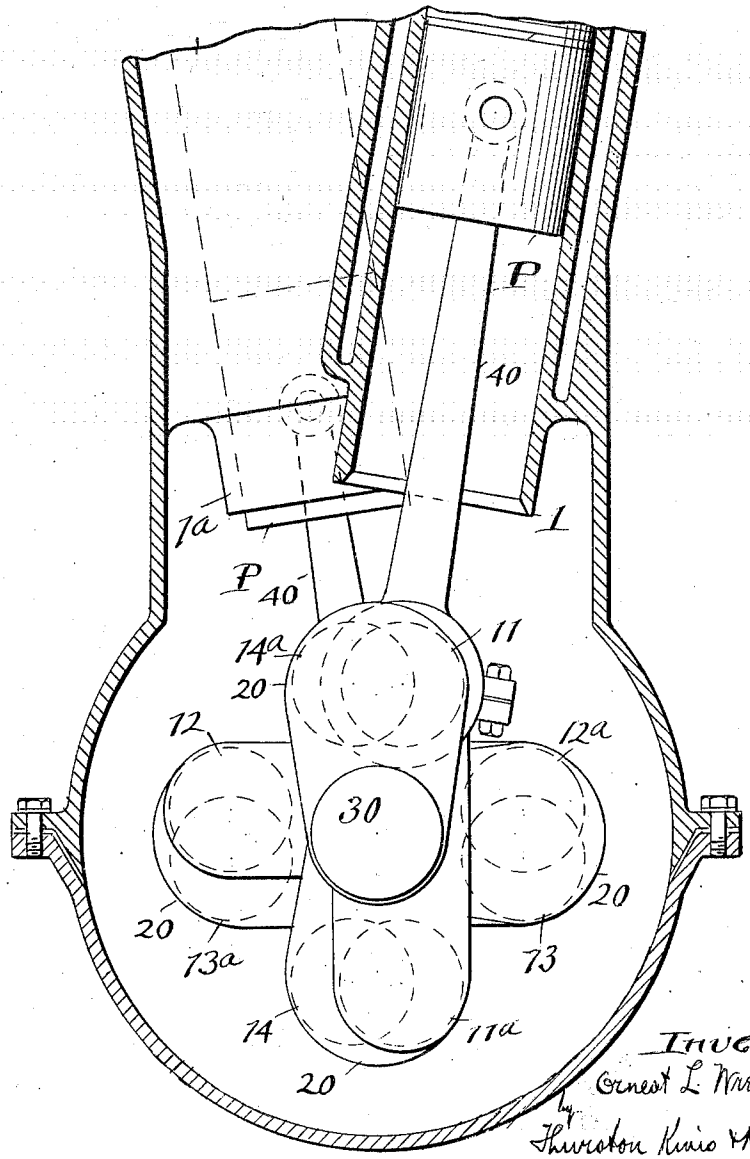
April 10, 1928. 1,665,521

E. L. WRENTMORE

INTERNAL COMBUSTION ENGINE

Filed Aug. 25, 1920 4 Sheets-Sheet 1

Fig. 1.



