British Marine Engine History in Meccano

VI.—Modern Heavy Oil Engines

As shown in last month's *"Meccano Magazine,"* turbines have largely replaced reciprocating engines as the means of propelling ships. A serious competitor to both types of steam engines has now made its appearance, for recent years have seen the introduction and development of an entirely new type of marine motive power. This is the heavy oil engine, the pioneer of which was Dr. Rudolf Diesel, an engineer who was born in Paris and trained at the Munich Polytechnic. Early in his career Diesel was impressed by the low efficiency of the steam engine, and after experiments with an engine employing coal dust as fuel he took out in 1892 a patent for an engine utilising crude oil. Three years later he produced his first successful engine. Improvements followed rapidly, the original engine being greatly modified, and the Diesel engine in its various forms eventually became a formidable competitor of the steam turbine and reciprocating engine. Diesel disappeared at sea in 1913 while on a voyage to England, and his mysterious death prevented him from seeing the triumph of the heavy oil engine.

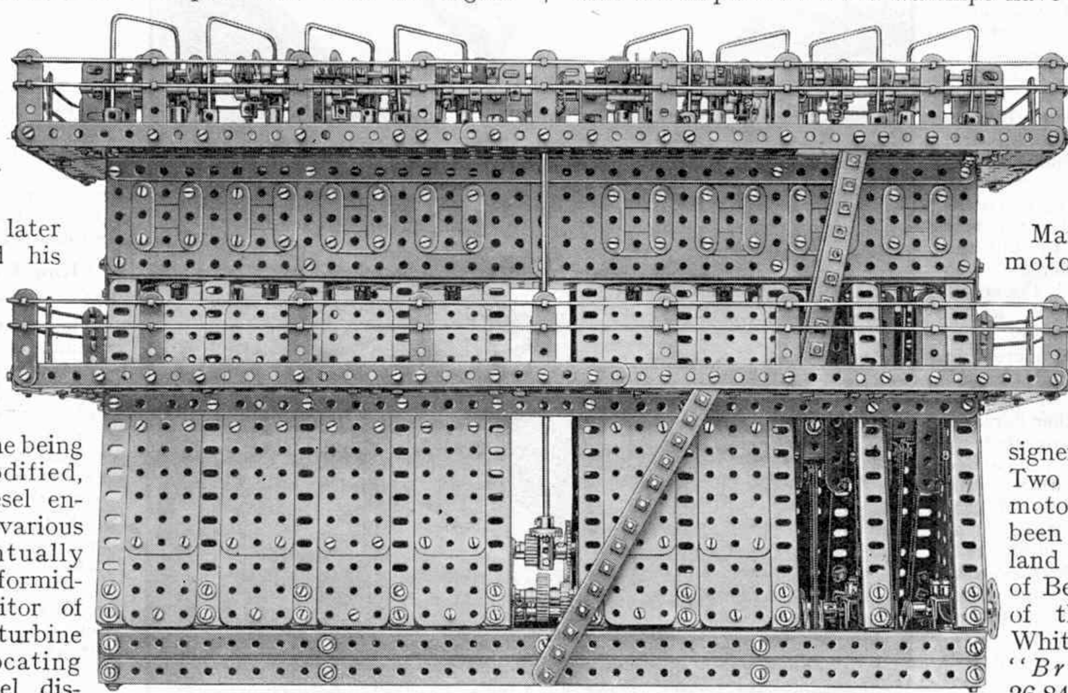

Fig. 1. A fine model of an M.A.N. eight cylinder, airless injection, heavy oil engine.

Early marine engines of the internal combustion type used different types of fuels, but it was soon realised that for general use the residue from refined petrol was the most advantageous. The fuel is now generally known as crude oil, and engines using it differ in many respects from internal combustion engines employing petrol. The chief difference is that the mixture injected into the cylinders is not ignited by means of an electric spark; instead its temperature is raised to ignition point by the heat developed during the compression stroke. The absence of an ignition system is one of the chief reasons for the popularity of the heavy oil engine and in addition the possibilities of fire are reduced to a minimum, since in normal circumstances, the fuel used is not inflammable.

Although the installation of a heavy oil engine in a ship is usually more costly than that of a steam engine, whether of the turbine or reciprocating type, the extra initial outlay is more than recovered in savings on running costs, for smaller engine room staffs are required, and other expenses are reduced. In addition less space has to be allotted to the fuel than would be needed in a steamship for coal or oil fuel, and a motor vessel therefore can be given a remarkably large cruising radius. This is of special value in the case of warships. Many remarkable voyages have been made of recent years by the German vessels, the light cruiser *"Karlsruhe,"* and the pocket battleship, *"Deutschland,"* both motor vessels, and the impression these warships have made is being shown by the interest taken in their performances in many maritime countries.

