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## (54) AN INTERNAL COMBUSTION ENGINE HAVING AN AUXILIARY COMBUSTION CHAMBER RECEIVING A PISTON PROJECTION


(71) We, SOCIETE ANONYME AUTOMOBILES CITROËN, a French Company organised and existing under Article 118 to 150 of the French Law on commercial companies, of 117 à 167 Quai Andre Citroen, 75747 Paris, Cedex 15, France, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-


This invention relates to an internal combustion engine of the stratified charge kind.

In particular, the invention concerns a stratified charge engine, comprising: a cylinder, closed by a cylinder head in which a combustion chamber is formed; a piston, slidable in the cylinder and having a head provided with a projection capable of cooperating with a recess forming part of the combustion chamber in the cylinder head to define an auxiliary chamber in the combustion chamber, which recess has a first aperture facing the piston so as to receive said projection; means for producing a fuel rich mixture in this auxiliary chamber; and ignition means for the fuel rich mixture in the auxiliary chamber.

An internal combustion engine of the stratified charge kind is an engine in which, at the moment of ignition, there is formed a heterogenous mixture of the combustive agent and the fuel. This mixture is rich in fuel adjacent the ignition means so as to be easily ignited, whereas the mixture is weak in fuel in the remainder of the combustion chamber. The ready ignition of the rich mixture fraction is propagated to the remaining weak mixture. With such a stratified charge, there is obtained substantially complete combustion of a heterogenous mixture which, taken as a whole, is weak so that the pollutant content of the combustion gases, particularly carbon monoxide, nitrogen oxides and hydrocarbides, is reduced.

In such engines, there is however sometimes difficulty in ensuring substantially complete combustion of the heterogenous mixture and more particularly difficulty in ensuring total propagation of the combustion of the rich mixture to the weak mixture.

According to the present invention, there is provided an internal combustion engine of the stratified charge kind, comprising: a cylinder, closed by a cylinder head in which a combustion chamber is formed; a piston, slidable in the cylider and having a head provided with a projection capable of cooperating with a recess forming part of the combustion chamber in the cylinder head to define an auxiliary chamber in the combustion chamber, which recess has a first aperture facing the piston so as to receive said projection, and, means for producing a fuel rich mixture in the auxiliary chamber; and ignition means for the fuel rich mixture in the auxiliary chamber; in which engine the recess is formed by a mortice provided between two shoulders projecting into the combustion chamber and the projection of the piston is formed by a tenon projecting from the piston head and capable of being inserted in the said mortice, the recess thus having a second aperture facing in a transverse direction relative to the directon of movement of the piston, the auxiliary chamber remaining in communication with the remainder of the combustion chamber through the second aperture of the recess, the ignition means being located adjacent the second aperture of the recess and the means for producing the fuel rich mixture opening into the recess on the side of the recess distant from the second aperture.

The connecting surface between the upper part of the tenon and the piston head may be formed by a concave cylindrical surface, capable of causing, when the tenon is introduced into the mortice, a turbulence

of gases expelled from the auxiliary chamber towards the remainder of the combustion chamber.

Preferably, the beginning of the entry of the projection of the piston into the recess of the combustion chamber takes place at about 60° before top dead centre of the piston.

Inlet and outlet valves may be disposed in the part of the combustion chamber not formed by the recess.

In order that the invention may be readily understood, an embodiment thereof will now be described, by way of example, with reference to the accompanying drawing, in which:

*Figure 1* shows schematically in section a part of an engine embodying the invention:

*Figure 2* is a view along line II-II of Figure 1;

*Figure 3* is a perspective view of the piston of the engine; and

*Figure 4* is a diagram showing the variation in the concentrations of polluting agents in the combustion gases, the concentrations being shown on the Y-axis against the increasing weakness of the mixture shown on the X-axis.

Figure 1 shows a partial view of an internal combustion engine embodying the invention and of the stratified charge kind. This engine comprises at least one cylinder 1 closed at its upper end by a cylinder head 2 in which a combustion chamber 3 is formed. A piston 4 is slidable in the cylinder and has a head 5 provided with a projection 6 capable of cooperating with the cylinder head to define an auxiliary chamber A in the combustion chamber 3.

