proper to ſuſpend its rod by a chain from the great beam ; for it muſt not only pull down that end of the beam, but alſo puſh it upwards. It may indeed be ſuſpended by double chains like the piſtons of the en­gines for extinguiſhing fires; and Mr Watt has accor­dingly done ſo in ſome of his engines. But in his draw­ing from which this figure is copied, he has communi­cated the force of the piſton to the beam by means of a toothed rack OO, which engages or works in the toothed ſector QQ on the end of the beam. The rea­der will underſtand, without any farther explanation, how the impulſe given to the piſton in either direction is thus transmitted to the beam without diminution. The fly XX, with its pinion Y, which alſo works in the toothed arch QQ, may be ſuppoſed to be removed for the preſent, and will be conſidered afterwards.

We ſhall take the preſent opportunity of deſcribing Mr Watt’s method *of* communicating the force of the ſteam-engine to any machine of the rotatory kind. VV repreſents the rim and arms of a very large and heavy metalline fly. On its axis is the concentric toothed wheel U. There is attached to the end of the great beam a ſtrong and ſtiff rod TT, to the lower end of which a toothed wheel W is firmly fixed by two bolts, ſo that it cannot turn round. This wheel is of the ſame size and in the ſame vertical plane with the wheel U ; and an iron link or ſtrap (which cannot be ſeen here, becauſe it is on the other side of the two wheels) connects the centres of the two wheels, ſo that the one cannot quit the other. The engine being in the position repreſented in the figure, suppoſe the fly to be turned once round by any external force in the di­rection of the darts. It is plain, that since the toothed wheels cannot quit each other, being kept together by the link, the inner half (that is, the half next the cylin­der) of the wheel U will work on the inner half of the wheel W, ſo that at the end of the revolution of the fly the wheel W muſt have got to the top of the wheel U, and the outer end of the beam muſt be raiſed to its higheſt position. The next revolution of the fly will bring the wheel W and the beam connected with it to their firſt positions ; and thus every two revolutions of the fly will make a complete period of the beam’s re­ciprocating movements. Now, inſtead oſ ſupposing the fly to drive the beam, let the beam drive the fly. The motions muſt be perfectly the ſame, and the aſcent or deſcent of the piſton will produce one revolution of the fly.

A side view of this apparatus is given in fig 12. marked by the ſame letters of reference. This ſhows the ſituation of parts which were fore-ſhortened in fig. 11, particularly the deſcending branch C of the ſteam pipe, and the ſituation and communications of the two pumps K and I. 8, 8 is the horizontal part oſ the ſteam pipe. 9 is a part of it whoſe box is repreſented by the dark circle of fig. 11. D is the box of the ſteam clack, and the little circle at its corner repreſents the end of the axis which turns it, as will be described af­terwards. N is the place of the upper eduction valve. A part only of the upper eduction-pipe G is repreſent­ed, the rest being cut off, becauſe it would have covered. the deſcending ſteam pipe CC. When continued down, it comes between the eye and the box E of the lower ſteam valve, and the box F of the lower educ­tion valve.

Let us now trace the operation of this machine through all its ſteps. Recurring to fig. 11, let us ſuppoſe that the lower part of the cylinder BB is exhauſted of all elaſtic fluids; that the upper ſteam valve D and the lower eduction valve F are open, and that the lower ſteam valve E and upper eduction valve N are ſhut. It is evident that the piſton muſt be preſſed toward the bottom of the cylinder, and muſt pull down the end of the work­ing beam by means of the toothed rack OO and ſector QQ cauſing the other end of the beam to urge for­ward the machinery with which it is connected. When the piſton arrives at the bottom of the cylinder, the valves D and F are ſhut by the plug frame, and E and N are opened. By this laſt paſſage the ſteam gets into the eduction-pipe, where it meets with the injection water, and is rapidly condenſed. The ſteam from the boiler enters at the ſame time by E, and preſſing on the lower side of the piſton, forces it upwards, and by means of the toothed rack OO and toothed ſector QQ forces up that end of the working beam, and cauſes the other end to urge forward the machinery with which it is connected : and in this manner the operation of the engine may be continued for ever.

The injection water is continually running into the eduction-pipe, becauſe condenſation is continually go­ing on, and therefore there is a continual atmoſpheric preſſure to produce a jet. The air which is diſengaged from the water, or enters by leaks, is evacuated only during the riſe of the piſton of the air-pump K. When this is very copious, it renders a very large air-pump neceſſary ; and in ſome ſituations Mr Watt has been obliged to employ two air-pumps, one worked by each arm of the beam. This in every caſe expends a very conſiderable portion of the power, for the air-pump is always working againſt the whole preſſure of the atmoſphere.

Is is evident that this form of the engine, by main­taining an almoſt conſtant and uninterrupted impulſion, is much fitter for driving any machinery of conti­nued motion than any of the former engines, which were inactive during half of their motion. It does not, however, ſeem to have this ſuperiority when employed to draw water ; But it is equally fitted for this task. Let the engine be loaded with twice as much as would be proper for it if a single ſtroke engine, and let a fly be connected with it. Then it is plain that the power of the engine during the riſe of the ſteam piſton will be accumulated in the fly; and this, in conjunction with the power of the engine during the deſcent of the ſteam piſton, will be equal to the whole load of water.

In ſpeaking of the ſteam and eduction-valves, we ſaid that they were all puppet valves. Mr Watt employed cocks, and alſo sliding valves, ſuch as the regulator or ſteam-valve, and the old engines. But he found them always loſe their tightneſs after a ſhort time. This is not ſurpriſing, when we conſider that they are always perfectly dry, and almoſt burning hot. He was therefore obliged to change them all for puppet clacks, which, when truly ground and nicely fitted in their motions at firſt, are not found to go out of order by any length of time. Other engineers now universally uſe them in the old form of the ſteam-engine, without the ſame. reaſons, and merely by ſervile and ignorant imitation.

The way in which Mr Watt opens and ſhuts theſe valves is as follows. Fig. 13. repreſents a clack with