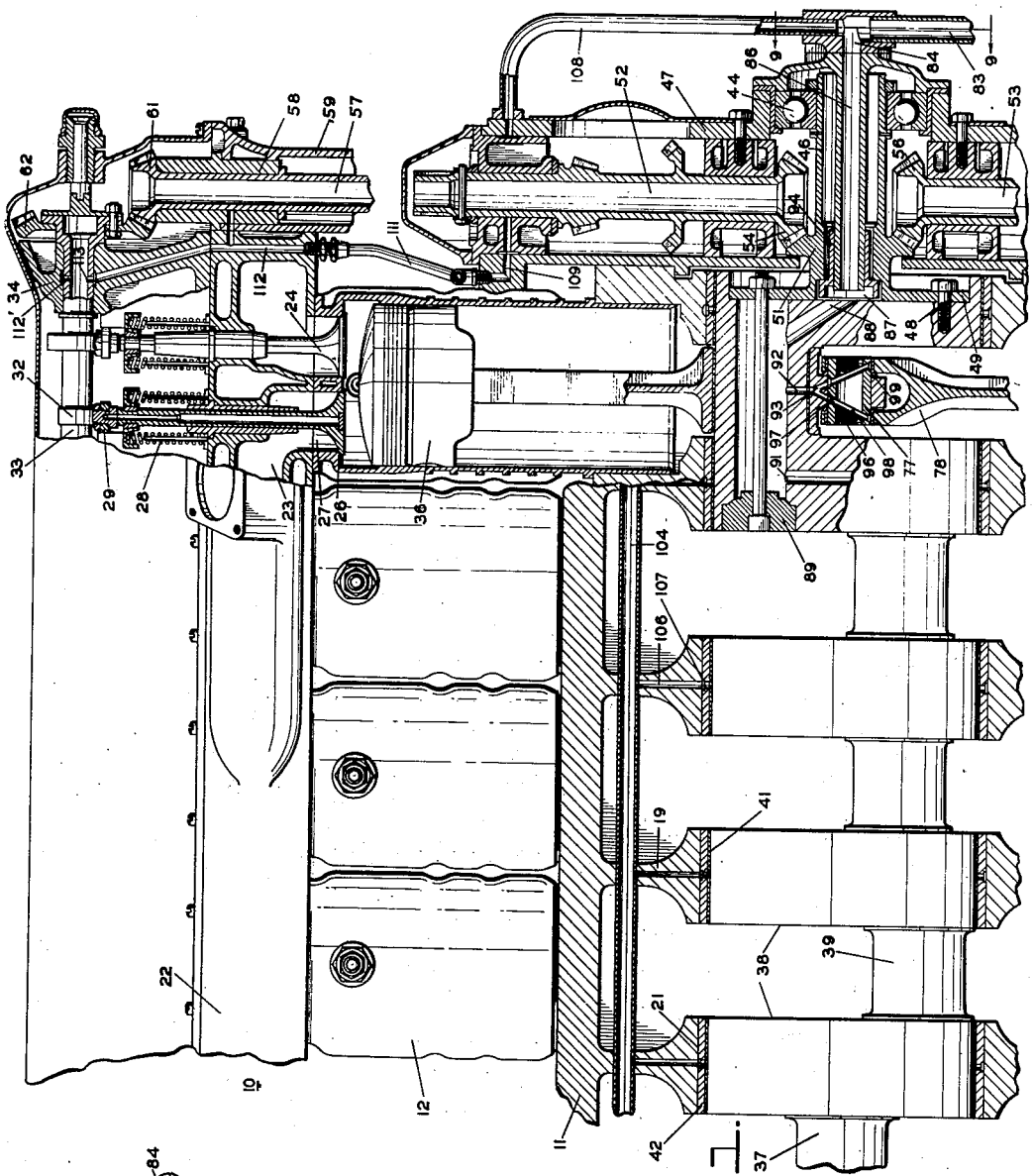
Jan. 1, 1935. L. M. WOOLSON 1,986,549

INTERNAL COMBUSTION ENGINE

Original Filed Oct. 1, 1928 2 Sheets-Sheet 1



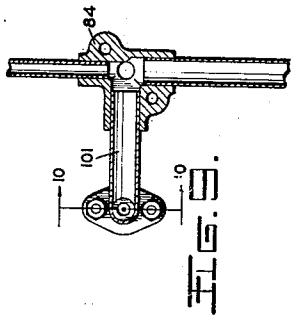


FIG. 8.

