C. F. PARK.

INTERNAL COMBUSTION ENGINE APPARATUS.

APPLICATION FILED FEB. 28, 1917.

1,303,954.

Patented May 20, 1919.

4 SHEETS—SHEET 1.

Fig. 1.

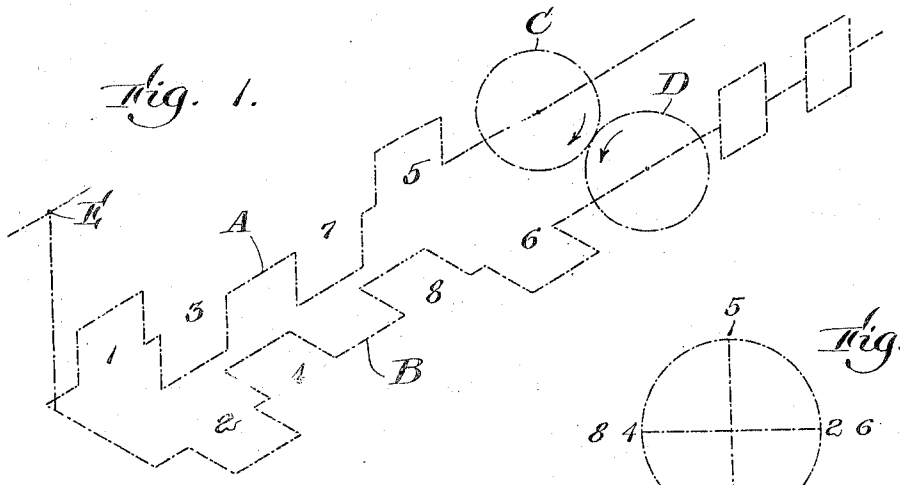


Fig. 4.

Fig. 2.

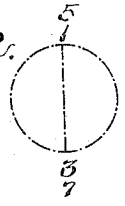


Fig. 3.

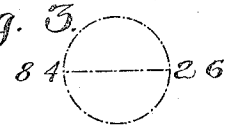


Fig. 5.

Fig. 8.

Fig. 6.

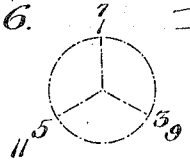
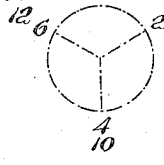


Fig. 7.



Inventor:
Charles F. Park,
by Roberts Roberts & Cushman
Attorneys.

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4 SHEETS—SHEET 2.

