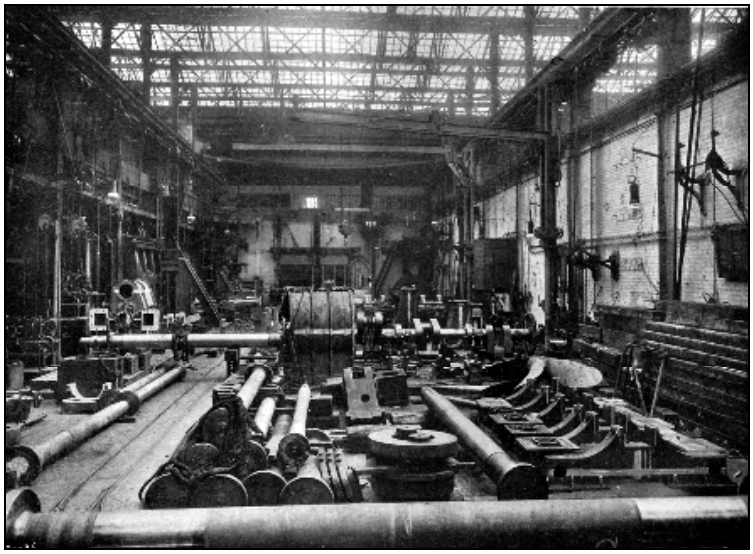
The Engine and Boiler Works

Rapidity of construction has been characteristic of the engine and boiler works of the Scotts to at least as great an extent as in the shipbuilding yard. Several instances might be noted, beginning with six blockade-runners, built in a very short period, in 1864, and fitted with engines to give a speed of 12 knots at sea and 13.5 knots on trial. A recent and striking instance is the construction of boilers and engines for twenty of the passenger steamers built for traffic on the Thames, to the order of the London County Council, and described on pages 83 and 84, ante. The contract for this work was signed towards the end of November, 1904, and work was commenced about the beginning of December. The various parts of the engines were being machined and finished during the month of January and the beginning of February, 1905; and all of the twenty sets of engines and boilers were completed by the end of May. Another noteworthy case is the construction of the machinery for the steamship Fengtien, described on page 80, ante. Work was commenced on the machinery in the middle of January, and finished about the end of April. The machinery was fitted in the ship and ready for the trials on the 29th May. The total time taken from the beginning of work was well under five months. The pattern shop, where all work originates, is fitted with the usual pattern-making machinery, including a core-making machine.

The iron foundry, which was begun in 1790, and around which the large engineering establishment has since been raised step by step, continues to do sound work. There are four cupolas, of a combined capacity of about 20 tons, and cylinders up to 120 in. in diameter are cast. These facts suggest the satisfactory character of the equipment.

The brass foundry is an equally important department, where first-class work is done. There are fifty-two crucible pots in use, varying in size up to 150 lb., and of a collective capacity of about 2 tons; also an air furnace capable of producing at one heat 12 tons of metal, for such heavy castings as are required for preparing shaft liners, large sea chests for naval ships, etc. The strength of Admiralty gun metal made in this foundry is up to 18 tons per square inch, with 30 per cent, of elongation in a 2-in. length. The foundry is served by an electrically-operated jib crane.

In the forge and smiths' shops a large amount of detail work is done, in units ranging up to 3 tons in weight. The hammers vary up to 15 cwt, power. A considerable amount of die-stamping is done in connection with auxiliary engine forgings, etc. All paddle-wheels are made in this department. The blast for the fires is got from an electrically-driven fan.



View in the Main Machine Shop

The machine shop, which was one of the first constructed with a completely glazed roof, occupies a site on a steep slope, one side being formed by a heavy retaining wall, as shown above. At the level of the top of the wall, which is 25 ft. high, there is the light machine shop, while at the end of the bay and over the annexe situated to the left of the engraving, is the brass-finishing shop. There is a 2-ton hoist between the erecting-shop floor and the galleries, so that no inconvenience, so far as transport is concerned, is involved by this arrangement.

Originally a stream ran down the hill and over the site on which the Works are located, and its waters have for many years been utilised as a source of power. A special 24-in. inward-flow turbine works in the conduit which conveys the water across the site, and this turbine develops continuously 80 horse-power. This serves to drive some of the machines in the boiler works. The turbine runs in parallel with a compound vertical engine, which drives the shafts actuating the groups of small machines in the engine shop. Many of the larger tools, however, are electrically-driven by separate motors, the current being transmitted from the central station already described.

