Jan. 6, 1931. L. M. WOOLSON 1,788,140

INTERNAL COMBUSTION ENGINE

Filed April 19, 1928 3 Sheets-Sheet 1

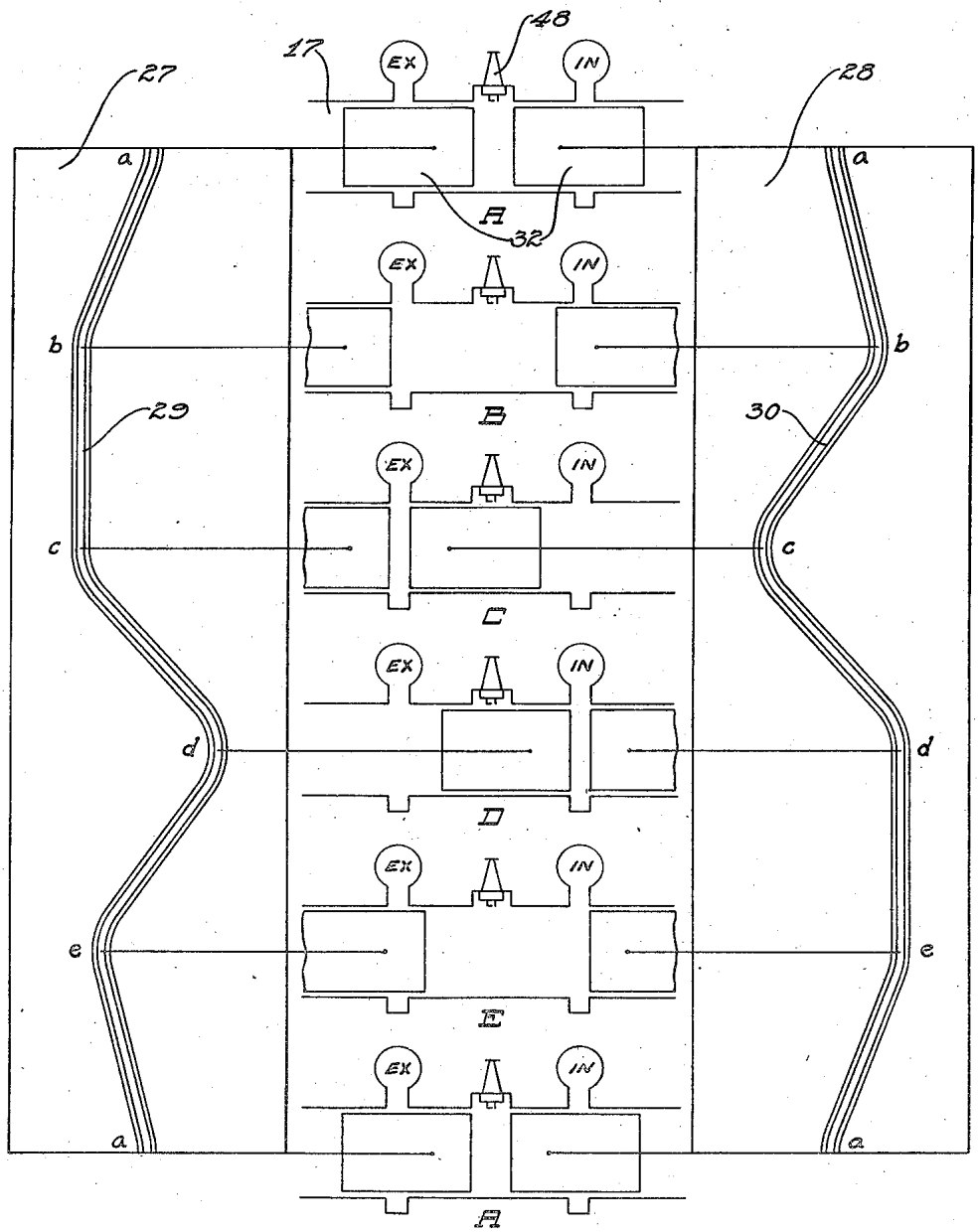

FIG. 1

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Jan. 6, 1931. L. M. WOOLSON 1,788,140

