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British Marine Engine History in Meccano

II.—The Paddle Wheel Era

LAST month some of the early British experiments with steam-propelled vessels were described, the last being Henry Bell's vessel, the "*Comet,*" of 1812. The "*Comet*" did not meet with much public enthusiasm, and it was only with difficulty that she was made to pay for her upkeep, although, as an advertisement put it, "the elegance, safety, comfort and speed of this vessel require only to be seen to meet the approbation of the public."

The limited success of the "*Comet*" did not deter others from attempting to commercialise steam passenger boats, however, and the following 10 years saw many small vessels brought into service on the Clyde and elsewhere. Of these the "*Argyle,*" subsequently the "*Thames,*" appears to have been the most successful. She was a packet steamer of 70 tons, measuring 79 ft. on the keel and 16 ft. in beam, with paddle wheels 9 ft. in diameter and engines of 14 h.p. Her smoke was carried away by a funnel that acted also as a mast, being rigged with a large square sail. She had a gallery, on which the cabin windows opened, that projected to form a continuous deck except where broken by the paddle boxes, and on the outside of this gallery were painted 18 large portholes which, with two on her stern, gave her a very striking appearance. After plying for about 12 months between Glasgow and Greenock the "*Argyle*" was sold to a London firm who renamed her the "*Thames.*" The voyage of this small ship from the Clyde to the Thames was a very remarkable one. Almost throughout the trip the weather was very wild, and it was only the skill and determination of Captain Dodd, an ex-Naval officer, that brought her safely through. It is interesting to note that when the "*Thames*" was off Wexford the smoke from her funnel led the local pilots to believe that she was on fire, and they put off to her assistance. Their surprise was great when they found the true state of affairs!

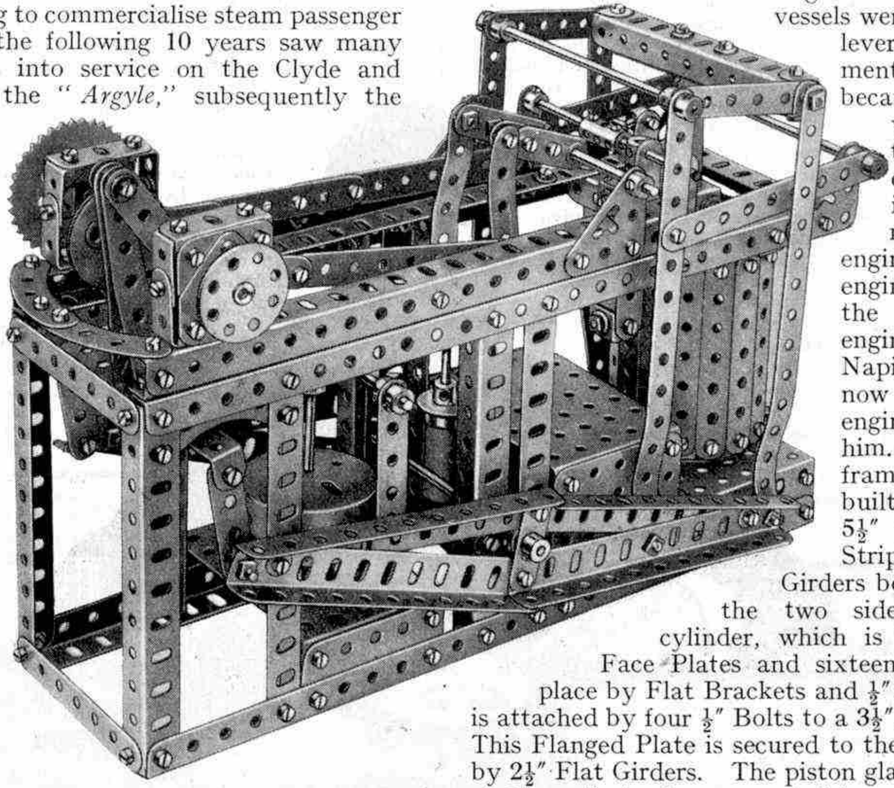

Fig. 1. A scale model of the side lever engine of the steamship "Leven," described in this article.

With reference to this vessel "*The Times*" of 8th July, 1815, said: "The *Thames*, steam yacht, from London to Margate, starts from Wool Quay, near the Custom House, Thames Street, every Tuesday and Saturday at 8 o'clock a.m. precisely, and leaves Margate on her return to London every Monday and Thursday at the same hour. . . . She has the peculiar advantage of proceeding either by sails or steam, separated or united, by which means the public have the pleasing certainty of never being detained on the water after dark, much less one or two nights, which has frequently occurred with the old packets. Against the wind, the tide, or in the most perfect calm, the passage is alike certain, and has always been achieved in one day."

