THE HEAT ENGINE PROBLEM

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BY

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INTRODUCTION.

IT is now a good many years since the first proposition was made for obtaining work by the heat-transforming action of a perfect gas and though each process as it appeared has been more or less completely worked out by those interested in it to show the possibilities of the system and compare it with others yet no investigation of all systems with their mutual relations has ever been made by a general method. This is desirable because no comparisons can be justly drawn otherwise and it is, unfortunately, true that invariably in the past the best conditions of one system have been selected for comparison with some other system working under indifferent conditions. This may not have been done intentionally, in fact it appears that in many cases the comparison seemed perfectly just to the author but the results are almost valueless as bases of generalization for the purpose of reaching clear notions of comparative value.

A commonly used mode of comparison considers different cycles working through the same temperature range whereas equal quantities of heat for each case will result in different temperature ranges and it is pretty clear that comparisons should be made on the basis of some initial conditions one of which is the heat supplied.

A perfect gas will transform heat into work and considering the gas alone without reference to any engine the fraction of the heat that is transformed is dependent on the relation both in sequence and extent of the operations of heating, cooling, expansion and contraction—in short is dependent on the cycle first and the extent of each cyclic phase secondly. It is first required to find out just how much heat energy will be transformed by each cycle and if other things are equal one should be the best for application to engines. But in this comparison we should consider not only which cycle transforms the largest amount of the heat energy supplied to it into work but also through just what range of pressures, volumes and temperatures these cycles must operate to produce the work This comparison will be purely mathematical and will, when completed, enable us to select the best cycle or best two cycles as the case may be, *i. e.*, that one or those two cycles that promise the best returns for the labor spent on designing mechanism to execute the cyclic changes.

Having made the mathematical selection of the cycles best adapted to our purpose we are called upon to consider how to heat or cool to cause expansion or contraction with the means at our command and at the rate required. This second part involves all questions of possibility or practicability of doing what seemed mathematically to be desirable.

To place each of the cycles in proper relation each with the other and to show the physical possibility of executing those promising good returns as power generators is the general problem. More particularly the question resolves itself into a search for an effective competitor of the Otto cycle engine which now is the only good heat engine of the perfect gas sort.

As the work progressed beyond the mathematical analytic stage there appeared a cycle which promised good returns for any labor expended on its development but which has been comparatively neglected. The latter part of the work is taken up with a study of physical and engineering problems entering into the execution of this theoretically desirable cycle in engines and includes the determination of many of the physical constants necessary for computation of designs. In this part also there is set down all the difficulties to be encountered and both the solutions obtained and the need of solutions for those questions still open are noted.

Résumé of Work and Results.

The work was taken up in detail as follows, and each section brought to a successful conclusion except where otherwise stated:

PART I.

New Classification of Cycles and Diagrams of Same in P. V. & $\theta\phi$ Coördinates.

Cycle I Isometric heating; adiabatic expansion; isopiestic cooling.

Cycle IA Isometric heating; adiabatic expansion; isometric cooling; isopiestic cooling.

Cycle IB Isometric heating; adiabatic expansion; isothermal cooling; isopiestic cooling.

Cycle IC Isometric heating; adiabatic expansion; isothermal cooling.

Cycle II Adiabatic compression; isometric heating; adiabatic expansion; isopiestic cooling.

Cycle IIA_2 Adiabatic compression; isometric heating; adiabatic expansion; isometric cooling.

Cycle IIA_1 Adiabatic compression; isometric heating; adiabatic expansion; isometric cooling; isopiestic cooling.

Cycle IIB Adiabatic compression; isometric heating; adiabatic expansion; isothermal cooling; isopiestic cooling.

Cycle IIC Adiabatic compression; isometric heating; adiabatic expansion; isothermal cooling.

Cycle III Adiabatic compression; isopiestic heating; adiabatic expansion; isopiestic cooling.

Cycle IIIA Adiabatic compression; isopiestic heating; adiabatic expansion; isometric cooling; isopiestic cooling.

Cycle IIIB Adiabatic compression; isopiestic heating; adiabatic expansion; isothermal cooling; isopiestic cooling.

Cycle IIIC Adiabatic compression; isopiestic heating; adiabatic expansion; isothermal cooling.

Cycle IV Adiabatic compression; isothermal heating; adiabatic expansion; isopiestic cooling.

Cycle IVA Adiabatic compression; isothermal heating; adiabatic expansion; isometric cooling; isopiestic cooling.

Cycle IVB Adiabatic compression; isothermal heating; adiabatic expansion; isothermal cooling; isopiestic cooling.