INTERNAL COMBUSTION ENGINE

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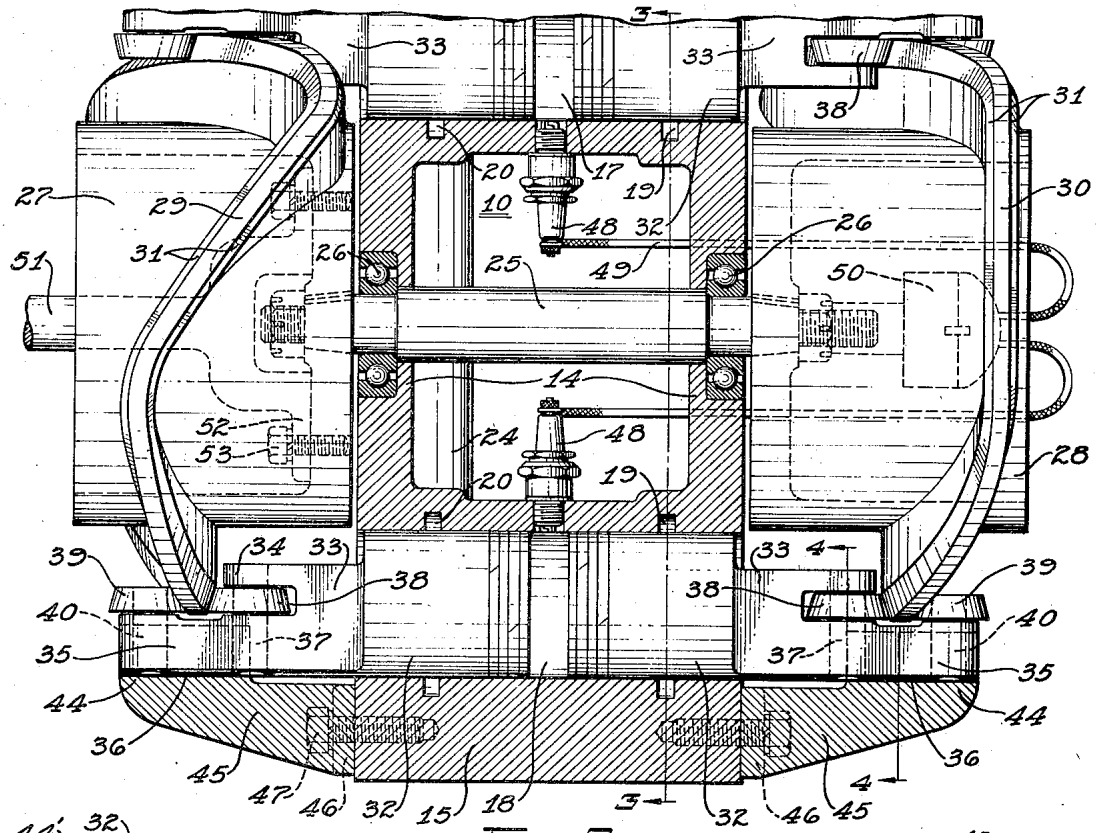

FIG. 2

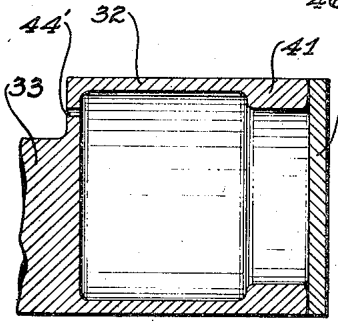

FIG. 7

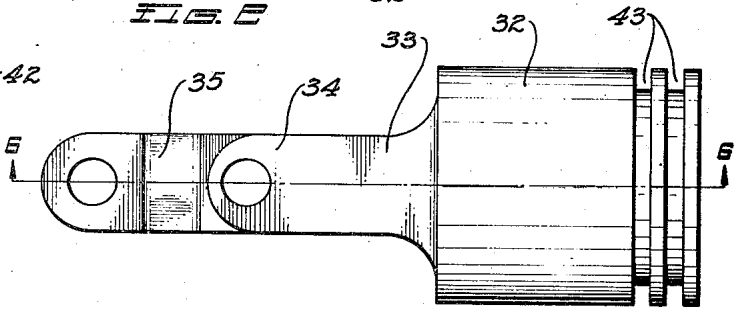

FIG. 5

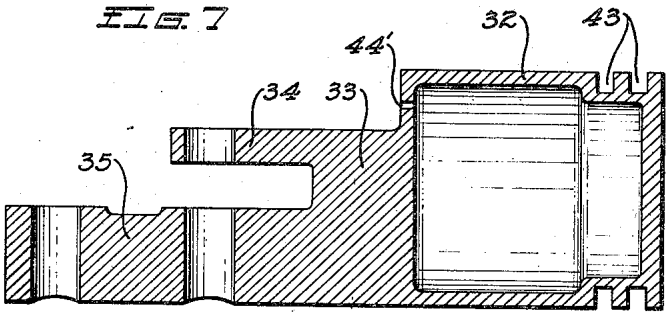

FIG. 6

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Jan. 6, 1931. L. M. WOOLSON 1,788,140

