Aug. 7, 1923.

1,463,973

J. V. RICE, JR

INTERNAL COMBUSTION ENGINE

Filed June 1, 1922

3 Sheets-Sheet 1

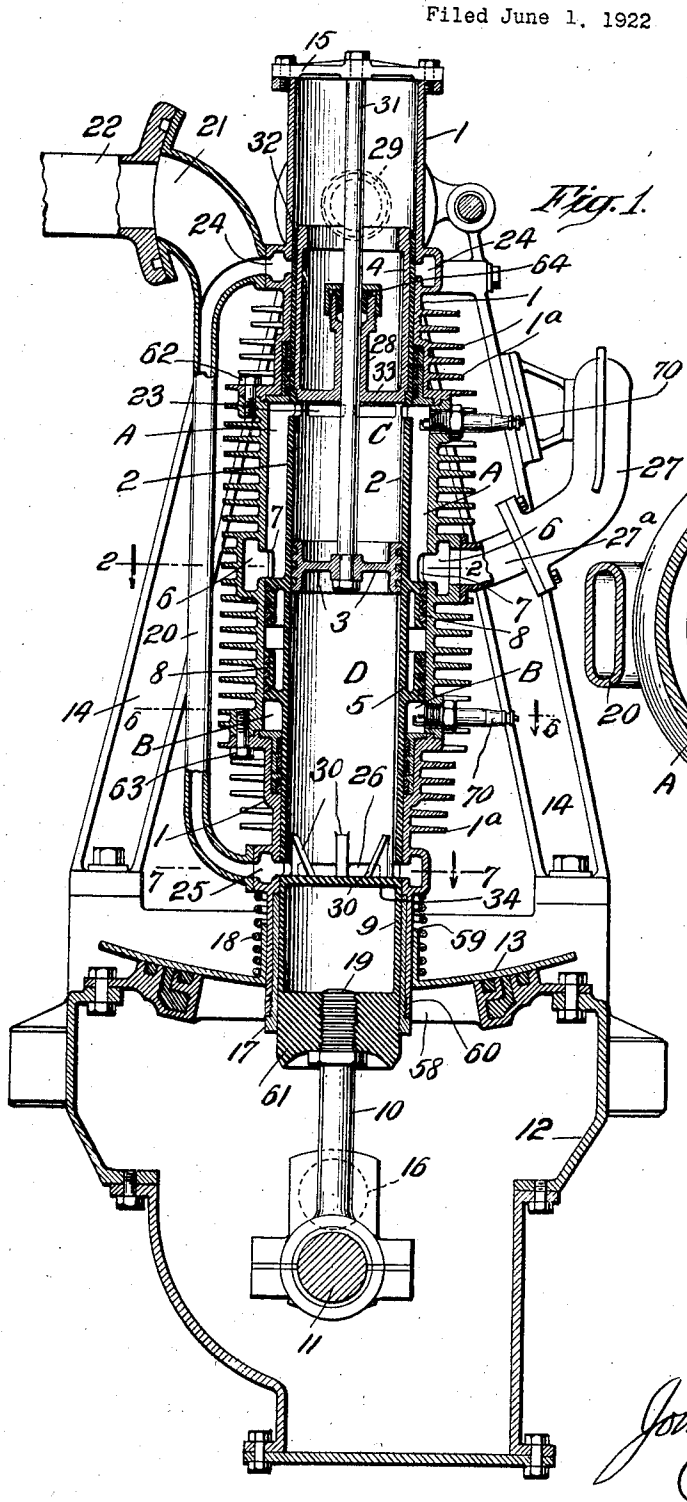
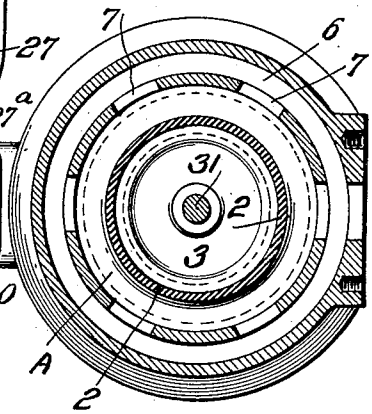


Fig. 1.

Fig. 2.



