Oct. 5, 1954 M. C. KUEPFER 2,690,742

COMPRESSION IGNITION INTERNAL-COMBUSTION ENGINE CONSTRUCTION

Filed Dec. 22, 1952 2 Sheets-Sheet 1

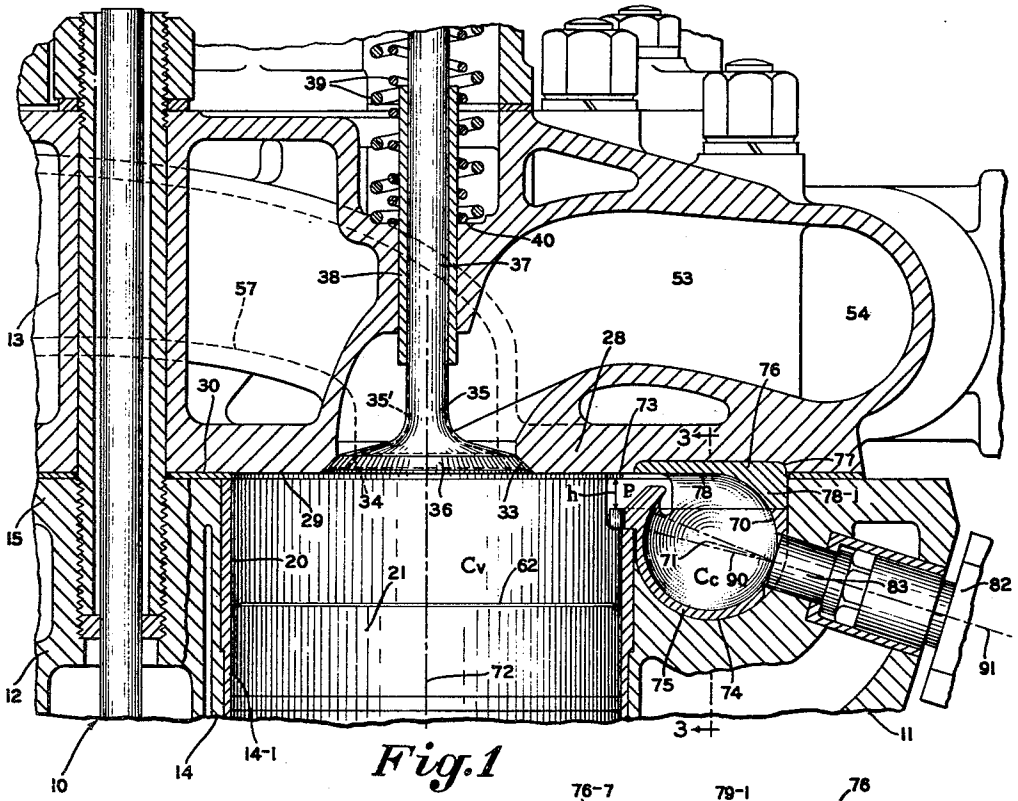


Fig. 1

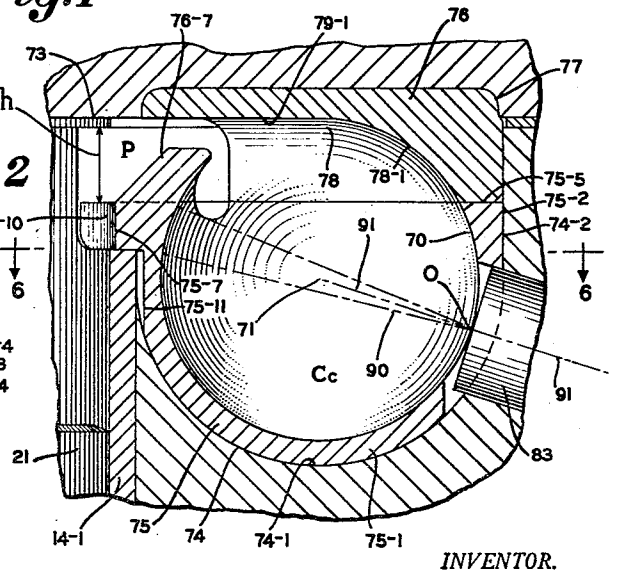


Fig. 2

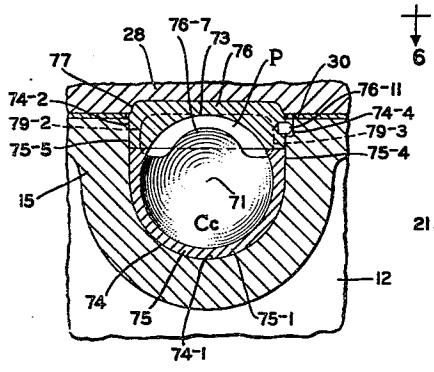


Fig. 3

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Filed Dec. 22, 1952 2 Sheets-Sheet 2

