April 20, 1943. G. T. JOHNSON 2,316,794

COMBUSTION CHAMBER

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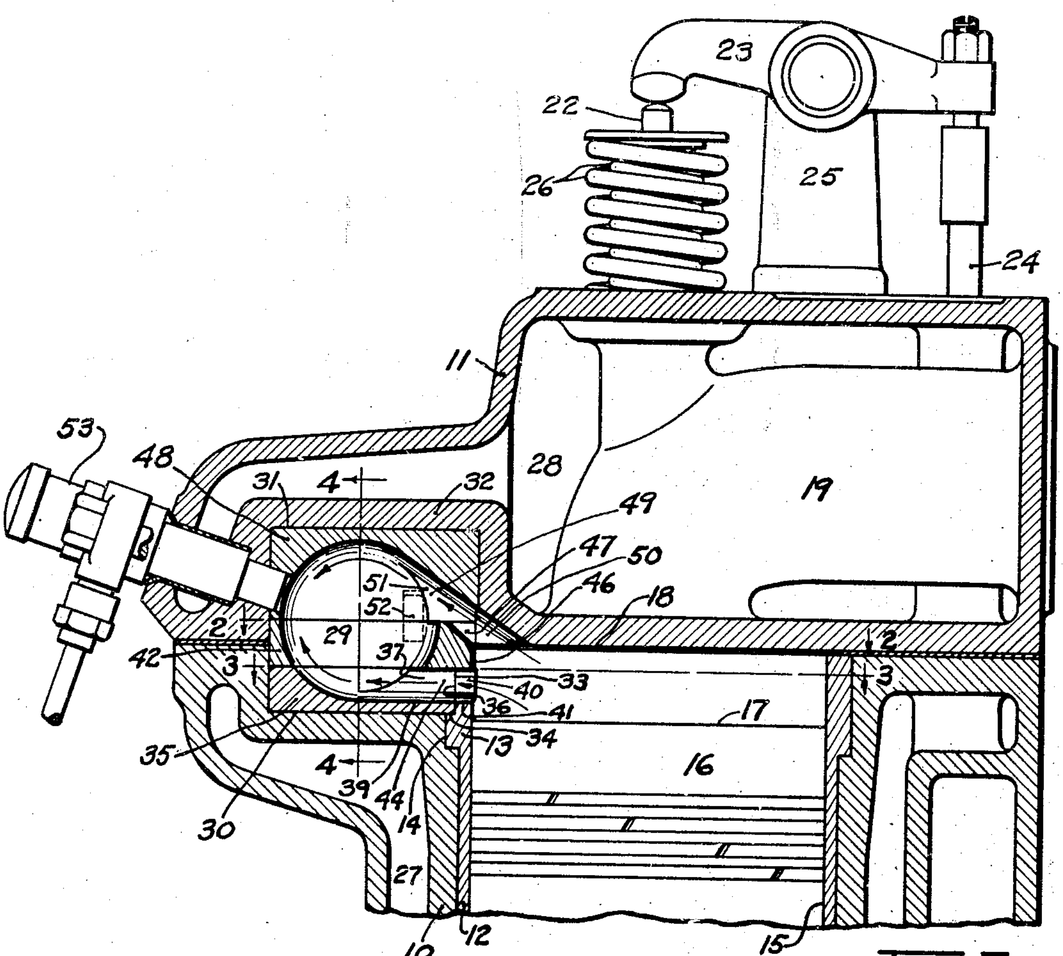