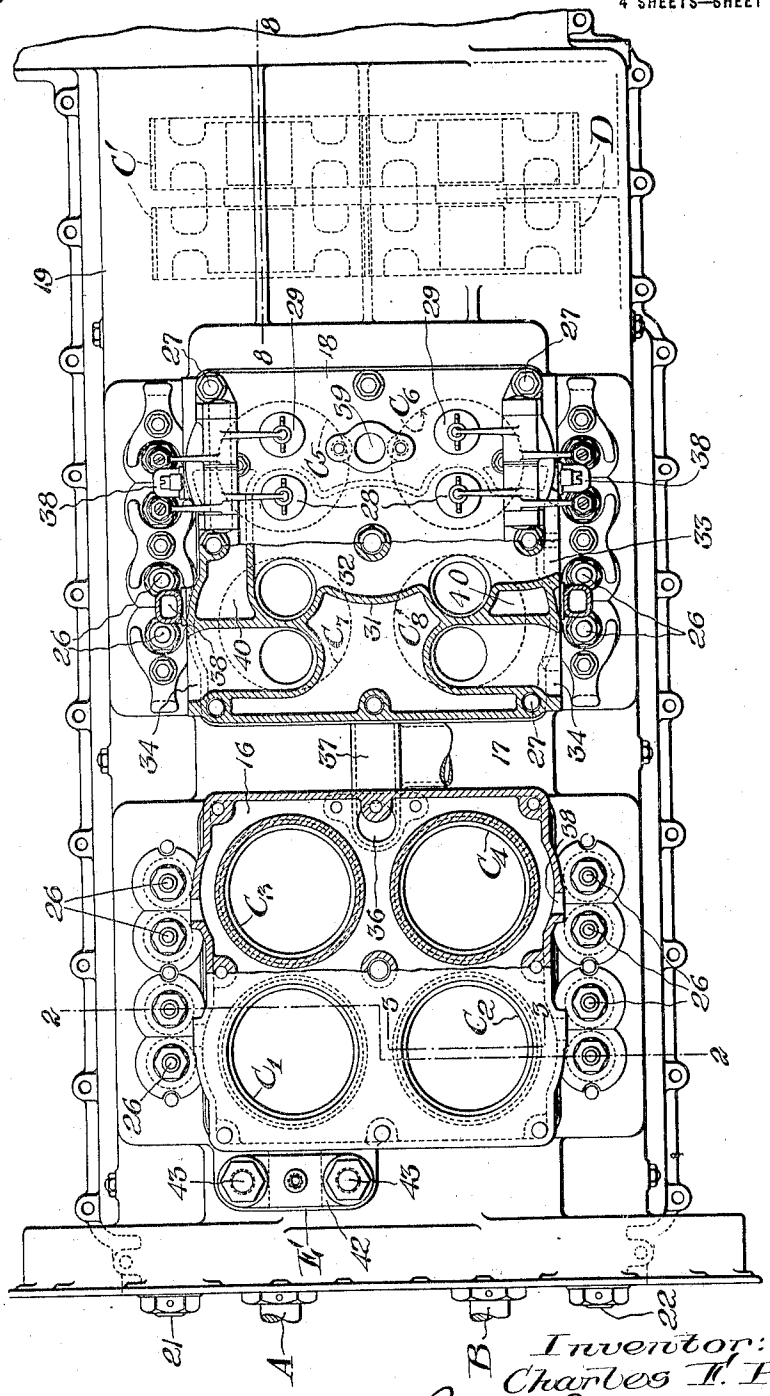


Fig. 9.

Inventor:
Charles F. Park,
by Kohrs Kohrs Kushman
Attorneys.

C. F. PARK.

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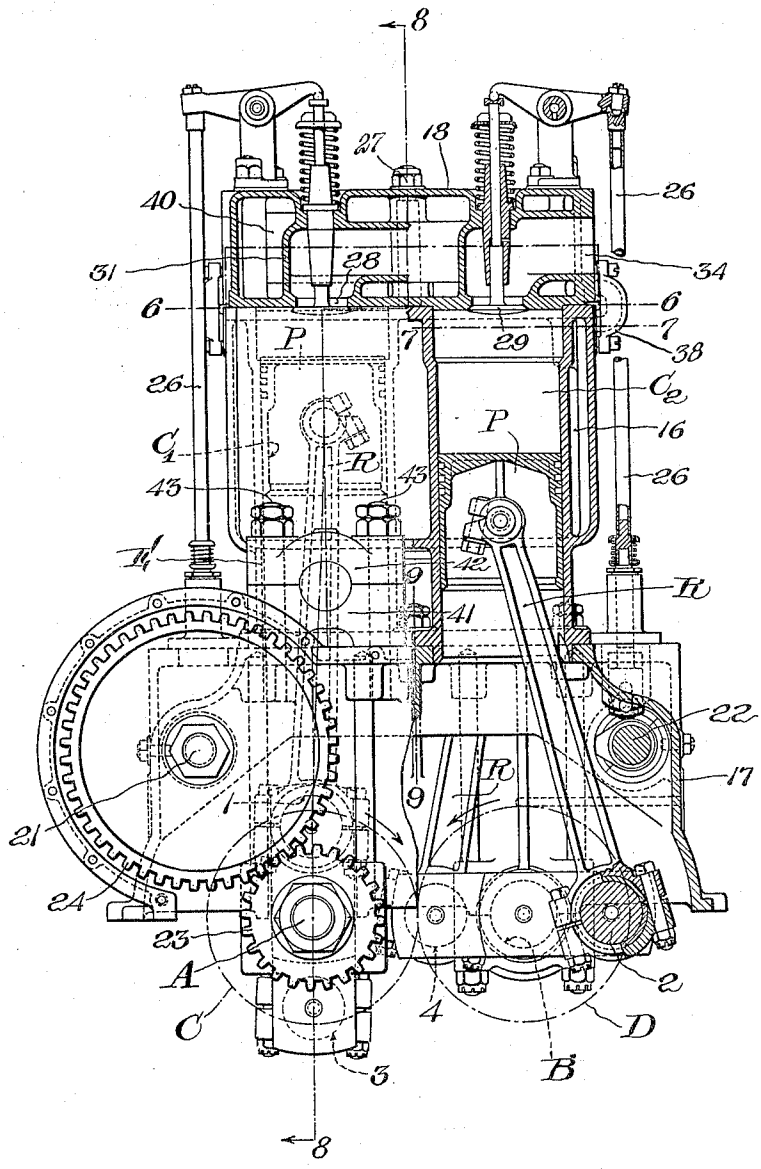
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4 SHEETS—SHEET 3.

