Dec. 31, 1929. J. A. H. BARKEIJ 1,741,355

INTERNAL COMBUSTION ENGINE

Filed Feb. 11, 1928

FIG1

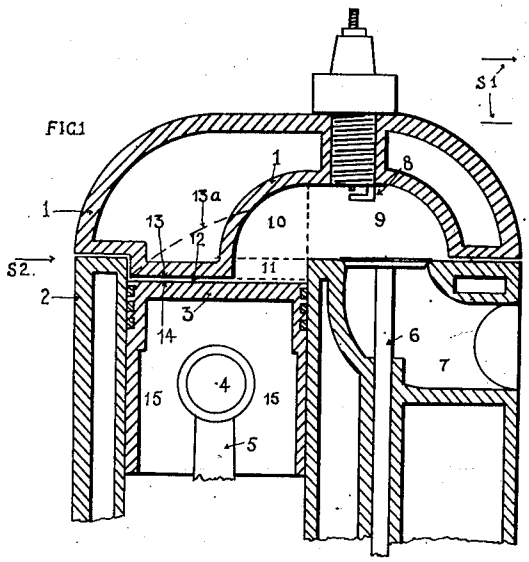


FIG2

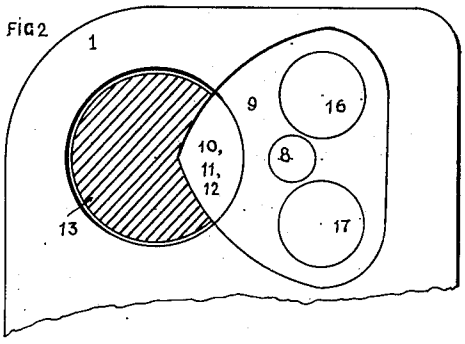


FIG3.

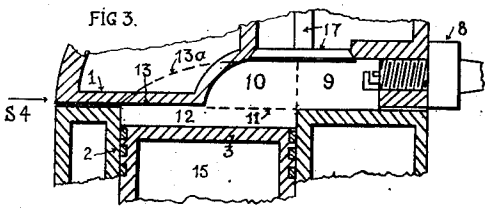


FIG4.

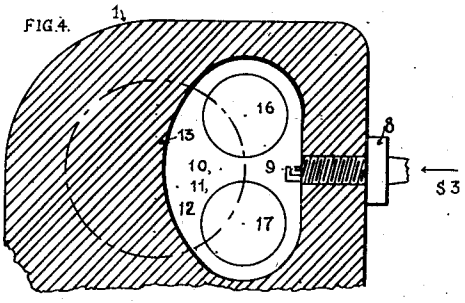


FIG5.

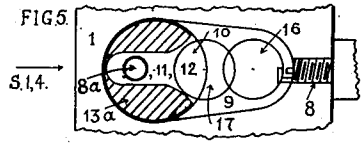


FIG6

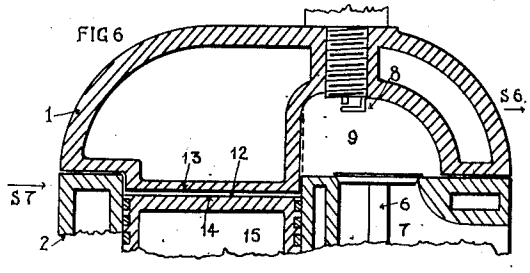


FIG7

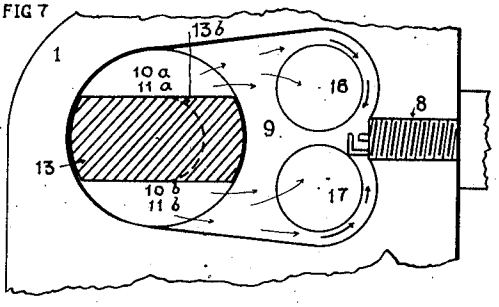


FIG8.

