G. K. DAVOL.

INTERNAL COMBUSTION ENGINE.

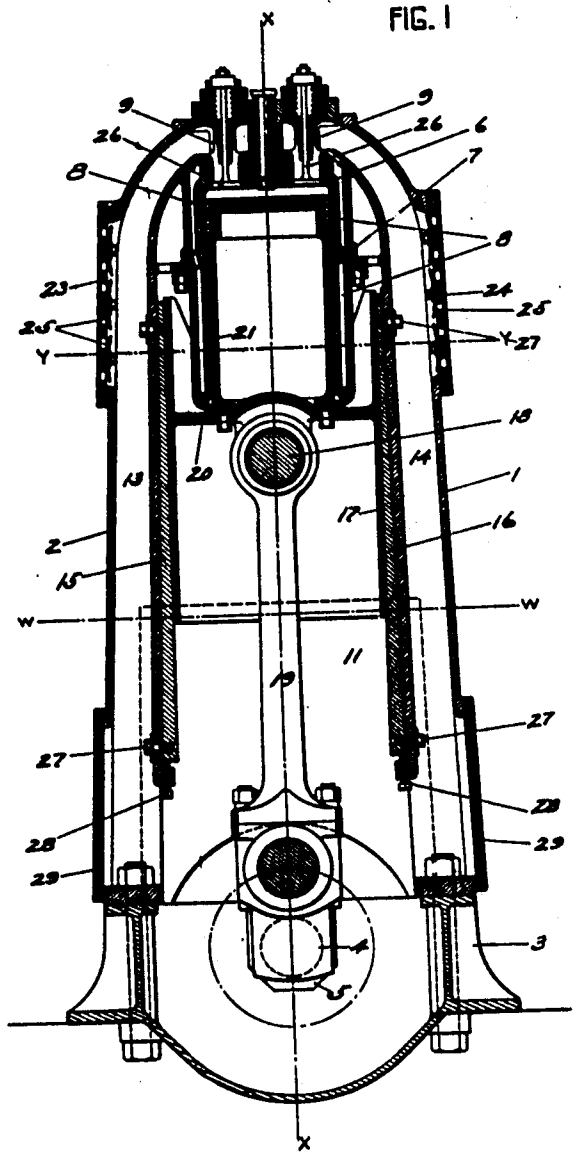
APPLICATION FILED NOV. 12, 1912.

1,194,722.

Patented Aug. 15, 1916.

3 SHEETS—SHEET 1.

FIG. 1




WITNESSES

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3 SHEETS—SHEET 2.

FIG. 2

FIG. 3

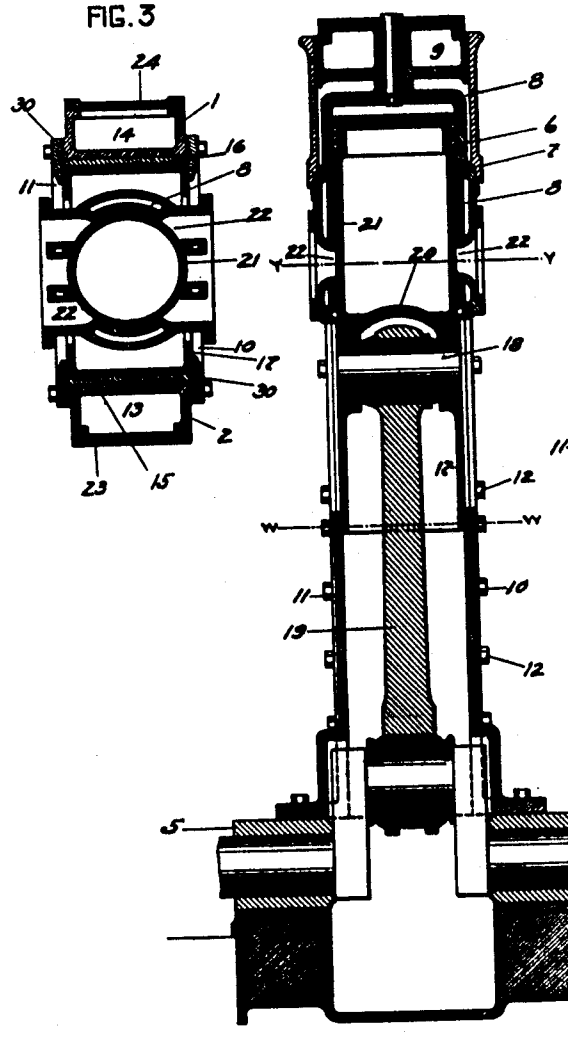
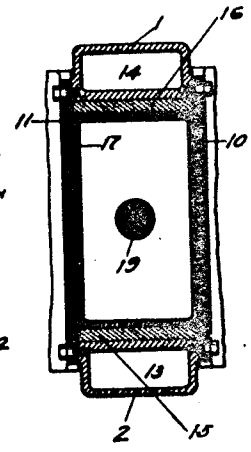