Fig. 10.



Inventor:
Charles F. Park,
by Roberts Roberts Cushman
Attorneys.

C. F. PARK.

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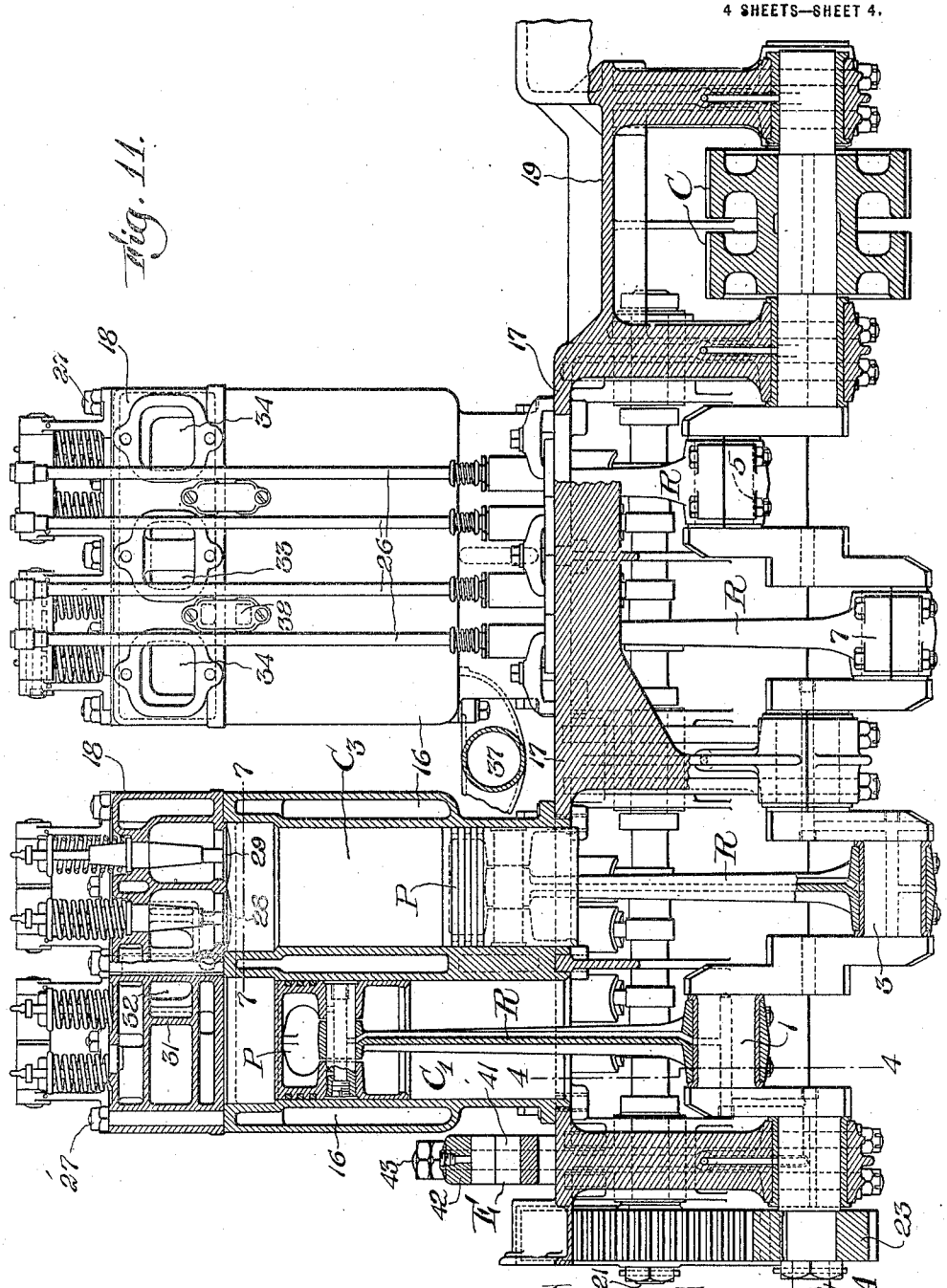
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1,303,954.

