up at each stroke ; and as this is done by the sudden descent of the loaded lever of the pump, the water is injected very suddenly into the receiver.”

*The Atmospheric steam-engine of Newcomen and Cawley.*

The title of this steam-engine correctly indicates the principle of its action. The effect which it produces is not by the direct and immediate agency of steam, but of the atmosphere. All that the steam does in this machine is merely to make way for the atmosphere, and give effect to its pressure. It is therefore necessary to retrace our steps, and give some consideration to the mode of operation of atmospheric pressure as an introduction to this description. A full exposition of the nature and laws of the pressure of atmosphere has been given in the article Pneumatics, to which our readers are referred for a more perfect acquaintance with this subject. We shall only touch upon such branches of experiment, concerning atmospheric pressure, as are so closely intertwined with our more immediate investigation as to constitute an essential part of it.

We have merely to notice, that after the discovery of the laws of atmospheric pressure by the pupils of Galileo, we owe most of our information on the phenomena resulting from the pressure of the atmosphere, and of the apparatus constructed for exhibiting its powers on a large scale, to Otto Guericke, privy councillor of his serene highness the Elector of Brandenburg, and consul of Magdeburg, who had in 1654 brought his pneumatic apparatus to considerable perfection, and continued to make his experiments to an advanced age. They were published by Gasparus Schottus in his work “ De Arte Mechanica Hydraulica Pneumatica," in 1657, and again by the author himself, in a thin volume, entitled “ Ottonis Guericke Experimenta Nova Magdeburgica de Vacuo Spatio, Aeris Pondere,” &c. Amstelodami, 1672, fol.

We have extracted and translated the following pas­sages of this rare work from a copy in the library of the College of Physicians at Edinburgh. They show us that the mode of raising water above its level by atmospheric pressure, and by a vacuum, was by him so clearly made known, that the use of steam as the instrument for effecting that vacuum was a very direct and easy tran sition. Indeed the apparatus we have first to consider is a very simple illustration of the action of Savary’s machine.

Illustration of raising water by a vacuum, and the pressure of the atmosphere, taken from chapter xx. of Otto Guericke.

“ Make four tubes or pipes *ab, cd, ef, gh,* each about eight feet long, made of glass, and mount ed at the extremities with conically tapered fittings, so as to be accurately joined to each other, each joint surrounded by a small cup, into which liquid being poured, the joints may be prevented from taking in air ; let there also be a stopcock on the lowest, and let there he taken a glass flask *i,* also fitted air tight with a stopcock *k.*

“ Having joined all these tubes together, so as to form a tube erected on the wall of a house, the lower end being

immersed under water in the open vessel ; the large flask or receiver having been previously emptied of air by the air-pump, and being now placed on the top of the long tube, and the stopcock *l,∙* being opened, the water will violently rush up the tube to the height of above thirty feet. The rationale is this, that the external air presses on the surface of the water in the bucket., which finds free exit from this force up the vacuous space of the tube, from which the air has been withdrawn, into the flask *i;* and settles at such a height as will balance by the weight of the column of water the weight of the circumambient air.”

The reader of this very clear and accurate exposition may easily perceive that when it has once been discovered that water, after having been rarefied by heat into steam, so as to fill a large space, is afterwards condensed by cold, so as to leave a portion of that space vacuous, nothing remains to be done except to make the vacuum of the flask ι by steam instead of an air-pump, and the machine of Savary is obtained. In fact, the flask *i* of Otto Guericke cor responds accurately to the receiver of Thomas Savary. The reader has only to understand the former, in order to perceive at a glance the action of the latter.

This first experiment of Otto Guericke, therefore, represents with fidelity the principle of Savary’s engine for raising water by the formation of a vacuum. Not less beautifully does another experiment of the same philosopher exemplify the principle of the species of engine known as the atmospheric engine, or Newcomen's steam engine. And its construction is peculiarly important at this stage of our progress, as the reader has only to take the trouble of following the details of the experiment of Guericke, in order to comprehend correctly the machine of Newcomen. In fact, all his experiments on the power of the atmosphere are admirable illustrations of the principle of the atmospheric steam-engine ; so that the reader will do well to remember that the only use of the steam in the atmospheric steam-engine is to form a vacuum.

Description and operation of the atmospheric apparatus for raising great weights by a vacuum under a piston in a cylinder, exhibited amongst other experiments, at the diet of Ratisbon in 1654, to the court and their Majesties Ferdinand 111. and his son Ferdinand IV, &e., chap, xxvii. and xxviii.

“ A large vessel of copper, *a,* made truly cylindrical, and having its sides perfectly even and parallel, and about twenty inches high and eight inches wide, was fixed firmly in a vertical position by the strong ring S. In the next place, a piston, PQR, was made to fit exactly the inside of the aforesaid cylinder, P being of iron and

Q wood, and the rounded head R, formed of the hardest oak, being hollowed out on the edge like the pulley of a common well, in which groove flax or hemp is to be rolled round so as to fill it up, and the whole is then to be placed in the aforesaid cylinder *a,* (like as a piston and its head in a common syringe or pump for extinguishing fires,) and fitted so exactly that nir can neither pass outwards or inwards through between the piston and cylinder. Thirdly, the cylinder *a* is to be attached to the great upright beam, Fig. 20, by an iron bracket, through the ring aforesaid S, and the piston PQR is to he let into the cylinder *a,* and the iron handle PQ of the piston is to be passed through the ring of a second iron arm O, in such a manner that it can play freely up and down through the whole height of the cylinder, and at the same time be steadily preserved in the straight line, hut not permitted to rise further than O. In the *fourth* place, a rope, to the end of which is firmly attached