March 20, 1945. E. H. O'BRIEN 2,371,911

INTERNAL-COMBUSTION ENGINE

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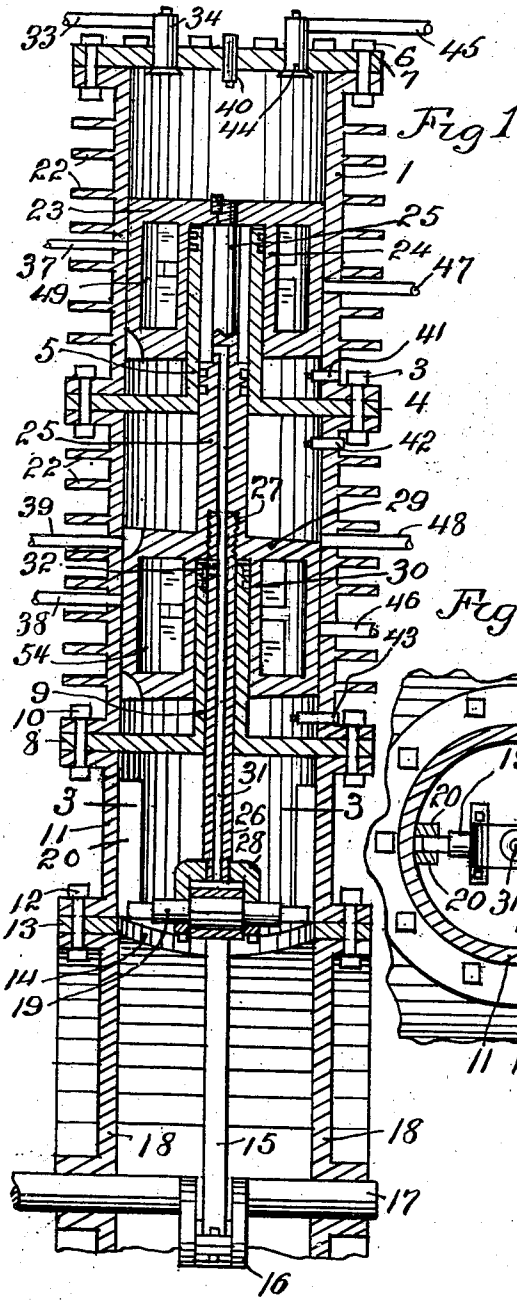