Patented May 20, 1919.

4 SHEETS—SHEET 4.

Fig. 11.



Inventor:
Charles F. Park,
by Rohrts Rohrts Kuehman
Attorneys.

UNITED STATES PATENT OFFICE.

CHARLES F. PARK, OF TAUNTON, MASSACHUSETTS.

INTERNAL-COMBUSTION-ENGINE APPARATUS.

1,303,954. Specification of Letters Patent. Patented May 20, 1919.

Application filed February 28, 1917. Serial No. 151,439.

To all whom it may concern:

Be it known that I, CHARLES F. PARK, a citizen of the United States, and resident of Taunton, in the county of Bristol and State of Massachusetts, have invented new and useful Improvements in Internal-Combustion-Engine Apparatus, of which the following is a specification.

This invention relates to a power-plant, and more particularly to a power-plant especially designed for use upon automobiles and the like, the apparatus comprising an internal combustion engine having a plurality of crank-shafts associated together.

The principal object of the invention is to provide an engine possessing the advantage of the well-known V-type of engine and being free from the disadvantages of this type of engine. More particularly, the principal object consists in providing an engine possessing the advantages of vertical cylinders, simplicity of construction, compactness, accessibility, simple connections between the engine-pistons and crank-shafts, and an engine which is free from the oiling difficulties peculiar to the V-type of engine.

Other objects of the invention will be apparent from the following description of the preferred form of my invention, which comprises a plurality of cylinders arranged in two rows and having the cylinders so arranged that their axes are substantially parallel, so that they may all be vertically disposed. With each row of cylinders is associated a crank-shaft, suitable connecting rods being employed to connect the pistons in the cylinders in each row with the corresponding crank-shaft, and the crank-shafts are connected together by suitable gearing so that the two crank-shafts turn together with the same angular velocity and preferably in opposite directions. Each of the cylinders is provided with its own inlet and exhaust valves so that with its connection to the crank-shaft and with its other accessories constitutes a complete engine in itself. The connections are so made that the explosion of the impulses in all the cylinders occur at regularly recurring intervals so that a rotative effect is produced which is as nearly constant as the particular number of cylinders employed will permit. With an eight-cylinder motor, as shown in the accompanying drawings, the cranks on one crank-shaft are angularly displaced 90° with respect to the cranks on the other crank-shaft. However, the invention is not limited to an eight-cylinder motor, but on the other hand is applicable to any number of cylinders greater than two, but more particularly it is applicable to any even number of cylinders. When employing twelve cylinders, for example, the cranks on the two crank-shafts are preferably displaced with respect to each other 60°, instead of 90° as in the eight-cylinder engine.

Several novel features of construction are involved in my improved apparatus, among which may be mentioned the following: In the preferred form the cylinders are preferably cast in block in groups of four, the four cylinders being symmetrically arranged in the form of a parallelogram and preferably in the form of a rectangle or a square. The water-jacket for cooling the cylinders is continuous about all four cylinder-barrels, there being a single water-inlet for each group of four cylinders, this inlet being disposed at the bottom of the continuous jacket surrounding the group of cylinders. By virtue of this arrangement a very short inlet-manifold for the cooling water may be disposed between two groups of four cylinders in such manner as to supply cooling water to both groups. The heads for the respective groups of cylinders are preferably cast integrally, and the inlet and outlet valves for the four cylinders are preferably disposed in the single head. The water-jacket is continuous about all of the eight valve-chambers in each valve-head and over the four cylinder heads. The cooling water may be circulated directly from the jacket surrounding the cylinders through openings in the upper surface of the cylinder casting into the valve-head jacket, but it is preferably circulated by by-pass connections extending upwardly around the junction between the cylinder casting and the valve-head casting. The partitions in the valve-head casting are preferably so placed that the four inlet-valves are in a single chamber which communicates with the inlet-manifold and carbureter through a single opening. Each exhaust-valve chamber preferably communicates with an individual exhaust-manifold, two such manifolds being disposed on each side of each group of four cylinders. The cylinders and valve-heads are preferably symmetrically arranged, in the form of a square or other parallelogram so that the valve-head can be mounted on

the cylinders with the inlet-manifold communicating with the carbureter on either side of the engine.

