

Jan. 1, 1946.

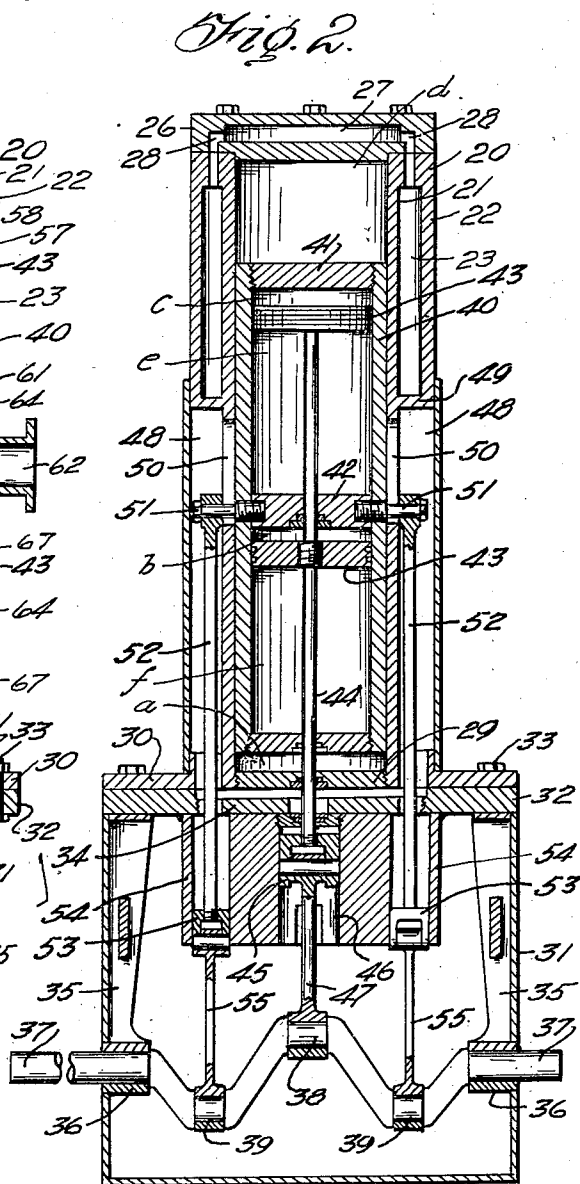
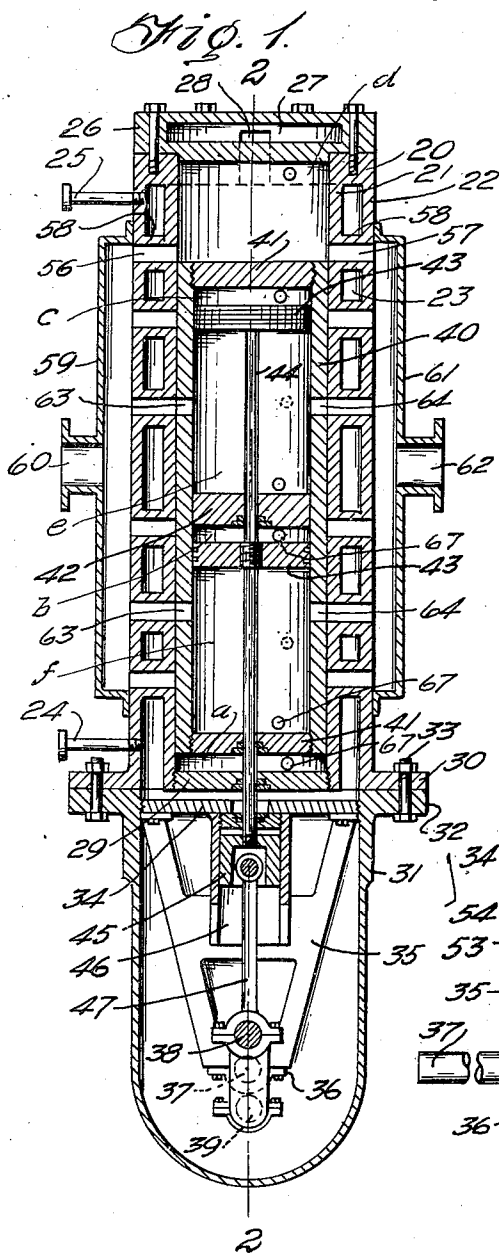
R. A. MATHEISEL, JR

2,392,052

MOTOR

Filed June 16, 1944

5 Sheets-Sheet 1



Inventor  
R. A. Matheisel, Jr.

By *T. R. Bryant*  
Attorney.

Jan. 1, 1946.

