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G. K. DAVOL

INTERNAL COMBUSTION ENGINE

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FIG 1.

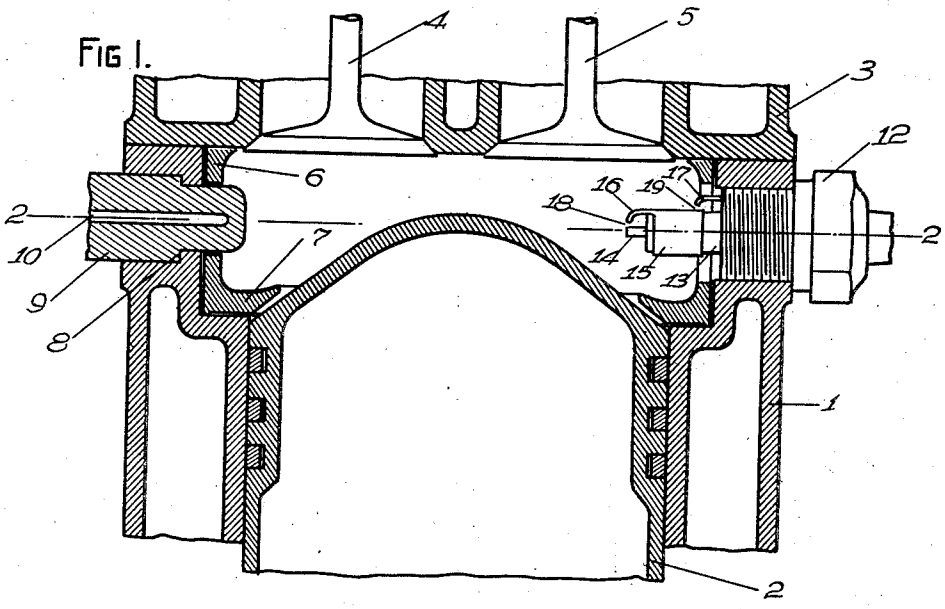
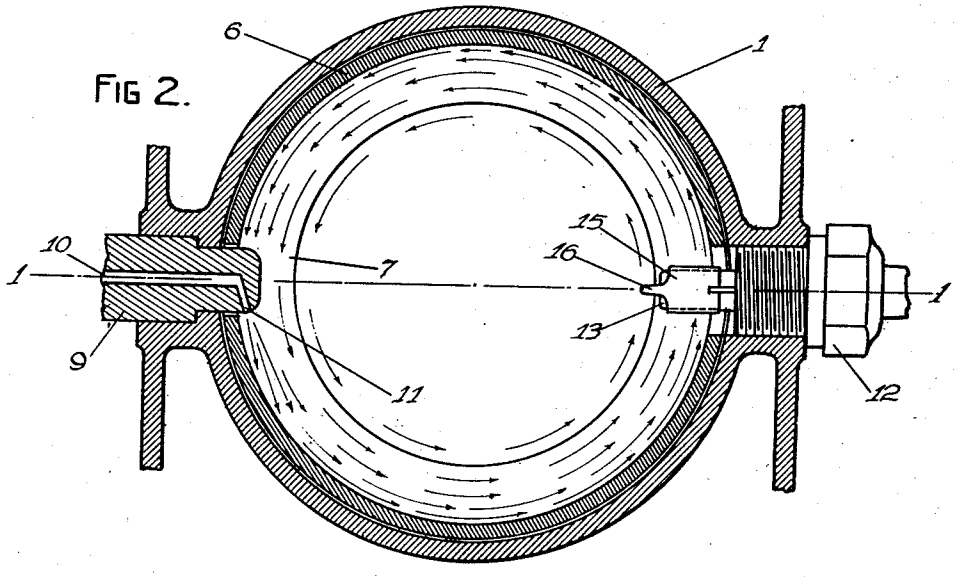


FIG 2.



