Feb. 28, 1939. C. G. A. ROSÉN 2,148,505

ENGINE

Filed April 30, 1934 2 Sheets-Sheet 1

FIG. 2.

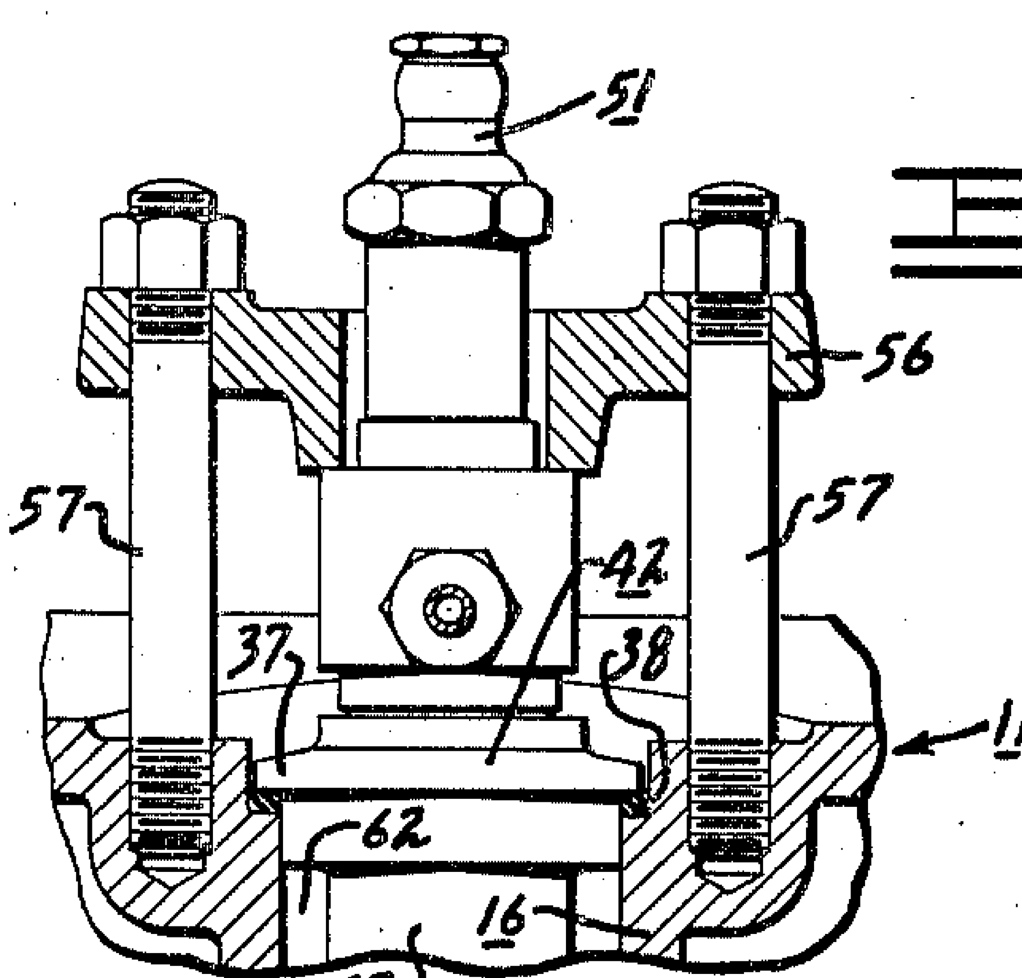


FIG. 1.

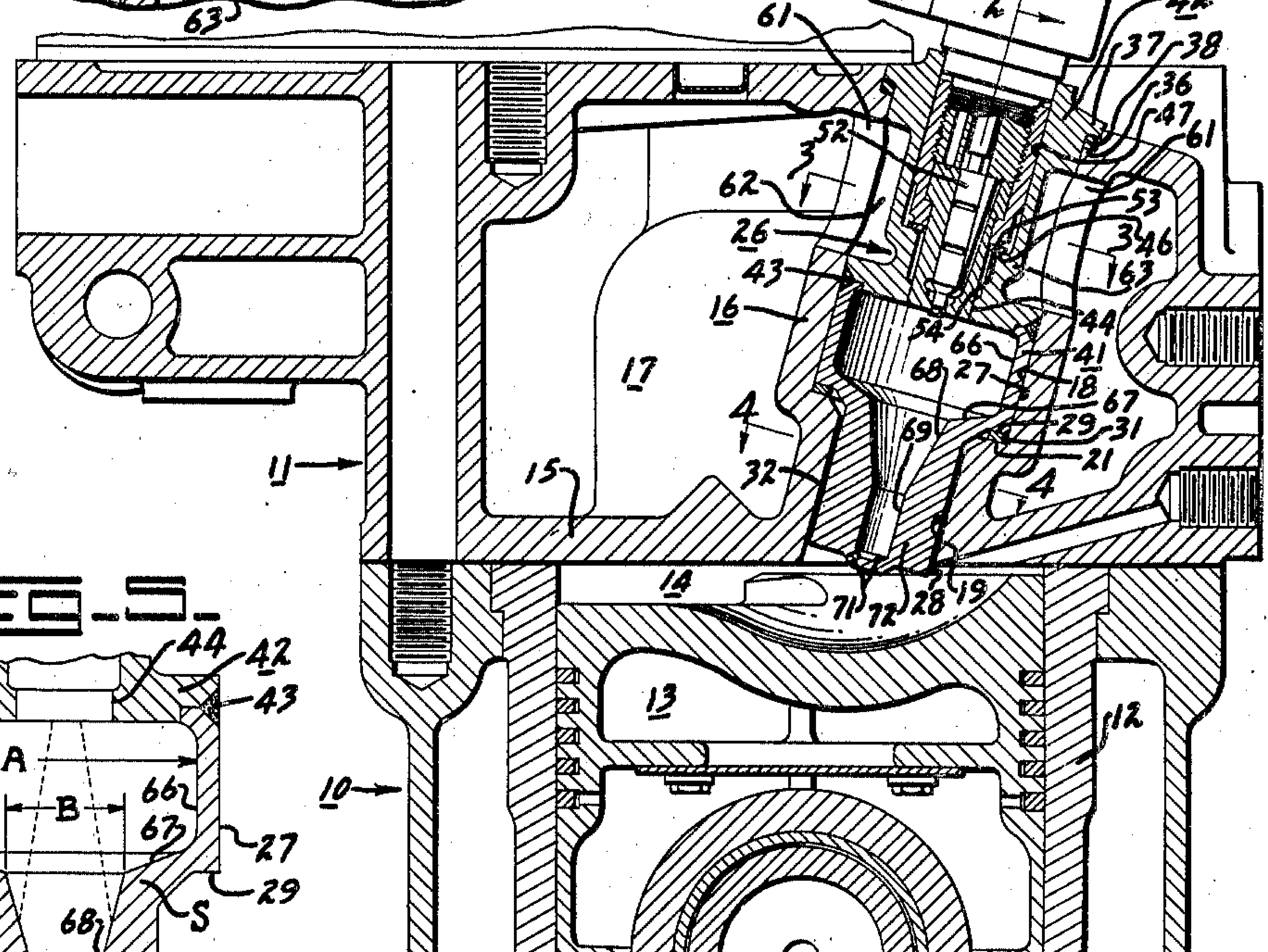
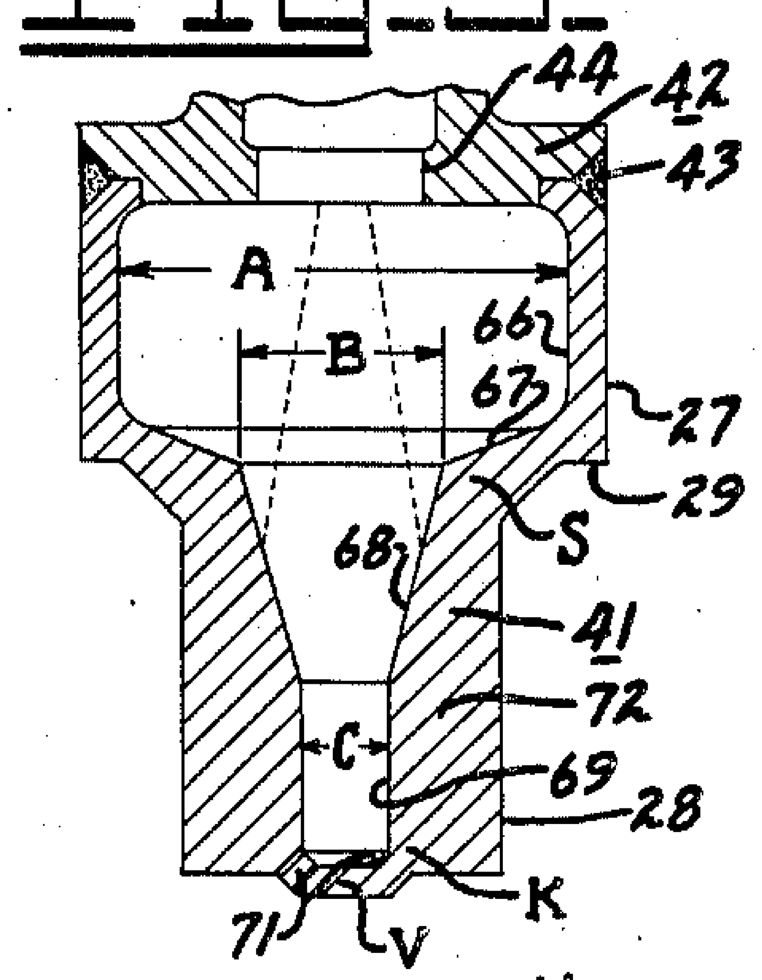


FIG. 5.



