Jan. 28, 1958 G. A. HOLT 2,821,177

INTERNAL COMBUSTION ENGINES OF THE COMPRESSION IGNITION TYPE

Filed Oct. 7, 1955 2 Sheets-Sheet 1

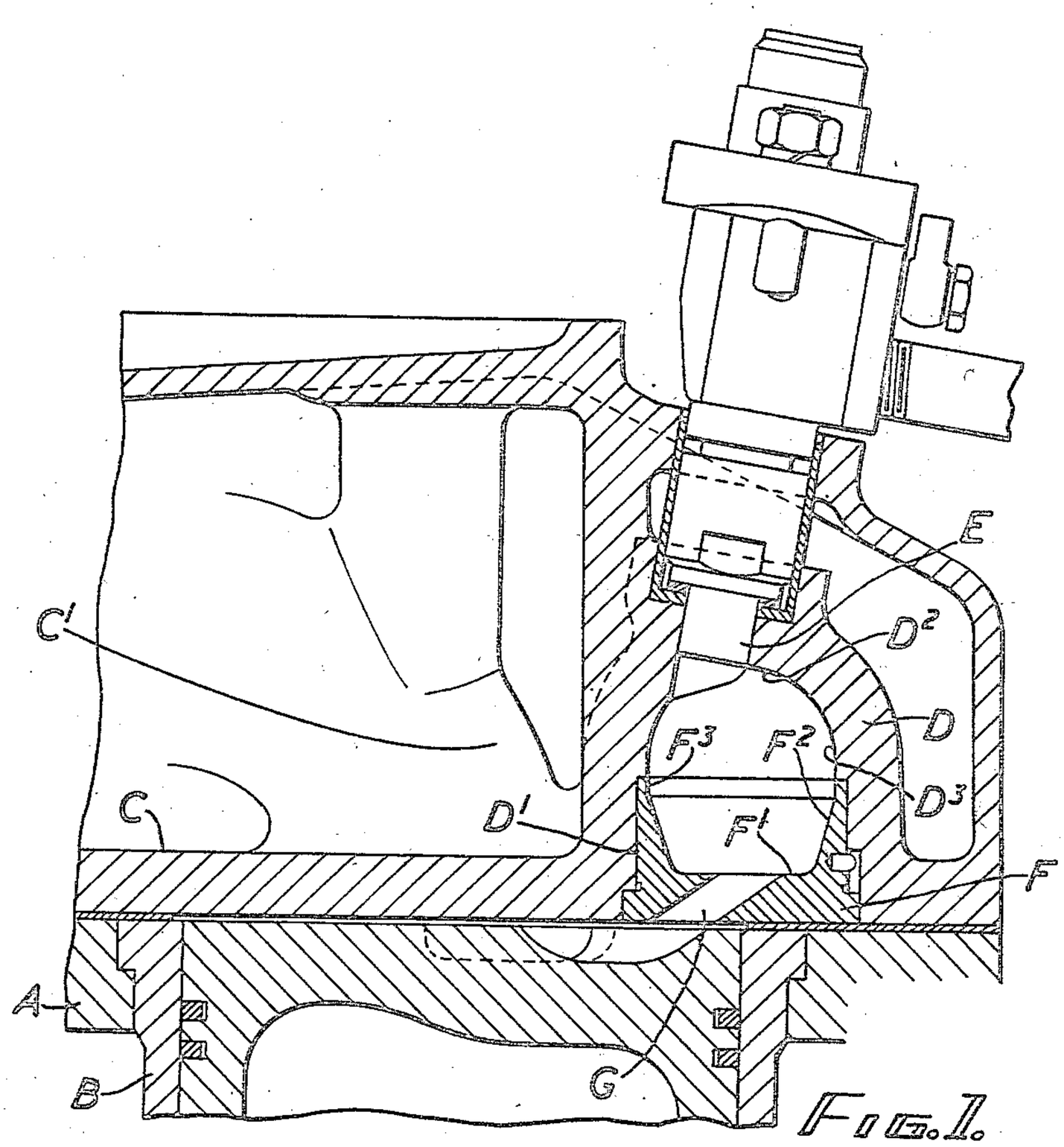

FIG. 1.

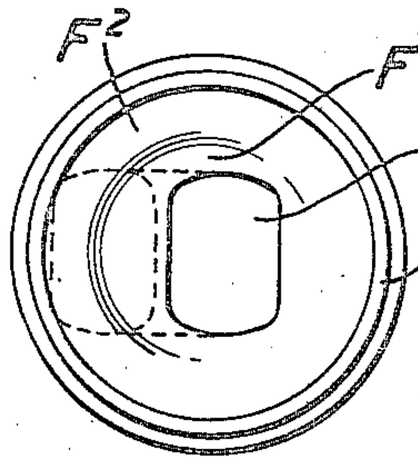

FIG. 2.

