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D E C I S I O N
of 26 November 1996

Case Number: T 0026/96 - 3.2.4

Application Number: 89901184.5

Publication Number: 0397710

IPC: F02F 3/22

Language of the proceedings: EN

Title of invention:
Engine including a piston member having a high top ring groove

Patentee:
CATERPILLAR INC.

Opponent:
AE Goetze Automotive Ltd

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - yes"

Decisions cited:
T 0204/83

Catchword:
-

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Case Number: T 0026/96 - 3.2.4

D E C I S I O N
of the Technical Board of Appeal 3.2.4
of 26 November 1996

Appellant: (Opponent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 10 November 1995 rejecting the opposition filed against European patent No. 0 397 710 pursuant to Article 102(2) EPC.**

Composition of the Board:

Chairman: C. A. J. Andries
Members: M. G. Hatherly
J. P. B. Seitz

Summary of Facts and Submissions

I. The decision of the opposition division to reject the opposition against European patent No. 0 397 710 was dispatched on 10 November 1995.

The appellants (opponents) filed an appeal against this decision on 8 January 1996, paid the appeal fee on 8 January 1996 and filed the Statement of Grounds of Appeal on 8 March 1996.

II. Claim 1 as granted reads as follows:

"An engine (10) of the type having a block (12, 14) defining an upper bore (34); a cylinder liner (48) located in the block bore (34) and defining a piston bore (54); a cylinder head (16) connected to the block (12,14); a piston assembly including a steel piston member (78) disposed for reciprocation in the piston bore (54), the steel piston member (78) having an upper portion (96) of substantially cylindrical shape and a preselected diameter D, a peripheral top end surface (98), a recessed crown surface (100), a tubular wall (108) depending from the top end surface (98) and defining an outwardly facing top land (110), a top ring groove (112) disposed a preselected minimal elevational distance TRH from the top surface (98), a lower end surface (124), and an annular inwardly facing wall surface (126) extending upwardly from the lower end surface (124), the upper portion (96) further including an annular outwardly facing wall surface (128) and a downwardly facing transition portion (130) smoothly joining with the inwardly and outwardly facing wall surfaces (126, 128) to collectively define an annular downwardly facing cooling recess (132), the piston member (78) also having a lower portion (158) including

a pair of depending pin bosses (160) smoothly joining with the outwardly facing wall surface (128) of said cooling recess (132) and individually defining a bore (168) and with the bores (168) being aligned on a common axis (84); and an annular recess (38) defined between the cylinder liner (48) and the block (12, 14) that, in use, receives a liquid coolant; characterised in that: the piston member is capable of withstanding an operating combustion chamber pressure of above substantially 13,790 kPa; the ratio TRH/D is less than 0.06; the top of the cooling recess (132) is located in an elevationally aligned relationship with the top ring groove (112); and the top of the annular recess (38) is located in an elevationally aligned relationship with the top ring groove (112) when the piston member (78) is at top dead center in order to dissipate heat away from the piston member (78) thereat."

III. The following documents were referred to during the appeal proceedings:

D0 US-A-4 056 044

D1 GB-A-554 918

D2 AE Group Symposium 1986, Paper No. 6, "Improved Piston Designs for Heavy Duty Diesel Applications", AE PLC

D3 AE Group Symposium 1986, Paper No. 7, "The Development of a Lightweight Steel Piston", AE PLC

D4 US-A-4 638 769

D9 British Standard Specification 3526 of 1962 "Specification for dimensions of wet type cylinder liners for i.c. engines", pages 1 to 29, British Standards Institution, London

IV. Each party made an auxiliary request for oral proceedings and attended the oral proceedings which took place on 26 November 1996.

In the appeal proceedings the appellants argued that the subject-matter of claim 1 as granted lacked inventive step over the documents D0, D2 and D3 taken together or alternatively over the documents D1 and D3 (and if necessary) D2 taken together.

The respondents (proprietor of the patent) essentially countered the appellants' arguments.

V. The appellants request that the decision under appeal be set aside and the patent revoked.

The respondents' main request is for dismissal of the appeal (which would mean maintaining the patent as granted). Their auxiliary request is to set the decision aside and to maintain the patent amended, with the wording "the liner is a midsupported liner" added to claim 1 as granted.

Reasons for the Decision

1. The appeal is admissible.

2. *Interpretation of claim 1 as granted (the main request)*

2.1 The wording "the steel piston member (78) having ... a peripheral top end surface (98), a recessed crown

surface (100)" in lines 15 to 19 of column 10 means that the recess at the top end of the piston member is crown shaped (see Fig. 1) and not merely that there is a recess in the crown (i.e. top end) of the piston member.

2.2 Because of the word "cooling" in the expression "annular downwardly facing cooling recess 132" of the piston member (see claim 1 at column 10, lines 33, 37 and 47), the board concludes, particularly in view of the problem to be solved and with the agreement of the respondents, that the claim is to be interpreted as meaning that cooling inside the piston member is provided.

2.3 The board sees the statement in column 10, lines 43 to 45 that "the piston member is capable of withstanding an operating combustion chamber pressure of above substantially 13,790 kPa" as a functional restriction, the fulfilment of which is due to the other features of the claim.