The main machine shop, which has a width of 60 ft., and, with the adjoining bay, accommodates some of the finest marine engineering tools made. Perhaps the best indication of their efficiency is the fact that three weeks suffice for the machining of the parts of a complete set of engines to develop 2000 horse-power. The shops are traversed by five overhead electric cranes, ranging up to 40 tons lifting capacity.

The leading dimensions and the principal work done by the more important tools afford an idea of the extent of the equipment. There are several planing and slotting machines, one of which is shown in the engraving on Plate L., facing this page. There are two combined machines, to plane 21 ft. and to slot 18 ft., used in connection with the condensers, cylinders, large bearing frames and sole-plates of engines, while two other smaller tools are devoted to finishing the castings for bed-plates and columns. For machining eccentric-rod ends, etc., there is a 24-in. slotter with a circular table. There are two high-speed planers with two tool-boxes on the cross-slide, which take in pieces 10 ft. by 5 ft. by 5 ft., and one to take work 12 ft. by 3 ft. by 3 ft.

In the driving of some of the heavier tools very good results have been attained by the application of a reversible motor, which in one case has dispensed with four belts, a pair of bevel wheels, and two countershafts, reducing enormously the frictional waste, and enabling higher speeds and quicker return strokes to be attained.1

For drilling work there are several large tools. Recently there has just been fitted a multiple machine which, while primarily intended for drilling the tube-holes in drums and water-pockets of Yarrow water-tube boilers, is also utilised in connection with ordinary machine work. This tool was manufactured by Messrs. Campbells and Hunter, Limited, Leeds. It has a massive cross-slide carrying four saddles, movable by a powerful screw, driven by spur-gearing and friction-clutch, controlled from one of the saddles. The steel spindles are balanced, and have a special self-acting, variable, rack-feed motion, as well as a quick vertical motion by hand for rapidly adjusting the drill through the jig. Each spindle can be operated independently. The table has a sliding motion, directed by two straight screws coupled to the cross shaft and vertical shaft, and is carried by a straight bed with three bearing surfaces. This machine, which weighs 20 tons, is driven by a 30 brake-horse-power electric motor.

There are two vertical boring mills used for cylinder work, one being capable of boring up to 120 in. in diameter, and the other to 94 in. in diameter. A combined boring and facing machine, with a table 4 ft. square, is usefully employed on propeller bosses, valve-chests, small cylinders, and built-up bed-plates, machine bearings, etc.

The installation of high-speed lathes is especially noteworthy. In one, the face-plate can take in 12ft. in diameter, and, as the length of bed is 30 ft.; it is useful for large surfacing work, as well as for turning crankshafts of the larger sizes. There are two 12-in. double-geared lathes for surfacing and screw cutting. These are self-acting, and the lengths of bed are 19 ft. and 12 ft. respectively. For turning piston and connecting rods, two screw-cutting lathes of 16.25-in. centres are in use, the length of the bed being 22.5 ft. These have each a triple-gear headstock, and a chuck 48 in. in diameter; with rack motion and slide-rest feeds. A 20-in. centre lathe, with a bed 28 ft. 6 in. long, is fitted with two saddles and four slide-rests for shaft liners, etc. Amongst others, there is a 27-in. centre lathe for shafting, the bed being 36 ft. long.

An example of the lathes is a 48-in. surfacing and boring lathe, by Messrs. John Lang and Sons, Limited, Johnstone. The two new features introduced are the variable speed drive and automatic speed-changing mechanism. The headstocks can be used for single or triple gear, and are so arranged that, even when running at the greatest speed, there is a reduction by gearing. With this arrangement the lathes have greater power when turning small diameters than when the belt is used driving direct to the main spindle. The spindles, which are hollow, with hexagonal turrets, are of crucible cast steel, and run in gun-metal bearings. By means of the speed-changing mechanism, the cutting speed of the tool is kept practically constant when surfacing. This means that any surface can be finished off in about one-half of the time taken by a lathe having the ordinary step-cone drive, where the workman will not change the position of the belt while surfacing. The self-acting feed-motions are positive.

Milling is adopted in many instances in preference to planing or slotting, and this is especially so in connection with valve quadrants, columns, faces, etc. For the first-named there is a large vertical miller, and for the latter a horizontal tool with a vertical milling apparatus. For grinding bolts, etc., a machine having a separate head for grinding taps is used, the emery wheel being 18 in. in diameter and 1.5 in. broad.

