by cold water; and through the regulated aperture N a jet of cold water is allowed to play in the inside of it amongst the steam. P the air-pump is also placed in the cold well surrounded by water ; Q the piston or bucket of the air-pump is worked up and down by the piston-rod Q Y Z *g* from the great lever. The valve It closes when the piston descends, and opens on its ascent, allowing water and air to pass into the air-pump, but prevent­ing its return ; and the upper valve of the air-pump S allows the escape of water and air outwards, but prevents its return ; this valve S leads to the hot well T, from which the feedpump U draws off a supply of water for the boiler.

“ The great advantage of Mr Watt's form is the almost total annihilation of the waste of steam by con­densation in the cylinder. The cylinder is always hot, and therefore perfectly dry. This must be evident to any person who υnderstands the subject. By the time that Mr Watt had completed these improvements, his experiments on the production of steam had given him a pretty accurate knowledge of its density : and he found himself authorized to say, that the quantity of steam employed did not much exceed what would fill the cylinder, so that very little was unavoidably wasted. But before he could bring the engine to this degree of perfection, he had many difficulties to overcome. He in closed the cylinder in another containing steam, and that in a wooden case at a small distance from it, which effectually prevents all condensation in the inner cylinder from external influence ; and the condensation by the outer cylinder itself, which was very small, had no other bad consequence than the loss of so much steam as formed the condensed water.

“ The greatest difficulty was to make the great piston tight. The old and effectual method, by water lying on it, was inadmissible. He was therefore obliged to have his cylinders most nicely bored, perfectly cylindrical, and finely polished ; and he made numberless trials of differ ent soft substances for packing his piston, which should be tight without enormous friction, and which should long remain so, in a situation perfectly dry and very hot.

“ After all that Mr Watt has done in this respect, he thinks that the greatest part of the waste of steam which he still perceives in his engines, arises from the unavoidable escape by the sides of the piston during its descent.

“ But the fact is, that an engine of this construction, of the same dimensions with a common engine, making the same number of strokes of the same extent, does not consume above one-fourth *or one-third* part of the fuel that is consumed by the best engines of the common form. It is also a very fortunate circumstance, that the performance of the engine is not immediately destroyed, nor in deed sensibly diminished, by a small want of tightness in the piston. In the common engine, if air get in in this way, it immediately puts a stop to the work ; but although even a considerable quantity of steam get past the piston during its descent, the rapidity of condensation is such, that hardly any diminution of pressure can be observed.

“ When Newcomen's engines are working under loads inferior to their whole power, they are regulated to pre vent shocks which would be prejudicial, by lessening the quantity of injection, or by shutting the injection-cock sooner. These new engines may, in some degree, be regulated in the same manner ; but it is done more effectually and economically, first, by limiting the opening of the regulating-valve which admits the steam above the piston, and letting it continue so far open during the whole length of the stroke ; secondly, by letting it open

fully at first, and shutting it completely when the piston has proceeded downwards only part of its stroke ; or, lastly, by the use of a throttle-valve, which, acting in the same manner as the floodgate of a mill, admits no more steam than gives the desired power.

“ The second of these methods of regulating the power of the engine, forms the basis of what is called the *Expansive Engine,* which renders available the greater part of the power with which the steam would rush into empty space, were the piston acted upon by the whole force of the steam, from the bottom to the top of the stroke, through the whole length of the cylinder—a principle which had first occurred to Mr Watt in 1769, and was adopted in an engine at Soho manufactory, and some others, about 1776, and in 1778 at Shadwell water works, and afterwards particularly described in his specification of a patent for several new improvements upon steam-engines, in 1782.

“ The construction of this engine is as has been described. The steam-valve is always allowed to open fully ; the pins of the plug-frame are regulated so, that that valve shall shut the moment that the piston has descended a certain portion, suppose one-fourth, one third, or one-half, of the length of the cylinder. So far the cylinder was occupied by steam as elastic as common air. In pressing the piston farther down, it behoved the steam to expand, and its elasticity to diminish. It is plain that this can be done in any degree we please, and that the adjustment can be varied in a minute, according to the exigency of the case, by moving the plug pins.

“In the mean time, it must be observed, that the pressure on the piston is continually changing, and consequently the accelerating force. The motion, therefore, will no longer be uniformly accelerated. It will approach much faster to uniformity ; nay, it may be retarded, be cause although the pressure on the piston at the beginning of the stroke may exceed the resistance of the load, yet when the piston is near the bottom, the resistance may exceed the pressure. Whatever may be the law by which the pressure on the piston varies, an ingenious mechanic may contrive the connecting machinery in such a way that the chains or rods at the outer end of the beam shall continually exert the same pressure, or shall vary their pressure according to any law he finds most convenient. It is in this manner that the watchmaker, by the form of the fuzee, produces an equal pressure on the wheel-work by means of a very unequal action of the mainspring. In like manner, by making the outer arch, heads portions of a proper spiral instead of a circle, we can regulate the force of the beam at pleasure.

« Thus we see how much more manageable an engine is in this form than Newcomen's was, and also more easily investigated in respect of its power in its various positions. The knowledge of this last circumstance was of mighty consequence, and without it no notion could be formed of what it could perform, which may be called a discovery of great importance in the theory **of** the engine. We shall give here Mr. Watt’s theory of the expansive engine which we have just described.

“ Let ABCD (Fig. 43.) represent a section of the cylinder of a steam-engine, and EF the surface of its piston. Let us suppose that the steam was admitted while EF was in contact with AB, and that as soon as it had pressed it down to the situation EF, the steam-cock is shut. The steam will continue to press it down, and as the steam expands, its pressure diminishes. We may express its pressure (exerted all the while the piston moves from the situation AB to the situation EF) by the line EF. If we suppose the elasticity of the steam