Meccano Tandem Pumping Engine

A Realistic Working Model

THE first steam pumping engine seems to have been built about 1663 at Vauxhall, London, by the Marquis of Worcester, who was famous for his mechanical ingenuity, and spent a large fortune in efforts to devise and construct efficient steam engines. The following description of his engine appeared in a list of his many ingenious inventions that he published in 1663.

"An admirable *most forcible way to drive up water by fire;* not drawing or sucking it upwards, for that must be, as the philosopher calleth it, 'infra sphaeram activitatis,' which is but at such a distance, *but this way hath no bounder, if the vessel be strong enough; for I have taken a piece of a whole cannon,* whereof the end was burst, and filled it three quarters full, stopping and screwing up the broken end as also the touch-hole, *and making a constant fire under it; within twenty-four hours it burst and made a great crack;* so that, having found a way to make my vessels so that they are strengthened by the force within them, and the one to fill after the other, I have seen the water run like a *constant fountain forty feet high.* One vessel of water, rarefied by fire, driveth up forty of cold water; and a man that attends the work is but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively." From this curiously-worded description it will be seen that the object of the engine was to raise water. Although the information given is very meagre, it appears that the engine had two cylinders, from each of which water was forced alternately by steam supplied from an independent boiler. The Marquis made many other experiments with steam vessels, but none of his schemes achieved any practical success.

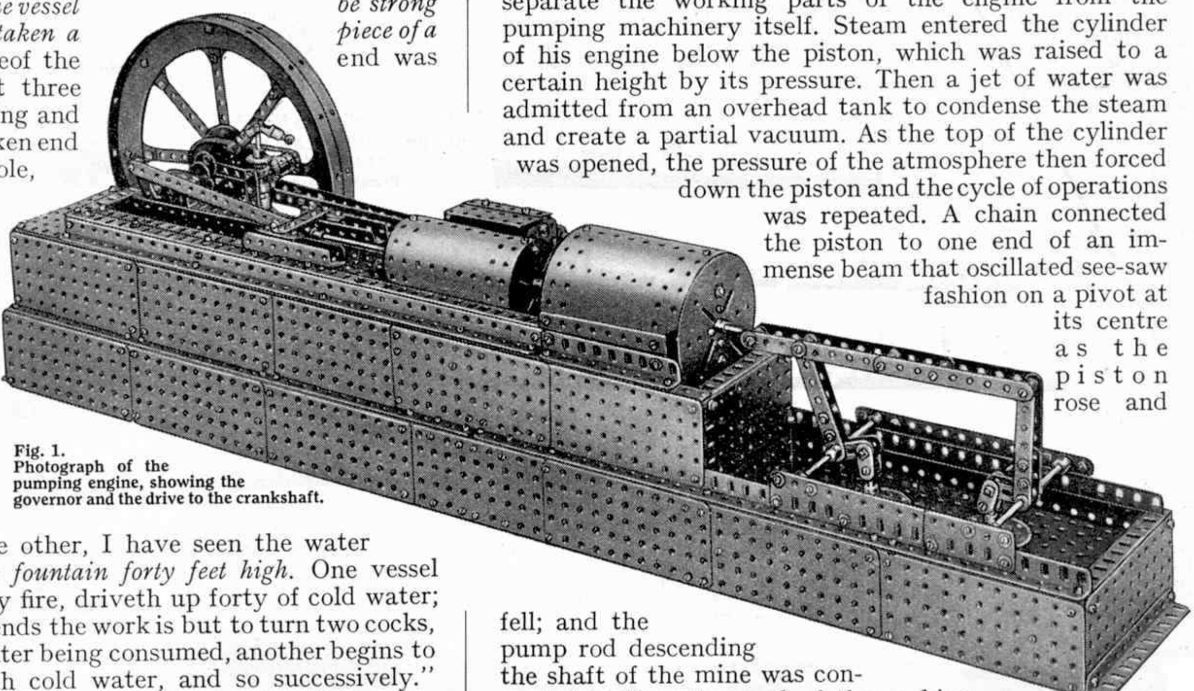

Fig. 1. Photograph of the pumping engine, showing the governor and the drive to the crankshaft.

The credit for making the first really practical steam engine belongs to Captain Thomas Savery, a Devonshire man who in 1698 patented an engine that resembled the Marquis of Worcester's invention in certain respects, but was a great improvement on it. In Savery's engine, steam from a boiler was admitted to a receiver connected through a valve with a suction pipe having its lower end in the water to be pumped. The steam inlet cock was then closed and a valve opened that allowed a stream of cold water to flow over the outside of the receiver, causing condensation of the steam within it. In this manner a vacuum was produced in the vessel and atmospheric pressure forced mine water into it through the suction pipe. The cold water was then shut off and the steam cock again opened, permitting the steam from the boiler to enter the receiver and force the water out of it through a delivery valve and discharge pipe. Two receivers were employed so that one could be filled with water while the other was being emptied. The engine was placed about 20 ft. above the bottom of the water to be pumped and the overflow from the discharge pipe was about 30 ft. above the receiver.