A shop, now in course of construction, is to be specially laid out for the manufacture of turbine machinery of the greatest power. It is to be 285 ft. long, with a span of 60 ft. Heavy lifts will be taken by a 100-ton overhead crane, and ordinary work will be handled by a 40-ton electric crane. The heavy machine tools, while specially chosen for turbine work, are also adaptable for use in the manufacture of the heaviest reciprocating machinery. The principal tools are large lathes suitable for turbine rotors and crank-shafts; vertical boring machines which may be utilised for work on cylinders as well as on turbine casings; and a heavy planer, 10 ft. by 10 ft. by 25 ft. stroke. The necessary small machine tools for turbine work will be put down in this department, whence also some of the large tools will be removed from the existing shops, so that it will be fully equipped for the purpose intended.

Brass Finishing Shop

The brass-finishing shop, which is illustrated above, serves both for ship and engine work. It has only recently been laid out anew. The machines, according to the latest practice, are arranged down each side of the shop, and the benches occupy the centre. Each alternate bench is utilised for the material to be operated upon, so that the working bench is not littered in a confused way, as is too often the case. There are representative types of the best makes of automatic tools, turret lathes, brass - finishers' lathes, and grinding machines with especially large discs.

Tool, Gauge, Template and Jig Department

A considerable amount of work is done to limit gauge in all the shops which we have described. This practice has been considerably developed recently, and a specially equipped department has been organised, where gauges, templates, and cutting tools are made. This department is illustrated above. A word may first be said as to the significance of this new department. Where three or four ships have engines of the same type, a set of jigs and templates for the most important parts are at once made, so that a unit from an engine in one ship may be fitted to an engine in another. This simplifies the ordering of new parts, and greatly reduces the number of spare items which have to be kept in store by the owners, in order that repairs or refits may be effected at short notice.

For some time the Scotts have adopted this system, so that it was a simple matter to enforce it in connection with the machinery of the twenty Thames Steamers, and in recent naval work, where the practice is being applied in an extended form. In the recent Admiralty work every part of an engine is made interchangeable and identical with the corresponding parts of other engines for the same type of ship, although built in different parts of the country; and this fact alone will indicate the extent and intricacy as well as the care and degree of accuracy necessary. This standardisation to ensure interchangeability has reached its highest exemplification in the case of the machinery for the armoured cruiser Defence, of 27,000 indicated horsepower, to be completed in twenty-one months from the placing of the order by the Admiralty.

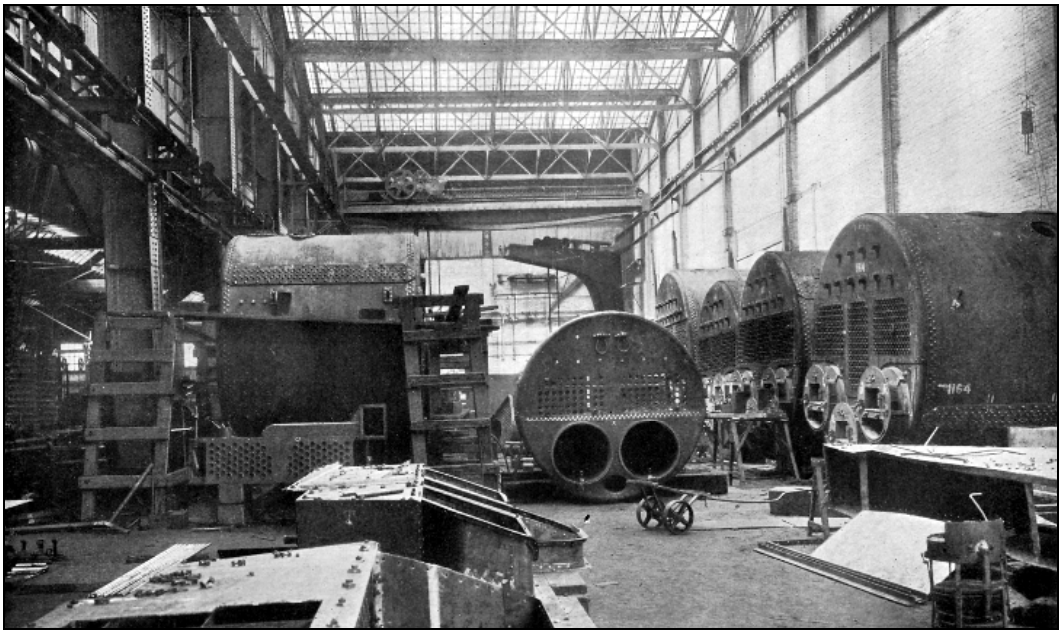
Then, as regards the tool-making and fettling—the other branch of work carried out in the tool room—it has been recognised that, to make the cutting tools efficient, it is necessary to utilise the most suitable steel for the tools working on various metals and alloys; and the selection of the tool steel for each metal has been systematised by the careful collation of data of actual work. In the manufacture of the tools special appliances are used and will be referred to presently. The workmen are encouraged to use only tools in sound condition. Each machine-man in the shops has ten checks, and may borrow from the store a corresponding number of tools, but these must be returned as soon as possible for overhaul and re-grinding. The bonus system further induces the men to ensure that their tools are in good condition.