FIG. 4




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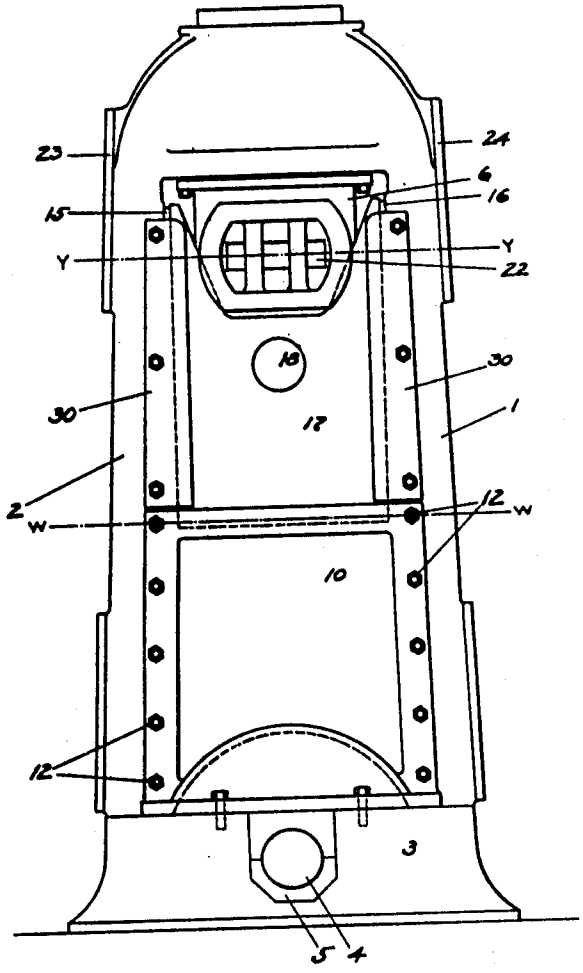
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3 SHEETS—SHEET 3.

FIG. 5




WITNESSES

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# UNITED STATES PATENT OFFICE.

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## INTERNAL-COMBUSTION ENGINE.

1,194,722. Specification of Letters Patent. Patented Aug. 15, 1916.

Application filed November 12, 1912. Serial No. 730,884.

*To all whom it may concern:*

Be it known that I, GEORGE K. DAVOL, a citizen of the United States, residing in the city and county of San Francisco, in the State of California, have invented a new and useful form of Internal-Combustion Engine, of which the following forms a specification.

My invention has particular reference to internal combustion engines operating on the two-stroke cycle. It provides a means of utilizing the crank chamber for the compression of the scavenging air without rendering the engine parts inaccessible and is a way to supply an exceptionally large volume of scavenging air. It permits of the scavenging air being compressed without bringing it in contact with lubricated surfaces. It provides for a very efficient means of supporting and guiding the working piston and presents a simple, light, and mechanically advantageous design. These and many other important ends are attained by my invention.

In the accompanying drawings: Figure 1 shows a section taken through the center of the engine in a plane perpendicular to the axis of the crank shaft. Fig. 2 shows a section taken through the center of the engine in the plane of the axis of the crank shaft or on line X—X, Fig. 1. Fig. 3 shows a cross section taken on line Y—Y, Figs. 1, 2 and 5. Fig. 4 shows a cross section taken on line W—W, Figs. 1, 2 and 5. Fig. 5 shows an end external view of the engine.