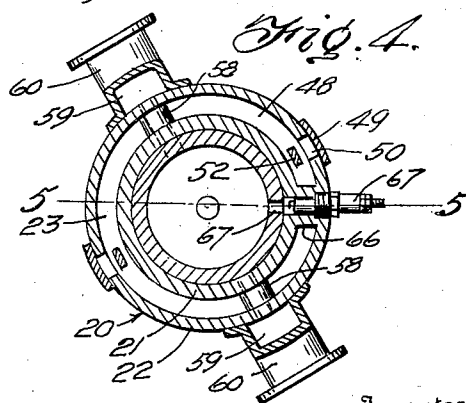
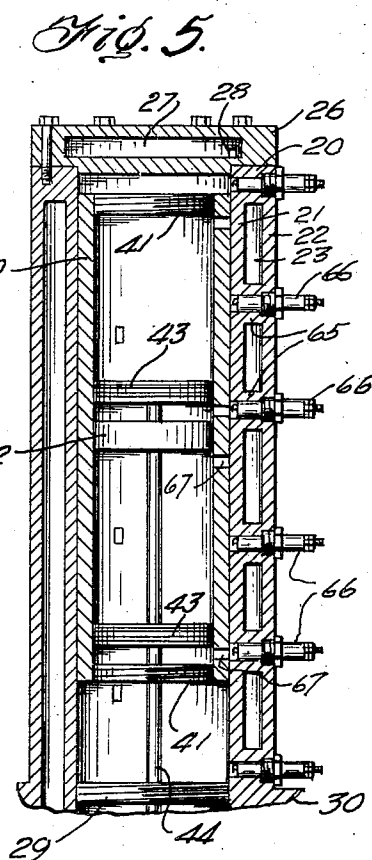
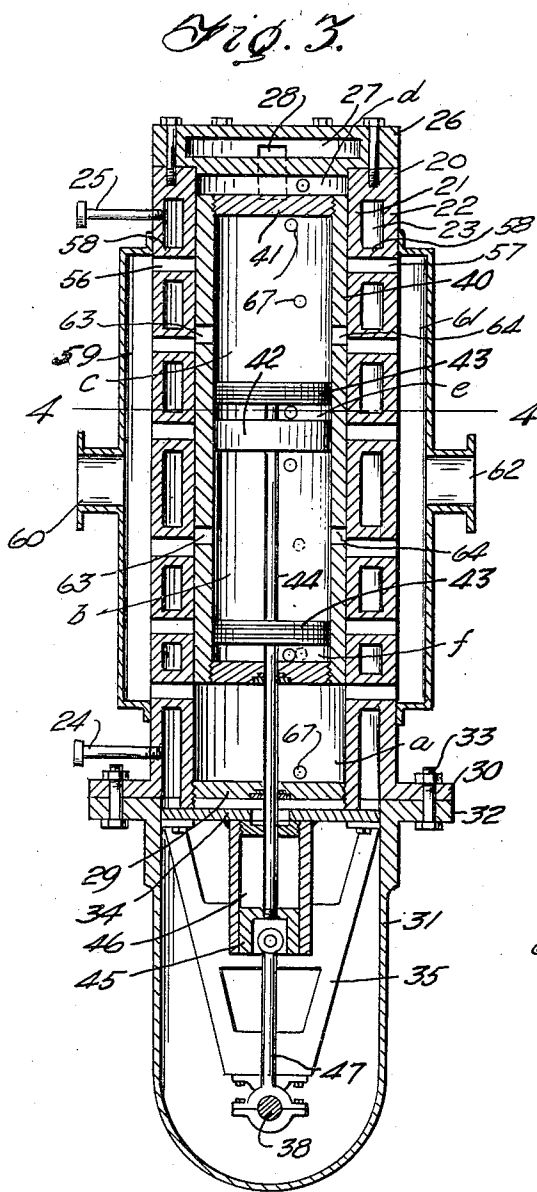
R. A. MATHEISEL, JR

2,392,052

MOTOR

Filed June 16, 1944

5 Sheets-Sheet 2



Inventor

R. A. Matheisel, Jr.

By

*J. T. Bryant,*  
Attorney.

Jan. 1, 1946.

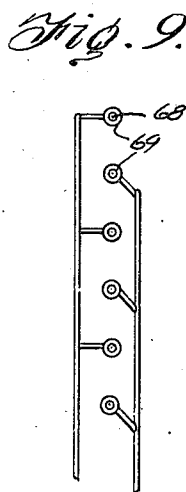
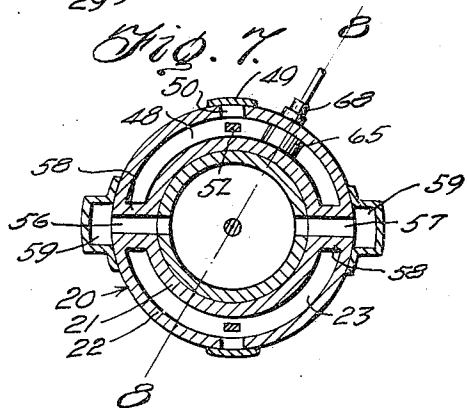
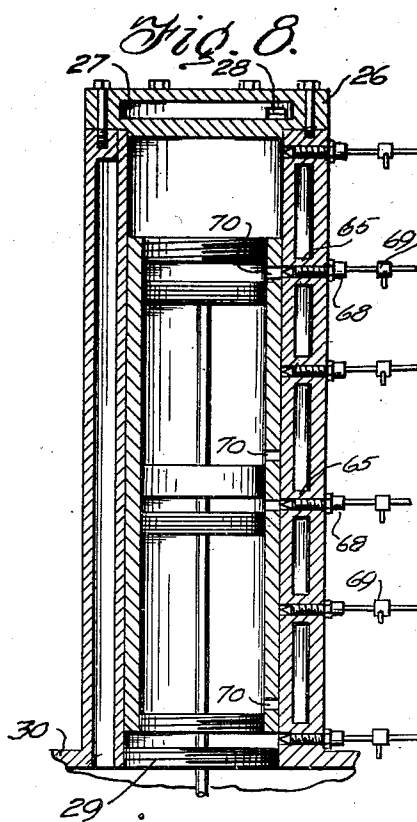
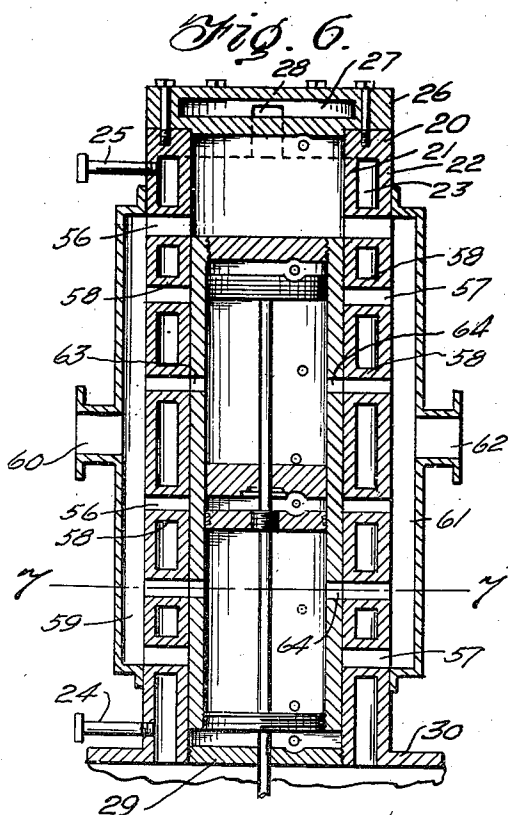
R. A. MATHEISEL, JR

