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D E C I S I O N
of 29 April 1997

Case Number: T 0962/96 - 3.2.4

Application Number: 92200926.1

Publication Number: 0563456

IPC: F02B 41/06

Language of the proceedings: EN

Title of invention:
Combustion engine of high efficiency

Applicant:
Berg, Tore Gustav Owe

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 83

Keyword:
"Disclosure - sufficiency - (no)"

Decisions cited:
-

Catchword:
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Case Number: T 0962/96 - 3.2.4

D E C I S I O N
of the Technical Board of Appeal 3.2.4
of 29 April 1997

Appellant: Berg, Tore Gustav Owe
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 10 July 1996 refusing European patent application No. 92 200 926.1 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: C. A. J. Andries
Members: H. A. Berger
J. P. B. Seitz

Summary of Facts and Submissions

I. The Appellant (Applicant) has lodged an appeal against the Examining Division's decision of 10 July 1996 to refuse European patent application No. 92 200 926.1 for failure to disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (Article 83 EPC). The appeal was received on 7 September 1996 on which date also the appeal fee was paid. The statement of grounds of appeal was received on 21 October 1996.

II. Independent Claims 1 and 3 under consideration and as originally filed are worded as follows:

"1. Combustion engine of high efficiency comprising two cylinders with a channel between them, each cylinder containing a sliding piston, said pistons being coupled in such a manner that they move syncronously and in opposite directions so that the volume between the two pistons is always the same, said volume containing a gas at a pressure and a temperature that are higher than those of the ambient air, said gas being continuously or intermittently transferred back and forth between the two cylinders, while the temperature of the gas in the cylinder of increasing volume is maintained substantially constant by injection of a fuel and oxygen or air, or the hot gaseous combustion products thereof, and the pressure of the gas in the cylinder of increasing volume is maintained substantially constant by the supply of gas from the cylinder of decreasing volume, and while an amount of gas equal to the injected amount of heating gas is exhausted from the cylinder of decreasing volume, each cylinder being provided with an inlet and an outlet for injection of heating gas and exhaust of added gas, respectively."

"3. Combustion engine of high efficiency comprising a stator and a rotor, the stator being shaped as a duct in the form of a closed circle, at least one vane being fastened to the rotor and sliding in the duct, the duct being filled with a gas at a pressure and a temperature greater than those of the ambient air, said gas streaming in the duct in the direction of the moving vane or vanes, the gas behind the moving vane or vanes being maintained at a substantially constant temperature by injection of a fuel and oxygen or air, or the hot gaseous products thereof, behind the moving vane, and the gas behind the moving vane or vanes being maintained at a substantially constant pressure by the supply of gas from in front of the moving vane or vanes, while an amount of gas equal to the injected amount of heating gas is exhausted from in front of the moving vane, an inlet and an outlet being provided for the injection of heating gas and exhaust of added gas, respectively."

III. In a communication dispatched on 3 January 1997 the Board stated the reasons why in its view the application fails to meet the provisions of Articles 52(1), 57 and 83 EPC and informed the Appellant about the Board's intention to reject the appeal.

IV. The Appellant argues with regard to the first instance's reasons, which conclude that the pistons would not at any time be subjected to differential pressures sufficient to make the engine turn, that it is within the skill of the person skilled in the art to arrange valves and adjust the flow areas in different channels etc. in order to prevent the heating gas from passing directly to the exhaust (see page 6, penultimate paragraph of the statement of grounds dated 16 October 1996). In the Appellant's opinion the pressure will not be exactly the same everywhere in the volume between the moving pistons and therefore an exchange of the gas between, and movement of, the two pistons can be effected. In support of this argument he refers to two scientific papers, "Experimental Studies of Shock Waves from Detonating Explosives" and "Collisions in Washout". In response to the communication of the Board he filed a third paper titled "The entropy of transformation".

The Appellant thus asserts that the combustion engines of his application result in a high thermal efficiency, mainly due to the fact that heat losses via cooling and exhausted gas are avoided. In structural terms this is attainable by using two work cylinders interconnected by a channel and with two coupled, but 180° phase-shifted pistons. The Appellant explains how the essential substantially-constant-pressure, substantially-constant-temperature gas behaviour in the cylinder of increasing volume is to be effected and how this should result in all heat being converted into work.

Therefore, the Appellant considers Article 83 EPC to be met, implying that only features well known to the skilled person, e.g. how to start a combustion engine, how to control the ignition and the supply of fuel and air, etc. need to be combined with the teachings of the invention in order to put the claimed invention into practice.