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INTERNAL-COMBUSTION ENGINE.

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My invention has largely to do with a means of stratifying the charge of fuel and air in the cylinder of an internal combustion engine so that a quantity of air, in excess of that which is required for combustion of the fuel, may be present within the cylinder and yet be prevented from completely mixing with the fuel, whether the fuel be liquid or gaseous.

In an engine in which the ignition of the charge is accomplished by means other than the heat of compression of the charge, it is necessary to have at the point of ignition a mixture of fuel and air which is ignitable, or which possesses a certain proportion of fuel to air, or a certain "fuel density", within limits. This requirement is ordinarily met by employing a homogeneous mixture within the cylinder having approximately the same fuel density or ratio of fuel to air throughout its entire mass. At partial loads such an engine must have the quantity of fresh charge drawn into the cylinder reduced, which is ordinarily done by throttling the entire intake. This throttling of the intake, reducing the density of the charge drawn in to considerably less than atmospheric, has for a number of well known reasons a very bad effect on the efficiency of the engine.

My invention renders it practicable to have an internal combustion engine draw into its cylinder at all loads a full charge of air without throttling, and to separately inject the fuel with or without additional air in such a manner that it will not intimately mix with the whole of the charge of air before ignition. To accomplish this in an effective manner I employ a centrifugal action, or resort to the centrifugal stratification or segregation of the charge, whereby the heavier fuel vapor or finely atomized liquid fuel in suspension, is thrown to the outer zones of a whirling charge while the lighter portion of the mass comprising the more pure air is held in the center. This procedure is not intended of course to effect a complete separation of fuel and air, and a certain necessary degree of mixture will always take place as the principle is carried out; but there will exist in the whirling mass, zones or strata having different ratios of fuel to air, or different degrees of fuel density, and certain of these zones or strata will provide the fuel density proper for ignition.

This and other features of my invention will be understood from the description which follows:

In the accompanying drawings:

Figure 1 shows a partial section taken through the axial center of the cylinder of an engine, on line 1—1 in Figure 2, showing portions only of the cylinder, piston, and cylinder head and certain other parts; and

Figure 2 is a partial section through the same cylinder taken perpendicularly to the axis of the cylinder, on line 2—2 in Figure 1.

Referring to the drawings, a portion, comprising the end of the cylinder of an internal combustion engine is shown at 1. A piston 2 of which only the inner end is shown reciprocates within the cylinder and is shown in Figure 1 at the inner end of its stroke. A cylinder head 3 of which only a portion is shown in Figure 1 is secured to the cylinder in the usual manner. Main inlet and exhaust valves 4 and 5 respectively are indicated in Figure 1, seating in the head 3.

The upper end of the cylinder is recessed or heavily counterbored, forming a short cylindrical chamber of larger diameter than the main cylinder bore, and in this enlarged bore is loosely held a ring 6. The lower end of this ring 6 has an inwardly projecting flange 7 which projects as shown in Figure 1 over the piston 2. This ring so held forms a liner for the side walls of the cylinder clearance space or combustion chamber. At one side of this combustion chamber a bored opening is formed having two diameters and a shoulder 8, and through this opening the fuel injection nozzle 9 passes, being held in place tight against the shoulder 8 by any suitable means. The end of the nozzle passes also through an opening in the liner ring 6 and extends slightly into the combustion chamber. The nozzle 9 has a central hole 10 connecting at the inner end of the nozzle with the atomizing or injection orifice 11, Figure 2. This final injection orifice is directed tangentially with reference to the combustion chamber walls as shown clearly in Figure 2.

The fuel, gaseous or liquid, with or without admixture of air, is supplied through the passage 10 in the nozzles 9 from any suitable source, at the proper periods and at suitable pressure, and issuing in a tangential direction, indicated in Fig. 2, whirls around the cylindrical combustion chamber and imparts to most of the charge of air therein the whirling motion indicated by the arrows in

Figure 2. In this whirling movement it mixes to a greater or less extent with the air charge, but owing to the fuel, whether a vapor or a finely atomized liquid, being heavier than the air, there will be a strong tendency and action to concentrate the fuel toward the outer strata or zones of the mass—next to the inner face of the liner ring 6.