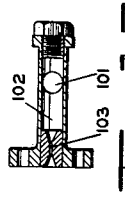


FIG. 9.

FIG. 7.

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INTERNAL COMBUSTION ENGINE

Original Filed Oct. 1, 1928 2 Sheets-Sheet 2

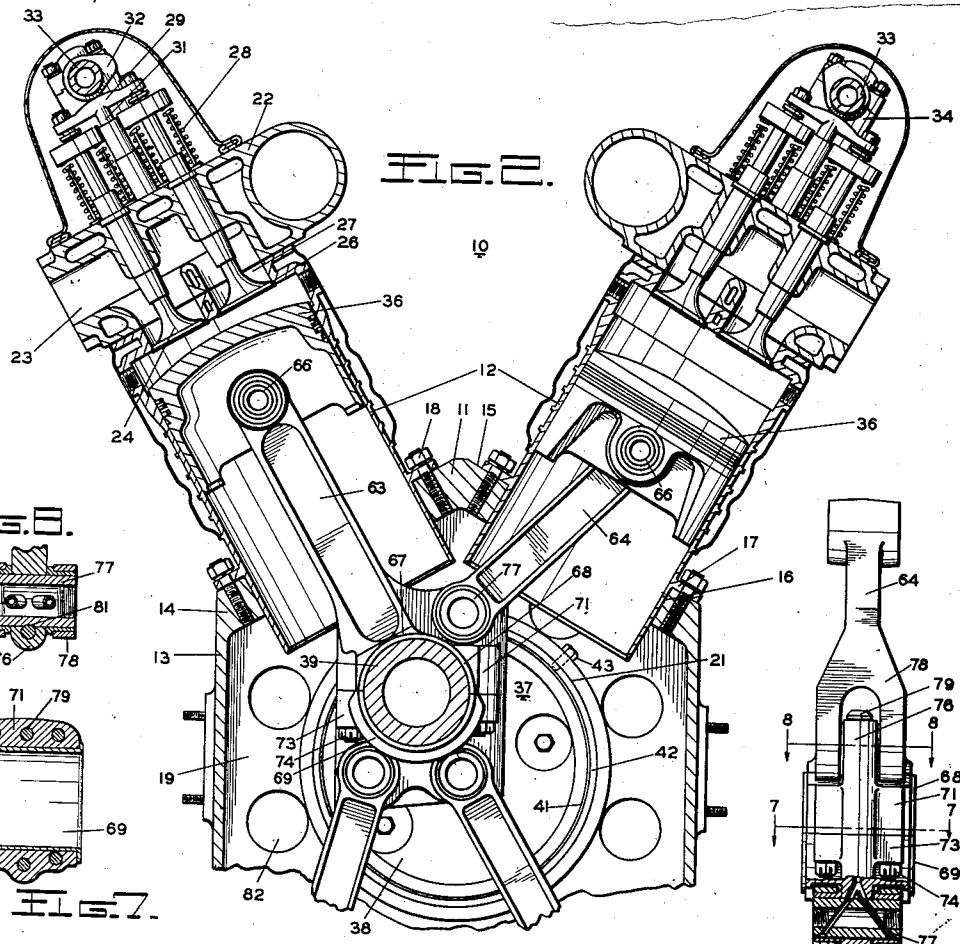


FIG. 2.

FIG. 8.

FIG. 7.

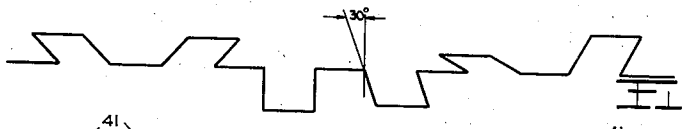


FIG. 4.

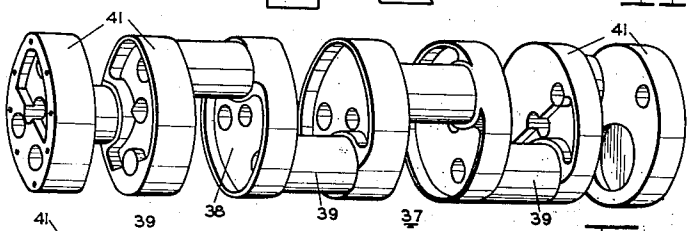


FIG. 3.

FIG. 5.