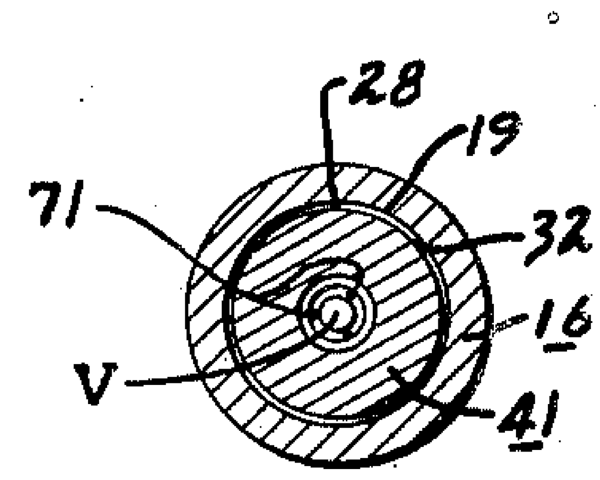


FIG. 4.

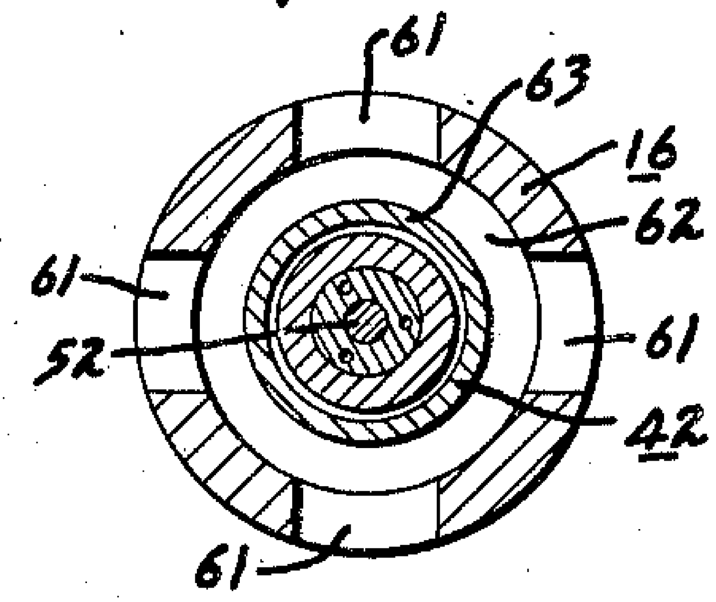


FIG. 3.

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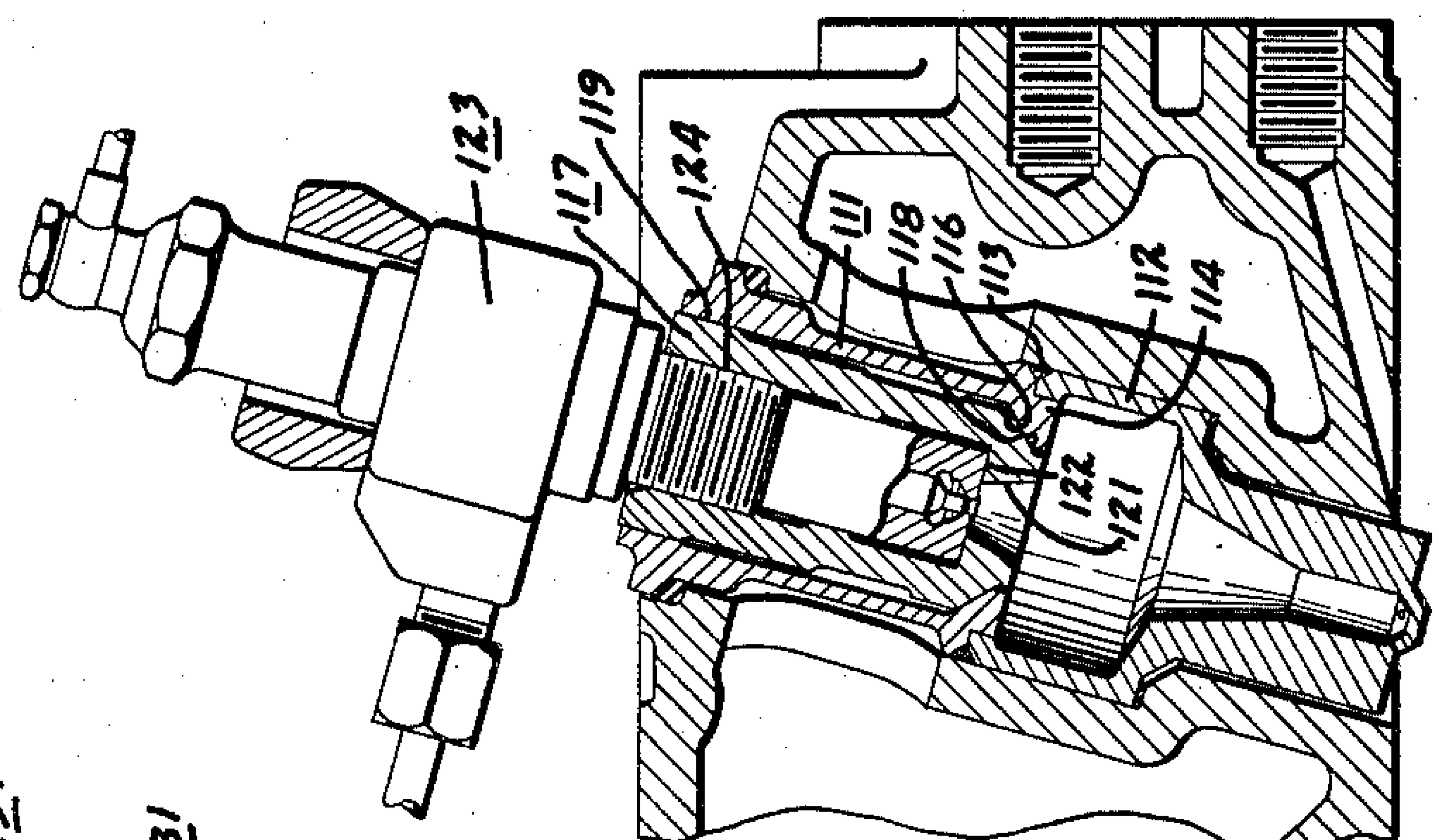

FIG. 7.