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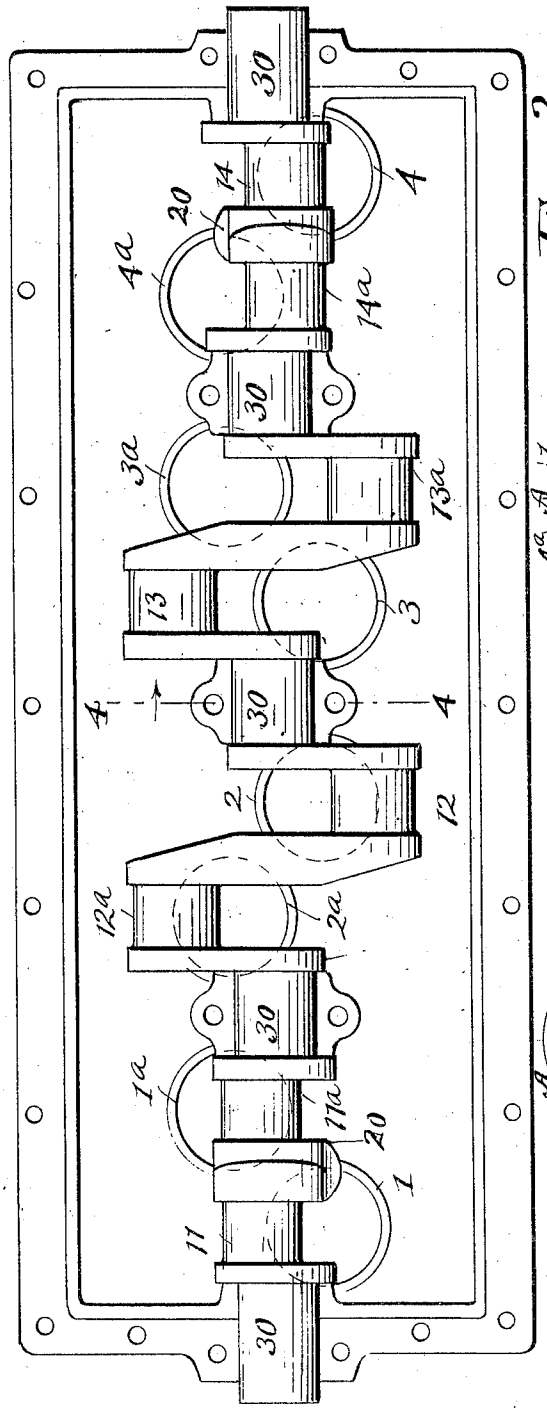


Fig. 2.

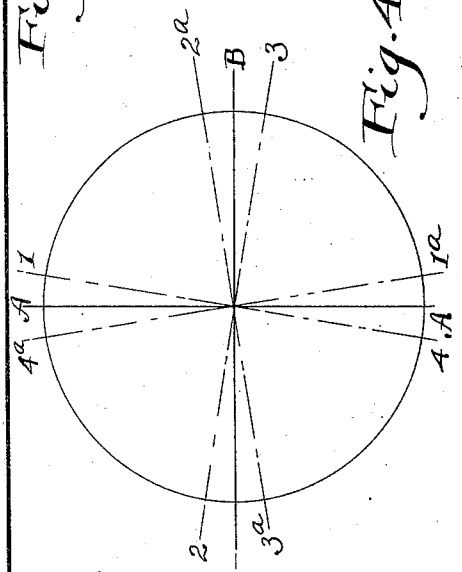


Fig. 4.

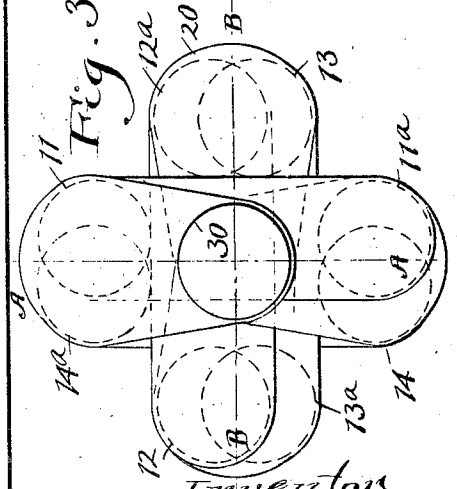


Fig. 3.