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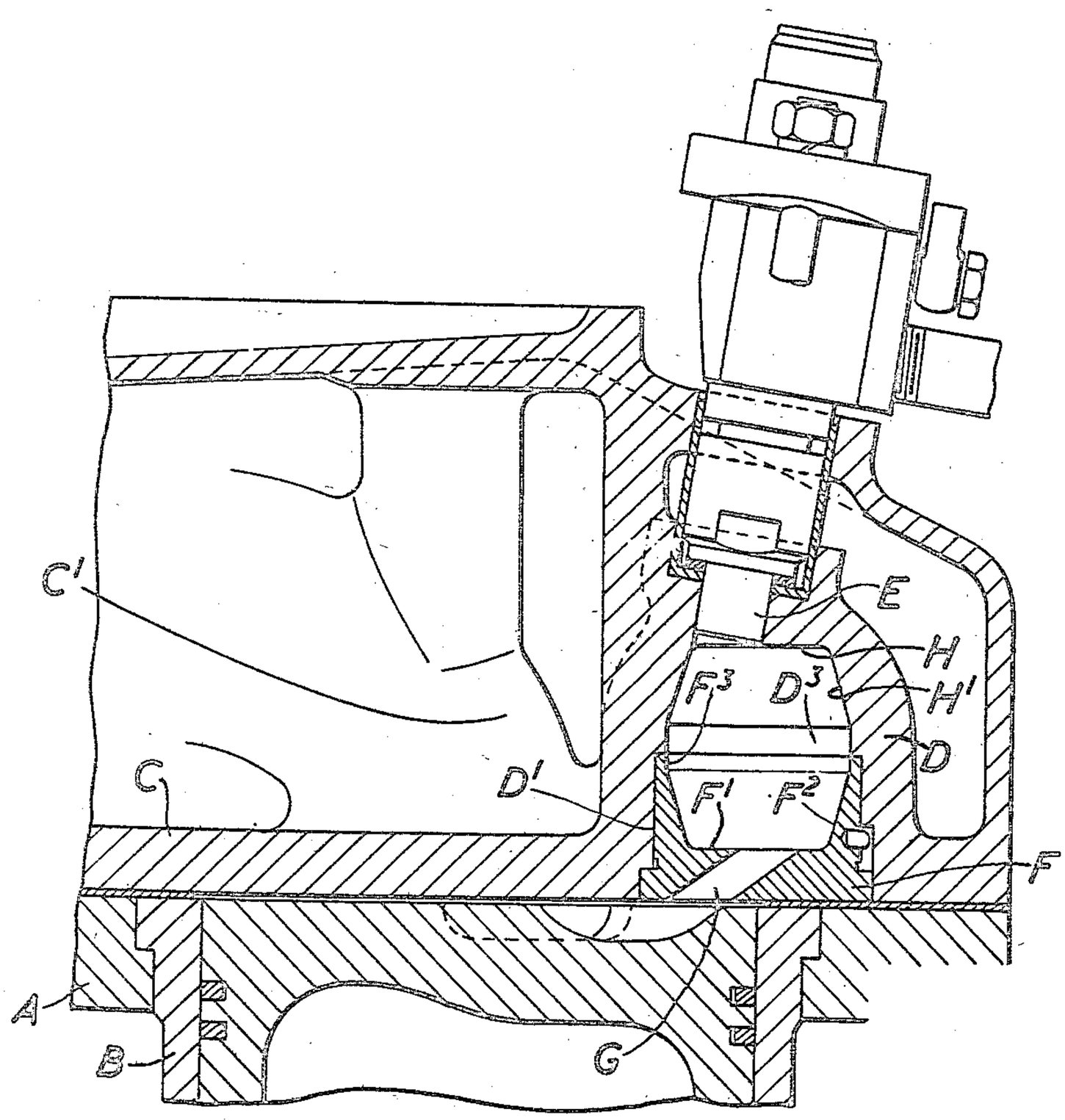

FIG. 3.