FIG. I

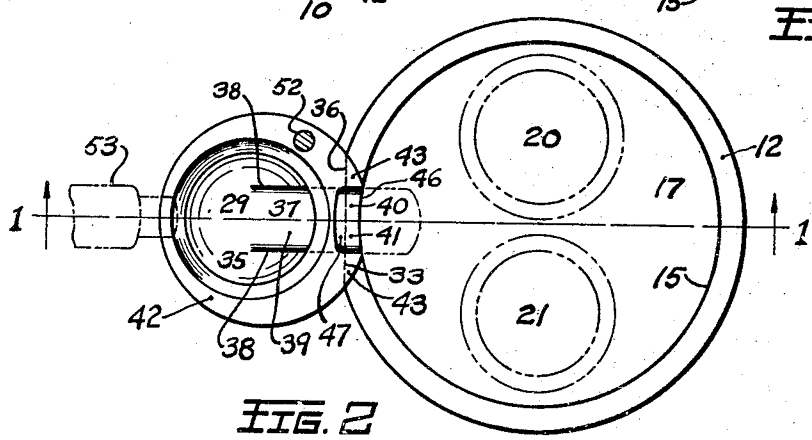

FIG. 2

INVENTOR
GEORGE T. JOHNSON
BY
Martin E. Anderson
ATTORNEY

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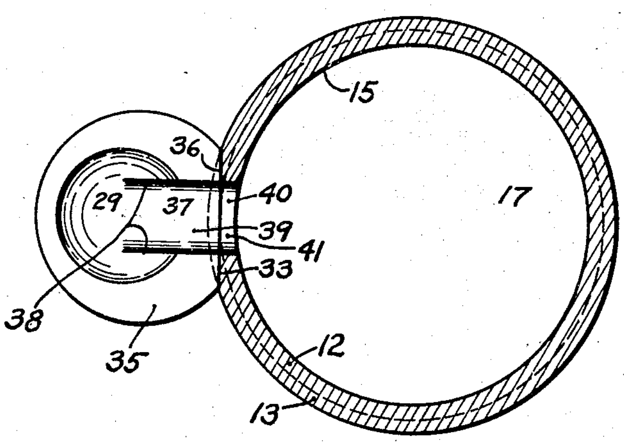