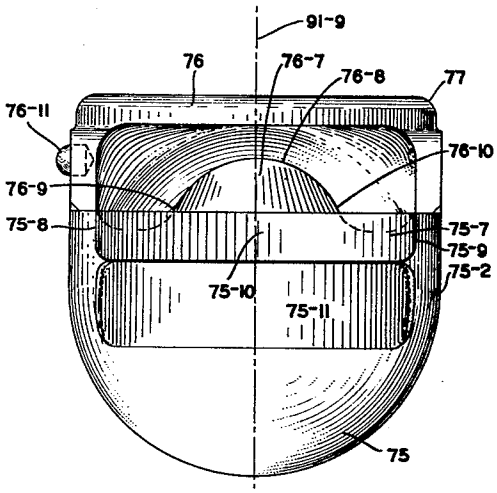


Fig. 5

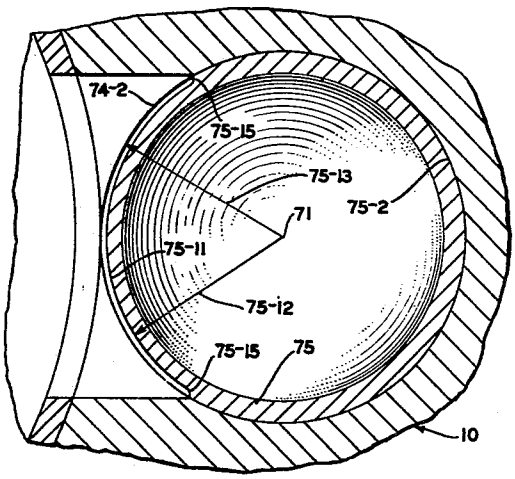


Fig. 6

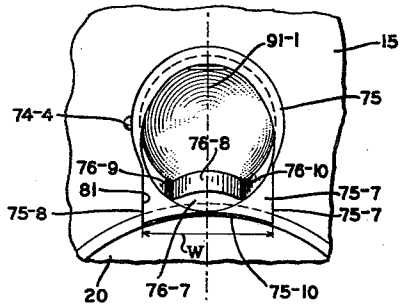


Fig. 4

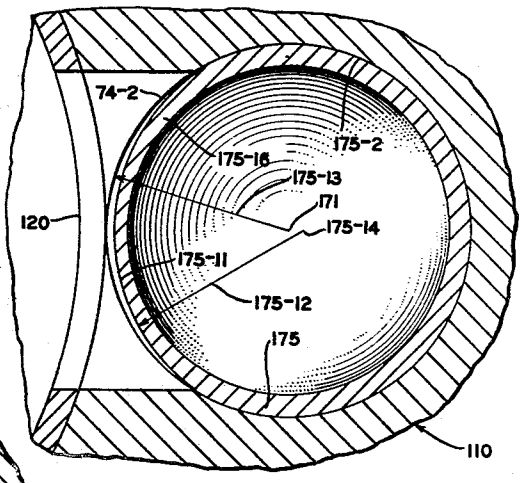


Fig. 7

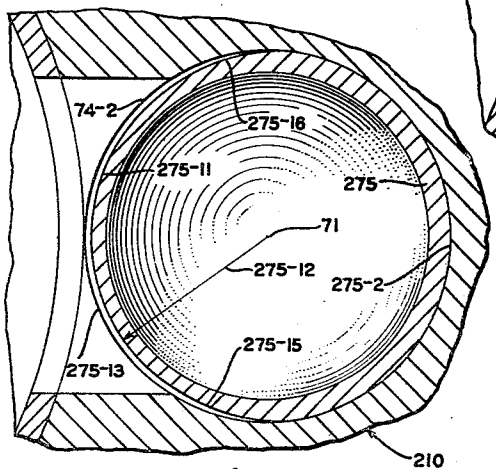


Fig. 8

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COMPRESSION IGNITION INTERNAL-COMBUSTION ENGINE CONSTRUCTION

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Application December 22, 1952, Serial No. 327,239

14 Claims. (Cl. 123—32)

1

The invention or discovery relates in general to internal combustion engines of the compression ignition type and having preferably spherical injection, mixing, and combustion chambers of relatively small volume, one for each cylinder of the engine, the maximum cylinder volume being relatively large, and each cylinder and the associated preferably spherical chamber being communicatingly connected with each other by a passageway.

The present invention or discovery includes improvements in the internal combustion engines of the compression ignition type set forth in my prior application for U. S. Letters Patent, Serial No. 259,365, filed December 1, 1951.

The present invention or discovery and the invention or discovery of said prior application relate more particularly to compression ignition engines of the foregoing general type and which include broadly the improvements set forth in the prior U. S. Letters Patent No. Re. 19,742, reissued October 22, 1935, to Otis D. Treiber, for his original U. S. Letters Patent No. 1,960,093, issued May 22, 1934. The present invention or discovery and the invention or discovery of said prior application also relate more particularly to compression ignition engines of the type broadly set forth in said U. S. Letters Patent No. Re. 19,742, and to the type of such engines specifically set forth in the prior U. S. Letters Patent No. 2,062,951, issued December 1, 1936 to Otis D. Treiber.

In each of said U. S. patents, No. Re. 19,742, and No. 2,062,951, there is set forth a high speed, high compression, high power, compression ignition internal combustion engine in which the spherical chambers are located entirely at the sides of the cylinders, and in which the passageways open into the cylinders through the sides thereof, and in which the normally upper surfaces of the passageways are flat laterally continuous extensions of preferably flat lower faces of the cylinder head and are tangential with the spherical inner surfaces of the spherical or constant volume chambers, and which engine is further characterized by a sideward and upward injection of the liquid hydrocarbon fuel into the spherical chambers, each fuel spray having an origin preferably at the crank shaft side of the associated passageway, and being directed sidewards and upwards towards the passageway and flat cylinder head inner face.

Engines including the improvements set forth in said U. S. Patents No. Re. 19,742 and No. 2,062,951 are characterized by operating at relatively high speeds which may be from 2000 to 3000 R. P. M., and at relatively high mean indicated pressures which may be as high as 160 pounds per square inch at 2000 R. P. M., and with a consequent relatively high power output, which is accomplished at an economical rate of fuel consumption.

2

In the engines set forth in U. S. Patent No. 2,062,951, the constant volume chambers are formed by parts adapted for relatively easy commercial production, and which form constant volume chambers having a maximum internal spherical surface area, and the parts of each constant volume chamber fitting with one another and forming the constant volume chamber end of the connecting passageway with a height less than the radius of the spherical inner surface.