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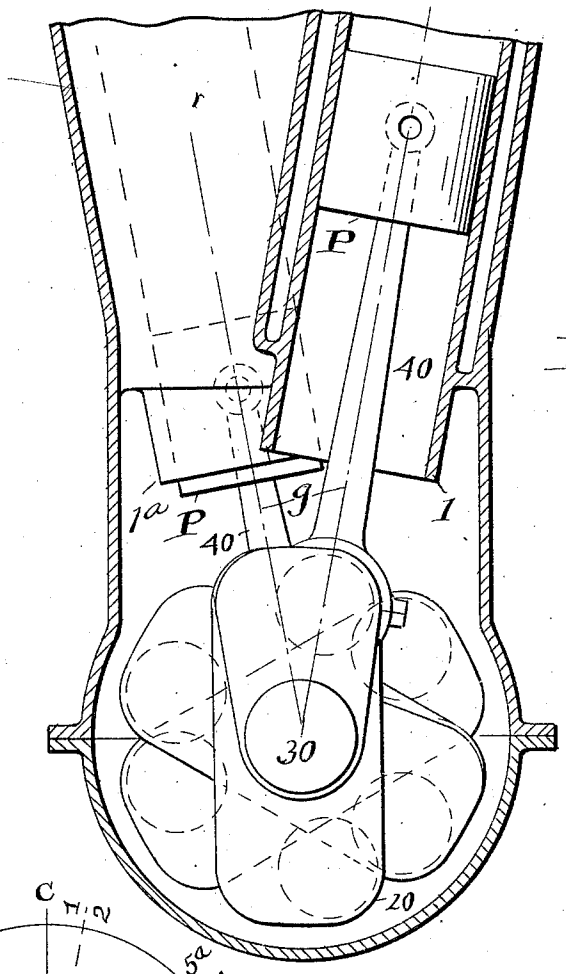


Fig. 5.

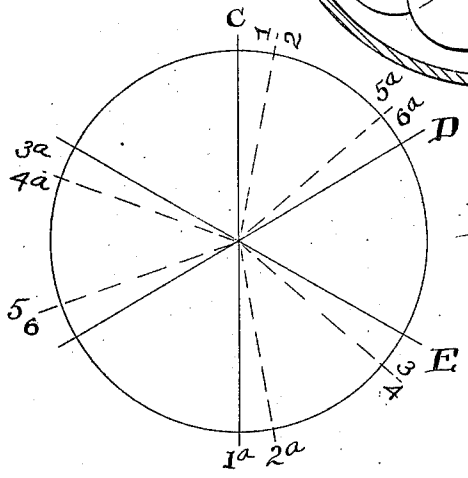


Fig. 10.

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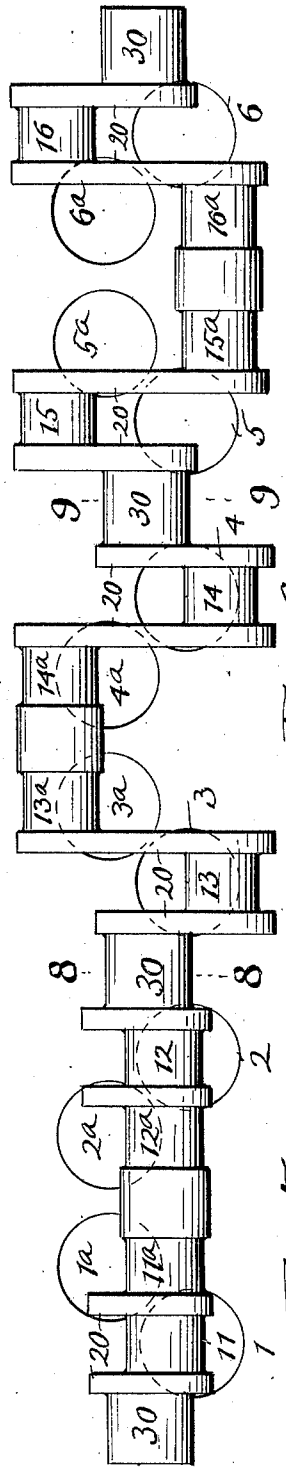


Fig. 6.

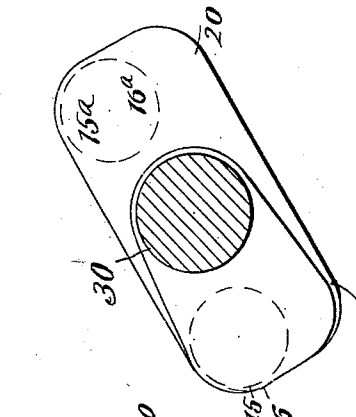


Fig. 9.

