tions of the fly will make a complete period of the beam’s reciprocating movements. Now, instead of 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.

“ It is proper here to give the history of this invention I had very early turned my mind to the producing continued motions round an axis, and it will be seen by reference to my first specification in 1769, that I there described a steam-wheel, moved by the force of steam acting in a circular channel against a valve on one side, and against a column of mercury or some other fluid metal on the other side. This was executed upon a scale of about six feet diameter at Soho, and worked repeatedly, but was given up, as several practical objections were found to operate against it. Similar objections lay against other rotative engines which had been contrived by myself and others, as well as to the engines producing rotatory motions by means of ratchet-wheels. Having made my reciprocating engines very regular in their movements, I considered how to produce rotative motions from them in the best manner; and amongst various schemes which were subjected to trial, or which passed through my mind, none appeared so likely to answer the purpose as the application of the crank in the manner of the common turning lathe, (an invention of great merit, of which the humble inventor, and even its era, are unknown.) But, as the rotative motion is produced in that machine by the impulse given to the crank in the descent of the foot only, and behoves to be continued in its ascent by the momentum of the wheel, which acts as a fly, and being unwilling to load my engine with a fly heavy enough to continue the motion during the ascent of the piston, (and even were a counterweight employed to act during that ascent of a fly heavy enough to equalize the motion,) I proposed to employ two engines acting upon two cranks fixed on the same axis at an angle of one hundred and twenty degrees to one an­

other, and a weight placed upon the circumference of the fly at the same angle to each of the cranks, by which means the motion might be rendered nearly equal, and a very light fly only would be requisite. This had occurred to me very early, but my attention being fully employed in making and erecting engines for raising water, it remained *in petto* until about the year 1778 or 9, when Mr Washbrough erected one of his ratchet-wheel engines at Birmingham, the frequent breakages and irregularities of which recalled the subject to my mind, and I proceeded to make a model of my method, which answered my expectations ; but having neglected to take out a patent, the invention was communicated by a workman employed to make the model to some of the people about Mr Wasbrough’s engine, and a patent was taken out by them for the application of the crank to steam-engines. This fact the said workman confessed, and the engineer who directed the works acknowledged it, but said, nevertheless, the same idea had occurred to him prior to his hearing of mine, and that he had even made a model of it before that time, which might be a fact, as the application to a single crank was sufficiently obvious. In these circumstanees I thought it better to endeavour to accomplish the same end by other means, than to enter into litigation, and, if successful, by demolishing the patent, to lay the matter open to every body. Accordingly, in 1781, I in vented and took out a patent for several methods of producing rotative motions from reciprocating ones, amongst which was the method of the sun and planet wheels described in the text.

“ This contrivance was applied to many engines, and possesses the great advantage of giving a double velocity to the fly ; hut is perhaps more subject to wear, and to be broken under great strains, than the crank, which is now more commonly used, although it requires a flywheel of four times the weight, if fixed upon the first axis. My application of the double engine to these rotative ma chines rendered unnecessary the counterweight, and produced a more regular motion ; *so that, in most of our great manufactories, these engines now supply the place of water, wind, and horse mills ; and instead of carrying the work to the power, the prime agent is placed wherever it is most convenient to the manufacturer."*

“ Let us now trace the operation of this machine through all its steps. Let us suppose that the lower part of the cylinder BB, fig. 44, is exhausted of all elastic fluids ; that the upper steam-valve D and the lower eduetion 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 Iower side of the piston, forces it upwards, and by means of the toothed rack 00 and toothed sector QQ forces up that end of the workingbeam, 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 eductionpipe, 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.