3. *Novelty - claim 1 as granted (the main request)*

No prior art document on file discloses all the features of claim 1 as granted. This is not disputed by the appellants. Accordingly the subject-matter of claim 1 as granted is considered as new within the meaning of Article 54 EPC.

4. *Closest prior art, problem and solution - claim 1 as granted (the main request)*

4.1 The present invention is concerned with the need to transfer heat developed in the combustion process away from the region near the top ring groove in all positions of the piston and proposes to do this by providing for heat transfer, firstly, radially

outwardly to an annular recess between a cylinder liner and the engine block and, secondly, radially inwardly to a cooling recess in the piston itself.'

4.2 Document D1 is also concerned with the transfer of heat from the piston but chooses to limit the heat flow towards the piston skirt a with the piston rings by making the connecting ring of metal at e with a restricted depth (see page 2, left hand column, lines 38 and 39) while maximising heat flow towards the piston skirt c by making the cross sectional area at h relatively large (see page 2, left hand column, lines 50 to 58). What little heat has to be transferred from the region near the top ring groove a^1 is transferred outwardly to the cool cylinder wall f rather than radially inwardly since the gap g is not a cooling recess because oil would be present in this gap only for lubrication and in an insufficient amount for cooling.

4.3 Document D0 on the other hand is specifically concerned with piston crown cooling, see column 3, lines 55 to 57. Heat is transferred from the ring groove region outwardly to the cylinder liner 12 and inwardly to a chamber 67 in the piston body 48 which is supplied with cooling oil from nozzle 26, see Figure 1, column 2, lines 49 to 53, and column 3, line 23.

4.4 Thus the arrangement of document D0 is more like the arrangement of the present invention than is the arrangement of document D1. It must also be borne in mind that document D1 is more than 30 years older than document D0 and that in the meantime there has been considerable activity in the piston field to raise output, pressure and temperature.

4.5 Accordingly the board finds that document D0 and not document D1 is the most appropriate starting point for the present invention.

4.6 The board sees the problem facing the skilled person starting from the disclosure of document D0 as being to improve combustion efficiency.

4.7 By ensuring that the piston member can withstand a higher operating combustion chamber pressure, the engine can be designed to run at a higher pressure and so the combustion efficiency can be increased. The combustion efficiency can also be improved by reducing the crevice volume above the piston member's top ring to the top of the piston member. This cannot be done however unless the cooling around the top ring is improved. Accordingly, in the claimed engine, this is done in two ways. Firstly the top ring groove is located at the same height as the top of the annular downwardly facing cooling recess in the piston member. Secondly the top ring groove, when the piston is at top dead centre, is at the same height as the top of the annular recess between the cylinder liner and the bore of the engine block. Heat transfer radially inwardly and outwardly from the piston member top ring groove is thus maximised because there is a direct path of minimum length from the groove to the annular downwardly facing cooling recess in the piston member and, at all points in the engine cycle, there is a direct path of minimum length from the groove to the liquid coolant in the liner-block recess. These features cannot be examined in isolation from each other, it is the combination which provides the improved cooling necessary to make possible the raising of the top ring groove to the required level, which is defined by the claimed ratio TRH/D.

4.8 Thus the board is satisfied that the features of claim 1 as granted and in particular those of its characterising portion provide a solution to the problem of increasing combustion efficiency.

5. *Inventive step - claim 1 as granted (the main request)*

5.1 Starting from document D1

5.1.1 If, as argued by the appellants but despite the reasons given in sections 4.1 to 4.5 above, the skilled person were to start from the disclosure of document D1, he would see that the drafter of document D1 was concerned with the dimensions e and h on the Figures, see section 4.2 above, and not with the position of the top ring groove a^1 relative to the piston top surface, to the top of the gap g and to the cylinder wall. It is thus impermissible to measure the schematic Figure 1 of document D1 and calculate the TRH/D for the piston therefrom (see section 4 of decision T 0204/83, OJ EPO 85, 310). Still further, even if Figure 1 appears to approach in various respects what is specified by claim 1 as granted, because the relationships do not appear to be important there is no reason for the skilled person to retain these relationships when redesigning the engine for some reason.

5.1.2 Lines 56 and 57 of page 2 of the document D1 refer to a "cool cylinder wall" and it may well be that cooling was provided outside the cylinder wall f shown in Figure 1. However the cylinder wall f blends into the top part of the engine block with a curve which results in a thickening of the cylinder wall f at the elevation of the top ring groove, indicating that the skilled person did not realise the importance of a short path from the top ring groove to the coolant in the engine block (if coolant was indeed provided).

Furthermore, apart from the fact that no internal cooling in the region g is indicated, and an internal cooling even seems to be impossible due to the circumferential part having the thickness h, it is clear that the gap g is only present to isolate and thus restrict the heat from the combustion chamber reaching skirt portion a.