Fig 1

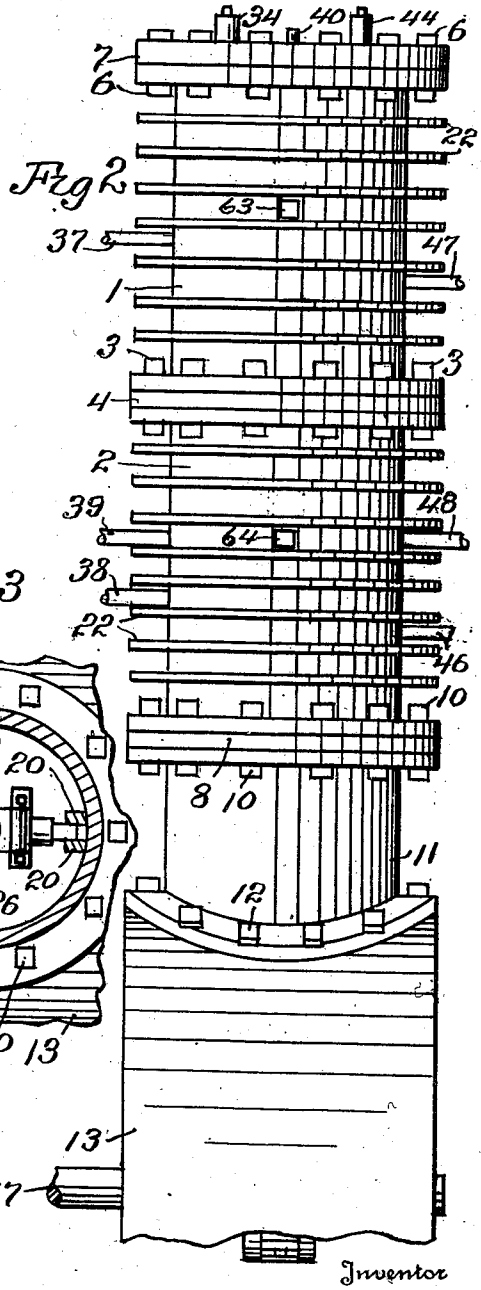



Fig 2

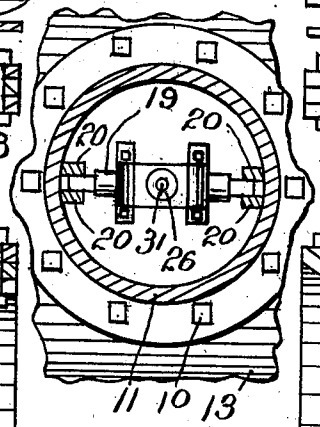



Fig 3

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INTERNAL-COMBUSTION ENGINE

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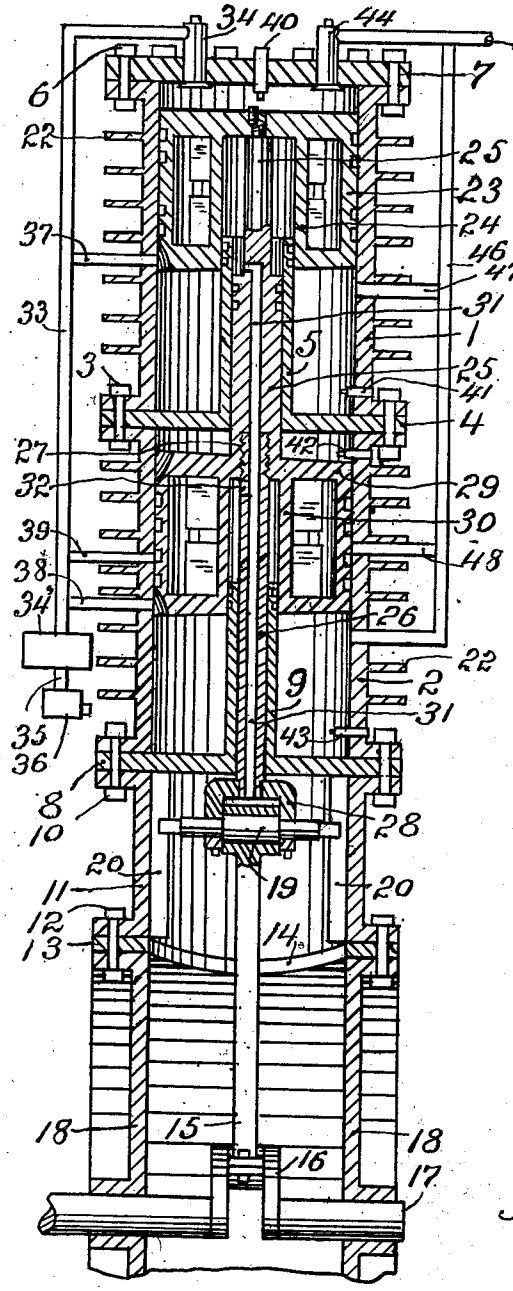



