher Mathematics	

A laboratory training is essential for Physics plus Chemistry.

Due notice of each examination will be given in the Press and to all applicants. Every candidate must obtain the application form for admission to the examinations from the Secretary, Civil Service Commission, Burlington Gardens, London, W.1. The written examinations are held at various centres, a list of which may be obtained from the same source. The fee for the written examination is £6.

As part of the scheme of examination, those candidates who qualify at the written examination will be required, irrespective of whether or not they have competed at a previous examination, to present themselves for interview before a Committee.

Candidates successful at the examinations will be required to pass a medical examination as soon as possible. Medical standard requires that candidates should be in good health and free from any disease or serious defect of vision or hearing.

An article dealing with the training of Engineer Officers from the Cadet stage will be found on pages 45 to 56 of this issue.

By entering as an Engineering Cadet, a boy has a very good prospect of becoming a Commander and can rise to the rank of Vice-Admiral.

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MARINE AND AERONAUTICAL ENGINEERING IN THE ROYAL NAVY