April 23, 1935. A. A. CAMPBELL 1,998,441

ENGINE

Filed Feb. 27, 1933 2 Sheets-Sheet 1

Fig. 1.

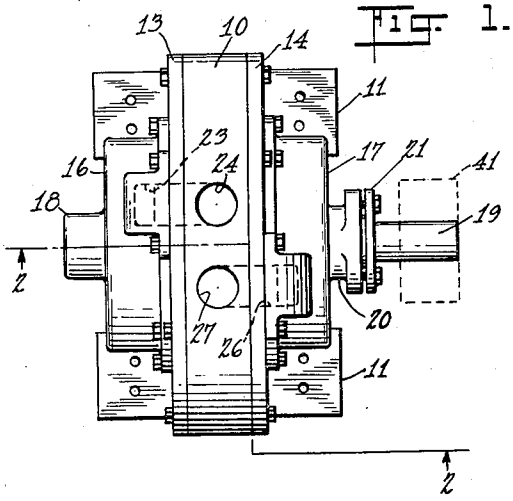



Fig. 3.

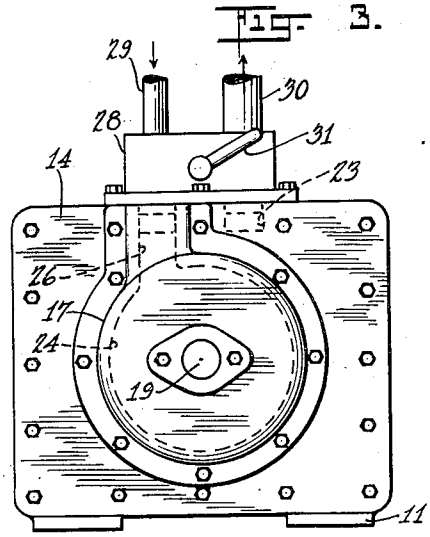



Fig. 2.

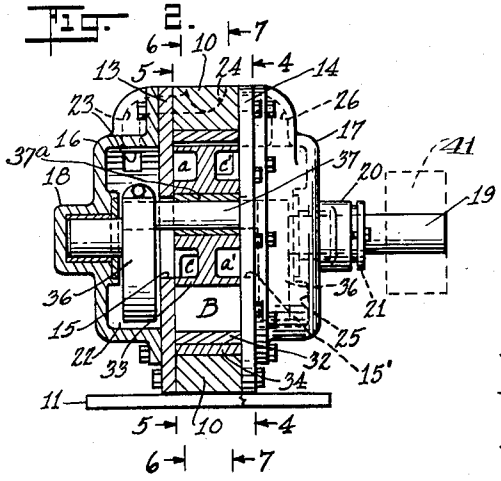



Fig. 4.

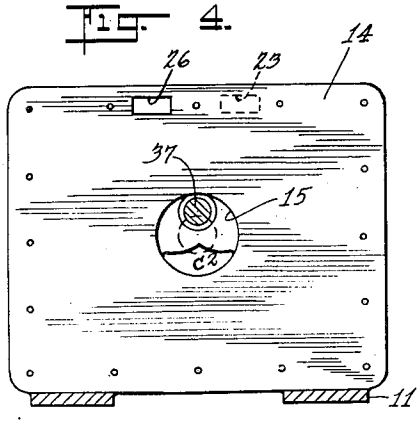
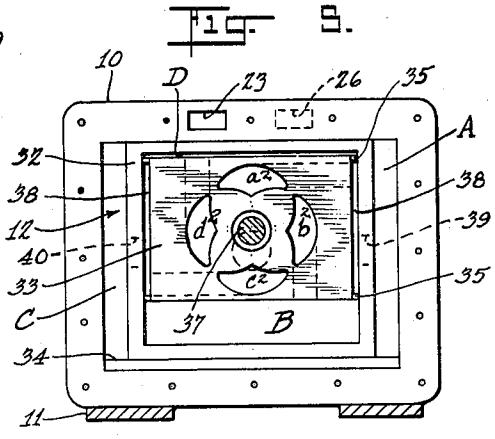



Fig. 5.