Fig 4

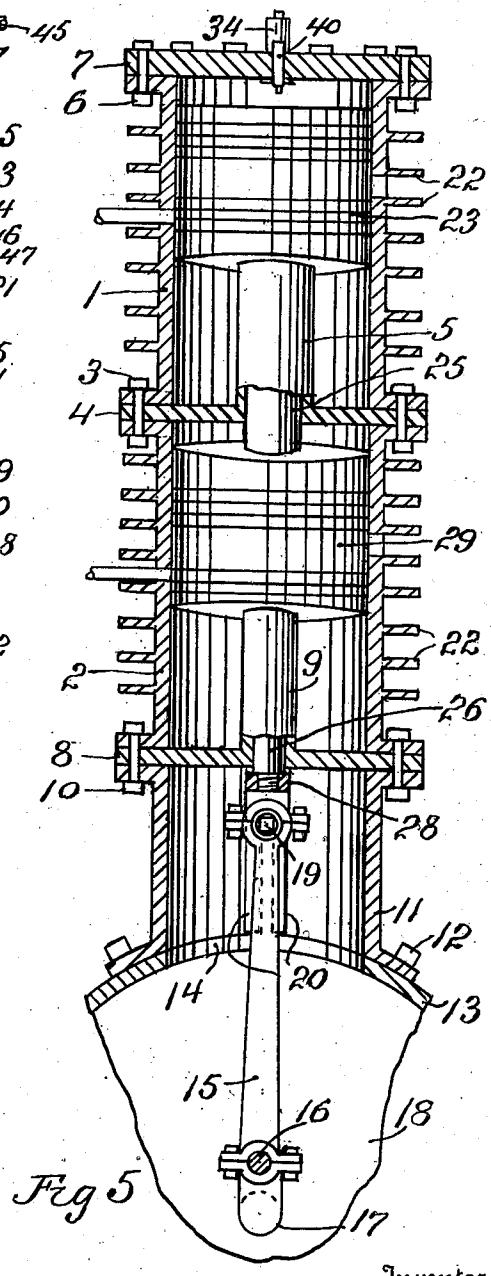



Fig 5

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Fig 6

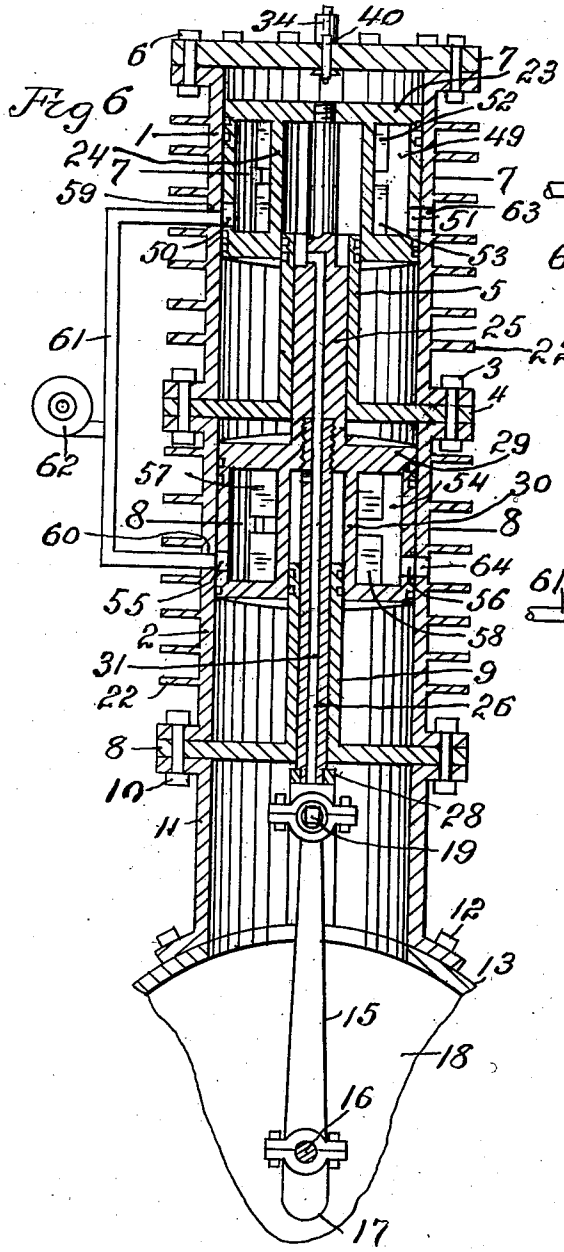



Fig 7

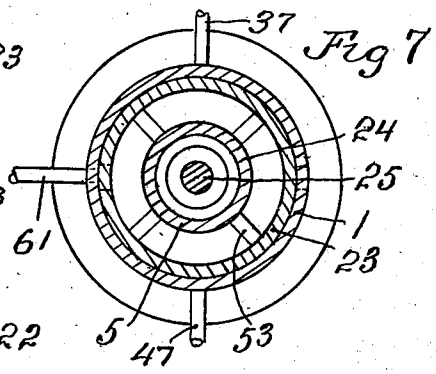
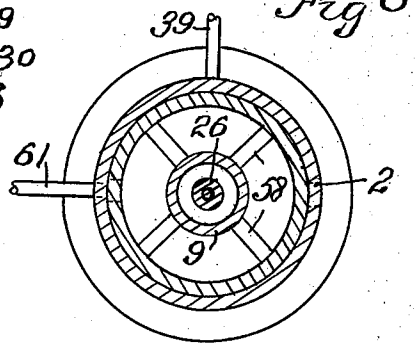



Fig 8




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INTERNAL-COMBUSTION ENGINE

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Fig 9

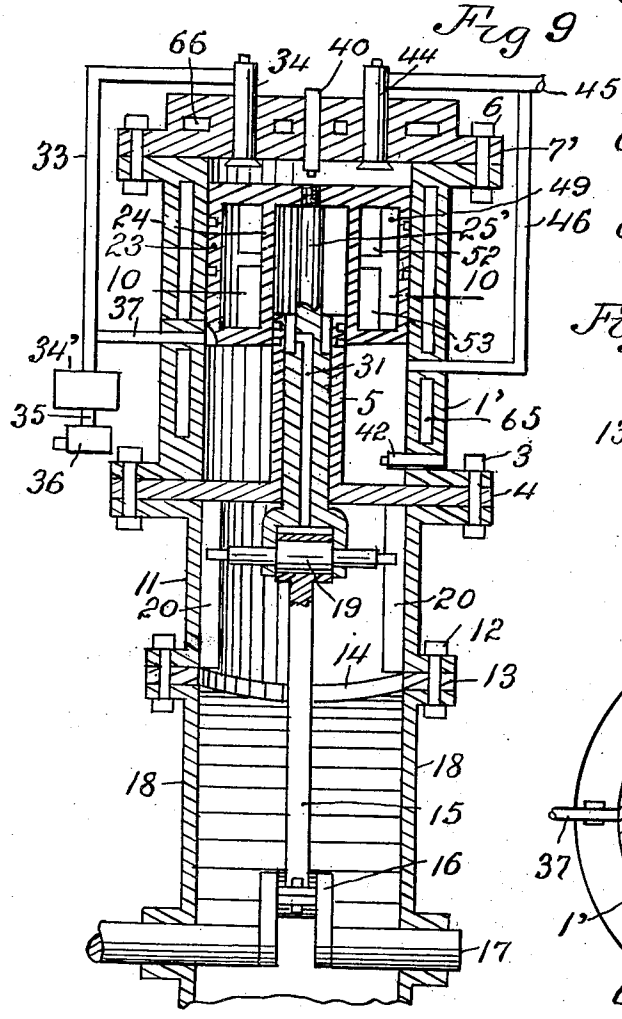



Fig 11

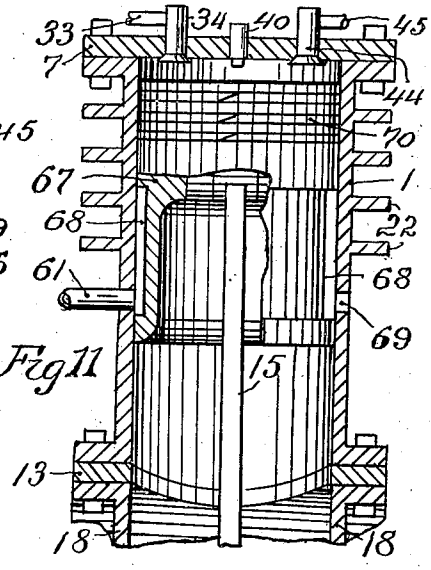
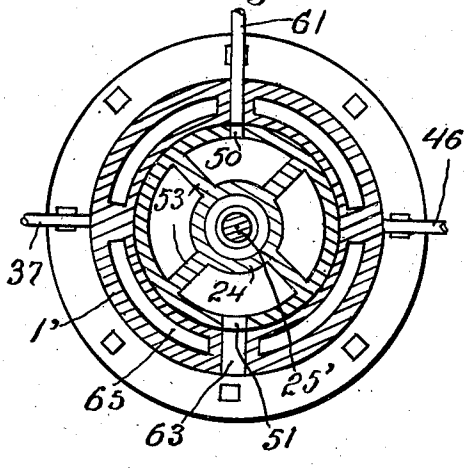



