Nov. 29, 1927. 1,651,147

J. J. MORRIS ET AL

INTERNAL COMBUSTION ENGINE

Original Filed Nov. 9, 1923 4 Sheets-Sheet 1

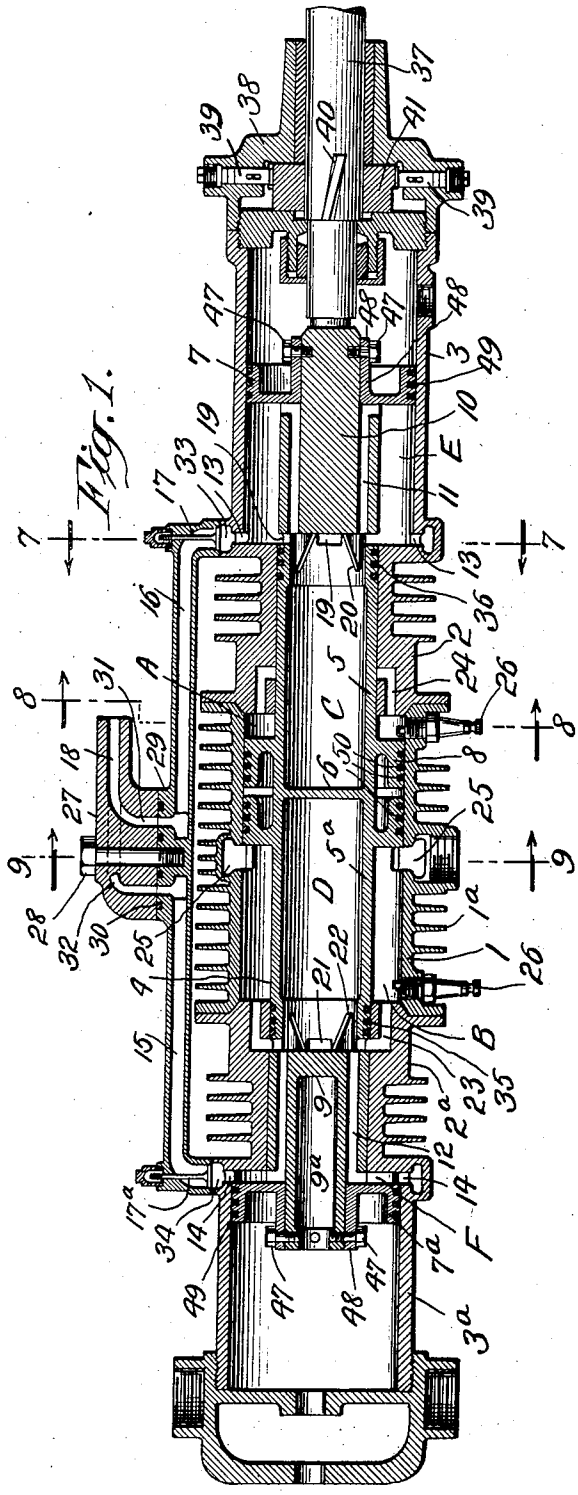


Fig. 1.

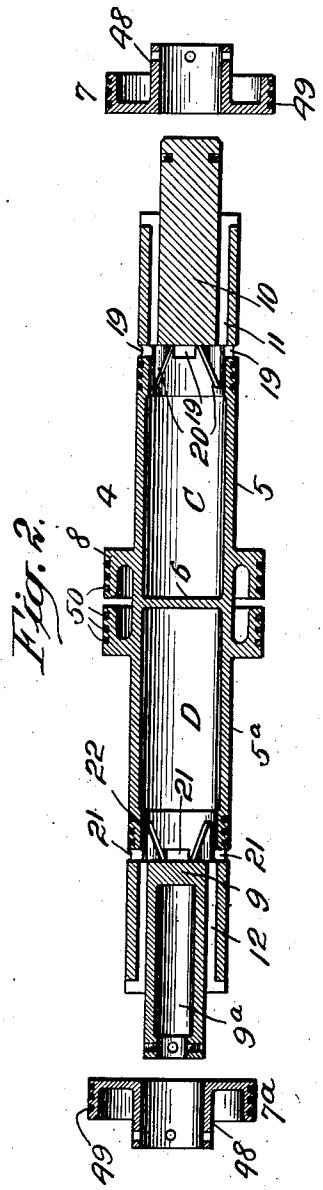


Fig. 2.