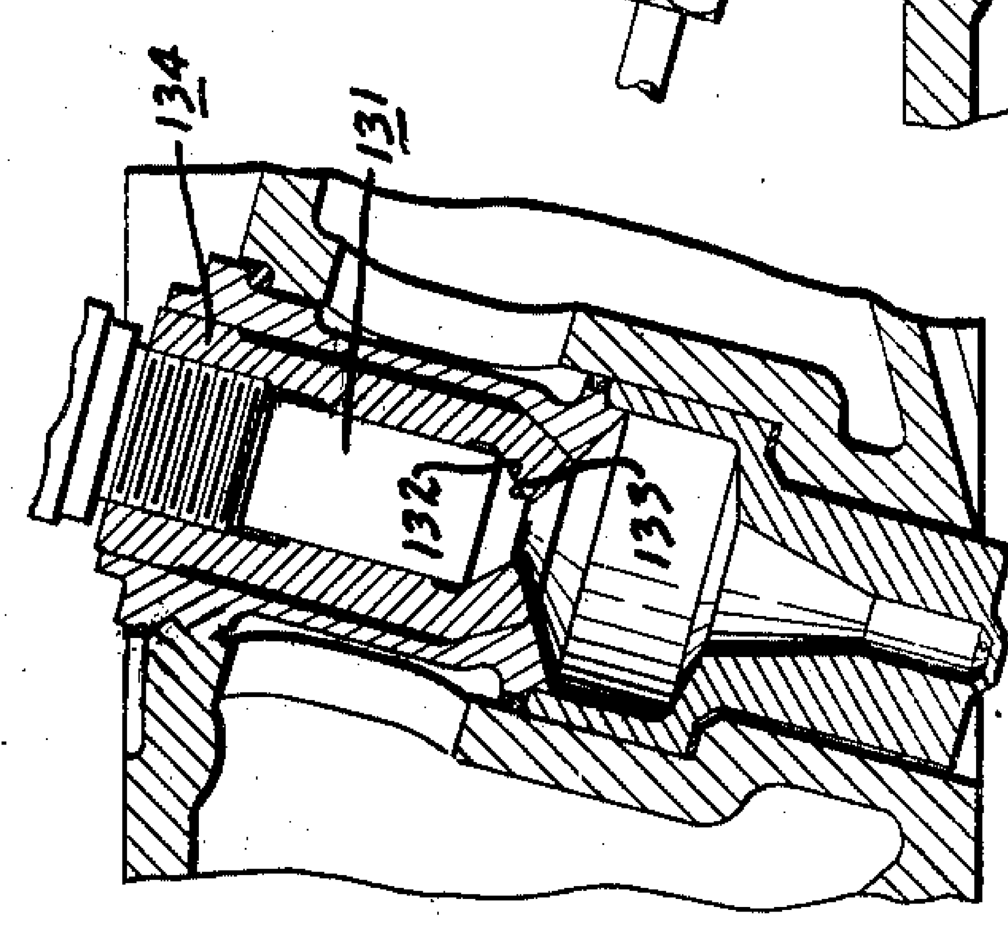

FIG. 8.

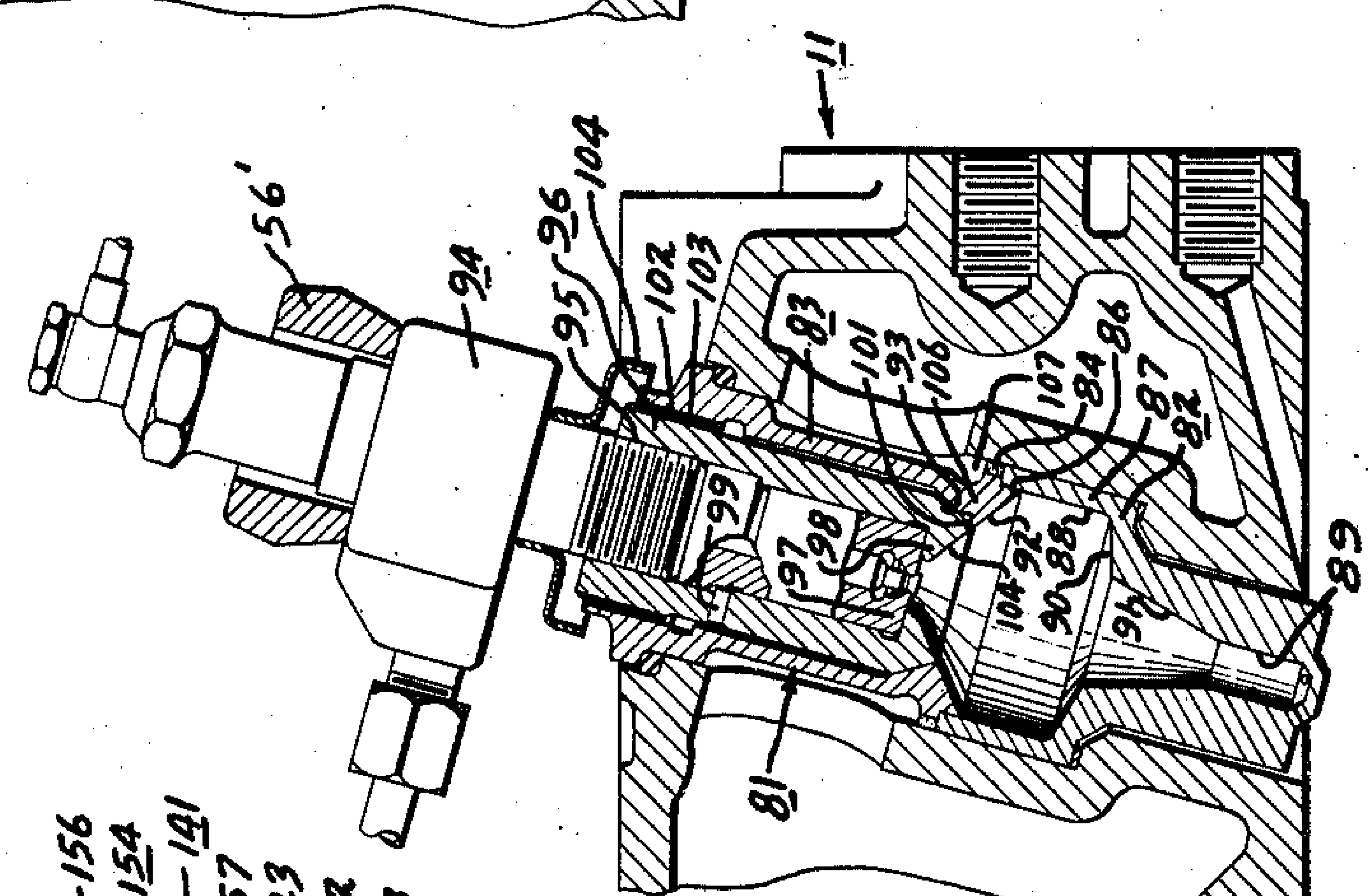

FIG. 6.

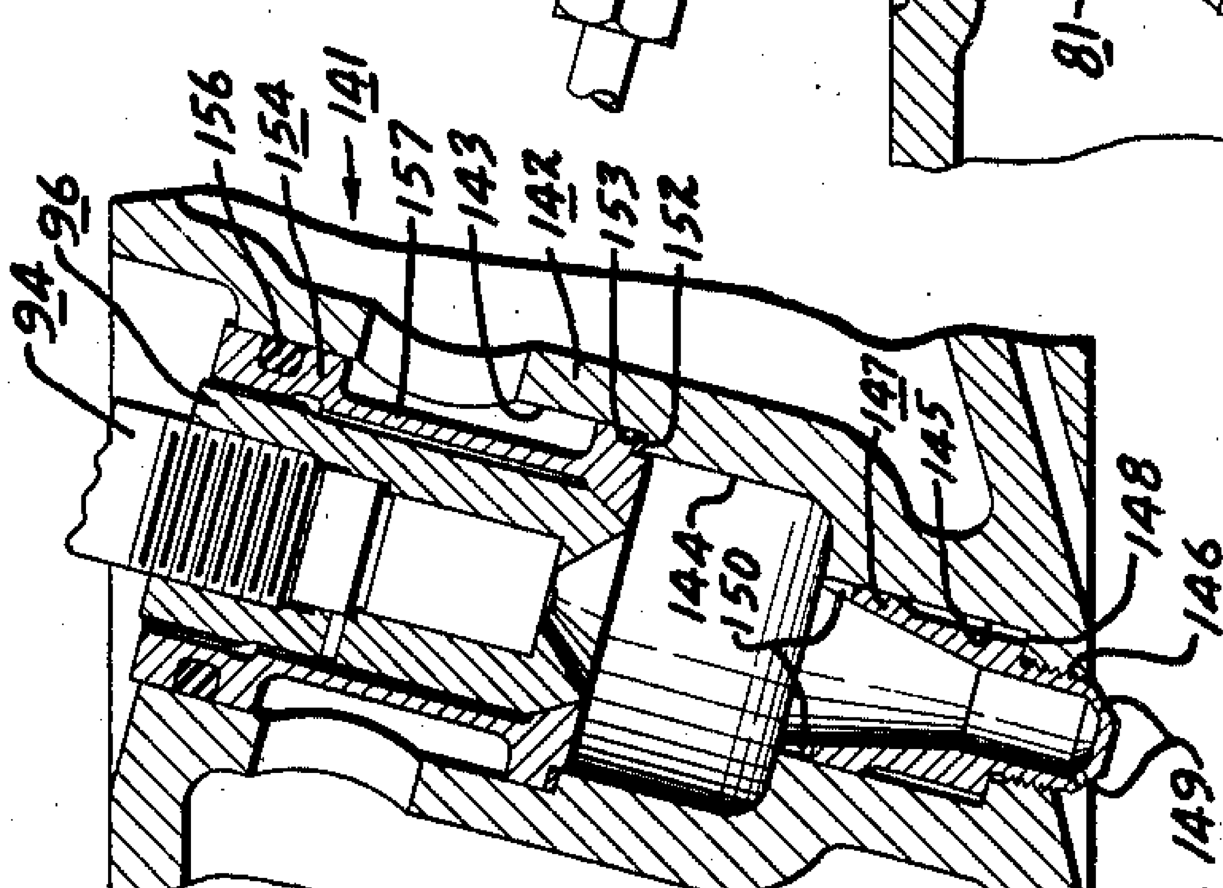

FIG. 9.