INTERNAL COMBUSTION ENGINE

Filed April 19, 1928 3 Sheets-Sheet 3

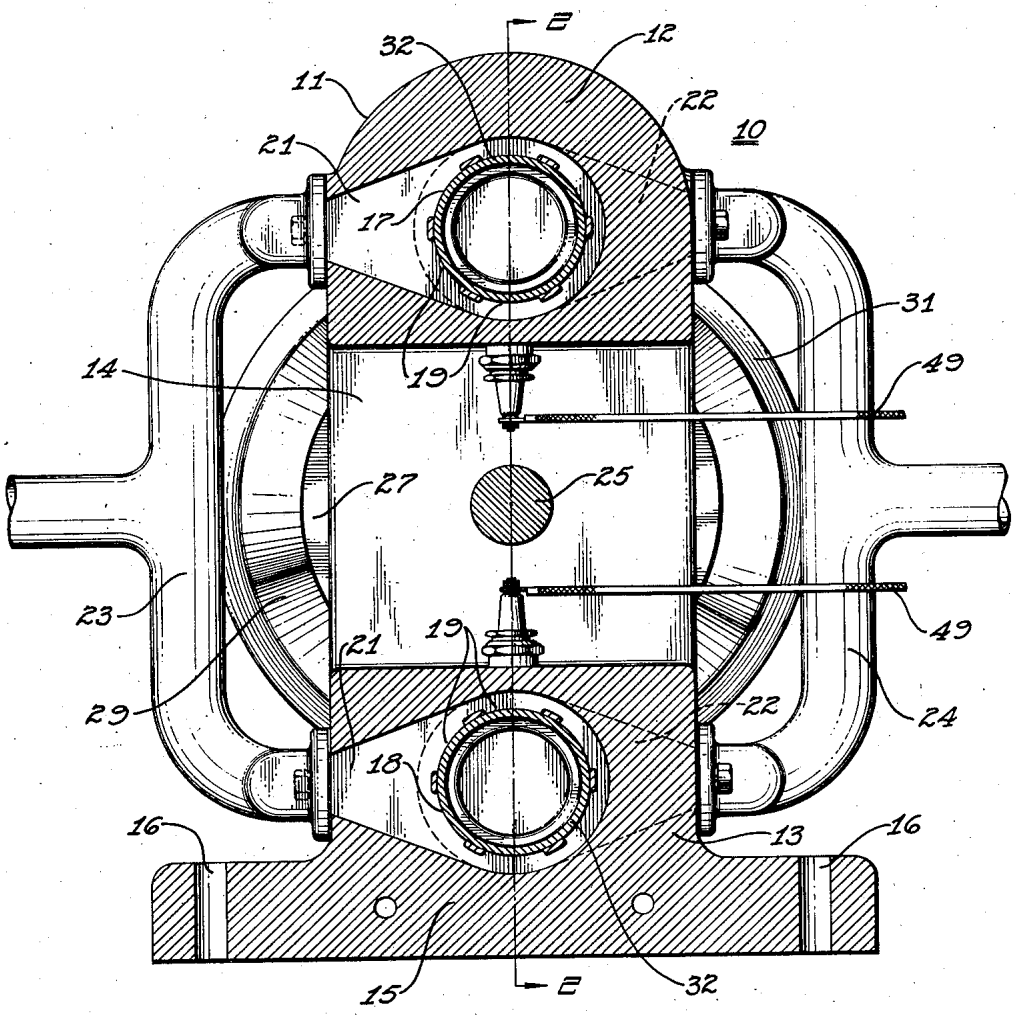

FIG. 3

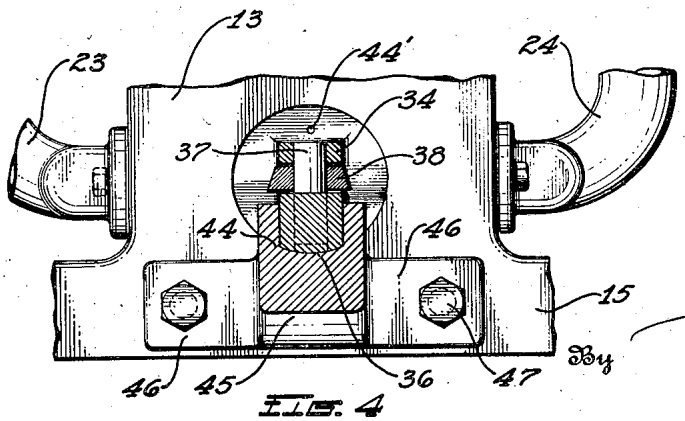

FIG. 4

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UNITED STATES PATENT OFFICE

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INTERNAL-COMBUSTION ENGINE

Application filed April 19, 1928. Serial No. 271,136.