Similar parts are designated by the same reference numbers in all the drawings. Some minor parts are not shown in all the drawings.

Referring to the drawings, the frame of the engine comprises two side columns 1 and 2 joined at their upper ends and secured at their lower ends to the engine base 3, on opposite sides of the crank shaft 4. The crank shaft 4 is carried by the bearings 5 held in the base, the top surface of the bearings being faced off level with the top surface of the base. The bearings are fitted to make air tight connections with the base.

The upper end of the frame where the two side columns join, takes a cylindrical form and is bored vertically to receive the working cylinder 6. The cylinder 6 is pushed into this bored hole in the frame from below until the shoulder 7 bears against the frame. This shoulder takes the cylinder thrust. The cylinder 6 has tight contact with the bore in the frame throughout the circumference at its upper end, and at a point between the upper and lower ends. In this way an inclosed space 8 is provided between the frame and cylinder, forming a water jacket, while the open space 9 in the cylinder head is connected to the passages in the frame opening into this central bore.

The two side columns 1 and 2, extending downward from the upper portion of the frame have the whole or a portion of their two sides which face the ends of the crank shaft, faced off to form plane surfaces perpendicular to the axis of the crank shaft, and the two columns are preferably of the same width in the direction of the axis of the crank shaft, as is shown in the drawings. Further, the side of either of the two columns which faces either end of the crank shaft lies in the same plane with the corresponding side of the opposite column.

Two flat surfaced end plates, 10 and 11, are secured to the lower ends of the two columns by fitted bolts or by bolts and dowels 12, and so connect the opposite columns. These end plates have their lower edge or side in contact with the upper face of the base, and may be secured to the base by bolts or not, as desired; they must, however, make contact or connection or joint with the base and tops of the bearings, 5, sufficiently tight to hold the pressure of the scavenging air.

Actual metallic contact between end plates 10 and 11, and top surfaces of base and bearings is not an absolute necessity, as a slight clearance packed with rubber or otherwise will effect the same ends, the essential requirement being that an air tight joint may be made between these parts, which is most simply made by actual contact. It is now seen that the base and bearings together with the two side columns and the two end plates form an inclosed crank chamber open only at the top.

The two columns 1 and 2 are hollow and form passages 13 and 14, which connect the crank chamber with the central bore in the upper end of the frame, or when the cylinder 6 is in place, with the air passage 9 within the cylinder head.

The two columns have their two inner opposing surfaces faced off to present two planes preferably converging toward each

other at their upper ends, and against these two surfaces are held two slides 15 and 16, which are wedge shaped or thinner at their upper ends than at their lower ends. By making the angle of convergence of the surfaces of the columns the same as that of the wedge shaped slides, the inner or opposing faces of the slides when in place will present two parallel vertical planes. These slides 15 and 16 are made the same width as that of the columns against which they are held, so that the end plates 10 and 11 secured to the columns are also substantially in contact with the slides. The contact between the end plates and the columns and between the end plates and the slides is sufficiently close to be substantially air tight against the pressure of the scavenging air. It is now seen that the inner surfaces of the two slides 15 and 16, together with the inner faces of the two end plates 10 and 11, form a vertical passage of uniform rectangular cross section, opening from above into the crank chamber, and in this passage or guide so formed reciprocates the cross head 17.

The cross head 17 is of rectangular cross section and fits and fills the section of the guide as shown in Fig. 4 and acts as a plunger or piston to compress the scavenging air within the crank chamber. The cross head 17 carries the wrist pin 18 which engages with the connecting rod 19 which in turn has the usual connection to the crank on the crank shaft 4.

The inner faces of the columns 1 and 2 may, of course, be finished to present vertical surfaces and the slides 15 and 16 omitted, but this would be at a considerable sacrifice, as the slides allow of adjustment for wear and inaccurate workmanship and also serve the important purpose of centering or adjusting the position of the piston within the cylinder.

It is of course not essential that the contacting surfaces of the slides with the columns and with the cross head be plane surfaces although this is my preferred form; cylindrical or other forms of surfaces could be employed without departing from the essentials of my invention.

