No. 808,902.

PATENTED JAN. 2, 1906.

N. CRANE.

GAS ENGINE.

APPLICATION FILED MAY 23, 1903.

5 SHEETS—SHEET 1.

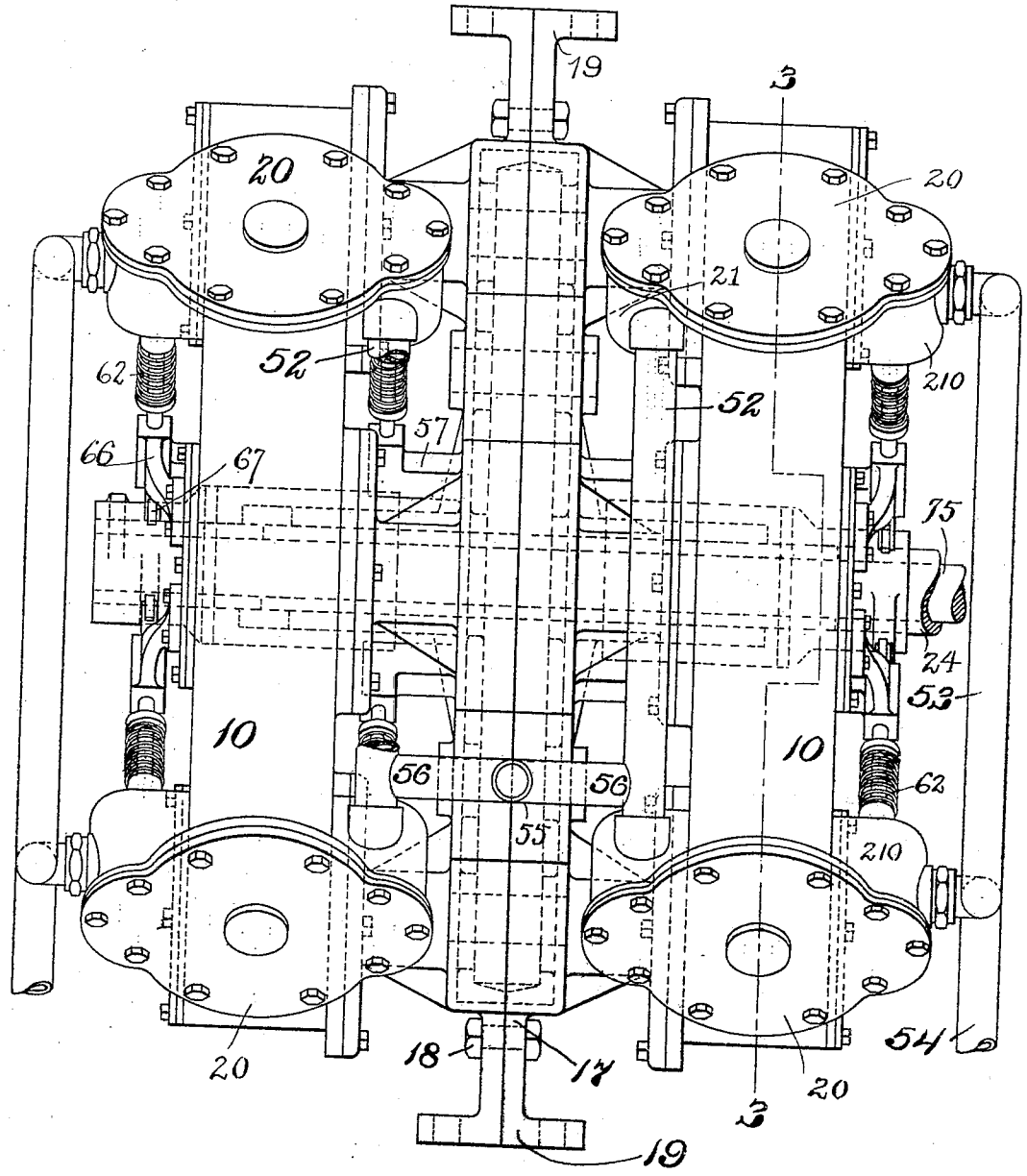

Fig. 1.

WITNESSES.

Fred. E. Dorr.

Laurence E. Kennedy

INVENTOR.

Newton Crane

by Wright Brown Quinby & his attys

No. 808,902. PATENTED JAN. 2, 1906.

N. CRANE.

GAS ENGINE.

APPLICATION FILED MAY 23, 1903.