Fig 10




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Fig 12

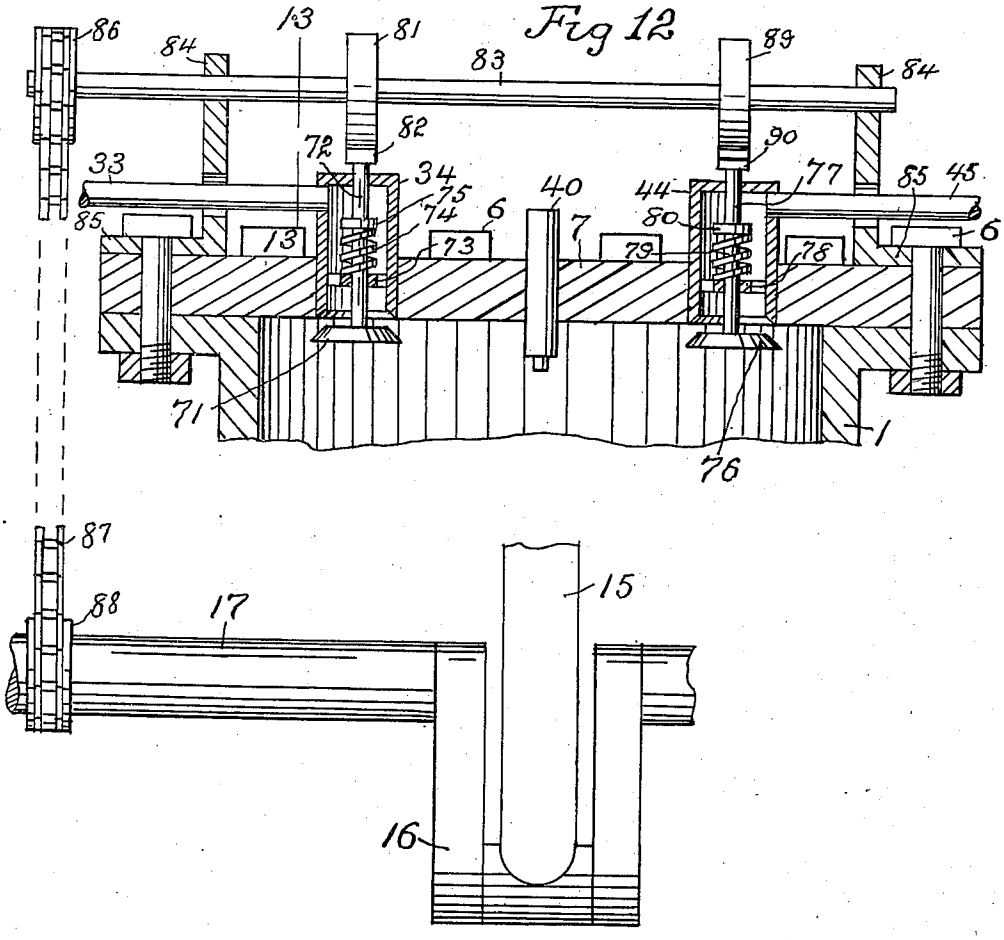
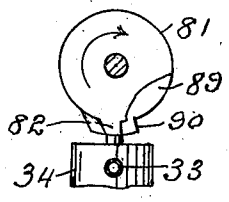



Fig 13




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Patented Mar. 20, 1945 2,371,911

# UNITED STATES PATENT OFFICE

2,371,911

## INTERNAL-COMBUSTION ENGINE

Edmund Hale O'Brien, Kansas City, Mo.

Application July 30, 1943, Serial No. 496,816

5 Claims. (Cl. 123—57)

My invention relates to improvements in internal combustion engines.

It relates particularly to engines of the two cycle reciprocating piston type, and is well adapted for use in propelling airplanes.

The novel features of my invention are applicable to engines of the single piston type or to the multiple piston type having cylinders arranged in tandem with the pistons attached to a single connecting rod through a single piston rod.

The object of my invention is the provision of a novel engine of the kind described, which is simple, strong, durable, not likely to get out of order, which exerts a maximum of power with a minimum of material in its construction, and which is efficient in its operation.

Another object of my invention is the provision of novel means for heating or cooling the parts exposed to the heat resulting from the exploded charges.

Still another object of my invention is the provision of a novel arrangement of the fuel supply, ignition and exhaust mechanism.

The novel features of my invention are hereinafter fully described and claimed.

In the accompanying drawings, which illustrate my invention,

Fig. 1 is a central longitudinal vertical sectional view of the form of my invention provided with cylinders arranged in tandem, showing the pistons at the lower end of their stroke, with some parts omitted.

Fig. 2 is an outside elevation of what is shown in Fig. 1.

Fig. 3 is a section on the line 3—3 of Fig. 1.

Fig. 4 is a longitudinal vertical sectional view of what is shown in Fig. 1, showing the parts as positioned when the piston heads are at the upper end of their stroke.

Fig. 5 is a view of the structure shown in Fig. 4, but in a direction at right angles thereto, parts being shown in longitudinal vertical section, and other parts in side elevation, the parts being positioned as when the piston heads are at the upper end of their stroke.

Fig. 6 is a longitudinal vertical sectional view, with the parts positioned as shown in Fig. 4 and Fig. 5, viewed in the same direction as in Fig. 5.

Fig. 7 is a cross section on the line 7—7 of Fig. 6.

Fig. 8 is a section on the line 8—8 of Fig. 6.

Fig. 9 is a longitudinal vertical sectional view of a modified form of my invention employing but one explosion cylinder and one piston head.

Fig. 10 is a section on the line 10—10 of Fig. 9, parts being omitted.

