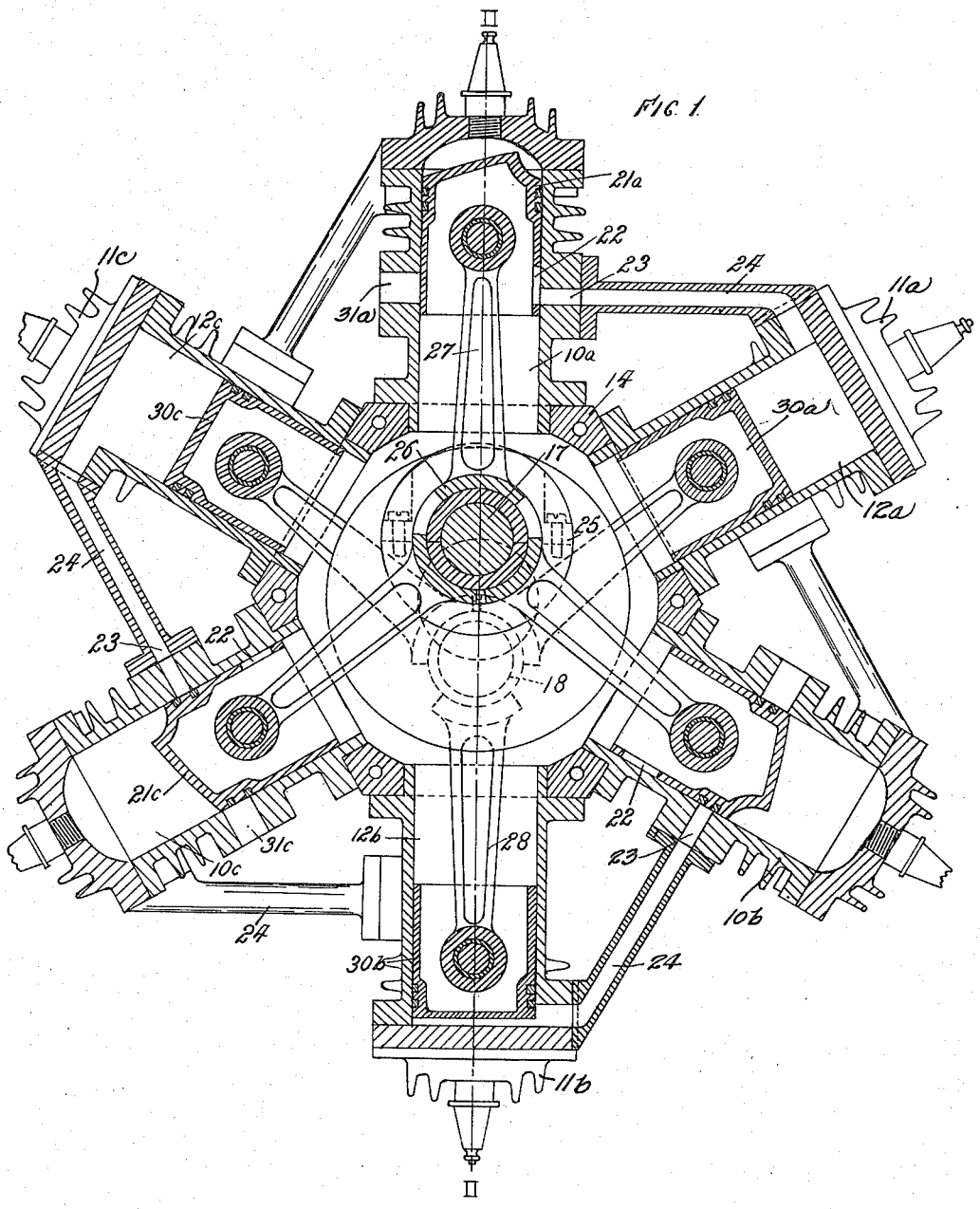
Aug. 3, 1937. W. McCLELLAND 2,088,863

TWO-STROKE CYCLE INTERNAL COMBUSTION ENGINE

Filed May 9, 1935 4 Sheets-Sheet 1

FIG. 1.