By virtue of the fact that two crank-shafts are employed in my improved engine, one shaft can be employed to drive the automobile or other working apparatus and the other shaft may be employed to drive the auxiliary apparatus such as the pumps, fan, magneto, electric generator, etc. With the crank-shafts geared together, the energy delivered to either of the crank-shafts in excess of that required to drive the apparatus connected thereto, is transferred to the other crank-shaft through the aforesaid gearing. For example, a relatively small amount of energy is normally required to drive the auxiliary apparatus, so that the energy supplied to the auxiliary crank-shaft is ordinarily greatly in excess of that required to drive this apparatus, and the excess energy is transferred through the gearing connecting the crank-shafts together and is thus employed to assist in driving the automobile or other machine. The gearing connecting the two crank-shafts together may be included in the crank-case, but in order to give the gearing the most suitable lubrication it is preferably placed in a compartment separate from the crank-case.

One embodiment of the invention is illustrated in detail in the accompanying drawings in which,—

Figure 1 is a diagrammatic perspective showing the relative disposition of the two crank-shafts in an eight-cylinder engine, the coupling-gearing, the manner of supporting the engine, etc.;

Fig. 2 is a diagram illustrating the order of operation of the cylinders connected to the respective cranks on the main crank-shaft;

Fig. 3 is a diagram illustrating the order of operation of the cylinders connected to the respective cranks on the auxiliary crank-shaft;

Fig. 4 is a diagram illustrating the relative order of operation of the cylinders connected to both crank-shafts;

Fig. 5 is a perspective view similar to Fig. 1 showing the invention applied to a twelve-cylinder engine;

Fig. 6 is a diagram illustrating the order of operation of the cylinders connected to the main crank-shaft in Fig. 5;

Fig. 7 is a diagram illustrating the order of operation of cylinders connected to the auxiliary crank-shaft in Fig. 5;

Fig. 8 is a diagram illustrating the relative order of operation of the cylinders connected to both crank-shafts in Fig. 5;

Fig. 9 is a top plan view of a complete eight-cylinder engine, the first pair of cylinders being shown in plan with the head removed, the second pair of cylinders being shown in horizontal section on line 7—7 of Figs. 10 and 11, the third pair of cylinders being shown in section taken through the heads on line 6—6 of Fig. 10, and the fourth pair of cylinders being shown with the common valve-head in place;

Fig. 10 is a front view of the engine, the valve-head being shown in section taken on line 2—2 of Fig. 9, the right-hand front cylinder being shown in section on line 3—3 of Fig. 9, and the crank-casing being shown in section on line 4—4 of Fig. 11; and

Fig. 11 is an elevation of the complete engine showing the forward portion of the engine, including the forward group of cylinders, in section on line 8—8 of Fig. 10, and showing the crank-case beneath the rearward group of four cylinders in section on line 9—9 of Fig. 10, and showing the portion in the rear of the rearward group of cylinders in section on line 8—8 of Figs. 9 and 10.

In the preferred embodiment of my invention illustrated in the drawings, the forward group of four cylinders C_1, C_2, C_3 and C_4 are cast in block, and the rearward group of cylinders C_5, C_6, C_7 and C_8 are likewise cast in block, and both groups of cylinders are preferably arranged in square formation, as shown. Each group of cylinders is surrounded by a water jacket 16, which is spaced away from the cylinders and which extends continuously around each group of cylinders so that the cooling water within the jacket may contact with the cylinders throughout their entire outer surface. The blocks of cylinders are mounted upon the crank-casing 17, and upon each block of cylinders is mounted a valve-head 18. The cylinders C_1, C_3, C_7 and C_5 are arranged in alinement and the pistons P within these cylinders are connected by means of connecting-rods R with cranks 1, 3, 7 and 5 respectively, of crank-shaft A, the crank-shaft A being disposed in parallelism with the plane of the axes of this row of cylinders and preferably in this plane. The cylinders C_2, C_4, C_8 and C_6 are also disposed in alinement and preferably in parallelism with the other row of cylinders, and the pistons P within these cylinders are connected to the cranks 2, 4, 8 and 6, respectively, on the crank-shaft B, the crank-shaft B being disposed in parallelism with and preferably in the vertical plane of the axes of the corresponding row of cylinders and preferably in the horizontal plane of the crank-shaft A. While the cylinders of the two rows may be disposed in staggered relationship and still maintain the symmetrical parallelogram grouping above referred to, the cylinders are preferably arranged side by side so that they lie in transverse pairs, thereby being in transverse alinement as well as in longitudinal alinement.