This invention relates to internal combustion engines.

One of the objects of the present invention is to provide a new method of operating an internal combustion engine.

Another object of the invention is to provide an internal combustion engine operating on a new cycle.

Another object of the invention is to provide an internal combustion engine operating on a cycle including an idle stroke.

Another object is to provide an internal combustion engine operating on a five-stroke cycle.

Another object is to provide an internal combustion engine characterized by extreme simplicity of construction.

Another object is to provide an internal combustion engine constructed of a relatively small number of parts.

Another object is to provide an internal combustion engine of the opposed piston type in which the pistons move in the same direction in the cylinder throughout a complete stroke of the engine.

Another object of the invention is to provide an internal combustion engine of the opposed piston type in which the travel of the pistons on each stroke of the engine, except the idle stroke, is unequal.

Another object is to provide an internal combustion engine of the opposed piston type having spaced cylinder ports in which only one of the pistons on the power stroke of the engine uncovers only one of the ports.

Another object is to provide an internal combustion engine of the opposed piston type in which one of the pistons remains substantially stationary during part of the engine cycle.

Another object is to provide an internal combustion engine of the opposed piston type in which each piston moves in substantially the same part of the cylinder during part of the engine cycle.

Another object of the invention is to provide a new method of making a piston.

Another object is to provide an internal combustion engine having a piston provided with means adapted to eliminate side thrust of the pistons on the cylinder walls during operation of the engine.

Other objects of the invention will appear from the following description taken in connection with the drawings forming a part of this specification, in which:

Fig. 1 is a view showing the development of the cams used in the engine of the present invention and diagrammatic views of a cylinder and the positions of the pistons therein corresponding to the points on the cams opposite which they appear, the positions shown being the beginning of the power, exhaust, idle, intake and compression strokes of the engine;

Fig. 2 is a vertical sectional view of the engine on line 2—2 of Fig. 3, the cams and pistons being shown in elevation;

Fig. 3 is a sectional view of the engine on line 3—3 of Fig. 2;

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

Fig. 5 is a plan view of one of the pistons used in the engine of the present invention;

Fig. 6 is a sectional view of the piston on line 6—6 of Fig. 5, and

Fig. 7 is a partial sectional view of the piston showing the head welded thereon and before the ring grooves are formed in the piston.

Referring to the drawings, 10 represents generally a two cylinder internal combustion engine constructed in accordance with the present invention. As shown, the engine has a cylinder block 11 consisting of upper and lower cylinder portions 12 and 13 and interconnecting portions 14 joining the cylinder portions. A base 15 preferably formed integrally with the lower cylinder portion 13 provides means for supporting the engine on any suitable foundation or bed and apertures 16 are adapted to receive suitable fastening means for securing the engine in position. Cylinder portion 12 is provided with a cylinder 17 and cylinder portion 13 with a cylinder 18, each cylinder preferably extending the full length of the cylinder portions and being open at both ends. As shown, each cylinder is provided with an inlet port preferably consisting of a series of ports 19 at one side

of the center of the cylinder and with an exhaust port preferably consisting of a series of ports 20 at the other side of the center of the cylinder. The inlet port of each cylinder communicates with a passage 21 and the exhaust port of each cylinder with a passage 22 formed in the cylinder portions 12 and 13. Each of these passages preferably completely surrounds the cylinder in the zone of the ports and the intake passages conveniently extend to one side of the cylinder block and the exhaust passages to the other side as shown. A manifold 23 connects a carburetor, not shown, with each of the intake passages 21 and a manifold 24 connects each exhaust passage with a suitable muffling device, not shown.

Rotatably mounted in cylinder block 11 is a drive shaft 25 and, in the form shown, this shaft is journaled in the interconnecting portions 14 preferably midway between the cylinders 17 and 18 in suitable anti-friction bearings 26. Keyed or otherwise non-rotatably mounted on the tapered ends of the drive shaft 25 projecting outside the cylinder block 11 are cam wheels 27 and 28, each cam wheel being preferably of cylindrical cup-shaped formation and mounted on the drive shaft with the closed ends of each wheel toward the cylinder block as shown. Each of these cam wheels 27 and 28 carries a continuous cam preferably projecting from the outer cylindrical surface of the wheels and integral therewith as shown, wheel 27 carrying a cam 29 and wheel 28 a cam 30, the opposite outer edges of each cam being beveled to provide opposed bearing surfaces 31. The development of these cams is clearly shown in Fig. 1.