FIG. 3

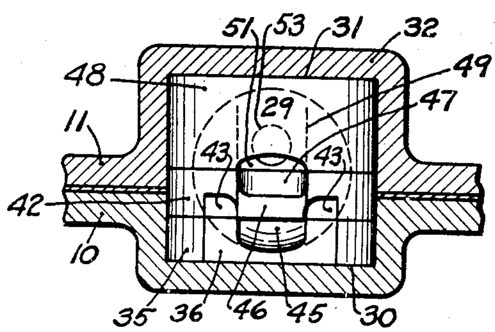

FIG. 4

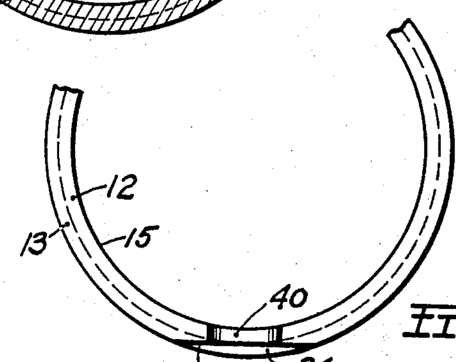

FIG. 5

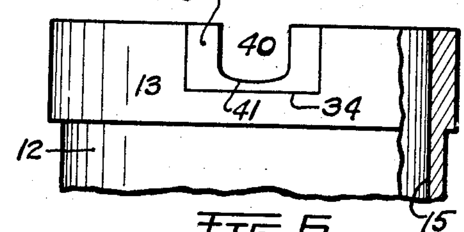

FIG. 6

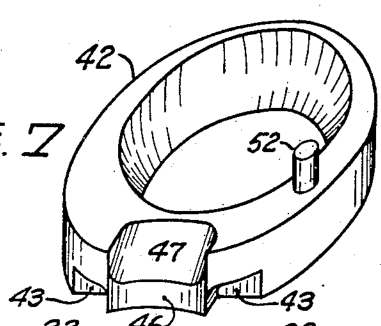

FIG. 7

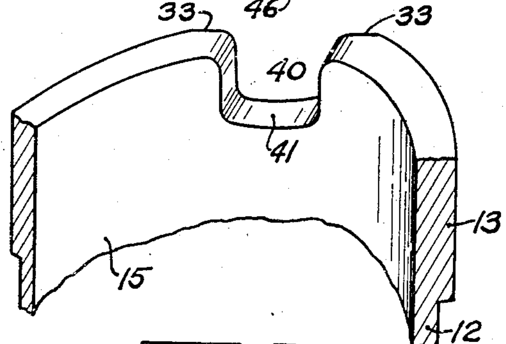

FIG. 8

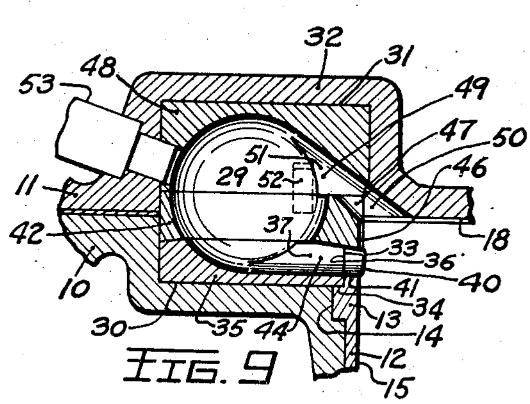

FIG. 9

INVENTOR
GEORGE T. JOHNSON
BY
Martin E. Anderson
ATTORNEY

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COMBUSTION CHAMBER

George T. Johnson, Denver, Colo.

Application July 24, 1941, Serial No. 403,791

4 Claims. (Cl. 123—32)

This invention relates to internal combustion engines of the compression ignition, fuel injection type, and more particularly to the combustion chambers of such engines.

It is a principal object of this invention to provide controlled turbulence with respect to time and degree that will conform to the requirements of combustion in its various phases.

More specifically, it is an object of the invention to transfer most of the air through separate passages to a restricted combustion zone, and nullify the establishment of high turbulence therein by causing the separated air portions to flow in opposition to each other.

A further object is to impart moderate and directed movement to the air during the fuel injection period to facilitate fuel mixture and distribution.

Another object is to produce a new and improved method of displacing the compressed air charge and releasing the combustible mixture so as to reduce heat losses and to facilitate combustion.

Other objects relate to: uniflow scavenging of the residual products in the combustion chamber; the imparting of turbulence during the latter part of the combustion process; novel and simple structural components and arrangement of same for embodying the invention; and otherwise to impart improved engine performance.

These and any other objects of the invention which may become apparent as the description proceeds are achieved by means described in the following specification, and illustrated in the accompanying drawings, in which:

Figure 1 is a transverse section through the upper portion of an engine, taken on a plane through the cylinder axis, as represented by line 1—1, in Figure 2;

Figure 2 is a plan section showing the pertinent elements on broken planes perpendicular to the cylinder axis, as represented by the line 2—2, in Figure 1;

Figure 3 is a plan section, similar to that shown in Figure 2, perpendicular to the cylinder axis, as represented by the line 3—3, Figure 1;

Figure 4 is a view showing the parts that form the combustion chamber, in side elevation, looking from the inside of the cylinder toward the ports in the wall of the combustion chamber, the parts of the cylinder block and cylinder head which enclose the combustion chamber being shown in section taken on line 4—4, Figure 1;

Figure 5 is a fragmentary, top plan view of the cylinder liner;

Figure 6 is an elevation of the upper portion of the cylinder liner, partially in section, and as projected directly from the plan view of Figure 5;

Figures 7 and 8 show respectively in enlarged isometric views the middle member of the three piece combustion chamber assembly in spaced apart relation with the cylinder liner;

Figure 9 is a transverse, fragmentary section similar to that of Figure 1 and showing a modified arrangement of the combustion chamber assembly.

Referring more particularly to the drawings, a cylinder block is indicated at 10, and secured thereupon is a cylinder head 11. The cylinder block is preferably bored to receive a cylinder liner 12, the upper part of which is provided wtih a shoulder 13 to seat in a registering counter bore 14 in the top portion of the cylinder block. The inner cylindrical wall 15 of the cylinder liner provides the guiding surface for the reciprocating piston 16, which is of usual construction with a preferably flat head 17. The normally lower surface 18 of the cylinder head extending transversely over the cylinder bore is also preferably flat.

The cylinder head is provided with the usual air inlet passage and exhaust passage (not shown) leading to respective inlet and exhaust ports 20 and 21 opening into the cylinder bore. An air inlet valve 22 is associated with the port 20 and derives its opening motion from an engine driven mechanism including a rocker arm 23 and a push rod 24. The rocker arm is pivoted in a bracket 25 which is mounted on the cylinder head. The valve is normally maintained closed by the usual compression springs 26. An exhaust valve and actuating mechanism therefore (not shown) is in similar manner associated with the port 21. Suitable passages 27 in the cylinder block and 28 in the cylinder head are provided for the circulation of a cooling medium.

