STEAM-ENGINES AND OTHER HEAT-ENGINES

1. **A** Heat-Engine is a machine in which heat is employed to do mechanical work. In all practical heat-engines, work is done through the expansion by heat of a fluid which overcomes resistance as it expands—in steam-engines by the expansion of water and water-vapour, in air-engines by the expansion of hot air, in gas-engines by the expansion of a burnt mixture of air and gas. One of the most simple and historically one of the oldest types of heat-engines are guns, in which heat, generated by the combustion of an ex­plosive, does work in giving energy of motion to a projec­tile. But guns differ so widely from all other types, both in their purpose and in their development, that it is con­venient to leave them out of account in treating of engines which may serve as prime movers to other mechanism.

I. Early History of the Steam-Engine.

2. The earliest notices of heat-engines are found in the *Pneumatica* of Hero of Alexandria (*c*. 130 b.c.). Two contrivances described there deserve mention. One is the æolipile, a steam reaction-turbine consisting of a spherical vessel pivoted on a central axis and supplied with steam through one of the pivots. The steam escapes by bent pipes facing tangentially in opposite directions, at opposite ends of a diameter perpendicular to the axis. The globe revolves by reaction from the escaping steam, just as a Barker’s mill is driven by escaping water. Another apparatus described by Hero (fig. 1)@@1 is interesting as the prototype of a class of

engines which long after­

wards became practically

important. A hollow

altar containing air is

heated by a fire kindled

on it ; the air in expand­

ing drives some of the

water contained in a

spherical vessel beneath

the altar into a bucket,

which descends and

opens the temple doors

above by pulling round

a pair of vertical posts

to which the doors are

fixed. When the fire is

extinguished the air cools, the water leaves the bucket, and the doors close. In another device a jet of water driven out by expanding air is turned to account as a fountain.

3. From the time of Hero to the 17th century there is no progress to record, though here and there we find evidence that appliances like those described by Hero were used for trivial purposes, such as organ-blowing and the turning of spits. The next distinct step was the publica­tion in 1601 of a treatise on pneumatics by Giovanni Bat­tista della Porta, in which he shows an apparatus similar to Hero’s fountain, but with steam instead of air as the displacing fluid. Steam generated in a separate vessel passes into a closed chamber containing water, from which a pipe (open under the water) leads out. He also points out that the condensation of steam in the closed chamber may be used to produce a vacuum and suck up water from a lower level. In fact, his suggestions anticipate very fully the engine which a century later became in the hands of Savery the earliest commercially successful steam-engine.

In 1615 Solomon de Caus gives a plan of forcing up water by a steam fountain which differs from Della Porta’s only in having one vessel serve both as boiler and as displace­ment-chamber, the hot water being itself raised.

4. Another line of invention was taken by Giovanni Branca (1629), who designed an engine shaped like a water-wheel, to be driven by the impact of a jet of steam on its vanes, and, in its turn, to drive other mechanism for various useful purposes. But Branca’s suggestion was unproductive, and we find the course of invention revert to the line followed by Della Porta and De Caus.

5. The next contributor is one whose place is not easily assigned. To Edward Somerset, second marquis of Wor­cester, appears to be due the credit of making the first useful steam-engine. Its object was to raise water, and it worked probably like Della Porta’s model, but with a pair of displacement-chambers, from each of which alternately water was forced by steam from an independent boiler, or perhaps by applying heat to the chamber itself, while the other vessel was allowed to refill. Lord Worcester’s de­scription of the engine in his *Century of Inventions* (1663) is obscure, and no drawings are extant. It is therefore difficult to say whether there were any distinctly novel features except the double action ; in particular it is not clear whether the suction of a vacuum was used to raise water as well as the direct pressure of steam. An engine of about two horse-power was in use at Vauxhall in 1656, and the walls of Raglan Castle contain traces of another, but neither Worcester’s efforts nor those of his widow were successful in securing the commercial success of his engine.

6. This success was reserved for Thomas Savery, who in 1698 obtained a patent for a water-raising engine, shown in fig. 2. Steam is admitted to one of the oval vessels A, displacing water, which it drives

up through the check-valve B. When the

vessel A is emptied

of water, the supply

of steam is stopped,

and the steam al­

ready there is con­

densed by allowing

a jet of cold water

from a cistern above

to stream over the

outer surface of the

vessel. This pro­

duces a vacuum and

causes water to be

sucked up through

the pipe C and the

valve D. Mean­

while, steam has

been displacing

water from the other

vessel, and is ready

to be condensed

there. The valves B and D open only upwards. The supplementary boiler and furnace E are for feeding water to the main boiler ; E is filled while cold and a fire is lighted under it; it then acts like the vessel of De Caus in forcing a supply of feed-water into the main boiler F. The gauge-cocks G, G are an interesting feature of detail. Another form of Savery’s engine had only one displacement- chamber and worked intermittently. In the use of arti­ficial means to condense the steam, and in the application

@@@1 From Greenwood’s·translation of Hero’s *Ρneumatica.*