INVENTOR
William McClelland
by
atty.

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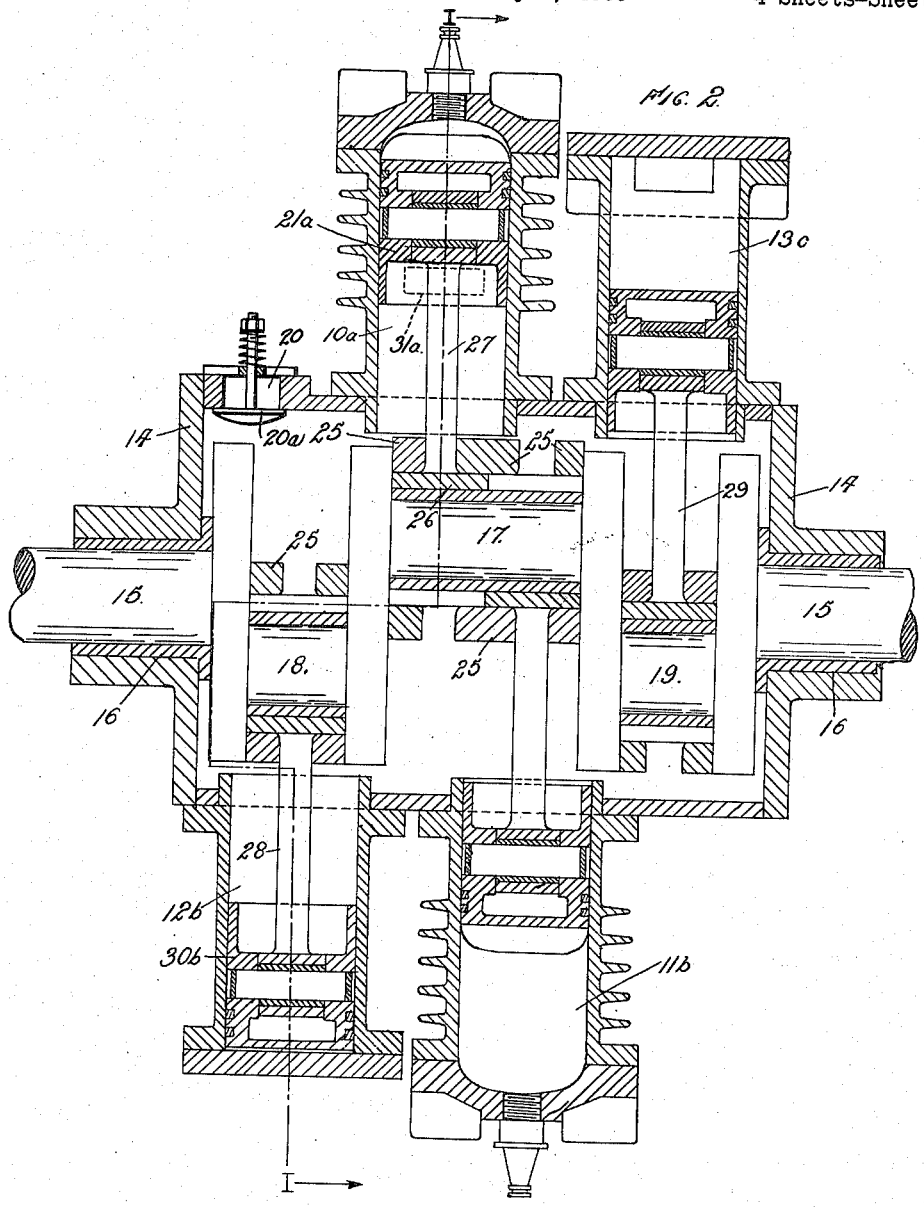
FIG. 2.



INVENTOR

William McClelland

by

atty.