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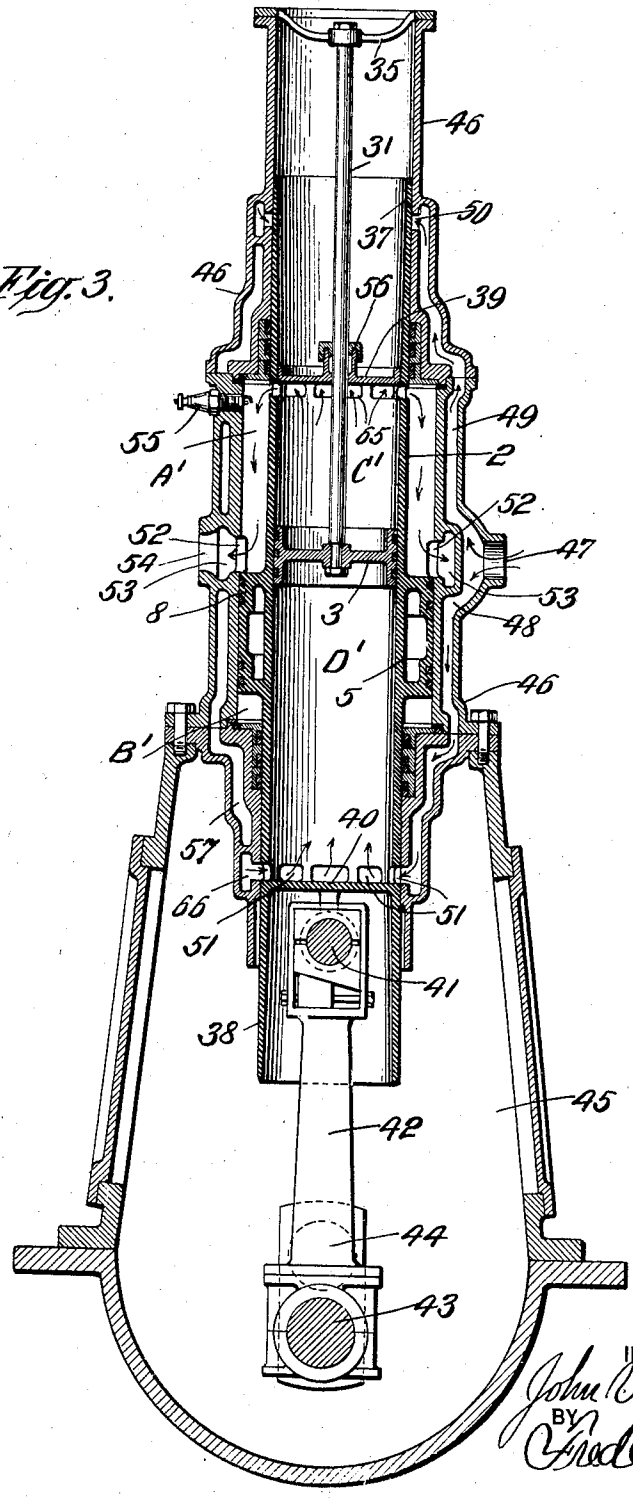
3 Sheets-Sheet 2

Fig. 3.



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3 Sheets-Sheet 3

Fig. 4.

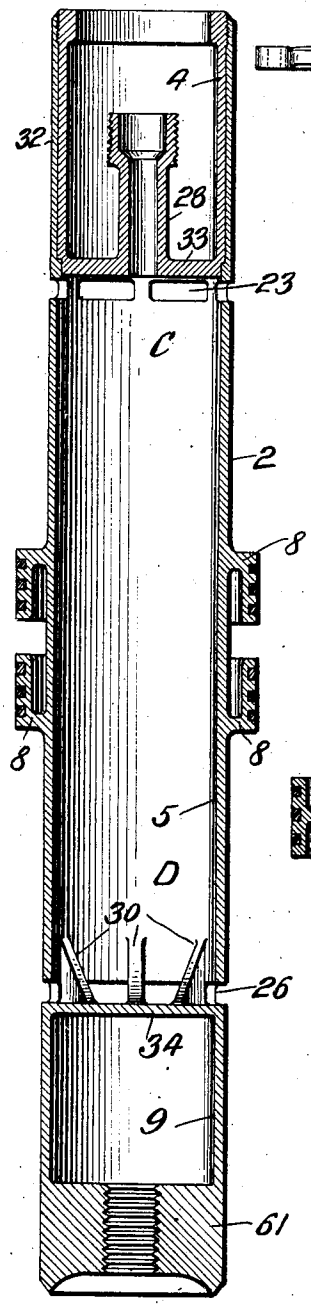


Fig. 5.

