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**Datasheet for the decision  
of 18 September 2019**

**Case Number:** T 2400/16 - 3.2.04

**Application Number:** 06735815.0

**Publication Number:** 1851421

**IPC:** F02B71/00, F02B75/04,  
F02D15/02, F02D41/30

**Language of the proceedings:** EN

**Title of invention:**

A FOUR-CYLINDER, FOUR-CYCLE, FREE PISTON, PREMIXED CHARGE  
COMPRESSION IGNITION, INTERNAL COMBUSTION RECIPROCATING PISTON  
ENGINE WITH A VARIABLE STROKE

**Applicant:**

Fitzgerald, John W.

**Headword:**

**Relevant legal provisions:**

EPC Art. 56

**Keyword:**

Inventive step - after amendment - (yes)

**Decisions cited:**

**Catchword:**



**Beschwerdekammern**  
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Case Number: T 2400/16 - 3.2.04

**D E C I S I O N**  
**of Technical Board of Appeal 3.2.04**  
**of 18 September 2019**

**Appellant:** Fitzgerald, John W.  
(Applicant) 2827 River Trace Circle  
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**Representative:** Miller, James Lionel Woolverton  
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**Decision under appeal:** **Decision of the Examining Division of the  
European Patent Office posted on 18 May 2016  
refusing European patent application No.  
06735815.0 pursuant to Article 97(2) EPC.**

**Composition of the Board:**

**Chairman** S. Oechsner de Coninck  
**Members:** G. Martin Gonzalez  
C. Heath

## **Summary of Facts and Submissions**

I. The appellant (applicant) lodged an appeal, received on 30.06.2016, against the decision of the examining division, dated 18 May 2016, refusing the application No. 06735815.0. The appeal fee was also paid on the same day. The statement setting out the grounds of appeal was received on 19 September 2016.

II. The examining division came to the conclusion that the subject-matter of claim 1 according to the main request and auxiliary request lacked an inventive step and thus did not meet the requirements of Articles 52 and 56 EPC having regard to the state of the art as disclosed in documents:

D1: US 2003/0200955 A1

D2: US 2003/0044293 A1

The following document is also cited in the international search report:

D3: GB 893 029 A

III. In a communication dated 13 June 2019, the Board gave its provisional opinion regarding the requirements of Article 56 EPC.

IV. In a letter of 10 September 2019 the appellant filed a new main request as well as a first and second auxiliary requests.

V. In preparation for oral proceedings some remaining issues concerning the requests were discussed with the appellant.

- VI. In his letter of 17 September 2019 the appellant filed a new main request.
- VII. Oral proceedings were held on 18 September 2019.
- VIII. The appellant requests that the decision under appeal be set aside and that a patent be granted based on the main request of 17 September 2019. In the auxiliary, the appellant requests that the decision under appeal be set aside and that a patent be granted on the basis of the 1st or 2nd auxiliary request filed with letter dated 10 September 2019.
- IX. Claim 1 of the main request as now on file reads as follows:

"1. A four-cycle, free piston, premixed charge, compression ignition, internal combustion reciprocating piston engine with a variable piston stroke comprising: four cylinders constructed in a manner typical of reciprocating engines, each of said cylinders having two open ends;  
at least one cylinder head (2A, 2B) affixed to said cylinders and configured to close one of said open ends of each said cylinders;  
four pistons (23A, 23B, 23C, 23D), each associated with and positioned for free movement within a different one of said cylinders;  
two of said pistons coupled by a first mechanism to form a first piston pair (23A, 23B) so as to reciprocate together and the other two of said pistons coupled by a second mechanism to form a second piston pair (23C, 23D) so as to reciprocate together;  
means (1, 25, 26, 27) of causing said first piston pair (23A, 23B) to reciprocate together, and said second piston pair (23C, 23D) to reciprocate together, all

without a predetermined stroke length, and in a manner that allows a variable stroke length and variable compression ratio, and wherein said reciprocation together of the said second piston pair (23C, 23D) is selected from a group consisting of reciprocation in the opposite direction to said first piston pair (23A, 23B) and reciprocation in the same direction as said first piston pair (23A, 23B);

means of forming a premixed charge of fuel and reactant, said means of forming said premixed charge of fuel and reactant comprising means of controlling the size of said premixed charge and means of controlling the composition of said premixed charge;

at least one intake valve (1106CI) associated with each of said cylinders which is configured to control timing of the introduction of said premixed charge into the associated one of said cylinders, wherein said intake valves (1106CI) are variably actuated to open and close by respective independent intake valve actuators (20A, 20B);