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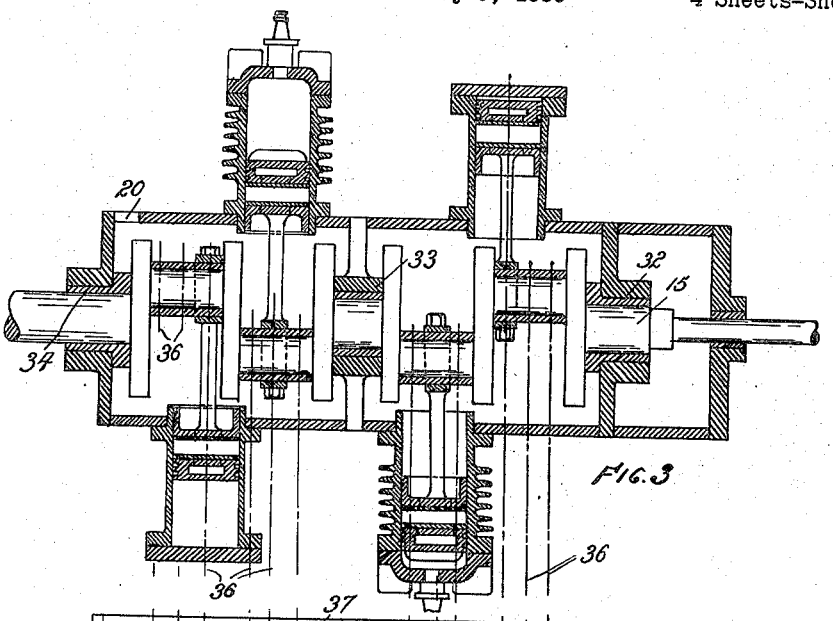

FIG. 3

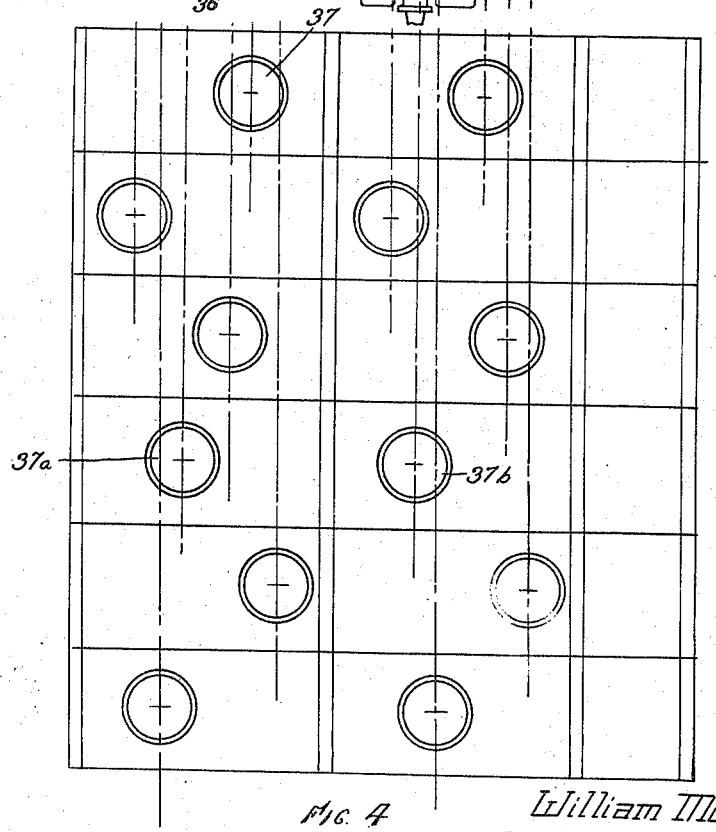

FIG. 4

INVENTOR
William McClelland
By
Atty.

Aug. 3, 1937. W. McCLELLAND 2,088,863

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FIG. 5.