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Fig. 6.

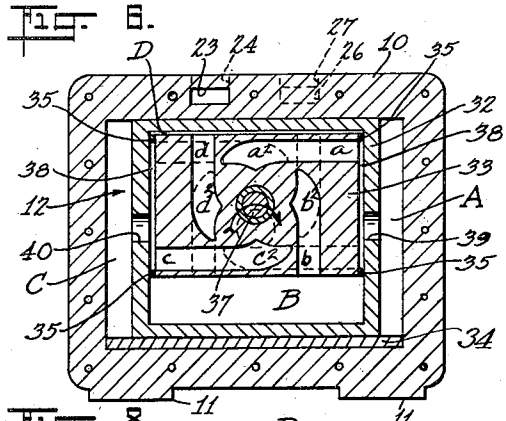



Fig. 7.

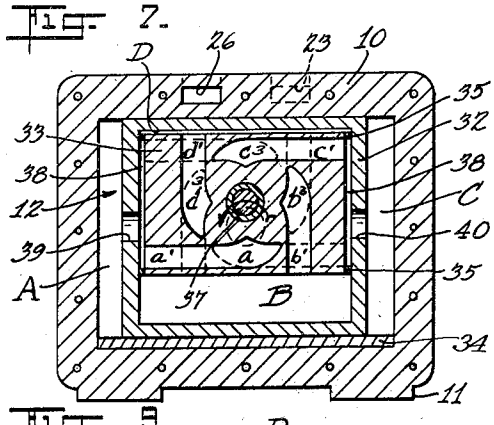



Fig. 8.

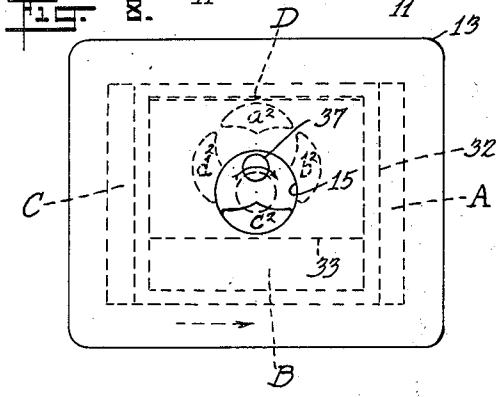



Fig. 9.

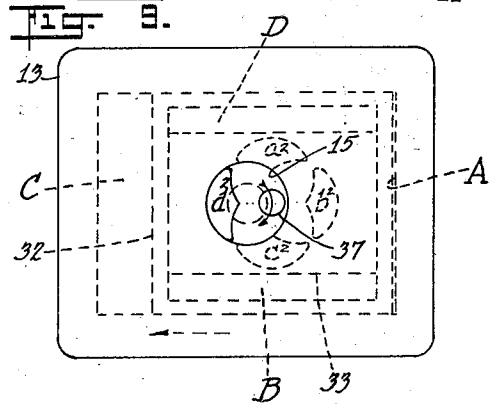



Fig. 11.

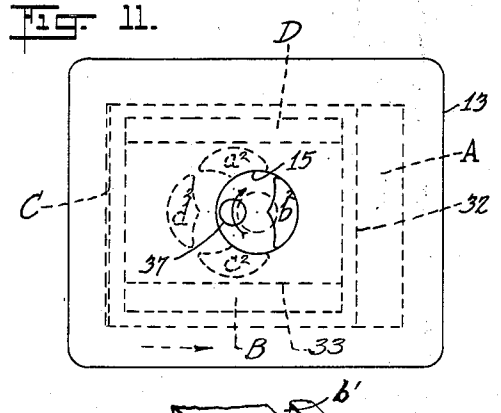



Fig. 10.