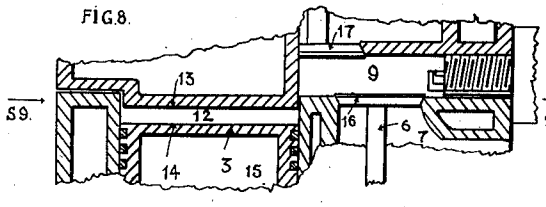
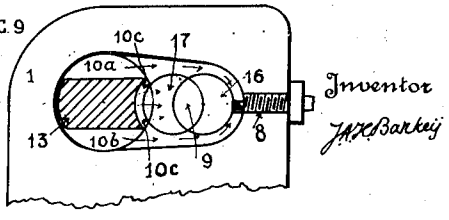


FIG9



Inventor
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Patented Dec. 31, 1929 1,741,355

UNITED STATES PATENT OFFICE

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INTERNAL-COMBUSTION ENGINE

Application filed February 11, 1928. Serial No. 253,594.

This invention relates more particularly to the form of the explosion or combustion chamber of said engines.

This invention includes especially the principles set forth in my application Ser. 152,708, in Fig. 36 together with the description thereof on pages 4 and 5, to decrease the combustion space, for the turbulence principle set forth in the Patent No. 1,474,003 to H. R. Ricardo, by placing the valves in inverted position above, and overlapping the cylinder bore; thereby decreasing the horizontal section of said chamber appreciably compared with a construction, in which said valves are constructed in upright position in the cylinder beside the cylinderbore, not overlapping same.

It is well known that internal combustion engines provided with a turbulence- or so-called Ricardo-head are harsh in operation and are more or less subject to detonation, piston slap and lubrication troubles on account of the sudden sideway pressure of the explosion on the piston.

The socalled semi-Ricardo head provides an additional explosion space in the cylinderhead above the piston and improves aforesaid disadvantages appreciably, but looses to a great extent the desirable turbulence in the cylinderhead on account of the absence of a throat between the cylinderbore and cylinderhead and secondly on account of the absence of the squeezing effect between the lower side of the head and the piston top.

It is the purpose of this invention to combine the advantages of both types without its disadvantages by forming a turbulence and explosion chamber in the cylinderhead and an additional explosion chamber in the cylinder.

The second object is to protect the top of the piston against the heat of the explosion and to decrease its working temperature, thereby decreasing the danger of detonation, the center of the piston being the hottest place in the explosion space with the exception of the exhaust valve.

The third object is to obtain said advantages in an explosion chamber composed of more than two adjoining chambers. Its fourth object is to combine said advantages with any position of the valves, located in the cylinder, or in the cylinderhead, or in both.

My fifth object is to make the throat between the explosion space in the head and the cylinderbore of a crosssection substantially greater than the effective inlet valve port area and greater than the area of the inlet valve, but smaller than half the cylinderbore.

My sixth object is to place the sparkplug nearer the exhaust valve than the inlet valve for reasons to be explained here below.

Fig. 1 is vertical section through an L-head cylinder, cylinderhead and piston, showing an explosion space in the head and partially in the cylinder, as will be explained here below.

Fig. 2 is a horizontal section through Fig. 1, through the undersurface of the head and through the cylinderbore at its upper end to show the relative position of the throat, valves, sparkplug, and form of combustion chamber.

Fig. 3 is a vertical section through a valve-in-head cylinderhead, a cylinderbore, showing the valves both overlapping the cylinderbore partially.

Fig. 4 is a horizontal section of Fig. 3 through the undersurface of the head and through the plane where the valves and sparkplug are located.

Fig. 5 is a horizontal section through a similar section in which however the exhaust valve is in upright position beside the cylinderbore and the inlet valve in inverted position overlapping said cylinderbore for reasons to be explained hereafter. The throat has a section different from that shown in Fig. 4 and more or less conform to the position of the inlet and exhaust valves. The sparkplug is placed near the exhaust valve and another plug, (optionally), if so desired to allow a higher compression ratio than without it, for reasons to be explained hereafter, near the center of the piston top surface.

Fig. 6 is a vertical section through an L-head motor of the type described in my application No. 238,587 of Dec. 8, 1927, in which

the upper part of the cylinderbore or rather space above said cylinderbore is divided in two passages on either side of an intermediate wall or a depression of the cylinderhead re-entering the cylinderbore.

Fig. 7 is a horizontal section through Fig. 6, through the upper end of the cylinderbore and depression, forming part of the cylinderhead, showing further the relative position of valves and sparkplug.

Fig. 8 is a vertical section of a similar arrangement as shown in Fig. 7, applied on an F-head construction, in which the inlet valve is shown in the head in inverted position overlapping the cylinderbore, the exhaust valve in the cylinder in upright position, as already shown in horizontal section in Fig. 5.

