S1 S2 to descend into the position of fig. 64, as at first. This operation being repeated, so that at the end of each upward and downward stroke, the descent and ascent of the piston and lever prepare the valves for producing the inverse effect, and giving the next succeeding stroke, the machine becomes independent and automatic. It is rather curious that these simple valves, now described, are the latest improvements that have been introduced in the steam-engine.

Considerable ingenuity has been expended on the valves and passages of the steam-engine, for the purpose of forming all these communications by means of a couple of passages, instead of four. The following diagrams are designed to explain the manner in which this has been effected, by means of a four-way cock, similar to that introduced by Leopold into his high-pressure engine. For this purpose the steam-pipe S, the eduction-pipe E, and the pipes of the upper and lower ends of the cylinder, communicating with it above A and below B the piston, are all brought to the circumference of a single circle, so as to form a St George’s cross, as in fig 66. A metallic circular disc O P O B, with two curved channels communicating at successive quadrants of a circle, as shown in fig. G7, is inserted in this circle, so as to fit it exactly, and to be moved round by a protruding handle H. In fig 68, this valve is represented *in situ,* a communication being formed from S to A, and the other from B to E ; and, in fig. 69, the handle being pushed

down a communication is made betwixt S and B, and between A and E. The means of effecting this commu­nication is given in fig. 70.

A vertical rod T T2 being suspended from the end of the great lever, with two plugs T T2, by means of which the handle H of the valve is raised, in that po­sition the steam enters at S and passes up through the superior passage into the top of the cylinder, forcing the piston down, while the steam already below the piston finds free egress, along the inferior passage B, through the valve, and escapes at the eduction pipe E into the open air.

Just before the piston gets to the bottom of its stroke, the plug T strikes the handle II into the position H2. The steam before let in above the piston suddenly escapes by the port A through the valve into the eduction-pipe E, while by the same motion a connexion has been effected

between S and B, so that the steam now enters below the piston, again to raise it up until the plug T2 strikes the handle H2 upwards once more into the position H as at first, when the piston once more descends ; and this process is repeated to the end.

We shall next describe a kind of valve which is more commonly in use than either of the former, and by which the changes in the direction of the steam are still more

simply effected. In this case all the four passages are united in a square box called a valve-box, or valve-chest, as in fig. 71 ; S E A B being the steam, eduction, upper, and lower passages. Into this box is introduced a

small valve or cover D, fig. 72, which is of such a size as at one time to leave open only one of the three openings on the right; so that, by covering-two of the openings, A and E, as in fig. 73, the steam from S can only find its way through B into the lower part of the engine, while the steam already in the upper part of the cylinder can find its way, below the valve D, into the eduction-pipe E, so as to escape into the air. The valve is next shown in fig. 74 in its middle position, where all the three pas sages are closed, preparatory to reversing the direction of the steam, as in the third position when it slides from the upper part A, as is shown in fig. 75, so as to allow the steam to enter above the piston and press it down, while the steam formerly below the piston escapes into the air through the passage B, under the valve D, by the eduction-pipe E. This valve, named from its figure the D-valve, is also worked by the machine itself, either by some of its moving parts striking plugs on a rod which is fixed to the valve, or by some of the other apparatus which will afterwards be described.

Another form of valve is that called the long slide or long D-valve, the invention of Mr Murdoch, which gives the advantage of shutting off the steam, close to its ingress into the cylinder ; and so saving what in the common short D-slide is lost in the passages from A and B to the ends of the cylinder. It is formed thus. The valve chest extends along the side of the cylinder. It is shown in fig. 76, without the valve. In figure 77 the long D-slide valve is shown separately. It is a pipe extending along the whole length of the cylinder. Towards the ends, this pipe is almost semicircular, its flat side which forms the diameter of the circle, being a narrow flat plate capable of covering the opening or port of the cylinder. This pipe is left open, and perfectly clear from one end to the other, so that steam