5 SHEETS—SHEET 2.

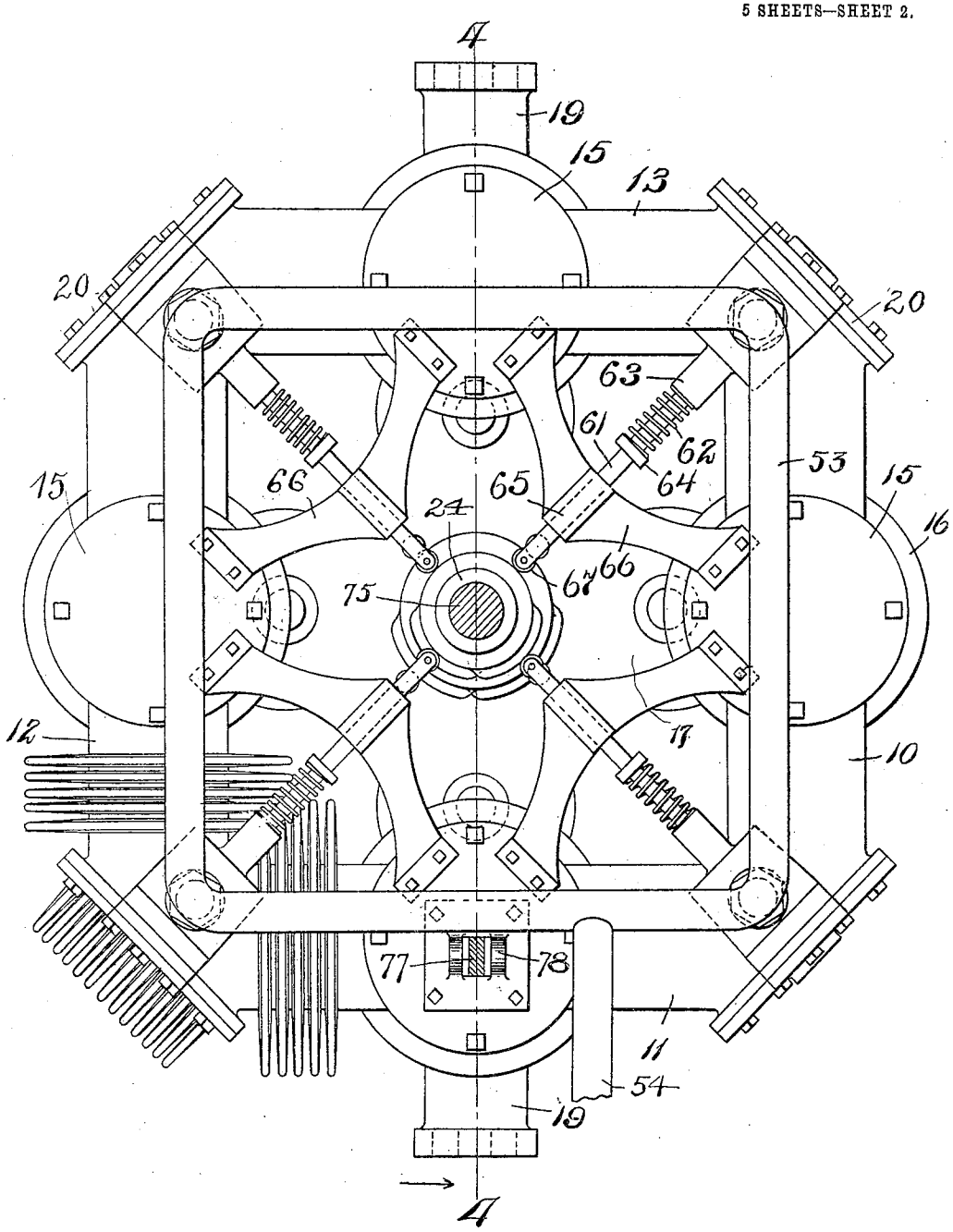

FIG. 2.

WITNESSES.

Fred. E. Dorr.

Laurence E. Kennedy

INVENTOR.

Newton Crane

by Creighton Brown & Dumby

his attys

No. 808,902. PATENTED JAN. 2, 1906.

N. CRANE.

GAS ENGINE.

APPLICATION FILED MAY 23, 1903.