Fig. 9 is a horizontal section of Fig. 8 through the upper part of the cylinderbore, showing further the relative position of the throat, valves and sparkplug near the exhaust valve, as shown in Fig. 5.

It is seen that in all combustion chambers shown the longitudinal axis of the chamber and the transverse axis thereof, perpendicular to the first axis, are longer than the height of the combustion chamber. In Figs. 1, 2 in a special L-head formation these axes have lengths, which approach each other, in Figs. 3, 4 in a special valve-in-head formation the longitudinal axis is positively greater than the transverse axis, equally in Fig. 5. In Figs. 6, 7 the same condition obtains again for a special L-head formation, and in Figs. 8–9 in a special F-head formation this condition obtains also, only in varying degrees.

In the first form of Figs. 1 and 2, the L-head construction, the longitudinal axis runs through the axes of the two valves, parallel to the cylinderaxis. The transverse axis, perpendicular to the first axis, runs midway the axes of the valves through the cylinderaxis. These two axes have about the same length.

In the second form of Figs. 3 and 4 a valve-in-head construction, the longitudinal axis runs, as in the first form described, and has the same length. The transverse axis, perpendicular thereon, runs also in the same way, but the length is substantially shorter than in the first form. This shortening enables one better to construct an additional explosion chamber above the piston, separated from the first combustion chamber, above the valves, by a restricted passage, to be described later as to the area thereof, compared with the area of the inlet valve.

In the third form of Fig. 5, an F-head construction, the longitudinal axis runs through the axes of both valves and through the cylinderaxis. This axis runs clear across the cylinderbore and is substantially longer than the same two previous ones. The transverse axis, perpendicular to the first, runs through one of the axes of the two valves, parallel to the axis of the cylinder and is smaller than said axis in the first form and about equal to that in the second form.

In the fourth form, an L-head construction, the longitudinal axis may be considered to run through the two axes of the valves, parallel to the axis of the cylinder, or to run midway the axes of the valves through the axis of the cylinder. It may be even considered to run parallel to the axis of the cylinder through the axis of only one valve through the restricted passages 11^a and 11^b. This depends upon the length of the central depression 13, whether it extends from one side of the cylinderwall to the other side thereof. The transverse axis may run resp. to the first axis, perpendicularly thereon, through the same resp. axes or parallel thereto. The longitudinal axis is considered always to be the longest, the transverse axis, the width-axis the shortest. In the fifth form the F-head construction Figs. 8 and 9, the longitudinal axis runs through the axes of both valves and the cylinderaxis. It may run however parallel to these three axes, through the middle of the two restricted passages 11^a and 11^b approximately, depending again upon the length of the central depression 13. The transverse, width-axis runs through one of the axes of the valves, or midway between the two, parallel to the cylinderaxis, and perpendicular to the longitudinal axis, where this may be, one or two axes as explained.

In all five cases the transverse and longitudinal axes are greater than the height of the combustion chamber, especially the longitudinal axis.

Figs. 1–5 show one type of the species, having two adjoining combustion spaces, one in the head and one in the cylinder.

Figs. 6–9 show another type of the species, having more than two adjoining combustion spaces, one in the head, the others in the cylinder.

In all figures, 1 is the cylinderhead, 2 the cylinder, 3 the piston, 4 the wristpin, 5 the connecting rod, 6 the exhaust valve stem, 7 the exhaust valve passage in the cylinder, 8 the sparkplug.

In the first type, shown in Fig. 1, the explosion space in the cylinderhead can be divided into a space 9 over the valves and a space 10 over the cylinderbore. The second space 11 is in the cylinder, between the cylinder and the cylinderhead, which may extend into the cylinderbore as shown. The cylindrical space 12 between the head and the piston is as small as mechanical considerations allow or nearly so. If the piston approaches the head very close, approximately within $\frac{1}{32}$ of an inch, the turbulence will be violent, due to the squeezing effect of piston and head. It is however dangerous to produce too much turbulence as this might even cause, instead of prevent, detonation. For that reason it is