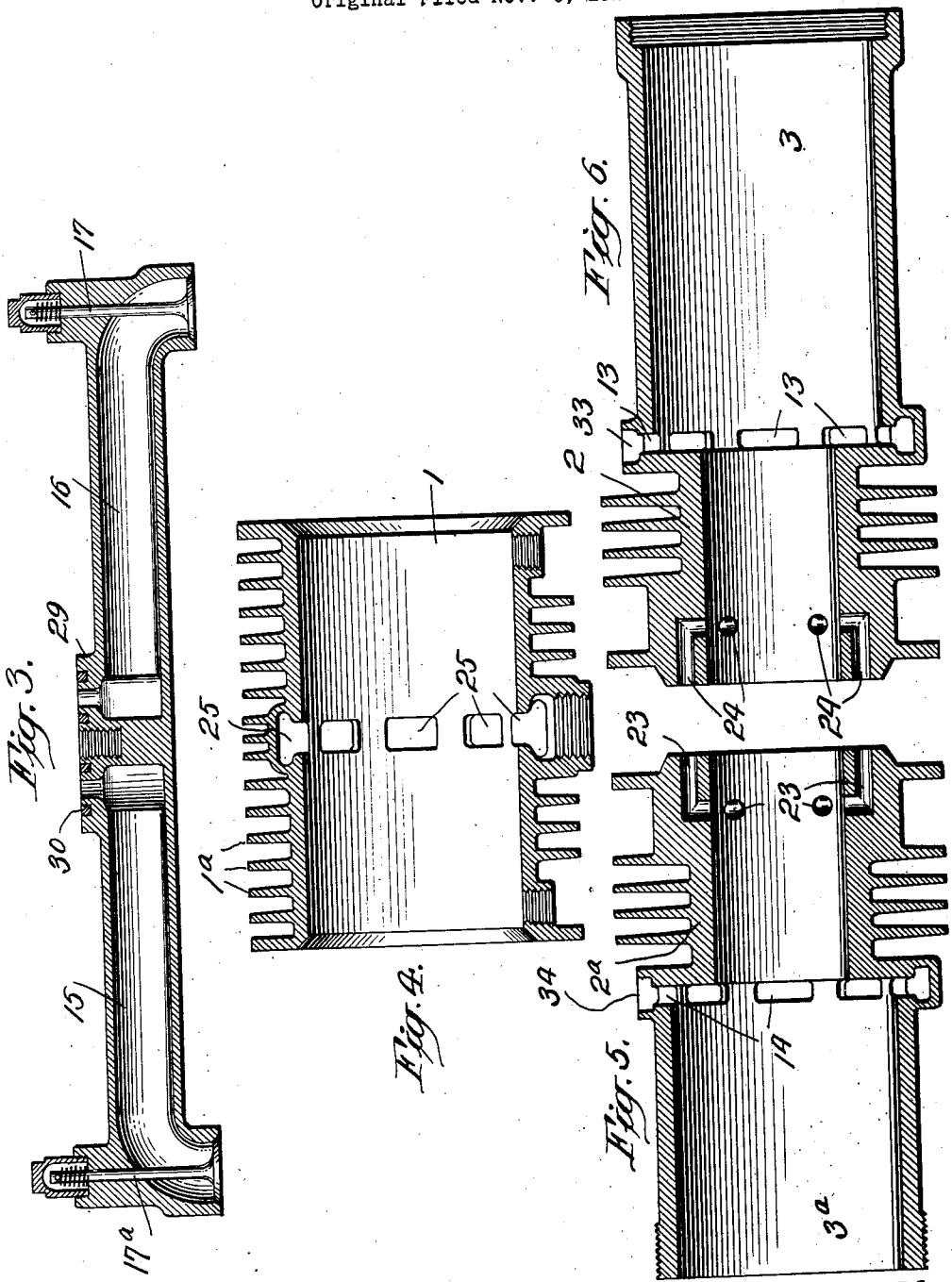
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INTERNAL COMBUSTION ENGINE

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INTERNAL COMBUSTION ENGINE

Original Filed Nov. 9, 1923 4 Sheets-Sheet 3

Fig. 7.

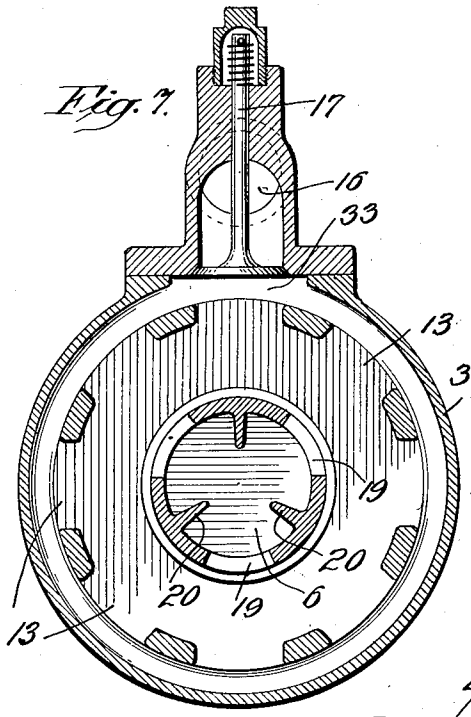
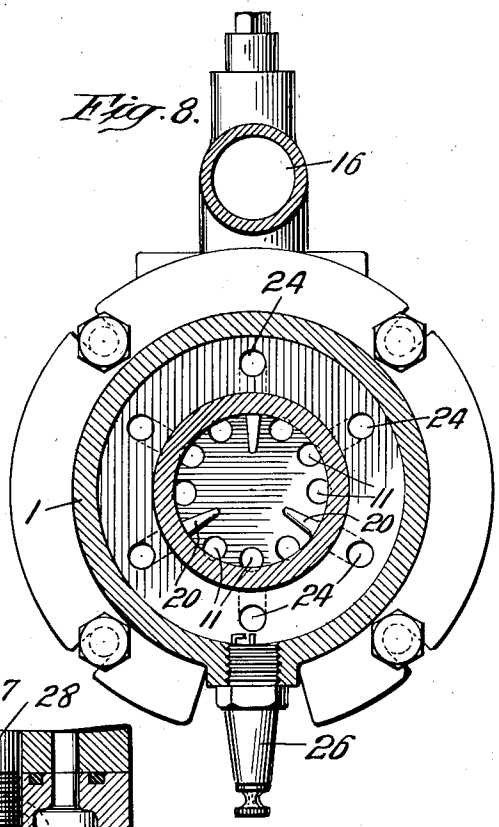


Fig. 8.