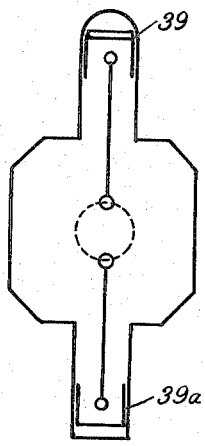


FIG. 6

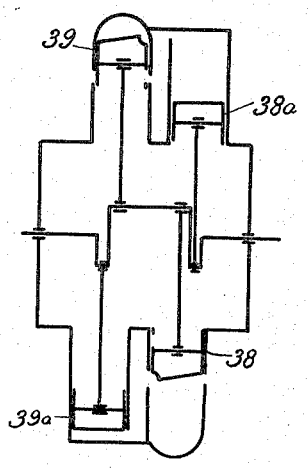


FIG. 7

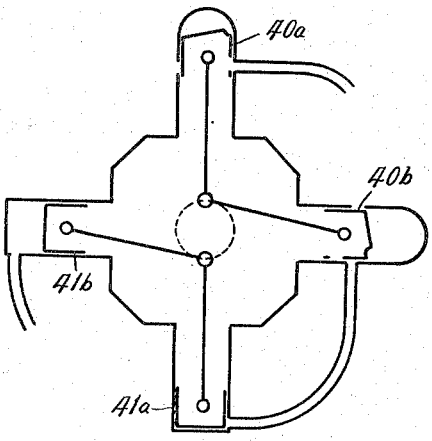
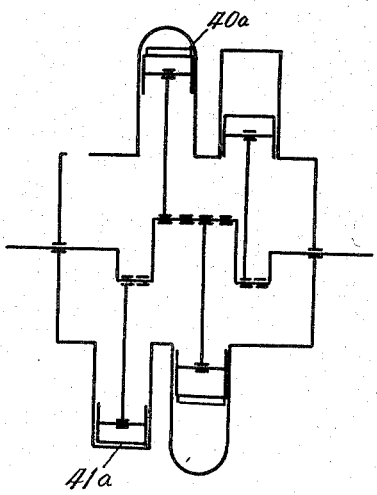


FIG. 8.



INVENTOR
William McClelland
by
atty.

Patented Aug. 3, 1937

2,088,863

UNITED STATES PATENT OFFICE

2,088,863

TWO-STROKE CYCLE INTERNAL COMBUSTION ENGINE

William McClelland, Rock Ferry, Birkenhead, England

Application May 9, 1935, Serial No. 20,695
In Great Britain May 11, 1934

5 Claims. (Cl. 123—72)

This invention is for improvements in or relating to internal combustion engines of the kind adapted to operate on the two-stroke cycle. The invention is applicable to engines fired by a spark or the like or to compression-ignition engines.

Among the objects of the present invention are to provide an engine of the above kind in which the mass of the moving parts is balanced about the axis of rotation of the engine so as to minimize as far as possible engine vibration, and in addition to provide a two-stroke engine in which the combustible fuel or a component thereof is positively driven into the working cylinder.

Accordingly the present invention provides an internal combustion engine of the kind described comprising in combination a crank case, a crank shaft supported within the crank case so as to be rotatable relatively thereto, at least two power-cylinders mounted on the crank case, at least two pump-cylinders also mounted on the crank case, a power piston in each power cylinder and a pump piston in each pump cylinder operatively connected to the crank shaft wherein the pistons and their respective connecting rods are of substantially equal mass, and wherein the pistons are so connected to the crank shaft that each power piston has a balancing pump piston substantially diametrically opposite thereto, and moving 180° out of phase therewith, whereby the power piston and its balancing pump piston are always at the same distance from the crank shaft axis, and wherein each pump piston serves to charge the cylinder of a neighboring power piston with a combustible mixture or a component thereof. Preferably each power piston is provided with a skirt having an inlet port which can be brought into register with an inlet port in the power cylinder, whereby a piston in the neighboring pump cylinder connected to the power cylinder inlet port can be used to draw a charge through the ports in the skirt and power cylinder into the neighboring pump cylinder, and expel the said charge into the combustion chamber of the power cylinder by way of the power-cylinder inlet port. The port in the skirt of the power piston can be made of such a size that the neighboring pump piston is drawing a charge into its cylinder during substantially the whole of its suction stroke, whereby an adequate charge can be expelled into the power cylinder combustion chamber during reverse movement of the neighboring pump piston. The invention is conveniently applied to a six cylinder radial engine wherein the engine has six power cylinders and six pump cylinders arranged in two banks comprising three power cylinders and three pump cylinders in each bank, the power and pump cylinders being alternately disposed around the crank case, and wherein all the power pistons are connected to one crank pin of the crank shaft and wherein the three pump pistons of one bank and the three pump pistons of the other bank are respectively connected to crank pins located on either side of the crank pin of the power pistons. This arrangement of a six-cylinder engine provides a good timing with no crank case compression, and the explosive mixture is positively moved during the working of the engine. Furthermore, the crank shaft can be short and stiff and the whole engine is well balanced.