The engines set forth in U. S. Patent No. 2,062,951 are furthermore constructed and arranged so as to substantially eliminate "knock" or "detonation" in the operation of the engine, without any substantial loss of power, by the provision of deflector means preferably a tongue or lip extending into the passageway opening from the lower face of the constant volume chamber end of the connecting passageway. The inner surface of the tongue or lip is a continuation of the spherical inner surface of the constant volume chamber, and the tongue or lip is adapted to intercept the conical fuel spray injected thereagainst toward the passageway. The area of the lip or tongue is relatively small as compared with the total area of the passageway, the passageway opening above and about the sides of the lip or tongue.

Compression ignition internal combustion engines combining the improvements of said U. S. Patents No. Re. 19,742 and No. 2,062,951 have come into widespread use in a series of engines having cylinders with bores of increasing diameters.

In increasing the bore diameter of a cylinder of such an engine without otherwise substantially changing the position of the combustion chamber, the cylinder wall is brought closer to the combustion chamber and the space between the walls of the cylinder and combustion chamber is reduced so that they are joined and prevent the coolant from reaching these areas. Instead of transmitting heat from these areas to the cooling water, the cylinder wall adjacent the constant volume chamber gathers heat and cracks, and this takes place frequently even when a cylinder liner is used.

From another standpoint, it has been found in

engines constructed according to U. S. Patent No. 2,062,951, modified as described above that the hot gases constituting the burning fuel emerging from the spherical side chambers through the passageways tend to heat the deflector lips to an undesirable degree, tend to damage the cylinder side walls immediately adjacent the cylinder ends of the passageways, tend to direct the burning gases towards the upper ends of the pistons as they approach the cylinder heads, and tend to burn off sharp edges which are present in the spherical chamber ends of the passageways.

Furthermore, in engines constructed according to U. S. Patent No. 2,062,951, modified as described above and in engines including the improvements of my said prior application for U. S. Letters Patent, Serial No. 259,365, it has been found that under some operating conditions, the separate combustion chamber walls in the zone of the lip and passageway overheat and expand, and the lower portions of the combustion chamber walls just below the passageway bulge outwardly, and the bulging combustion chamber wall portions push the adjacent cylinder wall portions out of round.

The objects of the present invention or discovery include the provision of a compression ignition internal combustion engine combining the improvements of said U. S. Patents No. Re. 19,742 and No. 2,062,951, as modified above and in which the parts of each constant volume side chamber are constructed and arranged with each other and with the other engine parts so as to resist the transmission of heat to the cylinder block and to promote the transmission of heat to the cooling water, or in other words so as to control the transmission of heat in the engine parts.

The objects of the present invention or discovery also include the provision of a compression ignition internal combustion engine combining the improvements of said U. S. Patents No. Re. 19,742 and No. 2,062,951, and in which the parts of each constant volume side chamber are constructed and arranged with each other and with the other engine parts so as to provide for an improved controlled flow of the hot gases constituting the burning fuel emerging from the spherical side chambers through the passageways, the controlled hot gas flow preferably being combined with the controlled heat transmission.

The objects of the present invention or discovery also include the provision of a compression ignition internal combustion engine combining the improvements of said U. S. Patents No. Re. 19,742, and No. 2,062,951, and including certain of the improvements of said application for U. S. Letters Patent, Serial No. 259,365, and in which portions of the separate walls of the spherical or constant volume chamber are constructed and arranged with walls of the engine mounting the constant volume chamber walls, so that expansion or bulging of portions of the separate constant volume chamber walls will not distort adjacent portions of the cylinder wall.

The foregoing and other objects are attained by the improved compression ignition internal combustion engine construction, apparatus, parts, combinations, and subcombinations, which comprise the present invention or discovery, and the nature of which is set forth in the following general statement, and preferred embodiments of which, together with their mode of use, are set forth in the following description, and which are particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The nature of the improvements of the present invention or discovery may be described in general terms as including in an internal combustion engine combining the improvements of said U. S. Patents No. Re. 19,742 and No. 2,062,951 and having one or more side constant volume chambers, a construction and arrangement by which each constant volume chamber may be formed either by separable parts or members or by welded parts or members, each constant volume chamber member being made of high heat resisting metal preferably steel, the members forming each constant volume chamber having a plurality of wall portions of different thicknesses, including an upper portion whose external surface is partially cylindrical, and a lower portion whose external surface includes a hemispherical section tangential with the cylindrical surface of the upper portion and a preferably cylindrical section lying within and joining the hemispherical lower external surface section. The other wall portions including a tongue flange extending a substantial distance radially beyond the boundary of the externally cylindrical wall portion, top wall portions joining the tongue flange and intermediate cylindrical wall portions and forming therewith the passageway, and the upper portion of the side chamber, and the lip, and the lip having faired side and lower faces.

By way of example, embodiments of the improved compression ignition internal combustion engine construction of the present invention or discovery are illustrated in the accompanying drawings forming part hereof in which:

Figure 1 is a fragmentary transverse sectional view of a compression ignition internal combustion engine including one embodiment of the improved construction hereof, portions being broken away to illustrate details of construction and arrangement, and in which the piston is shown displaced from the cylinder head and from the passageway connecting the varying volume cylinder with the constant volume chamber, and in which the piston may be considered to be traveling towards the cylinder head on the compression stroke, and before commencing to traverse the end of the passageway terminating in the cylinder bore;

Fig. 2 is an enlarged view of portions of Fig. 1 for more clearly illustrating details of construction;

Fig. 3 is a fragmentary vertical sectional view as on line 3—3, Fig. 1, looking in the direction of the arrows, and illustrating details of construction and arrangement of the parts or members;

Fig. 4 is an enlarged fragmentary top plan view of the cylinder block of the engine of Fig. 1 showing a portion of one cylinder and showing the cylinder bore connecting recess in the cylinder block with the lower constant volume chamber forming member fitted therein;

Fig. 5 is a detached elevational view showing the assembled constant volume chamber forming members, looking towards the passageway opening thereof;

Fig. 6 is a fragmentary plan sectional view as on line 6—6, Fig. 2, looking in the direction of the arrows;

Fig. 7 is a view similar to Fig. 6, showing a second embodiment of the improved construction hereof; and

Fig. 8 is another view similar to Fig. 6, show-

ing a third embodiment of the improved construction hereof.