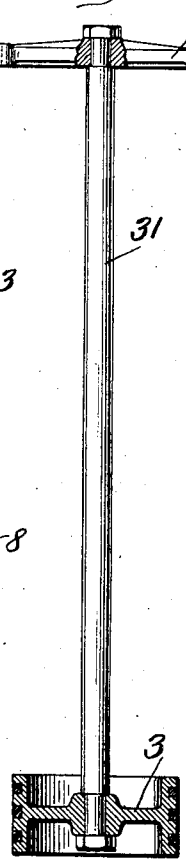


Fig. 6.

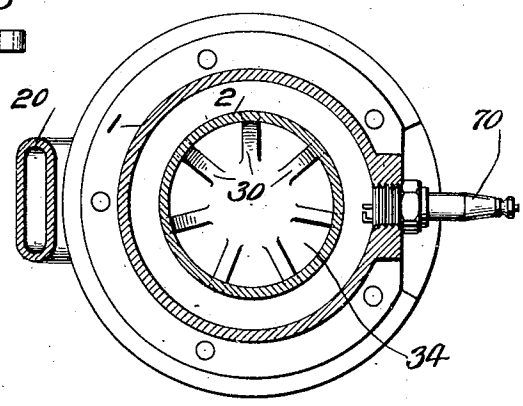
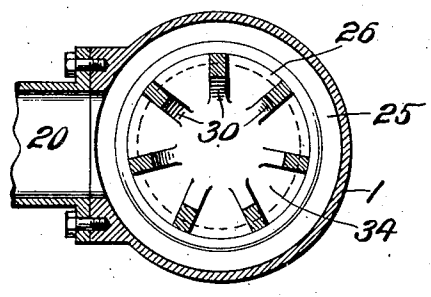


Fig. 7.



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Patented Aug. 7, 1923. 1,463,973

UNITED STATES PATENT OFFICE.

JOHN V. RICE, JR., OF BORDENTOWN, NEW JERSEY, ASSIGNOR TO RICE GAS ENGINE COMPANY, OF BORDENTOWN, NEW JERSEY, A CORPORATION OF NEW JERSEY.

INTERNAL-COMBUSTION ENGINE.

Application filed June 1, 1922. Serial No. 565,108.

To all whom it may concern:

Be it known that I, JOHN V. RICE, Jr., a citizen of the United States, and resident of Bordentown, in the county of Burlington and State of New Jersey, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification, reference being had therein to the accompanying drawing.

This invention relates to internal combustion engines, and to the special subdivision of the same known as two-cycle, whether double-acting or single-acting, and whether of the oscillating cylinder or non-oscillating cylinder type, the design of the invention having a broad application to these various forms, and to any others with which it may be found effective.

The oscillating cylinder type of gas engine possesses many advantages as compared with the common and well known reciprocating, non-oscillating engine, particularly with reference to economy of space and weight coupled with high efficiency. It will be understood, however, that my invention, although well adapted to the oscillating design, is not restricted thereto, since I can arrange the cylinder and pistons so that they may function as in the ordinary reciprocating explosive engine, having no rocking support. It will be further seen that whether the oscillating or non-oscillating type is utilized, there may be one or more cylinders arranged in relation to the same crank-shaft and supported in a suitable frame for enabling them to discharge their full functions in operative relation to each other.