The engines fitted into these early vessels were usually of the side lever type, this arrangement being necessitated because of the lack of vertical space under the deck of these early vessels. Fig. 1 illustrates a scale model of a side lever engine, copied from the engine of the "*Leven,*" the first vessel to be engined by Robert Napier, founder of the now famous firm of engineers named after him. Each side of the frame of the model is built up from 12½" and 5½" Angle Girders, 3½" Strips and 3½" Angle Girders being used to connect the two sides together. The cylinder, which is built up from two Face Plates and sixteen 3½" Strips held in place by Flat Brackets and ½"×½" Angle Brackets, is attached by four ½" Bolts to a 3½"×2½" Flanged Plate. This Flanged Plate is secured to the frame of the model by 2½" Flat Girders. The piston gland on the upper end of the cylinder is represented by a Double Bent Strip through the centre hole of which the piston rod passes.

The condenser is built up from three 3½"×2½" Flanged Plates and two 2½"×2½" Flat Plates, and is situated close to the cylinder as shown in the photograph. Two cylinders are bolted to the condenser, each of which is composed of a Sleeve Piece and a ¾" Flanged Wheel. These represent the bilge or waste pumps, the pump rods being operated through a series of levers and cranks from one of the Eccentrics on the crank-shaft, as shown in the illustration.

The piston rod, a 4½" Rod, is connected by a Double Arm Crank to a channel section girder built up from two 4½" Angle Girders. Each end of these two Girders carries a Double Bracket the underside lugs of which are connected together by a 4½" Strip. The method of connecting the 4½" Angle Girders to the beam is shown clearly in the illustration.

The connecting rod is built up as illustrated, and is pivotally attached at its upper end to the crank, which consists of two Cranks locked securely together by a ½" Bolt. Each half of the crankshaft, a 2½" Rod, carries a Triple Throw Eccentric, one of which has already been described. The other is coupled by a 7½" Strip to a 2" Strip that operates the valve rod through a series of levers shown plainly in the illustration.

There remains to be fitted the air-pump. A 3½"×2½" Flanged Plate is secured to the base of the model by means of two 2½" Flat Girders, and to the upper face of this Plate are attached two Boiler Ends secured together by four Flat Brackets and attached to the Plate by four Bolts. The pump rod is attached to a horizontal Rod by a Coupling, this latter Rod being linked to the side levers by 2½" Strips.

The side lever engine held the field against all competitors for many years, and it was a very suitable engine for its type of work, the pumps and other auxiliaries being driven with little or no difficulty from the beam. Its main disadvantage lay in its great weight, and in the number of its moving parts, this latter point being of great importance when the efficiency of the engine is considered. Among the engineers who were trying to eliminate the clumsy and weighty double beam was Joseph Maudslay, who designed several different types of engines.

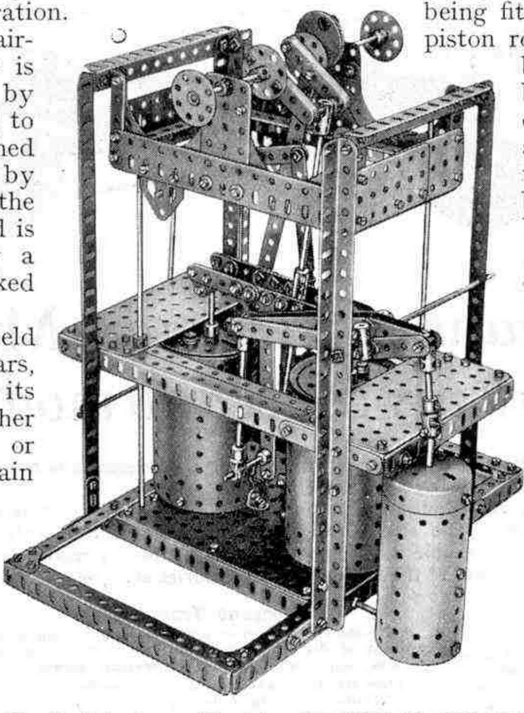

Fig. 2. A tandem paddle engine the original of which was designed by Joseph Maudslay.