The illustrated compression ignition internal combustion engine is indicated generally at 10, and includes the combined improvements of said U. S. patents, No. Re. 19,742 and No. 2,062,951, and the present improvements thereof.

The engine 10 is a six cylinder, four stroke cycle, single action, high speed, compression ignition internal combustion engine, in which the air for combustion is obtained normally directly from the atmosphere, and in which separate quantities of charges of the preferred liquid hydrocarbon fuel, such as diesel oil, are successively injected into the combustion chambers of the engine at successive timed intervals, one charge being injected into the combustion chambers of each cylinder during each four stroke cycle of the piston operatively mounted in the cylinder.

The engine 10, includes in combination with other parts of a high speed internal combustion engine, a unitary casting 11 including a lower crank case portion, not shown, and an upper cylinder block portion 12, and front and back cylinder heads 13 are secured at the upper end of the cylinder block portion 12, each cylinder head accommodating three cylinders, and one cylinder head 13 being shown in the drawings.

The cylinder block portion 12 includes therein walls forming the cylinders, one of which is shown in the drawings and is indicated at 14, and is preferably an integral part of the preferably cast iron cylinder block portion. As shown the cylinder block cylinder 14 is provided with a cylindrical liner 14–1.

Each cylinder liner 14–1 has a bore 20, and in each cylinder bore 20, a piston 21 is operatively mounted for reciprocation in the usual manner for high speed engines.

Each cylinder head 13 includes a normally lower wall 28 which is provided for each cylinder covered thereby with a preferably flat normally lower surface 29 extending transversely across the upper end of the bore 20 of the particular cylinder.

A usual gasket 30 is interposed in a usual manner between the normally lower wall 28 of each of the cylinder heads 13, and the normally upper wall 15 of the cylinder block portion 12.

As illustrated, the engine 10 is a valve-in-head engine, and accordingly each normally lower wall 28 of the cylinder heads 13 has formed therein above the normally upper end of the bore 20 of each cylinder covered thereby, an air intake valve seat orifice 33 and an exhaust valve seat orifice 34, and each of the valve seat orifices has a valve seat formed therein.

A valve 35 is operatively associated with each valve seat orifice 33, and a valve 35' is operatively associated with each valve seat orifice 34, and each of the valves includes a valve head 36 fitting in its respective seat, and a valve stem 37 extending upwardly from the head.

The cylinder heads 13 have mounted therein valve stem guide tubes 38, one for each valve stem 37, and each valve head 36 is normally maintained in its seat by usual means such as a set of compression springs 39, one end of which reacts against a spring seat 40 formed about each valve stem guide tube 38 in the cylinder heads 13, and the other end of which reacts against a flanged washer, not shown, secured in a usual manner at the upper end of the particular valve stem 37.

Each air intake valve seat orifice 33 communicatingly connects with one end of an air intake port or passageway 53, the intake ports 53 being formed in the walls of the cylinder heads 13, and the intake ports of each cylinder head connecting at their outer ends with an intake manifold 54, and each intake manifold 54 communicatingly connecting as by means of an elbow, not shown, preferably with an air cleaner, not shown.

Each exhaust valve seat orifice 34 communicatingly connects with one end of an exhaust port or passageway 57, the exhaust ports 57 being formed in the walls of the cylinder heads 13 and the exhaust ports of each cylinder head terminating at their outer ends in a connector flange, not shown, whereby the exhaust ports may be communicatingly connected with an exhaust manifold, not shown.

In the engine 10, a chamber C_v is formed within the bore 20 of each cylinder liner 14–1 and between a normally top or end flat circular face 62 of the piston 21 operating within the particular bore 20 and the opposite flat circular normally lower surface or face 29 of the normally lower cylinder head wall 28 covering the particular bore 20.

Each of the chambers C_v by reason of the reciprocation of the piston forming one wall of the same may be termed a varying volume chamber, and in the engine 10, at top dead center, that is, when the end face 62 of each piston 21 has reached its position of maximum travel away from the crank shaft, there is only mechanical clearance between the end face 62 of the piston and the opposite flat cylinder head inner face 29.

Walls of the engine form constant volume chambers, one for each cylinder. Each constant volume chamber C_c is located closely adjacent to and entirely at the side of the corresponding varying volume chamber C_v; and between each constant volume chamber C_c and its cylinder, walls of the engine form a passageway P communicatingly connecting at one end with the particular constant volume chamber C_c and at the other end with the cylinder bore of the adjacent varying volume chamber C_v.

Each constant volume chamber C_c is formed with a curved inner surface 70 which is partially symmetrical about an axis extending through the center 71 of the chamber C_c and at right angles or normal to the plane passing through the center 71 of the constant volume chamber and the longitudinal axis 72 of the bore of the adjacent cylinder.

As illustrated, the curved inner face 70 of each constant volume chamber C_c is preferably spherical.

Each passageway P connecting a particular constant volume chamber C_c with the adjacent varying volume chamber C_v is provided with an inner face 73 which is laterally and slopingly continuous with the preferably flat inner cylinder head face 29 of the adjacent varying volume chamber C_v, and each laterally continuous passageway face 73 is tangential with the curved inner surface 70 of the constant volume chamber C_c connected with the adjacent varying volume chamber C_v by the particular passageway P.

The width w of each passageway P is preferably as illustrated somewhat greater than the diameter of the spherical inner surface 70 of each constant volume chamber C_c, and the minimum height h of each passageway P is preferably somewhat less than the radius of the spherical inner surface 70.