The object of the invention is to provide a simple, convenient, and effective construction, whereby economy and ease of operation may be attained, with the use of very few parts, and with little likelihood of breakage or disrepair, but capable of developing a very large amount of power. A signal feature of the invention lies in the piston, which is more or less elongated or extended and is differential in character to correspond with a differential design of the cylinder. This piston is a hollow sleeve or cylinder, having at each end a tubular and usually open-ended extension, the interior of the piston being provided with two non-communicating chambers divided by a stationary partition or diaphragm, said chambers serving as primary compression chambers for the fuel mixture. These primary compression chambers alternately receive the charges at the ends of the stroke through ports in the chambers near the piston heads, and after each initial compression deliver the compressed charges through the same ports into the final compression and explosion chambers which surround the piston in the central portion of the cylinder and communicate alternately with a common exhaust system located between said explosion chambers. Thus I am able to introduce the charge through ports running entirely around the pistion, and also to exhaust through ports running entirely around the piston, that is to say to use a very large inlet and a very large outlet, whereby a large charge is quickly and completely introduced and whereby also a thorough and adequate scavenging is attained. Thus also it will be seen that I provide a compression chamber in one end of the piston for compressing the charge preliminarily for one explosion, and another compression chamber in the other end of the piston for compressing the charge preliminarily for the next explosion, these partially-compressed charges being transferred from the piston chambers into the firing chambers, where they are again and finally compressed before being exploded. The stationary diaphragm in the piston is independently supported by connections with the cylinder, and the piston sleeve plays back and forth on said fixed diaphragm, while the latter separates the two compression chambers from each other. Obviously during the reciprocations of said piston these chambers change in size from maximum to minimum; when of maximum size the chambers receive the charge and as they decrease in size the charge is compressed until the minimum capacity of the chambers is reached, at which moment the initially-compressed charges are transferred to the explosion chambers. In addition to these important structural characteristics of the piston and other parts, the invention may be said to consist essentially in the construction, arrangement and combination of the various parts, and in various details and peculiarities of the same, substantially as will be hereinafter more fully described and then pointed out in the claims.

In the accompanying drawings illustrating my invention:

Figure 1 is a vertical longitudinal section of my improved internal combustion engine, when the same is of the oscillating type, and shows the piston at the lower limit of its stroke.

Figure 2 is a horizontal cross-section on the line 2, 2, of Figure 1.

Figure 3 is a vertical longitudinal section similar to Figure 1 of my improved internal combustion engine, when the same is of the reciprocating, non-oscillating type.

Figure 4 is a detail longitudinal section of the piston.

Figure 5 is a detail sectional side view of the diaphragm or partition within the piston, and the means for supporting the same in a stationary position with reference to the moving piston.

Figure 6 is a horizontal cross-section on the line 6, 6, of Figure 1.

Figure 7 is a horizontal cross-section on the line 7, 7, of Figure 1.

Similar characters of reference designate corresponding parts throughout the different figures of the drawing.

The main frame of the engine, when of the oscillating type, may be built as shown in Figure 1, so as to permit the pendulous support of the cylinder or cylinders, of which there will usually be a plurality, all applying their power to the same crankshaft. As an example of such frame construction, the same being suggestive merely and without any intention of being confined thereto, I have shown the standards or uprights 14, between which is a cylinder 1, or a series of similar cylinders, hung in a vibratory fashion, on suitable journals or trunnions, as at 29, the details of which it is not necessary to show.

I will first explain a structural example of my engine as designed for the oscillating cylinder type, as shown in Figures 1, 2, 4, 5, 6 and 7. The explosive mixture is introduced into the engine by means of a lateral pipe 21 that slides loosely over the end of a fuel feed conduit 22, (leading from the carburetter and source of supply) during the oscillatory motion of the engine, a tight joint being kept between the members 21 and 22 by suitable means, and said pipe 21 being a part of the longitudinal feed pipe 20, which lies alongside the cylinder 1 and which delivers fuel at both ends of the latter; at one end through circular port 24, and at the other end through circular port 25, see Figure 1.

At the base of the engine moreover is the main crankshaft 16 having crank pin 11, to which the piston rod 10 is connected, it being obvious that this shaft will have as many cranks as there are cylinders, and that the connection of the piston rods with the crank pins will be direct without the intervention of any other mechanism. The crank-shaft is enclosed within the lubricant-filled crank casing 12. In order to keep the same tight at the point where the end of the piston and the piston rod 10 enter the casing 12 and allow these parts the necessary range of movement during the swing of the cylinder, I provide the cylinder with a curved plate 13, which covers an opening 58 in crank casing 12 and slides on the edge of this opening so as to prevent the escape of oil, said plate having a central sleeve 59 that telescopes with a boss or ring 60 on the lower end of the cylinder 1, in connection with which it adjusts itself and is held by an enveloping spring 18, so tensioned that plate 13 may be kept closely over opening 58. There is also a packing gland 17 between boss 60 and the lower end 61 of the piston 2, to effect a tight joint between these parts this gland 17 being thus within sleeve 59 and boss 60, and being screwthreaded to enable it to be loosened or tightened. In this way a tight joint is made for the end of piston carrying rod 10. Said rod has a screwthreaded end 19 which screws tightly into the solid member 61 at the bottom end of piston 2.