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UNITED STATES PATENT OFFICE

2,148,505

ENGINE

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Application April 30, 1934, Serial No. 723,056

11 Claims. (Cl. 123—33)

The present invention relates to compression ignition and the like engines, and more particularly to the provision of improved fuel combustion and injection means for such engines.

It is an object of the invention to provide a precombustion chamber construction for engines of the character described, which is economical to manufacture and assemble.

Another object of the invention is to provide a cylinder head for compression ignition and the like engines in the form of a casting, which provides a mounting for a removable precombustion chamber unit, and which can be produced with a large measure of security against defects caused by gas pockets and shrinkage.

Another object of the invention is to provide a simple mounting for a fuel injection nozzle.

Another object of the invention is to provide, in an engine of the character described, a fuel injection nozzle which is mounted to promote desirable heat conditions at the discharge end thereof.

Another object of the invention is to provide, in an engine of the character described, an improved method of maintaining the discharge end of a fuel injection nozzle at efficient operating temperatures.

Another object of the invention is to provide a mounting for fuel injection nozzles which promotes quick and facile replacement of one nozzle by another.

Another object of the invention is to provide a precombustion chamber construction for engines of the character described, in which proper heat conditions in the chamber are promoted by virtue of the method of assembly and mounting therefor.

Another object of the invention is to provide a precombustion chamber construction for engines of the character described in which air available for combustion is properly distributed and directed with respect to the injected fuel spray.

Another object of the invention is to provide a precombustion chamber construction for engines of the character described in which the fuel spray is received on a heated surface, and is met by an incoming current of air which is heated by the portion of the precombustion chamber through which it passes.

Another object of the invention is to provide an improved method of fuel combustion in precombustion chambers for engines of the character described.

Other objects will appear as the description progresses.

Description of figures

Figs. 1 through 4 illustrate one form of the invention.

Fig. 1 is a fragmentary transverse vertical section through the axis of the cylinder.

Fig. 2 is a fragmentary sectional view taken in the plane of line 2—2 in Fig. 1.

Fig. 3 is a sectional view taken in the plane of the line 3—3 in Fig. 1.

Fig. 4 is a sectional view taken in the plane of the line 4—4 in Fig. 1.

Fig. 5 is a schematic view of the precombustion chamber.

Fig. 6 is a fragmentary sectional view similar to Fig. 1 and illustrates the preferred form of the invention.

Fig. 7 is a view similar to Fig. 6 illustrating a third form of the invention.

Fig. 8 is a fragmentary section similar to Fig. 6 illustrating a fourth form of the invention.

Fig. 9 is a fragmentary sectional view similar to Fig. 6 illustrating a fifth form of the invention.

Description of mechanism

The compression ignition and the like engine disclosed herein is of the precombustion chamber type, which comprises generally a main combustion chamber, and a precombustion chamber in restricted communication therewith. Measured amounts of fuel are injected into the precombustion chamber of each cylinder by means of a fuel injection nozzle, which is preferably provided with a single hole discharge orifice and is preferably operated by differential pressure from an associated fuel injection pump. For a complete disclosure of this type of engine, reference is made to my copending application, Serial No. 684,179, filed August 8, 1933. Only that portion of the engine necessary for an understanding of the present invention will now be described.

Engine block 10 (Fig. 1) has head 11 suitably secured thereon. Each cylinder is formed by a cylinder liner 12, suitably mounted in block 10 and having piston 13 mounted therein to form main combustion chamber 14 between bottom wall 15 of cylinder head 11 and the dished top of piston 13. The cylinder head is a metal casting which is formed to provide a mounting for a unit assembly in which the precombustion chamber is formed.

Cylinder head 11 is provided with internal cylindrical wall 16 (Fig. 1) surrounded by water jacket or space 17; wall 16 having inner cylindrical surfaces 18, 19, of differing diameters to provide annular seat or shoulder 21 therebetween. A removably positioned precombustion chamber unit 26, the construction of which is described more specifically hereinafter, is provided with external cylindrical surfaces 27, 28 of different diameters to provide annular seat or shoulder 29 therebetween for support on wall seat 21. Sealing washer 31, of any suitable metal having high heat conductivity such as copper for example, is placed between seats 21 and 29. Surface 27 of precombustion chamber unit 26, and wall surface 18 are machined to fit closely, while unit surface 28 is of less diameter than wall surface 19 to provide annular space 32 (Figs. 1 and 4) therebetween for a purpose later described. The size of space 32 in the drawings is exaggerated for the purpose of clear illustration; the clearance between surfaces 19, 28 in the actual engine construction being in the order of .003-.005 of an inch. At the top, cylinder head 11 (Fig. 1) is provided with annular shoulder or seat 36 axially aligned with wall 16 to support annular flange 37 of unit 26; gasket 38, of rubber composition or other suitable compressible material, being interposed between seat 36 and flange 37.

Because of the provision of the separate precombustion chamber unit 26 within the space or passage enclosed by wall 16, the internal diameters of such space must necessarily be larger for a precombustion chamber of a predetermined size than would be the case if the separate unit 26 were not employed. Hence, the cores used in casting wall 16 as part of the cylinder head will be larger than would obtain without employing separate unit 26. This enables a large measure of security against casting defects caused by gas pockets and shrinkage, because, in casting, the larger the cores the less chance for such defects.

Precombustion chamber unit 26 is formed of two molecularly united members, which can be readily machined to the desired form and dimensions before being welded together. Unit 26 includes lower member 41 and upper member 42 molecularly united at 43 by welding. Lower member 41 is formed to provide the precombustion chamber proper, while the upper member 42 provides mounting means for the fuel injection nozzle having its single hole discharge orifice axially aligned with the precombustion chamber axis. Upper member 42 is provided with a central bore forming small cylindrical wall surface 44 at the bottom, and seat 46 located between surface 44 and cylindrical wall surface 47 of larger diameter than surface 44. Fuel injection nozzle 51, provided with differential pressure operated discharge needle 52, seats, with just enough clearance to provide a free fit, within surface 44 and, with minimum clearance to provide a close fit, within surface 47; seat 53 of the nozzle being spaced from seat 46 of unit 26 by metallic gasket 54. Nozzle 51 is rigidly clamped in place by fitting 56 (Figs. 1 and 2) engaging the top thereof, and by studs 57 threaded in cylinder head 11 and passing through fitting 56. Suitable nuts are threaded on the upper ends of studs 57 to engage fitting 56.

Means are provided for cooling the fuel injection nozzle, and for this purpose cylinder head wall 16 (Figs. 1 and 3) is provided with a plurality of vertically elongated apertures 61 leading from water space 17 to water space 62 formed by recessed wall portion 63 of upper member 42 of unit 26. In this connection, it will be noted that the wall of upper member 42 covers or shields the apertures 61, and is in sealed contact with the solid walled portion 16 of the passage in the cylinder head. Since wall member 42 provides a mounting for the injection nozzle, the nozzle may be readily removed for replacement or repair without the water in water space 17 entering the auxiliary or precombustion chamber proper. Hence, the head need not be drained free of water when any of the nozzles are removed. As clearly seen in Fig. 1, a metallic path of heat flow is provided through the nozzle, from the discharge end thereof to upper member or unit part 42, via seats 53, 46 and metal gasket 54, and via wall surface 47 having the close fit with member 42; and from said member 42 heat is readily conducted to cooling chamber or water space 62. Cooling of the nozzle reduces to a minimum formation of carbon around the discharge orifice of discharge needle 52, caused by excessive heating of fuel which clings to the nozzle after injection terminates. Thus, clogging of the nozzle discharge orifice is substantially obviated. Also, sticking or binding of the nozzle needle is prevented, which might otherwise occur by expansion of the metal caused by heat of combustion.