advisable to increase said distance to a little more than $\frac{1}{32}$ of an inch to decrease said turbulence and to effect simultaneously a pressure upon the entire surface of the piston, to prevent the piston to "rock" or "slap" in the cylinderbore at the moment of explosion. This increase of distance can be effected of course equally when said cylinderhead does not reenter the head, as shown in Fig. 3 and 4, and this space may be even in the head, if it is very small, without eliminating the throat and its effects. It may be even partially in the head, partially in the cylinder, again provided the distance between head and piston in top position is decidedly more than that proposed in the Patent 1,474,003 to H. R. Ricardo, and decidedly less than that shown and proposed (in proportion to drawing) in the Patent No. 1,537,775 to I. F. Kelly in which a throat is entirely absent between the cylinderbore and the explosion space in the head. The distance in said patent is further so great that the squeezing effect between piston and head is practically absent and it is the purpose of this application to retain said effect to a certain extent acquiring thereby simultaneously the advantage of an explosion pressure on the entire surface of said piston. The piston, after the inlet valve is closed, comes up and forces the gas during the entire compression period from the space 15 swept by the piston, through the additional explosion space 11, forming more or less a throat, into the space 10 and 9 in the cylinderhead. During the last distance of piston-travel the gas is trapped between the lower end 13 of the head and the top 14 of the piston and causes an additional turbulence. The explosion force from the spark plug cannot hit the piston top immediately in case the head protrudes into the cylinder but has to make a double curve, which is probably responsible for the absence of harsh action and detonation tendency. If the space 12 is increased a little beyond the mechanical minium of about less than $\frac{1}{32}$ of an inch, the squeezing effect between piston and head together with said throat will still create enough turbulence in the space 9 to increase the flame propagation. Fig. 2 shows a top view cross section of Fig. 1, showing the explosion spaces 9, 10 in the cylinder head and the reentrant portion 13 of the head 1 and additional explosion space 11 in the cylinder.

In Fig. 3 by raising the lower end 13 of the head to a practically flush-position with the top of the cylinder, the space 12, which was in one variation or modification of the type of Fig. 1 negligible on account of the small height, is increased to a full cylindrical, additional, explosion space in the cylinder and the former additional explosion space 11 is reduced to a mere throat between the explosion space in the head and the explosion space in the cylinder. It resembles thereby the semi-Ricardo head construction, but with this important difference that in the latter the throat is eliminated and thereby also the turbulence-creating-action during the entire compression period. During the explosion, the force of the sudden pressure is appreciably decreased by this throat, resulting in a more gradual expansion. However in this type as in the semi-Ricardo type the squeezing action between head and piston is lost, but on account of the retained turbulence action of the throat it is not lost entirely and especially not during the last distance travelled by the piston before it reaches its top position. The amount of this additional turbulence is due to the distance which remains between the piston in its top position and the undersurface of the head, which should be a little more than $\frac{1}{32}$ of an inch and less than $\frac{3}{16}$ of an inch, in case the head does not enter the cylinder bore so that the throat has practically no length. In case however this head reenters the cylinder, it is not absolute necessary to increase this distance above $\frac{1}{32}$ of an inch, as the throat has now a certain length and softens already thereby the explosion force. However the distance may be also increased in this form to soften the explosion still more, but this is not absolute necessary. As shown in Figs. 3–5 this arrangement is very adaptable for a construction in which at least one of the valves, by preference the inlet valve, is placed in the cylinderhead instead of in the cylinder adjacent to the exhaust valve. In Figs. 3 and 4 both valves are shown in the head, in Fig. 5 only the inlet valve 17 is shown in the head.

Comparing Fig. 4 with Fig. 2 it can be seen that the space 9 in the cylinderhead is considerably decreased compared with the same space in Fig. 2. This allows the construction of the additional cylindrical explosion space 12 without constructing the spaces 9 and 10 in the head too shallow or without increasing the stroke abnormally. The spark plug is placed in a horizontal position to obtain the maximum benefit of the softening effect of the throat 11 on the explosion. If this plug is placed to the left of the inlet valve 17 above said throat, the explosion would be much harsher. Consequently the throat and spark plug position together soften the explosion, not the position of the plug only, or the throat only. Another factor enters here affecting the specific position of sparkplug and exhaust valve. I found that the position of the sparkplug in relation to the position of the exhaust valve is as important as the position thereof relative to the throat and its size. It is possible to give a good and sound explanation to this particular phenomenon. The sparkplug ignites the gas in the neighborhood thereof, a region of pressure is produced and this region drives in front of it the gases, which did not yet have the

