ON THE INVENTIONS OF JAMES WATT, AND HIS MODELS PRESERVED AT HANDSWORTH AND SOUTH KENSINGTON.

(*For illustrations see pages* 69, 72, 73, 76, 77, 92 *and* 93.)

(CONTINUED FROM PAGE 51.)

It should be noticed that what is now commonly known as the single-acting pumping engine has the stuffing-box and cover, and the equilibrium valve.

In the patent of 1782 Watt states that there are various arrangements that may be made of the several engines, but that he has given only those that appeared the best, and this no doubt is the case, and is what a patentee is bound to do. The author has found a model at South Kensington, which he takes to show a transition state, or form of engine that may probably represent an attempt to produce a double-acting engine by two single-acting cylinders, connected together by a chain over a pulley as follows.

Fig. 27, shows two single-acting vertical *air pumps* placed at some little distance apart, and with passages below leading to them; and there is an unique arrangement of two single-acting vertical *cylinders*, having their upper ends connected by passage without valves, but the pistons having self-acting valves in them, opening upwards, so that *any steam* below *either piston* could pass to the *upper sides* of *both* pistons. A chain connects the top ends of the piston-rods together, and and it passes over a pulley or drum to which it is attached, so that the drum will *reciprocate*, if the pistons work up and down in the cylinders.

To this drum is attached a long crank-pin, which could take hold of a pump-rod, or a connecting-rod.

There are conical valves to let steam into and out of the bottoms of the cylinders, and in each passage leading downwards from the eduction valves there is a small pipe, terminating in a jet of pointing upwards, no doubt for the *injection water*. Now, although when the models were first examined there was not the slightest indication that these pumps belonged to the cylinders, it appeared probable to the author that they had some relation to each other; and on further examination, two dowel-pins were found on one model, and two holes were found on the other model, into which the dowel-pins fitted, thus at once proving that the supposition that they belonged to each other was correct.

Thus we have a model of a double-acting arrangement for pumping or other reciprocating motion, such as a connecting-rod or crank, with the pressure of the steam *always* on the top of *both* pistons, and a vacuum formed alternately under one or other of the pistons, by injection of cold water into the eduction pipes; and with air-pumps to keep up the vacuum, and discharge the air, and the water of condensation, and the condensed steam. This is an arrangement that has not before been noticed, and of which, it appears, there is no description extant; and it is a good example of the ingenuity and inventive genius of James Watt.

Another *grand invention* in this 1782 patent is the use of steam *expansively;* and so thoroughly did Watt understand this action, that he has drawn a good indicator figure of what would take place in the cylinder of an engine, if the steam were cut off at one quarter of the stroke. See Fig. 25.

This figure, the author finds, is identical with Marriette's Law, and not far from the true expansion curve that the author constructed from Pambour's table of the bulk of steam in proportion to the water that produced it; that is, so far as the figure goes, *i. e.*, to an expansion of steam at atmospheric pressure to four times its volume. (The author's diagram, Fig. 26, goes to 44 times the volume with 120 lbs. steam.)

At this point, it may be well to leave the consideration of the specification for a moment, to examine the drawing, Fig. 19, Page 48, of a model which it is believed is at the root of the invention of the "*Indicator*." This consists of a simple, small cylinder about 2 in. diam. and 3 in. stroke, open at top and closed at bottom, and with a cock and pipe to it; the piston-rod is connected by a light chain to a rocking-beam above, and a chain fastened to the other end of the beam is attached to the upper end of a good spiral spring, fastened at its lower end. There is a long light finger on the centre of the beam moving in front of a large segment. Now, if the pipe below was connected to an engine cylinder, and the cock opened, the degree of vacuum in the cylinder would at once be *indicated*. It only remains now to attach a pencil to the top of the piston-rod of this indicator, and move a sheet of paper on a board in front of it, to and fro, as the main piston of the engine moved, and we have "Watt's Indicator" as used by himself and all his people for very many years, in fact up to the author's time, when he saw the instrument in Mr. William Bennett's possession in Manchester. Mr. Bennett then showed the author's late father how to take indicator figures, of which some are shown in Figs. 23 and 24, Page 48, taken by Professor Cowper in 1840.

Mr. W. Bennett was originally at Soho, and on going to Manchester and joining Mr. Wren, he became Messrs. Bolton & Watt's agent there, for indicating their engines and taking orders for the same.

Our member, Mr. Henry Wren, has very kindly made the author a present of one of these indicators, shown in Page 49, Figs. 20 and 21, and it is now before you: you will see that it is just like engravings of Watt's indicator in the Encyclopædias.

Watt goes on in his specification to say that when the steam is cut off at one quarter of the stroke, there must be an equalising arrangement, to enable the piston to complete its stroke when pumping; and several plans are put forth. In one, Fig. 22, Page 49, there is a small fly-wheel with a pinion mounted up above the cylinder, the pinion taking into a toothed segment on the end of the beam (in place of the old "Horse-head"). The piston-rod has a rack attached to it, also taking into the toothed segment, so that at every stroke of the engine, either up or down, the fly-wheel must start from a state of rest and revolve rapidly and then stop, and in so doing would of necessity take a good deal of power to overcome its inertia, and would give it out again (less the double friction towards the end of the stroke. Another plan is, to mount a weight high up on the top of the beam of an engine, so that it should be somewhat lifted, in starting from either end of the stroke, and fall somewhat after passing the centre. Another plan is that of a loose weight, to roll along the top of the beam and do the same thing. Again, one plan is to have two large short-stroked, open-headed pumps, one attached to the beam on either side of its centre, so that one bucket rises while the other falls; and there being a trough between the heads of the pumps, the water is intended to flow from the one to the other, thus giving the engine more to do at the commencement of the stroke, and gaining a little towards the end of the stroke, by the weight of so much of the water as has flowed over in the time.

There are also several arrangements of levers, to give a variation in the leverage during the stroke, so that the piston should have more to do at the commencement of the stroke, and less to do at the end, when the steam was gradually losing its pressure from expansion.

Thus, in 1782 Watt had made a thoroughly good rotative, or mill engine, and an economical one also, though it does not appear that he actually use any considerable pressure of steam at any time. This engine is shown in Figs. 30 and 31, taken from a model in the South Kensington Museum.

One form of engine he describes, and which he calls a compound engine, consists of using two cylinders of the same size, and then, having used full steam in one cylinder, he lets that piston stand still whilst part of the steam expands into the second cylinder, and finally the steam from both is condensed.

In the patent of 1782 is described the plan of allowing the piston-rod of an engine to pass out through a stuffing box in the bottom, the beam being placed below, like what is now known as a "Bull Engine," (Figs. 28 and 29.) It is believed the name arose from an engineer of the name of Bull, who put some up in Cornwall, and whose son went into partnership with Trevithick, at the time that James Watt was complaining of their infringing his first patent for the condensation of steam.

It is a remarkable fact that the model from which this diagram was taken is almost exactly the same as the engraving at page 59 of the "Life of Trevithick," the injection jet being in the eduction pipe, as shown in some of Watt's drawings.

Watt, in a patent of 1784 describes an ingenius method of obtaining rotary motion in opposite directions, by two connecting rods from a crosshead at one end of the beam of an engine (Figs. 32 and 33.) Inasmuch as one shaft is placed somewhat lower than the other, that rod is jointed to a lower part of the beam, so that both may turn the centres at the same instant. The lower shaft drives the bottom roll of a rolling mill, and the higher one drives the top roll. This was probably intended for rolling metals for coining. The gearing by spur-wheels carries the power to another mill for slitting.

In the same patent the idea of a steam carriage for common