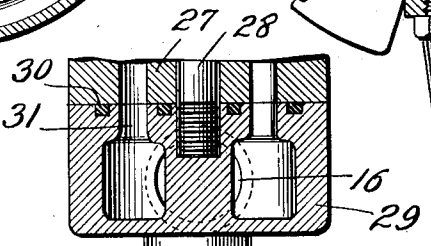
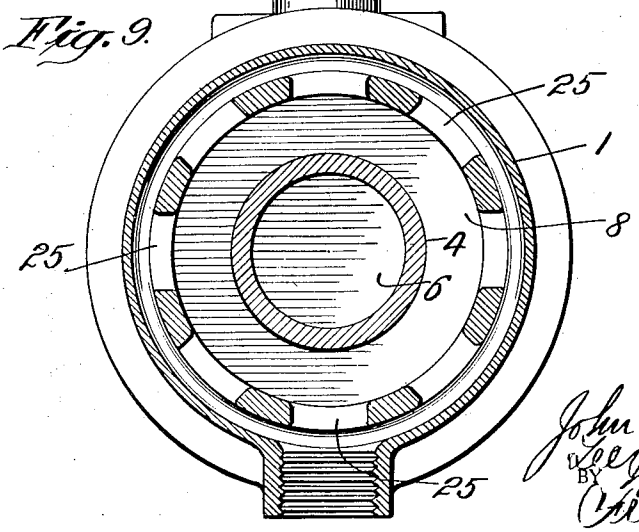


Fig. 9.



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INTERNAL COMBUSTION ENGINE

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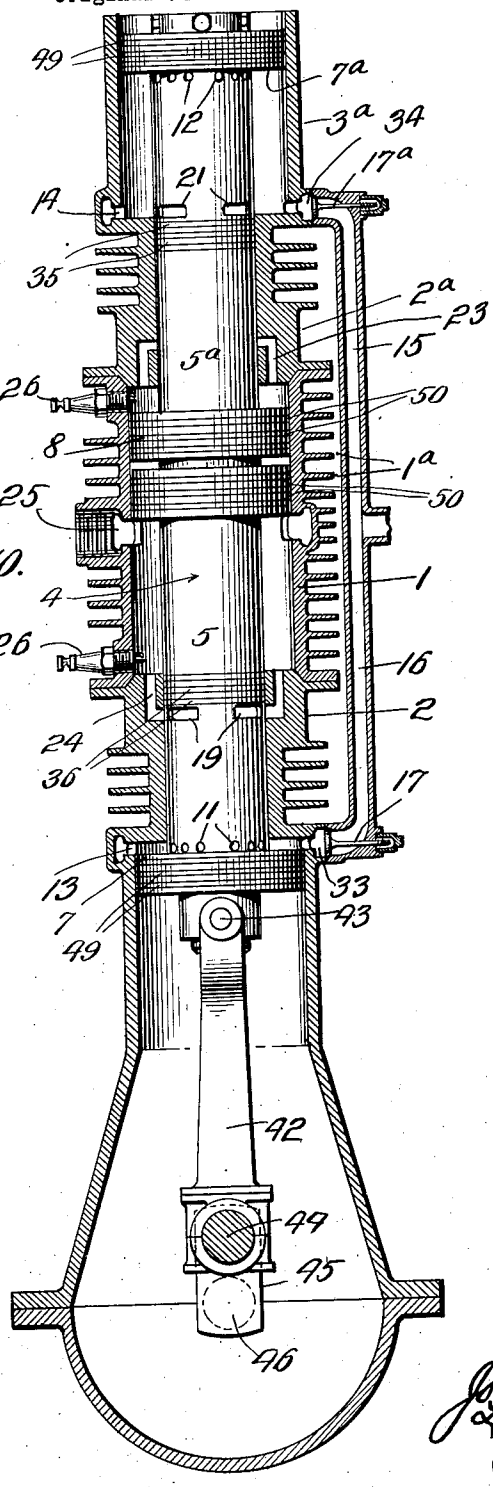


Fig. 10.

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UNITED STATES PATENT OFFICE.

JOHN J. MORRIS, OF AUDUBON, NEW JERSEY, AND LEE N. GULICK, OF GERMANTOWN, PENNSYLVANIA, ASSIGNORS, BY MESNE ASSIGNMENTS, TO RICHARD C. SCHWOERER, OF PHILADELPHIA, PENNSYLVANIA.

INTERNAL-COMBUSTION ENGINE.

Application filed November 9, 1923, Serial No. 673,792. Renewed May 3, 1927.

Our invention relates to the general class of internal combustion engines and the special sub-class of the same known as two-cycle, whether double-acting or single-acting, the object being to provide a simple, convenient and effective construction which will be elastic in its adaptability for every engine purpose, and will be characterized by having only a few parts and being economical and easy in operation and with very little chance of breakage or disrepair, but capable of developing a very large amount of power.

The engine mechanism embraced in this invention may have a very wide variety of uses, prominent among which we note its use as the motor mechanism of a gas-actuated rock drill, and another its use as a reciprocating engine to furnish the operative power for an automobile, an aeroplane, or various other kinds of mechanism; and we shall explain the use and offer certain structural features peculiarly applicable to drilling, as well as another construction which enables the engine to actuate a driveshaft; these, however, being given obviously merely as special explanatory specimens of the use of the invention, and without any idea of restricting its operative value thereto.

Underlying the construction and combination of the various parts we have dealt with various problems, among them being that of the minimum fuel volume which will satisfy the requirements of the engine, the area of the ignition chamber as compared with that of the fuel supply chamber, the type and location of the piston rings so as to insure against leakage at any point, the location, number and kind of the spark plugs or other ignition appliances, the length of the piston stroke and other features.