2,392,052

MOTOR

Filed June 16, 1944

5 Sheets-Sheet 3



Inventor

R. A. Matheisel, Jr.

By *J. K. Bryant*  
Attorney

Jan. 1, 1946.

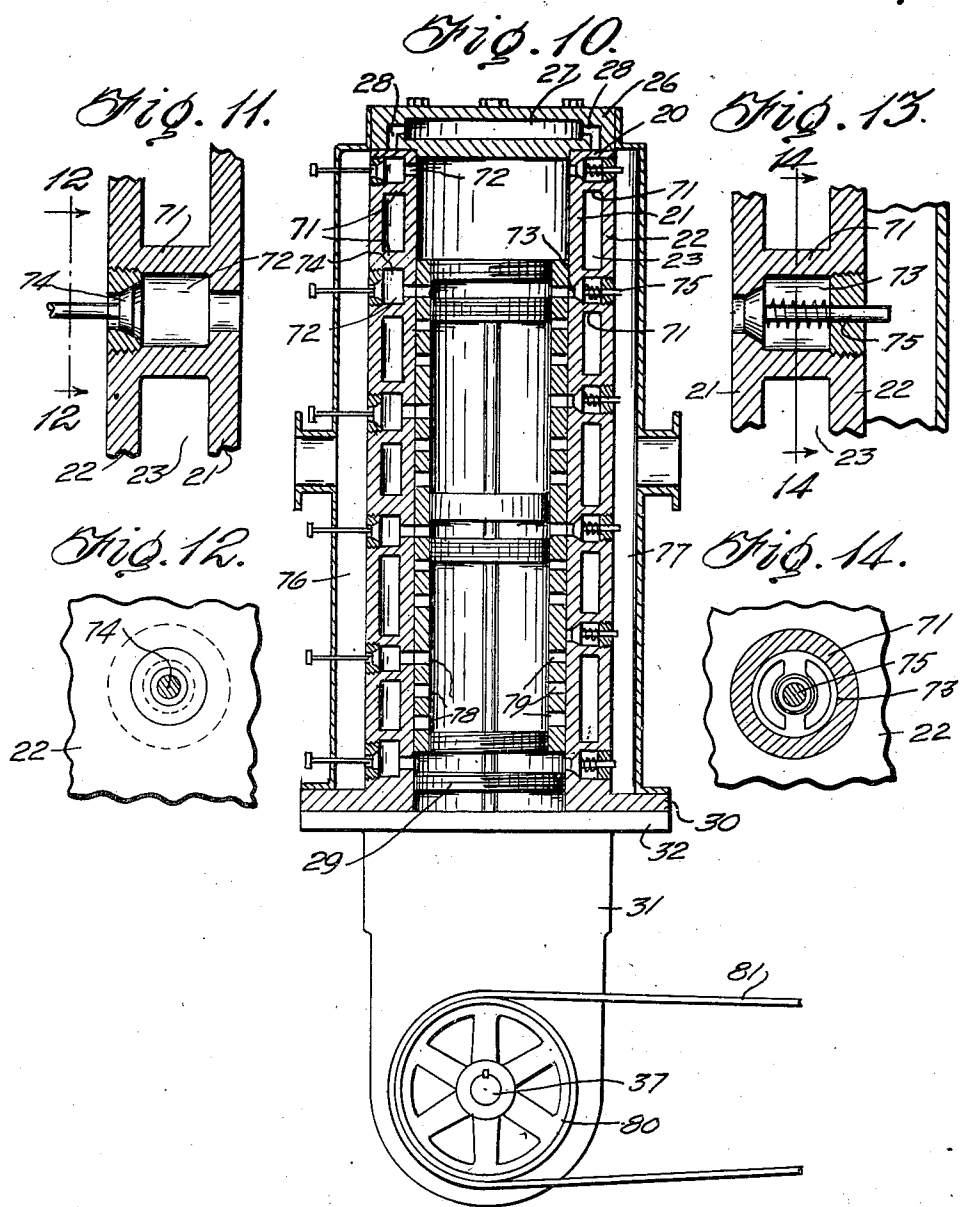
R. A. MATHEISEL, JR

2,392,052

MOTOR

Filed June 16, 1944

5 Sheets-Sheet 4



Inventor

R. A. Matheisel, Jr.

By

*T. K. Bryant*

Attorney

Jan. 1, 1946.