In order to render the distribution of impulses from the cylinders to the crank-shafts uniform, and also to permit the crank-shafts to be placed closer together without interference, the crank-shafts are preferably disposed in some such manner as indicated in Fig. 1, the same arrangement being shown in Figs. 10 and 11. With this arrangement, when forward crank 1 on crank-shaft A extends upwardly, forward crank 2 on crank-shaft B extends horizontally to the right, the two cranks being angularly displaced 90° with relation to each other. With cranks 1 and 2 in this position cranks 3 and 7 on crank-shaft A extend downwardly and crank 5 extends upwardly while cranks 4 and 8 on crank-shaft B extend horizontally to the left and crank 6 extends horizontally to the right.

With a twelve-cylinder engine as diagrammatically illustrated in Fig. 5, when crank 1 on crank-shaft A′ extends vertically, the opposed crank 2 on crank-shaft B′ is disposed 60° in a clockwise direction from the vertical; cranks 3 and 9 are 120° from the vertical in a clockwise direction; cranks 4 and 10 extend downwardly; cranks 5 and 11 are 120° from the vertical in a counter-clockwise direction; cranks 6 and 12 are 60° from the vertical in a counter-clockwise direction; crank 7 extends upwardly as does crank 1; and crank 8 is 60° in a clockwise direction from the vertical, in parallelism with crank 2.

The crank-shafts are directly connected together by suitable means such as herring-bone gears or spur gears C and D disposed in the separate compartment 19 at the rear of and in alinement with the crank-casing 17. The crank-shafts A and B may be extended rearwardly from the gearing compartment 19 through suitable bearings to the working apparatus and auxiliary apparatus above referred to. As shown in Fig. 1, for example, shaft A may constitute the main driving-shaft and the crank-shaft B may be employed as the auxiliary drive-shaft to drive the auxiliary apparatus such as a generator and pump, diagrammatically illustrated in Fig. 1. At the forward end of the engine the crank-shafts are respectively connected to the cam-shafts 21 and 22 through the medium of sets of spur-gears 23—24, the cam-shafts 21 and 22 being arranged to control the inlet- and exhaust-valves in proper sequence, through the medium of push-rods 26 in any suitable manner.

As above stated, the valve-heads for the respective groups of cylinders are preferably cast in block and the inlet- and outlet-valves for the respective cylinders are so disposed in each valve-head that the heads may be connected to the cylinder-casing through the medium of stud-bolts 27 or other suitable means, with the inlet-manifold, later to be described, extending either to the right or the left. Each cylinder is provided with an inlet-valve 28 and an exhaust-valve 29, the valves being arranged in alinement with the respective rows of cylinders so as to be operated by the cam-shafts 21 and 22, through the medium of push-rods 26, in any suitable manner. The inlet-valves 28 are disposed in juxtaposition on the inside of the exhaust-valves so that they are grouped at the center of each block of four cylinders. The partition wall 31 of the valve-head is so shaped as to include the four inlet-valves within a common inlet-manifold 32, this inlet-manifold being provided with an inlet-opening 33 communicating with the carbureter so that fuel is supplied to the four cylinders of each block through the common manifold 32. Each of the exhaust-valve openings communicates with an individual exhaust-chamber 34, these chambers connecting with a common exhaust-manifold (not shown) extending along each side of the cylinders. Where a plurality of groups of cylinders are employed, as in eight-, twelve- or sixteen-cylinder engines, the manifold inlets 33 are preferably disposed on the same side of the engine so that they may readily communicate through suitable supply-manifolds with a single carbureter.