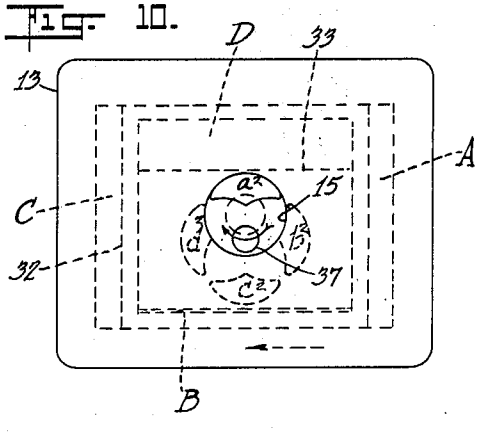
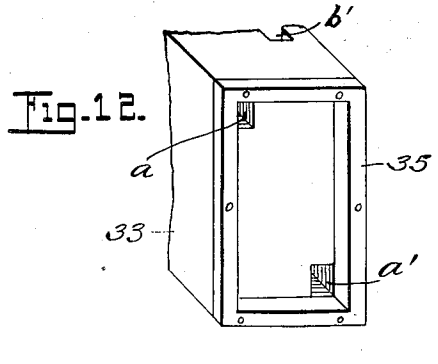



Fig. 12.




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Patented Apr. 23, 1935 1,998,441

# UNITED STATES PATENT OFFICE

1,998,441

## ENGINE

Archibald A. Campbell, Grand Haven, Mich.

Application February 27, 1933, Serial No. 658,766

6 Claims. (Cl. 121—52)

This invention relates to improvements in engines.

One object of the invention is to provide an engine of the so called square piston type, having an outer and an inner piston, the latter being provided with two sets of ports for the intake and exhaust of the motive fluid, which ports and the ducts communicating therewith are so arranged on opposite sides of the piston that the engine is perfectly reversible, that is, it develops maximum power when operated in either direction.

Another object of the invention is to provide an engine structure comprising outer and inner pistons, the latter of which is journaled on a crank shaft which in turn is journaled on opposite sides of the pistons in the engine casing. In numerous forms of square piston engines as heretofore designed, in which the inner piston acts as the valve mechanism, it has been feasible to provide the crankshaft with one or two bearings on one side only of the pistons and hence the engines have not been truly balanced, and required excessive space for the out-board bearing, (either as part of the engine or as a separate bearing) and did not provide accurate alinement especially after a little wear.

In the present improvements, due to the novel arrangement of the ports or valves and related parts, the crank shaft is preferably provided with two bearings in the engine structure, one disposed on each side of the pistons and crank arms, and hence maintenance of the proper alinement of the shaft without resort to supplementary outboard bearings is possible. In engines of the present type the maintenance of precise alinement is particularly desirable in view of the fact that the pistons have a substantial flat area contacting with the walls of the piston chamber and disalinement increases wear of the contacting parts resulting in leakage of the motive fluid and a consequent lessening in efficiency.

The present improvements are further characterized by the provision of inlet and outlet ducts in opposite faces of the inner piston, which inlet ducts communicate in proper sequence with an inlet opening in one wall or closure plate of the piston chamber, while the outlet ducts communicate in sequence with an exhaust opening in an opposite wall of the chamber, said inlet and exhaust openings being of a size to accommodate the revoluble pin of the crank shaft and also provide adequate area for the free passage of the motive fluid to or from the respective working or pressure chambers.

A further object of the invention is to provide an improved engine of the type described which is of relatively simple construction and of few moving parts, and wherein an inner piston is provided with pressure fluid intake and exhaust ducts having ports so spaced each with respect to the others and with respect to inlet and exhaust openings as to insure proper timing and to enable the utilization of inlet and exhaust ducts of such size as to improve the performance of the engine under various operating conditions.