5 SHEETS—SHEET 3.

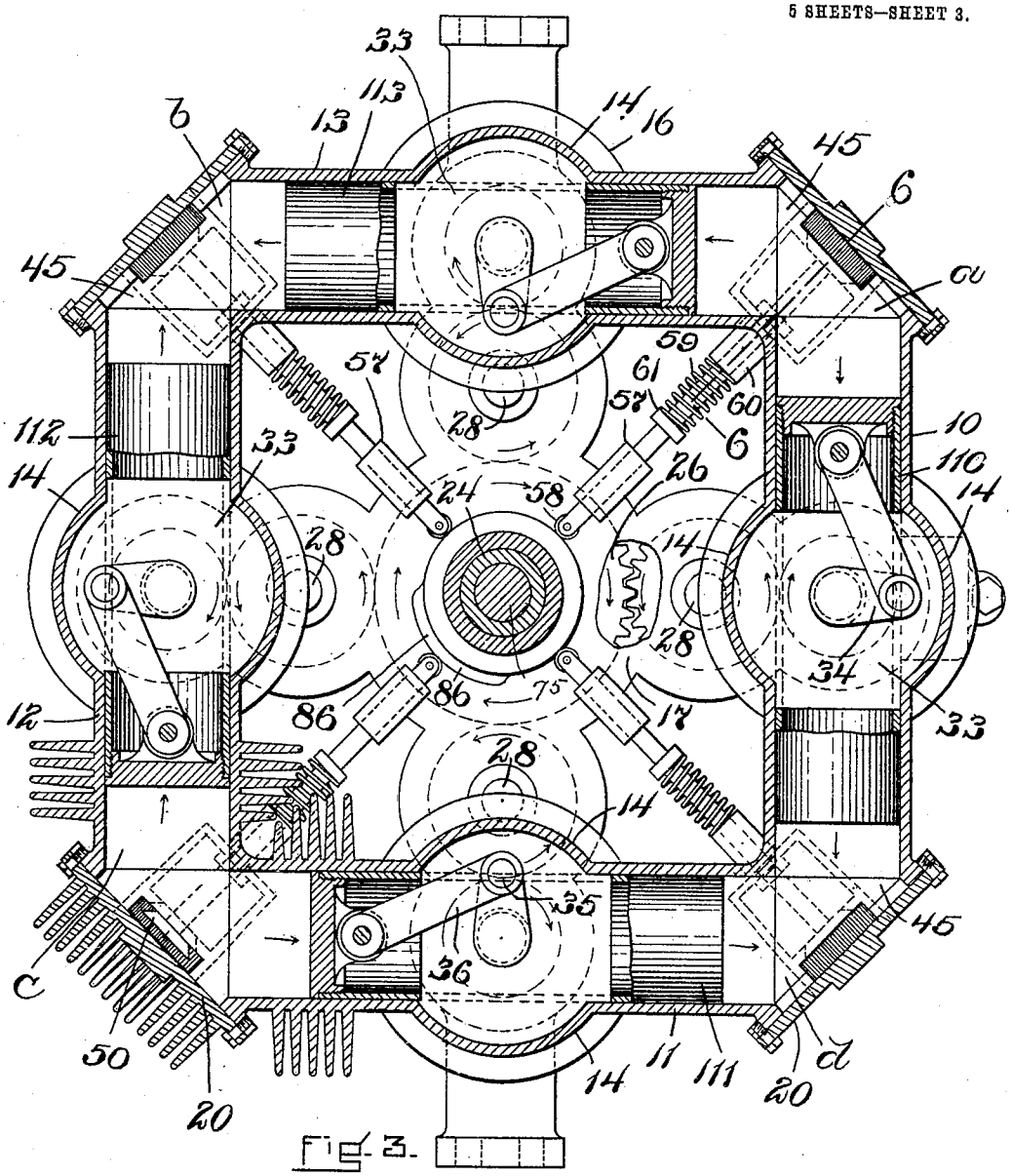

Fig. 3.

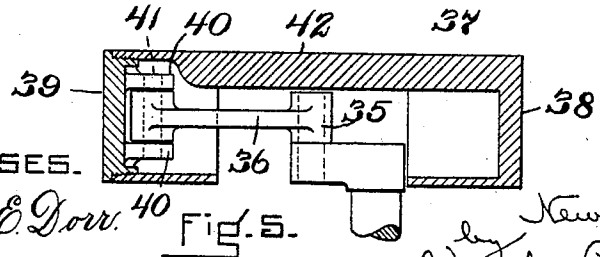

Fig. 5.

WITNESSES.

Fred. E. Dorr.

Laurence E. Kennedy

INVENTOR.

Newton Crane

by Wright Brown & Quinby

his attys

No. 808,902. PATENTED JAN. 2, 1906.

N. CRANE.

GAS ENGINE.

APPLICATION FILED MAY 23, 1903.