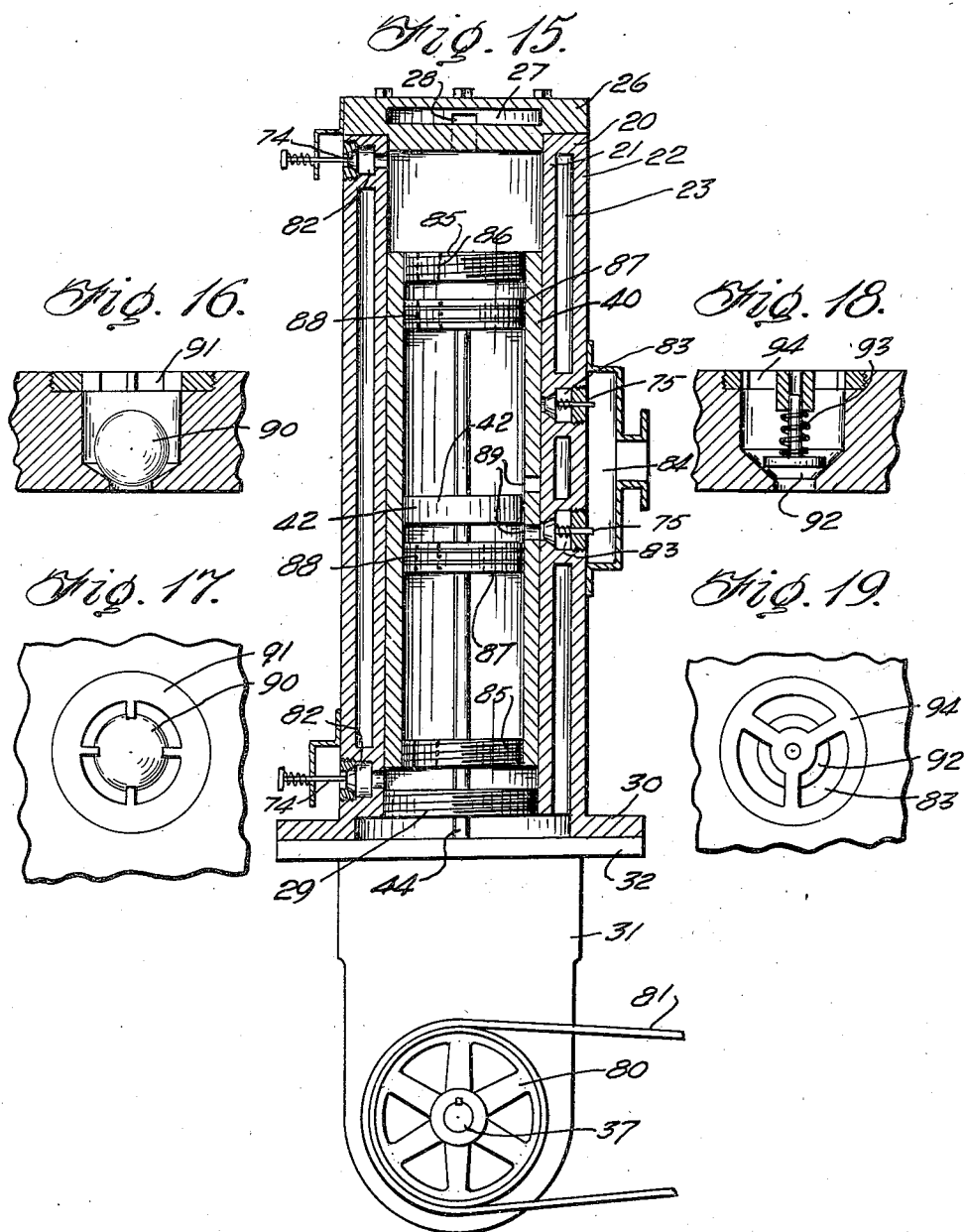
R. A. MATHEISEL, JR

**2,392,052**

MOTOR

Filed June 16, 1944

5 Sheets-Sheet 5



Inventor  
R. A. Matheisel, Jr.

334  
T. H. Bryant,  
Attorney

## UNITED STATES PATENT OFFICE

2,392,052

MOTOR

Rudolph A. Matheisel, Jr., Tilton, N. H.

Application June 16, 1944, Serial No. 540,725

17 Claims. (Cl. 123—50)

This invention relates to reciprocal mechanisms suitable for engines, pumps, compressors and the like.

One important object of the invention is to provide a highly compact and powerful mechanism for the above purposes.

A second important object of the invention is to provide a mechanism of this class wherein there is utilized a cylinder which forms at the same time a piston.

The third important object of the invention is to provide a device of the character set forth wherein there will be arranged on the same axis of reciprocation means for the production of six impulse chambers.

The fourth important object of the invention is to provide a reciprocating internal combustion engine having six axially aligned chambers four of which reciprocate between the remaining two.

The fifth important object of the invention is to provide an internal combustion engine having an outer cylinder, a combined inner cylinder and piston reciprocating in the outer cylinder and piston means reciprocating within the second cylinder.

The sixth important object of the invention is to provide an internal combustion engine of the above construction and having means for translating the reciprocations of the reciprocal members to a common crank shaft.