Other objects of the invention relate to various features of construction and arrangement of parts which will be apparent from a consideration of the following specification and accompanying drawings, wherein

Figure 1 is a top plan view of an engine embodying the present improvements,

Figure 2 is an end elevation of the engine, part of the structure being shown in vertical section taken on line 2—2 of Figure 1;

Figure 3 is an elevation showing the right hand side of the engine illustrated in Figure 2; the reversing valve being omitted;

Figure 4 is a sectional view taken on line 4—4 of Figure 2;

Figure 5 is a sectional view taken on line 5—5 of Figure 2;

Figure 6 is a vertical sectional view through the two pistons taken on line 6—6 of Figure 2;

Figure 7 is a similar view taken on line 7—7 of Figure 2;

Figures 8, 9, 10 and 11 are progress views showing various relative positions of the pistons and fluid ports during the operation of the engine, thus in Figure 8 the outer piston is moving to the right and the inner piston has reached the uppermost point of its travel; in Figure 9 the outer piston has completed its movement to the right and the inner piston has completed about one half its downward movement; in Figure 10 the outer piston has completed about one half its movement to the left while the inner piston has completed its downward movement, and in Figure 11 the outer piston has completed its movement to the left while the inner piston has completed one half its upward movement.

Figure 12 is a broken perspective view of one end of the inner piston.

In the drawings, 10 is the central portion of the engine casing, and in the form shown, is rectangular in shape and formed integrally with the base sections 11. The rectangular shaped interior 12 of the casing section 10 is termed a piston chamber, in that the pistons hereinafter described are positioned therein.

Secured to the sides of the section 10 are closure plates 13 and 14, which are provided with central openings 15, 15', respectively, through which the motive fluid used for operating the engine passes into the piston chamber 12 for actuating the pistons.

Secured to the plates 13 and 14 are also side casing sections 16 and 17, respectively. Casing section 16 is preferably provided with a bearing housing 18 for receiving the inner end of the engine shaft 19 which is also journaled on the opposite side of the engine in the hub extension 20 which may be provided with a suitable packing gland 21 of suitable construction.

The casing section 16 is provided with an interior recess or chamber 22 which communicates by means of passage 23 with a pressure fluid opening 24. The casing section 17 is provided with a similar recess or chamber 25 which communicates by means of a passage 26 with another fluid opening 27.

Either opening 24 or 27 may comprise the pressure fluid intake and the other the exhaust.

In Figure 3 a conventional reversing valve 28 is shown and communicates with the openings 24 and 27, and has connected thereto a fluid pressure delivery pipe 29 and exhaust conduit 30.

By operating the valve handle 31 communication of the pressure line 29 with either opening 24 or 27 can be effected for delivering the pressure fluid to either recess 22 or 25 for operating the engine in the desired direction as will be more fully described.

Positioned within the piston chamber 12 is an outer reciprocating frame-like piston 32 and an inner piston 33, as shown in Figure 5. The outer piston 32 reciprocates horizontally in the chamber 12, the bottom wall of which may be provided with a wear plate or slipper 34. The inner piston 33 is positioned within the outer piston 32, and is arranged for reciprocating motion therein.

The ends of the inner piston are provided with slippers 35.

As illustrated in Figure 5, the outer piston is arranged for horizontal reciprocating movement within the chamber 12, while the inner piston is arranged for vertical reciprocating movement within the outer piston. The two pistons cooperate with each other and with the walls of the chamber 12 to provide four pressure chambers into which the motive fluid is admitted for actuating the pistons.

Thus, as viewed in Figure 5, one pressure chamber A is defined by the inner right hand wall of chamber 12 and the adjacent end of the outer piston 32. Pressure chamber B is defined by the lower inner wall of outer piston 32 and the lower surface of inner piston 33. Chamber C corresponds to chamber A but is at the opposite end of the piston chamber 12, and chamber D corresponds to chamber B but is on the opposite side of the inner piston 33.

The pressure fluid is admitted to the various pressure chambers for effecting the reciprocation of the outer piston within the chamber 12 and the reciprocation of the inner piston within the outer piston for effecting the rotation of the shaft 19.