time to be ignited and to combust. These gases will be compressed away from the sparkplug, if only one is employed. If this plug (or plugs) is located near the inlet valve, which is much cooler than the exhaust valve (where it may be located) the unburned gases are compressed towards the exhaust valve. What happens? The gases having there during a small fraction of a second, a high pressure, will detonate, being raised in temperature not only by the increased pressure, but also by the radiating heat from the hot exhaust valve. Reversely if the gases are ignited in the neighborhood of the exhaust valve, the unburnt gases are compressed towards the cooler regions of the combustion chamber and the unburnt gases there can only detonate on account of the increase in temperature due to the increase of temperature, but minus the temperature given off to the cooler walls in the neighborhood of said inlet valve. Undoubtedly some truth must be in this theory, as it is possible in certain combustion chambers to increase the compression about one atmosphere, without being bothered by detonation more than with a lower compression rate and the sparkplug near the inlet valve. It has been steadfast practice, for so long as internal combustion engines working with a mixture and a sparkplug are made, to place the latter near the inlet valve to insure regular firing without missing. This practice is reversed here. In some cases, if two sparkplugs are used, one may be as close to the inlet valve as to the exhaust valve, but they may be placed both near the exhaust valve. However the first practice will already prevent detonation with certain compression ratios, as the gases unburnt have no time to be ignited and to detonate on account of the radiation of heat from the exhaust valve. In other cases, it may be advisable to place the second plug near the center of the top surface of the piston to prevent the unburnt gases from being compressed towards the other hot spot in the combustion chamber. This practice is shown in Fig. 5 and will be discussed in connection therewith.

In Fig. 5 it is shown that the throat 11 can be increased across the cylinder bore, as shown at 13^a in Figs. 1 and 3, and an additional plug 8^a can be placed opposite the plug 8 at the other end of the explosion space in the cylinderhead. According to the theory just explained, the center of the piston in this arrangement is exposed to the explosion-compression space and the unburnt gases will be compressed thereagainst, away from the sparkplug near the exhaust valve, at 8 and 16 resp. To suppress this tendency to detonation at certain pressures, it is advisable to place a second plug, 8^a, firing simultaneously with the other plug 8, at the other end of the longitudinal axis of said combustion chamber. It is not absolutely necessary to use two sparkplugs, but the application thereof at the designated places will allow a higher compression without a serious tendency to detonation. The explosion chamber is shown here considerably long and extends to the other side of the cylinderbore. The decreased space 9 in the head will allow this additional volume without transgressing the volume necessary for an adequate compression.

Figs. 6–9 show the other types of the species and are modifications of the arrangement shown in my application No. 238,587 of Dec. 8, 1927. In said application the underside of the depression 13 of the head is flush with the flat surface of the cylinderblock. Here this depression is further lowered into the cylinderbore, thereby obtaining the same advantages for this type. In Figs. 6 and 7, the depression 13 divides the space in the cylinderhead in three spaces, one 9 above the valves, and two spaces 10^a and 10^b over the cylinder. These two latter spaces adjoin the additional explosion spaces 11^a and 11^b in the cylinder. The piston comes up close to the cylinderhead to increase the turbulence at the very last moment before explosion. The spaces on opposite sides of the piston balance the explosion force on the piston, eliminating piston slap, lubrication troubles, and unequal heating and expansion of the piston. Here again the distance between the top surface of the piston may be increased a little above $\frac{1}{32}$ of an inch to decrease the turbulence due to the squeezing effect spoken of before. The effect of a balanced pressure on the piston is however in this arrangement, as that shown in Figs. 5, 6 and 7, already accomplished by the equal areas on both sides of a plane through the cylinderaxis perpendicular to the piston pin. In Fig. 5 these areas differ only in form from those of Figs. 6 and 7 and those of Figs. 8 and 9. These areas may be located on both sides of a plane through the axis of the piston pin and axis of cylinder, or may be located on both sides of a plane perpendicular thereto.

In Figs. 8 and 9 the space 9 in the cylinderhead is again decreased by the position of both valves, or only one, by preference the inlet valve, in the cylinderhead. An additional cylindrical explosion space 12 in the cylinder can be applied without making the chamber in the head too shallow. The spaces or throats 10^a and 10^b cause a flow in opposite direction in the space 9 as shown by arrows in Fig. 7. If the inlet valve is placed in the head and partially overlapping the cylinderbore to facilitate the flow of the gas, the depression 13 has to be decreased as shown in Fig. 9, thereby forming an additional throat 10^c, from which an additional flow of gas will hit the flow in opposite directions, from the throats 10^a and 10^b, in the middle during the entire compression period. If the piston comes again close to the head this turbulence

will be increased at the very last moment by the squeezing effect between head and piston. If the piston does not approach the head very close the turbulence caused by the throats only have to increase the speed of the flame propagation. It is understood that the construction of the central depression 13 can be combined with an arrangement of the valves in the head as shown in Figs. 3 and 4. The depression can extend clear across the cylinderbore, but can be decreased to a distance a little beyond the center as shown at 13^b to obtain the flow and ejection of the gas in opposite direction from the cylinderspace into the explosion space.