A fuel supply means 7*a*, formed in particular by a fuel injector, is disposed in a bore 7 to produce a fuel rich mixture in the auxiliary chamber A.

Ignition means, formed by a sparking plug 8, schematically shown and screwed into a sparking plug bore 9, is provided for triggering the combustion of the fuel rich mixture. The combustion is then propagated to the remainder of the combustion chamber 3 which contains a weak mixture.

Combustion chamber 3 comprises a recess 10 having a first aperture 11 (Figure 2) opening on the remainder of the combustion chamber 3 in a directon D shown by a double arrow in Figures 1 and 2, transverse and practically at right angles to the direction of movement (shown in a double arrow △) of piston 4. The recess 10 comprises also a second aperture 12 facing piston head 5 so as to receive projection 6 of the piston; auxiliary chamber A is formed when projection 6 enters into recess 10 through the aperture 12.

The aperture 12, like the cross section of recess 10 in a plane perpendicular to direction △, mates with the shape of the cross section of projection 6 in a plane also perpendicular to direction △, except for an operating clearance.

Auxiliary chamber A remains in communication, through aperture 11, with the remainder of the combustion chamber 3. The volume of this auxiliary chamber A diminishes during the travel of piston 4 up to its top dead centre point; the minimum value of the volume of auxiliary chamber A is reached at top dead centre of piston 4, projection 6 then being inserted to a maximum extent in recess 10.

Sparking plug bore 9 and sparking plug 8 are situated substantially parallel to the aperture 11 providing communication between auxiliary chamber A and the remainder of the chamber 3. The bore 7 for the supply means opens through an orifice 13 into recess 10 on the side distant from the aperture 11, as can be seen in the drawing. Orifice 13 is in the part of recess 10 which is furthest from piston head 5; according to Figure 1, orifice 13 is in the upper part of recess 10.

The recess 10 is formed by a mortice or groove provided between two shoulders 14, 15 (Figure 2) projecting into the combustion chamber; faces 14*a*, 15*a* of these shoulders which define recess 10 are flat, parallel to each other and symmetrical with each other in relation to a plane P passing through the axis of cylinder 1; this plane of symmetry corresponds to the sectional plane of Figure 1. The axes of sparking plug bore 9 and the recess of injector 7 are located in this plane P.

In elevation, i.e. following a direction parallel to △, as can be seen in Figure 1, shoulders 14 and 15 are limited by a concave contour 14*b*, 15*b* which is concave towards the centre of chamber 3, so that dimension *x* of recess 10 in a direction perpendicular to direction △ increases progressively from aperture 12 (see Figure 1).

The edges of shoulders 14 and 15 have a rounded section, in a plane perpendicular to the axis of cylinder 1, as can be seen from contours 14*c*, 15*c* of Figure 2; these shoulders 14 and 15 are contiguous with the wall of combustion chamber 3.

Distance *y* (Figure 2) separating walls 14*a*, 15*a* is equal, except for an operating clearance, to the width of projection 6, as can be seen in Figure 3.

The projection 6 is formed by a tenon, defined by two flat walls 6*a*, 6*b* parallel to each other and symmetrical to one another in relation to a diametral plane passing through the axis of piston 4. Tenon 6 extends to the periphery of the cylindrical wall of piston 4 and is defined by a cylindrical wall portion *c* (Figures 1 and 3) forming an extension of the wall of piston 4. The

upper part of tenon 6 is formed by a flat wall 6*d* perpendicular to direction △. The connecting surface 6*e* (Figures 1 and 3) between the upper part 6*d* of the tenon and the piston head is formed by a concave cylindrical surface which is concave towards the cylinder head 2.

The surface 6*e* is capable of causing a turbulence of the gases in combustion chamber 3; in fact, as the volume of auxiliary chamber A diminishes, as a result of the progressive rise of tenon 6 inot recess 10, the gases in auxiliary chamber A are expelled towards the remainder of the combustion chamber 3 and flow along surface 6*e* which causes a turbulent movement.

Advantageously, the assembly is such that the beginning of the entry of tenon 6 into recess 10 takes place at an angle of the engine crank-shaft of about 60° before top dead centre of piston 4.