Cooling water is preferably supplied to the water jackets 16 through openings 36 in the bottom of the jackets, these openings being disposed near the adjacent sides of the jackets, so that water may be supplied to the two jackets through a branch duct 37. After circulating freely about the cylinders the water is conducted through by-passes 38 to the water compartment 40 in the valve-heads from which the heated water passes through openings 39 into a return water-manifold (not shown).

One phase of my invention involves a novel means for supporting an engine and particularly an engine of the character herein described. My improved supporting means is preferably of the three point suspension type, having two points of support at one end and one point of support at the other end. In the drawings I have illustrated an engine adapted to be supported at its two rear corners in any usual or suitable manner and having a forward single point suspension arranged at its forward end as will now be described.

A bearing E comprising two parts 41 and 42 is mounted upon the crank-casing 17 at the forward end of the engine by means of stud bolts 43, the bearing being adapted to receive a trunnion for supporting the engine at its forward end. It will be noted that the bearing E is not disposed centrally of the engine but is opposite to the left of the cen-

ter line (Fig. 10), and in the particular embodiment of the invention herein disclosed it is disposed substantially in alinement with the left-hand row of cylinders. The engine is preferably so arranged that the cranks throw inwardly, as indicated by the arrows in Figs. 1 and 10, the cranks on both crank-shafts passing downwardly between the two crank-shafts. If the engine were mounted centrally the reaction of the impulses imparted to the crank-shafts from the left-hand row of cylinders would tend to rotate the engine in a counter-clockwise direction about the bearing, and the reaction of the impulses from the right-hand row of cylinders would tend to rotate the engine in a clockwise direction about the bearing. This reversal of rotating impulses would tend to produce undue vibration of the motor, whereas with the motor mounted off-center as indicated, the reactions resulting from the impulses transmitted to each crank-shaft are in a counter-clockwise direction about the bearing, thus obviating the reversal of direction of the reactions. Furthermore, with the engine mounted off-center, as indicated, the unbalanced weight of the engine sets up a moment in a clockwise direction about the bearing and this clockwise moment tends to counteract the counter-clockwise moment set up by the reactions of both rows of cylinders.

The operation of the apparatus is as follows: The valve and ignition mechanism is so timed that the explosions occur in the respective cylinders in the order indicated by the reference characters applied to the cranks of the respective crank-shafts in Fig. 1, and also as indicated by the subscripts applied to the character C designating the respective cylinders in Figs. 9 to 11; that is, the explosions occur in the respective cylinders in the following order: $C_1, C_2, \ldots C_8$, so that impulses are transmitted to the crank-shafts in the order 1, 2, . . . 8. Thus the impulses transmitted to crank-shaft A are spaced 180° apart, as represented in Fig. 2; the impulses imparted to crank-shaft B are likewise spaced apart 180°; and inasmuch as the cranks on crank-shaft B corresponding to the cranks on crank-shaft A are angularly displaced 90° from the latter cranks, the impulses transmitted to the two crank-shafts are regularly spaced apart by intervals of 90°. Consequently, the two crank-shafts function as a single crank-shaft by virtue of their being positively geared together and the same uniformity of torque is afforded by this engine as that of the V-type engine. But, unlike the V-type engine, this engine possesses all the important advantages incident to vertical cylinders: and owing to the provision of a separate crank-shaft for each longitudinal row of cylinders, the opposed cylinders of the two rows do not have to be connected to a single crank-shaft as in the V-type motor, which has offered many mechanical difficulties, but on the contrary the cylinders can be placed in direct opposition and still be connected to the crank-shafts as simply as in the ordinary four- or six-cylinder engine.

While the above order of operation of the respective cylinders is suitable for most purposes, other arrangements may be employed and under some circumstances may be deemed preferable. For example, instead of imparting impulses to the cranks in the order 1, 2, . . . 8, by suitably arranging the valve and ignition mechanism the impulses may be imparted to the following order 1, 6, 3, 8, 5, 2, 7, 4. With this arrangement impulses are uniformly spaced apart by intervals of 90°, as with the first mentioned arrangement. However, instead of the four cylinders of one group being successively operated and then the four cylinders of the other group being successively operated this latter order of operation involves the alternate operation of the cylinders in the respective groups, that is, cylinder C_1 is in the forward group, the next cylinder C_6 is in the rearward group, the following cylinder C_3 is in the forward group, and so on, the only exception being that cylinder C_5, which is in the same group with cylinder C_8, follows the latter cylinder. Obviously, other arrangements in which the impulses are uniformly spaced apart may be employed.