The spark plug is here again placed by preference horizontally to obtain the benefit of the softening effects of the throats on the explosion. The single sparkplug is placed near the exhaust valve. The center of the piston is already protected and shielded by the depression 13 of the head. Two sparkplugs could be used also here, one in horizontal position as shown in Fig. 9, and one in vertical position above said exhaust valve as shown in Fig. 1. They both may be placed in vertical position above or near the passages 10^a and 10^b as already shown in said application No. 238,587. Finally attention is drawn to the fact, that if the throat has a greater area, the squeezing effect between piston and head decreases, and also the turbulence effect solely due to the swirling of the mixture through said restricted passage during the entire compression period. On the other hand the throat cannot be made too narrow as the volumetric efficiency would be affected too much. For that reason, if the piston does not approach the head as close as possible (let us say anything more than $\frac{1}{32}$ of an inch) the ratio between the area of throat and inlet valve and cylinderbore should be made very accurate after results of experiments. In general, said area of the throat should not be less than half the cross-section of the cylinderbore. The throat will consequently have an area less than half of the cylinderbore and larger than the inlet valve port area. The area of the exhaust port is usually less than that of the inlet valve, but this area is not very relevant in this matter, as the volumetric efficiency would be already a maximum in view of the inlet valve, unless one of them is placed in a more favorable position above the cylinderbore, as is shown for both valves in Figs. 3 and 4, and for the inlet valve in Figs. 5, 8 and 9.

Finally it is pointed out that the distance between piston in top position and the underside of said head should not be more than about $\frac{3}{16}$ of an inch, otherwise the squeezing effect will be so little as to have little effect on the acceleration of the flame, due to this turbulence. The throat would still produce a certain amount of turbulence during the entire compression period, but the last flip due to the squeezing effect is highly important, more so than the turbulence due to the throat only.

It is understood that the undersurface of the head with central depression, as shown in the last Figs. 6–9, can be so constructed as shown in Fig. 3, that said undersurface is flush with the upper rim of the cylinderbore. The piston may then come up close to said undersurface, as shown in Fig. 1, or remain in top position at a distance therefrom, forming an additional chamber, as shown in Fig. 8. It is also understood that the Diesel principle may be applied with the proposed constructions and forms of combustion chambers, without deviating from the spirit of this application. The fuel-fluid may be then injected mechanically, with or without air, in the cylinder.

I claim:

1. In an internal combustion engine, in combination, a cylinder, a piston reciprocating therein, a cylinderhead entering said cylinder, said cylinderhead being formed with a combustion chamber therein, which lies partially over said cylinderbore, a throat formed between the cylinderwall and the head by which said combustion chamber communicates with the space swept by said piston in said bore, said throat having a crosssection at least equal to the area of the inlet port communicating with said combustion chamber, and controlled by a poppet valve, an exhaust port controlled by a poppet valve in said combustion chamber, sparkignition means in said combustion chamber.

2. The combination of claim 1 in which said entering part of the head is a central depression from said head, forming thereby two restricted passages at opposite sides of said depression and opposite sides of the cylinderbore.

3. The combination of claim 1 in which said throat has an area substantially in excess of the area of said inlet valve.

4. The combination of claim 1 in which said spark ignition means are substantially closer to said exhaust valve than to said inlet valve.

5. An internal combustion engine of the explosive type operating on a four stroke cycle, in combination, a cylinder, a piston, reciprocating therein, a cylinder head entering said cylinder, a combustion chamber in said cylinderhead, lying partially over said bore, containing sparkignition means and an inlet and an exhaust valve, said entering cylinderhead forming with said cylinderbore a throat, said throat having an axis parallel to the cylinderbore, having a length, said combustion chamber in said head communicating with the cylinderbore through said throat with a longitudinal axis, perpendicular to its diameter.