At a suitable point alongside of the main frame is the stationary exhaust pipe 27 for carrying off the waste products of combustion, and this will usually have a branch pipe 27^a for each cylinder, whenever there is more than one cylinder, the details thereof not being herein shown, but a tight joint must evidently be kept at all times between the moving or vibratory parts, suitable means being employed for the purpose. The exhaust outlet pipe 27^a leads from the central portion of cylinder 1 where is situated the circular exhaust passage 6 and the exhaust ports 7, see Figure 2, it being clear that this arrangement of ports may be greatly modified without varying from the design of a large exhaust outlet at the center of the cylinder that will function on each stroke and after each explosion, there being a single common exhaust outlet for both explosion chambers.

I will now proceed to describe the construction and operation of the cylinder 1 and its appurtenant parts, it being understood that the engine may be single or multi-cylinder in construction, and that where there are several cylinders, they will be duplicates of the one I am describing; but in the drawings I have only thought it necessary to show a single cylinder, in order to impart the fullest understanding of the invention. Such cylinder is double-acting, compresses and fires at each stroke, and hence generates great power.

Cylinder 1 may be of any specific construction, dimensions and proportions. Its

cooling system may use water or other liquid, a fan, or any other means for the purpose, but I preferably build it with a multiplicity of radiating fins or flanges 1ª, which cover the surface, so as to avoid some of the objections incidental to water jackets and the like, said flanges being properly proportioned to provide the radiating surface necessary for the amount of heat generated in the operation. The cylinder 1 is usually open-ended at top and bottom. Such cylinder may be made in three castings, as shown, which are flanged to engage each other, said flanges being securely fastened together by means of bolts, as at 62 and 63, so that in this manner the sections of the cylinder may be effectually united.

The bore of the cylinder 1 is of smaller diameter at the upper and lower ends than it is in the middle portion, its differential character in this respect corresponding to the differential piston which reciprocates within the cylinder 1. The middle and larger portion of the cylinder furnishes the two explosion chambers A and B, between and in which the widest part 8 of the piston operates, while the upper and lower ends of the cylinder are open-ended and of smaller diameter than the middle section so as to accommodate therein the hollow extensions of the piston which project beyond the heads of the same, and are of the same diameter as the main length of the piston and the parts on both sides of the central section 8.

The piston is of the differential type, consisting of a hollow sleeve or cylinder of the same interior diameter throughout, but with an exterior middle portion 8 of larger diameter than the sections 2 and 5 that are between said middle portion 8 and the upper head 33 and lower head 34 respectively, said section 2 having an interior primary compression chamber C, and said section 5 having also an interior primary compression chamber D. The section 2 beyond head 33 has an open-ended sleeve-like extension 32 in which slides and screws the sleeve 4 carrying head 33 and bearing 28, there being preferably this arrangement of parts, and the section 5 of the piston below head 34 having a hollow extension 9 that slides in the lower part of cylinder 1, below chamber B, as already explained. The inner compression chambers C and D are divided by a stationary partition or diaphragm 3, on which the hollow piston slides up and down, thus causing the said chambers C and D to respectively increase or decrease in size, and thus enabling the fuel contents of these chambers to undergo a primary compression against the diaphragm 3. This diaphragm is supported by a central rod 31, attached securely to the center of the diaphragm, and extending through a bearing 28 on piston head 33, which bearing 28 is provided with a packing gland 64 to make a tight joint so that the piston may reciprocate on the rod 31 without leakage. And the upper end of rod 31 is carried by a cross-head or frame 15 that is securely bolted to the upper end of cylinder 1. In this way the partition 3 maintains a stationary and rigid position with relation to the cylinder 1, and divides the hollow piston into two primary compression chambers. The chamber C, adjoining head 33, is provided with ports 23, that during the reciprocations of the piston, register at one time with the circular supply port 24 and at another time with the explosion chamber A; while the chamber D, adjoining head 34, is provided with a series of ports 26 that register at times with the circular supply port 25 and at other times with the explosion chamber B. The piston near head 34 is preferably strengthened by ribs 30 lying between ports 26.