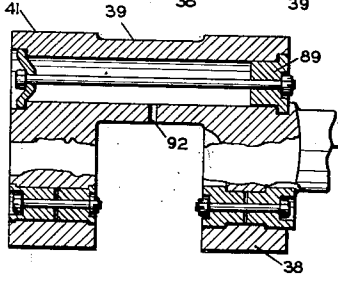


FIG. 6.

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Patented Jan. 1, 1935 1,986,549

UNITED STATES PATENT OFFICE

1,986,549

INTERNAL COMBUSTION ENGINE

Lionel M. Woolson, Detroit, Mich., assignor to Packard Motor Car Company, Detroit, Mich., a corporation of Michigan

Application October 1, 1928, Serial No. 309,631
Renewed March 1, 1934

12 Claims. (Cl. 123—55)

This invention relates to internal combustion engines and particularly to engines such as are used in the propulsion of aircraft.

It has for one of its objects to provide an improved crank shaft and connecting rod assembly particularly adapted for use in aircraft engines of large power and low weight.

Another object of the invention is to provide a relatively short crank shaft of the character designated adapted to connect the pistons from a large number of cylinders.

Another object of the invention is to provide a crank shaft having an angular disposition of cranks adapted for use in an engine having a large number of cylinders.

Another object of the invention is to provide a crank shaft which shall be very rigid in proportion to its size and to the power transmitted.

Another object of the invention is to provide a crank shaft in which the crank arms and the adjacent crank shaft bearings are arranged in the same transverse planes longitudinally of the shaft.

Another object of the invention is to provide a connecting rod assembly adapted for use on engines of the type designated having improved means for connecting the various sets of rods to the cranks of the crank shaft.

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

Fig. 1 is a view, partially in side elevation and partially in longitudinal section, through part of an engine constructed in accordance with and embodying this invention;

Fig. 2 is a view in transverse section through part of the engine shown in Fig. 1;

Fig. 3 is a perspective view of a crank shaft used in the engine of this invention;

Fig. 4 is a diagrammatic representation of the crank shaft illustrated in Fig. 3, showing the angular disposition of the cranks thereof;

Fig. 5 is an end elevation partially in section, through a connecting rod assembly for the engine shown in Figs. 1 and 2;

Fig. 6 is an enlarged detail section taken longitudinally through one of the cranks of the crank shaft illustrated in Fig. 3;

Fig. 7 is a detail section taken substantially on the line 7—7 of Fig. 5;

Fig. 8 is a detail section taken substantially on the line 8—8 of Fig. 5;

Fig. 9 is a detail section taken substantially on the line 9—9 of Fig. 1, and

Fig. 10 is a detail section taken substantially on the line 10—10 of Fig. 9.

Referring to the drawings, at 10 is shown an internal combustion engine having a crank case 11 on which are mounted cylinders 12. As shown, the crank case is in the form of a hollow prismatic housing, preferably hexagonal in cross section, having parallel side walls 13 and upper and lower cylinder supporting walls 14, each presenting a pair of inclined faces 15. The walls 14 are provided with holes 16 through which the barrels of the cylinders 12 project, the barrels being provided with integral flanges 17 which contact with the faces 15 and are secured to the walls 14 by bolts 18, in the well known manner. The interior of the crank case 11 is provided with transverse internal ribs or webs 19, preferably integral with the crank case and spaced longitudinally thereof between the cylinders 12, and each web 19 is provided at its central portion with a hole 21, which holes are in alignment axially of the crank case to receive the engine crank shaft, as will appear. Such structure, however, is particularly pointed out and claimed in my co-pending applications Serial No. 515,798 filed February 14, 1931 and Serial No. 295,937 filed July 28, 1928.

As will be readily seen from Figs. 1 and 2, this invention is well adapted for use with an engine having a plurality of cylinders 12 arranged in inclined rows or banks both above and below the crank case 11. In the present embodiment there are four such banks of six cylinders each, arranged in two upright banks above, and two inverted banks (not shown) below the crank case, in the general form of an X, with the banks of cylinders separated by angles of 60° alternating with angles of 120°. It is to be understood, however, that the invention is not limited in its application to engines having such a number and arrangement of cylinders.

The cylinder banks are each provided with a head member 22 in which are formed passages 23 for the intake and exhaust of each of the cylinders, these passages being controlled by valves as at 24 having seats 26 formed at ports 27 in the head. These valves are urged to closed position on their seats 26 by spring devices 28 of any suitable construction. The valves are arranged in pairs connected by a yoke or follower 29 having a guide stem 31 and operated from a cam 32 on a cam shaft 33, supported in suitable bearings 34 on the head member 22. As mechanism of this type is well known in the

art to which this invention relates, further description thereof is unnecessary.