6. The combination of claim 5 in which said piston approaches said undersurface of said

head with approximately a minimum mechanical clearance.

7. The combination of claim 5 in which said piston approaches said undersurface of said head with a little more than mechanical clearance so that an additional explosion chamber is formed between said combustion chamber in the head and the space swept by said piston.

8. In an internal combustion engine, in combination, a cylinder, a piston reciprocating therein, a cylinderhead entering said cylinder, said cylinderhead being formed with a combustion chamber therein, which lies partially over said cylinder bore, an additional combustion chamber being formed between the piston and head, a throat formed between the cylinderwall and the head by which the two chambers communicate, said throat being approximately equal to the area of the inlet port and less than the crosssection of the cylinderbore, and sparkignition means in said combustion chamber.

9. In an internal combustion engine, in combination, a cylinder, a piston reciprocating therein, a cylinderhead entering said cylinder, said cylinderhead being formed with a combustion chamber therein, which lies partially over said cylinderbore, an additional combustion chamber being formed between the piston and the head, throats formed between the cylinderwall and the head, by which the two chambers communicate, said throats being greater than the inlet-valve passage and less than the crosssection of the cylinderbore, gas inlet and outlet passages for said first chamber and ignition means in said chamber.

10. The combination of cl. 8, in which at least one of said valves is located in said cylinderhead to diminish the combustion space in said head.

11. The combination of cl. 9, in which at least one of said valves is located in the cylinderhead to decrease the combustion space in said head.

12. In an internal combustion engine, in combination, a cylinder, a piston reciprocating therein, a cylinderhead, said piston approaching said cylinderhead at more than a minimum distance, said cylinderhead being formed with a combustion chamber therein, lying partially over said cylinderbore, a throat formed between the cylinderhead and the cylinderwall, said throat being substantially greater than the area of the inlet port and less than the crosssection of the cylinderbore, and sparkignition means in said combustion chamber, said chamber containing at least one valve in inverted position overlapping the cylinderbore to decrease the area of the horizontal section of said chamber, said throat being formed by a part of said head, entering said cylinderbore.

13. In an internal combustion engine as described in cl. 12, in which said part of said head, entering the cylinderbore, forms a central depression over the central part of said bore from one side to the other side thereof, forming thereby two passages between the space in said combustion chamber, containing the valves, and the cylinderbore, one at either side of said depression and the cylinderbore.

14. In an internal combustion engine, in combination, a cylinder, a piston reciprocating therein, a cylinderhead, said piston approaching said cylinderhead at more than a minimum distance, said cylinderhead being formed with a combustion head therein, lying partially over said cylinderbore, a throat formed between the cylinderhead and the cylinderwall, said throat being substantially greater than the area of the inlet port and less than the cross-section of the cylinderbore, and sparkignition means in said combustion chamber, said chamber containing at least one valve in inverted position overlapping the cylinderbore to decrease the area of the horizontal section of said chamber, said cylinderhead forming a depression over the center of the cylinderbore substantially from one side to the opposite side of said bore, said depression forming at its undersurface two throats, at opposite sides of said depression with the upper surface of said cylinderbore.

15. In an internal combustion engine of the explosive type, operating on the fourstroke cycle, a cylinder, a piston reciprocating therein, a cylinderhead, a combustion chamber in said head lying partially over said cylinderbore, and containing the inlet and exhaust valves, an additional chamber being formed between the piston and head, a throat formed between the upper edge of the cylinder and the undersurface of the cylinderhead, by which the two chambers communicate, said throat being approximately equal to the area of the inlet port and less than the crosssection of the cylinderbore, sparkignition means in said combustion chamber, said throat being formed by a part of said head, entering said cylinder bore.

16. In an internal combustion engine, of the explosive type, operating on the fourstroke cycle, a cylinder, a piston reciprocating therein, a cylinderhead, a combustion chamber in said head lying partially over said cylinderbore and containing the inlet and exhaust valves, an additional combustion chamber being formed between the piston and the head, a throat formed between the upper edge of the cylinder and the undersurface of the cylinderhead, by which the two chambers communicate, said throat being approximately equal to the area of the inlet port and less than the crosssection of the cylinderbore, sparkignition means in said combustion chamber, said throat composed of two restricted passages, one at either side of a central depression in said head, said restricted passages

formed by the undersurface of said head and the upper part of the cylinderbore.