A great step forward was taken about the year 1712 by Thomas Newcomen of Dartmouth. Newcomen was the first to make use of a cylinder and piston and to separate the working parts of the engine from the pumping machinery itself. Steam entered the cylinder of his engine below the piston, which was raised to a certain height by its pressure. Then a jet of water was admitted from an overhead tank to condense the steam and create a partial vacuum. As the top of the cylinder was opened, the pressure of the atmosphere then forced down the piston and the cycle of operations was repeated. A chain connected the piston to one end of an immense beam that oscillated see-saw fashion on a pivot at its centre as the piston rose and fell; and the pump rod descending the shaft of the mine was connected to the other end of the rocking beam.

Newcomen's engine, like Savery's, was used only for pumping purposes—in some instances the water was used to turn water-wheels for driving other machinery. By 1725 the engine was in common use in collieries, and it held its place without any great alteration or improvement for nearly 75 years.

Newcomen's engine was very wasteful of coal, but it paved the way for the far more efficient engines of James Watt, Richard Trevithick and other inventors who transformed the steam engine into a cheap and reliable source of power. The many types of steam engine now in use for pumping and other purposes form splendid subjects for model-building and the illustration on this page shows a reproduction in Meccano of an interesting engine that has found extensive employment in pumping water from deep wells. It is a tandem compound engine, the single piston rod being common to the high-pressure and low-pressure cylinders.

Each side of the bed-plate of the model consists of two compound girders each built up of two 18½" Angle

Girders connected together by 3″ Angle Girders, and joined together by seven 5½″×2½″ Flat Plates. These are fitted as shown, some being overlapped in order to gain the correct length. The top compound girder is fitted with a further girder of similar design and dimensions, as shown, this being utilised to support five 5½″×2½″ Flat Plates forming the upper portion of the engine bed. When the two long sides of the model are complete they are connected together at the end fitted with the flywheel, by means of 5½″×2½″ and 4½″×2½″ Flat Plates, suitable Girders being used in order to add strength to the structure. The opposite ends are coupled by a 5½″×2½″ Flat Plate and two 5½″ Angle Girders, 2½″ Angle Girders being used at the ends of the Plate to enable it to be attached to the side members.

The inner faces of the Flat Plates forming the cut-away portion of the bed-plate are fitted with two 9½″ Angle Girders and these support the ends of four 5½″ Flat Plates. The Plates carry the tops of the two water pumps, each of which is represented by a Boiler End. Two 5½″ and two 2½″ Flat Girders are now fitted to the upper girders of the bed-plate, and these carry four Double Arm Cranks as illustrated. The use of these will be described later. At the point where the bed-plate is cut away, the end of the model is fitted with a 4½″×2½″ Flat Plate strengthened by means of two 4½″ and two 2½″ Angle Girders.

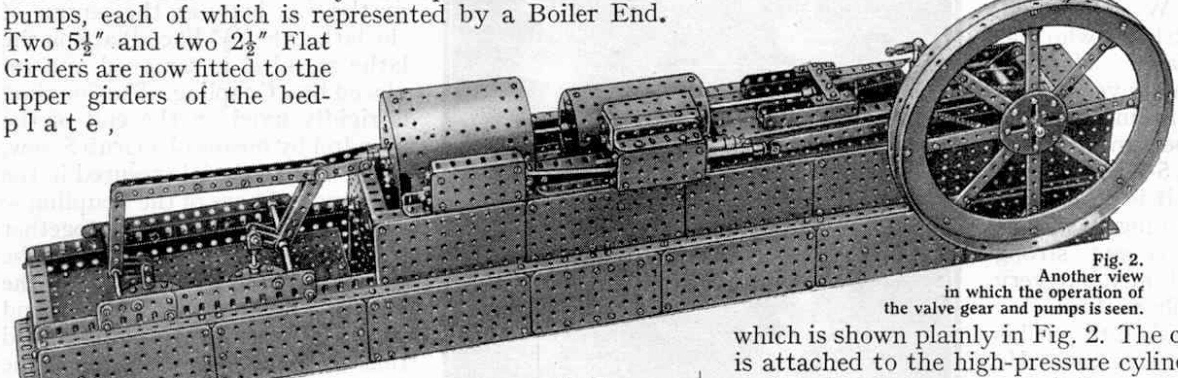

Fig. 2. Another view in which the operation of the valve gear and pumps is seen.

The cylinders can now be fitted. They are built up in the following manner. The low-pressure cylinder casing consists of two Boilers, without Ends, secured together so that they fit almost round the rim of two 4″ Circular Plates. Of these Circular Plates, the inner one is permanently fitted in place by means of two 1″×½″ Angle Brackets, and the other is fitted to two similar Angle Brackets by means of two locked Bolts so as to be quickly detachable, the final holding Nuts being placed on the outer side of the Circular Plate. The centres of the Plates are fitted with Bush Wheels, and the complete cylinder is attached to the engine by means of two 4½″ Angle Girders.