V. Request

The Appellant requests that the contested decision be set aside and a European patent be granted on the basis of the originally filed documents.

Reasons for the Decision

1. The appeal is admissible.

2. *Disclosure of the invention (Article 83 EPC)*

2.1 The invention according to independent Claim 1 relates to a cyclically working combustion engine, i.e. a machine involving a closed cycle process. The engine is claimed to reach a superior degree of thermodynamical efficiency in converting heat into mechanical work (the thermal efficiency of the engine may exceed 90%, according to page 4, line 56 of the published application). This is stated to be attained by avoiding the usual heat losses incurred through cooling. Heat losses via the exhaust gas are minimised by recirculating a substantial amount of gas between the two interconnected cylinders so that the exhaust gas of a work stroke in the first cylinder becomes the working gas of the following work stroke in the second cylinder. Gas is transferred back and forth between the cylinders by the mechanically interconnected pistons.

2.2 The invention however is not disclosed in a manner sufficiently clear to be carried out by a person skilled in the art (Article 83 EPC).

2.3 Observations of nature and extensive experimentation have led to the formulation of the commonly acknowledged laws of thermodynamics.

The first law of thermodynamics reads: Energy cannot disappear or appear - the sum of (internal) energy remains constant.

The second law of thermodynamics may be formulated in various ways, e.g:

(a) On its own, heat can never transfer from a lower temperature to a higher temperature, or

(b) A cyclically working machine that alone draws heat from a single heat reservoir and from that heat produces mechanical work is impossible.

2.4 It is an acknowledged fact that even under ideal (i.e. unrealistic) circumstances it is not possible to make a cyclically working machine which in terms of thermodynamical efficiency exceeds the so-called Carnot efficiency factor. This factor has been derived from the (ideal) Carnot closed cycle process which consists of isothermal expansion under heat supply, adiabatic expansion (i.e. isentropic), isothermal compression under cooling and adiabatic compression (i.e. isentropic).

2.5 If depicted in a T-s diagram (T in °K on the ordinate, s in J/°K on the abscissa) the Carnot cycle is represented by a rectangle whose 'horizontal', parallel upper and lower sides represent the isothermal processes and whose parallel, 'vertical' sides represent the adiabatic processes. The area enclosed by the rectangle represents the energy output of this closed cycle process. The pure thermodynamical efficiency (i.e. excluding the inevitable mechanical losses of a real life construction) of the Carnot cycle is $n_c = 1-(T_2/T_1)$ where T_2 is the lower temperature of the process, i.e. at isothermal compression and T_1 the higher temperature of the process, i.e. at isothermal expansion. The Carnot factor gives the upper limit for the portion of supplied heat that can be converted into mechanical work in a system working cyclically between temperatures T_1 and T_2. It is noteworthy that the efficiency increases with increasing temperature differential (T_1 minus T_2), that the higher temperature cannot exceed the temperature of the heat reservoir supplying heat to the process, and that the lower temperature must at least equal the temperature of the heat drain used for cooling.

2.6 A given closed cycle process - including the one claimed in the present application - must be able to be represented in a T-s diagram as a closed figure simply because otherwise it would not relate to a repeatable, cyclical process. Evidently it must be possible to circumscribe this closed figure - irrespective of its actual shape - by a 'rectangular' Carnot cycle working between the same two temperature limits. This shows that the efficiency of a real life cycle can never surpass (or even reach) the Carnot cycle efficiency. Keeping in mind that the entropy s is represented on the abscissa it is furthermore evident that a closed cycle process necessarily must include process(es) of decreasing entropy. Therefore the closed cycle heat input during the increasing entropy process(es) always **exceeds** the maximum attainable closed cycle work output because heat is irretrievably given off or lost during the process(es) under decreasing entropy in order to produce external work. In a T-s diagram the latter loss is illustrated by the fact that there is always an 'area' between the curve segment(s) representing the decreasing entropy process(es) and the abscissa. Thus, in reality in a closed cycle process **heat is never fully convertible into work**. The lost heat, in accordance with the first law of thermodynamics, takes the form of heat given off to the surroundings at the lower temperature level, and - according to the second law of thermodynamics - this heat cannot spontaneously return to the higher level, i.e. with repect to the closed cycle process in question this heat is irrevocably lost.