The engine illustrated is of the multicylinder, four-stroke cycle type and operates on compression ignition, whereby air charges drawn into the cylinders are compressed, and during said compression liquid fuel in atomized form is injected into and mixed with the air to form a combustible mixture which ignites under the influence of heat derived from further compression. The admission of air into the cylinders and the expulsion of the products of combustion therefrom are provided for in accordance with customary practice by means of the poppet type valves and associated mechanism as shown on the drawings.

Movement of the pistons is translated into rotary motion through the usual connecting rod and crank shaft linkage (not shown).

Pertinent to the present invention the engine further includes a combustion chamber preferably of spherical form in which the air and fuel charges are diffused and ignited, and which is in two-way communication with the cylinder.

The combustion chamber is indicated generally at 29, laterally and above the cylinder bore and in close proximity thereto. The combustion chamber comprises an assembly of three parts; the external lateral surfaces of which are cylindrical, and formed about a common axis to the same diameter. The circular end surfaces of the three parts are on parallel planes at right angles to their common longitudinal axis.

The combustion chamber assembly is included within both the cylinder block and the cylinder head, which are respectively bored in registering relationship for accommodating the assembly as indicated at 30 and 31. The bore 31 in cylinder head is completely enclosed by the surrounding walls 32 adjacent the cooling passage, but the bore 30 in the cylinder block intersects the counterbore 14 provided for the cylinder liner 12, and is therefore joined thereto on the chordal plane common to both bores. The axis of the bores 30 and 31 is substantially parallel to the axis of the cylinder and lies in the transverse center plane passing therethrough.

The upper end of the cylinder liner 12 is cut away on its external surface to form a flat surface 33 parallel to the axis of the liner, and a shoulder 34, as shown in Figures 5 and 6. The surface 33 is on the chordal plane of intersection between the counter bore 14 and the bore 30, and the shoulder 34 is in the transverse plane defined by the bottom of the bore 30.

The lower member 35 of the combustion chamber assembly is bottomed in the bore 30 and overlaps the shoulder 34 of the cylinder liner 12. A cylindrical segment is cut away from the member 35, leaving a flat surface 36 which is on the chordal plane of intersection between the bores 14 and 30. In assembled relationship the surface 33 of the cylinder liner and the surface 36 of the lower member of the combustion chamber assembly are in close-fitting engagement.

Perpendicular to the surface 36, and centrally thereof, is formed a notch 37 which is open to the normally upper face of the lower member, and extends therethrough to the portion of the combustion chamber 29 included therein. The side faces 38 of the notch 37 are preferably vertical, and the bottom surface 39 is formed transversely to the radius of the combustion chamber, and tangentially thereto.

The upper end of the cylinder liner has a notch 40 formed radially through the flat surface 33 and centrally thereof, and to a depth corresponding in assembled alignment to the bottom surface 39 of the notch 37 in the lower member 35 of the combustion chamber assembly. The bottom surface 41 of the notch 40 conforms in contour to the bottom surface 39 of the notch 37, and the two notches have the same width.

The middle member 42 of the combustion chamber assembly rests on the lower member 35 in axial alignment therewith, and covers the notch 37. Recessed segmental portions 43 are formed in the lower face and outer wall of the middle member 42 to each side of the transverse center line of the cylinder. The two recesses 43 are spaced apart a distance corresponding to the width of the notch 40 in the cylinder liner, thereby permitting the intermediate portion between the recesses to fit into the notch 40 and close the upper portion thereof. The recesses 43 accommodate the top portions of the cylinder liner adjacent the notch 40, and each recess comprises three surfaces at right angles to each other which correspond with co-mating male surfaces of the cylinder liner as clearly shown in Figures 7 and 8.

The assembled alignment of the lower and middle members, together with the cylinder liner thus provides a continuous passageway 44 affording communication laterally from the walls of the working cylinder to the combustion chamber tangentially thereof.

The port 45 in the inner wall of the cylinder liner leading to the passageway 44, is alternately covered and uncovered by the movement of the piston 16.

The outer wall 46 of the middle member 42 intermediate the recesses 43 is of concave curvature corresponding in radius to the inner wall of the cylinder liner, and in the assembly is concentric therewith.

A notch 47 is formed in the middle member 42, intersecting its upper face and the outer wall portion 46 of concave curvature. The lower surface of the notch 47 is inclined upwardly away from the cylinder, and is so contoured that its line of intersection with the concave surface 46 lies in the transverse plane of the top of the cylinder liner. The lower surface of the notch 47 intersects the upper face of the middle member 42 in a line spaced from, but closely adjacent to, the combustion chamber.