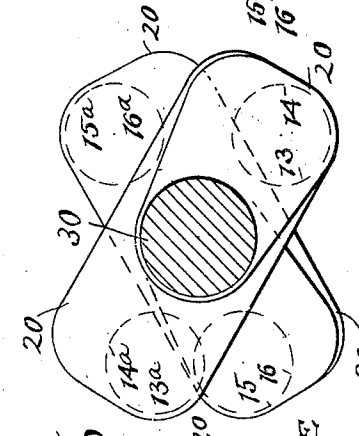


Fig. 8.

Fig. 7.

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UNITED STATES PATENT OFFICE.

ERNEST L. WRENTMORE, OF WARREN, OHIO; (MRS.) MAUDE V. WRENTMORE ADMINISTRATRIX OF SAID ERNEST L. WRENTMORE, DECEASED.

INTERNAL-COMBUSTION ENGINE.

Application filed August 25, 1920. Serial No. 405,919.

This invention relates to plural cylinder engines of the V-type, in which, during each revolution of the crank shaft, there will be half as many equally spaced explosive impulses as there are cylinders.

The objects of the invention are to increase the efficiency of such an engine, and to render it possible to arbitrarily determine the angle between the cylinders of the two rows regardless of the number of cylinders, provided they are multiples of four. This makes it possible to make the angle very small between the cylinders, which is desirable because the engine may be thereby made very narrow, and because also the moving parts will be in better balance, and because also the problems of providing efficient lubrication will be simplified.

The invention includes, as an essential part, a novel crank shaft having certain characteristics of construction which are shown in the drawing and are hereinafter described and definitely pointed out in the appended claims, in which said crank shaft, per se, as well as combinations of the crank shaft with other parts of the engine are definitely set forth.

The invention in its broader aspects is applicable to crank shafts for V-type engines, regardless of the number of cylinders, provided the number is four or any greater number which is a multiple of two. The crank shaft is especially valuable in connection with an eight cylinder engine or with a twelve cylinder engine; and the drawing shows both of these constructions.

In the drawing, Fig. 1 is a vertical transverse sectional view through the front cylinder of an eight cylinder engine, showing the front cylinder 1 and the associated cylinder 1^a in the other row. Fig. 2 is a projected bottom view of an 8-cylinder engine in which the invention is embodied; Fig. 3 is a front end view of said crank shaft, and Fig. 4 is a diagrammatic view of said crank shaft showing the relative positions of the crank pins thereof; Fig. 5 is a vertical transverse sectional view through the front cylinder of a 12-cylinder engine, showing also the associated cylinder 1^a in the other row; Fig. 6 is a projected bottom view of said engine; Fig. 7 is a front end view of the crank shaft; Fig. 8 is a sectional end view in the plane of line 8—8 on Fig. 6; Fig. 9 is a sectional end view on line 9—9 on Fig. 6, and Fig. 10 is a diagrammatic view showing the relative positions of the various crank pins of said shaft.

If in any engine, the cylinders are arranged in a single row, with their axes in one plane, the crank pins will be disposed in certain radial or diametrical normal planes whose relation to one another depends upon the number of cylinders. For example, in a 4-cylinder engine the crank pins are in a single normal diametrical plane and are arranged in pairs at opposite sides of the crank shaft. In an 8-cylinder engine the normal planes in which the crank pins are disposed are diametrical, and are at right angles to each other. In a 6-cylinder engine the normal planes are radial planes and are spaced 120° apart. In a 12-cylinder engine the normal planes are diametrical and are spaced 60° apart. In a 10-cylinder engine the normal planes are radial and are spaced 72° apart. It is, however, one of the peculiarities of the present invention that the crank pins do not lie in these normal planes, but are angularly displaced with respect to said planes to an extent determined by the angle between the two rows of cylinders.

In the 8-cylinder engine the cylinders in one row are consecutively numbered 1, 2, 3, 4, from front to rear; and the cylinders of the other row similarly numbered 1^a, 2^a, 3^a, 4^a. In the 12-cylinder engine the cylinders in one row are numbered 1 to 6 inclusive, consecutively from front to rear, and the corresponding cylinders in the other row are similarly numbered 1^a to 6^a, inclusive.