As illustrated, each constant volume chamber C_c is formed by members located in a socket 74 formed in the upper end wall 15 of the cylinder block portion 12. The bottom surface 74–1 of each pocket 74 is hemispherical. The upper surface 74–2 of each socket 74 is cylindrical and has a vertical axis passing through the center of the hemispherical surface 74–1, the radius of the cylinder surface 74–2 being the same as the radius of the hemispherical surface 74–1.

The members forming each constant volume chamber C_c and portions of its communicating passageway P as shown, include a bottom member 75 and a top member 76 which are separable from each other and which together fit in and mate with one of the sockets 74.

Each bottom member 75 includes a lower externally and internally hemispherical shell portion 75–1, an upper externally cylindrical portion 75–2 extending from the upper end of the hemispherical shell portion 75–1, and an upper flat end surface 75–5.

The external hemispherical surface of the lower shell portion 75–1 of each bottom member 75 mates with the internal hemispherical bottom surface 74–1 of its socket 74.

The top member 76 forming each constant volume chamber C_c is externally cylindrical and its upper end extends upwardly beyond the top wall 15 of the cylinder block portion 12 and into a downwardly opening cylindrical recess 77 formed in the adjacent cylinder head lower wall 28. In the normally lower face of each top member 76, there is formed a cavity 78 which includes a curved inner surface portion 78–1 connecting with the spherical inner portions of the lower member 75.

Each cavity 78 also includes a flat surface portion 79–1 extending tangentially from the curved inner surface portion 78–1, and opposite side surfaces 79–2 and 79–3 converging with the sides of the flat tangential surface portion 79–1 and with the curved inner surface portion 78–1. The flat tangential surface portion 79–1 has a slight upward slope from its junction with the curved surface portion 78–1, and forms with the opposite side surfaces 79–2 and 79–3 and with a portion of the upper flat end surface 75–5 of the lower member 75 opposite the flat tangential surface 79–1, the constant volume chamber end of the particular connecting passageway P.

The flat surface 79–1 of each top member 76 is thus the constant volume chamber end of the flat inner face 73 of the passageway P taken as a whole.

The remaining portions of each passageway P are formed by an extension of the inner face 29 of the adjacent and connected varying volume chamber C_v, by the side faces of a notch 81 formed in the top wall 15 of the cylinder block portion 12 between the constant volume chamber C_v and the adjacent socket 74, and by a cylinder end portion of the upper flat end surface 75–5 of the lower member 75.

The air intake valve means heretofore described in general, comprise means operated in a usual manner for introducing preferably atmospheric air including gaseous oxygen, or in other words a combustion supporting medium, into each varying volume chamber C_v on the air intake stroke of the piston thereof; and the exhaust valve means heretofore described in general, provide means for exhausting each varying volume chamber C_v during the exhaust stroke of the piston thereof.

Means are also provided for injecting preferably liquid hydrocarbon fuel into each constant volume chamber C_c preferably during the compression stroke of the associated piston, and as illustrated the fuel injecting means includes for each constant volume chamber C_c a pintle nozzle 82 each of which is operatively mounted in the cylinder block portion 12, and the discharge end 83 of each of which extends into and terminates in the constant volume chamber C_c, with which the particular nozzle is associated.

Each nozzle 82 is of usual construction, and is adapted to introduce into the constant volume chamber C_c with which it is associated, an atomized conical spray 90 of fuel particles, the conical spray having its origin O located between the plane of the inner face of the cylinder head and a plane of displacement of the piston from the inner face of the cylinder head, that is, at the crank shaft side of the passageway P; and the origin O of the spray is preferably located in the side of the internally spherical constant volume chamber C_c opposite the passageway P and the spray is preferably directed as illustrated sidewards and upwards towards the passageway P and towards the plane of the inner face 29 of the cylinder head, all as best shown in Figs. 1 and 2.

The longitudinal axis 91 of each conical spray is preferably located in the plane, which is the plane of the drawing sheet of Figs. 1 and 2, passing through the center 71 of the associated preferably internally spherical constant volume chamber C_c and the longitudinal axis 72 of the bore 20 of the associated cylinder.

For attaining other objects of the present improvements, that is the control of the flow of hot gases emerging from each constant volume chamber through its associated passageway, each bottom member 75 is provided with improved combined fuel spray and deflector means and gas flow directing means which as shown and preferably are constituted by a tongue or lip 76–7 which extends upwardly above the upper flat end surface 75–5 of the bottom member 75 into the constant volume chamber opening of its associated passageway P, and the inner surface of each lip 76–7 is a continuation of the spherical inner surface of the shell 75–1.

A passageway forming tongue 75–7 having parallel side faces 75–8 and 75–9 extends at opposite sides of a parallel plane indicated by the dot-dash line 91–1 in Fig. 4, and which passes through the center of the internal spherical surface of the bottom member 75. The outer end face 75–10 of the tongue 75–7 has a concave cylindrical curvature conforming to the curvature to the cylinder bore. The tongue 75–7 fits in the notch 81 and thus properly positions the constant volume chamber forming bottom member 75. The top face of the tongue 75–7 is an extension of the upper flat end face 75–5, of the bottom member 75.

Referring particularly to Fig. 4, the lip 76–7 extends upwardly from the inner end of the tongue 75–7 and symmetrically with respect to the plane 91–1. The upper end of the lip 76–7 has a convex curvature 76–8, and at one side the lower base portion of the tongue 76–7 has a faired and concave curvature 76–9 merging at its upper end with the lower end of the convex curvature 76–8 and merging at its outer end with the spherical inner surface of the bottom member 75.

At the other side, the lower base portion of the tongue 76–7 has a faired and convex curvature 76–10 merging at its upper end with the lower

end of the convex curvature 76–8 and merging at its outer end with the spherical inner surface of the bottom member 75.