The precombustion chamber proper includes three different portions of differing size; one of which provides a relatively large combustion space at the top and which is adjacent the discharge end of the fuel injection nozzle and is relatively cool, heat being transmitted from the walls thereof by conduction directly to water spaces. The second of these portions is a funnel-shaped passage having a relatively hot wall which receives the injected fuel, and by virtue of the heated condition thereof aids in combustion of the fuel. The third portion is a small passage, to provide for ingress of air from the combustion chamber which is heated in passing therethrough, and for discharge of the combustible mixture into the main combustion chamber. The second and third portions of the precombustion chamber are cooled only by radiation and convection as no direct metallic path of heat conduction to water spaces is provided. Lower member part 41 of unit 26 is provided with relatively large diameter inner cylindrical wall surface 66 to form the air supply or combustion chamber which is joined by comparatively short frusto-conical wall surface 67 to comparatively long frusto-conical wall surface 68, forming a funnel shaped fuel receiving chamber. The small diameter end of wall surface 68 merges with cylindrical wall surface 69. Wall surface 69 provides a cylindrical passage which communicates with main combustion chamber 14 through a plurality of restricted orifices 71. Orifices 71, having .139''-.141'' diameters, are inclined at an angle of substantially 45° with respect to the axis of the precombustion chamber and are formed in a wall section whose thickness should be from one and one-half to two times the diameter of the orifices, to obtain efficient results in controlling the flow of air and gasified fuel therethrough, as described later.

To promote efficient combustion, the total volume of the precombustion chamber, namely that portion enclosed by wall surfaces 66, 67, 68 and 69, should be from 25% to 32% of the total clearance volume; the total clearance volume being defined as the total volume of the precombustion chamber together with the total volume of main combustion chamber 14 when piston 13 is at the end of its compression stroke or, in other words, at upper dead center. Best combustion efficiency is, however, obtained when the precombustion chamber volume is from 27% to 30% of the total clearance volume. The ratio of the volumes of the chamber formed by surface 66, the chamber formed by surface 68 and the passage formed by surface 69 is not critical; it being only necessary to have the chamber formed by surface 66 of a volume sufficiently large to enable thorough intermixing of vaporized fuel with the air forced into the chamber during the compression stroke of the piston. Also, the chamber formed by surface 66 should be sufficiently deep to allow substantial conical spreading of the fuel jet or cone indicated by dotted lines in Fig. 5; and the funnel-shaped chamber formed by surface 68 should be wide enough at the top to have the fuel cone strike directly against the upper half of surface 68 for a reason to be subsequently explained.

Although the ratio of the volumes of the chambers formed by surfaces 66, 68 and 69 is not critical for efficient combustion, I have made the important discovery that certain cross sectional areas of the precombustion chamber should reduce in size in a definite ratio, from the tip of nozzle 51 to main combustion chamber 14, for most efficient combustion. I have found the following ratios preferable. (See Fig. 5.) A (the cross sectional area within wall surface 66): B (the cross sectional area at the upper end of wall surface 68): C (the cross sectional area within wall surface 69)::25:5:1. Though the foregoing ratios are preferable, I have found that satisfactory results can be obtained within the following limits: A:B:C::(30 to 22):(5.5 to 5):1. The value of A is such that a sufficient oxygen carrying envelope is provided around the fuel spray jet or cone, indicated in dotted lines in Fig. 5, to insure combustion of the proper quantity of fuel in the precombustion chamber. The values of B and C are selected, so that the center of the fuel spray cone, which is the hardest part to burn because it is shielded by the outer portion of the cone, is met by the incoming current of heated air which is forced by the ascending piston, from the main combustion chamber 14 through the passage defined by wall surface 69. As was stated previously, the funnel-shaped portion of the precombustion chamber, that is, the portion defined by frusto-conical surface 68, is so positioned with respect to the nozzle that the spray cone impinges on the upper half thereof at all times, irrespective of variations of pressure or amount of fuel injected. As a result, the center of the fuel spray cone is always thoroughly mingled with the inrushing heated air which, before encountering the fuel, is subjected to heating from the hottest part of the precombustion chamber wall surface, i. e., surface 69 because of the heat insulation which space 32 (Fig. 1) provides.

The outside dimensions of the precombustion chamber unit 26 are selected to insure the most advantageous thermal conditions, by providing suitable wall sections to obtain proper surface temperatures of the respective wall surfaces of the precombustion chamber. Wall portion 72 (Fig. 1) of lower part 41 which has wall surfaces 68, 69, is relatively thick and is spaced from wall 16 of the head, by annular insulating space 32, whereby no direct metallic path of flow of heat exists between wall 16 and wall portion 72. Thus, wall portion 72 remains heated during operation of the engine so that wall surface 68, which receives the conical spray of fuel discharged from nozzle 51, is maintained at a sufficiently high temperature to insure ready vaporization and combustion of the fuel. As wall portion 72 is cooled only by radiation and convention, it affords an efficient means for heating the air forced into the precombustion chamber, to overcome the cooling effect caused by expansion of the air after passing through orifices 71. Wall 16 of the cylinder head has surface to surface contact at 27 with the upper part of the precombustion chamber defined by surface 66, to promote the dissipation of excess heat from the portion of the chamber adjacent nozzle 51, whereby nozzle 51 is maintained at efficient operating temperatures.

It will be noted that the insulated wall portion of the auxiliary or precombustion chamber includes both the funnel-shaped passage or chamber defined by surface 68 and the axially extending cylindrical or tubular passage defined by wall surface 69, and that the thickest part of wall 72 is at the main combustion chamber end about tubular passage 69. Such tubular passage, which is in restricted communication with the main combustion chamber, is the channel of least diameter in the precombustion chamber, and is much longer than its width. Furthermore, the total cross sectional thickness of metal about such channel is greater than the width of the channel. This arrangement provides for mimimum expansion of the air entering the auxiliary combustion chamber, which would cause cooling thereof, and for maintaining such air hot in its flow through passage 69, so as to have no adverse effect on the vaporization of fuel striking the hot funnel-shaped passage 68. At the same time, as previously expained, the fuel becomes readily vaporized upon striking the funnel-shaped passage. Furthermore, when gases of combustion leave the precombustion chamber, they are not cooled in their passage through tubular passage 69, and this avoids undesirable condensation of ignited fuel which might otherwise occur in such constructions having a comparatively wide thin walled passage leading to the main combustion chamber.

From the preceding, it is seen that the portion of the precombustion chamber adjacent nozzle 51, is not unduly overheated by virtue of the direct heat transfer to the solid wall within water jacket 17 to preclude damage to the nozzle which might be caused by excessive heat. Also, by virtue of insulating space 32 and the wall thicknesses of the precombustion chamber surrounded by such space, the incoming air through the passage at surface 69 and the portion of the fuel cone which strikes surface 68, are maintained sufficiently hot for efficient combustion and vaporization of fuel. However, because of the presence of insulating space 32 about wall portion 72 and because the first direct transference of heat from insulated wall portion 72 to the cooling jacket is at gasket 31 some distance from the main combustion chamber end of the precombustion chamber, the thickness of wall portion 72 per se must also be so designed, as to provide for proper temperature conditions in wall portion 72 and to provide for sufficiently rapid transference of heat from location V (Fig. 5) adjacent orifices 71; it being apparent that the wall portion adjacent orifices 71 is subjected to the direct heat of the main combustion flame in main combustion chamber 14. Therefore, heat must be rapidly conducted away from location

V to prevent burning out of the metal adjacent orifices 71.

I have found that the temperature at V should not rise above 1100° F. Therefore, the thickest portion K of wall 12 is made sufficiently thick, so as to provide for a rapid transference and large path of heat flow from adjacent point V, and also for a temperature of about 750°–800° F. at portion K. Furthermore, the thick construction of wall portion 72 provides a sufficient amount of metal which forms a heat reservoir to cooperate with the insulating space 32, in maintaining the combustion chamber end of the auxiliary combustion chamber hot. During flow of heat from point K to point S, (namely that portion of the precombustion chamber adjacent the widest part of funnel-shaped chamber 68 just before the point where direct transference of heat is made to the water jacket 17) the temperature necessarily drops. However, it is not desirable for maximum combustion efficiency under full load and full speed operating conditions of the engine, to have the temperature at portion S fall below 400°–450° F. Consequently, portion S is made sufficiently thin to form a restricted neck and thereby provide a restriction to the flow of heat and to maintain the desired temperature at location S.

Thus, the restricted neck at S, throttles the flow of heat to preclude the temperature from dropping too low at funnel-shaped part 68, which would prevent proper vaporization of the fuel striking the funnel-shaped part. It will be noted that the wall thickness of the restricted neck is generally less than that of the wall thickness of funnel-shaped part 68, and that the restricted neck tapers or becomes narrower as it approaches the point at shoulder 29 where direct transference of heat is made to the water jacket 17, to facilitate the heat throttling effect.