5 SHEETS—SHEET 4.

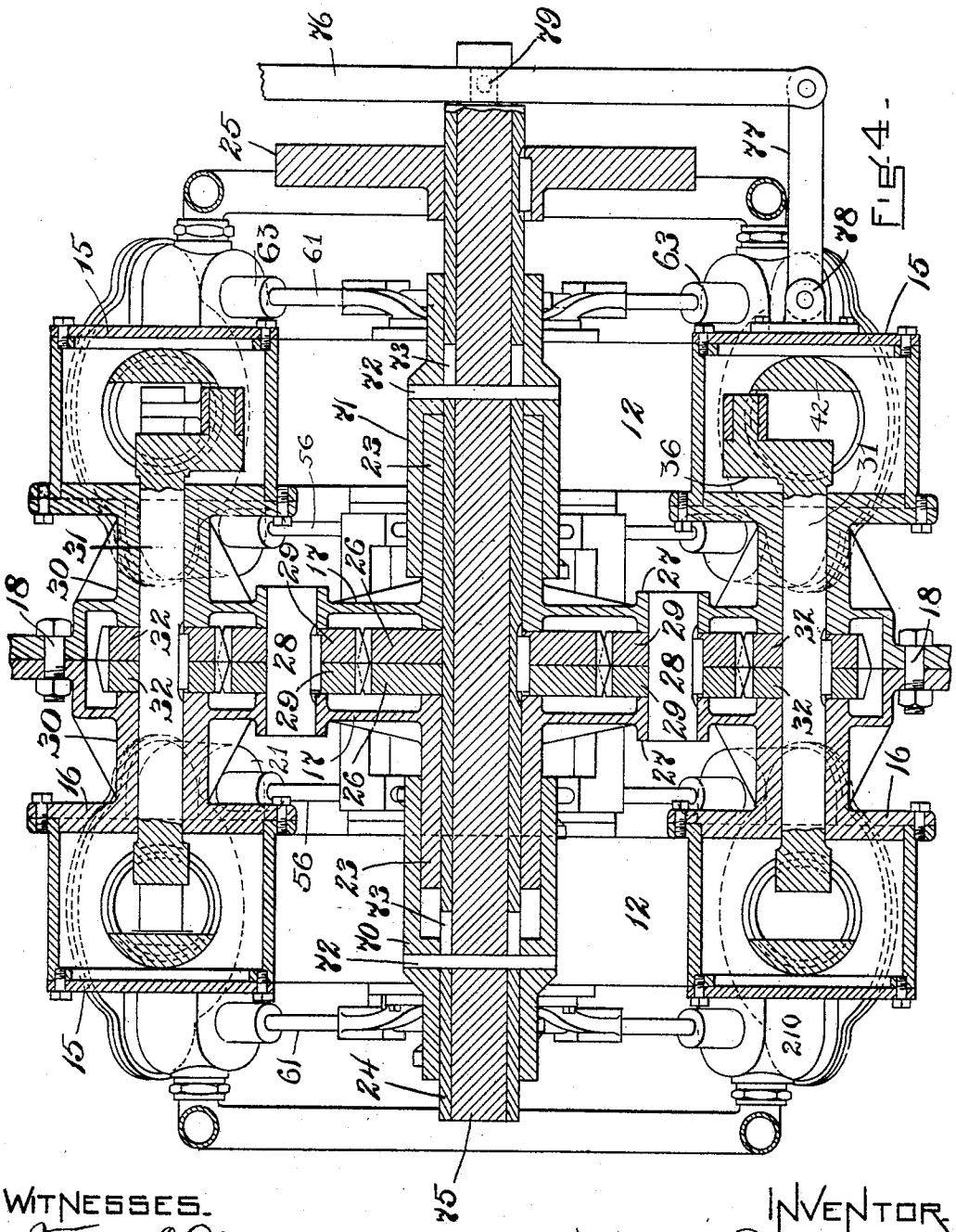

FIG. 4.

WITNESSES.

Fred. E. Dorr.

Laurence E. Kennedy

INVENTOR

Newton Crane

by Wright Brown & Quinby

his attys

No. 808,902. PATENTED JAN. 2, 1906.

N. CRANE.

GAS ENGINE.

APPLICATION FILED MAY 23, 1903.

5 SHEETS—SHEET 5.

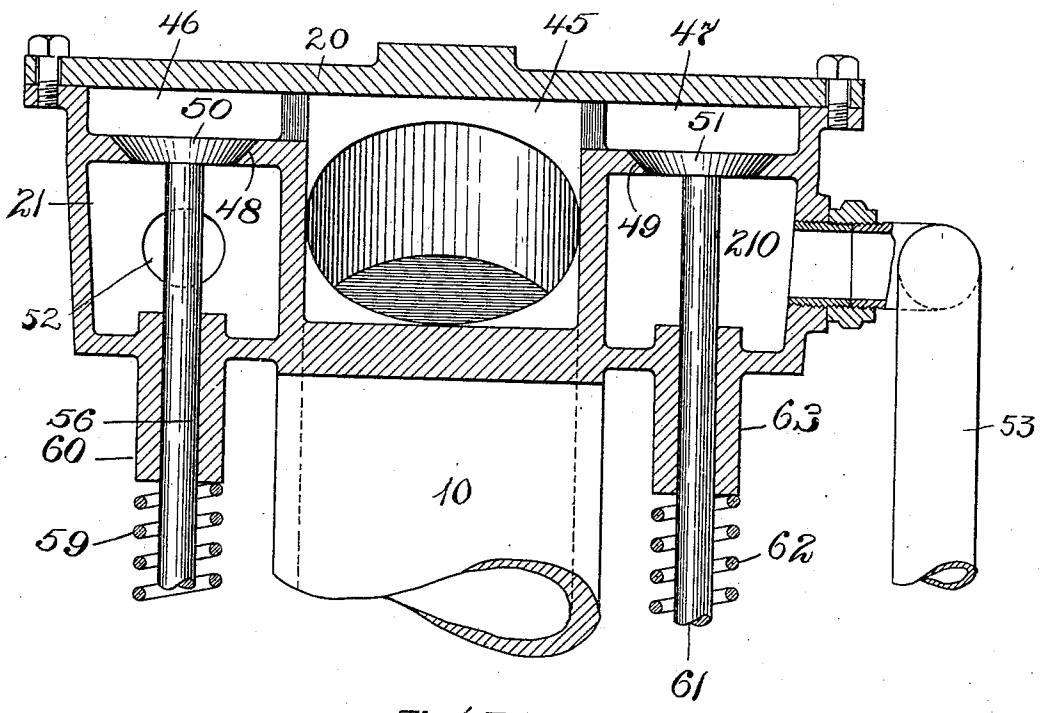

Fig. 6.

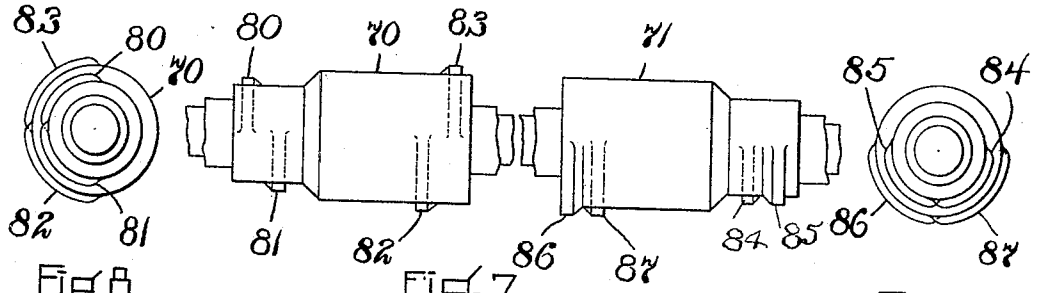

Fig. 8. Fig. 7. Fig. 9.

WITNESSES.