On the side opposite recess 10, combustion chamber 3 is limited by a concave surface 16 (Figure 1) which is concave towards the piston 4.

Inlet and outlet valves 17, 18 are disposed in the part 16 of chamber 3; it is to be noted that this arrangement permits the adoption, for valves 17, 18, of dimensions as large as in a conventional cylinder head, so that proper induction and proper exhaustion are ensured. The fuel supplying means 7 may be formed, for example, by a mechanical or electro-mechanical fuel injector or by a valve admitting a carburetted mixture under pressure. In the case where the supply means 7 is formed by an injector, the injector can be used alone to supply the main combustion chamber 3 and the auxiliary chamber. This injector then operates in two stages;

- in a first relatively long stage the injector introduces into the whole of combustion chamber 3, during the induction phase of piston 4, sufficient fuel to provide a homogenous weak mixture;
- in a second very brief stage, the injector supplies extra fuel to auxiliary chamber A as soon as tenon 6 is introduced into recess 10 and prior to ignition.

The use of a single double circuit injector falls within the ambit of the invention. Such an injector operates then in the following way.

The first circuit of the injector produces a homogeneous weak mixture over a relatively long time and in the whole of combustion chamber 3 during the induction phase of piston 4; in a very brief second stage the injector supplies extra fuel to auxiliary chamber A, as soon as tenon 6 is introduced into recess 10 and before ignition, through the second circuit.

Such being the case, the operation of the engine is as follows:

When piston 4 moves towards top dead centre during the compression phase, tenon 6 of piston 4 penetrates between shoulders 14 and 15 in the recess or mortice 10 rather like a "wedge"; auxiliary chamber A is then formed and is bounded by walls on five faces; aperture 11 maintains communication with chamber 3.

Supply means 7 ensures the provision of a fuel rich mixture after formation of this auxiliary chamber A.

Further upward movement of tenon 6 causes the enriched mixture to flow towards sparking plug 8 which triggers off, at the appropriate moment, the combustion of this rich mixture.

Further movement of the piston into recess 10 causes high turbulence favouring the ignition and the propagation of the flame into the remainder of the combustion chamber 3 containing the weak mixture.

A proper combustion of the whole of the heterogenous mixture in combustion chamber 3 is obtained.

Therefore, the operating point of the internal combustion engine may be situated adjacent point 19 on the X-axis shown in Figure 4, corresponding to an overall relatively weak mixture. The letters shown on the X-axis signify : R = rich mixture, P = weak mixture. It can be seen, according to the conventional diagram of Figure 4, that with an operating point 19 on the X-axis, the content C of polluting gases in the combustion gases: nitrogen oxides (NOX) carbon monoxide (CO) and hydrocarbides (HC), is reduced. Furthermore, auxiliary chamber A, which remains in permanent communication with the remainder of the combustion chamber 3, forms part of the combustion chamber 3; the auxiliary chamber is entirely swept during operation of the engine and the combustion gases are totally eliminated from this auxiliary chamber and replaced by fresh gases without it being necessary to have recourse to an extra valve.

WHAT WE CLAIM IS:

1. An internal combustion engine of the stratified charge kind, comprising: a cylinder, closed by a cylinder head in which a combustion chamber is formed; a piston, slidable in the cylinder and having a head provided with a projection capable of cooperating with a recess forming part of the combustion chamber in the cylinder head, to define an auxiliary chamber in the combustion chamber, which recess has a first aperture facing the piston so as to receive said projection, means for producing a fuel rich mixture in the auxiliary chamber; and ignition means for the fuel rich mixture in the auxiliary chamber; in which engine the recess is formed by a mortice provided between two shoulders projecting into the combustion chamber and

the projection of the piston is formed by a tenon projecting from the piston head and capable of being inserted in the said mortice, the recess thus having a second aperture facing in a transverse direction relative to the direction of movement of the piston, the auxiliary chamber remaining in communication with the remainder of the combustion chamber through the second aperture of the recess, the ignition means being located adjacent the second aperture of the recess and the means for producing the fuel rich mixture opening into the recess on the side of the recess distant from the second aperture.