Each of the cylinders 12 is provided with a piston 36 adapted to reciprocate therein in the usual manner, all of the pistons being connected to and adapted to operate a common crank shaft 37. As clearly shown in Figs. 3 and 4 the crank shaft preferably employed in the present embodiment of the invention is a six-throw shaft, there being four of the pistons 36 connected to each of the cranks thereof. It comprises spaced cylindrical crank arms or cheeks 38 in the form of discs, connected by integral crank pins 39, preferably hollow as shown. The cheeks 38 provide bearing surfaces 41 which constitute the crank shaft journals and on which the crank shaft is rotatably mounted in aligned bearings 42 in the crank case 11. These bearings 42 are preferably integral shells or rings of steel or other suitable material, which may be lined with babbitt or other bearing metal, that are supported in the openings 21 in the crank case webs 19 and are held tightly therein, preferably by inserting them in the crank case while it is heated, it being subsequently permitted to shrink over them. Set screws 43 are also threaded into suitable flanges on the webs 19, and engage these rings to further secure them in position. In this way large bearing surfaces are provided well adapted to take the heavy loads imposed on this crank shaft without increasing the length of the bearings or of the shaft.

The crank pins 39 are preferably arranged in sets or groups of three, as clearly shown in Figs. 3 and 4, the three forward pins comprising one such group and the three rear pins another. In each set the pins are disposed at equal angles of 120°, as in the conventional six-throw shaft, but there is preferably a phase difference between the sets which may conveniently be a lead or lag equal to the number of degrees between successive cylinder explosions. Thus in the present embodiment the fourth crank pin has a lead of 30° over the third pin, as best seen in Fig. 4, the crank shaft rotating in a counterclockwise direction viewed from the forward end.

The crank shaft 37 is maintained in correct axial position in the crank case by means of a thrust bearing 44 cooperating with a removable axial extension 46 at the rear end of the shaft. This bearing is mounted in a suitable housing 47, removably secured to the rear end of the crank case 11, in which the timing gears of the engine are preferably located.

The axial extension 46 may be conveniently secured to the rear face of the end crank cheek 38 by screws 48 passing through a flange portion 49, and this extension is provided with a gear 51 through which the timing gears are driven. This gearing comprises the vertical aligned shafts 52 and 53 extending above and below the crank shaft and provided with the integral gears 54 and 56 which mesh with and are driven from the gear 51, these gears being preferably bevel gears. The shafts 52 and 53 are provided near their ends with integral bevel gears adapted to mesh with and drive similar gears which are secured to inclined shafts 57, there being one of the shafts 57 for each of the banks of cylinders. These shafts 57 are journaled in bearings 58 in extensions 59 of the housing 47 and they are provided at their outer ends with gears 61 which mesh with and drive gears 62 connected to the ends of the respective cam shafts 33. In this way the four cam shafts are driven in synchronism from the crank shaft 37, the gear reduction being such as to secure the proper half speed for each of the cam shafts.

Each of the crank pins 39 is connected to four of the pistons 36, one in each of the cylinder banks, by a connecting rod assembly, as shown in Figs. 2 and 5, including a master rod 63, and link rods 64, each of which is pivotally connected to its piston by a piston pin 66 in the usual way. The crank shaft end of the master rod 63 is provided with an enlarged portion 67 in which is formed part of the crank pin bearing 68, the remainder of this bearing being formed in a cap member 69 which is removably secured to the portion 67. For this purpose the bearing members are provided with integral lugs 71 in which studs or bolts 72 are carried, being arranged on each side of the bearing and set in as close to the bearing as possible. They are adapted to pass through lugs 73 in the cap members 69 which correspond to and cooperate with the lugs 71, and are provided with nuts 74 by which the cap member may be clamped to the portion 67, and the halves of the bearing 68 positioned upon the crank pin 39.

The portions 67 and 69 are also provided with integral flange members 76 disposed in the median plane of the bearing 68, in which axially disposed tubular pins 77 are mounted to pivotally engage forked ends 78 on the link rods 64. These forked ends are adapted to straddle the flange members 76 as clearly shown in Figs. 1 and 5. The pins 77 are preferably locked in position in the flange members 76 by bolts 79, one on each side of the bearing 68, which pass through the cooperating flange members 76 parallel to the studs 72, and engage notches 81 in the pins 77. These bolts 79 assist the studs 72 to clamp the members 67 and 69 in operative position. The pins 77 are preferably threaded internally for engagement with the threaded end of a suitable bar (not shown) by which they may be inserted or withdrawn through axially disposed holes 82 arranged in the crank case webs 19, after removal of the bolts 79.