Fred. E. Dorr.

Laurence & Kennedy

INVENTOR.

Newton Crane

by Wright Brown Quinby & his attys

UNITED STATES PATENT OFFICE.

NEWTON CRANE, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO NEWTON CRANE GAS ENGINE COMPANY, OF BOSTON, MASSACHUSETTS, A CORPORATION OF MAINE.

GAS-ENGINE.

No. 808,902. Specification of Letters Patent. Patented Jan. 2, 1906.

Application filed May 23, 1903. Serial No. 158,420.

To all whom it may concern:

Be it known that I, NEWTON CRANE, of Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Gas-Engines, of which the following is a specification.

This invention has relation to internal-combustion engines; and it has for its object to provide an air-cooled comparatively high power motor of the balanced type in which there is for each revolution of the driven shaft a large number of explosions of comparatively small power singly and great power in the aggregate and in which the pistons and cranks are so disposed toward one another that the impulses grow successively, making the torque or initial starting power under load large.

The invention has further to provide other improvements by which the multiple cylinders may be arranged in compact form and the engine as a whole be simplified in construction and rendered more adaptable than heretofore for motor vehicles, boats, launches, &c., and for generating power for the actuation of machinery.

Referring to the drawings, Figure 1 represents in front elevation a gas or combustion engine embodying the invention. Fig. 2 represents a side elevation of the same. Fig. 3 represents a section on the line 3 3 of Fig. 1. Fig. 4 represents a section on the line 4 4 of Fig. 2. Fig. 5, Sheet 3, illustrates in detail the connection of a piston with its crank-shaft. Fig. 6 represents a section through the valve mechanism, taken on the line 6 6 of Fig. 3. Fig. 7 represents the driven shaft with the cams thereon. Fig. 8 represents an end view of the shaft with the cams on one of the cam-sleeves. Fig. 9 represents a view looking from the other end with the cams on the other cam-sleeve.

It will be understood that in the following specification and claims the phraseology which is employed is for the purpose of description and not of limitation, and, further, that various changes may be made in the described and illustrated construction without departing from the spirit and scope of the invention.

In its simplest form the motor consists of four cylinders which form the sides of a hollow square. The angles of the square furnish chambers for the reception of the explosive mixture and in which the explosion or combustion takes place. The pistons in each pair of adjacent cylinders coact, moving toward each other to compress the combustible material and exhaust the products of combustion and moving in opposite directions when the combustion takes place and to draw in a charge. Each piston is double-ended and double-acting and operates on an independent crank-shaft arranged substantially midway between the angles or combustion-chambers, so that there are four crank-shafts arranged at the same distance from a common center. The driven shaft passes through said common center, and it is geared or connected in any suitable way with the crank-shafts, so that it receives its power from all of them successively. Preferably, however, the motor is two-part and consists of two sets of pistons and cylinders arranged side by side with the cylinders on the four sides in parallelism, so that there is a crank-shaft common to the pistons of two parallel cylinders, there being a single driven shaft common to all the crank-shafts. Upon the common driven shaft or member is placed a cam mechanism for operating or controlling the operation of the valves. The cams for the valves of one set of pistons and cylinders are quartered with relation to the cams for the other set of pistons and cylinders, so that two explosions do not take place simultaneously, but successively, in the two sets of pistons and cylinders. It will be readily understood, however, that as many sets of pistons and cylinders, arranged as described, may be employed in case it be desired to increase the power transmitted to the common driven shaft.

Referring to the drawings and for the present to Fig. 3, the cylinders of one set are indicated, respectively, at 10, 11, 12, and 13. It will be understood that each set of cylinders may be cast integrally or that each cylinder may be formed separately and secured in place. For simplification, however, each set of cylinders is shown in the drawings as being cast integrally. The similar cylinders of the other sets are indicated by the same reference characters in Figs. 1 and 4. Each cylinder is cast or formed between its ends with outwardly-curved walls 14 14 to provide chambers 33 for the rotation of the crank, which is connected to the piston in the cylinder. The pistons are indicated by the nu-

merals 110 111 112 113 in order that each piston may be identified with the cylinder in which it is placed. The chambers 33, formed by the walls 14 of each cylinder, are closed by two substantially circular plates 15 16, as shown in Fig. 4. The inner plates 16 are all cast upon a single frame 17, the two frames 17 17 for the two sets of pistons and cylinders being bolted together by bolts 18, as shown in Fig. 4. The said frames 17 17 are formed with elongations 19, which afford means by which the motor may be secured in a vehicle or any desired place. These frames likewise afford means for connecting the cylinders together and for holding them in proper interrelation. The ends of each pair of adjacent cylinders are connected by a head or plate 20, so as to form a triangular chamber 45 between the ends of each pair of cylinders. Furthermore, as shown in Fig. 6, the meeting ends of each pair of cylinders are formed with laterally-extending valve-chambers 21 210. The plates 20 are formed with extensions, which cover the ends of the valve-chambers 21 210, as best shown in Fig. 6.