means of conducting said premixed charge of fuel and reactant to each of said at least one intake valves (11060);

said pistons (23A, 23B, 23C, 23D) each configured and dimensioned to create an intake stroke within an associated one of said cylinders wherein said intake stroke of said piston (23A, 23B, 23C, 23D) away from said cylinder head (2A, 2B) allows said premixed charge to travel through said at least one intake valve (1106CI) and into the one of said cylinders associated therewith;

a combustion chamber formed within each of said cylinders, each said combustion chamber defined by said piston (23A, 23B, 23C, 23D), the associated one of said cylinders, and said at least one cylinder head (2A, 2B) closing said cylinder;

said pistons (23A, 23B, 23C, 23D) each configured and dimensioned to also create a compression stroke within an associated one of said cylinders wherein said compression stroke of said piston (23A, 23B, 23C, 23D) toward said at least one cylinder head (2A, 2B) continues until said piston (23A, 23B, 23C, 23D) compresses said premixed charge in said combustion chamber sufficiently to raise the temperature of said premixed charge to cause auto-ignition of said premixed charge, wherein said premixed charge detonates with the piston not having the time to move during detonation, and form combusted gases;

said pistons (23A, 23B, 23C, 23D) each configured and dimensioned to further create an expansion stroke within an associated one of said cylinders into which said piston (23A, 23B, 23C, 23D) is positioned for free movement wherein said expansion stroke of said piston (23A, 23B, 23C, 23D) away from said at least one cylinder head (2A, 2B) allows said combusted gases in said combustion chamber to expand;

at least one exhaust valve (1107AE) associated with each of said cylinders and configured to control timing of the discharging of said combusted gases from said cylinder, wherein said exhaust valves (1107AE) are variably actuated to open and close by respective independent exhaust valve actuators (21 A, 21B);

said pistons (23A, 23B, 23C, 23D) each configured and dimensioned to create an exhaust stroke within an associated one of said cylinders into which said piston is positioned for free movement wherein said exhaust stroke of said piston toward said at least one cylinder head (2A, 2B) allows said expanded combustion gases to be exhausted through at least one said associated exhaust valve (1107AE);

means of conducting said combustion gases as exhaust from said engine; means of providing lubrication of said engine;  
closure means adapted for sufficiently closing so as to contain lubricants and gas leakage past said pistons (23A, 23B, 23C, 23D) the one of said open ends of each said cylinder not closed by said at least one cylinder head; means for starting said engine; and means of providing cooling of said engine."

X. The appellant argues as follows.

Amongst others, the following essential features of the application that would not be disclosed by the combination of D2 with D1: The engine of claim 1 operates with variable compression ratio yielding a high compression and rapid auto-ignition. In D2 the pistons are indirectly coupled and controlled, therefore are not freely floating. The target compression ratio allows to provide a classical four stroke operation with determined length, thereby quite different from the engine of claim 1. D1 discloses premix charge but also in a mechanically limited crankshaft engine, requiring slowed down combustion to avoid knock.



## **Reasons for the Decision**

1. The appeal is admissible.

2. *Subject-matter of the invention*

The application concerns a four cycle, free piston, premixed charge engine, and therefore concerns an engine working with variable stroke and compression ratio.

The purpose of the application is to provide, in a four-cycle engine, the variable or "floating" stroke capability of the two-cycle, linear, free piston, premixed charge compression ignition engine (page 8, lines 13-16).

3. *Amendments*

3.1 Apart from introducing the reference signs, the amended claim 1 according to the main request has been amended by further refinement of its wording.

3.2 The type of strokes have been defined in relation to each phase of the piston motion. Accordingly intake, compression, expansion and exhaust strokes instead of the general reciprocating motion has been added in the definition of each of the four strokes.

3.3 In the definition of the means of causing piston pairs to reciprocate, the variable stroke has further been defined to be a variable stroke length achieving the variable compression ratio as originally defined.

3.4 The means for controlling the timing and causing valves opening and closing has been individualised by specifying for each intake or exhaust valves that they are operated with a timing control. In addition the means for achieving this control is further defined by specifying that they are variably actuated by independent valve actuators. This is explicitly explained in lines 1 to 4 of page 9.

3.5 In the definition of the compression stroke, the type of auto-ignition has been supplemented by the remaining explanations of the whole contextual content of page 23, lines 1 to 4 with the corresponding expression: "wherein said premixed charge detonates with the piston not having time to move during detonation".