Fig. 11 is a side view, partly in vertical section and partly in vertical section of another modification of my invention.

Fig. 12 is an enlarged view showing the upper part of the upper cylinder, of the type, shown in Fig. 1, shown in vertical section; a part of the crank shaft, in side elevation; the intake and exhaust valves being shown in vertical section in the open positions; and the mechanism for opening said valves, shown mounted on the cylinder head and connected with the crank shaft, some parts in vertical section, others in side elevation, and parts omitted.

Fig. 13 is a section on the line 13—13 of Fig. 12, a portion of intake cam being broken away.

Similar characters of reference designate similar parts in the different views.

Referring first to the form of my invention shown in Figs. 1 to 8, 1 and 2, Fig. 6, designate respectively an upper explosion cylinder and a lower explosion cylinder, longitudinally alined and having fastened to and between them by bolts 3 a head 4 common to both.

The head 4 has a tubular extension 5 extending into and concentric with the cylinder 1 and having open ends. The upper end of the cylinder 1 has fastened to it by bolts 6 a head 7.

The lower end of the lower cylinder 2 has a head 8 provided with a tubular extension 9, open at its ends, and extending into and concentric with the cylinder 2.

The head 8 is fastened by bolts 10 to the cylinder 2 and to the upper end of cross head guide supporting means comprising a vertical cylinder 11, the lower end of which is fastened by bolts 12 to the periphery of a horizontal cylindrical crank case 13, having a peripheral opening 14 registering with the cylinder 11 and through which extends a connecting rod 15 pivoted to the crank 16 of a crank shaft 17 rotatable in and extending through heads 18 at the ends of the crank case 13.

A wrist pin 19 is reciprocative at its ends respectively between two pairs of cross head guides 20 fastened to opposite inner sides of the cylinder 11. The connecting rod 15 is pivoted to the wrist pin 19, adjacent to the middle thereof, and the wrist pin is parallel with the crank shaft 17.

The explosion cylinders 1 and 2 are shown as being air cooled, each being provided with spaced apart annular peripheral flanges 22.

A piston head 23 is reciprocatively fitted in the explosion cylinder 1, and is provided with an in-

ner cylinder 24, open at its lower end and tightly reciprocatively fitted on the tubular extension 5. The upper end of the inner cylinder 24 is closed and has attached to it the upper end of the upper part 25 of a two part piston rod, the lower part 26 of which has its upper end screwthreaded and fitted in a threaded opening 27 in the lower end of the part 25. The part 25 of the piston rod extends downwardly through the inner cylinder 24, its lower portion being of enlarged diameter and snugly reciprocatively fitted in the inner cylinder 24. The lower part 26 of the piston rod is reciprocative through the tubular extension 9, and has its lower end provided with a U shaped bearing 28 operatively engaging the wrist pin 19 at opposite sides of the connecting rod 15.

Reciprocatively fitted in the lower cylinder 2 is another piston head 29, the upper end of which is integrally connected to and reciprocative with the lower end of the upper part 25 of the piston rod. The piston head 29 has an inner cylinder 30 reciprocatively snugly fitted on the tubular extension 9. The piston heads 23 and 29 move simultaneously in like directions with the piston rod 25—26. To prevent air pressure resistance in the inner cylinders 24 and 30 during the reciprocation of the piston heads 23 and 29, an air passage 31 provided in the parts 25 and 26 of the piston rod, communicates at its upper end with the inner cylinder 24, through the tubular extension 5, and at its lower end with the interior of the cylinder 11. An opening 32 in the side of the portion 26 communicates with the passage 31 and with the inner cylinder 30 of the piston head 29.

For simultaneously supplying explosive charges to the explosion cylinders 1 and 2 at like ends of the piston heads 23 and 29, a supply conductor 33 is connected at one end to an intake valve 34 in the cylinder head 7, Fig. 12. The other end of the conductor 33 is connected to a compressor 34', which is connected by a pipe 35 to a carburetor 36, which is supplied by any suitable means, not shown, with explosive material.

A branch pipe 37 from the conductor 33 communicates with the interior of the explosion cylinder 1 at a point where it will discharge into the cylinder 1 below the piston head 23, when the latter is at the end of its upper stroke, as in Fig. 4.

Another branch pipe 38 from the conductor 33 communicates with the interior of the explosion cylinder 2 at a point where it will discharge into cylinder 2 below the piston head 29, when the latter is at the upper end of its stroke, as in Fig. 4.

A third branch pipe 39 from the conductor 33 communicates with the explosion cylinder 2 at a point where it will discharge into the cylinder when the piston head 29 is in the lowermost position, shown in Fig. 1. The intake valve 34 has controlling means, shown in Figs. 12 and 13, for causing it to open when the piston head 23 is in the lowermost position, shown in Fig. 1.

A spark plug 40 is mounted in the cylinder head 7, and another spark plug 41 is extended through the wall of the cylinder 1 below the stroke of the piston head 23.

Two spark plugs 42 and 43 are extended through the wall of the cylinder respectively above and below the limits of the stroke of the piston head 29.

An exhaust valve 44, see Fig. 12, is mounted in the cylinder head 7 for exhausting the spent gas from above the piston head 23, when the latter is in the lower position, shown in Fig. 1. The valve 44 discharges into a conductor 45 to which is connected a conductor 46, the other end of which communicates with the interior of the explosion cylinder 2, when the piston head 29 is in the upper position, shown in Fig. 4.

An exhaust branch pipe 47 from the conductor 46 communicates with the cylinder 1 at a point below the piston head 23, when the latter is in the upper position, shown in Fig. 4.