The cross head 17, which is closed midway in its length by the diaphragm 20, carries the working piston or plunger 21, rigidly attached to the diaphragm by bolts or otherwise. The upper part of the cross head 17 is formed by two side extensions which extend upon opposite sides of the piston or plunger 21, and so reduce the "overhang" or distance which the end of the piston or plunger extends beyond the end of the cross head. This feature is important as the piston is in this way guided with greater accuracy than if the cross head terminated, for example, at the diaphragm 20. These side extensions of the cross head reciprocate on the slides 15 and 16 within the spaces between the cylinder 6 and the columns 1 and 2. Thus the cylinder 6, extending down between the slides and columns together with the cross head having sides extending up on both sides of the cylinder and carrying the working piston or plunger between the extensions, makes an important and effective combination. The piston or plunger is thus rigidly held and guided to reciprocate within the cylinder 6, and if reasonable clearances be provided there need be no actual contact between the rigid body of the piston and the rigid walls of the cylinder, and the necessary gas tightness or working fits between piston and cylinder, will be secured by other means, as for example by the usual elastic packing rings as shown in Figs. 1 and 2.

Near the lower end of the cylinder 6, exhaust openings or ports 22, Figs. 2 and 3, are provided in the walls of the cylinder, which ports are overrun or uncovered by the piston at the lower end of its stroke. These exhaust ports open on opposite sides of the cylinder and connect with exhaust passages, to accommodate which the sides of the cross head are cut away as is shown clearly in Fig. 5.

Near the upper end of the passages 13 and 14, in the columns 1 and 2, openings are provided which are closed by the suction valve plates 23 and 24. These plates have openings through them which are covered by the flap valves 25, which are shown in Fig. 1, partly open. These suction flap valves permit air to enter the passages 13 and 14 from the outside but prevent passage of air in the opposite direction.

The slides 15 and 16 are secured to the columns by the bolts 27, which pass through large holes in the column sides allowing vertical movement to the slides. The slides are adjusted by the vertical screws 28 bearing against their lower edges.

Inspection doors 29 are placed in each of the columns 1 and 2.

Guide strips 30 are attached to the columns above the end plates and assist in guiding the cross head.

I will now describe the action of the engine: On the rising stroke of the piston and cross head, a partial vacuum is formed in the crank chamber and passages 13 and 14. This causes the external air to open the suction valves 25 and enter the passages 13 and 14. The cubic capacity of these passages is so proportioned that the charge of air so drawn in does not enter the crank chamber at all, as the said passages in the columns are large enough to hold the entire amount. On the descending stroke of the piston and cross head, the valves 25 close and the air entrapped within the crank chamber and passages 13 and 14 and connecting the space 9

within the cylinder head, is slightly compressed. During this downward stroke, the working gases within the cylinder 6, expand and at the lower end of the stroke are released and exhausted through the ports 22. The scavenging valves 26 in the cylinder head are then opened by a suitable means not shown, and communication established between the working cylinder and the air passages 9. The air compressed within the crank chamber and column passages 13 and 14, then expands and rushes through the scavenging valves 26 and the cylinder, scavenging out the cylinder and charging it for the next compression or up stroke of the piston. The air so rushing through the scavenging valves consists only of that air drawn through the suction valves 25 into the side passages 13 and 14. The air which actually filled the crank chamber expands only sufficiently to approximately fill the passages 13 and 14, but not sufficiently to enter the extreme end of the passages 13 and 14, or the cylinder head passages 9. On the succeeding upward stroke of the cross head 17, this same air is again drawn back into the crank chamber, being displaced in the passages 13 and 14 by fresh outside air entering through the valves 25. It is thus seen comprehensively that the same body of air remains in the crank chamber and acts as a displacer of the air drawn from the outside into the side passages 13 and 14, being forced back and forth from crank chamber into side passages. This feature is of great advantage as by it the outside scavenging air is kept substantially free from contact with lubricated surfaces during the preliminary compression, so that no dust is carried by it into the crank chambers or into a pump cylinder, and no lubricating oil can be carried by it into the working cylinder; both of which actions have been observed in the operation of other existing internal combustion engines.

