in figure 61 the steam is shown entering into the cylinder D to work it. This change is effected by turning round the disc A F into the position R S, which reverses the passages, as will appear on examination. It is to be noticed, that while the steam is entering the cylinder C through A C, the steam from the cylinder **D** is escaping through E F into the open air ; and that in the second sketch of the valves, the steam is passing into the cylinder D through A E, and passing out of the cylinder C through C F. The action of this *four-way stopcock* is very simple and beautiful, and deserves to be carefully studied. By continually turning it round in one direction, communications are simultaneously effected between the boiler and each of the cylinders alternately, and between each cylinder and the open air. We shall afterwards revert to this mechanism.

The modern steam-engine of high pressure is in many respects analogous to the machine of Leupold. It will be readily understood by the study of the few following illustrations. The engine is called double acting, because

the steam not only enters the cylinder below the piston to raise it, but also above the piston forcibly to depress it. The boiler B is placed on the left of the figure ; the pump, for raising water from the reservoir R to the reservoir R\*, is on the right of the figure ; and the cylinder is placed in the middle. From the boiler a *steam-pipe* S S S1 S'i proceeds to the upper and lower parts of the cylinder C ; and from the right hand side of the cylinder two short *eduction-pipes* E1 and E8 carry off the steam into the open air, after it has performed its duty. The piston P is accurately fitted into the cylinder, so as to be air and steam tight, and the piston-rod *p* is made to carry with it the end of the lever L F L, and work the pump W W. Perhaps the only difficulty that is felt in understanding the mechanism of the double-acting steam engine, lies in the construction and operation of the valves. S, S’ El E2 are four plugs, each capable of exactly filling up the passage in which it is placed, like S’ El, or of being withdrawn from it, like Sl Es. Therefore it is evident that in figure 62, the steam has free ac­cess through the upper port Sl, into the cylinder above the piston, so as to press it down. In fig. 63, the case is shown reversed; the valve S1 is shut down, allowing steam to enter only by S', the lower-valve, so as to enter at the bottom of the cylinder and force the piston up.

The arrangement of the eduction

valves El and E2 is also to be ob

served. In fig. 62, where S1 is

open and S2 is shut, E2 is also open,

and E1 is shut ; so that, while steam

enters freely by S1 on the upper

side of the piston, pressing it down,

there is a free passage for escape

of steam from the under side of

the piston, by the bottom passage,

through E2 to the open air; and when

the whole is reversed, as in fig. 63,

the steam-valve S2 at the bottom

being opened for ingress of steam below the piston, E1 gives free egress to what was formerly admitted above, so that it may now pass along the passage E1 into the open air. Thus then, by opening and shutting alternately each of the two pairs of valves, first the under steam-valve and upper eduction-valve, and then the upper steam-valve and under eduction-valve, so as first to allow steam to enter above and escape below, and then to get in below and out above, the one pair being always shut when the others are open, the whole effect is accomplished.

It is an object of great importance to the precision of •a machine's operation, that it should be automatic ; that is to say, that it should not require for its successful action the continual attention and unvarying assistance of an attendant. In the machine which we have just described, the valves are opened and shut by the attendant. With the following simple mechanism the valves are opened and shut by the machine itself :—

The two valves S1 and S2 are connected together by a straight rod, and the two eduction-valves E1 E2 by another straight rod ; these valve-rods are made to rest on opposite ends of a lever *I l,* which turns on a centre O. By this simple arrangement it is brought about that the pair of valves S1 S2 being depressed, as in fig. 64, the other pair E1 E2 are raised; but when, as in fig. 65, S1 S2 are raised, E1 and E2 are depressed, while at the intermediate position both are situated similarly to each other. In the next place it is to be noticed that the rod E1 E2 is prolonged to T upwards, and that it carries two projections fixed to it at M and T. These projections are struck by the lever L L as it rises and falls. When in fig. 64, the lever is making its downward stroke, it comes on the plug M; and pushes it down, first into the middle position, and then into the position of fig. 65. The steam then entering below, raises up the piston to the top of the cylinder, and with it raises also the lever, which striking on the upper plug T, carries it upwards, raising the eduction valves E1 E2, and allowing the opposite valves