Each of the concave curvatures 76–9 and 76–10 are also faired downwardly from a junction with the upper end face of the tongue 76–7 in a slope towards the bottom of the inner spherical surface of the bottom member 75.

As in said U. S. Patent No. 2,062,951, the area of each tongue or lip 76–7 is such as to intercept such part of the conical fuel spray injected into the particular constant volume chamber C_c as may reach the tongue or lip 76–7, and thus prevent the injection of any solid unmixed fuel through the passageway P into the varying volume chamber C_v.

The area of each tongue or lip 76–7 is preferably as illustrated relatively small as compared with the total area of the associated passageway P, the passageway opening above and about the sides of the lip or tongue.

As aforesaid mechanical clearance only is preferably provided between each flat piston end face 62 and the opposite flat inner cylinder head face 29 at the dead center position of the piston, and the total volume of each constant volume chamber C_c and the associated passageway P, which constitute the clearance volume of the particular cylinder, is small relative to the maximum volume of the associated varying volume chamber C_v, so that the compression ratio of the engine may be high, for example 14 to 1.

Parts of the engine 10, not specifically described herein may be as set forth in said U. S. Patent No. 2,062,951, or may be other usual and similar engine parts.

For the purposes of the present improvements, the external surface of the constant volume chamber forming bottom member 75 is provided with a cylindrical section 75–11 below the tongue 75–7 as best shown in Figs. 5 and 6. This cylindrical section 75–11 in the embodiment of the improved construction shown in Figs. 1 to 6 inclusive, is formed as the bottom surface of a recess bordering partly in the upper externally cylindrical portion 75–2 and the lower hemispherical portion 75–1 of the constant volume chamber forming lower member 75, the radius 75–12 of the cylindrical section 75–11 being less than the radius 75–13 of the externally cylindrical portion 75–2 of the member 75. The cylindrical section 75–11 may be otherwise termed an arcuate section.

In Fig. 7, a second embodiment of the improved engine construction is indicated generally by 110 and is similar to the engine construction 10 with the exception that the engine construction 110 includes a constant volume chamber forming lower member 175 having a cylindrical or arcuate section 175–11 bordering other portions of the external surface of the lower member 175, and the arcuate section 175–11 having a radius 175–12 which may be the same as the radius 175–13 of the externally cylindrical portion 175–2 of the lower member 175, the center 175–14 of the radius 175–12 being offset to the rear of the center 171 of the radius 175–13 in the plane passing through the center 171 of the constant volume chamber and the longitudinal axis of the adjacent cylinder bore 120.

In the improved engine construction 10 the recess formed by the cylindrical section 75–11 has abrupt side corners 75–15.

In Fig. 8, a third embodiment of the improved engine construction is indicated generally by 210, and includes a constant volume chamber forming bottom member 275 provided with a cylindrical or arcuate section 275–11 below a tongue similar to the tongue 75–7. The cylindrical or arcuate section 275–11 has a radius 275–12 less than the radius 275–13 of the externally cylindrical portion 275–2 of the member 275. The opposite sides or borders of the cylindrical or arcuate section 275–11 have ramp ends 275–15 and 275–16 connecting with the externally cylindrical portion 275–2.

In each of the engine constructions 10, 110, and 210, the section of the wall of the constant volume chamber forming lower member including the cylindrical section is thinner than the other wall portions of the constant volume chamber forming lower member, and this thinner wall section is below the passageway forming tongue of the constant volume chamber forming lower member.

Each cylindrical section 75–11, 175–11, and 275–11, is spaced from the cylindrical upper surface 74–2 of the mounting socket for the lower members 75, 175, and 275.

In the operation of the engine 10 including the present improvements, the suction stroke of each piston draws intake air into the varying volume chamber C_v thereof, and the succeeding compression stroke of the piston compresses the charge of air and forces it with very rapidly increasing pressure and velocity from the varying volume chamber C_v through the associated passageway P and into the associated constant volume chamber C_c. As the piston moves across and substantially traverses the passageway P on its compression stroke, the opening of the passageway P into the varying volume chamber C_v is rapidly reduced in area, which still further increases the pressure and velocity of the air being forced through the passageway P into the associated constant volume chamber C_c.

The fact that as aforesaid the passageway face 73 is an extension of the inner flat face 29 of the varying volume chamber C_v, and is tangential to the symmetrical and preferably spherical inner surface 70 of the constant volume chamber C_c, causes an unusually effective whirling of the air forced into the chamber C_c, the velocity of the whirl increasing as the piston moves across the passageway P and approaches top dead center.

The fuel is sprayed in the manner above set forth across and towards the whirling or revolving air in the combustion chamber C_c, and the resulting combustion is of the desired character, whereby the engine operates at relatively high speeds and with relatively high mean indicated pressure.

It is to be noted that when the conical fuel spray 90 for any particular constant volume chamber C_c strikes the limited area of the associated lip 76–7 in the associated passageway P, towards which the spray is directed from the side of the constant volume chamber and at an angle to the tangential face of the passageway, there will be a deflection of a portion of the fuel spray above and about the sides of the lip 76–7 so that a portion of the fuel spray is impinged directly by the incoming air charge in and at the constant volume chamber end of the passageway P.

This combined effect is such that the mixing of the fuel charge with the incoming air charge commences virtually at the constant volume chamber end of the passageway and continues through the entire motion of the air charge in and through the constant volume chamber.

There is a very short period of time during

which the complete cycle of mixing and combustion must take place, and the initiation of the mixing action of each unit volume of air charge as it enters its spherical side chamber, and the consequent attainment of a mixing action through a maximum period or portion of the complete cycle of mixing and combustion is of great benefit.