On account of the cross head having a cross section of rectangular form which can conveniently be made large, the amount of scavenging air handled can conveniently and with advantage be made large. The bearing surfaces of the cross head on the slides is also conveniently made exceptionally large and subject to easy and efficient adjustment.

The form of the frame of the engine comprising as it does two separate legs or columns having no integral connection above the base and below the upper end of the frame, permits, by removing the end plates 10 and 11, the greatest degree of accessibility to the working parts of the engine. By removing the end plates 10 and 11 and disconnecting the connecting rod, all reciprocating parts, including working piston, can be removed, as can also the crank shaft without disturbing other parts of the engine; and this accessibility is attained with the simplicity attendant upon compression of the scavenging air within the crank chamber.

While I have shown my invention in the particular embodiments herein shown and described, I do not, however, limit myself to these exact constructions, as I may employ any equivalents known in the art without departing from the spirit of my invention.

What I claim is:

1. In an internal combustion engine, the combination of a closed crank chamber in which compression of the air takes place, a base, a frame comprising two columns secured to the base on opposite sides of the crank shaft, and two end plates secured to and connecting the said two columns and making substantially air tight joints with said columns and with said base.

2. In an internal combustion engine, the combination of a closed crank chamber in which compression of the air takes place, a base, a cylinder head, a frame comprising two columns secured to the base on opposite sides of the crank shaft, the two said columns being hollow and forming passages between the crank chamber and the cylinder head, and two end plates secured to and connecting the two said columns and making substantially air tight joints with the base and with said columns.

3. In a substantially vertical internal combustion engine, the combination of a closed crank chamber in which compression of air takes place comprising an engine base, two columns secured at their lower ends to the engine base on opposite sides of the crank shaft, each of said columns having its two side surfaces which face the two ends of the crank shaft lying in two parallel planes approximately perpendicular to the axis of the crank shaft, the said plane surfaces extending from the lower end of the columns where connection with the base is made upward, and two flat end plates secured to said plane surfaces and connecting the two columns and making substantially tight connection with the engine base.

4. In an internal combustion engine, the combination of a closed crank chamber in which compression of the air takes place, said closed crank chamber comprising an engine base, two columns secured to the engine base on opposite sides of the crank shaft, and two end plates secured to and connecting the lower portions of the two said columns, and a cross-head reciprocating in said crank chamber and having a cross-section to fit the space between said columns and between said end plates.

5. In an internal combustion engine, the combination of a closed crank chamber in which preliminary compression of the air takes place, an engine base, two columns secured to the engine base on opposite sides

of the crank shaft, two end plates secured to and connecting the said two columns, two adjustable slides held against the opposing faces of said columns, and a reciprocating cross head or plunger of rectangular cross section moving in contact with said slides and with said end plates.

6. In an internal combustion engine, the combination of a closed crank chamber in which compression of the air takes place, an engine base, a cylinder head, two columns secured to the engine base on opposite sides of the crank shaft, the said two columns being hollow and forming passages between the crank chamber and the cylinder head, two end plates secured to and connecting the said columns, two adjustable slides held between said end plates and against the faces of the said two columns, and a reciprocating cross head or plunger having a cross section to fit and fill the cross section of the space inclosed by the said two slides and the said two end plates.

7. In an internal combustion engine, the combination of a closed crank chamber in which compression of the air takes place, an engine base, two columns secured to the engine base on opposite sides of the crank shaft, two slides held against the inner faces of the columns, the said slides and the said columns being of substantially the same width in the direction of the length of the crank shaft, two end plates secured to and connecting the two said columns and having substantially air tight connection with the engine base, said end plates forming with said slides a tubular passage or cross head guide of rectangular cross section, and a reciprocating cross head or plunger of cross section to fit and fill said tubular guide.

8. In an internal combustion engine, the combination of a closed crank chamber in which compression of air takes place, an engine base, a cylinder head, two columns secured to the engine base on opposite sides of the crank shaft, said columns being hollow and forming passages between the crank chamber and the cylinder head, two slides held against the inner faces of said columns, said slides and said columns being of substantially the same width in the direction of the axis of the crank shaft, two end plates forming substantially air tight joints with the engine base secured to and connecting the two said columns and forming with the two said slides an inclosed cross head or plunger guide of rectangular cross section, and a reciprocating cross head or plunger of cross section to fit and fill said guide.