The frames 17 17, of which mention has been previously made, are formed with elongated bearings 23 for the reception of a tubular driven shaft or member 24, having upon one end a momentum or fly wheel 25. The middle portions of the frames 17 17 are separated to receive between them a pair of gears 26, which are keyed to the driven shaft 24. Mounted in bearings 27, afforded by the frames 17, are four shafts 28, arranged at equal distances from each other and at the same radial distance from the driven shaft. Each of these shafts carries a pair of gears 29, intermeshing with and driving or at times driven by the gears 26. The frames 17 are further provided with bearings 30 for a series of parallel crank-shafts 31, having keyed thereto gears 32, intermeshing with those at 29. The gears are all of the herring-bone type. The end of each crank-shaft 31 projects into a chamber 33 in one of the cylinders, as shown in Figs. 3 and 4. The crank-shaft of each cylinder has its axial line midway between the ends of the cylinder and has a crank-arm 34, with a crank-pin 35, connected by a pitman 36 with the piston.

One of the pistons is shown in detail in Fig. 5. As will be observed, it is formed of a cylindrical shell, having a solid end 38 and an end 39, screwed to the shell and provided with lugs 40 40 to receive the pintle 41, which connects the pitman 36 with the piston. Each piston is double-acting and consists practically of two hollow end portions connected by a side portion 42, so that it is described as "double-ended." This construction of the piston permits of the location of the crank-shaft in the plane of the cylinder and midway between its ends, thereby making it possible to produce an engine whose cylinders form the sides of a polygon with each angle or corner space between two cylinders doing duty as a combustion-chamber. As a consequence of this there may be, as will be explained, a series of combustions or explosions following each other successively as the main shaft rotates.

It is quite apparent that each crank-shaft may be formed of one piece, or else it may be formed in two parts whose ends meet in the plane of division of the gears 32.

By reason of the structure as thus described it is apparent that the two frames 17 17 hold the eight cylinders all firmly connected together with the four cylinders of each set at right angles to each other to form the sides of a hollow square and, further, that the driven shaft 24 is connected directly by noiseless gearing with the crank-shafts, so that said driven shaft may receive the impulses due to the movement of the pistons upon explosion or combustion of the gas or else may actuate said pistons for the compression of the gas or for the exhaustion or scavenging of the products of combustion from the cylinders.

There remains now to be described the valve mechanism and the means by which the engines may be reversed. By an examination of Fig. 6 it will be observed that communicating with the chamber 45 at the end of each adjacent pair of cylinders are two lateral ducts 46 47, one of these ducts serving for the inlet of the explosive or combustible mixture and the other serving for the eduction of the products of combustion. The duct 46 communicates with the chamber 21 by a port 48, whereas the duct 47 communicates with the chamber 210 by the port 49. The port 48 is normally closed by a valve 50, a valve 51 serving to close the port 49. The chamber 21 of each set of cylinders is connected by conduits 52, (see Fig. 1,) whereas the chambers 210 of each set of cylinders are all connected by conduits 53, having a common outlet-conduit 54 leading therefrom. The two conduits 52 52 of the two parts of the motor are connected with an inlet-conduit 55 by branches 56 56. (See Fig. 1.) The conduits 52 introduce the explosive mixture into the chambers 45 through the chambers 21 and the ducts 46, whereas the products of combustion are carried out from the cylinders and the chambers 45 through the ducts 47, the ports 49, the chambers 210, and the conduits 53. The stems of the valves all extend toward the axis of the shaft 24. The stems 56 of the valves 50 pass through guides 57, formed on or secured to the frames 17, and are provided on their ends with rollers 58. Springs 59 are coiled about the valve-stems and bear against guides 60, formed on the cylinders and against shoulders or collars 61 on the stems, so as to hold the valves 50 normally seated. The stems 61 for the valves 51 are likewise held normally seated by springs 62, bearing against

guides 63, similar to those at 60, and against collars 64, formed on said stems. The ends of the stems 61 pass through guides 65, formed on braces 66, bolted to the plates 15, and are equipped with rollers 67. Slidingly mounted on the shaft are two sleeves 70 71, which are connected by pins 72 72, passing through slots 73 73 in the tubular shaft 24, with a bar 75, arranged inside of said tubular shaft. This bar is adapted to be moved longitudinally by a lever 76, pivoted to a link 77, in turn pivoted to lugs 78 on one of the plates 15. The lever has a yoke with a pin 79 extending into a circumferential groove in the end of the bar 75.

Each of the sleeves 70 71 is adapted to slide on one of the bearings 23, as shown in Fig. 4, and it is formed with a series of cams adapted for coaction with the rollers on the stems 56 61, as the case may be, of the valves 50 51. The cams on the outer reduced ends of the sleeve 70 are shown in Fig. 7 at 80 81, and the sleeve 70 may be moved longitudinally to bring either of said cams 80 81 to register with the rollers 67 of the stems 61. The larger end of the sleeve 70 has two cams 82 83, either of which may be caused to register with the rollers 58 of the valve-stems 56. The cams 80 and 81 and the cams 82 83 are quartered with relation to each other, as shown, so that by shifting the sleeve longitudinally the timing of the operation of the valve is changed to effect the reversal of the engine. The sleeve 71 is provided with cams 84 85, equivalent to those at 80 81, and with cams 86 87, equivalent to those at 82 83, and arranged in similar relation to each other, but in quartered relation to the cams 80 81 82 83. The cams 80 84 82 86 operate their respective valves in the order named to effect the rotation of the driven shaft in one direction, and when the slides are shifted the cams 85 81 87 83 operate the valves in the order given.