One of Maudslay's early experiments resulted in the "steeple" engine which, although efficient in operation, was tall and weighty, no less than nine heavy pieces of metal being required to replace the simple connecting rod. Maudslay also invented the trunk engine which, like a petrol engine, dispenses with a piston-rod altogether, the connecting rod being attached direct to the piston. In this engine the piston was fitted at its centre with a large diameter tube that protruded from the cylinder at each end, and the connecting rod was pivoted in the centre of this. The great disadvantage of this engine lay in the greatly reduced piston area and the alternate heating and cooling of the trunk as it moved in and out of the cylinder. The necessarily large stuffing boxes also caused considerable friction and still further reduced efficiency. The trunk engine therefore never found favour with engineers for driving paddles, although it was revived later for driving screw propellers when piston speeds were increased.

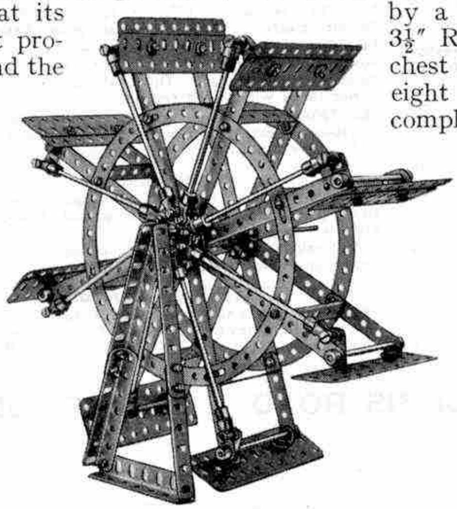

Fig. 3. A "feathering" paddle wheel suitable for fitting to any of the engines described in the article.

One of Maudslay's most successful engines is shown in model form in Fig. 2. The base of the model consists of two 12½" and two 7½" Angle Girders joined together by Corner Brackets at each corner to form a rigid structure. In the centre of this frame is secured a platform, built up from 7½" Angle Girders and 5½"×3½" Flat Plates, on which the cylinders rest. Each cylinder consists of two boilers, minus ends, opened out so that when bolted together they fit round the periphery of a 3" Pulley. The upper ends of these cylinders consist of 3" Pulleys held in place by 1"×½" Angle Brackets.

The cross-head slide bars, 3½" Strips, are bolted one to each cylinder as shown by ⅜" Bolts, Washers being used for spacing purposes between the cylinders and 3½" Strips. The cylinders are now attached to the base by means of ½"×½" Angle Brackets the piston rods also being fitted, represented by 4½" Rods. The piston rods are coupled together by a yoke built up as illustrated, and to this is bolted two 5½" Strips, at the lower ends of which the crosshead is attached. This crosshead consists of two 1½" Flat Girders secured together by two Double Brackets, Set Screws being used in place of ordinary Bolts for clearance purposes. The crosshead carries a short Rod that connects the piston yoke to the connecting rod, and it carries also a Small Fork Piece that couples the condenser pump to the main engine through the medium of the small beam as shown. The piston rod of the air pump is journalled, inside the cylinder, in the end hole of a 1"×1" Angle Bracket.

Each web of the crankshaft consists of six 2½" Strips bolted by ⅜" Bolts to a Bush Wheel, and the crank-pin is attached to the webs by means of Cranks. The valve derives its motion from an Eccentric on one side of the crankshaft, a 7½" Strip attached to this coupling it to a Double Arm Crank mounted on a horizontal Rod that is partly shown in the illustration. The opposite end of this Double Arm Crank carries a 5½" Strip, the upper end of which is locknutted to a 3½" Strip mounted on a 5" Rod supported in Flat Trunnions attached to the main bearings. The 3½" Strip is mounted two holes from one end, and the long portion is attached, by a 3½" Strip and an End Bearing, to a 3½" Rod forming the valve rod. The valve chest is built up from two Bush Wheels and eight 3½"×½" Double Angle Strips, the complete fitting being held in place by means of ½"×½" Angle Brackets.

About the year 1827 Maudslay introduced his first oscillating cylinder engine. This met with immediate universal approval, and in a very few years almost every paddle-propelled vessel was fitted with engines of this type. Even up to quite recently oscillating engines have been fitted into certain vessels where space was very restricted.

A model of a set of early paddle engines, copied from those of the "*Leinster*," a mail boat of 1860, is shown in Fig. 4. From this illustration it will be seen how neatly engines of this type could be fitted into a vessel, minimum space and perfect balance being the outstanding features of the installation. This model is shown inside a section of the hull of an early paddle boat, but if desired the hull may be dispensed with and a framework substituted. Each of the main bearings supports is built up from a 12½" Angle Girder and a 12½" Flat Girder, their ends being bolted to each side of the hull section or framework.