The operation of the improved engine **10** as thus far described is substantially the same as the operation of the engine set forth in said U. S. Patent No. 2,062,951. An engine including only the construction of said U. S. Patent No. 2,062,951, has the disadvantages previously set forth, and which may be summarized as including: (1) insufficient heat transfer from each cylinder wall and constant volume or mixing and combustion chamber C_c to the cooling water; (2) expansion or bulging of portions of the separate walls of each mixing and combustion chamber such as to distort adjacent portions of the associated cylinder wall; and (3) unsatisfactory flow of hot gases emerging from each mixing and combustion chamber C_c.

In the present improved engine **10**, as above set forth, each mixing and combustion chamber C_c is constructed by a unit including a bottom member **75** and a top member **76** which are separable from each other and which together fit in and mate with one of the sockets **74**. The relatively thin lower hemispherical shell **75–1** of the bottom member **75** is topped by the upper externally cylindrical portion **75–2** having thicker walls, and by the externally cylindrical top member **76** having thicker walls, and these differential wall thicknesses provide heat collecting and transfer means for each mixing and combustion chamber C_c, whereby transmission of heat from the chamber C_c through the cylinder block walls of the socket **74** to the cooling water is promoted, and transmission of heat is resisted from the chamber C_c to the cylinder wall of the associated cylinder and other parts of the cylinder block not in direct contact with members **75** and **76**.

Also, as above set forth, each thinner externally cylindrical or arcuate section **75–11**, **175–11**, and **275–11** of the constant volume chamber forming bottom members **75**, **175**, and **275**, is spaced from opposite sections of the internal cylindrical upper surface **74–2** and upper portions of the lower internal hemispherical bottom surface **74–1** of its mounting socket **74** in the cylinder block.

This spacing of each thinner externally cylindrical section **75–11**, **175–11**, and **275–11** from opposite sections of its mounting socket **74**, forms an expansion chamber between each bottom member **75**, **175**, and **275**, and the cylinder block in which it is mounted. Each such expansion chamber is shown and preferably is located below the passageway forming tongue **75–7** of each bottom member **75**, **175**, and **275**. Thus, expansion or bulging of each bottom member **75**, **175**, and **275** by temperature rise during operation of the engine of which it is a part, is localized in its thinner externally cylindrical section **75–11**, **175–11**, or **275–11**, and such expansion takes place in the expansion chamber, without pushing of the expanding section against the opposite section of the associated cylinder wall. Consequently there is substantially no distortion of the associated cylinder wall.

Accordingly in the improved engine **10**, cylinders having a maximum bore may be included in an otherwise standard cast cylinder block, without encountering cracking of the cylinders or cylinder liner portions in the operation of the engine.

From the standpoint of the flow of hot gases from each chamber C_c through its associated passageway P and into its associated chamber C_v, the provision of the lower faired concave curvatures **76–9** and **76–10** at each side of the upper central convex curvature of the lip **76–7**, directs the hot gases upwardly as they emerge from the chamber C_c, so as to strike the lower face **29** of the cylinder head **13** and not the end face **62** of the piston, thereby avoiding damage of the piston end face and cylinder walls. Moreover the faired or rounded surfaces **76–8**, **76–9**, and **76–10**, merging with each other and with the spherical inner surface of the chamber C_c, minimizes the tendency to burn-off of such bounding surfaces when sharp corners are present therein.

The convex curvatures **76–9** and **76–10** may be otherwise termed upwardly sloping channels at each side of the base of the deflector lip **76–7**.

In the engine **10**, each mixing and combustion chamber forming top member **76** is prevented from turning in the upper end of its socket **74**, by the provision of a vertical groove **74–4** in the upper cylindrical surface **74–2** of the socket **74**. A pin **76–11** extends from a side opening socket in each member **76** into the associated groove **74–4**.

When desired each top member **76** may be welded to its associated bottom member **75**.

The mixing and combustion chamber forming members **75** and **76** are preferably each made of heat resisting steel, which in itself serves to protect the cast iron cylinder block from damage by the hot gases in the mixing and combustion chambers.

In the foregoing description, certain surfaces and curvatures of the improved mixing and combustion chambers have been defined as being "faired," by which it is meant that these faired faces and curvatures have smooth junctions with adjacent surfaces without sudden or angular deviations.

In the foregoing description, certain terms have been used for brevity, clearness, and understanding but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such words are used for descriptive purposes herein and are intended to be broadly construed.

Moreover, the embodiments of the improved constructions illustrated and described herein are by way of example, and the scope of the present invention or discovery is not limited to the exact details of construction set forth.

Having now described the invention or discovery, the construction, the operation, and use of preferred embodiments thereof, and the advantageous new and useful results obtained thereby; the new and useful constructions, and reasonable mechanical equivalents thereof obvious to those skilled in the art, are set forth in the appended claims.

I claim:

1. In an internal combustion engine, walls forming a cylinder block having an end wall, a cylinder head secured on the cylinder block end wall, the cylinder head including an end wall abutting the cylinder block end wall, a cylinder extending from the cylinder block end wall. the cylinder having a bore opening through the cylinder block end wall, other walls of the cylinder block forming a recess including a socket

opening through the cylinder block end wall and a notch extending between the socket and the cylinder bore and opening through the cylinder block end wall, the cylinder head end wall having an inner face extending over the cylinder bore and the recess, a mixing and combustion chamber unit including mixing and combustion chamber forming bottom and top members located in the socket, the socket having internal surfaces, and the unit bottom member having external surfaces, some of the external surfaces of the unit bottom member fitting internal surfaces of the socket, and one of the external surfaces of the unit bottom member being spaced from one of the internal surfaces of the socket and forming therewith an expansion chamber.

2. In an internal combustion engine as set forth in claim 1, and in which the mixing and combustion chamber unit bottom and top members have inner surfaces forming a mixing and combustion chamber having an opening communicating with the notch, the notch and portions of the cylinder head end wall inner face constituting a passageway communicating between the mixing and combustion chamber opening and the cylinder bore, and the expansion chamber being located adjacent and spaced from the combustion chamber opening.