Many remarkable motor ships for mercantile purposes also have given great satisfaction to the designers and owners. Two famous British motor vessels have been built by Harland and Wolff Ltd. of Belfast. The first of these was the White Star liner, *"Britannic,"* of 26,840 tons, the construction of which was closely followed by that of her sister ship, the 27,759 ton *"Georgic."* Both vessels have been running for several years on the regular trans-Atlantic service and also on pleasure cruises. They are exceptionally good sea boats, and have shown marked efficiency.

Heavy oil engines for ocean-going vessels have been developed so rapidly that it is difficult to follow the stages through which they have passed. The tendency has been in the direction of six or more cylinders, as many as 10 or 12 being commonly used for large vessels in which freedom from vibration is of major importance. A fine Meccano model of a multi-cylinder crude oil engine is illustrated in Figs. 1 and 2. This model is a scale reproduction of an M.A.N. eight cylinder airless injection, four stroke cycle engine, developing over 3,000 B.H.P. In an engine of this type the fuel from the main tanks is injected into the cylinders by means of a force pump. It passes through fine nozzles, and as it enters the cylinders is mixed with air passed through a separate valve and compressed by the piston until it reaches a high temperature. This is not in accordance with general crude oil engine practice, the usual method being to force the fuel into the cylinder by compressed air. In the model the pipes taking the fuel from the control valves to the cylinder heads are seen above the valve gear.

The base of the model is constructed from 18½" Angle Girders and 4½" Angle Girders, Flat Girders being used as shown in order to give depth to the base. At the point where the long Girders forming the sides of the base are secured to the shorter Girders representing the ends, 1" Corner Brackets are used for strengthening purposes. At intervals of 2½" eight pairs of 4½" Angle Girders are fitted to carry the main crankshaft bearings.

As shown in Fig. 1, each bearing is represented by two 1½" Flat Girders and two Angle Girders of similar length, the Angle Girders being fitted with ½"×½" Angle Brackets and Collars in order to give the effect of a plumber block. The construction of the crankshaft is similar throughout its entire length to the portion shown in Fig. 1, the two side plates of the engine at this point being removed in order to show the internal construction. The space between the two centre bearings of the engine is fitted with a 1" Gear that meshes with a similar gear carried on a 2" Rod and journalled in two 1½" Flat Girders. The Rod carrying this second 1" Gear also supports a ¾" Pinion that is in engagement with a 50-teeth Gear mounted on a Rod and carried in bearings as shown. A second ¾" Pinion, driven by the 50-teeth Gear, drives a long vertical Rod that will be described later.

At similar intervals to those between the crankshaft bearings, 1"×1" Angle Brackets are fitted to the base at each side, and these support the main standards supporting the cylinder block. Each standard is composed of two 7½" Angle Girders fitted with a 4½"×2½" Flat Plate. This Plate carries two 4½" Angle Girders to form a channel in which slides one side of the corresponding crosshead, a Channel Bearing, and the standards must be secured rigidly to the 1"×1" Angle Brackets already mentioned, since they are unsupported at their upper ends. Each of the end pairs of standards is fitted with a 2½" Flat Girder by means of which the cylinder block is held in place.

The cylinder block is composed of a number of 5½"×2½" and 2½"×2½" Flat Plates that are held in place on a framework of 18½" and 2½" Angle Girders. The top of the cylinder block is not fitted until the valve gear is to be attached. The underside of this part of the model is fitted with eight Bush Wheels representing the bottom ends of the cylinders. Each of these forms a bearing for a piston rod, a 3½" Rod, and this is secured to its crosshead by means of a Coupling, the underside of the crosshead being secured to the connecting rod by a ⅜" Bolt, and two ½"×½" Angle Brackets. The lower end of the connecting rod is carried on a ¾" Bolt forming the connection between the two crank webs. Great care must be exercised in "lining up" the various bearings, especially the crankshaft bearings, for the connections between the crank webs are liable to work loose if these are not correctly fitted.

The general appearance and construction of the cat-walks round the engine will be seen on reference to Figs. 1 and 2. The ladders communicating with these walks are constructed from Strips of suitable lengths and 1" Threaded Rods held in place by locknuts. Handrails are represented by lengths of Spring Cord held in place by Dredger Bucket Clips.

The valve gear is shown in detail in Fig. 2. The camshaft is journalled in the upper holes of six bearings formed from 1½" Angle Girders and Simple Bell Cranks. The cams are formed from Collars and Bolts and the timing of these for each cylinder must be carefully adjusted. The inlet valve, which is the first on the left of each cylinder head, opens as the piston descends during the inlet stroke. The valve then closes, and all three valves are closed as the piston ascends to effect compression and remain closed during the explosion stroke. The exhaust valve opens as the piston ascends for the exhaust stroke, and the scavenger valve, which is the middle one of the set of three, opens when the piston is halfway through this stroke.