The temperatures given above are those occurring in the particular engine in which the precombustion chamber is employed. Such temperatures may vary in different types of engines. However, depending upon the type of engine, one skilled in the art can readily employ the principles of construction described to obtain the results of the present invention; such principles lying severally or collectively in the insulating space 32 about wall portion 72, the direct transfer of heat to the water jacket in the widest portion of the precombustion chamber, namely, the portion adjacent the nozzle, the relatively thick wall portion 72 adjacent orifices 71, the restricted neck portion S adjacent the widest portion of funnel-shaped part 68, and the area and volume relationships of surfaces 66, 68 and 69 and the fuel cone, as was explained with reference to Fig. 5. In this connection, Fig. 5 is a full scale drawing of the precombustion chamber described, and, consequently, illustrates the preferred relationship of all surfaces and walls.

The combustion process will now be described briefly. Upward movement of piston 13 (Fig. 1) compresses air in main combustion chamber 14 which has access to the precombustion chamber through holes or orifices 71. About 15° before top dead center of the compression stroke, pressure is applied to the fuel in the fuel supply line by a fuel injection pump to cause nozzle 51 to begin introducing the fuel charge into the precombustion chamber. Fuel is introduced in the form of a conical spray which strikes the upper half of frusto-conical wall 68, which is maintained at a high temperature by virtue of the varying thickness of wall 72 and annular space 32 insulating wall 72 from wall 16. The interior of the conical spray is met by a stream of air forced up through restricted orifices 71. Expansion of the air passing through orifices 71 occurs as it enters the cylindrical passage defined by wall surface 69. Cooling of the air would, therefore, normally obtain. However, by virtue of the insulated space 32 which maintains wall portion 72 hot, the expanded air is heated by hot wall portion 72 to enhance efficient combustion. The fuel spray cone impinges on the upper half of wall 68 so as to meet the full incoming air stream, and thereby provide maximum contact of the interior portion of the fuel cone with the air stream.

At about 8° before top center, ignition takes place in the precombustion chamber solely due to the vaporized condition of the fuel injected therein and the temperature existing therein. Inasmuch as the total volume of the precombustion chamber is only a small proportion of the total combustion chamber space, preferably between 27% to 30%, only a limited amount of fuel can be consumed in the precombustion chamber space, such amount being substantially 20% of the fuel introduced for the full load charge.

Remaining fuel introduced is shattered by the explosion of the preliminary portion of introduced fuel, whereby the remaining fuel charge is gasified. The increased pressure existing in the precombustion chamber space, due to the explosion therein, causes a flow of gasified fuel down through the channel defined by frusto-conical wall surface 68 and cylindrical wall surface 69, and out through openings 71 into the main combustion space. Fuel which emerges from openings 71 is of a gaseous nature, moving at a high velocity with considerable turbulance. The charge of fuel is introduced into a swirling current of air in the main combustion chamber 14 whereby thorough fuel distribution and high turbulence is obtained. In the main combustion chamber, a sufficient supply of air is available to complete the combustion process.

The preferred type of construction is illustrated in Fig. 6; in which the precombustion chamber proper employs essentially the same principles already described with reference to Figs. 1 and 5. However said construction provides an improved nozzle mounting which enables facile replacement of the nozzle by another in the event repair thereof is necessary. Further, the nozzle construction and mounting, and the precombustion chamber construction provide for more efficient cooling of the discharge end of the nozzle than is the case with respect to the construction of Fig. 1. Precombustion chamber unit 81 is generally similar to unit 26 described above, and is similarly mounted in head 11. Unit 81 includes lower member 82 and upper member 83 which are molecularly united at 84 by welding; upper member 83 having annular flange 86 extending within and closely fitting wall 87 of member 82. Lower member 82 has respective cylindrical wall surfaces 88, 89 and frusto-conical wall surfaces 90, 91, similar to respective wall surfaces 66, 69, 67 and 68 of the construction shown in Fig. 1. At the top of the cylindrical wall surface 88, upper member 83 has frusto-conical surface 92 forming a part of the top wall of the precombustion chamber; and immediately adjacent thereto and facing in the opposite direction, second frusto-conical wall 93 of upper member 83 provides a seat for mounting the nozzle assembly.

In this connection, member 83 serves the same as member 42 in Fig. 1, to shield the apertures through which water from the water jacket passes to cool the nozzle.

The nozzle assembly, which is mounted as a unit in the precombustion chamber unit, comprises a nozzle and an adapter therefor, which are preadjusted with respect to each other before assembly on the engine, to prevent any undue stresses at the discharge end of the nozzle which would interfere with proper fuel spray characteristics, or prevent proper seating of the spray needle. Nozzle 94 (Fig. 6) fits freely within adapter 96, and has threaded engagement therewith at 95; lower end 97 of nozzle 94 engaging inwardly projecting annular lip 98 of adapter 96. Thus, the adapter member also serves as a nut to secure separate parts of the nozzle structure together, by virtue of the threaded connection 95. Pin 99 inserted through a suitable aperture in adapter 96 engages a vertical slot in nozzle 94 to maintain accurately nozzle 94 in its preadjusted position in adapter 96. Adapter nut 96 is provided at the bottom as an integral part thereof with frusto-conical seat 101 which rests on seat 93 of the precombustion chamber unit. The angular position of adapter 96 with respect to unit 81 is fixedly maintained by engagement of splined portions 102, 103 of adapter 96 and upper member 83. Frusto-conical surface 104 on adapter 96 adjacent frusto-conical seat 101 provides a continuation of frusto-conical surface 92 of upper member 83, to form the top wall of the precombustion chamber. Shield 105 on nozzle 94 extends outwardly over the joint between adapter 96, and unit 81 to prevent the entry of deleterious matter between the parts.

From the foregoing description, it is seen that adapter 96 also has an integral lip or shield portion 98 in overlapping annular engagement with discharge end 97 of nozzle 94, providing a direct metallic path of heat flow which diverges outwardly and downwardly therefrom, through upper member 83 at 106, and to water space 107 positioned below discharge end 97 of nozzle 94. Such positioning of water space 107 in cooperation with the metallic path of heat flow provided, enables efficacious cooling of the nozzle. The area of the nozzle discharge end exposed to the flame of combustion is materially less than the annular area of the discharge end contacted by seat 97, being less than half as can be seen from Fig. 6. The cross section of the path of heat flow increases as it diverges outwardly and downwardly; the area of seat 101 being several times greater than the area of the seat at 97, the ratio of the areas being about 7 to 1. The metallic path of heat flow is preferably proportioned so that the temperature of the discharge end of the nozzle is maintained below 400° F.

By virtue of the downwardly extending and increasing metallic path of heat flow, heat is readily conducted away from the discharge end of the nozzle without passing up through the nozzle body, thereby maintaining said discharge end at a sufficiently low temperature to decrease substantially formation of carbon deposits by the action of the heat of combustion of dribbled fuel.

Nozzle 94 is clamped in position by means including clamp bar 56', similar in construction to the arrangement disclosed in Figs. 1 and 2 for clamping nozzle 51 in position. The provision of the described adapter nut 96, which is pre-assembled and pre-adjusted with respect to the associated nozzle, provides a quick and simple method of installing or removing the nozzle in relation to the precombustion chamber. Also, the preadjusted nozzle assembly provides for ready interchangeability of the nozzle by another nozzle, which can be accomplished by unskilled operators at places remote from expert service facilities inasmuch as the preadjustment of the adapter and nozzle can be made at the factory.

The modification shown in Fig. 7 is generally similar to that described in connection with Fig. 6, particularly as to the construction and mounting of the precombustion chamber unit in relation to the cylinder head. In Fig 7, upper member 111 and lower member 112 of the precombustion chamber unit are integrally joined by welding 113. Upper member 111 has annular projection 114 at the bottom, fitting closely within lower member 112, and has frusto-conical seat 116 formed therein for receiving the fuel nozzle assembly. Such fuel nozzle assembly includes adapter 117 having frustro-conical seat 118 adjacent the bottom thereof and engaged with seat 116; while at the top adapter 117 has a press fit at 119 within upper member 111. At its lower end, adapter 117 has flange or wall 221 having a central aperture. Wall 121 overlaps the lower end of the nozzle to form a shield therefor; and annular seat 122 is provided on the top of wall 171 for engagement by the discharge end of nozzle 123. Nozzle 123 has threaded engagement at 124 with adapter 117. From the foregoing description, it is seen that in the modification shown in Fig. 7, many of the advantages noted in connection with the structure shown in Fig. 6 are obtained. However, the Fig. 7 modification does not provide the same degree of cooling efficiency at the discharge end of the nozzle as that in the Fig. 6 arrangement.