If a gas lighter than air be used as fuel, this action will not logically take place, and the invention is intended to be applied to the use of gaseous fuels or vapors heavier than air, and to finely atomized liquids or pulverized solid fuel.

The degree to which the injected fuel mixes with the contained air charge may be controlled in a number of ways, as for example by varying the exact direction of the entering jet, or by obstructions projecting into the chamber from its walls such as the obstruction formed by the projecting end of the spark plug 12 or by modifying the form of the piston end so that it may fill more of the center portion of the combustion chamber and crowd the air charge closer to the side walls. In these ways a sufficient degree of mixture of the injected fuel with the air charge can be insured so that the heavier fuel charges will readily find sufficient air to afford proper combustion; while at the same time a rich mixture or a strata of high fuel density is insured adjacent to the side walls of the chamber even with light fuel injections for light loads.

If a spark plug be so located that the spark gap is close to the side walls of the combustion chamber or close to the inner face of the liner ring 6 the spark will always be formed in the zone or strata of the greatest fuel density.

It is logically conceivable that the extreme outer strata next the side walls might contain under some conditions and arrangements, too great a fuel density to be readily ignitable and on this account the location of the spark gap or other igniting means might more advantageously be placed further inward toward the center of the chamber, where less density of fuel would exist.

It may be found with certain conditions of arrangement of the chamber, and in engines which are called upon for great variation in output, that no one location of the spark gap or other igniting means will give the best results under all conditions of light and heavy loads, with large and small injections of fuel, and to meet such extreme differences of loading my invention provides for the use of more than one spark gap or other igniting means, each spark gap being placed in a different centrifugal strata or a centrifugal zone of different fuel density. In other words two spark gaps may for example be used, one spark gap being located close to the side wall of the chamber and one being placed well within the chamber or closer to its axis. With such arrangement each spark gap will be in a different annular zone or stratum, or each spark gap will occupy a position in a zone or stratum of a fuel density differing from that of the other. In this manner although a great variation in the fuel density, or fuel content of all strata or zones may occur, one of the spark gaps will always be in a position where an ignitable mixture exists.

In the drawings I have shown provision for two spark gaps, one close to the side wall of the combustion chamber and one placed well within the chamber. I have there shown the spark gaps arranged in series, so that the electrical discharge jumps two gaps one after the other in the same circuit. This arrangement it will be understood is not at all essential but merely forms a convenient manner of arranging for two points of ignition. Two or more separate spark plugs or any other suitable means may be employed.

In the drawings the spark plug 12 is shown screwed through the tapped opening in the cylinder wall. The center porcelain core 13 projects well into the chamber, passing through the liner ring 6. Through the porcelain core passes the usual center wire or spark point 14. Around the projecting end of the porcelain 13 a metal sleeve 15 is fixed having a projecting point 16. A sparking point 17 is fixed to the outer shell of the plug and is brought close to the sleeve 15. It can now be seen that two spark gaps in series are provided one at 18 well within the combustion chamber and one at 19 close to the side wall. These spark gaps are in zones or strata of different fuel densities.

The liner ring 6 is employed to form a heated surface on which the injected fuel impinges after issuing from the atomizing orifice. This ring 6 is not closely in contact with the surrounding walls of the cylinder, but has a suitable clearance from such surfaces and is held from close contact by small projections suitably placed and proportioned. In this manner flow of heat from the ring 6 to the water jacketed cylinder walls is properly obstructed, with the effect that the ring attains a higher temperature than the water jacketed cylinder walls.