It will be understood that the cylinders are to be formed with heat-dissipating ribs, as shown on the adjacent ends of the cylinders 11 and 12, and that the plates 20 may be formed with similar ribs or flanges, so that the motor may be air-cooled. These ribs or flanges are omitted from the drawings, except in the part mentioned, for the purpose of not interfering with the illustration of the rest of the mechanism.

Inasmuch as the motor, as shown, consists of two parts, each of which is practically similar to the other, the operation of but one part will be described. In this description reference may be had to Fig. 3. It may be assumed that the pistons are all moving in the direction of the various arrows placed upon the drawings. Consequently the pistons 111 and 112 and the pistons 113 and 110 are moving away from each other by reason of an explosion or combustion having taken place in the chamber *a*. At this time the valve 50 is raised by a cam 86, so that the explosive mixture is being drawn into the chamber *c*. At the same time the pistons 112 113 are approaching each other and the chamber *b* and are forcing out the products of combustion from said chamber *b* through the duct 47 and the port 49, the valve 51 being lifted for this purpose by the cam 84. Simultaneously with this described operation the pistons 110 and 111 are approaching the chamber *d* and are compressing the explosive mixture previously introduced into that chamber. As the pistons all reach the ends or limits of their movement (by means of proper sparking or igniting mechanism, which is not illustrated, as it is well known) the compressed explosive mixture in the chamber *d* is ignited, and the pistons 111 and 110 and 112 and 113 are immediately forced in the opposite directions. This causes the scavenging of chamber *a*, the compression of the explosive mixture in chamber *c*, and the induction of the explosive mixture in chamber *b*, the valves being operated in proper time. Then as the pistons reach the end of that movement an explosion occurs in chamber *c*, with a consequent scavenging in chamber *d*, the induction of explosive mixture in chamber *a*, and the compression of the explosive mixture in chamber *b*. Thus it will be seen that the explosion takes place in the chambers *a*, *d*, *c*, and *b* successively in the order named.

The crank-shafts 31 are geared to the tubular driven shaft 24 at a ratio of two to one, so that in each set of cylinders there are four explosions for each single rotation of the tubular shaft 24. As, however, the motor is two-part and the cranks and cams are quartering, the explosions in the two parts of the motor take place alternately, so that there are eight successive explosions for each single rotation of the central shaft. The result of this construction is that it accomplishes two things. It accomplishes an explosive balance, for all the pistons move at the same rate of speed, and it also effects a thoroughly mechanical balance.

Many minor details are omitted from the drawings—such as the sparking or igniting mechanism, bolts for connecting parts together, &c.; but as they constitute no essential part of the invention their omission simplifies the drawings and description.

It may be considered that in each part of the motor the cylinders, which communicate at their ends and are arranged in the form of a hollow square, are, in effect, each double cylinders with connecting chambers, and hence a construction in which each side of the polygon was formed of two separate but connected cylinders would be a manifestly equivalent construction and one which I have contemplated. In that case the pistons for each double cylinder would be either as shown or separate and connected directly or intermediately.

Having thus explained the nature of the invention and described a way of constructing

and using the same, although without attempting to set forth all of the forms in which it may be made or all of the modes of its use, I declare that what I claim is—

1. An engine comprising communicating cylinders forming the sides of a polygon, and double-acting pistons in said cylinders.

2. An engine comprising communicating cylinders forming the sides of a polygon, double-acting pistons in said cylinders, and connections whereby each pair of adjacent pistons move in opposite directions.

3. An engine comprising communicating cylinders forming the sides of a polygon, double-acting pistons in said cylinders, and a driven shaft operatively connected to all of said pistons.

4. An engine comprising communicating cylinders forming the sides of a polygon, each end of each cylinder forming with the end of the adjacent cylinder a combustion-chamber, double-acting pistons in said cylinders, a driven shaft, crank-shafts connected to said pistons, and operative connections between said crank-shafts and said driven shaft.

5. An engine comprising communicating cylinders forming the sides of a polygon, double-acting pistons in said cylinders, means whereby the pistons of each adjacent pair of cylinders operate in opposite directions, and means whereby combustible fluid is consumed in the meeting ends of said cylinders in a predetermined order.

6. An engine comprising communicating cylinders forming the sides of a polygon, double-acting pistons in said cylinders, a shaft located in the center of the polygon, and means connecting said pistons with said shaft.

7. An engine comprising communicating cylinders arranged in the form of a hollow polygon, each cylinder having an enlarged chamber between its ends, crank-shafts extending into said chambers, pistons in said cylinders connected to said crank-shafts, and a driven member connected to all of said crank-shafts.

8. A motor comprising a series of communicating cylinders forming the sides of a polygon, double-acting pistons in said cylinders, and means for successively effecting explosions in the chambers formed by all the meeting ends of said cylinders.

9. A motor comprising a series of communicating cylinders forming the sides of a polygon, double-acting pistons in said cylinders, means for successively effecting explosions in the chambers formed by the meeting ends of said cylinders, and a common driven member operatively connected to each of said pistons, independently of the others.

10. A motor comprising a series of cylinders forming the sides of a polygon with those cylinders which form the corners of the polygon communicating, double-acting pistons in said cylinders, a common conduit for supplying explosive mixture to the chambers formed by the meeting ends of said cylinders, and a common exhaust-conduit leading from said chambers.

11. A motor comprising four cylinders arranged in the form of a square, double-acting pistons in said cylinders, connections by which the pistons of each pair of adjacent cylinders move in opposite directions, and valve mechanism by which the explosions take place in the four corners of the square in succession.