In a four or six cylinder engine the cylinders are arranged in pairs, one in each row. In an eight or twelve cylinder engine the cylinders are arranged in groups of four, two in each row; and the arrangement is such that in each group of four the first and fourth cylinders are in one row, and the second and third cylinders are in the other row. It will be also noted that the cylinders of each associated pair, one in each row, as for example, 1 and 1^a, are offset longitudinally with respect to each other, that is, one is nearer the front of the engine than the other. By reason of this offset disposition of the cylinders the lower ends of each associated pair may be made to overlap and therefore the angle between the cylinders may be made very small. In fact, the more they overlap the smaller may this angle be.

The normal planes referred to in an 8-cylinder engine, when the cylinders are in a single row, are indicated by lines A and B in the diagrammatic Fig. 4, these lines being at right angles to each other. The normal diametrical planes in a 12-cylinder engine are indicated in diagrammatic Fig. 10 by the lines C, D and E.

The angle between the two rows of cylinders may, as stated, be arbitrarily determined, and for the purpose of this description it will be referred to as "angle g".

In an 8-cylinder engine the two crank pins 11, 11^a, which are respectively associated with cylinders 1, 1^a, are located on opposite sides of the axis of the crank shaft, one in advance of and one behind normal diametrical plane A, the angular displacement of each of these two crank pins from said normal plane being equal to one-half of "angle g." Therefore, when the axis of the crank pin 11 is at its upper dead center, its axis lies in the plane containing the axes of the cylinders in the right hand row of cylinders, viewed from the front. At the same instant the axis of the crank pin 11^a is in the plane which contains the axes of the cylinders in the left hand row of cylinders, and is at its lower dead center.

This disposition of these two crank pins is such that they tend to unbalance the crank shaft, because both crank pins 11, 11^a are on the same side of the normal diametrical plane A. This tendency is, however, overcome or counterbalanced by the crank pins 14, 14^a, which are associated with the cylinders 4, 4^a. The crank pin 14^a is displaced behind said normal diametrical plane A, while the crank pin 14 is displaced in advance of said normal diametrical plane A; the angular displacement of each crank pin from said plane being one half of "angle g." But while both of the crank pins 11 and 11^a lie on the same (right) side of said normal diametrical plane A, (when said plane is vertical) both of the crank pins 14, 14^a, lie on the opposite (left) side of said plane A. The unbalanced parts of the two crank pins 11, 11^a, and their crank arms are therefore counterbalanced by the unbalanced crank pins 14, 14^a, and their associated crank arms.

The crank pins 12 and 12^a which are associated with cylinders 2, 2^a, are disposed the former in advance of the normal diametrical plane B and the latter behind said normal diametrical plane, the angular displacement of these two crank pins from said normal diametrical plane being one-half of the "angle g." The two crank pins 13, 13^a, respectively, associated with the cylinders 3, 3^a, are displaced compared with the normal diametrical plane B, the former in advance of and the latter behind said normal diametrical plane, the degree of displacement with respect to said plane being one half of "angle g." The two crank pins 12 and 12^a are both on one side of said plane, while the crank pins 13, 13^a are both on the other side of said plane, and balance the pins 12, 12^a.

When the parts are constructed as above described, the crank pins 11, 12, 13, 14, are all connected by suitable connecting rods with pistons in the cylinders in the right hand row of cylinders. The crank pins 11^a, 12^a, 13^a, 14^a, are all connected by connecting rods with pistons in the left hand row of cylinders. When the crank pin 11 is at its upper dead center with respect to the cylinder 1 with which it is associated, the crank pin 11^a is at its lower dead center with respect to the cylinder 1^a with which it is associated. At the same time the crank pin 14 is at its lower dead center with respect to the cylinder 4 with which it is associated, and the crank pin 14^a is at its upper dead center with respect to the cylinder 4^a with which it is associated. At the same time the crank pins 12, 12^a, 13, 13^a, are midway between their dead centers with respect to the cylinders with which they are associated. The crank pins 12 and 13^a moving toward their upper dead centers with respect to the cylinders 2 and 3^a with which they are respectively associated, while the crank pins 12^a and 13 are moving down toward their lower dead centers with respect to the cylinders 2^a and 3 with which they are respectively associated. For each quarter revolution of the crank shaft two crank pins reach their upper dead centers, one on its compression stroke, the piston and the other cylinder on its exhaust stroke.