If desired the connecting rods for all the pistons may have their big ends of segmental shape flanged outwards so that a loose-mounted ring can couple these ends to a crank pin, that is to say the segmental shaped cheeks of the connecting rod are sandwiched between the loose-mounted sleeve and the crank pin.

Various examples of the invention as applied to engines comprising two, four and six cylinders will now be described with reference to the accompanying drawings, whereon:—

Figure 1 is a sectional front elevation of a six-cylinder radial engine, the section being taken on the line I—I of Figure 2, looking in the direction of the arrow.

Figure 2 is an immediate-section side elevation on the line II—II of Figure 1,

Figure 3 is a diagrammatic sectional side elevation of a six-cylinder radial engine having a modified arrangement for coupling the pistons to the crank shaft.

Figure 4 is a developed plan view of the crank case of the engine shown in Figure 3,

Figures 5 and 6 are diagrammatic front and side elevation respectively of a two-cylinder engine according to the invention, and

Figures 7 and 8 are diagrammatic front and side elevation respectively of a four-cylinder engine according to the invention.

With reference to Figures 1 and 2, the six-cylinder engine is arranged to work on the two-stroke cycle, and comprises two banks of power cylinders, one bank 10*a*, 10*b*, 10*c*, and a second cylinders 10*a*, 10*b*, 10*c*. Both banks of cylinders arranged at 120° radially of the crank shaft axis in each bank, but the cylinders in the second bank are arranged at an inclination of 60° to the cylinders 10*a*, 10*b*, 10*c*. Both banks of cylinders are similarly constructed, and therefore the detailed description of one bank with reference to

Figures 1 and 2 will apply to the second bank. The power cylinders 10a, 10b, 10c are associated with three pump cylinders 12a, 12b, 12c so that power and pump cylinders are arranged alternately round the crank case. A similar bank of pump cylinders is associated with the second bank of power cylinders, and one such pump cylinder 13c is shown in Figure 2. The crank case 14 is of hexagonal shape, and the pump cylinders and power cylinders are mounted on the case 14 radially round a crank-shaft 15 which is of the two-throw type and is rotatably supported in bearings 16 on the crank case. The power pistons in both banks are connected to the center crank pin 17 and the three pump pistons of each bank are respectively connected to crank pins 18, 19, on either side of the center crank pin 17. As is usual with engines working on the two-stroke cycle, the explosive mixture enters the crank case 14 by way of the port 20 controlled by a spring loaded non-return valve 20a.

The power pistons 21a, 21b and 21c are of the normal deflector type with the exception that the port 22 in the skirt of the piston operates in conjunction with a port 23 in the power cylinders 10a, 10b and 10c which communicates by way of the conduit 24 with the neighboring pump cylinders 12a, 12b and 12c into which a combustible charge is drawn through the port 22 as will be described later. The connecting rods of the power pistons are coupled to the crank pin 17 by means of a split ring 25 which bears on segmental shaped cheeks 26 on the connecting rods 27 to hold these rods on to the crank pin 17. Rings similar to the rings 25 serve to hold the pump-piston connecting-rods 28, 29 to the crank-pins 18, 19. The pump pistons 30a, 30b, 30c and the power pistons 21a, 21b, 21c are all of the same mass, and so are the connecting rods for each pump piston and power piston. Since, therefore, the crank shaft is of the two-throw type the pump pistons being all connected to one throw, and the power pistons to the other throw, it will be seen that each power piston has, diametrically opposite to it as in Figure 1, a pump piston moving with the same velocity in the opposite direction so that radially about the axis of the crank shaft the mass of the moving parts of the engine is balanced.