2.7 The T-s diagram shows that an isothermal expansion process (at the highest possible temperature) represents the best possible heat-to-work transformation and that an isothermal compression process (at the lowest possible temperature) minimises the inevitable heat loss to the surroundings. The diagram also shows that the larger the working interval temperature difference, the larger is the thermodynamical efficiency of the process and vice versa. In the extreme case of no temperature difference at all, the thermodynamic efficiency is zero and no external work can be produced.

2.8 According to Claim 1 of the present application, the engine functions according to a repeated, combined isothermal-isobaric expansion process. The isothermal part of this combined process is stated to be attainable by supplying heat in the form of hot (combustion) gas to the cylinder of increasing volume, and the isobaric part should be attainable by transferring to the same cylinder 'exhaust' gas from the cylinder of decreasing volume. After one full expansion stroke in the first cylinder heat injection is switched to the other cylinder and the expansion process is repeated. 'Surplus' matter corresponding to the injected amount of heated matter is exhausted from the cylinder of decreasing volume, so that the amount of matter in this 'open' system in actual fact may be considered constant. A consequence of the described process is that the state of gas (temperature and pressure) in the cylinder of increasing volume is identical at the beginning and at the end of the expansion stroke. Reverting to the fact that the engine temperature is implied to be by and large constant and that the "...heat in the exhaust is substantially completely utilized..." this clearly implies that no cooling takes place, in particular no cooling of the recycled exhaust gas during compression thereof. In a T-s diagram, therefore, the disclosed process cycle defines no area. In other words, the mere fact that no cooling is effected during said process means that from a thermodynamical point of view useful work could not possibly be derived from the claimed process.

2.9 However, also reservations of a more general, mechanical character exist concerning the feasibilty of the disclosed process. These reservations concern the mechanical work pattern of the engine, in particular how motion at all is effected. The state of the gas in the cylinder of increasing volume has the same pressure and temperature at the end of the expansion stroke as at the beginning thereof. Moreover, this gas is subsequently substantially completely transferred to the other cylinder for use in a renewed expansion process. Hence, the end state of the gas at the end of an expansion process in one cylinder equals the initial state of the gas in the following expansion process in the next cylinder. The cylinders are connected via an open (but possibly constricted) channel. This means that the effective pressures acting on the two equally large piston areas must also be equal, but oppositely directed. In these circumstances no differential force is created and no movement appears possible. Seemingly, this is not altered by the claimed supply of heat to the cylinder which is to perform the next expansion stroke under increasing volume. It is true that if the channel were closed, and gas corresponding (at least) to the injected amount of gas were continuously allowed to escape from the cylinder of decreasing volume, then the supply of heat in the form of an injected amount of hot gas to the cylinder of increasing volume would result in a (relative) pressure increase in said cylinder and therefore possibly also in movement of the pistons. Concerning the channel, however, it appears that opening thereof would only serve to impede such movement to the point where no movement at all would be possible. Firstly, if the channel were open at all times then the cylinders would constantly be connected and the pressures would be equal - at least to such an extent that no useful movement could be attained. Secondly, if the channel were opened at some stage before the end of a movement resulting from a pressure differential as accounted for above, this would appear to result in no more than 'premature' ending of such movement because once the channel was open this would result in equal pressures in the two cylinders. Moreover, in these circumstances (open channel) it does not appear plausible that any gas at all should be able to transfer from the cylinder of decreasing volume to the cylinder of increasing volume because it appears mandatory that the pressure in the cylinder of increasing volume always exceeds that in the other cylinder - otherwise useful piston movement would be impossible. Although small pressure and temperature differences may exist locally and temporarily in the gas volume between the two pistons, such differences are incapable of being used to produce any useful piston movement.

2.10 In conclusion, the engine according to Claim 1 relies on a process infringing the laws of nature, in the present case laws of both thermodynamics and mechanics. The same applies to the engine according to Claim 3 which relies on the same 'impossible' process and pressure conditions, respectively, although carried out in a rotary type engine.

2.11 Pursuant to Article 83 EPC an invention must be disclosed sufficiently clearly to allow the skilled person to carry out the invention. Since the basic process cycle does not obey the laws of nature, it is impossible for a person skilled in the art to carry out the invention with the help of the teaching disclosed in the present application. Therefore, the requirements of Article 83 EPC are not met.

2.12 The Appellant has briefly referred to the above identified scientific papers (see section IV) but has failed to make any explicit references to text passages supporting his arguments. The Board has studied these papers but has found no reason to consider them of more than marginal relevance in the present circumstances.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

N.Maslin C. Andries