When applying the invention to an engine having a plurality of cylinders, the number of which is a multiple of three, such as the twelve-cylinder engine diagrammatically shown in Fig. 5, the cylinders may be brought into operation in the order of the numbers 1 to 12 applied to the cranks in Fig. 5. With this arrangement the impulses imparted to crank-shaft A′ are uniformly spaced apart 120°, as represented in Fig. 6; the impulses imparted to crank-shaft B′ are likewise uniformly spaced apart 120°, as shown in Fig. 7; and owing to the fact that the corresponding cranks of the two crank-shafts are relatively displaced 60°, the impulses imparted to the unitary system comprising the two crank-shafts are uniformly spaced apart by intervals of 60°, as indicated in Fig. 8.

It is to be further noted that by virtue of the two crank-shafts being geared directly together, the crank-shafts rotate in opposite directions, and that the throw of the cranks on both crank-shafts is downwardly between the two shafts. This results in a minimization of vibration due to the tendency of the reactions from the impulses imparted to one crank-shaft to compensate for the reactions of the impulses imparted to the other crank-shaft. That is, the reactions from crank-shaft A tend to produce rotation of

the cylinders in a counter-clockwise direction relatively to the central vertical longitudinal plane of the engine while the reactions from crank-shaft B tend to produce rotation of the cylinders in a clockwise direction, whereby the reactions from the respective crank-shafts are mutually counteracted.

Moreover, it is to be understood that my invention in most of its aspects is in no wise limited to the type of cylinders herein shown and described for the purpose of illustration, but on the contrary it is also adapted to engines of other types and particularly to engines having the Knight type of cylinders and valves.

What I claim is:

1. An internal combustion engine comprising two parallel crank-shafts, piston and cylinder means associated with each crank-shaft and disposed on one side of the plane of the crank-shafts, means operatively connecting the respective piston and cylinder means with the respective crank-shafts so as to rotate the crank-shafts in opposite directions, and means for supporting the engine off-center so that the reactions of each piston and cylinder means will be directed in the same angular direction around the off-center support.

2. An internal combustion engine comprising two parallel crank-shafts, piston and cylinder means associated with each crank-shaft and disposed on one side of the plane of the crank-shafts, means operatively connecting the piston and cylinder means with the crank-shafts so as to rotate the crank-shafts in opposite directions, and means for supporting the engine off-center so that the reactions of each piston and cylinder means will be opposed to the moment of the unbalanced weight of the engine resulting from the off-center support.

3. An internal combustion engine comprising two parallel crank-shafts, piston and cylinder means associated with each crank-shaft and disposed on one side of the plane of the crank-shafts, means operatively connecting the piston and cylinder means with the crank-shafts so as to rotate the crank-shafts in opposite directions, and means for supporting the engine off-center so that the reactions of each piston and cylinder means will be directed in the same angular direction around the off-center support and will be opposed to the moment of the unbalanced weight of the engine resulting from the off-center support.

4. An internal combustion engine comprising a plurality of cylinders arranged in parallel rows, a valve-head fitting upon the cylinders, the valve-head having a common inlet chamber disposed centrally thereof and having exhaust chambers disposed on each side of the inlet chamber, inlet valves in the valve-head between the inlet chamber and the respective cylinders, exhaust valves in the valve-head between the exhaust chambers and the respective cylinders, and the exhaust chambers having outlets extending outwardly in opposite directions.

5. An internal combustion engine comprising a plurality of cylinders, a valve-head fitting upon the cylinders, water-jackets for the cylinders and valve-head, respectively, the valve-head and cylinders being symmetrically arranged so that the valve-head will fit upon the cylinder in either of two positions and the water-jackets of the valve-head and cylinders respectively communicating with each other symmetrically so that water may be circulated therebetween in either of said positions of the valve-head, ducts extending between the said water-jackets and a duct opening out of the water-jacket of the valve head, said ducts being symmetrically disposed so that they occupy the same relative positions in either of said positions of the valve-head.

Signed by me at Boston, Massachusetts, this 23rd day of February, 1917.

CHARLES F. PARK.