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INTERNAL COMBUSTION ENGINES OF THE COMPRESSION IGNITION TYPE

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Claims priority, application Great Britain October 11, 1954

13 Claims. (Cl. 123—32)

This invention relates to internal combustion engines of the compression ignition liquid fuel injection type and of the kind in which substantially the whole or a substantial proportion of the air charge is forced during each compression stroke through a transfer passage into a combustion pocket of such shape and in such manner that the charge is caused to rotate within the pocket about an axis which is normal to planes to which the direction of entry of the charge into the pocket is approximately parallel, the fuel being injected into the rotary air charge in the pocket, usually in a manner such that it is directed towards a part of the surface of the pocket across which the circumferential portions of the rotating air sweep shortly before they reach the mouth of the transfer passage, the term "mouth" being herein used to refer to the end of the transfer passage which opens into the combustion pocket.

In many engines the transfer passage is formed in a separate plug, usually referred to as a hot plug, having limited heat conducting contact with the cooled surrounding walls so that it tends to become highly heated during operation of the engine, in which case it will be seen that the surface of the plug remote from the cylinder bore constitutes the part of the surface of the combustion pocket in which the mouth of the transfer passage lies. The limited heat conducting contact between the plug and the surrounding walls is achieved by providing an air gap between the plug and the surrounding walls. It is quite possible that when the plug becomes hot it expands until it comes into contact with the surrounding walls, but when this occurs the rate of heat transfer to the surrounding walls will be increased so that the temperature of the plug will start to decrease. Thus, a plug having limited heat conducting contact with the surrounding walls may be said to have an air space between it and the surrounding walls at least when it is cold. Forms of engine of the kind referred to and including such a hot plug are described and shown for example in U. S. Patents Nos. 2,003,311; 2,037,339; 2,106,124 and 2,113,711.

In other forms of engine of the kind referred to no such hot plug is provided but a hot surface is provided at the end of the combustion pocket remote from the transfer passage.

The present invention is applicable to engines of the kind in question whether the transfer passage is formed in a hot plug or not and in the latter case whether such a hot surface is provided at the end of the pocket remote from the transfer passage or not.

In an internal combustion engine of the kind referred to according to the present invention the part of the surface of the combustion pocket through which the mouth of the transfer passage opens is formed as a flat or approximately flat area of substantial dimensions.

It will be understood that the flat area referred to makes an appropriate angle with the transfer passage and this area will generally lie approximately in a plane

parallel to the axis of rotation of the air charge within the pocket.

It is found that constructions in accordance with the invention provide improved efficiency of operation, and it is believed that this is due at least partly to the fact that, with the invention liquid fuel, which may tend to accumulate in the circumferential surface of the charge due to the centrifugal force produced by the rotating air charge and to be swept over the surface of the pocket by the rotating charge, is caused when it reaches a point where its direction is abruptly changed by a flat surface to be swept by local eddies into the body of the air charge, and partly due to the fact that the edge of the mouth of the transfer passage in the flat surface over which the rotating charge is swept tends to prevent fuel in the circumferential portions of the rotating charge from flowing round the edge into the transfer passage, but to retain them rotating in the combustion pocket for a longer period. In addition, when the charge is eventually carried out through the transfer passage, the edge serves to prevent unburnt fuel running down the sides of the transfer passage, but tends to cause it to flow in the heart of the gases as they leave through the transfer passage.

It will be appreciated that the construction according to the invention permits an appreciable variation in the position of the mouth of the transfer passage and in the inclination of the transfer passage in relation to the axis of the cylinder with which the pocket is associated, which was not possible with previous constructions employing approximately spherical pockets and in which the appropriate side of the transfer passage had to run substantially smoothly into the spherical surface of the pocket to give satisfactory results. Thus with the present invention variations in the angle and disposition of the transfer passage can be made with comparative freedom when designing an engine according to the present invention, to suit requirements and obtain optimum efficiency.

Moreover the arrangement facilitates and cheapens manufacture since the mouth of the transfer passage does not have to blend smoothly and accurately into the surface of the pocket, while, if desired, the mouth of the transfer passage can be widened without its cutting into the sides of the pocket, as would happen with a spherical pocket.

According to a further and preferred feature of the invention the flat or approximately flat area through which the mouth of the transfer passage opens and which lies in a plane approximately parallel to the axis about which the charge rotates in the pocket, is surrounded by an approximately frusto-conical surface area of the pocket, which frusto-conical surface is generated from an axis of revolution approximately at right angles to the said flat area and at the smaller end of which frusto-conical surface such flat area lies.

According to a further feature of the invention the end of the pocket remote from the transfer passage may be formed with a second flat area of substantial dimensions and approximately parallel to the flat area of the pocket through which the mouth of the transfer passage opens. The part of the wall of the pocket adjacent to this second flat area may also be of frusto-conical form with the said flat area at the smaller end of the frustum, the dimensions of the frustum and of the flat area at each end of the pocket then conveniently being substantially the same so that the pocket has a substantially symmetrical cross section in planes containing the axis joining the centres of the two flat areas.