Another exhaust branch pipe 48 from the conductor 46 communicates with the cylinder 2 at a point above the piston head 29, when the latter is in the lower position, shown in Fig. 1.

Means accessory to the annular peripheral flanges 22 on the cylinders 1 and 2 are provided for cooling the said cylinders and the parts therein. Referring to Figs. 6, 7 and 8, the inner cylinder 24 of the piston head 23 is encircled by a chamber 49 having an air intake opening 50 extending through the peripheral wall of the piston head. An air discharge opening 51 is provided in the piston head wall diametrically opposite to the intake opening 50, Fig. 6.

In the chamber 49 is an upper row of radial partitions 52 extending from the inner cylinder 24 to the peripheral wall of the piston head 23. In the chamber 49 below the partitions 52 is another row of partitions 53, respectively alined with but spaced from the partitions 52, so as to form air passages.

Correspondingly, the piston head 29 has a chamber 54 encircling the inner cylinder 30 and provided with an air intake passage 55 extending through the peripheral wall of the piston head 29, which wall has in it, diametrically opposite from the opening or air passage 55, an air discharge passage or discharge opening 56.

In the chamber 54 are also provided upper radial partitions 57 extending from the inner cylinder 30 to the peripheral wall of the piston head 29. Below and spaced from the partitions 57 are partitions 58 respectively parallel with the partitions 57.

When the piston heads 23 and 29 are at the limit of their upper stroke, as shown in Fig. 6, the air intake openings 50 and 55 register with two openings 59 and 60 in the side walls of the explosion cylinders 1 and 2, in which last two named openings are tightly respectively fitted the ends of an air conducting pipe 61, which is supplied by air under pressure by a blower 62.

When the piston heads 23 and 29 are at the limit of their upper stroke, as shown in Fig. 6, the discharge openings 51 and 56 respectively register with two discharge openings 63 and 64 provided through the walls of the cylinders 1 and 2 respectively.

Thus once during each reciprocation of the piston heads 23 and 29, cool air under pressure is forced by the blower 62 through the air pipe 61, intake openings 50 and 55, chambers 49 and 54, discharge openings 51 and 56, and through discharge openings 63 and 64 to the atmosphere, whereby the engine is internally thoroughly cooled.

In the operation of the engine, assuming the parts to be in the positions shown in Figs. 4 and 5, with the piston heads 23 and 29 in their uppermost positions, and explosive charges respectively in the cylinders 1 and 2 above the piston heads 23 and 29, the spark plugs 4 and 42 are operated to explode the charges, fresh charges, having just previously been admitted into the cylinders 1 and

2, below the piston heads 23 and 29, through the supply branch pipes 37 and 38.

The exploded charges above the piston heads 23 and 29 force them downwardly with the piston rod 25—26 to the lowermost position shown in Fig. 1, compressing the charges below the piston heads, at which time the exploded charges above the piston heads 23 and 29 escape through the exhaust valve 44 and the exhaust pipe 48, at which time fresh charges enter the cylinders 1 and 2 through the intake valve 34 and the supply pipe 39.

The spark plugs 41 and 43 are then operated to explode the compressed charges under the piston heads, forcing the latter upwardly, with the piston rod 25—26, and compressing the charges above the piston heads, thus completing a cycle.

As has been explained, when the piston heads 23 and 29 reach the upper position shown in Figs. 4 and 6, cool air is discharged through the chambers 49 and 54.

While in the drawings, but one set of explosion cylinders 1 and 2 is shown mounted in tandem on the periphery of the cylindrical crank case 2, one or more duplicates of this structure may be similarly mounted thereon, disposed in the same transverse plane as this one, and in spaced radial positions.

In Figs. 9 and 10, is shown a modification of my invention, in which but one explosion cylinder, 1' and one piston head 23 are employed. The cylinder 1' corresponds to the cylinder 1 of the other form of my invention, excepting that it is shown as having an annular peripheral chamber 65 containing water for water cooling. The upper cylinder head 7' also contains chambers 66 holding water for water cooling.

The lower cylinder head 4 corresponds to the cylinder head 4 of the other form of my invention, and is provided with an inward tubular extension 5 snugly reciprocatively fitted in an inner cylinder 24 provided in a piston head 23 reciprocative in the cylinder 1'.

The cylinder head 4 is fastened by bolts 3 to the lower end of the explosion cylinder 1', and to the upper end of a vertical tubular cylinder 11 having on its inner side diametrically opposite pairs of cross head guides 20. As in the other form of my invention, the lower end of the cylinder 11 is fastened by bolts 12 to the periphery of a crank case 13 having a peripheral opening 14 registering with the interior of the cylinder 11.

A wrist pin 19 having its ends reciprocatively engaging the guides 20 has pivoted to it one end of a connecting rod 15, the other end of which is pivoted to the crank 16 of a crank shaft 17 rotatably mounted in the heads 18 of the crank case 13.

A piston rod 25' is fastened at its upper end to the upper closed end of the inner cylinder 24, and extends through said inner cylinder and through the tubular extension 5.

The lower end of the piston rod 25' is bifurcated and operatively engages the wrist pin 19. The piston rod 25' is provided with a longitudinal air passage 31 communicating with the interior of the inner cylinder 24 and with the interior of the cylinder 11.

The cylinder head 7' has mounted in it an intake valve 34 and an exhaust valve 44. An air conductor 33 is connected to the intake valve 34 and to a compressor 34', connected by a pipe 35 to a carburetor 36, as in the other form of my invention.

A branch pipe 37 from the conductor 33 extends through the side wall of the cylinder 1' at a point where it will discharge into said cylinder below the piston head 23, when the latter is in the upper position, shown in Fig. 9.