The inwardly projecting flange 7 on the ring 6 is intended to catch any liquid fuel which, particularly under starting conditions when all surfaces are cold, may escape combustion and run down the inside face of the ring. Such liquid fuel if allowed to reach the main bore of the cylinder has a tendency to work by the piston and into the crank chamber below, contaminating or diluting the lubricating oil on cylinder walls and in crank case. The inwardly projecting flange 7 catches and holds any such liquid fuel for a time and before any can reach the main cylinder bore it must collect and overrun

the inside upwardly projecting lip of the flange 7. This inner lip of the flange being of relatively thin section, rapidly becomes hot on starting the engine, and is maintained at a high temperature, and any liquid fuel coming into contact with it is rapidly vaporized and burned away and so cannot reach the main cylinder bore below.

The inside face of the liner ring 6 is shown in the drawings as a smooth surface, but it may, if desired to give it an increased heating or vaporizing effect for certain fuels or conditions of operation, be provided with inwardly projecting flanges, or pins, or projections, to increase its vaporizing surface or its mechanical mixing effect.

In referring herein to strata or zones of differing fuel densities, it is of course not intended to imply that any given annular stratum or zone is sharply defined from an adjacent stratum by difference of fuel content but that the average fuel density of any given stratum or zone does differ from that of an adjacent one.

In the claims which follow I have used the term "circular section" in defining the form of the combustion chamber and this chamber of circular section is the simplest form and the form I prefer. It is, however, perfectly obvious that a departure from the truly circular form, producing a section more or less oval or elliptical, will not sensibly affect the action sought and the expression "circular section" is intended to cover such slight deviations from the truly mathematical circular from.

Without further elaboration, the foregoing will so fully explain the gist of my invention that others may by applying current knowledge, readily adapt the same for use under various conditions of service, without eliminating certain features which may properly be said to constitute the essential items of novelty involved; which items are intended to be defined and secured to me by the following claims.

I claim:

1. The method of operating an internal combustion engine consisting of stratifying or segregating a charge of fuel and air within a combustion chamber by centrifugal action into zones or strata of different fuel densities and igniting the charge at points of different fuel densities.

2. The method of operating an internal combustion engine consisting of whirling or rotating a charge of fuel and air within a combustion chamber about an axis, and igniting the charge at a plurality of points at different distances from said axis.

3. The method of operating an internal combustion engine which consists of compressing a charge within a combustion chamber, injecting fuel thereinto in a manner to set up a circumferential whirling or rotation of the charge and igniting the charge at points of different fuel densities.

4. The method of operating an internal combustion engine which consists of injecting a fuel into a charge compressed within a combustion chamber, stratifying or segregating the charge by centrifugal action into cylindrical strata or zones of different fuel densities and igniting the charge at points of different fuel densities.

5. In an internal combustion engine, a combustion chamber, means for whirling the charge in the said chamber to stratify it, thermally isolated means encircling the periphery of the said chamber and means for igniting the charge at points of different fuel densities.

6. In an internal combustion engine, a combustion chamber, means for whirling the charge in the said chamber to stratify the charge into zones of different fuel densities, thermally isolated means of appreciable heat capacity and good conductivity encircling the periphery of the said chamber, and means for igniting the charge at points of different fuel densities.

7. In an internal combustion engine, a working cylinder, a combustion chamber, means for supplying a charge of fuel to the said chamber, means positioned within the combustion chamber for preventing the fuel from seeping into the lower parts of the working cylinder and means for igniting the charge at points of different fuel densities.

8. In an internal combustion engine, a working cylinder, a combustion chamber, means for supplying a charge to the said chamber, a thermally isolated sleeve positioned within the said combustion chamber, a trough formed on the said sleeve for preventing the fuel from seeping into the lower parts of the working cylinder, and means for igniting the charge at points of different fuel densities.

In witness whereof, I hereunto subscribe my name this 23rd day of August, 1921.

GEORGE K. DAVOL.