When these two main supports are in place they are connected across by the four main bearings shown in the photograph, each of which consists of two 1½″ Angle Girders and three 3½″ Strips. The 1½″ Angle Girders protrude below the main supports and these ends are fitted with 2½″ Small Radius Curved Strips and 1″ Corner Brackets as shown.

Each of the two cranks consists of two separate webs, one of which is built up from six 1½″ Strips and two Cranks, and the other from six Flat Trunnions and two Cranks. The crank-pin is represented by a 1½″ Rod and the big-end by three Couplings held together by two 1″ Threaded Rods. The crankshaft also carries two single throw Eccentrics and a third crank, this latter being composed of two Couplings and a 1″ Rod. The two connecting rods on this crank are built up from 1½″ Strips and End Bearings, the End Bearings being attached to 2″ Rods. These Rods form the pistons of the two condenser pumps, both of which are mounted on ⅜″ Bolts. The Bolts for each pump are supported in the end holes of two 1″ × 1″ Angle Brackets that are attached to one of the two main cylinder supports by two 1″ Triangular Plates.

The two oscillating cylinders are each built up from two Face Plates joined together by means of eight 3½″ × ½″ Double Angle Strips. The spaces between the Double Angle Strips are filled in by 3½″ Strips held in place by Flat Brackets. It should be noted that one of the Double Angle Strips and its attendant Strip is made detachable by clamping the securing nuts in place by ½″ × ½″ Angle Brackets. Two valve chests are fitted to each cylinder, these being built up from Channel Bearings and 1″ × ½″ Angle Brackets. They are fitted in place as shown in the photograph and the two valve rods are connected together by two Flat Brackets and one 2½″ Strip, bent slightly as desired. The 2½″ Strip is locknutted at its centre to a second 2½″ Strip bolted at its upper end to one of the single throw Eccentrics that have already been referred to in this article.

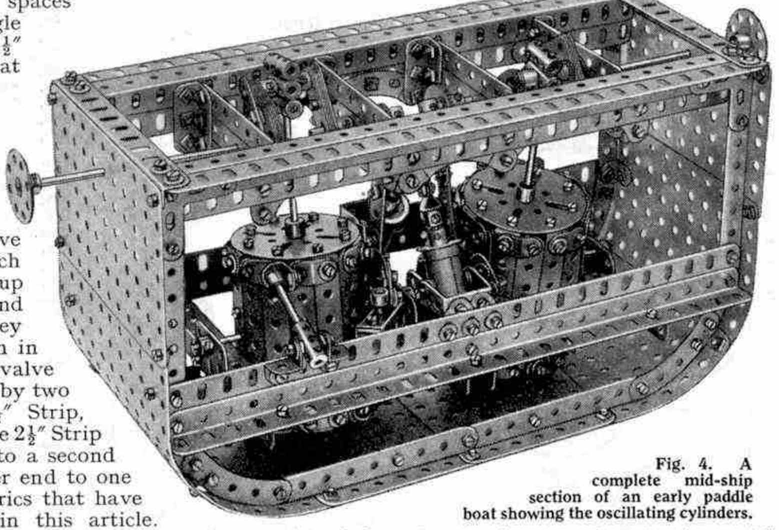

Fig. 4. A complete mid-ship section of an early paddle boat showing the oscillating cylinders.

The cylinder pivots, which in the actual engine consist of the steam inlet and exhaust pipes, are represented in the model by a Crank Shaft locked rigidly to the cylinders by Double Arm Cranks. These Crank Shafts allow the piston rods free movement in the cylinders. The ends of each cylinder pivot are mounted in the centre hole of a 1½″ Flat Girder attached by a 5½″ Angle Girder to a main cross member of the hull section.

To complete the model two subsidiary pumps are fitted. Each of these is built up from a Coupling mounted on the shanks of two Bolts that are supported in Corner Angle Brackets, one right-hand and one left. The pump rod, a 2″ Rod, is fixed by a Collar to a Flat Bracket bolted to the cylinder top.

Paddle Wheels of the "feathering" type

The paddle wheel shown in Fig. 3, is provided for the benefit of those wishing to fit paddles to any of the models described in this article. It is of the "feathering" type, and will greatly enhance the appearance of any model to which it is fitted. The two hub centres are represented by Bush Wheels mounted on a suitable Rod and spaced apart for a distance of 2½″ by means of Couplings and Collars. Each Bush Wheel carries eight spokes formed from 5½″ Strips, which are braced by a 7½″ Circular Strip, bolted in place as shown in the illustration. The two halves of the paddle wheel are coupled together by means of eight 2½″ × ½″ Double Angle Strips.

