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The Stirling engine

2.1 The invention

In open-cycle engines mechanical work is performed by a quantity of working fluid which is made to undergo successively certain operations, such as induction, compression, heating, expansion, and exhaust. On the other hand, in closed-cycle engines these phases merge into each other, and while part of the working fluid may be heated in one part of the engine, in another part it may simultaneously be cooled. Thus the process is rather more difficult to understand. The invention of the closed-cycle external combustion engine by Stirling in 1816 is therefore probably one of the most amazing innovations that has ever been made. It was so much in advance of scientific knowledge at the time that at least 30 years passed before anyone was in a position to understand what made the engine work at all. Nearly 100 years later engines were still 'invented', which, due to lack of understanding of the fundamental principles, missed such essential features as the provision of a regenerator, or compact cylinder arrangement, whose importance Stirling must have realized intuitively. This invention was made by the Reverend Robert Stirling, D.D., of Cloag, Methwin, Perthshire, when he was 26 years old and had just been ordained to his first parish. Robert Stirling's family produced a number of prominent engineers over several generations, from his grandfather, Michael Stirling, inventor of the first rotary threshing machine in 1756, to his four sons, all of whom became well known, mainly as railway builders, in places as far apart as Honolulu, Chile, and Scotland. The original patent, No. 4081 of 1816, had the obscure title 'Improvements for Diminishing the Consumption of Fuel, and in particular an Engine capable of being Applied to the Moving (of) Machinery on a Principle Entirely New'. In it Stirling not only described the construction and use of a regenerator for the first time in history, but also foresaw its principal applications, such as for glass furnaces or iron smelting. It also included a description of the first closed-cycle hot-air engine, as shown in Fig. 2.1. This is reproduced, with minor corrections, from the original patent specification (London version). It should be noted that this engine was considered by Stirling to be a logical development based on the regenerator, a fact sadly neglected by later innovators. Even today, the working principle of this original Stirling engine – as that of many later engines based on this prototype – is obscure. Diagrams explaining the working principle are therefore shown here in Fig. 2.2. On the right,

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