Before finally fitting the detachable cylinder end, the valve chest must be constructed and fitted. It consists of a 3″×1½″ Flat Plate carrying round its edge two 3″ and two 1½″ Angle Girders, the 1½″ Angle Girders being fitted with two similar Girders used to secure the valve chest to the cylinder. Washers are used to space the two units apart in order to bring the low-pressure valve chest into line with the valve chest of the high-pressure cylinder.

The top girders of the engine are now fitted with two double "L" section girders, one of these being attached as shown to each side of the model. Each of these girders consists of two 24½″ Angle Girders, and the upper one of the two supports one end of a 3½″ Angle Girder. This part is bolted between the two compound girders in order to keep them rigid. In addition a 3½″×2½″ Flanged Plate is fitted as shown, and this carries the two cross-head slides. Each of these is built up from two 3½″ Angle Girders, the end nearest the flywheel being supported by a 1½″ Flat Girder.

The high-pressure cylinder consists of a Boiler, without Ends, bent round the outside of two Face Plates. These Face Plates are fitted with 1″×½″ Angle Brackets by means of which the high-pressure cylinder is attached to two transverse 4½″ Angle Girders.

The casing for the "cut-off" plates is built up from two 3″×1½″ Flat Plates secured together at right angles by a 3″ Angle Girder. The vertical Plate carries the high-pressure slide valve casing, the construction of which is shown plainly in Fig. 2. The complete valve unit is attached to the high-pressure cylinder and also to the engine frame by means of two pairs of ½″×½″ Angle Brackets.

Two ¼″ Throw Eccentrics are fitted on the crankshaft, the inner one of which is coupled to the cut-off plates by two 5½″ Strips overlapping three holes. The outer Eccentric is connected by two 5½″ Strips, similarly arranged to those already mentioned, to an end Bearing that is carried on one end of the valve rod. This valve rod is represented by an 11½″ Rod and runs through both valve chests.

In addition to the Eccentrics, the crankshaft carries a 2″ Sprocket Wheel that is connected by a short length of Sprocket Chain to a ¾″ Sprocket Wheel. This Sprocket, shown in Fig. 1, is attached to a Socket Coupling carrying a ⅞″ Bevel Gear, the complete unit being mounted so that it is able to rotate on a short Rod.

A 4½″ Rod, carrying at its upper end a governor as shown, is fitted with a ⅞″ Bevel and passes completely through the Coupling, Socket Coupling and Double Arm Crank. The ⅞″ Bevel meshes with the Bevel driving the flywheel, as already described. The 4½″ Rod carries at its lower end a 1½″ Contrate that is in mesh with a ½″ Pinion. This Pinion is secured on a Rod journalled in the top end holes of the side plates of an E6 Electric Motor, and is connected to the armature shaft by three stages of gearing, each consisting of one 57-teeth Gear and one ½″ Pinion.

Parts Required to Build the Meccano Tandem Pumping Engine

2 of No. 1b	6 of No. 9a	2 of No. 13	400 of No. 37	2 of No. 72	18 of No. 111	1 of No. 162
2 ,, ,, 2	6 ,, ,, 9b	2 ,, ,, 15	16 ,, ,, 37a	6 ,, ,, 73	4 ,, ,, 111a	2 ,, ,, 162b
11 ,, ,, 2a	9 ,, ,, 9c	4 ,, ,, 15a	110 ,, ,, 38	11 ,, ,, 94	3 ,, ,, 111c	2 ,, ,, 166
8 ,, ,, 4	12 ,, ,, 9d	4 ,, ,, 16a	4 ,, ,, 52a	1 ,, ,, 95	3 ,, ,, 116a	2 ,, ,, 167b
2 ,, ,, 5	4 ,, ,, 9e	1 ,, ,, 18b	3 ,, ,, 53a	1 ,, ,, 96a	2 ,, ,, 127	2 ,, ,, 170
8 ,, ,, 6a	9 ,, ,, 9f	2 ,, ,, 24	20 ,, ,, 59	2 ,, ,, 103	2 ,, ,, 128	2 ,, ,, 171
18 ,, ,, 7a	4 ,, ,, 10	3 ,, ,, 26	1 ,, ,, 62	1 ,, ,, 103e	18 ,, ,, 133a	1 E6
2 ,, ,, 8a	5 ,, ,, 12	2 ,, ,, 27a	9 ,, ,, 62b	4 ,, ,, 103f	2 ,, ,, 136	Electric Motor.
4 ,, ,, 8b	2 ,, ,, 12a	1 ,, ,, 28	2 ,, ,, 63	6 ,, ,, 103h	2 ,, ,, 146a	
6 ,, ,, 9	6 ,, ,, 12b	2 ,, ,, 30	27 ,, ,, 70	4 ,, ,, 109	1 ,, ,, 147b	