A signal feature of the invention lies in the fuel section of the piston which is more or less elongated or extended and is differential in character to correspond with the differential design of the cylinder, this differential character of the piston embracing a middle and end sections of larger diameter, between which are intermediate sections of smaller diameter, and the cylinder having a corresponding middle portion of larger diameter as well as end sections of larger diameter, between which end and middle sections are sections of smaller diameter. The piston is a hollow sleeve or cylinder having a central transverse partition which divides it into two non-communicating chambers, said chambers serving as fuel chambers to receive the fuel supply and deliver the same into the firing chambers. The ends of the piston are provided with heads, having members of larger diameter which reciprocate within the end fuel chambers of the cylinder, which latter are of larger diameter than the cylinder sections between these chambers and the middle firing chambers in the cylinder that surround the piston, said end chambers of the cylinder functioning as fuel supply chambers and being permanently connected by smaller divisions with the chambers within the piston.

Thus at each end of the engine there is a preliminary compression chamber for the fuel, as it may be termed, each consisting of a chamber within the piston on one side of its central partition and a chamber in the end portion of the cylinder, said sections or chambers being connected together by a smaller section or division having passages therein. These preliminary compression chambers at the ends of the engine alternately receive charges during the strokes of the piston. Thus each fuel chamber receives a fuel charge when the piston moves towards the end of the machine, or away from the firing chamber located adjacent to said fuel chamber. Upon each return stroke of the piston, or as each fuel chamber in the piston moves towards its corresponding firing chamber, the manifold inlet valve closes and the entire charge which fills each section or division of the fuel chamber is compressed into the smaller part of the fuel chamber in the piston. Hence there is a compression preliminarily taking place in each compression chamber during the return stroke thereof; and after each initial compression in each preliminary compression chamber the partly compressed charge is delivered into the final compression and explosion chambers which surround the piston in the central portion of the cylinder, and which explosion chambers communicate alternately with the common exhaust system located between said explosion chambers, it being noted that we use certain lengthened and angular ports for the pur-

pose of establishing communication between the interior of the piston fuel chambers and the firing chambers in order to provide for the proper location of the piston rings, it being further noted that the proper location of such rings as the points just referred to as well as on the central and the end enlarged portions of the piston is a matter of unusual importance, to avoid leakage and on which we lay much stress in the explanation of our construction. Thus we introduce the charge through ports running entirely around the cylinder and during the full length of the stroke and compress the same during such stroke between the end portions of the heads of the piston and the opposite surfaces of the smaller sections of the cylinder, and also through ports running entirely around the piston, so that we 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 the compression chambers for the initial compression, each consisting of various sections, enable the charge to be compressed in one end of the piston for one explosion and in the other end of the piston for the next explosion, these partially compressed charges being transferred from the fuel chambers in the piston into the firing chambers where they are again and finally compressed before being exploded. Obviously during the reciprocations of the piston and its heads the cylinder fuel chambers which directly receive the fuel and transfer it through ports into the chambers within the piston, change in size from maximum to minimum, and as they are constantly receiving the charge during the return stroke, said charge is partly compressed and forced into the piston chambers. The fuel is received when the piston moves towards the cylinder ends, and when the piston is moving toward the center, or firing section, compression is uniform throughout the entire length of the fuel chamber which, of course, includes both large and small sections.

In addition to these important structural characteristics of the piston, the cylinder and contiguous parts, the invention may be said to consist essentially in the construction, arrangement and combination of 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 drawing illustrating our invention:

Figure 1 is a vertical longitudinal section of our improved internal combustion engine and shows the piston at the right hand limit of its stroke, the details of the engine being so constructed and coupled up with the appurtenant parts as to enable the engine to serve as a motor device for a drill mechanism.

Figure 2 is a detail longitudinal section of the piston with parts of its heads detached therefrom.

Figure 3 is a detail longitudinal section of the feed pipes for the opposite ends of the engine, the same being provided with inlet valves.

Figure 4 is an enlarged longitudinal section of the middle part of the cylinder which is of larger diameter and provides the explosion chambers.

Figure 5 is an enlarged longitudinal section of one end, and Figure 6 an enlarged longitudinal section of the other end of the cylinder, showing the parts that are of larger diameter and also the intermediate sections between the latter parts and the part shown in Figure 4, which intermediate parts are of smaller diameter, these figures 4, 5 and 6 indicating clearly the differential character of the cylinder with its variable diameters at the ends and in the middle.

Figure 7 is an enlarged transverse section on the line 7, 7, of Figure 1.

Figure 8 is an enlarged transverse section on the line 8, 8, of Figure 1.

Figure 9 is an enlarged transverse section on the line 9, 9, of Figure 1.

Figure 10 is a longitudinal section of our improved internal combustion engine with the piston thereof shown in side elevation and coupled up to the connecting rod so that the engine itself may serve as a reciprocating engine for any purpose to which it may be put.

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

We will now proceed to describe the construction and operation of the cylinder 1 and its appurtenant parts, it being understood that any engine of our design may be single or multi-cylinder in construction and that where there are several cylinders they may be duplicates of the one we are now describing, but in the drawing we 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 develops great power. The cylinder 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 we preferably build it with a multiplicity of radiating fins or flanges, as 1^a, 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 developed in

the operation. The cylinder may be made in several castings as shown, for example a middle casting 1, being of larger diameter than the piston so as to provide the firing chambers that surround the piston; an adjoining section 2 of smaller diameter; another similar section 2^a; and the end sections 3 and 3^a of larger diameter and may be of any size demanded by the fuel charge, so as to provide auxiliary cylinder fuel chambers that co-operate with the fuel chambers within the piston. But it will be noted that although this differential design of the cylinder is important, yet the proportions and relative characteristics may be changed and varied within wide limits without departing from the invention, if only the differential features are made to properly correspond with the shape of the piston.