5.1.3 If the skilled person wishing to modify the engine disclosed by document D1 were to consult document D2 he would learn that alternatives to aluminium alloy such as cast iron or steel can be used for piston manufacture (see document D2, page 6.1, section 1). He would also learn that there is a trend to locate the top groove as high on the piston as possible for reasons of fuel economy and emissions (see page 6.3, section 6) and that calculations have been made to predict the temperatures at various places on pistons for top rings located at 16% and 8% of piston diameter below the crown (the equivalent upper limit given by claim 1 as granted being 6%) and even in the headland position although for this position the document points towards reinforcing the top ring groove with ceramic or metal fibre. Due to its improved cooling, the piston of the present invention however needs no such top ring reinforcement.

Figure 6.15 of document D2 shows a piston with an internal recess and a high top ring, but

- firstly, it is impermissible to derive from the Figure by measurement whether the claimed TRH/D ratio is satisfied,

- secondly, the crown of this piston is of cast iron not steel as required as claim 1 as granted, and

- thirdly, the piston is shown in isolation with no information about the engine bore in which it is to be installed, whether this might have a cylinder liner and, if so, what the relative elevations of the top of the liner recess and the piston top groove at top dead centre position might be

Document D2 deals mainly with aluminium alloy and cast iron as piston materials. Being a paper for a symposium, it presents many ideas for piston design without envisaging that all ideas could be incorporated in a single piston. Even mosaicing the ideas in the document and combining them with the teaching of document D1 would not lead the skilled person to the subject-matter of claim 1 as granted.

5.1.4 Document D2 mentions the use of steel but refers the reader in this respect to document D3. The appellants argue that Table 6.2 of document D2 indicates that low thermal conductivity can lead to raised ring positions, Table 6.3 of document D2 and Table 7.2 of document D3 teach that the thermal conductivity of steel is less than that of cast iron, and so that the use of steel would lead to a still higher ring position.

However document D3 presents very different piston designs to that shown in Figure 6.15 of document D2. The cooling recess of the steel piston shown in each of Figures 7.2 and 7.4 to 7.7 extends far above the top ring groove. Indeed it cannot be assumed that a general piston design will be retained when the piston material is changed, e.g. section 7 of document D2 points out that the wall thickness is reduced when changing from aluminium alloy to ferrous materials.

5.1.5 The skilled person starting from document D1 would need to pick just the specific ideas from documents D2 and D3 necessary to take him towards the claimed engine, while rejecting all the ideas that would lead him away from the necessary path. Moreover, even though cylinder liners (and indeed midsupported cylinder liners) are well known (e.g. from document D4 so that the citation of document D9 was superfluous), the skilled person must make the choices to employ a cylinder liner in his engine construction and to locate the top ring groove at piston top dead centre position level with the top of the liner-block recess.

The board does not consider that the skilled person would make all these particular choices, since there is no clear information in the documents D2 and D3 to lead him to do so. The documents present too many alternatives which would lead him in other directions.

5.2 *Starting from document D0*

5.2.1 Figure 1 of the closest prior art document D0 shows the top ring groove 54 of the piston main body 48 to be out of alignment both with the top of the main body annular outer chamber and with the top of the recess between the cylinder liner 12 and the engine block 10. Moreover while the document gives no concrete information as to the ratio of the distance TRH between the top of the piston main body 48 and the top ring groove 54 to the diameter D of the piston, the Figures imply that the top ring groove 54 is located rather low on the piston main body 48 and so would not yield the TRH/D ratio necessary to satisfy claim 1 as granted.

5.2.2 While the skilled person starting with the engine according to document D0 might be led by other prior art documents and pistons to considering locating the top ring groove higher on the piston body, there is no

reason to suppose either that he would locate it level with the top of the piston cooling outer chamber 67 or that he would locate it high enough to yield the required TRH/D ratio. Moreover, it does not seem that the top dead centre position of the piston main body 48 could be the position shown in the schematic Figures 1 and 2 and therefore raising the top ring groove 54 would move it above the top of the recess between the liner 12 and the engine block 10 at the top dead centre position. The outward radial cooling from the top ring-groove would then not be optimal. To lower the top dead centre position to achieve alignment of the top ring groove and the top of the recess would result in a larger dead space above the piston main body, counteracting the reduction of the crevice volume.

5.2.3 The board considers that, for similar reasons to those given in sections 5.1.3 to 5.1.5 above, the addition of the teachings of documents D2 and D3 still would not bring the skilled person to the subject-matter of claim 1 as granted in an obvious way.

5.3 Thus the board cannot see that the prior art documents on file, on their own or in combination, could lead the skilled person in an obvious manner to arrive at the engine specified in claim 1 as granted.

6. The subject-matter of claim 1 as granted (forming the basis of the respondents' main request) is thus patentable as required by Article 52 EPC. The patent may therefore be maintained unamended with this independent claim and claims 2 to 10 which are dependent on claim 1.

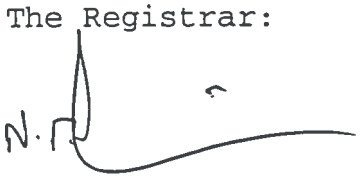
7. Accordingly the respondents' auxiliary request need not be considered.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:



N. Maslin C. Andries