3. In an internal combustion engine as set forth in claim 2, and in which a portion of an inner surface of the combustion chamber and the expansion chamber forming spaced external surface of the unit bottom member are on opposite sides of a wall section of the unit bottom member which is thinner than its bounding wall sections of the unit bottom member, whereby expansion of the thinner wall section may take place in the expansion chamber.

4. In an internal combustion engine as set forth in claim 3, and in which the notch has a bottom wall with side edges opposite the passageway forming portion of the cylinder head end wall inner face, and the notch has opposite side walls extending from its bottom wall side edges to the passageway forming portion of the cylinder head end wall inner face, and the unit bottom member has a tongue extension located in the notch and having surfaces abutting the surfaces of the notch bottom wall and side walls, the unit bottom member tongue extension constituting a top wall of the expansion chamber.

5. In an internal combustion engine as set forth in claim 4, and in which the notch side and bottom walls include inner ends adjacent the socket, and the internal surfaces of the socket include a bottom surface and cylindrical surfaces extending between the bottom surface and the cylinder block end wall opening of the socket and the cylindrical surfaces intersecting the inner ends of the notch side and bottom walls, and in which the external surfaces of the unit bottom member include a bottom surface fitting the socket bottom surface and cylindrical surfaces extending from the unit bottom member bottom surface and fitting cylindrical surface portions of the socket, the expansion chamber forming spaced external surface of the unit bottom member being an arcuate section bordering other external surfaces of the unit bottom member.

6. In an internal combustion engine as set forth in claim 5, and in which the bottom surface of the socket is hemispherical, and the bottom surface of the unit bottom member is hemispherical and fits the hemispherical bottom surface of the socket.

7. In an internal combustion engine as set forth in claim 6, and in which the expansion chamber forming spaced arcuate external surface section of the unit bottom member is coaxial with the cylindrical surfaces of the socket, the radius of the spaced external surface section of the unit bottom member being less than the radius of the cylindrical surfaces of the socket.

8. In an internal combustion engine as set forth in claim 6, and in which the expansion chamber forming spaced arcuate external surface section of the unit bottom member has an axis eccentric with respect to the axis of the cylindrical surfaces of the socket.

9. In an internal combustion engine, walls forming a cylinder block having an end wall, a cylinder head secured on the cylinder block end wall, the cylinder head including an end wall abutting the cylinder block end wall, a cylinder extending from the cylinder block end wall, the cylinder having a bore opening through the cylinder block end wall, other walls of the cylinder block forming a cylinder block recess including a socket opening through the cylinder block end wall and a notch extending between the socket and the cylinder bore and opening through the cylinder block end wall, the cylinder head end wall having an inner face extending over the cylinder bore and the cylinder block recess, a mixing and combustion chamber unit including mixing and combustion chamber forming bottom and top members located in the socket, the socket having internal surfaces, and the unit bottom member having external surfaces, one of the external surfaces of the unit bottom member having a recess formed therein, other external surfaces of the unit bottom member fitting internal surfaces of the socket, and the recess in the one external surface of the unit bottom member and an opposite portion of one of the internal surfaces of the socket forming an expansion chamber.

10. In an internal combustion engine as set forth in claim 9, and in which the mixing and combustion chamber unit bottom and top members have inner surfaces forming a mixing and combustion chamber having an opening communicating with the notch, the notch and a portion of the cylinder head end wall inner face constituting a passageway communicating between the mixing and combustion chamber and the cylinder bore, and the expansion chamber being located adjacent and spaced from the combustion chamber.

11. In mixing and combustion chamber construction for an internal combustion engine and the like including a cylinder block having an end wall and walls forming a cylinder having a bore opening through the end wall and a recess opening through the end wall and the recess including a socket and a notch communicating between the socket and the cylinder bore, and a cylinder head having an end wall with an inner face extending over the cylinder bore and the recess; a combustion chamber unit adapted for separably fitting in the socket, the unit including mixing and combustion chamber forming bottom and top members, the unit bottom member having external surfaces, one of the external surfaces being a portion of an entirely cylindrical surface, and another external surface lying within the entirely cylindrical surface and making junction with the portion thereof.

12. In mixing and combustion chamber construction as set forth in claim 11, and in which the other external surface is the bottom surface of a recess.

13. In an internal combustion engine, walls forming a cylinder block having an end wall, a cylinder head secured on the cylinder block end wall, the cylinder head including an end wall abutting the cylinder block end wall, a cylinder extending from the cylinder block end wall, the cylinder having a bore opening through the cylinder block end wall, other walls of the cylinder block forming a recess including a socket opening through the cylinder block end wall and a notch extending between the socket and the cylinder bore and opening through the cylinder block end wall, the cylinder head end wall having an inner face extending over the cylinder bore and the recess, a mixing and combustion chamber unit including mixing and combustion chamber forming bottom and top members located in the socket, the socket having internal surfaces, and the unit bottom member having external surfaces, some of the external surfaces of the unit bottom member fitting internal surfaces of the socket, and one of the external surfaces of the unit bottom member being spaced from one of the internal surfaces of the socket and forming therewith an expansion chamber, and the mixing and combustion chamber unit bottom and top members having inner surfaces forming a mixing and combustion chamber having an opening communicating with the notch, the notch and a portion of the cylinder head end wall inner face constituting a passageway communicating between the mixing and combustion chamber and the cylinder bore, and the expansion chamber being located adjacent and spaced from the combustion chamber opening.

14. In an internal combustion engine as set forth in claim 13, and in which a piston is operative for reciprocation in the cylinder bore and forming with the cylinder bore and the cylinder head wall inner face a cylinder chamber, means for introducing a charge of combustion supporting medium into the cylinder chamber, and means for injecting fuel particles into the mixing and combustion chamber.

No references cited.