A spark plug 40 in the head 7' extends into the cylinder 1' above the limit of the stroke of the piston head 23. A spark plug 42 extends through the side wall of the cylinder 1' below the lower end of the stroke of the piston head 23.

Connected with the exhaust valve 44 is a discharge pipe 45 to which is connected an exhaust pipe 46 which extends through the side wall of the cylinder 1' at a point below the piston head 23 when the latter is at the upper end of its stroke.

The piston head 23 has the chamber 49 between the inner cylinder 24 and the peripheral wall of the piston head 23, and the two rows of radial partitions 52 and 53, as in the other form of my invention, and the same means are provided for supplying cold air to the chamber 49, as in the other form of my invention.

The operation of the piston head 23 and parts connected therewith, and the operations of supplying charges of propelling fluid to the cylinder 1' and the compression, exploding and exhausting of the charges, corresponds to those described in connection with the other form of my invention.

In both forms of the invention, shown in Figs. 4 and 9, the engines have been described as being operated above and below the piston heads on the two cycle type, however, if desired, the engines may each be operated above the piston head on the four cycle type, by employing the usual type of mechanism for operating the intake valve 34 and the exhaust valve 44, and the spark plug 40 on the four cycle type. In such operation, when the piston head 23 moves downwardly, the intake valve 34 will be opened and the exhaust valve 44 closed, thus admitting an explosive charge into the explosion cylinder above the piston head 23.

When the piston head 23 moves upwardly, the charge above the piston head will be compressed, the valves 34 and 44 being closed during such upward movement. When the piston head reaches the uppermost position, shown in Figs. 4 and 9, the spark plug 40 will be operated to explode the compressed charge, thus forcing the piston head downwardly. On the up stroke, the intake valve will be closed and the exhaust valve opened, thus exhausting the exploded charge and completing the cycle.

During this four cycle type of operation, the engines, below the piston heads will operate on the two cycle type.

When the engines are used in very cold climates, or flown at very high altitudes, the blower 62 may be employed to force a heating fluid, as hot air, through the pipe 61, through the explosion cylinder walls and against and through the piston heads to heat, instead of cooling the cylinders and piston heads, to the proper best operating temperatures.

In the modified form of my invention, shown in Fig. 11, is shown a portion of a usual single cylinder, single piston head four cycle type of explosive engine provided with a mechanism of my invention adapted for discharging a heating or cooling fluid, as hot or cold air, through the explosion cylinder wall, against and around the piston head again through the cylinder wall to the atmosphere.

Referring to Fig. 11, 1 designates the explosion

cylinder side wall, corresponding to the cylinder wall 1, shown in Fig. 4, having the upper head 7 in which are mounted the intake valve 34, the exhaust valve 44 and the spark plug 40, said valves and spark plug having the usual means for operating them on the four cycle type.

The piston head 67 has pivoted to it in usual manner one end of a usual connecting rod 15, the other end of which is pivoted to the crank 16 of the driven crank shaft 17, mounted in the heads 18 of a crank case 13, as shown in Fig. 9. The lower end of the explosion cylinder 1 is bolted in the usual manner to the crank case 13.

The side wall of the explosion cylinder 1 is provided therethrough with an opening in which is tightly fitted the discharge end of a pipe 61 connected to a blower 62, as shown in Fig. 6, for supplying a temperature controlling fluid, as hot or cold air to an annular groove 68 provided in the periphery of the piston head 67, and communicating with the discharge end of the pipe 61 and with an opening 69 through the cylinder wall 1 communicating with the atmosphere diametrically opposite the cylinder wall opening in which is fitted the discharge end of the pipe 61.

The heating or cooling fluid which is discharged through the pipe 61, annular groove 68 and discharge opening 69, is of such temperature as will retain the piston head 67 at the proper operating temperature. The cylinder wall 1 may be provided also with the usual peripheral flanges 22 for cooling the cylinder by contact with the external atmosphere.

The annular groove 68 is disposed in the periphery of the piston head 67 so as to be in constant communication with the pipe 61, and the pipe 61 is located below the limit of stroke downward of the usual piston rings 70 disposed in the upper peripheral portion of the piston head 67.

In Figs. 12 and 13, is shown mechanism for operating the intake valve 34 and the exhaust valve 44 on a two cycle basis.

The intake valve comprises a tubular cylindrical casing 34, closed at its upper end and having an open lower end inwardly beveled, and adapted to have seated therein the beveled edge of a valve disk 71 for closing the intake valve.

A valve stem 72, fastened at its lower end centrally to the upper side of the valve disk 71, extends upwardly through and is vertically slidable in a vertical hole through a transverse guiding member 73 having a notched perimeter fastened to the inner wall of the casing 34. The valve stem 72 extends upwardly from the guiding member 73 to and through a central vertical hole in the closed upper end of the casing 34, in which hole the stem 72 is snugly slidably fitted, so as to project at all times above the top of the casing 34.

For normally forcing the valve disk 71 upwardly to its closed position, shown in Fig. 1, a coil spring 74 encircles the stem 72 and bears at its lower end against the upper side of the guiding member 73, the upper end of the spring bearing against the under side of a collar 75 fastened on the stem 72. The tension of the spring 74 normally forces the valve disk 71 to the closed position against the lower end of the casing 34. The lower portion of the valve casing 34 extends through and is tightly fitted in a vertical hole in the cylinder head 7. The supply conductor 33 has its discharge end tightly fitted in an opening in one side of the casing 34 near the upper end thereof, as shown.

The construction of the exhaust valve 44 and its mode of operation corresponds to that of the intake valve 34, just described.