The middle and larger portion 1 of the cylinder furnishes the two explosion chambers A and B, between and in which the widest exterior part 8 of the piston operates; the end sections 3, 3^a, of the cylinder are likewise of larger diameter, and furnish the fuel chambers E and F which first receive the fuel supply and deliver the same through smaller divisions into the interior of the piston; while between the end sections 3 and 3^a of the cylinder and the middle section 1 are the intermediate sections 2 and 2^a which are of smaller diameter so as to accommodate closely therein the portions of the piston which are of smaller diameter and which reciprocate closely in said intermediate sections 2 and 2^a.

The piston is of the differential type, consisting of a hollow sleeve or cylnder of virtually the same diameter throughout, but with the exterior middle portion 8 of larger diameter than the sections 5 and 5^a that extend between said middle portion 8 and the members 7 and 7^a on the heads 9 and 10, which members fit closely and respectively within the cylinder sections 3 and 3^a and the inner chambers E and F in said sections. Section 5 of the piston on the right hand side of the central partition 6 contains the interior primary compression chamber C for the fuel, and section 5^a of the piston on the left hand side of the central partition 6 contains the interior primary compression chamber D for the fuel. Further, the end of the section 5 is provided with a head 10, or terminal part, so shaped in this example of the invention that it may serve as a hammer when the engine is used in connection with a drill, which head part 10 carries the circular piston member 7 thereon, the same having a central sleeve 48 which slips over the end of the member 10 and is held thereon by set screws 47, or other equivalent means as may be desired, while the end of the section 5^a is provided with a similar head or terminal member 9, preferably hollowed out at 9^a for the sake of permitting the starting rod to enter it, which carries the other circular piston member 7^a, having a central sleeve which slips over the head of the member 9 and is held thereon by means of set screws or other devices. The wall of chamber C adjoining or in the head 10 is provided with ports 19 that during the reciprocations of the piston open into the chamber E to receive a supply and at another time into the chamber A through elongated and angular ports 24 to deliver the charge into the explosion chamber; while the chamber D is provided similarly with a series of ports 21 which register at times with the cylinder fuel chamber F to let in the fuel supply and at another time communicate with the firing chamber B through the elongated transfer ports 23. The piston near the ports 19 is strengthened by means of ribs 20 lying between said ports, and also near the ports 21 is strengthened by means of ribs 22 lying between said ports. Furthermore it will be noted that the heads 9 and 10 are formed with smaller divisions provided with longitudinal or axial passages 11 and 12 running lengthwise from the chambers C and D into the chambers E and F which they enter at points closely contiguous to the members 7 so that the chambers E and F respectively are in communication with the chambers C and D, these connecting passages 11 and 12 being always open to establish such communication and the ports 19 and 21 being open for a certain length of time during each stroke, as inlets and at other times as outlets. Thus the chambers E and F supply fuel to the piston chambers C and D through these passages 11 and 12, the supply at the end of the stroke being through ports 19 or 21 as well as passages 11 and 12, but being continued during the whole length of the return strokes through the elongated axial passages 11 and 12.

A supply of the explosive mixture is delivered to the cylinder and pistons from suitable means which will allow a steady inflow at each end during the reciprocating suction strokes and will automatically check the outflow on the compression strokes. This supply means may be widely diversified in its construction and application. When the device functions as a drill we find it convenient to arrange piping in connection with the cylinder 1, as follows: A casting 27 is attached by means of a bolt 28 to another casting 29, there being suitable packing rings 30 interposed between the castings 27 and 29 to enable the casting 27 to swivel or rotate upon said bolt 28 during the adjustments of the drill mechanism. The casting 27 contains a supply passage 18 which divides into the two passages 31 and 32 which communicate respectively with the pipes 15 and 16 which lead from the casting 29 and run alongside

of the cylinder, said pipe 16 leading to the right hand end of the cylinder and delivering into the circular port 33 in the cylinder wall and said passage 15 running to the left hand end of the cylinder and delivering into the circular port 34. The circular port 33 delivers into the preliminary compression chamber E through the ports 13 in the wall of the cylinder, as already described, and the circular port 34 delivers into the other preliminary compression chamber F through the ports 14 in the wall of the cylinder, as already described. Pipe 15 is provided with a check valve 17ª and pipe 16 is provided with a similar check valve 17. These valves open on the suction movement of the piston but instantly close when the reverse movement takes place, so that while a supply of fuel mixture is readily drawn into the cylinder through the piping as described, it cannot flow back because on the compression movement of the piston each time the check valve or its equivalent will close and prevent any outflow.

When each end of the piston in turn reaches on its stroke the point where the ports 19, in the one case, or the ports 21, in the other case, are to deliver into the explosion or ignition chambers A or B, as the case may be, the delivery is made through the ports 23 and 24 which have an angular or a right-angled shape, and are cut through the parts 2 and 2ª of the cylinder which are of the smallest diameter, the object of having elongated ports of this character instead of a direct admission from the interior of the piston to the interior of the ignition chambers being to allow the packing rings 35 and 36 which surround the sections 5 and 5ª of the piston, near the heads of said piston and closely adjacent to the ports 19 and 21, to be properly supported and covered and held between the surface of the piston and the adjacent surfaces of the cylinder, in order that there may be a tight and efficient joint and no possibility of any leakage, as these piston rings do not enter the explosion chambers, but always remain between the walls of the piston and the cylinder.