17. In an internal combustion engine of the explosive type operating on the fourstroke cycle, a cylinder, a piston reciprocating therein, a cylinderhead, a combustion chamber in said head lying partially over said clyinderbore and containing the inlet and exhaust valves, an additional combustion chamber being formed between the piston and the head, a throat formed between the upper edge of the cylinder and the undersurface of the head, by which the two chambers communicate, said throat being approximately equal to the area of the inlet port and less than the crosssection of the cylinderbore, sparkignition means in said combustion chamber, said throat composed of two restricted passages, one at either side of a central depression in said head, of which the undersurface is approximately flush with the upper edge of the cylinderbore, said restricted passages formed by the edges of said depression and the cylinderbore.

18. The combination of cl. 15, in which said throat is formed at opposite sides of a central depression of said head entering said cylinderbore, said throat composed of two restricted passages between said depression and said cylinderbore.

19. In an internal combustion engine, in combination, a cylinder, a piston reciprocating therein, a cylinderhead, said piston approaching said cylinderhead at more than a minimum distance, said cylinderhead being formed with a combustion chamber therein, lying partially over said cylinderbore, a throat formed between the cylinderhead and the cylinderwall, said throat being substantially greater than the area of the inlet port and less than the crosssection of the cylinderbore, and sparkignition means in said combustion chamber, said chamber containing at least one valve in inverted position above the cylinderbore to decrease the area of the horizontal section of said chamber, an additional chamber being formed between said piston and the undersurface of said cylinderhead, separated from said combustion chamber in the head by said throat, said additional chamber having a substantial volume compared with said first combustion chamber in the head in view of the bore and stroke of said engine, said volume allowable on account of the overlapping position of one of said valves over said cylinderbore.

20. In an internal combustion engine of the explosive type, operating on the fourstroke cycle, a cylinder, a piston reciprocating therein, a cylinderhead, a combustion chamber in said head, lying partially over said cylinderbore and containing the inlet and exhaust valves, an additional combustion chamber being formed between the piston and head, a throat formed between the upper edge of the cylinder and the undersurface of the cylinderhead, by which the two chambers communicate, said throat being approximately equal to the area of the inlet port and less than the crosssection of the cylinderbore, sparkignition means in said combustion chamber, at least one of said valves located in said combustion chamber, above the cylinderbore, thereby decreasing the horizontal crosssection of said chamber above the dividing line of the head and the cylinder, compared with said crosssection of a chamber having its valves besides the cylinder not overlapping said bore.

21. In an internal combustion engine, in combination, a cylinder, a piston recriprocating therein, a cylinderhead, a combustion chamber in said head partially lying over said cylinderbore, an additional combustion chamber formed between the piston and head, a throat formed between the cylinderwall and the head by which the two chambers communicate, said throat being approximately equal to the area of the inlet port and less than the crosssection of the cylinderbore, an inlet and exhaust port controlled by poppet valves opening into said combustion chamber in the head, sparkignition means close to said valves in said first combustion chamber, one of said valves overlapping said cylinderbore, thereby decreasing the horizontal section of said first chamber in the head, said throat further formed by two restricted passages between a depression in said head, lying over the center of said cylinderbore from one side to the other side thereof, and the cylinderbore.

22. In an internal combustion chamber, in combination, a cylinder, a piston reciprocating therein, a cylinderhead, a combustion chamber in said head lying partially over said cylinderbore, an additional combustion chamber formed between the piston and head, a throat formed between the cylinderwall and the head, by which the two chambers communicate, said throat being approximately equal to the area of the inlet port and less than the crosssection of the cylinderbore, an inlet and exhaust port controlled by poppet valves opening into said combustion chamber in the head, sparkignition means close to said valves in said first combustion chamber, one of said valves by preference the inlet valve overlapping said bore, thereby decreasing the horizontal cross-section area of said first combustion chamber in said head, said head entering said cylinderbore with a central depression, said throat formed by two restricted passages, one at each side of said central depression, between said depression and opposite sides of the cylinderbore.

23. In an internal combustion engine, in combination, a cylinder, a piston reciprocating therein, a cylinderhead, a combustion chamber in said head partially lying over said cylinderbore, two throats formed be-

tween the cylinderwall at its upper rim and said head at its undersurface, said throats being greater than the area of the inlet port and less than the cylinderbore, inlet and exhaust valves controlled by poppet valves opening into said combustion chamber in the head, ignition means in said combustion chamber in said head.

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