3.6 The Board therefore concludes that these amendments introduced in claim 1 of the main request comply with the provisions of Art. 123(2) EPC.

4. *Novelty*

Novelty was not at issue in the present case, and the board is also satisfied that none of the cited documents D1, D2 or D3 discloses all the features of the amended claim 1.

5. *Inventive step*

5.1 D2 discloses a free piston internal combustion engine, and also discloses an embodiment with four-cycle, a cylinder head and four pistons, coupled by pairs as is shown in figures 8A to 8D. Disclosing a similar engine working according to the same principle of free floating piston, D2 therefore represents a suitable starting point for assessing inventive step of the

four-cycle, free piston, compression ignition, internal combustion reciprocating piston engine of claim 1.

5.2 The amended claim 1 can now be distinguished over D2 in particular by the following essential features:

- reciprocation of the piston allows a variable stroke length and compression ratio,
- means for forming a premixed charge of fuel and reactant is provided as recited in the claim,
- the timing of both intake and exhaust valves is controlled, and variably actuated by independent valve actuators,
- the compression strokes achieves auto-ignition in the manner defined in the claim.

5.3 The variable stroke length allows to obtain the compression ratio required to achieve auto-ignition of the premixed charge formed by the corresponding means, in each compression cycle, with the technical effect that it becomes fully independent of any other cylinders compression stroke (page 22, lines 7-13). The control of the timing of the intake and exhaust variably actuated valves by independent actuators allows to control each cylinder independently, and efficiently obtain the above variable stroke characteristic.

5.4 Based on the above related technical effects, the objective technical problem to be solved may be regarded as improving the efficiency of the free piston four stroke engine of D2, while reducing the constraints related to spark ignition and related valve tuning. Such a problem formulation is also consistent with the problem as expressed on page 8, lines 13 to 16 of the published application as filed.

- 5.5 To solve the above problem, the teaching D1 has been proposed by the examining division to generally suggest the use of a premixed charge operation. In relation to figure 1A, it is explained that the piston transmits forces generated by a combustion event into a conventional engine drive system (paragraph 118). Although the disclosure explains the possible means for varying the compression ratio or control of the intake valve timing in its paragraph 123, this is always within the framework of a controlled and therefore relatively long lasting combustion event (paragraph 115) in a conventional crankshaft engine and without detailed information on valve actuation to obtain variable timing.
- 5.6 In the Board's view, using a premixed charge combustion applied to a crankshaft engine according to D1 would not have been considered as suitable for improving the quite different type of free floating four cycle, four piston engine of D2. Even if considered useful to solve the problem of improving efficiency of an engine according to D1, the skilled person would not have come to the claimed solution of controlling the timing not only of the intake valve but the exhaust valve as well by independent valve actuators, necessary for the premix charge present in the cylinder during the compression strokes to achieve auto-ignition and associated rapid combustion by detonation.
- 5.7 Therefore, the combination of D2 with D1 cannot obviously suggest to the skilled person to arrive at the four-cycle, free piston, premixed charge, compression ignition, internal combustion reciprocating piston engine with a variable piston stroke defined in the amended claim 1 according to the main request.

- 5.8 Further, considering the last document of the international search reports, it concerns a free floating piston set 4,7 operated on a two-stroke cycle. It also appears unsuitable to modify a four stroke four piston engine according to D2, as it does not need any valve control.
6. The Board thus concludes that the subject-matter of claim 1 of the main request fulfils the requirements of novelty and inventive step, Article 52(1) with Articles 54(1) and 56 EPC.
7. The dependent claims 2 to 6 define further features of the engine of claim 1. These claims therefore also comply with the requirements of novelty and inventive step, Article 52(1) with Articles 54(1) and 56 EPC.
8. The Board is also satisfied that the description has been brought into line with the amended claims of the main request.

## Order

**For these reasons it is decided that:**

1. The decision under appeal is set aside.
2. The case is remitted to the department of first instance with the order to grant a patent based on the following application documents:

**Claims:**

1 to 6 filed with letter of 17 September 2019

**Description:**

Pages 4-7, 9-13, 15, 19, 26, 31, 45 filed with letter of 17 September 2019

Pages 1-3, 8, 14, 16-18, 20-25, 27-30, 32-44, 46 as published

**Drawings:**

Sheets 1/20-20/20 as published.

The Registrar:

The Chairman:



G. Magouliotis

S.Oechsner de Coninck

Decision electronically authenticated