Each cylinder 17 and 18 is provided with a pair of opposed pistons 32, each piston being preferably hollow and having projecting from one end an extension 33 of substantially rectangular cross-section, preferably formed integrally with the piston and having spaced parallel arms 34 and 35. The arm 35, preferably longer than the arm 34, has an arcuate bottom surface 36, as shown, of substantially the same curvature as that of the outer wall of the piston. Rotatably mounted between arms 34 and 35 on a shaft 37 supported at its ends in the arms is a beveled roller 38, and axially spaced from this roller 38 is another beveled roller 39 rotatably mounted on a shaft 40 supported at one end in the arm 35 as shown. These beveled rollers 38 and 39 are adapted to engage the opposed bearing surfaces 31 of cams 29 and 30 to actuate the cam wheels or to be actuated thereby as will presently appear.

Each piston assembly, including the integral extension and arms, is preferably produced from a blank of solid metal. The portion of the blank from which the piston is produced is hollowed from the end opposite to the end from which the extension 33 projects by any suitable machining process, this hollowing process being carried out so that the annular wall of the piston for a short distance from the open end is of greater thickness than the wall of the remainder of the piston, this thicker portion being shown at 41 in Fig. 7. The open end of the piston is then closed by a cover 42 permanently secured to the piston, preferably by welding, and the piston ring grooves 43 are formed in the thicker portion of the piston wall as shown. A vent 44′ is provided for the piston preferably in the bottom wall thereof.

The alignment of each piston in its cylinder during operation of the engine is maintained by suitable guides in which the piston extensions 33 are adapted to move. These guides are shown at 44 and each consists of an elongated member, substantially U-shaped in transverse cross section as best shown in Fig. 4, the guiding surfaces being finished to provide a running fit with the arm 35 of piston extension 33. As shown the guides 44 are spaced from the outer ends of the cylinders so as not to interfere with the pistons on their outward strokes, and each guide is provided with an arm 45 having attaching flanges 46 for securing the guides to the cylinder block in any suitable manner such as by means of the bolts 47 shown. A spark plug 48 is threaded into the wall of each cylinder preferably at the center of the cylinder and connected through wiring 49 to a suitable distributor 50 preferably mounted on one end of drive shaft 25 within the cam wheel 28 as shown.

Power is suitably transmitted from the engine by means of a shaft 51 connected in any convenient manner to the drive shaft 25 or to one of the cam wheels 27 or 28. In the form shown, the shaft 51 is provided with an annular flange 52 which is conveniently secured to cam wheel 27 by bolts 53.

The engine may be lubricated by any suitable means or method, such as by means of a force feed or splash system, or it may be lubricated by merely supplying lubricant to the inside of the cam wheels whence it will flow or be impelled by centrifugal force during operation of the engine through suitable passages, not shown, provided in the cam wheels and cams, to the rollers, guides, pistons, cylinders and other parts requiring lubrication.

The engine is cooled preferably by water, the cylinder water jackets and connections, not shown, being of conventional design, although it is apparent that the engine may be cooled by air if desired.

The operation of the engine will be clearly and more readily understood by referring to Fig. 1 of the drawings which shows the development of the cams 29 and 30 used in the engine of the present invention together with diagrammatic views of a cylinder and the position of the pistons therein corresponding

to the points on the cams opposite which they appear, the positions shown being the beginning of the power, exhaust, idle, intake, compression and power strokes of the engine in the order named beginning from the top of Fig. 1. The drive shaft and cams of the engine having been rotated and an explosive charge having been drawn into the cylinder, the pistons at the beginning of the power stroke, or at the time when the charge is fired, will occupy the positions shown in position A of Fig. 1. On the power stroke of the engine both pistons will be moved apart or outwardly of the cylinder and the roller 38 carried by each piston extension will be forced against that portion of each cam corresponding to the power stroke of the engine between the points *a* and *b* of each, these cam portions *a b* being preferably constant acceleration curves. On the power stroke, the left hand piston as shown in Fig. 1, or the piston moving toward the exhaust port, moves outwardly of the cylinder until the exhaust port is completely uncovered while the right hand piston, or the piston moving toward the inlet port, moves outwardly of the cylinder only so far as to maintain the inlet port completely closed, these positions of the piston at the end of the power stroke and at the beginning of the exhaust stroke being shown at position B of Fig. 1. On the exhaust stroke of the engine the rollers 38 and 39 carried by the piston extension travel on that part of the cams between the points *b* and *c* and as clearly indicated the left hand piston remains stationary or substantially so during this stroke while the right hand piston is moved inwardly of the cylinder to the exhaust port. At the end of the exhaust stroke of the engine the pistons will occupy the positions shown in position C of Fig. 1.

