45 lbs. on the square inch is called 3 atmos. or 4 atmos.

60 4 5

75 5 6

90 6 7

105 7 8

&c. &c. &c.

Owing to this degree of ambiguity in these technical measures of pressure, it is always necessary to observe and to specify whether the pressure spoken of is pressure total, or excess above the atmosphere of air. If, for example, four atmospheres be specified, it must be considered whether four atmospheres above the pressure of the atmosphere be meant, as in the first column of the table, or four atmospheres including the atmospheric air pressure, in which case the number in the second column is meant ; for, in the former case, high-pressure steam of 60 lbs. on the square inch is meant, and in the latter high-pressure steam of only 45 lbs. above the atmosphere.

Such are some of the various methods by which the elastic force of high-pressure steam in a boiler may he estimated and shown. We have next to consider the manner in which that force may be applied to the useful purpose of forming a high-pressure steam-engine.

We have already seen how the force of steam, confined in a close boiler and heated until it acquires great elastic force or high pressure, acts upon every point of the surface in which it is enclosed, tending to press it asunder; and how, by sufficiently confining and heating it, weights of five, fifteen, or fifty pounds, resting on only a single square inch of surface, may be supported and upraised. To apply this force to the raising of great weights, is the object of the high-pressure steam-engine ; and it has been calculated that 6 lbs. of coal, applied in heating 6 gallons of water into steam, has sufficient force to perform the most arduous labour of a man, for a whole day.

One of the simplest and earliest applications of the force of high-pressure steam to raising weights, is given by Jacob Leupold, in his *Theatrum Machinarum Hydrauli­carum,* Leipzig, 1725. This we have copied from his work in the accompanying figures. We have already seen that the boiler C, fig. 58, being placed on a fire, the elastic force of the steam will raise a weight resting on an aperture. Now, if we conduct the steam in a pipe into any other vessel, such as the cylindrical tube F, in which there is a piston or movable plug D, on the top of which rests the weight E, by a metallic rod E B, connected with the piston, and passing freely through a hole in the top of the cylinder, it is manifest that when the steam becomes strong enough to overcome the pressure of the weight, it will raise up the piston to any required height. If the weight be 15 lbs , and the size of the surface of the piston one square inch, and if the pressure of the steam be equal to any thing more than one atmosphere of elastic force, it will overcome the weight and raise it. If the surface of the piston were double the size, or two square inches in extent, then each inch would be acted on by a force of 15 lbs., and the same elastic force acting on two inches would raise double the weight, or 30 lbs., and so on for any number of square inches ; so that, if the piston were a circle of four inches in diameter, which would have a surface of about 12 square inches, on each and all of which a pressure of 15 lbs. was sustained, there might be a total weight of 12 times 16 lbs., or 180 lbs., sus­tained and raised to the top of the cylinder. The boiler being removed from the fire and allowed to cool down again, the piston might again descend, and this operation be repeated as often as necessary.

But a more convenient form of this apparatus is that which Leupold gives in the next figure,— in which it is un necessary to remove

the fire. The boiler G H, fig. 59, having a constant fire placed under it, the communication with the cylinder ABC takes place through a pas­sage capable of regu­lation by a stopcock S, which is shown at S as shut by turning the handle T. This stopcock is similar to that commonly used for regulating the flow of liquors in vessels of any kind ; a small conical plug S' stops up the passage entirely, but being perforated in one direction, allows the communication to take place whenever that perforation is turned round into such a position as to form a continuation of the channel. By this means it is provided that this stopcock shall remain in the position, S' being closed, until the steam has collected in the boiler a sufficient elastic force, after which it is allowed to pass up into the cylinder, by turning the stopcock into the position S when the steam entering the cylinder pushes up the piston and the piston-rod by which the great weight E is raised as before. The piston will then be allowed to descend to the bottom, by allowing the cylinder gra dually to cool, when the weight may again be raised as at first ; and so on for any number of operations.

But the most perfect of Leupold's machines is that re presented in the following figures, 60, 61. It is a true water pumping high-pressure steam-engine ; a machine which

might be efficiently used without any alteration at the present day, only the modern machines are calculated to do the work with a smaller expenditure of fuel. Two pumps for raising water are directly worked by steam, by connecting the handles of the pumps with the pistons of two high-pressure cylinders, in such a manner, that when the pistons are raised by the steam the water is forced up in the pump-pipe. T and V are the barrels of two pumps placed in a reservoir, from which water is raised through the joint-pipe K ; G arid H are the handles or levers by which the pumps are worked. The pistons of the steam cylinders C and D are attached to the ends of the levers. In figure 60, at A C the steam is shown **in** the act of entering into the cylinder C, and pushing up the end of the lever G, so as to force the water; and