of producing its rotation. In the most common form of the rotatory engine, the cylinder, piston-rod, and cranked axle are superseded by a cylinder, valve, stop, and axis. In the same way as a millwheel is compelled to move in a circle, either by the direct action of water or wind upon it, so is the drum, or wheel, with valves, fans, or other projections on its circumference, urged round by the force of the steam, and, enclosed in an outer cylinder, or ease, gives revolution to an axis to which it is attached. This direct rotatory action of the steam will, it is imagined, give out the effect of the steam more powerfully, uniformly, and economically, than the common mode of reciprocating action when converted by the crank into re volution.

Rotatory engines may be arranged, according to their manner of action, into four classes :—

1st Class—Rotatory engines of simple. emission.

2d Class—Rotatory engines of medial effect.

3d Class—Rotatory engines of hydrostatical reaction.

4th Class—Rotatory engines of the revolving piston.

As closely connected with the rotatory engines, in the fallacy which has given rise to most of them, we may add a series of inventions, forming a

5th Class—Revolving mechanism substituted for the crank.

Class I.—The rotatory engine of simple emission forms the earliest, as well as the most rude and element ary, method of giving motion to mechanism by the escape of vapour or steam. It is described by Hero of Alex andria, in his *Pneumatica,* upwards of 120 years before the Christian era, and depends for its effect upon the same principle which gives to a rocket its career, and makes a fire-wheel revolve in displaying its beautiful lights. In these, as in all instances where fire or steam or any fluid or gas is generated in a chamber, from which it is permitted to issue with violence, it will, in its exit, drive the vessel from which it issues away from it in the opposite direction; and it is, in fact, merely an application of the principle of recoil, where the gas generated by the explosion of the powder urges the hall outwards in one direction, and forces the breech of the gun backwards in the opposite one. The same recoil is felt in all cases of simple emission of a fluid from a reservoir ; and if it be so arranged that water, steam, air, or the gaseous product of gunpowder, rushes out of a chamber through the arms of a revolving wheel, the openings of escape being properly directed, the recoil will urge round the wheel, and we shall have a revolving engine of simple emission. By availing himself of this principle, the machinist of Alexandria produced a working engine, merely by heating a vessel containing water and air, and allowing the vapour to rush from two opposite orifices, at the end of two arms proceeding from a sphere, which the emission was employed to move.

Instead of using the principle of recoil, the force of steam, issuing with violence as we see it from the month of a kettle or boiler, may be directed upon the naves of a wheel so as to blow them round ; and thus we have a second variety in the manner of converting the simple issue of steam into a moving power. This second species of the rotatory steam-engine of simple emission was in vented by Branca. 1629. Since that time the engines of this class have been frequently reinvented and slightly modified.

The theory of machines of simple emission has been frequently and fully investigated ; and the result is, that there is no possibility of obtaining by simple emission, in the most favourable circumstances imaginable, more than one-half of the whole power of the steam, so as to make it available to useful mechanical effect. The other half is wasted in giving off its impulsion to the air, or is ex­

pended in a current equally unavailing. Practical experience corroborates the predictions of theory. Smeaton and Pelectan have made the machine of simple issue the subject of careful experiment:—3 parts out of 11, 8 parts out of 27, and 2 parts out of 5, are the highest measures of the useful effect that it has been found practicable to attain ; and by no possible improvement can more than one-half of the whole power be turned to a useful effect.

Class II.—Rotatory engines of medial effect are those which do not immediately give revolution to an axis, by the action of steam upon the wheel, but have a medium of communication between the power and the effect, which medium is the direct agent in circular motion. This class of engines will ba well understood, by taking as its type any simple steam-machine, such as Savary's or Newcomen’s, used for raising water; which water, by falling on the floats of a common millwheel, will then give rotatory motion to it. The engine of Savary raises water by pressing directly on its surface ; and it is only necessary to allow this water to fall on a wheel, and it will be made to revolve, and form an engine of the second class.

A variety of this class has been invented, of which the Fire-wheel of Amontons is a type. The steam pushes water through certain channels that form the arms of the wheel, from a set of chambers on one side of the wheel, to a corresponding set of chambers on the opposite, and thus the side filled with water preponderates over the other, and the wheel revolves. The water being constantly driven off by the steam from a given side of the wheel to that opposite, uniform revolution is the result of the weight of the water. In this case, although steam is the agent, water is the means of communicating the rotatory motion.

Solids have also been made the medium of effecting rotation in this manner. Weights of solid matter, in the form of pistons, have been transferred by the force of steam to a considerable distance from the centre on one side of a wheel, and drawn nearer to it on the other side, so as, by bringing about a continual preponderance of one side, to effect a revolution. Watt and De Witty have de signed arrangements of mechanism of this nature.

In this class of engines the loss of effect is manifest ; for it is necessary that the steam, in order to produce the circular motion, shall give out its force in setting the medium in motion, and in overcoming the very great *re­sistance* of the liquid in all the pipes and passages and valves, through which it is transmitted to alternate sides of the wheel in every revolution. The force thus subtracted from useful effect, is power lost.

In those which move weights from and towards the circumference, there are mere groups of reciprocating pis­tons, without cranks, and partaking of the defects to be explained in Class V. In fact, itι the engines of Watt and Do Witty of this class, we have a number of reciprocating engines ranged round a wheel to do the work of one.

In the case of the fluid medium we have not only a loss of all the power expended in moving the medium itself, but also the additional loss of effect encountered in all modes hitherto adopted for applying a fluid to the rotation of a wheel; a loss, in the best examples ever presented in practice, amounting of itself to more than 1/6th part of the power.

Class III.—Engines of hydrostatical reaction are more

effective than either of the former classes. As invented by Watt, in 1796, this species of engine consisted of steam-vessels, in the form of hollow rings or circular channels, with proper inlets and outlets for the steam, mounted on horizontal axles, like the wheels and buckets of a watermill, and wholly immersed in some fluid.