The tool department is separate from the main structure, and in it all jigs, templates, and gauges, as well as tools, are constructed. Standard gauges, as well as limit gauges, are used, and both are marked in metrical and English dimensions. The tool room is not only carefully maintained at a regular temperature, in order to prevent the templates and jigs from varying in the course of their manufacture, but the appliances adopted have been selected so as to get the most precise results. In connection with the manufacture of large boiler taps, drill gauges, milling cutters, etc., a specially designed gas furnace has been built, with a number of compartments which can be used separately or collectively, according to the size of the tool being made. The tool-smith's forge is on the down-draught principle, so that, in addition to carrying off all smoke and dust, it tends to keep the atmosphere pure.

Amongst the principal machines used in this tool-manufacturing department is an 8-in. Whitworth self-acting, sliding-surfacing, and screw-cutting lathe, with a backing-off and taper-turning attachment. The milling, drilling, and grinding machines are all by the best makers. A 10-ffc. machine is used for making the comparative measurements from existing standards. This machine, also of Whitworth make, has a measuring screw in a fast headstock with a large dividing wheel, one division of the latter representing 0.0001-in. in the end movement of the spindle. All transverse and tensile testing of bars is done in this department.

A check system is used in connection with the distribution of templates, tools, drawings, etc., and a separate store in the centre of the works is arranged for this purpose. As to the boiler works, the fact that in 1905 the production was practically one boiler per week is, of itself, testimony to the nature of the plant adopted. The main boiler shop, together with its yard, has an area of 7000 square yards, and a height of 45 ft. to the crane rail, and is served by five overhead electric cranes, ranging in lifting power up to 100 tons, with numerous jib and other cranes associated with the various machine tools.

The machine tools fitted in the boiler works are all of a very powerful character; but only a few of these need here be referred to. There is a 13-ft. gap hydraulic plate-bending machine, which is entirely automatic in its action, and can be set to any radius to bend plates up to 2 in. thick when cold. The flanging for the front and back plates of boilers is done in an hydraulic machine, exerting a pressure of over 160 tons. This machine has four rams, two of which act downwards, one upwards, and the other horizontally. It is served by a special hydraulic jib-crane, capable of lifting the heaviest plates. There are also plate-edge planers and triple boring mills of corresponding power, while the vertical rolls take in plates up to 10-ft. wide.



The Boiler Shop

For the riveting of the boilers there is a 13-ft. gap hydraulic riveting machine, capable of exerting a load on each rivet of 200 tons. The weight of this riveting machine alone is about 60 tons, and it is served by an independent hydraulic jib-crane. All the valves in connection with the crane and riveter are led to a common platform, so that one man is able to manipulate the whole of the work.
There is also a large installation of special plant for the manufacture of water-tube boilers, but it is scarcely necessary to describe this in detail.

A large part of the boiler work, especially for warships, is galvanised, and a special department has been organised for this purpose. The tubes, in the first place, are thoroughly cleaned, then placed in a zinc bath, and coated by electrolysis to the desired extent; the object being to expose defects, as well as to protect the tubes from corrosion during manufacture. The amount of work done is, perhaps, the best indication of the equipment of this department, as well as of the water-tube department; and this will be realised when it is stated that over 24,000 tubes are required for the boilers of one cruiser, and that six months suffices for their construction.

It would be possible to give other indications of the splendid equipment of the Works, but enough has been said to show that there is directed towards the realisation of the best work in all departments — firstly, the advantages of accumulated experience, carefully collated throughout two hundred years; secondly, the benefits which the psychologists claim for hereditary influence—applicable here not only through the proprietors, but also through many of the workmen; and, thirdly, a sound progressive spirit, which recognises the necessity for continual improvement in administration and design, and in machine tools and methods of manufacture.