The lower end of the shaft 53 is connected to and drives the engine pump assembly, comprising pumps for the fuel, cooling and lubricating systems of the engine. As combined pump units of this nature are well known in the art the pumps have not been illustrated in the drawings, but it is to be understood that the water pumps are adapted to supply cooling water to the jackets of each of the banks of cylinders, and that the lubricating pumps serve to scavenge or remove oil from the crank case and the camshaft housings as well as to supply oil under pressure for the various engine bearings.

The outlet of the oil pressure pump is connected to a conduit 83 through which it delivers oil under pressure to a fitting 84. From this fitting part of the oil passes to a tube or nozzle 86 which is supported on the housing 47 and projects through the hollow crank shaft extension 46 into a pressure chamber 87 in the inner end thereof. From this chamber a passage 88 leads to the inside of the rear crank pin 39. Each of the hollow crank pins is closed at the ends by suitable plugs 89, and the chambers thus formed are connected by passages 91, forming a continuous conduit through the crank shaft supplied with oil under pressure from the tube 86. A passage 92 is formed in each of the crank pins 39 which passage terminates at the bearing surface in a port 93, through which oil flows

under pump pressure to the crank pin bearings, escaping at the ends thereof into the crank case in the usual way.

Loss of oil between the tube 86 and the crank shaft is prevented by a bushing 94, having a tight fit on the tube and a relatively loose fit in the crank shaft extension. This bushing has a flanged end located in and contacting the wall of the pressure chamber 87, in which position it is retained by the pressure of the oil in the chamber, thus effectually sealing possible leakage at this point, and permitting slight variations in axial alignment between the tube and the shaft.

Passages 96 are also provided in each of the cap and the bearing portions of the master connecting rods, terminating in ports 97 at the bearing surface, which register once per engine revolution with the ports 93, receiving therefrom a measured charge of oil. This oil is conducted from passage 96 through branch passages 98 to the link pin bearings through ports 99, whereby these passages are lubricated.

The lubrication of the main bearings is preferably effected by a low pressure system connected to the fitting 84. It has been discovered that bearings which have a large diameter in proportion to their width, and a relatively large clearance, offer very little resistance to the flow of lubricating oil and in fact frequently have a pumping action which increases the flow of oil through them. For this reason the high pressure under which oil is fed to the connecting rod bearings is not desirable at the main bearings, since it causes the circulation of an unnecessarily large quantity of oil which must be removed by the scavenging pumps, and requires a large circulation pump to maintain the pressure. This invention provides for the supply to the main bearings of oil under a lower pressure. To this end high pressure oil from the fitting 84 is conducted through a branch pipe 101 to a reducing chamber 102 having a pressure reducing passage 103, Fig. 10. From this chamber oil at a reduced pressure is conducted through a suitable pipe (not shown) to a manifold 104 extending longitudinally of the crank case 11 and supported from the webs 19 thereof. A passage 106, formed in each of the webs 19, conducts the low pressure oil from the manifold 104 to an orifice 107 of the bearing surface, thus providing ample lubrication for these bearings without excessively reducing the pressure in the remainder of the lubricating system.

Oil from the fitting 84 is also supplied by a pipe 108 to the upper bearing of the shaft 52, and thence through a passage 109 to a branched pipe 111 which leads to each of the heads 22. These heads are provided with passages 112, communicating with the pipes 111, by which the oil is conducted to an annular groove 112' in the rear camshaft bearing 34, and thence through ports 113 to the interior of the hollow camshaft. From the camshaft the oil is distributed through suitable ports and passages (not shown) to the other bearings 34, the cams and cam followers, and to the valve cooling system, in the well known manner. Oil is supplied in a similar way to the camshafts of the lower cylinder banks through pipes (not shown) connecting with the pump conduit 83.

The operation of the engine described is apparent and many of the constructional advantages will also be seen from the foregoing description. Because of the disposition of the main journals in the plane of the adjacent crank cheeks, the crank shaft is very short and stiff, and its rigidity is increased by the provision of one of these main journals on each side of each crank pin, and close thereto. Moreover, the large journals made possible by the construction of this invention reduce the peripheral velocity at the rubbing surfaces, while the increase in bearing area reduces the unit load on the bearings, and the stresses thereon. It will also be observed that the crank shaft may be readily removed from the crank case after disconnection of the connecting rod assembly, by the simple removal of the retaining thrust bearing in the crank case housing.