2. An engine according to claim 1, wherein a connecting surface between the upper part of the tenon and the piston head is formed by a cylindrical concave surface capable of causing , when the tenon is introduced into the mortice, a turbulence of the gases expelled from the auxiliary chamber towards the remainder of the combustion chamber.

3. An engine according to claim 1 or 2, wherein the projection of the piston is defined by two flat walls parallel to each other and symmetrical to each other in relation to a diametral plane passing through the axis of the piston, the recess of the combustion chamber comprising flat parallel walls defining the recess and separated by a distance equal, except for the operating clearance, to the width of the projection.

4. An engine according to claim 1, 2 or 3, wherein the shoulders adjacent said first aperture are each defined by a concave contour so that the dimension of the recess in a direction perpendicular to the direction of movement of the piston increases progressively from the second aperture.

5. An engine according to any preceding claim, wherein the beginning of the entry of the projection of the piston into the recess of the combustion chamber takes place at an angle of about 60° before top dead centre of the piston.

6. An engine according to any preceding claim, wherein the combustion chamber provided in the cylinder head is defined, on the side remote from the recess, by a concave surface.

7. An engine according to any preceding claim, comprising inlet and outlet valves disposed in the part of the combustion chamber not formed by the recess.

8. An engine according to any preceding claim, comprising a single fuel supplying device, formed by an injector, opening into said recess, means being provided for ensuring a two-stage operation of the injector so that in a first stage, which takes place during the induction phase corresponding to the descent of the piston, a homogenous weak mixture is produced in the whole of the combustion chamber, whereas, in a second stage, shorter than the first, extra fuel is introduced into the auxiliary chamber when the projection of the piston enters the recess, prior to ignition.

9. An engine according to any one of claims 1 to 7; comprising a single fuel supply device formed by a double circuit injector opening into the recess, the first circuit causing a weak mixture to be produced in the whole of the combustion chamber during the induction phase corresponding to the descent of the piston, the second circuit supplying extra fuel into the auxiliary chamber when the projection of the piston enters into the recess, prior to ignition.

10. An internal combustion engine of the stratified charge kind, substantially as hereinbefore described with reference to the accompanying drawing.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale

Fig.1.

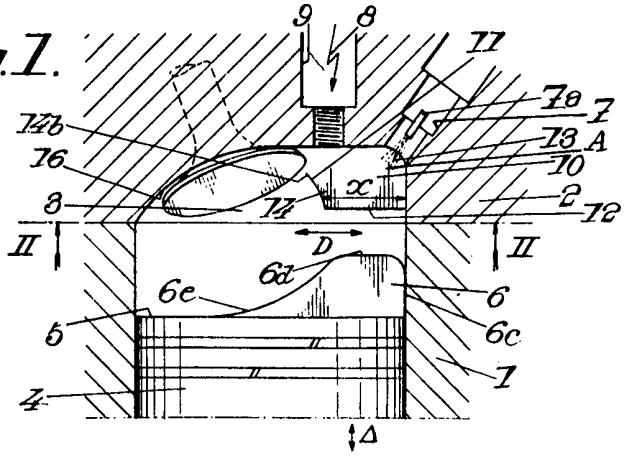


Fig.2.

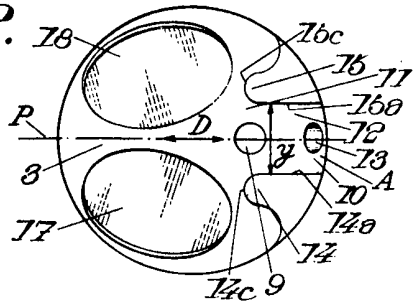


Fig.3.

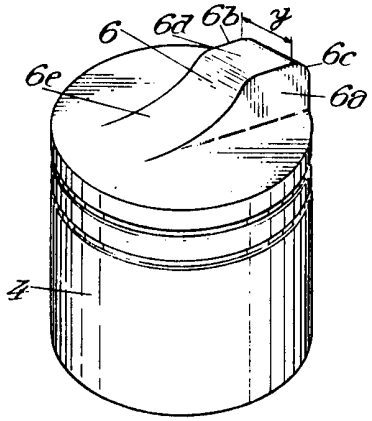


Fig.4.