The exhaust valve is provided with a disk valve 76, a valve stem 77, a guiding member 78, a coil spring 79 and a collar 80, which correspond in structure and mode of operation to the disk valve 71, stem 72, guiding member 73, coil spring 74 and collar 75 of the intake valve, just hereinbefore described.

For opening the intake valve disk 71, a cam 81 having a tooth 82 on its periphery, for engaging and depressing the valve stem 72, is rigidly mounted on a horizontal shaft 83 rotatably mounted in the vertical portions 84 of two L shaped bearings having horizontal portions 85 resting on the top of the cylinder head 7, to which they are respectively fastened by two diametrically opposite ones of the bolts 6 located in the vertical central plane of the valve casings 34 and 44.

For revolving the shaft 83 once during each revolution of the crank shaft 17, a sprocket wheel 86 rigidly fastened on the shaft 83 is connected by a sprocket chain belt 87 with a sprocket wheel 88, of the diameter of the sprocket wheel 86, rigidly fastened on the crank shaft 17.

For depressing the valve stem 77 of the exhaust valve, a cam 89 is rigidly fastened on the shaft 83, and has a tooth 90 positioned to engage the upper end of the valve stem 77 during a revolution of the crank shaft 17 and of the shaft 83.

As shown in Fig. 13, the cam tooth 90 first engages the valve stem 77 and depresses said stem, after which, while it is so engaged, the tooth 82 of the cam 81 engages and depresses the valve stem 72. These engagements are timed so that, when the crank shaft is at the limit of its down stroke, both disk valves 71 and 76 will be in the open positions shown in Fig. 12, so that a charge of explosive mixture enters the cylinder 1, above the upper piston 23 through the conductor 33 and intake valve casing 34, while exhaust gas is passing from the cylinder through the valve casing 44 and the discharge conductor 45.

The piston 23 in its upward movement compresses the charge which has entered the cylinder 1 above the piston, as described, the exhaust gas above the piston will be discharged, and the compressed new charge will be ignited by the spark plug 40, upon which the piston will be forced downwardly, the valves 71 and 76 being closed at the time. This completes the cycle.

Other modifications of my invention, within the scope of the appended claims, may be made without departing from the spirit of my invention.

What I claim is:

1. In an explosive engine, an explosion cylinder having end heads, one of which has a tubular inward extension open at its ends, a piston head reciprocative in said cylinder and having an inner cylinder with an open end in which said extension is tightly reciprocatively fitted, the other end of said inner cylinder being closed, said piston head having a chamber encircling said inner cylinder, a piston rod attached to said closed end and extending through said inner cylinder and said extension, means by which a fluid may be admitted into and discharged from said chamber, and means for admitting propelling charges into and exhausting them from said explosion cylinder at opposite ends of said piston head.

2. In an explosive engine, in combination with a crank case having cross head guide supporting means, cross head guides on said supporting means, a wrist pin operatively engaging said guides, a crank shaft rotative in said crank case,

and a connecting rod connecting said wrist pin with said crank shaft, of an explosion cylinder having end heads, one having an inward tubular extension, means supporting said cylinder on said supporting means, a piston head reciprocative in said cylinder and having an inner cylinder tightly reciprocatively fitted on said tubular extension, and a piston rod attached to said piston head and extending through said inner cylinder and said tubular extension and operatively engaging said wrist pin.

3. In an explosive engine, two longitudinally alined explosion cylinders, each having end heads, the head of one cylinder forming the head at the adjacent end of the other cylinder and having a tubular inward extension open at its ends, the other head of said other cylinder also having a tubular inward extension open at its ends, two piston heads respectively reciprocative in said cylinders and having each an inner cylinder tightly reciprocatively fitted on the adjacent one of said tubular extensions, a piston rod integrally connected with said piston heads and extending through said inner cylinders and said tubular extensions and tightly reciprocatively fitted in said first named tubular extension, each of said piston heads having a chamber encircling its inner cylinder, and means by which a temperature controlling fluid may be admitted into and discharged from said chambers.

4. In an explosive engine, two longitudinally alined explosion cylinders each having end heads, the head of one cylinder forming the head at the adjacent end of the other cylinder and having a tubular inward extension open at its ends, the other head of said other cylinder also having a tubular inward extension open at its ends, two piston heads respectively reciprocative in said cylinders and having each an inner cylinder tightly reciprocatively fitted on the adjacent one of said tubular extensions, a piston rod integrally connected with said piston heads and extending through said inner cylinders and said tubular extensions and tightly reciprocatively fitted in said first named tubular extension, means for admitting propelling charges into and exhausting the spent charges from said explosion cylinders simultaneously at like ends of said piston heads, each of said piston heads having a chamber encircling its inner cylinder, and means by which a temperature controlling fluid may be admitted into and discharged from said chambers.

5. In an explosive engine, in combination with a crank case having cross head guide supporting means, cross head guides on said supporting means, a wrist pin operatively engaging said guides, a crank shaft rotative in said crank case, and a connecting rod connecting said wrist pin and said crank shaft, of two longitudinally alined explosion cylinders each having end heads, the head of one cylinder forming the head at the adjacent end of the other cylinder and having a tubular inward extension open at its ends, the other head of the other cylinder being supported by said supporting means and also having a tubular inward extension open at its ends, two piston heads respectively reciprocative in said cylinders and having each an inner cylinder tightly reciprocatively fitted on the adjacent one of said tubular extensions, and a piston rod integrally connected with said piston heads and extending through said inner cylinders and said tubular extensions and tightly reciprocatively fitted in said first named tubular extension, and operatively engaging said wrist pin.

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