Fig. 8 illustrates a fourth modification which is primarily the same as that illustrated in Fig. 6, differing only in the adapter construction for mounting the nozzle. In Fig. 8, nozzle 131 is provided at the bottom with frusto-conical seat 132 which is engaged with corresponding frusto-conical seat 133 in adapter 134.

Fig. 9 illustrates a type of construction in which the precombustion chamber proper is formed directly in a wall of the cylinder head. With such construction, the advantageous nozzle mounting referred to in connection with Figs. 6–8 is obtained by adapter means similar to those described in the preceding portions of the specification. Head 141 (Fig. 9) is generally similar to the head construction illustrated in Figs. 1 through 4, and includes internal cylindrical wall 142 which has cylindrical internal wall surfaces 143, 144, 145 and 146 of decreasing diameter. Burner tube 147 is seated against shoulder 148 between wall surfaces 145 and 146, and at the top engages wall surface 145. At its lower end, tube 147 is threaded within wall surface 146, and is provided adjacent its end with a plurality of orifices or openings 149 providing for egress of gasified fuel from the precombustion chamber to the combustion chamber and for ingress of air into the precombustion chamber. Slots 150 at the top of tube 147 provide means for engagement with a suitable tool for effecting screwing of tube 147 in wall surface 146. The inner wall surfaces of burner tube 147 converge conically from the top to a cylindrical portion closed at its lower end, except for openings 149.

A removable assembly is provided for closing the top of the precombustion chamber, and for mounting the discharge orifice of the fuel injection nozzle in axial alignment therewith. Wall surfaces 143 and 144 (Fig. 9) have seat 152 formed therebetween, to receive corresponding seat 153 of fitting member 154, a suitable metallic gasket being interposed. Member 154 fits closely within wall surface 143 at the top, and gasket 156, of rubber or other suitable material, is provided to seal the engagement therebetween. Intermediate its end portions, member 154 is recessed at 157, to provide water jacketing inside of wall surface 143 and closely adjacent the discharge end of the nozzle. Adapter 96 and nozzle 94 are identical with those shown in Fig. 6 and are similarly mounted. However, the same cooling effect of the nozzle is not obtained as in the Fig. 6 modification, by virtue of the absence of the metallic path of heat flow which diverges outwardly and downwardly to cooling fluid below the discharge end of the nozzle.

The above-described construction of Fig. 9 provides for cooling of the discharge end of the nozzle by means of an assembly which can be readily assembled in engines already manufactured which do not employ precombustion chamber units of the character disclosed in Figs. 1 through 8. It is to be noted that respective adapters 96 and nozzles 94 which make up the fuel injection assemblies in Figs. 6 and 9 are identical, clearly demonstrating the interchangeability of such assemblies provided by the construction shown.

Therefore, I claim as my invention:

1. In a compression ignition and the like engine, a main combustion chamber; a cooling fluid jacket having a walled passage therethrough communicating with said main combustion chamber, the end portion of the wall adjacent said main combustion chamber being substantially solid and the opposite end portion of said wall being apertured to admit cooling fluid from said jacket; and an auxiliary combustion chamber in the substantially solid walled portion of said passage, an end portion of said auxiliary combustion chamber adjacent said main combustion chamber being out of contact with said wall to provide a substantially annular insulating space between said end portion and said wall and which is in communication with said main combustion chamber whereby a suitable amount of heat is maintained in said end portion for combustion of fuel and heating of air, said insulated end portion of said auxiliary combustion chamber including a tubular passage of greater length than width extending axially of the auxiliary combustion chamber and in communication with said main combustion chamber, and also a funnel-shaped part adapted to receive sprayed fuel thereon and which is in communication with said tubular passage, the side wall of said insulated portion being relatively thick at the end thereof adjacent said main combustion chamber and the total cross sectional thickness of the metal about said tubular passage being greater than the width of the passage to cooperate in maintenance of heat and to conduct heat away rapidly from the hot main combustion chamber end, the metal leading from adjacent the wide portion of said funnel-shaped part being arranged to provide a restriction to the flow of heat from such funnel-shaped part and thereby maintain the funnel-shaped part at a temperature enhancing vaporization of the fuel sprayed thereon.

2. In a compression ignition and the like engine, a main combustion chamber; a cooling fluid jacket having a walled passage therethrough communicating with said main combustion chamber, the end portion of the wall adjacent said main combustion chamber being substantially solid and the opposite end portion of said wall being apertured to admit cooling fluid from said jacket; and an auxiliary combustion chamber in the substantially solid walled portion of said passage, an end portion of said auxiliary combustion chamber adjacent said main combustion chamber being out of contact with said wall to provide a substantially annular insulating space between said end portion and said wall and which is in communication with said main combustion chamber whereby a suitable amount of heat is maintained in said end portion for combustion of fuel and heating of air, said insulated end portion of said auxiliary combustion chamber including a tubular passage of greater length than width extending axially of the auxiliary combustion chamber and in communication with said main combustion chamber, and also a funnel-shaped part adapted to receive sprayed fuel thereon and which is in communication with said tubular passage, the side wall of said insulated end portion about said tubular passage being the thickest part of the entire auxiliary combustion chamber wall and the total cross sectional thickness of the metal about said tubular passage being greater than the width of the passage to cooperate in maintenance of heat and to conduct heat away rapidly from the hot main combustion chamber and, the metal portion leading from adjacent the wide portion of said funnel-shaped part being arranged to provide a restriction to the flow of heat from such funnel-shaped part and thereby maintain the funnel-shaped part at a temperature enhancing vaporization of the fuel sprayed thereon, another portion of said auxiliary combustion chamber leading from said metal portion being in heat conducting contact with the wall of said passage.

3. In a compression ignition and the like engine, a main combustion chamber; a cooling fluid jacket having a walled passage therethrough communicating with said main combustion chamber, the end portion of the wall adjacent said main combustion chamber being substantially solid and the opposite end portion of said wall being apertured to admit cooling fluid from said jacket; an auxiliary combustion chamber in the substantially solid walled portion of said passage, an end portion of said auxiliary combustion chamber adjacent said main combustion chamber being out of contact with said wall to provide a substantially annular insulating space between said end portion and said wall and which is in communication with said main combustion chamber whereby a suitable amount of heat is maintained in said end portion for combustion of fuel and heating of air, said insulating end portion of said auxiliary combustion chamber including a funnel-shaped part adapted to receive sprayed fuel thereon, the side wall of said insulated end portion being relatively thick at the end thereof adjacent said main combustion chamber to cooperate in maintenance of heat and to conduct heat away rapidly from the hot main combustion chamber end, the metal portion leading from the wide portion of said funnel-shaped part being arranged to provide a restriction to the flow of heat from such funnel-shaped part and thereby maintain the funnel-shaped part at a temperature enhancing vaporization of the fuel sprayed thereon, another portion of said auxiliary combustion chamber leading from said

metal portion being in heat conducting contact with the wall of said passage; a fuel injection nozzle assembly in said passage adjacent the apertured wall portion thereof; and means shielding the discharge end surface of the nozzle from heat of combustion and providing a path for conducting heat away from said surface to the cooling fluid admitted through the apertured wall portion.

4. In a compression ignition and the like engine, a main combustion chamber; a cooling fluid jacket having a walled passage therethrough communicating with said main combustion chamber, the end portion of the wall adjacent said main combustion chamber being substantially solid and the opposite end portion of said wall being apertured to admit cooling fluid from said jacket; an auxiliary combustion chamber in the substantially solid walled portion of said passage, an end portion of said auxiliary combustion chamber adjacent said main combustion chamber being out of contact with said wall to provide a substantially annular insulating space between said end portion and said wall and which is in communication with said main combustion chamber whereby a suitable amount of heat is maintained in said end portion for combustion of fuel and heating of air, said insulated end portion of said auxiliary combustion chamber including a funnel-shaped part adapted to receive sprayed fuel thereon, the side wall of said insulated end portion being relatively thick at the end thereof adjacent said main combustion chamber to cooperate in maintenance of heat and to conduct heat away rapidly from the hot main combustion chamber end, the metal portion leading from the wide portion of said funnel-shaped part being arranged to provide a restriction to the flow of heat from such funnel-shaped part and thereby maintain the funnel-shaped part at a temperature enhancing vaporization of the fuel sprayed thereon, another portion of said auxiliary combustion chamber leading from said metal portion being in heat conducting contact with the wall of said passage; a fuel injection nozzle assembly in said passage adjacent the apertured wall portion thereof; and means shielding the discharge end surface of the nozzle from heat of combustion and providing a metallic heat conducting path converging downwardly and outwardly from said surface to the cooling fluid admitted through the apertured wall portion.