The shaft 19 as shown in Figure 2, is provided with crank arms 36 each of which is disposed within one of the recesses 22 or 25, and preferably is counterbalanced as shown in said figure.

A crank pin 37 extends through the inner piston 33 which carries a suitable bearing 37a therefor. The pin 37 passes through and is revoluble within the openings 15, 15' of the plates 13 and 14, respectively, said openings being large enough to accommodate the revolving movement of the pin and also of sufficient area to admit pressure fluid in required quantities to ducts which conduct the fluid to the respective pressure chambers or permit the free exhausting of the fluid therefrom. The arrangement of said ducts and the respective duct ports, as hereinafter described, gives relatively large latitude in providing the ports and ducts with such areas or fluid carrying capacity as may be necessary to obtain maximum operating efficiency under given conditions.

The inner piston 33 as shown in Figure 5 is provided on one side of the central vertical plane thereof with four ducts, *a*, *b*, *c*, and *d*, the inner ends of which terminate in ports $a^2$, $b^2$, $c^2$ and $d^2$, respectively preferably shaped as shown in the drawings, (see Figs. 8 to 10) and which open at one face of the piston.

In the opposite half of the inner piston are four similarly arranged ducts indicated as *a'*, *b'*, *c'* and *d'*. These ducts likewise terminate in similar ports $a^3$, $b^3$, $c^3$ and $d^3$ respectively in the adjacent face of the piston, and serve as exhaust ducts when the ducts *a*, *b*, *c* and *d* function as intake ducts, and vice versa. Each of the ducts *a* to *d* and *a'* to *d'* inclusive are passages formed in the inner piston and extend from the respective ports above mentioned to one end or the upper or lower edge of the piston as clearly shown in Figures 6 and 7.

All the duct ports are equally spaced about the axis of the crank pin 37, as clearly shown in Figures 5 to 11 inclusive, the pin being eccentric to the axis of the shaft 19, and the openings 15, 15' in the closure members 13, 14, respectively being concentric with the axis of the shaft.

It will be seen that as the shaft rotates the duct ports will be brought in sequence into communication with the respective intake or exhaust openings 15, 15' for delivering or exhausting pressure fluid to or from the respective pressure chambers.

Figures 6 and 7 are sectional views through the pistons illustrating the arrangement of the above mentioned ducts. If it be assumed that Figure 6 shows intake ducts and Figure 7 exhaust ducts, steam will be supplied to pressure chamber A by duct *a*, to chamber B by duct *b*, to chamber C by duct *c*, and to chamber D by duct *d* in succession. Steam in flowing from duct *a* to pressure chamber A flows through a channel 38 formed in the slipper 35 through an opening 39 in the end of the outer piston. Pressure fluid flowing to chamber C passes through duct *c*, channel 38 in the slipper 35 and thence through opening 40.

Pressure fluid is exhausted from the pressure chambers A, B, C, and D through ducts *a'*, *b'*, *c'* and *d'*, respectively.

In Figure 8 the port $c^2$ of duct *c* is shown in fully opened position with reference to the intake opening 15. Pressure fluid will, therefore, flow to pressure chamber C and move the outer piston to the right, the crank shaft and pin moving in the direction of the arrow. The outer piston has, therefore, completed one half its stroke, and as it continues its movement to the right, the port $d^2$ of duct *d*, as shown in Figure 9, will move into communication with the intake opening 15. Duct *d* carries the motive fluid into chamber D and hence causes the inner piston 33 to move downwardly within the outer piston in

Figure 9. This movement of the inner piston with respect to the outer is likewise shown in the middle of the stroke, and it will be seen that the port $a^2$ of duct $a$ will, upon further downward movement of the inner piston, move into registration with the opening 15.

In Figure 10 the port $a^2$ of duct $a$ is shown in fully opened position and as this duct directs the fluid into chamber A, the outer piston is being moved to the left.