Each paddle float consists of two 4½″ Flat Girders joined together to form a double width flat girder, and the complete float is attached to the wheel by 1″ × ½″ and ½″ × ½″ Angle Brackets. The 1″ × ½″ Angle Bracket is fitted with a Pivot Bolt on which a Small Fork Piece is free to swing. This Fork Piece is connected by a 4½″ Rod and End Bearing to a Bush Wheel that, in the model, is supported on a framework of Angle Girders. In actual practice this part of the paddle wheel is carried on the outer edge of the paddle box, its work being to "feather" the floats. This means that the floats are made to enter and leave the water in a vertical position, thus increasing the efficiency of the paddle. It should be noted that one of the rods connecting the floats to the "feathering" mechanism is bolted rigidly to the Bush Wheel, but all the others are free to pivot.

No history of marine engineering would be complete without mentioning the "*Great Eastern*," which at the time of her launch in 1858 was nearly twice as long as the largest ship in the world, and considered to be absolutely impregnable to attacks from either wind or sea. She was double-hulled, and it was estimated that the space between her two hulls would hold 2,500 tons of water ballast if necessary. She was 680 ft. long, 82 ft. 6 in. wide and 58 ft. deep. Transverse bulkheads divided her into a series of 60-ft. compartments.

"Great Eastern" too far in advance of the times

This remarkable ship was equipped with paddles and a screw propeller, and sails were fitted on her six masts. Her designer, the famous engineer Isambard K. Brunel, hoped that she would attain a service speed of 15 knots, but she never came up to expectations. Commercially she was a failure, but this was due almost entirely to the fact that she was too far in advance of the times, and thus never really had a fair chance.

The paddles of the "*Great Eastern*" weighed 836 tons and were driven by two double-cylinder oscillating engines having a total indicated horse power of 3,411. The cylinders were 6 ft. 2 in. in diameter, with a stroke of 14 ft., and each weighed 28 tons. The engines could be worked independently if required. Apart from the number of cylinders these engines were almost identical with the oscillating engines already described. For screw propulsion the "*Great Eastern*" was equipped with a huge four-bladed cast iron screw 24 ft. in diameter, and of 44 ft. pitch. The shaft of the propeller was 150 ft. long. The screw was driven by horizontal direct acting engines with a total indicated horse power of 4,886. When driven by both screw and paddles the ship attained a speed of 14½ knots, by the screw alone her speed was about nine knots, and under her paddle wheels alone about seven knots.

The launching of the "*Great Eastern*" was fixed for 3rd November, 1857, but on that occasion the great ship moved only a few feet and then stuck fast, and it was not until 31st January, 1858, that she actually took the water. Her bad luck began with her first trial in September, 1859, for an explosion occurred that resulted in the death of six men and injuries to several others. Her first voyage was from Southampton to New York, and was accomplished in 11 days. The return trip was made in 9 days 11 hours. In 1861 she carried over 2,000 troops to Quebec and returned to Liverpool with about 500 passengers.

The only work on which the "*Great Eastern*" could be really successfully employed was that of cable laying, for which her great size was very valuable in enabling large quantities of cable to be carried on board. In 1868 she was employed on laying the Atlantic cables and she continued on this work at intervals until 1886. No other suitable work at sea could be found for her, and in that year she was bought by a firm of drapery and tea merchants and subjected to the indignity of being used as a kind of show place for advertising purposes. Four years later she was sold to be broken up, and thus ended her career.

Development of high steam pressures

It should be remembered that steam pressure also has played a tremendous part in the fight for efficiency in marine engines, and although it is not intended to discuss boilers and steam generating plant generally in these articles, a short comparison will doubtless help the reader to realise the tremendous change that has overtaken marine engines in this direction. The very early engines worked at a boiler pressure of between two and 7 lb. per sq. in., and anything over this was considered undesirable, one firm going so far as to ask Parliament to prohibit the use of steam generated at pressures of more than 10 lb. per sq. in.! These ideas have passed with the greatly improved metals now obtainable, however, and to-day it is quite commonplace for marine engines to have a working pressure of 250 lb. per sq. inch, and over. Recent experiments have shown that such a pressure is far from being the practicable limit, and although difficulties still present themselves in regard to material, it is certain that before long far higher pressures will be adopted.