A seventh important object of the invention is to provide an internal combustion engine of the foregoing description and having means for the admission of an explosive mixture to the several chambers, means for expanding said chambers, and means for firing the explosive mixture in each of the chambers.

An eighth important object of the invention is to provide a two-cycle gasoline engine having the above construction.

A ninth important object of the invention is to provide a two-cycle Diesel engine of the above character.

A tenth important object of the invention is to provide a means for pumping or compressing fluids having a main pump cylinder, a combined inner cylinder and piston reciprocating in the main pump cylinder, a plurality of pistons reciprocating in the inner cylinder, valves controlling the admission and exhaust of fluid to the chambers formed by said cylinders and pistons, and means to actuate the reciprocating cylinder and the reciprocating pistons.

An eleventh important object of the invention is to provide a pump of the character just de-

scribed wherein the valve means includes check valves in the pistons and the ends of the reciprocating cylinder whereby a compounding pressure effect is produced.

5 With the above and other objects in view the invention consists in general of certain novel details of construction and combinations of parts hereinafter fully described, illustrated in the accompanying drawings and particularly claimed.

10 In the accompanying drawings like characters of reference indicate like parts in the several views and:

Figure 1 is a vertical diametric sectional view of a gasoline engine constructed in accordance with this invention, the section being taken through the inlet and outlet ports.

Figure 2 is a section on the line 2—2 of Figure 1.

Figure 3 is a section similar to Figure 1 but with the reciprocating parts of the engine at the opposite end of the piston stroke.

Figure 4 is a section on the line 4—4 of Figure 3.

Figure 5 is a section on the line 5—5 of Figure 4.

Figure 6 is a section similar to Figure 1 but showing the arrangement for a Diesel engine.

Figure 7 is a section on the line 7—7 of Figure 6. Figure 8 is a section on the line 8—8 of Figure 7.

Figure 9 is a diagrammatic view showing the means controlling the inlet valves of the Diesel engine.

Figure 10 is a view similar to Figure 1 but showing the parts arranged to act as a single acting pump.

Figure 11 is an enlarged fragmentary section showing the arrangement of one of the inlet valves.

Figure 12 is a section on the line 12—12 of Figure 11.

Figure 13 is an enlarged fragmentary section showing the arrangement of one of the outlet valves used in Figure 10.

Figure 14 is a section on the line 14—14 of Figure 13.

Figure 15 is a view similar to Figure 10 but showing the parts arranged for pressure compounding effect.

Figure 16 is an enlarged sectional view showing the arrangement of a ball type of check valve suitable for use in connection with the construction shown in Figure 15.

Figure 17 is a plan view of the parts shown in Figure 16.

Figure 18 is a fragmentary section to enlarged scale and showing a poppet valve arrangement for uses in connection with the mechanism shown in Figure 15.

Figure 19 is a plan view of the valve arrangement shown in Figure 18.

In each of the forms of the invention herein set forth there is provided an outer cylinder 20 having an inner wall 21 and an outer wall 22 spaced therefrom to provide a coolant-receiving space 23 into which coolant may be conducted through a pipe 24 and from which the coolant may be withdrawn through a pipe 25 for recooling. The upper end of the outer cylinder 20 is closed by cap or head 26 having a coolant space 27 communicating with the coolant space 23 by ports 28. The lower end of the outer cylinder is provided with a closure 29 and at its lower end the outer cylinder has flanges 30. A housing 31 is provided with flanges 32 which are secured to the flanges 30 by bolts 33. This housing is closed at its upper end by a closure 34 and depending from the closure 34 are bearing hangers 35 at the lower ends of which are bearings 36 wherein are journaled the end portions 37 of a crank-shaft having a central crank journal 38 and a pair of lateral crank journals 39, the journals 38 and 39 being diametrically opposed with respect to the axis of the members 37.

Mounted within the cylinder 20 is a cylinder 40 closed at each end by a head 41 and provided centrally with a partition 42. The two heads 41 and partition 42 thus provide two chambers and in each of these chambers is a piston 43. A rod 44 extends through the partition 42 and connects the pistons 43. This rod 44 further extends downwardly through the closure 29 and carries at its lower end a cross head 45 operating in a guide 46. A connecting rod 47 connects the cross head 45 to the crank journal 38. At diametrically opposite portions of the outer cylinder 20, this cylinder is cut away as at 48 and the spaces thus provided are closed by removable covers 49. Furthermore, the inner wall 21 of the cylinder 20 is likewise slotted as at 50 opposite each of the spaces 48. Stub shafts 51 are screwed through the wall of the cylinder 40 and into the partition 42. These stub shafts extend outwardly through the slots 50 and into the spaces 48. On the outer ends of these stub shafts are mounted rods 52 which pass down through the closure 34 and carry at their lower ends cross heads 53 operating in guides 54. Connecting rods 55 connect the cross heads 53 with the crank journals 39.

In the form of the invention shown in Figures 1 to 9 the outer cylinder 20 is provided with a series of inlet ports 56 opposite to which are a series of outlet ports 57. Each of these ports passes through a boss 58 connecting the walls 21 and 22 so that the ports do not in any way communicate with the coolant space 23. The ports 56 receive an explosive mixture such as that of gasoline and air from a suitable source in the usual manner, the source being connected to a manifold 59 through a connection 60. An exhaust manifold 61 has the ports 62 connected thereto and exhausts through a pipe 62. The cylinder 40 has on each side of the partition 42 an inlet port 63 and an outlet port 64. Furthermore, there is provided between the walls 21 and 22 certain other bosses 65 and in the form of the invention shown in Figures 1 to 5 there is screwed into each of the bosses 65 a spark plug 66. As before noted, the inner cylinder has a chamber

at each side of the partition 42 and at each end of these chambers there is provided a sparking port 67.