In order that the cylinder may now be filled with a fresh charge, it is necessary that both pistons be moved from the exhaust port to the inlet port, or from a position in which the exhaust port is between the pistons to a position in which the inlet port is between the pistons, and this is accomplished on the next stroke of the engine during which the rollers 38 and 39 move on that part of each cam between the points *c* and *d*. Since during this stroke of the engine, no change takes place with respect to the working fluid and since the pistons are merely moved from one position to another in the cylinder, this stroke is properly termed an idle stroke of the engine. During this idle stroke, both pistons have substantially the same length of travel in the same direction and at substantially the same rate of speed from the positions occupied in position C of Fig. 1 with the exhaust port between the pistons, to the positions occupied in position D with the inlet port between the pistons. On the next or intake stroke of the engine, the rollers 38 and 39 move on the cams between the points *d* and *e*, and as clearly indicated, the right hand piston will remain stationary or substantially so while the left hand piston moves toward the exhaust port until its head portion just covers that port. This movement of the left hand piston draws into the cylinder a fresh charge. and at the end of this intake stroke or at the beginning of the compression stroke of the engine the pistons will occupy the positions shown in position E of Fig. 1.

On the succeeding or compression stroke, rollers 38 and 39 will move on that part of each cam between the points *e* and *a*, and as clearly indicated, both pistons will be moved toward each other or inwardly of the cylinder until they occupy the positions shown in position A. On this stroke the right hand piston has moved from a position on the right hand side of the intake port to a position near the center of the cylinder while the left hand piston has moved only from a position in which it still covers the exhaust port to a position near the center of the cylinder. Thus on this stroke, the pistons have different lengths of travel and move at different rates of speed toward each other and toward the center of the cylinder. At the end of this compression stroke the charge is fired by the spark plug and the pistons are forced apart or outwardly of the cylinder on the power stroke of the engine. The cycle is then repeated as has been described.

While the operation of the engine has been described with reference to one cylinder only, it will be apparent that the other cylinder of the engine shown will operate on the same cycle and in the same way, the cylinders firing alternately and not at the same time, as will be understood.

From the foregoing it will be seen that the engine operates on a five-stroke cycle consisting of a power, an exhaust, an idle, an intake and a compression stroke or a cycle consisting of a four-stroke cycle and an idle stroke interposed between the exhaust and intake strokes of the four-stroke cycle.

It will be noted that during the idle stroke of the engine, both pistons have the same length of travel and both move in the same direction and at substantially the same rate of speed. On each of the other strokes, however, that is, on the intake, compression, power and exhaust strokes, the pistons have different lengths of travel and on the exhaust and intake strokes, one of the pistons remains substantially stationary. It will also be noted that during the cycle, both pistons move successively in the cylinder between the inlet and exhaust ports, or in other words, the two pistons move on strokes that overlap during each cycle. This is true, however, in the form of the invention shown, only on the exhaust, idle and intake strokes. As has been described, on the exhaust stroke of the

engine, the right hand piston moves inwardly from a position in which it just covers the inlet port, past the center of the cylinder to the exhaust port; on the idle stroke, the right hand piston returns to a position at the right of the inlet port and the left hand piston moves inwardly from a position at the left of the exhaust port past the center of the cylinder to the inlet port, and on the intake stroke, the left hand piston returns to a position in which it just covers the exhaust port. Thus both pistons move in the same part of the cylinder between the ports.

The relatively small number of parts necessary to construct a complete engine in accordance with the present invention, exclusive of the carburetion and ignition systems and a few utility parts, and the economy of manufacture resulting from such extreme simplicity of construction will be apparent. The engine has a positive valve action with complete freedom from valve troubles of any kind and the spark plug is protected from the hot exhaust gases during the latter part of the exhaust stroke which will permit relatively high compression pressures to be maintained.

While a two-cylinder engine has been shown and described, it will be understood that any desired number of cylinders may be employed. It will also be understood that the form of invention selected for illustration and description is to be considered a preferred form and that the invention is to be limited only by the scope of the appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In an internal combustion engine, in combination, a cylinder, a piston movable in the cylinder and means for moving the piston on an idle stroke of the engine.

2. In an internal combustion engine, in combination, a cylinder, a pair of pistons in the cylinder and means for moving the pistons in the same direction on an idle stroke of the engine.

3. In an internal combustion engine, in combination, a cylinder, a pair of pistons in the cylinder and means for moving the pistons substantially equally in the same direction on one of the strokes of the engine.

4. In an internal combustion engine, in combination, a cylinder, a pair of pistons in the cylinder and means for moving the pistons substantially equally in the same direction on an idle stroke of the engine.