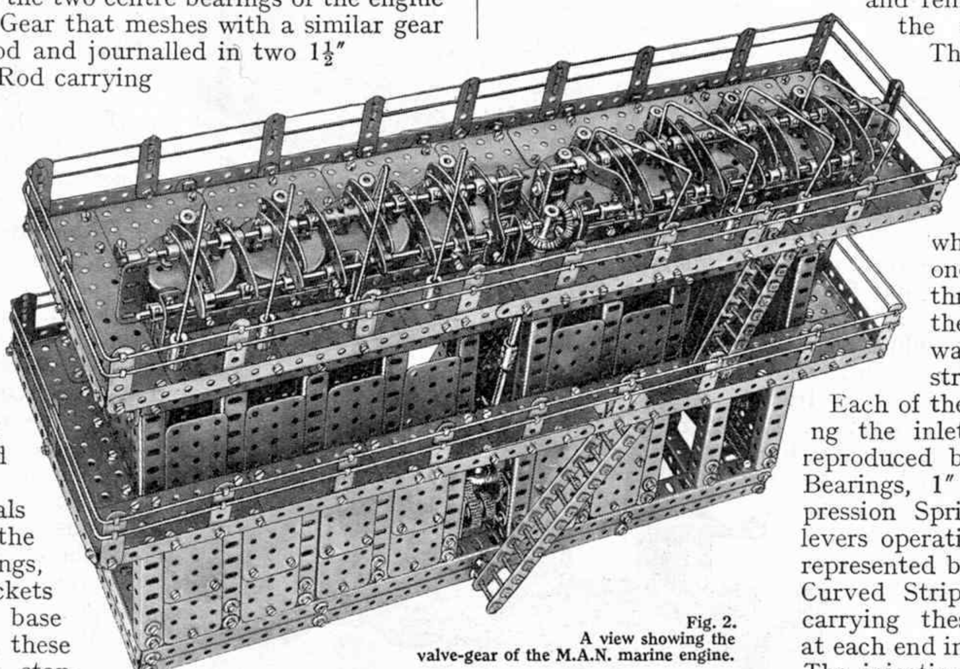

Fig. 2.
A view showing the valve-gear of the M.A.N. marine engine.

Each of the valves representing the inlet and exhaust is reproduced by means of End Bearings, 1" Rods and Compression Springs. The rocking levers operating the valves are represented by 2½" large radius Curved Strips, and the Rods carrying these are supported at each end in 2" Angle Girders. The injection pipes are shown in the illustration, from which the method of operating the camshaft will be gathered.

Among the modified and improved forms of heavy oil engines none have been quite so conspicuous as those introduced by William Doxford & Sons Ltd., whose works at Sunderland have produced some of the most remarkable heavy oil engines known. These engines employ two pistons in each cylinder that travel in opposite directions. They are coupled to the crankshaft by a system of three cranks per cylinder, the upper piston being coupled by two long connecting rods. Thus work is recovered that in an engine of normal type is lost owing to the expansion of the hot gases against the cylinder head. Water cooling is employed for the cylinder walls and the piston rod glands, the water being delivered to the upper piston rod by means of lengths of armoured hose.

The most recent Doxford engine has four cylinders arranged in separate pairs. It develops 3,300 I.H.P. when running at 92 r.p.m., and for its weight and size is a remarkably powerful and economic power unit. One of its most outstanding features is its comparatively small weight, for this has been reduced considerably by the adoption of electrically-welded construction for the engine framings.

The Meccano model shown in Figs 3 and 4 is a scale reproduction of this remarkable unit, and embodies all the main characteristics of the prototype. The lower portion of the frame consists of a rectangular base built up from 18½" and 7½" Angle Girders, the vertical members being composed of 9½" Angle Girders. The plating of the sides and ends is accomplished by means of 5½"×3½" Flat Plates and other Plates of various sizes. Inspection covers are represented by Face Plates, those fitted to the upper set of removable side plates being detachable, together with the sections of the model to which they are fitted. A platform is constructed round the entire engine at the top of the 9½" vertical members already mentioned. It is built up of Flat Plates braced underneath by means of 5½" and 4½" Strips held in place by means of Angle Brackets.