The form of the engine which is adapted for use with drilling appliances, as shown in Figure 1, and the form adapted for use with an engine construction having a crankshaft, as shown in Figure 10, is virtually the same and it is unnecessary to further describe the mechanism as it is illustrated in Figure 10 than to say, that the drilling devices which are shown at the right hand end of Figure 1 and which consist essentially of a drilling rod 37, to which a chuck and drilling instrument are applied, a cap 38 for the main cylinder section 3, and suitable interior means consisting of spring pins 39, ribs 40, and a revolvable ring 41 so that the drilling tool may be revolved, said rod 37 being adapted to be struck by the solid anvil head 10 of the piston as it is constructed in this figure, are omitted and dispensed with, and in lieu thereof in Figure 10 a connecting rod 42 is pivoted at 43 to the piston, and said rod has a crank pin 44 passing through it, which is attached to the crank 45 belonging to the main shaft 46, these features being preferably carried in an oil-tight crankcase, all as shown in Figure 10. It will be obvious, therefore, that the invention is substantially the same in these two forms, and that it may be embodied in many other equivalently-operating forms so that it may be put to any purpose to which it is found adaptable, and the especial features belonging to the drilling implement, etc., which may be superadded to the engine mechanism, are claimed in this application besides the general engine structure.

The operation will be quite evident from the foregoing description of the construction and arrangement of the various parts, the same being sufficiently ample to make the invention easily understood, and it is unnecessary to describe the operation in further detail. It may not be amiss to make a brief reference, however, to certain features of the operation.

Suppose that the cylinder and piston occupy the relative positions shown in Figure 1, where the final compression in the explosion chamber A is completed and an explosion is about to occur in chamber A which will drive the piston toward the left. At this moment the piston ports 19 are open to the auxiliary fuel chamber E, and as the piston starts to move toward the left under the influence of the explosion of the compressed mixture in chamber A, supply valve 17 will close and fuel will pass through the piston ports 19 into the piston-fuel-chamber C. The supply through the ports 19, however, will be instantly cut off and thereafter during the movement of the piston toward the left until it reaches the end of its compression stroke fuel will be fed from the chamber E through the elongated passages 11 into the piston chamber C, said elongated passages running from a point adjacent to the piston member 7 to a point closely contiguous to the inlet ports 19. Thus at the beginning of the compression stroke the supply of fuel has an opportunity of passing through the ports 19 and also the passages 11, a duplicate entry, but right away after the beginning of the compression stroke the supply will be only through the long passages 11. When the compression stroke begins the chamber E is of maximum size but this size or volume decreases as the stroke proceeds and the preliminary compression of the mixture takes place between the head 7 and the opposite face of the smaller section 2 of the cyl-

inder. Or, in other words, the capacity of the preliminary compression chamber consisting of the cylinder chamber E and the piston chamber C is decreasing during the movement of the piston and there is a certain amount of compression of the mixture taking place therein. When the piston reaches the limit of its stroke toward the left in this particular example, the ports 19 come into coincidence with the mouths of the firing ports 24, and the compressed mixture in this preliminary compression chamber is delivered through said ports into the explosion chamber A and on top of the outgoing exhaust, which by this time, owing to the movement of the piston, has uncovered the outlet port 25 to allow the products of the explosion to pass out of the cylinder, the fresh charge of the mixture going into the explosion chamber A and filling the same preparatory to being compressed therein when the piston starts again on its movement toward the right.

The same explanation of the operation of the various parts applies to the left hand portion of the cylinder and piston with the chambers D and F and the various ports as they are shown in Figure 1, and it is unnecessary to go through this entire explanation in detail. When the piston starts again toward the right, obviously the check valve 17 will be opened by its spring so as to admit fuel, and port 24 will be cut off so that the effect of the enlarged middle section 8 of the piston will be to compress the gas in chamber A until the moment arrives when the exploded gases in chamber B are enabled to escape through the exhaust 25, and the preliminarily compressed charge which has been received into the chambers F and D will be delivered into the explosion chamber B on top of the outgoing exhaust to furnish a supply in the chamber B which can be compressed on the next movement of the piston toward the left.

Viewing the cylinder and the piston in a more general way, the essentials of the structure will be seen to consist of a cylinder construction having central explosion chambers, end fuel supply chambers, and intermediate sections of smaller diameter, and a piston of the differential type having inner chambers divided by a partition which communicate through one or more sets of ports or passages with the cylinder fuel chambers. The chambers E and C constitute as it were a compound preliminary compression chamber, and the chambers F and D a similar compound preliminary compression chamber, the members of each preliminary compression chamber being permanently in communication with each other through passages of greater or less length which run through the heads of the piston. These heads are susceptible of a wide diversity in construction, being shorter or longer and narrower or wider, and designed to allow a greater or less number of supply ports to pass through them, and the heads carry on their outer ends circular sections which operate as pistons in the cylinder fuel chambers. Thus each preliminary compression chamber consists of two members, one of which is a space in the interior of the piston and the other of which is a space in the cylinder, and is therefore of a compound type, the cylinder fuel space being superimposed upon the piston fuel space.

The reason of this particular construction and the utilization of end chambers in the cylinder to receive the fuel before it is delivered into the interior of the piston is that a fuel supply chamber must contain sufficient volume to completely fill the firing chamber at atmospheric pressure, and it has not hitherto been found convenient to make a fuel chamber in the piston of sufficient size to provide this volume of gas. Such volume of gas must also be under pressure to insure its filling the explosion chamber when the ports open into each other for the purpose.

For the satisfactory working of an internal combustion engine it is found that the firing chamber should be in the neighborhood of from 24% to 30% of the cylinder volume. This is generally essential where the flame propagation has universal direction for its action. In the present construction flame propagation is unidirectional about the periphery of the firing piston and in order to insure that this will be effective and well taken care of, as well as having the proper area, it is found desirable to provide for dual or multiple ignition whereby the spark plugs are located diametrically opposite each other.