The staggered arrangement of cranks also assists the operation of this engine, resulting in an unusually smooth operation for the large number of cylinders. Because of this crank system, there is no possibility of closely adjacent cylinders firing simultaneously on the same or on adjacent cranks, and thus dangerously increasing the working stresses.

Considerable advantage is also presented by the connecting rod assembly. The connections provided between the link rods and the master rod are simple and strong, making the assembly or disassembly of the engine relatively easy but without sacrificing any of the rigidity of the tubular crank case. The strength of the crank pin bearing is also enhanced by the bolt arrangement provided, the studs being set in close to the bearing, and reinforced by the through bolts which also serve to lock the link pins in position. By this construction, each of the crank pins is connected to a number of pistons without greatly increasing the bearing length, or the overall length of the engine.

The invention also provides a very efficient lubricating system which avoids the unnecessary circulation of oil, and the consequent overloading of the oil return system, while insuring an ample supply of lubricant to all of the engine bearings.

While a specific embodiment of the invention has been herein described, which is deemed to be new and advantageous and may be specifically claimed, it is not to be understood that the invention is limited to the exact details of the construction, as it will be apparent that changes may be made therein without departing from the spirit or scope of the invention.

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

1. In an internal combustion engine having a crank case and more than two banks of cylinders on said crank case provided with pistons, a crank shaft journaled in the crank case having two sets of cranks each having pins arranged at equal angles about the shaft axis, one of said sets of pins leading the other set at an angle less than the angle between successive cranks of the same set, and means connecting each crank pin to a piston in each of the cylinder banks.

2. A six-throw crank shaft having sets of cranks, the cranks of each set being disposed at equal angles about the crank shaft axis, each set of cranks having an angular offset from the adjacent set different than the angle between successive cranks of the same set.

3. A six-throw crank shaft having cranks disposed in sets each having the same number of cranks disposed at equal angles about the shaft axis, each of said sets being disposed at an angle to the adjacent set less than the angle between successive cranks of the same set.

4. A crank shaft for an engine with more than 8 cylinders, said shaft having crank cheeks forn-

ing journal bearings and connected by crank pins, said crank pins being disposed at equal angles about the axis of rotation and arranged in sets, said sets having a phase difference on either side of the middle journal.

5. A six-throw crank shaft having sets of three cranks at each end disposed 120° apart, there being a phase relation of 30° between the two sets of cranks.

6. A crankshaft having cranks arranged in sets, each crank being subjected to more than one explosion for each two revolutions of the shafts, the cranks in each set being equi-angularly disposed about the axis of rotation and each set of cranks being displaced from the adjacent set at an angle less than the angle between the cranks in each set.

7. In an internal combustion engine having more than two banks of aligned cylinders, a crankshaft having cranks arranged in sets, said sets being angularly displaced by an angle equal to 180° divided by the total number of cranks on the shaft.

8. In an internal combustion engine having more than two banks of aligned cylinders, a crankshaft having cranks arranged in sets, said sets being angularly displaced by an angle equal to 90° divided by the number of cranks in each set.

9. In an internal combustion engine having more than two banks of aligned cylinders, a crankshaft having cranks arranged in sets, said sets being angularly displaced by an angle less than the angle between any two adjacent banks of cylinders.

10. In an internal combustion engine having more than two banks of aligned cylinders, a crankshaft having cranks arranged in sets, said sets being angularly displaced by an angle one-third as large as the angle between adjacent banks of cylinders.

11. In an internal combustion engine having more than two banks of aligned cylinders, a crankshaft having cranks arranged in sets, said sets being angularly displaced by an angle one-fourth as large as the angle between two banks of cylinders.

12. In an internal combustion engine having more than two banks of aligned cylinders, a crankshaft having cranks arranged in sets, said sets being angularly displaced by an angle equal to the angle between adjacent banks divided by an integer.

LIONEL M. WOOLSON.

CERTIFICATE OF CORRECTION.

Patent No. 1,986,549. January 1, 1935.

LIONEL M. WOOLSON.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, after line 46, insert the following sentence:

In this way the power impulses of the pistons on the shaft are staggered so that the simultaneous firing of two cylinders connected to the same crank or adjacent cranks is avoided, while a regular firing interval is maintained.

And that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of May, A. D. 1935.

(Seal)

Leslie Frazer
Acting Commissioner of Patents.