As the piston continues the movement to the left from the position shown in Figure 10, the port $b^2$ of duct $b$ will move into communication with the opening 15, and hence pressure fluid will be supplied to chamber B, which moves the inner piston upwardly. It will thus be seen that during the cycle of the movement just described, at least one of the pressure chambers will be supplied with motive fluid when the respective piston is at an effective crank angle, and therefore the torque remains approximately constant during the cycle of operation. Hence the engine has no dead center and a flywheel is not necessary.

While the outer piston reciprocates with a straight line movement and the inner piston is guided by the outer piston for relative movement at right angles to the direction of movement of the outer piston, it will, of course, be apparent that the inner piston has a revoluble movement, inasmuch as the crank pin is journaled therein.

Thus referring again to Figures 8 and 9, it will be seen that before the port $c^2$ of duct $c$ passes out of communication with the intake opening 15, the port $d^2$ of duct $d$ comes into communication therewith, and hence pressure is being applied to the outer piston in chamber C to move the latter to the right, and simultaneously is being applied in chamber D to move the inner piston downwardly. It will, of course, be understood that as the duct ports pass in succession out of communication with the openings 15 or 15', they are closed by the smooth contacting inner surface of the plate 13 or 14 respectively and while so closed, the admission or exhaust of the steam to the said openings is cut off.

The exhaust ducts $a'$ to $d'$ inclusive serve chambers A to D respectively.

Referring again to Figure 8, it will be seen that since outer piston 32 is moving into chamber A, duct $a'$ must serve for exhausting the spent steam of said chamber. As the piston moves to the right, as viewed in Figure 8, the spent steam of chamber A is forced through the opening 39 in the end wall of the outer piston, and thence by way of channel 38 into duct $a'$. The port $a^3$ of duct $a'$ opens in the face of the piston directly opposite the opening of duct $c$, and hence when duct $c$ is admitting pressure fluid, the port $a^3$ of duct $a'$ is in registration with the opening 15' in plate 14, and exhausting the spent fluid into the chamber 25, and thence through passage 26 to the exhaust 30.

In similar manner when the pistons are in the position shown in Figure 9 wherein fluid is entering duct $d$ and flowing to chamber D to move the inner piston 33 downwardly, the port $b^3$ of exhaust duct $b'$ is in corresponding registration with opening 15' of plate 14 to permit of the exhaust of the spent fluid from chamber B.

The arrangement of the intake ducts and their respective ports on one side of the inner piston and the exhaust ducts and ports on the other side as shown and described, to provide intake and exhaust passages of equal capacity, makes the engine perfectly reversible, that is, it develops equal power regardless of the direction of operation. Thus the steam can be admitted by means of the reversing valve through passage 26 into chamber 25, thence through opening 15' in plate 14 into the ducts $a'$ to $d'$ inclusive in sequence, and exhaust through the opposite ducts $a$ to $d$ inclusive, thence through the opening 15 in plate 13 to chamber 22, and thence through the passage 23 to the exhaust 30.

It will be understood, of course, in many uses to which engines of this type are placed, no reversing valve is required, since it is never necessary for the engine to operate in the reverse direction, in which instance motive fluid can be admitted through one of the ports 24 or 27 and exhaust through the other.

The arrangement of the ports of ducts $a$, $b$, $c$ and $d$, and $a'$, $b'$, $c'$ and $d'$ in the respective faces of the inner piston in spaced relation with respect to the crank pin, makes feasible the journaling of the crank shaft on each side of the piston structure, thus obviating the necessity for using additional bearings such as so-called outboard bearings for the shaft when the engine is employed for driving a pulley, such as the pulley 41 shown in dotted lines in Figures 1 and 2, or analogous uses.

The improved engine is of very simple construction, having no moving parts in addition to the shaft other than the two pistons which, as they operate, move the respective duct ports in sequence into registration with the ports 15, 15' in the plates 13 and 14 for both intake and exhaust purposes. It will be apparent that the engine structure herein described and claimed may be operated with either steam, compressed air, or water, and may also be employed as a pump, meter or compressor.