The pump pistons have, however, a function additional to balancing, and this function is to serve as a positive charging-means for the neighboring power cylinder, to which the pump piston is connected. For instance, with reference to the power cylinder 10a and the pump 12a it will be seen that when the power piston 21a is at the top of its stroke in the firing position the neighboring pump piston 30a is at the bottom of its stroke, and has drawn an adequate charge for the power cylinder through the port 22 by way of the conduit 24 into the pump cylinder 12a. When the power piston is on its working stroke it uncovers the exhaust port 31a and later uncovers the inlet port 23 and during this period the pump piston 30a is moving at its maximum velocity and forces a full charge into the cylinder 10a.

With the parts in their position illustrated in Figure 2 the piston 21a is in the firing position; piston 21b is commencing to compress the charge; piston 21c is completing the firing stroke and the exhaust port is about to open. Pump piston 30a is drawing a charge into the pump cylinder 12a from the crank case through port 23 and conduit 24; pump piston 30b has just completed pumping its charge through its associated port 23 and conduit 24 to cylinder 10b and pump piston 30c is commencing to pump a charge to power cylinder 10c. The operations described with reference to the bank of cylinders 10a, 10b and 10c and pumps 12a, 12b, and 12c are exactly similar in the bank of power cylinders 11a, 11b, 11c and the respective pumps but is 60° out of phase.

The port 22 in the skirts of the power pistons is of such a size that the neighboring pump piston can draw a charge into its cylinder by way of the said port during substantially the whole of the suction stroke of that pump piston. In this way an adequate charge for the combustion chambers of the power cylinders is ensured.

The modification shown in Figure 3 is similar in operation to the engine described with reference to Figures 1 and 2, but in this case the crank shaft 15 has three main bearings 32, 33, and 34, and the pump and power pistons have the usual big ends strapped around the crank pins so that they operate side by side. This necessitates arrangement of the center lines of the various pistons and cylinders as shown by the chain-dotted lines 36 which are transferred to the developed plan view Figure 4 so as to show how each cylinder is located on the crank-case. Thus, the power cylinder 37 is balanced radially by the pump cylinder 37a and as to torque in relation to the center-bearing 33 by the power cylinder 37b.

In the diagrammatic views Figures 5 and 6 there are two power pistons 38, 39 balanced respectively by two pumping pistons 38a, 39a. The portion of the engine otherwise is the same as described with reference to Figures 1 and 2.

In Figures 7 and 8 there are four power pistons 40a and 40b on one crank pin and two balancing pistons 41a and 41b on the other crank pin. This arrangement is duplicated to bring the working cylinders up to 4 as will be seen in Figure 8.

With the arrangement described for a six-cylinder radial engine there are six firing strokes per revolution of the crank shaft, thereby giving an even torque equal to a twelve-cylinder engine operating on the four-stroke cycle. The overall length of the engine is comparatively small, and the crank shaft can be very short and stiff. There is of course no cam shaft and drive and no valves or tappets.

It will be appreciated of course that any of the standard arrangements insofar as ignition cooling, lubricating and mounting of the engine may be adopted. In the case of a compression-ignition engine air only would be drawn through the crank case into the pump cylinders, and if desired the pump pistons can be made of larger diameter than the power pistons, still being of course of the same weight, thereby giving a thorough scavenging action by the large blast of air. The fuel would be injected at the top of each stroke of the power piston with or without suitable arrangements for producing turbulence, otherwise the cycle of operations will be substantially as herein described.

Furthermore, with the ordinary petrol engine by making the pump piston of substantially greater diameter than the power piston but of the same weight a super-charging effect may be produced. The invention is also advantageous when applied to rotary engines. In such cases of course the crank shaft remains stationary, and the engine casing rotates. For the rotary engines the mixture or air can enter the crank case through a hollow crank shaft.