9. In an internal combustion engine, the combination of a closed crank chamber in which compression of the air takes place, two columns secured to the engine base on opposite sides of the crank shaft, the two inner faces of the said columns converging at an angle, two adjustable slides having the same width as the columns and being held against the inner faces of the columns, and two end plates secured to and connecting the said two columns and making substantially air tight joints with the engine base and forming with said slides an inclosed cross head or plunger guide opening into the crank chamber.

10. In an internal combustion engine, the combination of a closed crank chamber in which compression of the air takes place, comprising an engine base, two columns secured to the engine base on opposite sides of the crank shaft, and two end plates secured to and connecting the said columns, the inner faces of said columns being farther apart at their lower ends than at their upper ends, two adjustable slides held against the inner faces of said columns, and a reciprocating cross head or plunger having a cross section to fit and fill the space inclosed by said slides and said end plates.

11. In an internal combustion engine, the combination of a closed crank chamber in which compression of the air takes place, comprising an engine base, two columns secured to the engine base on opposite sides of the crank shaft, and two end plates secured to and connecting the said two columns, said end plates making substantially air tight joints with the engine base, a piston and a cross head or plunger of rectangular cross section reciprocating between said columns and between said end plates and having rigidly attached to it the working piston of the engine.

12. In an internal combustion engine, the combination of a closed crank chamber comprising an engine base, a cylinder head, two side columns and two end plates, said end plates being secured to and connecting said columns and each of said columns and end plates having substantially air tight connection with the engine base, said columns being hollow and forming passages which open at their lower ends to the crank chamber and at their upper ends communicate with the cylinder head, and suction valves for air opening into the said passages near their upper ends.

13. In an internal combustion engine, the combination of a closed crank chamber in which compression of the air takes place, a tubular cross head or plunger guide of rectangular cross section opening into the said crank chamber, said guide comprising two slides held against the inner faces of two columns on opposite sides of the crank shaft and having the same width as said columns, and two end plates secured to the columns and forming substantially air tight joints with said columns and with said slides, and a reciprocating cross head or plunger of

cross section to fit and fill the cross section of said guide.

14. In a substantially vertical internal combustion engine having a closed crank chamber in which compression of the air takes place, an engine base, a frame comprising two columns secured at their lower ends to the engine base on opposite sides of the crank shaft, the said columns being connected at their upper ends by a part having a cylindrical opening, a working cylinder in said opening, said columns being hollow and forming passages which open at their lower ends to the crank chamber and at their upper ends to said cylindrical opening.

15. In a substantially vertical internal combustion engine having a closed crank chamber in which compression of the air takes place, an engine base, a frame comprising two columns secured at their lower ends to the engine base on opposite sides of the crank shaft, said columns being connected at their upper end by a part having a cylindrical opening, a working cylinder in said opening, said columns being hollow and forming passages which open at their lower ends to the crank chamber and at their upper ends to said cylindrical opening, said working cylinder having air passages in its head in open connection with said cylindrical opening.

16. In a substantially vertical internal combustion engine, the combination of an engine base, a frame comprising two columns secured to the engine base at their lower ends on opposite sides of the crank shaft, and united at their upper ends, a working cylinder secured to the upper end of the frame and extending downward between the two said columns, cross head slides carried by the said columns, a cross head reciprocating on said slides, the upper part of said cross head comprising two extensions which bear on said slides and reciprocate within the spaces between said working cylinder and said columns, and a working piston or plunger rigidly attached to and carried by said cross head between the two said extensions.

17. In an internal combustion engine having a closed crank chamber in which compression of the air takes place, the combination of a base having an upper plane surface, bearing recesses formed in said base, crank shaft bearings set in said recesses, said bearings having their top surfaces flush with said upper surface of the base, and two end plates closing said crank chamber, said end plates making substantially tight joints with said base and with said top surfaces of said bearings.

In witness whereof, I hereunto subscribe my name this 2nd day of November, A. D. 1912.

GEORGE K. DAVOL.

Witnesses:
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G. M. PAGE.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."