The circular end portions 7 and 7^a of the piston which serve to compress the gas in the preliminary fuel chambers are provided with suitable encircling packing rings 49 to make a tight joint between their peripheries and the wall of the cylinder; also the enlarged central part 8 of the piston is provided with suitable packing rings 50 in order to prevent any leakage. I have already mentioned the packing rings 35 which surround the piston section 5^a near the ports 21 and the packing rings 36 which surround the piston section 5 near the ports 19 and which packing rings prevent any leakage at the time of firing and at other times and which cover at certain times portions of the cylinder contiguous to the elongated angular ports 23 and 24, as already hereinabove explained; so that it will be seen that the way in which I apply the packing rings to the piston is of great importance in the operation of the engine for the purpose of preventing any possibility of leakage and thus enabling the operation of the machine to

proceed in such a manner that the full effect of the explosions is availed of in the generation of power.

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

1. In an internal combustion engine, the combination of a differential cylinder having central explosion chambers, and having also fuel chambers in each end of said cylinder, a dual-chambered differential piston having heads provided with circular compression members of greater diameter than the heads and operating in the cylinder-fuel-chambers and a middle enlarged portion operating in the explosion chambers, means for preliminarily and directly admitting fuel into both of the cylinder-fuel-chambers alternately, means in the piston structure for transferring the fuel from the cylinder-fuel-chambers to the piston-fuel-chambers, consisting of two sets of passages in each piston head, one of which sets opens intermittently at the beginning of each compression stroke, while the other set remains open permanently, and means for transferring the partly compressed charges through the piston chambers to the explosion chambers.

2. In an internal combustion engine, the combination of a differential cylinder having central explosion chambers and having also fuel chambers in each end of said cylinder, a dual-chambered differential piston having heads provided with circular compression members operating in the cylinder-fuel-chambers and a middle enlarged portion operating in the explosion chambers, said circular compression members being of the same diameter as the middle enlarged portion, means for preliminarily and directly admitting fuel into both of the cylinder-fuel-chambers alternately, means in the piston structure for transferring the fuel from the cylinder-fuel-chambers to the piston-fuel-chambers and also therefrom to the explosion chambers, consisting of two sets of passages in each piston head, one of which sets has the function of inlet ports to the interior of the piston at the beginning of the stroke and of outlet ports to the explosion chambers at the end of the stroke and opening intermittently to act as such ports, while the other set of passages remains permanently open as inlet ports for the interior of the piston from the cylinder-fuel-chambers.

3. In an internal combustion engine, the combination of a differential cylinder having central explosion chambers and end fuel chambers, a dual-chambered differential piston having heads provided with compression members, and operating in the cylinder-fuel-chambers, and a middle enlarged portion operating in the explosion chambers, means in the piston structure for transferring the fuel from the cylinder chambers to the piston chambers and then to the explosion chambers, consisting essentially of two sets of ports for each piston head, one set opening intermittently and acting alternately as inlet and transfer ports, and the other set being open permanently between the piston-fuel-chambers and the cylinder-fuel-chambers, together with means for admitting fuel to both cylinder-fuel-chambers, and valve devices to prevent outflow during compression.

4. In an internal combustion engine, the combination of a differential cylinder having explosion chambers and fuel chambers, a dual-chambered differential piston having heads operating in the cylinder-fuel-chambers and a middle enlarged portion operating in the explosion chambers, means in the piston structure for transferring the fuel from the cylinder chambers to the piston chambers and then to the explosion chambers, consisting essentially of two sets of ports for each piston head, one set opening intermittently and acting alternately as inlet and transfer ports, and the other set being open permanently between the piston chambers and the cylinder chambers, together with inlet means for introducing the fuel preliminarily into the cylinder-fuel-chambers and operating automatically to prevent outflow during compression.

5. In an internal combustion engine, the combination of a differential cylinder having explosion chambers and fuel chambers, a dual-chambered differential piston having heads operating in the cylinder-fuel-chambers and a middle enlarged portion operating in the explosion chambers, means in the piston structure for transferring the fuel from the cylinder chambers to the piston chambers and then to the explosion chambers, consisting essentially of two sets of ports for each piston head, one set opening intermittently and acting alternately as inlet and transfer ports, and the other set being open permanently between the piston chambers and the cylinder chambers, together with inlet means for introducing the fuel preliminarily into the cylinder-fuel-chambers and operating automatically to prevent outflow during compression, said means consisting of fuel supply pipes connecting with the cylinder-fuel-chambers and check valve devices arranged in said pipes.

6. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing inner fuel chambers and with its middle enlarged portion operating in the explosion chambers, a rigid imperforate partition in the piston dividing the fuel chambers from each other, means for transferring the charges from the piston chambers to the explosion chambers, fuel supply cham-

bers in the ends of the cylinder, means for admitting fuel preliminarily and directly into said cylinder-fuel-chambers alternately and preventing outflow during compression, means for transferring the charges from these cylinder-fuel-chambers to the piston-fuel-chambers, consisting of elongated ports that extend through the end portions of the piston structure from the inner chambers of the piston to a point close to the ends of the piston heads which operate in the cylinder chambers, together with compression members on the ends of the piston heads operating in the cylinder-fuel-chambers to compress the charges received therein.

7. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing inner fuel chambers and with its middle enlarged portion operating in the explosion chambers, a partition in the piston, means for transferring the charges from the piston chambers to the explosion chambers, consisting of lateral ports in the piston that intermittently open at one end of the stroke to receive fuel into the interior of the piston and at the other end to deliver said fuel out of the piston into the explosion chambers, and also of elongated passages in the piston structure that are constantly open to receive fuel into the interior of the piston from the cylinder-fuel-chambers, together with means on the ends of the piston having a compression function in the cylinder-fuel-chambers.

8. In an internal combustion engine, the combination of a cylinder having explosion chambers, a differential piston containing compression chambers and operating in connection wth said explosion chambers, and having ports to permit the passage of the mixture from the compression chambers to the explosion chambers, means for delivering the mixture to the cylinder and automatically operating to check the outflow of the same, a rigid diaphragm in the piston separating the chambers therein, and auxiliary fuel compression chambers in the cylinder that communicate with the chambers in the piston, together with circular piston members on the ends of the piston that operate in the auxiliary fuel-compression-chambers in the cylinder.

9. 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 to permit the passage of the mixture from the compression chambers to the explosion chambers, means for delivering the mixture to the cylinder and automatically operating to check the outflow of the same, a rigid diaphragm in the piston separating the chambers therein, and auxiliary fuel compression chambers in the cylinder that communicate with the chambers in the piston, together with circular piston members on the end of the piston that operate in the auxiliary fuel-compression-chambers in the cylinder, a connecting rod movably attached to the piston, and a crank shaft to which said piston rod is connected.

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 explosive mixture to pass from the compression chambers to the explosion chambers separately, together with a common exhaust system, a rigid imperforate partition in the piston between the two fuel chambers therein, auxiliary fuel chambers in each end of the cylinder having permanent communication with the chambers within the piston and intermittent communication also, means for permitting said permanent and intermittent communication, and circular piston means on the ends of the piston operating in the cylinder-fuel-chambers to preliminarily compress the fuel therein and in the piston chambers before it is transferred to the explosion chambers, and means for admitting fuel to both cylinder-fuel-chambers.

11. In an internal combustion engine, the combination of a cylinder having separate central explosion chambers and having also end fuel supply chambers, a differential piston with an enlarged middle portion operating in the explosion chambers which surround said piston, and said piston having heads with enlarged compression members operating in the end fuel supply chambers of the cylinder, and said piston having also a rigid imperforate inner partition dividing it into two fuel chambers permanently open to the cylinder-fuel-chambers, so as to provide preliminary fuel compression chambers, consisting each of a cylinder-fuel-chamber and a piston-fuel-chamber, and means for transferring the mixture through the piston from these compression chambers to the explosion chambers, together with means for admitting fuel to both cylinder-fuel-chambers and to prevent outflow during compression.

12. In an internal combustion engine, the combination of a cylinder having central separate explosion chambers, fuel supply chambers in the end sections thereof, and intermediate portions of smaller diameter, a differential piston with an enlarged middle portion operating in the explosion chambers, a central partition dividing it into two fuel chambers, and with enlarged heads operating in the fuel chambers in the ends of the cylinder, all arranged so as to provide preliminary compression chambers, each

consisting of one of the cylinder-fuel-chambers and one of the piston-fuel-chambers connected permanently with each other, and means for transferring the mixture through the piston from the preliminary compression chambers to the explosion chambers, said means including ports running through the cylinder sections of smallest diameter, and means for admitting fuel to both cylinder-fuel-chambers directly, together with valve mechanism for allowing the inflow of the mixture on the suction stroke and preventing its outflow on the compression stroke.

13. In an internal combustion engine, the combination of a cylinder having central separate explosion chambers, fuel supply chambers in the end sections thereof, and intermediate portions of smaller diameter, a differential piston with an enlarged middle portion operating in the exp'osion chambers and with enlarged heads operating in the fuel chambers in the ends of the cylinder, all arranged so as to provide preliminary compression chambers each consisting of one of the cylinder-fuel-chambers and one of the piston-fuel-chambers connected permanently with each other, and means for transferring the mixture through the piston from the preliminary compression chambers to the explosion chambers, said means including ports running through the cylinder sections of smallest diameter, and also including lateral ports in the piston-fuel-chambers which alternately function as inlet and outlet ports, together with elongated ports in the piston structure which are in permanent communication between the cylinder-fuel-chambers and the piston-fuel-chambers.

14. In an internal combustion engine, the combination of a differential cylinder hav ing central explosion chambers and terminal fuel supply chambers, a differential piston having a rigid partition and an enlarged middle portion operating in the explosion chambers and having heads provided with members operating in the cylinder-fuel-chambers, means for making a permanent communication between the cylinder-fuel-chambers and the piston-fuel-chambers, and means for transferring the mixture through the piston from the piston-compression-chambers to the explosion chambers, said means including angular ports in the cylinder wall leading from the piston to the explosion chambers and coming into coincidence with lateral ports in the piston at the end of the suction stroke of the engine.

15. In an internal combustion engine, the combination of a differential cylinder having central explosion chambers and terminal fuel supply chambers, a differential piston having a rigid partition and an enlarged middle portion operating in the explosion chambers and having heads provided with members operating in the cylinder-fuel-chambers, means for making a permanent communication between the cylinder-fuel-chambers and the piston-fuel-chambers, and means for transferring the mixture through the piston from the piston-compression-chambers to the explosion chambers, said means consisting of right-angled ports in the cylinder wall that extend from the piston to the explosion chambers and receive charges through lateral ports in the piston, the space below said ports and the interior of the explosion chambers covering piston rings so that the rings are not exposed to the effects of the explosion whereby all leakage is prevented.

In testimony whereof we hereunto affix our signatures.

JOHN J. MORRIS.
LEE N. GULICK.