When the piston is at the upper limit of its stroke, the ports 23 will be open to the supply port 24 and a fuel charge will be introduced through ports 23, which will fill the chamber C, said chamber being now of its maximum size and capacity, since the head 33 is removed to its farthest point from the middle fixed partition 3. When the piston reciprocates and goes to the other limit of its stroke, the mixture will be compressed in chamber C until the end of the stroke is reached, when the ports 23 will open into the explosion chamber A, as shown in Figure 1, and as the primary compression in chamber C is now complete, the initially-compressed fuel is transferred into the explosion chamber A for further compression and ignition.

Also it will be seen that when the piston is in the lower end of the cylinder, as shown in Figure 1, the chamber D, which is now of maximum size, will have its ports 26 opening into the circular supply port 25, so that said chamber may be filled with a fresh charge of gas through port 25, which will be compressed initially during the next upstroke of the piston, and when so compressed will be delivered by the ports 26 to the explosion chamber B as soon as said ports open into that chamber. The chambers A and B permit the charges of mixture therein to be compressed with a secondary or final compression and then ignited by suitable means, as by ordinary spark plugs, of which I indicate examples at 70.

The foregoing description of the construction and arrangement of the various parts is sufficiently ample to make it unnecessary to describe the operation in further detail. If we assume that the piston is at the lower limit of its stroke, after being driven there by a firing of the charge in chamber A, the parts will be in the position shown in Figure

1, where exhaust from chamber A is taking place through ports 7 and 6, while chamber A is being filled by a new charge on top of the outgoing exhaust through ports 23 from chamber C. At the same time a previously introduced charge in chamber B is receiving its final compression therein preparatory to its explosion which is about to occur; and also at this moment the lateral ports 26 in chamber D have been brought into communication with the inlet port 25 and a charge is being introduced into chamber D. A spark plug 70 will now explode the compressed charge in chamber B, which will drive the piston up to the other end of its stroke. On its way up the mixture in chamber D is compressed until the ports 26 are brought into communication with chamber B when the said mixture will be delivered into said chamber B, while simultaneously with such delivery the chamber B will open into exhaust ports 7 and 6 and the new mixture will flow in on top of the exhaust and help to force it out; and while this is being done the charge that was introduced into chamber A is undergoing compression, in readiness for the next explosion in chamber A. Thus cycle follows cycle, after the manner of a two-cycle engine, and with resulting effects of the character I have set forth.

I have now described the construction and operation of my improved internal combustion engine as it appears in Figure 1 when constructed after the oscillating type. I will now proceed to describe the same when built according to the reciprocating non-oscillating type and it will be seen that outside of the oscillatory feature the construction in both cases is very much the same, although I have illustrated a specimen of the non-oscillating type in Figure 3 in order to set forth its characteristics more clearly and also to briefly describe some additional features which, while not peculiar or distinctive necessarily to the non-oscillating type, I have thought it convenient to embody in a design illustrative of this type of engine. Referring therefore to Figure 3 it will be seen that the main features of the construction are substantially the same as in the other figures of the drawing.

Thus the cylinder 46 is a differential cylinder having a wider middle portion to contain the explosion chambers A^1 and B^1 while the upper and lower ends of said cylinder are smaller in diameter than the middle portion. The piston is of the differential kind and consists of a tube or sleeve whose interior diameter is the same throughout, but exteriorly it is formed near the center with a member 8 of larger diameter, at one side of which member is a section 2 and at the other side a section 5, just the same as in the construction in Figure 1. At the end of section 2 of the piston is an inserted head 39, alongside of which are the piston ports 65, and at the lower end of section 5 is a head 40, alongside of which are the piston ports 51. Beyond the head 39 the piston is provided with a sleeve-like extension 37, which slides within the smaller bore of the cylinder at the upper end thereof, while below the lower head 40 the piston has a sleeve-like downward-extending extension 38 which works through the lower smaller bored end of the cylinder. The explosion chambers A^1 and B^1 surround the piston. The piston contains initial compression chambers C^1 and D^1, into which the fuel charges are first introduced and compressed before they are delivered through the ports 65 and 51 into the explosion chambers. Furthermore there is a stationary partition or diaphragm 3 within the piston but independent thereof, which serves to separate the initial compression chambers C^1 and D^1 from each other and against which compression is made during the movement of the piston as it plays over said diaphragm. This diaphragm is carried by a vertical rod 31, which is supported in a cross-piece or frame 35 attached to the upper end of the cylinder 46, and the head 39 of the piston is provided with a suitably packed opening 56 in which the rod 31 slides tightly during the movements of the piston over said rod. It will thus be seen that this arrangement of the cylinder and piston in the initial and final compression chambers is virtually the same as in the other example of my invention which I have already described.