5. Auxiliary combustion chamber means adapted to be positioned in a walled passage through the fooling fluid jacket of a compression ignition and the like engine in communication with the main combustion chamber of said engine, comprising a walled member adapted for positioning adjacent said main combustion chamber out of contact with the wall of said passage to provide a substantially annular insulating space between said member and the wall of said passage which is adapted to communicate with said main combustion chamber, the insulatable portion of said walled member including a tubular passage of greater length than width extending axially of the auxiliary combustion chamber and adapted to have communication with the main combustion chamber, and also a funnel-shaped part adapted to receive sprayed fuel thereon and which is in communication with said tubular passage, the side wall of said member about said tubular passage being relatively thick adjacent the main combustion chamber end thereof to provide a total cross sectional thickness of the metal about said tubular passage greater than the width of such passage, the metal leading from the wide portion of said funnel-shaped part being arranged to throttle flow of heat from such funnel shaped part.

6. In a compression ignition and the like engine, a main combustion chamber; a cooling fluid jacket having a walled passage therethrough communicating with said main combustion chamber, the end portion of the wall adjacent said main combustion chamber being substantially solid; an auxiliary combustion chamber in the substantially solid walled portion of said passage including a tubular passage of greater length than width extending axially of the auxiliary combustion chamber and in communication with said main combustion chamber, and a funnel-shaped part adapted to receive sprayed fuel thereon and which is in communication with said tubular passage, the side wall of said auxiliary combustion chamber about said tubular passage being relatively thick to provide a total cross sectional thickness of the metal about said tubular passage greater than the width of the passage to cooperate in the maintenance of heat and to conduct heat away rapidly from the hot main combustion chamber end of said auxiliary combustion chamber; sleeve means above said auxiliary combustion chamber providing a shield for the cooling fluid to prevent access of cooling fluid to said auxiliary combustion chamber; an inwardly projecting seat in said walled passage for fuel injection means adapted to be positioned in said sleeve means whereby the fuel injection means may be readily removed without leakage of fluid into said auxiliary combustion chamber and said seat may be cooled by said cooling fluid to conduct heat away from said seat; and fuel injection means removably mounted on said seat comprising a fuel injection nozzle assembly held together by an adapter nut, said adapter nut having a lip portion integral therewith engageable with said seat and in overlapping engagement with the discharge end surface of the nozzle for shielding and providing a path for flow of heat from such surface.

7. In a compression ignition and the like engine, a main combustion chamber; a cooling fluid jacket having a walled passage therethrough communicating with said main combustion chamber, the end portion of the wall adjacent said main combustion chamber being substantially solid; an auxiliary combustion chamber in the substantially solid walled portion of said passage including a tubular passage of greater length than width extending axially of the auxiliary combustion chamber and in communication with said main combustion chamber, a funnel-shaped part adapted to receive sprayed fuel thereon and which is in communication with said tubular passage, and another tubular part in communication with said funnel-shaped part and of greater width than the wide portion of said funnel-shaped part, said tubular passage and said funnel-shaped part being insulated from the wall of the jacket passage and said another tubular part being in heat conducting contact with the wall of the jacket passage, the side wall of said auxiliary combustion chamber about said tubular passage being relatively thick to provide a total cross sectional thickness of the metal about said tubular passage greater than the width of the passage to cooperate in the maintenance of heat and to conduct heat away rapidly from the hot main combustion chamber end of said auxiliary com-

bustion chamber; sleeve means above the wall about said another tubular part to prevent access of cooling fluid to said auxiliary combustion chamber; an inwardly projecting seat in said walled passage for fuel injection means adapted to be positioned in said sleeve means whereby the fuel injection means may be readily removed without leakage of fluid into said auxiliary combustion chamber and said seat may be cooled by said cooling fluid to conduct heat away from said seat; and fuel injection means removably mounted on said seat comprising a fuel injection nozzle assembly held together by an adapter nut, said adapter nut having a lip portion integral therewith engageable with said seat and in overlapping engagement with the discharge end surface of the nozzle for shielding and providing a path for flow of heat from such surface.

8. Auxiliary combustion chamber means comprising a walled portion including a tubular passage extending axially of such chamber and adapted for communication with a main combustion chamber of a compression ignition and the like engine, a funnel-shaped part adapted to receive sprayed fuel thereon and which is in communication with said tubular passage, and a relatively large combustion space in communication with said funnel-shaped part and having a width greater than the wide portion of said funnel-shaped part, the tubular passage having a length along the axis of such chamber which is greater than the width thereof, and the side wall about said tubular passage being relatively thick to provide a total cross sectional thickness of the metal about said tubular passage greater than the width of the tubular passage.

9. Auxiliary combustion chamber means comprising a walled member including a tubular passage extending axially of such chamber and adapted for communication with a main combustion chamber of a compression ignition and the like engine, a funnel-shaped part adapted to receive sprayed fuel thereon and which is in communication with said tubular passage, and another tubular part in communication with said funnel-shaped part and of greater width than the wide portion of said funnel-shaped part, said funnel-shaped part and said another tubular part being joined by a section of metal which provides a restriction for throttling flow of heat from said funnel-shaped part to said another tubular part, said tubular passage having a length along the axis of such chamber which is greater than the width thereof, and the side wall about said tubular passage being relatively thick to provide a total cross sectional thickness of the metal about said tubular passage greater than the width of the tubular passage.

10. A precombustion chamber unit adapted to receive in its upper portion fuel injection means and provided at an intermediate point with an internal annular shoulder for seating said fuel injection means; a precombustion chamber below said annular shoulder including a passage extending axially of said chamber and adapted for communication with a main combustion chamber of a compression ignition or the like engine, a funnel-shaped part having the narrow end thereof in communication with such axial passage so as to taper outwardly therefrom and adapted to receive sprayed fuel thereon from fuel injection means supported in the upper portion of said unit, and a relatively wide combustion space in communication with the wide end of said funnel-shaped part and having a width greater than the wide end of said funnel-shaped part; the wall about said axial passage being relatively thick and of a cross sectional thickness greater than the width of the axial passage to cooperate in the maintenance of heat and to conduct heat away rapidly from the hot main combustion chamber end of said precombustion chamber, and the wall joined to the wide end of said funnel-shaped part being constricted to a relatively thin portion adjacent said relatively wide combustion space to provide a restriction for throttling flow of heat between said funnel-shaped part and said relatively wide combustion space.

11. A precombustion chamber unit adapted to receive in its inner portion fuel injection means and provided at an intermediate point with an internal annular shoulder for seating said fuel injection means; fuel injection means supported in the upper portion of said precombustion chamber unit on said shoulder and comprising a fuel injection nozzle assembly held together by an adapter element, said adapter element having a lip portion integral therewith and in overlapping engagement with the discharge end surface of the nozzle for shielding and providing a path for flow of heat from such end surface; a precombustion chamber below said annular shoulder including a passage extending axially of said chamber and adapted for communication with a main combustion chamber of a compression ignition or the like engine, a funnel-shaped part having the narrow end thereof in communication with such axial passage so as to taper outwardly therefrom and adapted to receive sprayed fuel thereon from said fuel injection means supported in the upper portion of said unit, and a relatively wide combustion space in communication with the wide end of said funnel-shaped part and having a width greater than the wide end of said funnel-shaped part; the wall about said axial passage being relatively thick to cooperate in the maintenance of heat and to conduct heat away rapidly from the hot main combustion chamber end of said precombustion chamber, and the wall joined to the wide end of said funnel-shaped part being constricted to a relatively thin portion adjacent said relatively wide combustion space to provide a restriction for throttling flow of heat between said funnel-shaped part and said relatively wide combustion space.

CARL G. A. ROSÉN.

CERTIFICATE OF CORRECTION.

Patent No. 2,148,505. February 28, 1939.

CARL G. A. ROSÉN.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 5, for the word "convention" read convection; line 37, for "expained" read explained; page 4, first column, line 5, for "wall 12" read wall 72; page 5, first column, line 68, for "of" before "dribbled" read on; and second column, line 25, for "wall 221" read wall 121; page 6, second column, line 32, claim 2, for "and" read end; line 60, claim 3, for "insulating" read insulated; page 7, first column, line 56, claim 5, for "fooling" read cooling; page 8, second column, line 26, claim 11, for "inner" read upper; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 25th day of April, A.D. 1939.

Henry Van Arsdale

(Seal) Acting Commissioner of Patents.