12. A motor comprising an even number of cylinders arranged to form the sides of a polygon, pistons in said cylinders arranged whereby the pistons in each adjacent pair of cylinders move in opposite directions, a driven shaft, speed-reducing connections between said pistons and said shaft, and means whereby the explosions effect the simultaneous movement of the pistons in each pair of cylinders, successively, so that during each rotation of the shaft, it receives a series of impulses equal in number to the cylinders.

13. A motor comprising communicating cylinders arranged to form the sides of a square, there being an explosion-chamber at each angle of the square, a driven shaft in the center of the square, pistons in said cylinders geared to the shaft, and valve mechanism including cams on said shaft and valve-rods radiating from the shaft toward the angles of the square.

14. A motor comprising cylinders arranged to form the sides of a square, each cylinder having a chamber intermediate of its ends, a crank-shaft extending into each chamber, plates closing the sides of said chambers, and a frame connecting said cylinders.

15. A motor comprising cylinders arranged to form the sides of a square, double-acting pistons in said cylinders, heads or plates closing the meeting ends of said cylinders, means connecting said cylinders, and heat-dissipating means on said cylinders and heads.

16. A motor comprising two communicating cylinders arranged at an angle to form a chamber between their meeting ends, and a valve-chamber on each side of said first-mentioned chamber and communicating therewith.

17. A two-part motor comprising a plurality of sets of cylinders, each set having the cylinders arranged to form the sides of a polygon, double-acting pistons in said cylinders, and a driven shaft operatively connected to all of said pistons.

18. A two-part motor comprising a plurality of sets of cylinders, each set having the cylinders arranged to form the sides of a polygon, pistons in said cylinders, a series of crank-shafts, each crank-shaft being connected to a piston in each set of cylinders and being located midway between the ends of a cylinder, and a driven shaft connected to all of said crank-shafts.

19. A two-part motor comprising a plurality of sets of cylinders, each set having the cylinders arranged to form the sides of a polygon, double-acting pistons in said cylinders, a series of crank-shafts, each crank-shaft being connected to a piston in each set of cylinders, a driven shaft connected to all of said crank-shafts, and means whereby the explosions occur alternately in said sets of cylinders and succesively in the cylinders of each set.

20. A motor comprising a driven shaft, a series of cylinders arranged tangentially to a circle circumscribed about said shaft, each cylinder having an explosion-chamber at each end and a series of double-acting pistons in said cylinders operatively connected to said shaft.

21. A motor comprising a driven shaft, a series of cylinders arranged tangentially to a circle circumscribed about said shaft, a series of pistons in said cylinders operatively connected to said shaft, said adjacent pistons moving in opposite directions, valves for supplying fluid and exhausting the products of combustion from the meeting ends of said cylinders successively, and cams on said shaft for actuating said valves, said cams being arranged in sets and being movable whereby the explosions follow each other in one direction or the other around the shaft to cause the rotation of the shaft in one direction or the other.

22. A motor comprising a driven shaft, a series of cylinders arranged tangentially to a circle circumscribed about said shaft, a series of pistons in said cylinders operatively connected to said shaft, said adjacent pistons moving in opposite directions, valves for supplying fluid and exhausting the products of combustion from the meeting ends of said cylinders successively, cams on said shaft for actuating said valves, said cams being arranged in sets and being movable whereby the explosions follow each other in one direction or the other around the shaft to cause the rotation of the shaft in one direction or the other, and manually-operated means for moving said cams on said shaft.

23. A two-part motor comprising two complemental frames, each having a series of cylinders secured thereto to form the sides of a polygon, pistons in said cylinders, a driven shaft journaled in said frames, crank-shafts journaled in said frames, and each having cranks on both its ends connected to pistons, a gear on the driven shaft, gears on the crank-shafts, and gears supported on the frames and connecting the gear on the driven shaft with the gears on the crank-shaft.

24. An engine comprising a plurality of cylinders, each cylinder communicating at its ends with two adjacent cylinders to form combustion-chambers, double-acting pistons in said cylinders, and a shaft connected to all of said pistons.

25. An engine comprising a plurality of cylinders, each cylinder communicating at its ends with two adjacent cylinders to form combustion-chambers, double-acting pistons in said cylinders, a series of crank-shafts each located in a line midway between the ends of a cylinder, and a shaft connected to all of said crank-shafts.

26. In internal-combustion engines having a plurality of combustion-chambers and cylinders, the arrangement of cylinders and combustion-chambers in which each cylinder is double-ended, the two ends forming parts of two separate chambers in which different phases of the Otto cycle are simultaneously taking place, the double cylinders and the combustion-chambers being arranged in a continuous series, so that adjacent ends of adjacent double cylinders are in communication with a common combustion-chamber, substantially as described.

27. In internal-combustion engines having a plurality of combustion-chambers and double cylinders arranged in a continuous series as herein described, the arrangement of the cylinder-pistons in which they are rigidly connected in pairs and each pair coupled to a separate crank, so that the two adjacent ends of adjacent pairs of pistons are performing one phase of the Otto cycle and simultaneously at their opposite ends performing the preceding or the consecutive phase of the same cycle, substantially as described.

In testimony whereof I have affixed my signature in presence of two witnesses.

NEWTON CRANE.

Witnesses:

MARCUS B. MAY,

C. C. STECHER.