45 denotes a crank casing which is filled with lubricating material and is bolted to the cylinder 46, the main shaft 44 being in said crank casing and having a crank pin 43 to which is connected a connecting rod 42 which is loosely pivoted to the piston by means of a pin 41. The inlet for the gas or explosive mixture to the cylinder is shown at 47 and from this point the mixture passes in one direction through the passage 49 to the circular port 50 which at times registers with the piston ports 65 for the introduction of the charge into the chamber C^1, and the explosive mixture flows in the other direction through inlet 47, through passage 48, to the circular port 66 which registers at times with the piston ports 51 to allow the charge to be introduced into the other initial compression chamber D^1. The cylinder itself instead of having radiating fins or flanges, is in this particular example preferably provided with a water jacket 57. The exhaust passes out at 54 through the circular port 53 into which the lateral ports 52 from the chambers A^1 and B^1 empty the spent products during the operation of the engine. It will be seen that suitable spark plugs, as 55, are provided in the explosion chambers to ignite the charges. It will be unnecessary to explain in detail

the operation of this form of the engine as it is exactly the same as in the other specimen illustrated in the other figures of the drawing.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In an internal combustion engine, the combination of a cylinder having separate explosion chambers adjacent thereto, a differential piston with an enlarged portion operating in the explosion chambers which surround said piston, and containing compression chambers, a partition between them, said partition being stationary with relation to the piston which slides over the same, and means for transferring the mixture through the piston from the compression chambers to the explosion chambers.

2. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing primary compression chambers, and having an enlarged portion operating in the explosion chambers which surround said piston, stationary means within the piston separating the compression chambers, means for transferring the mixture through the piston from the compression to the explosion chambers, a piston rod attached rigidly to the piston and reciprocating and swinging therewith, and a crankshaft to which the piston rod is directly connected.

3. In an internal combustion engine, the combination of a cylinder having explosion chambers, and said explosion chambers having a common exhaust, a differential piston containing primary compression chambers and having an enlarged portion operating in the explosion chambers which surround said piston, said piston being provided with a port for transferring the mixture from the compression to the explosion chambers, a stationary partition within the piston between the compression chambers and on which the piston slides, a piston rod rigidly attached to the piston, a crankshaft to which said piston rod is directly connected, and a pendulous support for the cylinder.

4. In an internal combustion engine, the combination of a cylinder, explosion chambers in said cylinder, fuel supply mechanism arranged in connection with the cylinder for admitting fuel at the proper time, a differential piston performing its functions in connection with interior compression and exterior explosion chambers, which latter chambers surround the piston, and means for transferring the mixture through the piston from the compression to the explosion chambers, and a stationary diaphragm located within the piston independently thereof and held stationary while the piston slides thereover.

5. In an internal combustion engine, the combination of a cylinder having separate explosion chambers, a differential piston containing initial compression chambers and with an enlarged portion operating in the explosion chambers which surround the piston, means for transferring the charge through the piston from the compression chambers to the explosion chambers, and a partition between the compression chambers in the piston and on which the piston slides, said partition being stationary with reference to the movements of the piston in sliding over the same.

6. In an internal combustion engine, the combination of a cylinder having chambers for secondary compression and ignition, a differential piston containing primary compression chambers and having an enlarged section operating in the ignition chambers, said latter chambers surrounding the piston and being provided with an exhaust and means for admitting the charge during suction and automatically checking its outflow during compression, and means for transferring the charge through the piston so that it may pass from the primary compression chambers to the ignition and secondary compression chambers, together with a stationary diaphragm supported in the piston but independent thereof.

7. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing compression chambers and having an enlarged portion operating in the explosion chambers which surround said piston, means for transferring the fuel mixture through the piston from the compression chambers to the explosion chambers, a piston rod rigidly attached to the piston, a crankshaft to which said piston rod is directly connected, a lubricant casing enclosing said crankshaft and having an opening through which the piston rod plays, and an automatically adjustable cover for said opening carried by the cylinder, and a partition within the piston and stationery with relation to the movements of the latter.

8. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston operating in the explosion chambers and containing compression chambers and having an enlarged portion operating in the explosion chambers which surround said piston, means for transferring the fuel mixture through the piston from the compression to the explosion chambers, a piston rod rigidly connected to the piston, a lubricant casing having an opening through which the piston rod plays, a curved sliding plate which covers said opening and vibrates during the movement of the engine, said plate having a sleeve engaging the cylinder and resilient means interposed between the plate and the

cylinder for keeping the said plate tightly upon the opening in the casing.

9. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing compression chambers and having its middle enlarged portion operating in the explosion chambers, said piston being provided with ports leading through the same to transfer the mixture from the compression chambers to the explosion chambers, and a partition in the piston with means for holding it stationary with relation to the movements of the piston while the piston reciprocates.

10. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing compression chambers and operating in connection with said explosion chambers and ported to permit the mixture to pass from one compression chamber to one explosion chamber, and to separately pass from the other compression chamber to the other explosion chamber, together with a common exhaust system, and a partition in the piston between the compression chambers, and means for holding it stationary with relation to the movements of the piston while the piston reciprocates.

11. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing compression chambers and operating in connection with said explosion chambers and having ports or recesses to permit the passage of the mixture from the compression chambers to the explosion chambers, means for delivering the mixture to said cylinder, and a stationery diaphragm in the piston, with means on the cylinder for supporting it.

12. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing compression chambers and with its middle enlarged portion operating in the explosion chambers, and means for transferring the charge through the piston to the explosion chambers, together with a partition in the piston on which it slides, said partition being stationary with relation to the movements of the piston.

13. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston having compression chambers and with its middle enlarged portion operating in the explosion chambers, which latter chambers surround the piston, said piston being provided with two sets of ports for transferring the fuel mixture alternately from the compression chambers to the explosion chambers, together with a partition in the piston on which it slides, said partition being stationary with relation to the movements of the piston.

14. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing compression chambers and having separate ports for enabling the fuel mixture to pass between the compression chambers and the explosion chambers, inlet means for admitting the fuel mixture into the piston compression chambers, a piston rod rigidly attached to the piston, and a crankshaft to which said piston rod is directly connected together with a stationary diaphragm within the piston between the compression chambers thereof.

15. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing compression chambers and having its ends of smaller section and its middle enlarged section operating in the explosion chambers, said piston having ports to permit the charge to be transferred from the compression chambers to the explosion chambers, a diaphragm in the piston between its chambers, a rod attached to said diaphragm, and a cross-head on the cylinder for carrying the rod.

16. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston having inner chambers for compression and its middle and enlarged portion operating in the explosion chambers, said piston being of elongated hollow form and comprising heads and hollow extensions at the ends, and having ports through which the charge is transferred from the compression chambers to the explosion chambers, inlet means at both ends of the cylinder for introducing the charge into the interior of the piston, a diaphragm in the piston between its chambers, a rod attached to said diaphragm, and a cross-head on the cylinder for carrying the rod.

17. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing compression chambers and having its ends operating in the ends of the cylinder and its middle enlarged portion operating in the explosion chambers, said piston being of elongated hollow form and comprising heads and connections between them, together with ports through which the charge is transferred from the compression chambers to the explosion chambers, a common exhaust for the explosion chambers, inlet means for introducing the charge, said inlet means having circular ports in the cylinder at each end, a diaphragm in the piston between its chambers, a rod attached to said diaphragm, and a cross-head on the cylinder for carrying the rod.

18. In an internal combustion engine, the combination of a cylinder having dual explosion chambers, a differential piston having its ends of smaller section operating in the ends of the cylinder and having inner compression chambers, and with its middle portion of larger section operating in the explosion chambers, means for transferring the charge through the piston from the compression chambers to the explosion chambers, inlet means for introducing at each end of the stroke of the piston in one direction a charge of the mixture, said means having automatically operating means for preventing outflow during compression.

In testimony whereof I hereunto affix my signature.

JOHN V. RICE, JR.