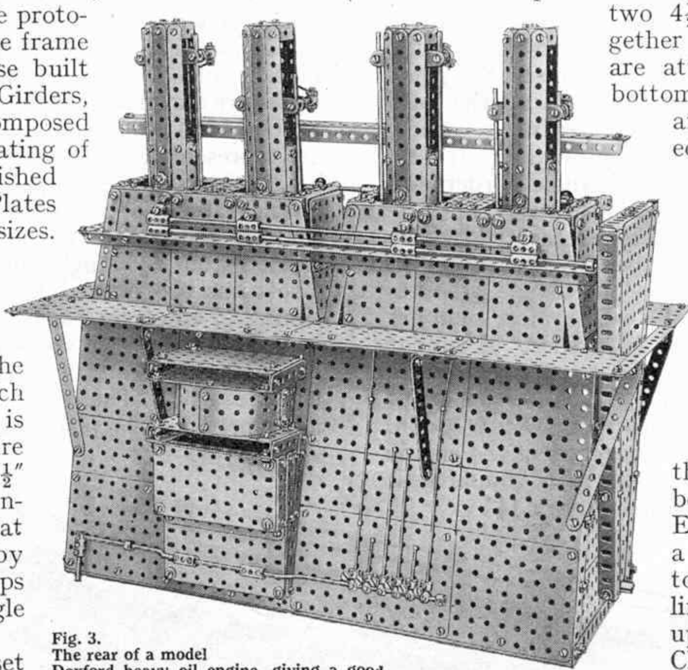

Fig. 3.
The rear of a model Doxford heavy oil engine, giving a good impression of the clean finish to an engine of this type.

Each pair of cylinders is set in a block secured to the top of the lower engine framework, as shown, and each cylinder is built up from 9½" and 5½" Strips bolted round the outside of 4½" Strips bent to the required shape. The two pistons in each cylinder slide in the bosses of Bush Wheels and are coupled up as shown by those sections of the engine framework that have been omitted. The main crankshaft bearings are built up from 2½"×2½" Flat Plates secured to 7½" Angle Girders and each is made sufficiently wide by spacing the two Plates used in its construction by means of Double Brackets.

The construction of the dummy valve gear on both sides of the engine is made clear in the two illustrations, and the drive for this gear is transmitted from a ¾" Sprocket Wheel on the crankshaft to two similar Sprockets, one on each side of the engine, by means of a length of Sprocket Chain that passes completely round the three Sprockets. The armoured hose directing the cooling water to the upper cylinders is represented by lengths of Spring Cord, the various fittings used in conjunction with this Spring Cord being constructed as shown.

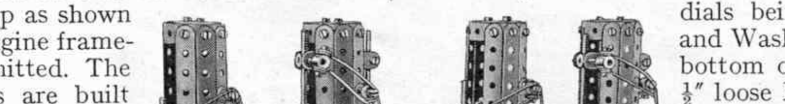

Fig. 4.
The Doxford engine from the control side, showing some of the cranks and connecting rods.

The rear of the engine is fitted with a large pump, the movement of the piston of which is taken from one of the two centre sets of cross-heads by means of two 2" Strips carried on a 4½" Rod. This Rod is secured to the two outer cross-heads of that set by means of two Cranked Bent Strips. The 2" Strips are pivotally attached to two 5½" Strips that are carried on a 5" Rod and connected to the pump piston by a 4½" Rod.

The lower portion of the pump casing is built up from two 4½"×2½" Flat Plates held together by 4½" Angle Girders. These are attached to the model at the bottom by two ½"×½" Angle Brackets and the spaces between the edges of the Plates and the side of the engine are filled in by Strips of suitable length. The pump proper is set between inflow and outflow pipes, as illustrated, these in actual practice conveying the cooling water and air to and from the pump. A pipe consisting of a large Crank Handle and a small one and a 2½" Rod crosses the lower portion of the pump, a number of branches being taken from this as shown. Each branch is represented by a length of Spring Cord secured to the pipe by a Handrail Coupling and held in place at its upper end by a Dredger Bucket Clip. The various pieces of the pipe already mentioned are secured together by Couplings, these being attached to the engine by Set Screws.

The indicator panel is situated, for convenience, immediately above the control levers, the various small dials being represented by Bolts and Washers. One large dial at the bottom of the panel consists of a ½" loose Pulley. The panel is built up from two large Corner Brackets and a 2½" small radius Curved Strip, the edge of the complete fitting being composed of Strips of various lengths.

We have now come to the end of the story of the growth of the marine engine. Modern engines of all types are remarkably efficient, but there is still scope for much improvement and invention. Time alone will show in which direction further development will take place, but there seems little doubt that in a few years some form of internal combustion turbine will be introduced. Many inventors are now hard at work on the problems involved in the construction of a satisfactory form of this type of engine, in which the crankshaft will be given a continuous torque instead of being subjected to violent impulses at intervals, as in the ordinary type of internal combustion engine. Success in these efforts would greatly strengthen the position of the heavy oil engine.