Two constructions according to the invention are shown in the accompanying drawings, in which

Figure 1 is a cross section through the upper end of a cylinder and cylinder head of one form of internal combustion engine of the kind referred to in a plane containing the axis of the cylinder and the axis about which the surface of revolution representing the wall of the pocket is generated,

Figure 2 is a plan view of the hot plug embodied in the construction shown in Figure 1, and

Figure 3 is a similar view to Figure 1 of another form of internal combustion engine according to the invention.

In the construction shown in Figure 1 the engine comprises a cylinder block A containing cylinders in the form of liners B of which one is shown, the upper ends of the cylinder bores being closed in the usual manner by a cylinder head C provided with inlet and exhaust ports controlled by poppet valves and communicating with inlet and exhaust passages indicated generally at C^1.

Formed in the cylinder head adjacent to each cylinder bore is a combustion pocket D having a generally cylindrical mouth portion D^1 and a hemi-spherical inner end portion D^2 in which is mounted a fuel injection nozzle E, all constructed and arranged in a known general manner which for this reason will not be further described.

Arranged in the mouth portion D^1 of the pocket is a hot plug F, also constructed, mounted and arranged in a generally known manner except that instead of its inner surface being of approximately hemispherical form so as to provide a pocket having an approximately spherical internal contour, it is formed on its inner surface with a flat area F^1 of substantial dimensions through which opens the transfer passage G by which the pocket communicates with the cylinder bore, while the part of the interior surface of the plug F which surrounds the flat area F^1 is of frusto-conical form as shown at F^2 with the flat area at the smaller end of the frustum. The larger end of the frustum runs into a short cylindrical surface area F^3 which runs smoothly into a short cylindrical area D^3 of the same diameter at the end of the hemispherical end surface D^2.

As will be seen more especially from Figure 2 the transfer passage G is of roughly rectangular form with its longer sides appreciably longer than its shorter sides and its mouth opens through the flat area F^1 with its periphery displaced from the periphery of this flat area. This arrangement renders the exact disposition of the mouth less critical than with a spherical pocket and avoids the necessity for it to be so accurately disposed and formed that the appropriate one of its sides runs smoothly into the inner surface of the pocket.

In the construction shown in Figure 3 the arrangement is generally similar to that shown in Figure 1 and similar parts have been given similar reference letters and will not be again described. The construction shown in Figure 3 differs from that shown in Figures 1 and 2, however, in that the end of the pocket remote from the plug F and in which the opening for the fuel injection nozzle E is provided, is formed with a flat area H of approximately the same dimensions and parallel to the flat area F^1 while the adjacent part of the inner surface of the pocket is formed frusto-conical as shown at H^1, the larger ends of the two frusto-conical surfaces F^2 and H^1 being joined by a short cylindrical surface area F^3, D^3 as in the construction shown in Figures 1 and 2.

The constructions according to the invention shown in the accompanying drawings have not only the advantages already pointed out but in addition facilitate manufacture since the accurate machining of flat surfaces, frusto-conical surfaces and cylindrical surfaces represents a simpler operation than that of machining accurately spherical or approximately spherical surfaces. Moreover the constructions according to the invention provide improved efficiency of operation. This is thought to be due at least partly to the fact that, as the charge rotates bodily in the combustion pocket of known engines of the kind to which the invention relates, employing an approximately spherical combustion pocket, a layer of fuel tends to accumulate in and be swept along with the circumferential portions of the rotating charge and therefore not to come into contact with sufficient air to be properly and efficiently burnt. With the present invention, however, eddies tend to be created in the circumferential portions of the air charge where the direction of these circumferential portions is abruptly changed by the contour of the pocket and these eddies tend to carry excess fuel in the circumferential portions of the charge inwards towards the centre of the charge where it can find sufficient air for efficient combustion. Thus in engines according to the invention there tends to be superimposed upon the bodily rotation of the charge two or more such eddies according to whether the surface of the combustion pocket includes a frusto-conical area adjacent to the flat area, through which the mouth of the transfer passage opens, and/or a second flat area at the opposite end of the pocket from the flat area through which such mouth opens and whether or not in the latter case there is a second frusto-conical surface area next to the second flat area referred to or not.