5. In an internal combustion engine, in combination, a cylinder, a pair of pistons movable in the cylinder, the cylinder having a combustion chamber between the pistons, and means causing the pistons to move substantially equally in the same direction on one of the strokes of the engine.

6. In an internal combustion engine, in combination, a cylinder, a pair of pistons movable in the cylinder, the cylinder having a combustion chamber between the pistons, and means causing the pistons to move substantially equally throughout a complete stroke of the engine.

7. In an internal combustion engine, in combination, a cylinder having spaced inlet and exhaust ports, a pair of pistons movable in the cylinder and cam means for moving the pistons on an idle stroke of the engine.

8. In an internal combustion engine, in combination, a cylinder, a pair of pistons movable in the cylinder, the cylinder having a combustion chamber between the pistons, and means for retaining one of the pistons substantially stationary during a stroke of the engine.

9. In an internal combustion engine, in combination, a cylinder, a pair of pistons in the cylinder, and means causing unequal travel of the pistons on one of the strokes of the engine and equal travel on another stroke of the engine.

10. In an integral combustion engine, in combination, a cylinder, a pair of pistons in the cylinder, and cam means causing unequal travel of the pistons on one of the strokes of the engine and equal travel on another stroke of the engine.

11. In an internal combustion engine, in combination, a cylinder, a pair of pistons in the cylinder, and means causing unequal travel of the pistons on one of the strokes and equal travel on an idle stroke of the engine.

12. In an internal combustion engine, in combination, a cylinder, a pair of pistons in the cylinder, and means causing unequal travel of the pistons on the intake, compression, power and exhaust strokes and equal travel on an idle stroke of the engine.

13. In an internal combustion engine, in combination, a cylinder, a pair of pistons in the cylinder and means causing the pistons to be separated on the power and inlet strokes of the engine, to be brought together on the compression and exhaust strokes, and to be moved substantially parallel on an idle stroke.

14. In an internal combustion engine, in combination, a cylinder, a pair of pistons in the cylinder, and cam means causing unequal travel of the pistons on the intake, compression, power and exhaust strokes of the engine and equal travel on an idle stroke of the engine.

15. In an internal combustion engine, in combination, a cylinder having spaced ports, a pair of pistons in the cylinder and means causing each piston to move in substantially the same part of the cylinder between the ports.

16. In an internal combustion engine, in combination, a cylinder having spaced ports, a pair of pistons in the cylinder, and means

causing movement of one of the pistons in a part of the cylinder on a stroke of the engine and movement of the other piston in substantially the same part of the cylinder on another stroke of the engine.

17. In an internal combustion engine, in combination, a cylinder having spaced ports, a pair of pistons in the cylinder, and means causing movement of each piston in the same predetermined part of the cylinder on successive strokes of the engine.

18. In an internal combustion engine, in combination, a cylinder having spaced ports, a pair of pistons in the cylinder and means causing movement of one of the pistons in a part of the cylinder on the exhaust stroke of the engine and movement of the other piston in substantially the same part of the cylinder on the intake stroke of the engine.

19. In an internal combustion engine, in combination, a cylinder having spaced ports, a pair of pistons in the cylinder and means causing movement of one of the pistons in a part of the cylinder between the ports on a stroke of the engine and movement of the other piston in substantially the same part of the cylinder between the ports on another stroke of the engine.

20. In an internal combustion engine, in combination, a cylinder having spaced ports, a pair of pistons in the cylinder and cam means causing movement of one of the pistons in a part of the cylinder on the exhaust stroke of the engine and movement of the other piston in substantially the same part of the cylinder on the intake stroke of the engine.

21. In a multi-cylinder internal combustion engine, in combination, a plurality of cylinders, a piston movable in each cylinder and means for moving the pistons on an idle stroke of the engine.

22. In a multi-cylinder internal combustion engine, in combination, a plurality of cylinders, a piston movable in each cylinder and cam means for moving the pistons on an idle stroke of the engine.

23. In a multi-cylinder internal combustion engine, in combination, a plurality of cylinders, a pair of pistons in each cylinder, each cylinder having a combustion chamber between the pistons, and means comprising a plurality of cams causing the pistons in each cylinder to move substantially equally in the same direction on one of the strokes of the engine.

24. In a multi-cylinder internal combustion engine, in combination, a plurality of cylinders, a pair of pistons in each cylinder, and means comprising a plurality of cams causing unequal travel of the pistons in each cylinder on one of the strokes of the engine.

25. In a multi-cylinder internal combustion engine, in combination, a plurality of cylinders each having spaced inlet and exhaust ports, a pair of pistons in each cylinder, and means comprising a plurality of cams causing the movement of both pistons in each cylinder, one piston in each cylinder moving to uncover one of the ports and the other piston in each cylinder moving toward but not uncovering the other port on a stroke of the engine.