The combustion chamber portions embodied within the lower and middle members constitute substantially the lower hemispherical part of the combustion chamber. The remaining upper hemispherical part is embodied within the upper member 48. A notch 49 is formed in the normally lower surface of the upper member 48. The normally upper surface of the notch 49 is upwardly inclined with respect to the cylinder axis, and opens into the combustion chamber tangentially thereof, and is transversely contoured to the same curvature as the combustion chamber. A notch 50 in alignment with notch 49 is formed in the lower face of the cylinder head 11, and intersects the bore 31 therein.

The inclination of the upper surfaces of notches 49 and 50 is preferably somewhat less with respect to the inclination of the lower surface of notch 47, thereby providing a passageway 51 of progressively diminishing area in the direction of the combustion chamber. The upper tangential passageway 51 constituted by notches 47, 49 and 50 is preferably of the same width as the lower tangential passageway 44, and in vertical alignment therewith. The intersection of the notch 50 with the lower face of the cylinder head forms the port of the upper tangential passageway 51 opening into the working cylinder, and said port overlies the working cylinder at the periphery thereof. The lower two members of the combustion chamber assembly are fixed in alignment by abutment against the flat surface 33 of the cylinder liner. The upper member is fixed in alignment with the lower two members by the dowel pin 52.

A fuel injection valve 53, preferably of the single orifice, pintle type, is mounted in the cylinder head 11 and projects therethrough, and through the lateral wall remote from the cylinder of the upper member 48 of the combustion chamber assembly through suitable apertures. The injection valve is positioned radially of the combustion chamber, and its longitudinal axis lies in the common transverse vertical plane of the working cylinder and the combustion chamber, and intersects the interior wall nearest the cylinder of the middle member 42 substantially midway between the two tangential passages.

The combustion chamber 29 as formed within the three piece assembly has been shown as offset with respect to the outer cylindrical walls of the assembly, thereby providing walls of heavier section on the side toward the cylinder where the tangential passages occur. This construction permits of the novel arrangement of parts as between the three piece assembly and the cylinder liner as heretofore described.

In the operation of the engine, including the present improvements, air is admitted to the cylinder through the intake port 20 during the suction stroke of the piston, and is compressed during the succeeding return stroke. As the compression pressure increases, the air within the working cylinder is displaced into the preferably spherical combustion chamber 29. Up to the point where the piston covers the port 45, leading to the lower tangential passageway 44, the air has access to the combustion chamber through both passageways 44 and 51. Each passageway as heretofore described is tangential to the combustion chamber, and air displaced thereinto through either passage would normally swirl rapidly in accordance with the direction of entry. As shown by the arrows in Figure 1, the air portions introduced simultaneously through the lower and upper passages are respectively in opposition to each other. Thus, the condition prevailing within the combustion chamber prior to the closing of the port 45 by the piston is characterized by a relatively non-turbulent or quiescent state due to the dampened energy of the opposing air streams.

Mechanical clearance only is provided between the head 17 of the piston and the under face of the cylinder head at the T. D. C. position. After the port 44 has been closed and during the remainder of the piston stroke, the volume of air yet to be displaced enters the combustion chamber through the top passage only and swirls counterclockwise as shown in Figure 1. The positive unidirectional swirl thereby produced during the latter portion of the compression stroke is of only moderate intensity; sufficient for the function of aiding fuel and air mixture, without having the objectionable tendency to extinguish the initial flame nucleus; an attribute common to engines employing high velocity swirl in the combustion chamber.

Fuel is normally timed for delivery to the injection valve 53 by the fuel pump (not shown) somewhat in advance of the T. D. C. position, which occurs during the period that air is being displaced into the combustion chamber through only the upper passage; in other words, after the port 45 has been closed by the piston, and the air becomes moderately activated in the combustion chamber.

The fuel charge enters the combustion chamber from the far side thereof with respect to the cylinder, and the fuel spray is directed across the air stream preferably in the range between the two passages. The movement of the air stream is not of high velocity owing to the fact that the piston which causes the displacement is nearing the end of its stroke, and therefore moving at relatively low velocity.