In the form shown in Figures 6 to 9 the construction is substantially the same except that the spark plugs 66 are replaced by fuel oil jets 68 supplied through suitably controlled valves 69 connected 3 and 3 as shown in Figure 9. The inner cylinder in this case is provided with port 70 corresponding in position to the ports 67 but forming inlet ports for the chambers on the opposite sides of the partition 42.

Now by observing the arrangement shown especially in Figures 1 and 3 it will be seen that in one extreme position of the piston and the crank shaft, that is when the journal 38 is in its highest position and the journals 39 are in their lowest positions, the cylinder 40 will be at the lower end of cylinder 20, while pistons 43 will be at the upper ends of the chambers in the cylinder 40. It may be supposed that there has now been effected a compression of explosive mixture in the spaces *a*, *b* and *c*. At this time a charge of explosive mixture has entered the space *d* through the upper port 56, the space *e* through the port 56 wherewith the upper port 63 registers and the space *f* through the port 56 wherewith the lower port 63 registers. By suitable timer means, not shown, at this instant the spark plugs 1, 3 and 5 counting from the bottom are energized and thereby the explosive mixtures which have been compressed act to force the inner cylinder upward to the position shown in Figure 3 and the pistons 43 downward as also shown in that figure. The explosive mixture previously introduced to the chambers *d*, *e*, and *f* will then be compressed and as the lower port 56 is uncovered and the ports 63 register with the ports as shown in Figure 3, pulling the upward movement of the inner cylinder, the exploded charge will be swept out through the exhaust ports by a fresh charge entering from the intake manifold.

In the form shown in Figures 6 to 9 only air will be introduced through the intake manifold 59 and the compression will be so arranged in proportion to cylinder volume that a jet of fuel oil will be discharged into the respective cylinder spaces when the air therein has been compressed to a sufficient degree to generate heat for firing introduced fuel.

In the form of invention shown in Figures 10 to 14 the walls 21 and 22 are connected at diametrically opposite points by bosses 71 through which pass inlet ports 72 and outlet ports 73. The ports 72 are controlled by inwardly opening check valves 74 while the ports 73 are controlled by outwardly opening check valves 75. The ports 72 are provided with fluid from a manifold 76 while the ports 73 open into a manifold 77. In place of a single port in the inner cylinder such as is shown at 67 there is preferably provided a series of ports 78 communicating successively with certain of the ports 72 and a series of ports 79 communicating successively with the ports 73. In place of the series of ports a single elongated port may be used and this will be found valuable especially when liquids are to be pumped. The crankshaft 37 in this case has mounted thereon a belt pulley or other similar device as shown at 80 and this is driven by a belt 81 from any suitable source of power. Figures 11 to 14 are introduced in order to show typical forms of check valves suitable for use in this invention and it is not deemed necessary to enter into a detailed

description of these devices as other check valves may readily be used.

Now while the parts shown in Figures 11 to 14 have been described as for a pump, the rotation of the crankshaft effecting reciprocation and thus drawing in fluid through the ports 73, yet the device may be used as a motive power since fluid under pressure may be provided through the manifold 76 and discharged through the manifold 77. Thus the construction in these figures may, by proper designation of the port areas, be used for either the pumping of liquids, the compression of gaseous substances or as a motor.

In the form shown in Figures 15 to 19 the construction is similar to that shown in Figure 10 but in this case there is provided but one inlet port 82 at each end of the cylinder 20 and two outlet ports 83 which lead to a manifold 84. Furthermore, the cylinder 40 in this form has a head at each end indicated at 85 and each of these heads has one or more check valves such as is shown by dotted lines at 86 controlling the passage of fluid through the respective head. The pistons 43 are replaced by pistons 87 similarly provided with check valves 88. The cylinder 40 has but two outlet ports and these ports 89 are located on opposite sides of the partition 42 and close thereto. The check valves in the lower piston and lower cylinder head open upwardly and these may be either a ball valve 90 wherein the weight of the ball effects seating, and wherein the ball is held by a retaining device 91 or the valve may be in the form of an upwardly opening poppet valve having a valve member proper 92 held on its seat by a spring 93 and guided through a spider 94. The valves in the upper cylinder head and upper piston open downwardly. The pistons and inner cylinder are reciprocated as in the form shown in Figure 10 by a belt pulley 80 and belt 81, or any other suitable means for rotating the crank shaft 37. Now if we assume the parts to be in the form shown in Figure 15 there will have been drawn into the upper chamber a charge to be compressed. As the crank shaft rotates the cylinder 40 rises, the inner check valve 74 at the upper end closes while the lower valve 74 opens. The charge in the upper chamber of the cylinder 20 passes down through the check valve 86 into the space above the upper piston 87 which is now moving downwardly and compressing the fluid below it. This movement continues until the upper port 89 is in registry with the upper port 83 whereupon the compressed fluid will escape into the manifold 84. While this is going on fluid will be drawn in the lower end of the cylinder 20 and the lower piston 87 will move downwardly so that the fluid between the lower piston and lower head 85 will escape upwardly through the check valve 88. Obviously, a continuation of the rotation of the crank will restore the parts to the position shown in Figure 15 and a charge of fluid which has been compressed between the lower piston 87 and the partition 42 will escape through the lower check valve 83 into the manifold 84.