It is also thought that some improvement in efficiency may be due to the fact that the edge of the mouth of the transfer passage over which any fuel carried round by the circumferential portions of the rotating charge is swept can readily be made sharp and this tends to prevent such fuel flowing round the edge into the transfer passage and to cause such fuel to be swept from the edge across the mouth of the transfer passage where it will meet and burn with air being carried from the pocket through the transfer passage with products of combustion and burning fuel from the pocket.

What I claim as my invention and desire to secure by Letters Patent is:

1. An internal combustion engine of the compression ignition liquid fuel injection type comprising a cylinder, a piston arranged for reciprocation within the cylinder, a combustion pocket communicating with the cylinder by way of a transfer passage having its mouth within the pocket and through which a substantial proportion at least of the air charge is forced into the pocket during each compression stroke in a direction to cause during the fuel injection period bodily rotation of the charge in the pocket about an axis in one direction only, and fuel injection means for injecting fuel into the rotating charge in the pocket of which the part of the surface of the pocket over which the circumferential portions of the rotating air charge sweep and through which the mouth of the transfer passage opens, is formed as an approximately flat area of substantial dimensions, the transfer passage lying at an appropriate acute angle to said flat surface while adjacent to the part of the flat surface over which circumferential portions of the rotating air charge sweep before passing over the mouth of the transfer passage, the surface of the pocket in planes perpendicular to the axis of rotation being at an obtuse angle to the flat surface to impart to circumferential portions of the rotating charge a substantial component velocity parallel with the flat surface.

2. An internal combustion engine as claimed in claim 1 in which the approximately flat area lies in a plane approximately parallel to the axis about which the charge in the pocket rotates, and is surrounded by an approximately frusto-conical surface area generated from an axis of revolution approximately at right angles to the said approximately flat area, said approximately flat area lying at the smaller end of the frustum.

3. An internal combustion engine as claimed in claim 2 in which the end of the pocket remote from the transfer passage is formed as a second substantially flat area of substantial dimensions and approximately parallel to the approximately flat area through which the mouth of the transfer passage opens.

4. An internal combustion engine as claimed in claim 3 in which the part of the wall of the pocket adjacent to said second approximately flat area is of frusto-conical form with said second approximately flat area at the smaller end of the frustum and lying in a plane normal to the axis of revolution from which the frustum is generated.

5. An internal combustion engine as claimed in claim 4 in which the larger ends of the two frusto-conical surfaces are joined by a short cylindrical surface area of the same diameter as the larger end of each frustum.

6. An internal combustion engine as claimed in claim 1 in which the end of the pocket remote from the transfer passage is formed as a second substantially flat area of substantial dimensions and approximately parallel to the approximately flat area through which the mouth of the transfer passage opens.

7. An internal combustion engine as claimed in claim 6 in which the part of the wall of the pocket adjacent to said second approximately flat area is of frusto-conical form with said second approximately flat area at the smaller end of the frustum and lying in a plane normal to the axis of revolution from which the frustum is generated.

8. An internal combustion engine as claimed in claim 1 including a plug forming the end of the pocket in which the transfer passage is formed and having limited heat conducting contact with the cooled surrounding walls.

9. An internal combustion engine as claimed in claim 8 in which the approximately flat area lies in a plane approximately parallel to the axis about which the charge in the pocket rotates and is surrounded by an approximately frusto-conical surface on the plug generated from an axis of revolution approximately at right angles to the said approximately flat area and approximately coincident with the axis from which the outer surface of the plug is generated.

10. An internal combustion engine as claimed in claim

9 in which the end of the pocket remote from the plug is formed with a second substantially flat area of substantial dimensions and approximately parallel to the approximately flat area on the plug through which the mouth of the transfer passage opens.

11. In an internal combustion engine of the kind in which an air charge is caused to rotate within a combustion pocket about an axis in one direction only, a plug fitting within a part of the engine and defining a transfer passage through which the air charge is forced into the pocket during each compression stroke, and defining a part of the walls of the combustion pocket, the part through which the mouth of the transfer passage opens being an approximately flat surface with which the transfer passage makes an approximate acute angle, and a part over which circumferential portions of the rotating air charge sweep before passing over the mouth of the transfer passage and being, in planes perpendicular to the axis of rotation, at an obtuse angle to the flat surface to impart to circumferential portions of the rotating charge a substantial component velocity parallel to the flat surface.

12. In an internal combustion engine as claimed in claim 11 in which the approximately flat surface area is surrounded by a frustoconical surface area at the smaller diameter end of which it lies.

13. An internal combustion engine as claimed in claim 1, including means for injecting the fuel into the pocket in a direction having a substantial component in the direction of flow of the rotating air charge.

References Cited in the file of this patent

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