The combustion chamber is always open to the cylinder through the passage overlapping the cylinder bore, and following the reversal of the piston on its power stroke the burning mixture expands into the cylinder first through the overlapping passage, and subsequently through both said passage and the piston controlled passage. The movement of the gases through the piston controlled passage into the cylinder is characterized by a uniflow condition due to the gases taking off tangentially from the previously established counter-clockwise rotation within the combustion chamber. This, together with the fact that two passages are available makes for more thorough scavenging of the combustion chamber. The uniflow exit of the gases through the piston controlled passage is necessarily somewhat retarded and the delayed introduction into the cylinder sustains turbulence during the later stages of combustion, contributing thereby to the efficiency of the cycle.

The two passages converge toward the cylinder, and the gas streams issuing simultaneously from the passages intersect in a common zone, and said action contributes to the dispersion and propagation of the burning mixture within the cylinder.

Heat losses are lessened through the walls of the combustion chamber, owing to the average low intensity of turbulence maintained therein.

In Figure 9 showing a modified construction, the mating end surfaces of the lower and middle members of the combustion chamber assembly comprise conical instead of flat surfaces in order to provide a tapering section to the piston controlled passage. With this construction a somewhat larger volume of displacement occurs through the passage overlapping the cylinder bore.

While I have shown and described specific embodiments of my invention, it is not intended that protection shall be limited thereto, but only by the scope of the appended claims.

Having described the invention what is claimed as new is:

1. In an internal combustion engine of the fuel injection, compression-ignition type having a cylinder block provided with a cylinder bore, a cylinder head having an inner face extending across one end of the bore, and a piston slidably mounted in the bore, the walls of the cylinder block and the cylinder head having a spherical combustion chamber closely adjacent and at the side of the cylinder bore, the top of the combustion chamber being above the lower surface of the cylinder head, and walls forming an upwardly and outwardly extending passageway communicating between the cylinder bore and the spherical combustion chamber, above the upper limit of piston travel, the cylinder wall having another passageway communicating the interior of the combustion chamber with the cylinder bore at a point below the top of the piston travel, the two passageways opening tangentially into the combustion chamber and converging towards the center of the cylinder bore.

2. In an internal combustion engine of the fuel injection, compression-ignition type, having a cylinder block provided with a cylinder bore in which a piston is mounted for reciprocation, the wall of the cylinder bore having a combustion chamber of substantially circular cross section positioned to one side of the bore adjacent the upper limit of piston travel, the wall of the com-

bustion chamber having two outwardly converging passageways communicating the interior of the combustion chamber with the cylinder bore, one of the passageways opening into the bore above the upper limit of piston travel whereby it is always open, the other passageway opening into the bore at a point below the upper limit of piston travel whereby it is covered by the piston as it approaches its upper limit of travel, and whereby during the compression stroke, a combustion supporting medium is first admitted to the combustion chamber through two vertically spaced openings and finally through the upper opening only and whereby during a portion of the power stroke gases from the combustion chamber are delivered to the cylinder in two convergent streams.

3. In an internal combustion engine of the fuel injection, compression-ignition type having a cylinder block provided with a cylinder bore, a cylinder head extending across and closing one end of the bore, and walls forming a spherical combustion chamber at one side of the cylinder bore, two outwardly convergent passageways extending and communicating between the combustion chamber and two vertically spaced points in the cylindrical bore, the upper of which is above the upper limit of piston travel and the lower being so positioned that it is wholly covered by the piston when it is in its uppermost position, and means for injecting a spray of fuel into the combustion chamber, the spray being directed to that portion of the wall of the combustion chamber that is positioned between the passageways.

4. In an internal combustion engine of the fuel injection compression ignition type having a cylinder block provided with a cylinder bore, a cylinder head having an inner face extending across one end of the bore, and a piston slidably mounted in the bore, the walls of the cylinder block and the cylinder head having a combustion chamber of substantially circular cross section closely adjacent and at the side of the cylinder bore, the top of the combustion chamber being above the lower surface of the cylinder head, and walls forming an upwardly and outwardly extending passageway communicating between the cylinder bore and the combustion chamber, above the upper limit of piston travel, the cylinder wall having another passageway communicating the interior of the combustion chamber with the cylinder bore at a point below the top of the piston travel, the two passageways opening tangentially into the combustion chamber and converging towards the center of the cylinder bore.

GEORGE T. JOHNSON.