Modifications may be made in the example hereinbefore described without departing from the nature of the invention as herein defined; for example, the number of working cylinders used may vary, and the pairing of these cylinders with an appropriate pump may be arranged in any desired manner. Furthermore the normal master connecting rod and auxiliary connecting rod arrangements may be used to couple the pistons and the crank shaft. The inside of the conduit 24 connecting the pump and power cylinders may be provided with a scroll or similar device for producing turbulence in the gas expelled into the combustion chamber of the power cylinder.

What is claimed is:—

1. A two-stroke cycle internal combustion engine, comprising in combination, a crank case, crank shaft bearings on the said crank case, a crank shaft rotatable in said bearings, at least two power units having inlet and exhaust ports, means connecting the said power units to the crank case, a pump unit diametrically opposite each power unit and having suction and discharge ports, a conduit connecting each of the said pump units to the crank case, said conduit also connecting the discharge port of each pump unit to the inlet port of an adjacent power unit whereby each pump unit serves to charge the cylinder of an adjacent power unit with a component of a combustible mixture, characterized by a power piston in each power unit, a pump piston in each pump unit, the mass of which is equally to that of the opposite power piston, crank pins on the crank shaft, arranged diametrically opposite each other, i. e. 180° out of phase, and of equal throw, and connecting rods of equal mass and length operatively connecting diametrically opposite power and pump pistons to diametrically opposite crank pins so that each power piston and its opposite pump piston are at all times during the operation of the engine, equi-distant from the crank shaft axis, whereby the engine is balanced dynamically.

2. A two-stroke cycle internal combustion engine comprising in combination a crank case, crank shaft bearings on said crank case, a crank shaft rotatable in said bearings, at least two power units having inlet and exhaust ports, means connecting the said power units to the crank case, a pump unit diametrically opposite each power unit and having a combined suction and discharge port, a conduit connecting each of the said pump units to the crank case, said conduit also connecting the said suction-discharge port of each pump unit to the crank case by way of the inlet port of an adjacent power unit whereby each pump unit serves to draw a component of a combustible mixture from the said crank case and charge it into the cylinder of the adjacent power unit by way of the inlet port thereof, characterized by a power piston, in each power unit, having a ported skirt controlling the inlet port of the said power unit, a pump piston in each pump unit, the mass of which is equal to that of the opposite power piston, crank pins on the crank shaft, arranged diametrically opposite each other, i. e. 180° out of phase, and of equal throw, and connecting rods of equal mass and length operatively connecting diametrically opposite power and pump pistons to diametrically opposite crank pins so that each power piston and its opposite pump piston are, at all times during the operation of the engine, equi-distant from the crank shaft axis, whereby the engine is balanced dynamically.

3. An internal combustion engine as claimed in claim 2, wherein the size of the port in the skirt of the power piston is such that the pump piston of the adjacent pump unit can draw a charge into its cylinder during substantially the whole of its suction stroke.

4. An internal combustion engine as claimed in claim 1, and of the radial type, wherein the engine has six power units and six pump units arranged in two banks comprising three power units and three pump units in each bank, the power and pump units being alternately disposed around the crank case and wherein all the power pistons are connected to one crank pin of the crank shaft, and wherein the three pump pistons of one bank and the three pump pistons of the other bank are respectively connected to crank pins located at either side of the crank pin of the power pistons, and 180° out of phase therewith.

5. A two-stroke cycle internal combustion engine as claimed in claim 1, and comprising a plurality of power cylinders and a plurality of pump cylinders arranged in banks radially around the crank shaft, the cylinders in each bank having their axes in a common plane at right angles to the crank shaft axis, and wherein the connecting rods of the power pistons and the pump pistons are provided with segmental big ends and are held on the crank pin by a split ring device whereby the big ends of the connecting rods of each bank of cylinders can be arranged to work on a common portion of a crank pin.

WILLIAM McCLELLAND.