While I have shown and described an embodiment of my improvements for the purpose of illustration, I do not wish to be restricted specifically thereto except as so limited by the appended claims.

I claim:

1. A square piston engine comprising a casing having a piston chamber therein, an inner and an outer piston in said chamber defining therein two pressure chambers for each piston, a crank shaft journaled in said casing at opposite sides of said piston and having a crank pin journaled in said inner piston, side closure members for said chamber having pressure fluid inlet and outlet openings each concentric with said shaft, and through which said crank pin extends, passages in said casing for conveying pressure fluid to one of said openings and conveying exhaust fluid from said other opening, and a group of ducts on each side of the longitudinal central vertical plane of said inner piston, the ducts of each group being arranged to communicate in sequence with the opening of the adjacent closure member for respectively conveying fluid to and from said pressure chambers.

2. A square piston engine comprising a casing having a piston chamber therein, an inner and outer piston in said chamber defining therewith two pressure chambers for each of said pistons, a crank shaft journaled in said casing, said shaft having a pin journaled in said inner piston, said casing having a fluid intake opening concentric with said shaft at one side of said pistons and a similar exhaust port on the opposite side, pressure fluid ducts in said inner piston having ports arranged for sequential registration with said intake opening and each ex-

tending to one edge of the inner piston for delivering fluid to the respective pressure chambers, and similar exhaust ducts in the opposite side of said inner piston.

3. A square piston engine comprising a casing having a rectangular piston chamber therein, a reciprocating outer frame piston therein defining therewith opposite fluid chambers, an inner piston relatively reciprocable within said outer piston and defining therein opposite fluid chambers, a crank shaft extending through said piston chamber and journaled in said casing on opposite sides of said chamber, said shaft having a crank pin journaled in said inner piston, said casing having pressure fluid inlet and outlet passages terminating in openings on opposite sides of said piston chamber concentric with said shaft, inlet ducts in one side of said inner piston arranged to communicate in sequence with said inlet openings for conveying fluid to said fluid chambers for actuating said pistons, and outlet ducts in the opposite side of said inner piston for conveying exhaust fluid in sequence from said respective fluid chambers to said exhaust opening.

4. An engine comprising a casing having therein a rectangular piston chamber, an outer piston therein defining fluid chambers at opposite ends thereof, an inner piston slidable within said outer piston and defining opposite fluid chambers therein, a crank shaft journaled in said casing and having a crank pin on which said inner piston is journaled, ducts in one side of said inner piston for conveying pressure fluid to said fluid chambers in sequence for actuating said pistons and effecting the rotation of said shaft, and an exhaust duct in the opposite side of said inner piston for each of said fluid chambers.

5. An engine of the class described comprising a casing having side walls and defining therewith a piston chamber therein, an outer and inner piston in said chamber defining therewith opposite pressure chambers for each piston, a crank shaft journaled in said casing and having a pin journaled in said inner piston, a fluid intake opening in one side wall of said piston chamber arranged concentrically with respect to said shaft, a similar exhaust opening in the opposite side wall of said chamber, intake ducts in one side of said inner piston and having the inner ends thereof disposed for sequential registration with said intake openings for delivering fluid to the respective pressure chambers, and similar exhaust ducts on the opposite side of said inner piston similarly disposed with respect to said exhaust opening.

6. Mechanism of the class described having a piston chamber, and an outer and an inner piston therein defining two pairs of opposed working chambers within said piston chamber, said piston chamber having an inlet opening in one side thereof and an exhaust opening in the opposite side, said inner piston having a group of intake ducts in one side thereof and a group of exhaust ducts in the other side, one of each group communicating at one end with one of said working chambers, the inner ends of said ducts terminating at their other ends in ports in the adjacent side walls of said inner piston and arranged for sequential registration with said intake and outlet openings.

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