It will be obvious that many variations of these arrangements may be made without departing from the idea of the outer and the inner cylinders and the pistons and no attempt will be made to here show all possible varieties. It may be mentioned, however, that as one such variety the lower end of the cylinder 40 may be left open and the lower piston dispensed with so that there will be but three active chambers in the device. Another such form could be readily understood as employing intercoolers in the form shown in the

Figure 15 between the several chambers in place of the check valves 86 and 88.

What is claimed, is:

1. In a device of the kind described, an outer cylinder, an inner cylinder closed at both ends forming a double acting piston for the outer cylinder, a piston reciprocating within the inner cylinder, a crank shaft, an operative connection between the sides of the inner cylinder and crank shaft outwardly of the outer cylinder, and a second operative connection between the piston in the inner cylinder and crank shaft.

2. In a device of the kind described, an outer cylinder, an inner cylinder closed at both ends forming a double acting piston for the outer cylinder, a piston reciprocating within the inner cylinder, a crank shaft, an operative connection between the sides of the inner cylinder and crank shaft outwardly of the outer cylinder, and a second operative connection between the piston in the inner cylinder and crank shaft, said cylinders having port means for the supply and exhaust of fluid thereto, the port means of the inner cylinder registering by movement of said inner cylinder with certain of the port means of the outer cylinder.

3. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocally in the outer cylinder forming a double acting piston for the outer cylinder, a partition extending transversely of the inner cylinder and dividing it into a pair of working chambers, a piston in each of said working chambers, a crank shaft, means connecting the pistons in fixed spaced relation and operatively to the crank shaft, and other means located laterally of the two cylinders for operatively connecting the inner cylinder and crank shaft.

4. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocally in the outer cylinder forming a double acting piston for the outer cylinder, a partition extending transversely of the inner cylinder and dividing it into a pair of working chambers, a piston in each of said working chambers, a crank shaft, means connecting the pistons in fixed spaced relation and operatively to the crank shaft, and other means located laterally of the two cylinders for operatively connecting the inner cylinder and crank shaft, said outer cylinder having inlet and outlet ports extending through its sides and the inner cylinder having ports leading from the working chambers and registering with ports of the outer cylinder in certain positions of reciprocation of the inner cylinder.

5. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocally in the outer cylinder forming a double acting piston for the outer cylinder, a partition, extending transversely of the inner cylinder and dividing it into a pair of working chambers, a piston in each of said working chambers, a crank shaft, means connecting the pistons in fixed spaced relation and operatively to the crank shaft, and other means located laterally of the two cylinders for operatively connecting the inner cylinder and crank shaft, said inner cylinder being shorter than the interior length of the outer cylinder and providing working chambers between the ends of the outer and inner cylinders.

6. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder

closed at each end and fitting reciprocally in the outer cylinder forming a double acting cylinder for the outer cylinder, a partition extending transversely of the inner cylinder and dividing it into a pair of working chambers, a piston in each of said working chambers, a crank shaft, means connecting the pistons in fixed spaced relation and operatively to the crank shaft, and other means located laterally of the two cylinders for operatively connecting the inner cylinder and crank shaft, said inner cylinder being shorter than the interior length of the outer cylinder and providing working chambers between the ends of the outer and inner cylinders, said outer cylinder having inlet and outlet ports extending through its sides and the inner cylinder having ports leading from the working chambers and registering with ports of the outer cylinder in certain positions of reciprocation of the inner cylinder.

7. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocally in the outer cylinder forming a double acting piston for the outer cylinder, a partition extending transversely of the inner cylinder and dividing it into a pair of working chambers, a piston in each of said working chambers, a crank shaft, means connecting the pistons in fixed spaced relation and operatively to the crank shaft, and other means located laterally of the two cylinders for operatively connecting the inner cylinder and crank shaft, said inner cylinder being shorter than the interior length of the outer cylinder and providing working chambers between the ends of the outer and inner cylinders, said outer cylinder having outlet and inlet ports in its side walls adjacent its ends and alternately closed by the reciprocation of the inner cylinder and having intermediate outlet and inlet ports disposed between said ports, the inner cylinder having ports in its side wall registering with ports of outer cylinder upon reciprocation of the inner cylinder.

8. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocally in the outer cylinder forming a double acting piston for the outer cylinder, a partition extending transversely of the inner cylinder and dividing it into a pair of working chambers, a piston in each of said working chambers, a crank shaft, means connecting the pistons in fixed spaced relation and operatively to the crank shaft, other means located laterally of the two cylinders for operatively connecting the inner cylinder and crank shaft, said inner cylinder being shorter than the interior length of the outer cylinder and providing working chambers between the ends of the outer and inner cylinder, said outer cylinder having outlet and inlet ports in its side walls adjacent its ends and alternately closed by the reciprocation of the inner cylinder and having intermediate outlet and inlet ports disposed between said ports, the inner cylinder having ports in its side wall registering with ports of outer cylinder upon reciprocation of the inner cylinder, and means to produce an explosion mixture and produce an explosion in alternate working chambers at each terminal position of reciprocation of the inner cylinder.

9. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocally in the outer cylinder forming a double acting pis-

ton for the outer cylinder, a partition extending transversely of the inner cylinder and dividing it into a pair of working chambers, a piston in each of said working chambers, a crank shaft, means connecting the pistons in fixed spaced relation and operatively to the crank shaft, other means located laterally of the two cylinders for operatively connecting the inner cylinder and crank shaft, said inner cylinder being shorter than the interior length of the outer cylinder and providing working chambers between the ends of the outer and inner cylinders, said outer cylinder having outlet and inlet ports in its side walls adjacent its ends and alternately closed by the reciprocation of the inner cylinder and having intermediate outlet and inlet ports disposed between said ports, the inner cylinder having ports in its side wall registering with ports of outer cylinder upon reciprocation of the inner cylinder, means to supply said inlet ports with a mixture of air and gasoline vapor, and spark plugs in the wall of the outer cylinder acting to fire the mixtures in the working chambers upon compression.

10. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocally in the outer cylinder forming a double acting piston for the outer cylinder, a partition extending transversely of the inner cylinder and dividing it into a pair of working chambers, a piston in each of said working chambers, a crank shaft, means connecting the pistons in fixed spaced relation and operatively to the crank shaft, other means located laterally of the two cylinders for operatively connecting the inner cylinder and crank shaft, said inner cylinder being shorter than the interior length of the outer cylinder and providing working chambers between the ends of the outer and inner cylinders, said outer cylinder having outlet and inlet ports in its side walls adjacent its ends and alternately closed by the reciprocation of the inner cylinder and having intermediate outlet and inlet ports disposed between said ports, the inner cylinder having ports in its side wall registering with ports of the outer cylinder upon reciprocation of the inner cylinder, means to supply air to said inlet ports, and fuel oil nozzles arranged to inject fuel oil into the working chambers upon compression of the air therein.

11. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocally in the outer cylinder forming a double acting piston for the outer cylinder, a partition extending transversely of the inner cylinder and dividing it into a pair of working chambers, a piston in each of said working chambers, a crank shaft, means connecting the pistons in fixed spaced relation and operatively to the crank shaft, other means located laterally of the two cylinders for operatively connecting the inner cylinder and crank shaft, said outer cylinder having inlet and outlet ports extending through its sides and the inner cylinder having ports leading from the working chambers and registering with ports of the outer cylinder in certain positions of reciprocation of the inner cylinder, inwardly opening check valves in the inlet ports of the outer cylinder and outwardly opening check valves in the outlet ports of the outer cylinder.

12. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocally in the outer cylinder, a partition extending trans-

versely of the inner cylinder and dividing it into a pair of working chambers, a piston in each of said working chambers, a crank shaft, means connecting the pistons in fixed spaced relation and operatively to the crank shaft, other means operatively connecting the inner cylinder and crank shaft, said outer cylinder having inlet and outlet ports extending through its sides and the inner cylinder having ports leading from the working chambers and registering with ports of the outer cylinder in certain positions of reciprocation of the inner cylinder, inwardly opening check valves in the inlet ports of the outer cylinder, outwardly opening check valves in the outlet ports of the outer cylinder, and check valves in said pistons and the heads of the inner cylinder opening toward said partition.

13. In a device of the kind described, an outer cylinder closed at both ends, an inner cylinder forming a double acting piston for the outer cylinder, a piston reciprocating within the inner cylinder, a structure adapted to be driven, an operative connection between the outer sides of inner cylinder and said structure and located at the outer sides of the outer cylinder and a second operating connection between the piston in the inner cylinder and said structure.

14. In a device of the kind described, an outer cylinder closed at both ends, an inner cylinder closed at both ends forming a double acting piston for the outer cylinder, a piston reciprocating within the inner cylinder, a crank shaft, an operative connection between the outer sides of the inner cylinder intermediate its ends and the crank shaft, and a second operative connection between the piston in the inner cylinder and the crank shaft.

15. In a device of the kind described, an outer cylinder closed at both ends, an inner cylinder closed at both ends forming a double acting piston for the outer cylinder, a piston reciprocating within the inner cylinder, a crank shaft, an operative connection between the outer sides of the inner cylinder intermediate its ends and the

crankshaft, and a second operative connection between the piston in the inner cylinder and the crank shaft, said cylinders having the port means for the supply and exhaust of fluid to said cylinder, the port means of the inner cylinder registering by movement of the inner cylinder with certain of the port means of the outer cylinder.

16. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocably in the outer cylinder, a piston in said inner cylinder, a crank shaft, operative means connecting the inner cylinder and the crank shaft, other operative means connecting the piston within the inner cylinder and the crank shaft, said outer cylinder having inlet and outlet ports extending through its sides and the inner cylinder having ports leading from the working chambers and registering with ports of the outer cylinder in certain positions of reciprocation of the inner cylinder, inwardly opening check valves in the inlet ports of the outer cylinder and outwardly opening check valves in the outlet ports of the outer cylinder.

17. In a device of the kind described, an outer cylinder closed at each end, an inner cylinder closed at each end and fitting reciprocably in the outer cylinder, a piston in said inner cylinder, a crank shaft, operative means connecting the inner cylinder and the crank shaft, other operative means connecting the piston within the inner cylinder and the crank shaft, said outer cylinder having inlet and outlet ports extending through its sides and the inner cylinder having ports leading from the working chambers and registering with ports of the outer cylinder in certain positions of reciprocation of the inner cylinder, inwardly opening check valves in the inlet ports of the outer cylinder and outwardly opening check valves in the outlet ports of the outer cylinder, and check valves in said piston and the heads of the inner cylinder opening toward the piston within the inner cylinder.

RUDOLPH A. MATHEISEL, Jr.