“ Lastly, Instead of using water to render the piston or other parts of the engines air and steam tight, I em­ploy oils, wax, resinous bodies, fat of animals, quicksilver, and other metals, in their fluid state.

“ And the said James Watt, by a memorandum added to the said specification, declared, that he did not intend that any thing in the fourth article should be un­derstood to extend to any engine where the water to be raised enters the steam-vessel itself, or any vessel having an open communication with it.”

Such is Mr Watt’s simple account of his beautiful invention—the condenser or refrigerator, which is the characteristic member of the modern steam-engine. The fire-engine of Newcomen possessed only two principal members, to which all the other parts may be considered as mere appendages. The modern steam-engine of Watt consists of three principal members. The two members of Newcomen’s engine are the generating apparatus, by which the steam is produced from the water and conveyed to the second member, or the apparatus of application, where the elastic force of the steam is brought in contact with the piston in the cylinder, so as to produce the motion required for the mechanical effect of the machine, and thus directly applied to the work to be done. The third member, added by Watt, is a refrigerator or condensing apparatus, perfectly separate from and independent of the other two, for reconverting the steam, after it has done its duty in filling the cylinder, into the liquid from which it had Seen originally formed. We have, then, the boiler or generator with its appen dages, the cylinder or applicator with its appendages, and the refrigerator or condenser with its appendages, —the function to be discharged by the first of these being altogether the reverse of the last ; the first producing steam by heat from water, the last producing water from steam by cooling.

The progress of improvement in the steam-engine may be very well illustrated by comparison with an early project of Dr Papin, who, although he contributed no part towards the production of the modern steam-engine, nevertheless exercised his ingenuity curiously, though fruitlessly, upon the project of deriving mechanical power from the motion of a piston in a cylinder, first of all by gunpowder, and afterwards by steam. In Papin’s project, fig. 37, he takes a cylinder, A B C D, containing a piston P, below which he places a fire, so as to generate steam from a little water in the bottom of the cylinder. This steam raises the piston, and it is evident that on the fire being removed, steam will be condensed, and the piston will again be carried to the bottom. Comparing this rude project, in which the steam is alternately produced and recondensed in the cylinder itself, which is alternately warmed and chilled, with the engine of Newcomen, fig. 38, we observe the following important change. The calefaυtion of the water and generation of steam are carried on in a boiler, W now removed to a considerable distance from and totally unconnected with the cylinder, except by a pipe of communication opened and shut alternately. Still, how ever, we have the process of cooling and condensation wholly carried on in the cylinder itself, by means of a jet of cold water

playing therein. But let us now make a third step, and we arrive at the model of a machine acting on the principle of Mr Watt’s, fig. 39. As we have already, in the machine of Newcomen, a separate heating apparatus, W, conducting the steam in a highly rarefied state to the cylinder, so now let us have a vessel, C. placed on the other side, and let this vessel have first been rendered empty or perfectly vacuous by expelling and pumping out the air; and let us also, *for* the sake of experiment, put a few lumps of ice and salt in the inside and on the outside of this vessel, surrounding it on every side; and we shall have a refrigerator as a counterpart to the boiler, and a type of the improvement of Watt.

If we now open the stopcock S. the steam generated in the boiler will rush into the cylinder, pressing the piston upwards; and if the stopcock E be next opened, the stopcock S having been previously shut, the steam in E will instantly escape into the vacuum in the refrigerator, and being condensed into less than a thousandth part of its bulk, will leave the cylinder vacuous. Thus the motion of the piston upwards and downwards is effected by the inventions of Newcomen and Watt, without either applying the fire or the cold directly to the cylinder in which the power is given out. Thus the loss of more than fifty per cent is remedied by the separate condenser of Watt. Papin's scheme was possible but not practicable ; Newcomen’s was practicable but wasteful. Watt's engine is practical, economical, and complete, both in theory and in practice, as it renders available all the power of heat which the steam contains, with the exception only of the very small part consumed in giving motion to the machine itself.

The following figure (40) approaches very closely to the form of Mr Watt’s first engines. Their details are as follows. In the diagram, A represents the cylinder of his earlier engine, B the boiler, and C the condenser, each with its various appendages. The appendages of the boiler B, are of course, *f,* the furnace in which the