26. In a multi-cylinder internal combustion engine, in combination, a plurality of cylinders, a pair of pistons movable in each cylinder, and cam means causing unequal travel of the pistons in each cylinder on one of the strokes of the engine and equal travel on another stroke of the engine.

27. In a multi-cylinder internal combustion engine, in combination, a plurality of cylinders, a pair of pistons in each cylinder, and means comprising a plurality of cams causing unequal travel of the pistons in each cylinder on the intake, compression, power and exhaust strokes and equal travel on an idle stroke of the engine.

28. In a multi-cylinder internal combustion engine, in combination, a plurality of cylinders having spaced ports, a pair of pistons in each cylinder and means comprising a plurality of cams causing movement of one of the pistons in a part of each cylinder between the ports on a stroke of the engine and movement of the other piston in substantially the same part of the cylinder between the ports on another stroke of the engine.

29. In an internal combustion engine, a cylinder having an inlet port, a piston reciprocable in the cylinder, said piston controlling the charge admission through the inlet port, and means associated with the piston causing uncovering of the port on alternate piston strokes and maintaining the piston stationary for a period after uncovering the port.

30. In an internal combustion engine, a cylinder having an exhaust port, a piston reciprocable in the cylinder, said piston controlling the passage of exhaust through the exhaust port, and means associated with the piston causing uncovering of the exhaust port on alternate piston strokes and maintaining the piston stationary for a period after uncovering the port.

31. In an internal combustion engine, a cylinder having spaced inlet and exhaust ports, a pair of reciprocable pistons in the cylinder, one of said pistons controlling the inlet port and the other of said pistons controlling the exhaust port, and means causing each of said pistons to uncover its respectively controlled port on alternate strokes, each piston being maintained stationary for a period after uncovering its respective port.

32. In an internal combustion engine, a cylinder, a pair of pistons in the cylinder, and means causing said pistons to be moved and stopped in a manner effecting five

strokes, one of said strokes being an idle stroke.

33. In an internal combustion engine, a cylinder, a pair of pistons, and means for causing said pistons to move in an idle stroke intermediate the exhaust and intake strokes.

34. The method of operating an internal combustion engine having a working chamber, comprising opening the chamber to a source of fuel supply, then expanding the chamber to thereby draw in a charge of explosive mixture, then closing the expanded chamber, then contracting the chamber and thereby compressing the charge therein, then firing the charge in the chamber and thereby again expanding the chamber, then opening the chamber to atmosphere, then again contracting the chamber to thereby exhaust the burnt gases therefrom, then closing the chamber, and then maintaining the chamber in closed and contracted condition for a period and until the opening of the chamber for the succeeding charge.

35. The method of operating an internal combustion engine having a working chamber, comprising opening the chamber to a source of fuel supply, then expanding the chamber to thereby draw in a charge of explosive mixture, then closing the expanded chamber, then contracting the chamber and thereby compressing the charge therein, then firing the charge in the chamber and thereby again expanding the chamber, then opening the chamber to atmosphere, then again contracting the chamber to thereby exhaust the burnt gases therefrom, then closing the chamber, and then maintaining the chamber in closed and contracted condition and moving it from one zone to another until the opening of the chamber for the succeeding charge.

36. The method of operating an internal combustion engine having a working chamber formed within the cylinder comprising opening the chamber in one part of the cylinder to a source of fuel supply, expanding the chamber while open to the fuel source to draw in a charge, closing the expanded chamber, contracting the chamber to compress the charge therein, firing the compressed charge and thereby expanding the chamber, opening the chamber to atmosphere in a part of the cylinder remote from the charge opening, contracting the chamber while open to atmosphere, closing the chamber, and moving the contracted chamber to a position for repeating the cycle.

37. In a five-stroke cycle internal combustion engine, a cylinder having spaced inlet and exhaust ports, a pair of reciprocable pistons in the cylinder, and means for causing said pistons to be positioned immediately adjacent opposite sides of the intake port at the beginning of the intake stroke, and causing said pistons to be positioned immediately adjacent the exhaust port at the completion of the exhaust stroke.

38. The method of operating an internal combustion engine comprising, introducing a charge of explosive mixture into an engine cylinder, then compressing the charge therein, then firing the charge in the cylinder, then exhausting the greater part of the burnt gases from the cylinder, and then trapping a portion of the burnt gases in the cylinder and moving the entrapped gases from one part of the cylinder to another without substantially expanding or contracting said gases, to be mixed with the succeeding incoming charge.

In testimony whereof I affix my signature.

LIONEL M. WOOLSON.