Since the charge in each cylinder is ignited at the end of the compression stroke of its piston and crank pin it is evident that there will be an explosive impulse for each quarter revolution of the crank shaft. The firing order in the eight cylinder engine is as follows: 1, 3^a, 4, 2^a, 4^a, 2, 1^a, 3.

As before stated, the offcenter crank pins 11 and 11^a are counterbalanced by the offcenter crank pins 14^a and 14, and the offcenter crank pins 12 and 12^a are counterbalanced by the off center crank pins 13^a and 13, and therefore an eight cylinder crank shaft is in static balance. It is, however, out of balance in different parts of its length. In order to prevent any bending of the crank shaft by reason of that fact a crank bearing 30 is formed on the crank shaft between each pair of cranks; and additionally each crank cheek 20 is extended to the opposite side of the normal diametrical plane to that on which its crank pin lies. To the extent which this crank cheek is so extended and weighted, the lack of balance due to the offcenter location of the crank pin is taken care of and the crank shaft is locally counterbalanced.

The 12-cylinder crank shaft is shown in

Figs. 5 to 10, inclusive. The normal diametrical planes are indicated as before stated by the lines C, D, E, shown in diagrammatic Fig. 10, which also shows the locations of the twelve crank pins with respect to these planes and with each other.

The crank pins 11 and 12, associated with cylinders 1 and 2 are in alignment, and so are the crank pins 11^a, 12^a, associated with cylinders 1^a, 2^a; but the crank pins 11 and 12 are displaced in advance of the normal diametrical plane C, while the crank pins 11^a, 12^a, are equally displaced behind said plane, the displacement being equal to one-half of the "angle g" between the two rows of cylinders. The aligned crank pins 13, 14, are displaced ahead of the normal diametrical plane E, while the aligned crank pins 13^a, 14^a, are equally displaced behind said plane E. The crank pins 15, 16, are displaced in advance of the normal diametrical plane D, while the crank pins 15^a, 16^a, are equally displaced behind said diametrical plane. The displacement of all of said crank pins with respect to said normal diametrical planes is one-half of the "angle g".

This produces a crank shaft which is in static balance; and the local unbalanced condition of the crank shaft may be restored, as with the crank shaft first described by, extending each crank cheek 20 sufficiently to the opposite side of a normal diametrical plane on which the associated crank pin lies.

The crank pins 11, 12, 13, 14, 15 and 16 are respectively connected by connecting rods 40 with the pistons P in the cylinders 1 to 6 inclusive in one row; and the crank pins 11^a, 12^a, 13^a, 14^a, 15^a and 16^a are similarly connected with the pistons P in the cylinders 1^a, 2^a, 3^a, 4^a, 5^a, 6^a.

For each sixth of a revolution of this crank shaft, a piston will come to its upper dead center on its compression stroke, and the charge will be ignited. The charges are ignited alternately in opposite rows of cylinders, the firing order being 1, 3^a, 5, 2^a, 4, 6^a, 2, 4^a, 6, 1^a, 3, 5^a.

Having described my invention, I claim:—

1. In an internal combustion engine having a plurality of cylinders arranged in two relatively inclined rows,—which cylinders are arranged in groups of four of which the first and fourth cylinder of each group is in one row and the second and third cylinders of said group is in the other row, with a crank shaft having its crank pins disposed in pairs for co-operation with associated pairs of cylinders,—of which one of each pair is in one row and the other is adjacent thereto but in the other row, the crank pins of each pair being disposed one in advance of and one behind the normal plane for said crank pins, the offsetting of said crank pins from said planes being equal to one-half of the angle between the planes in which the two rows of cylinders lie, the crank pins which are in advance of said normal diametrical planes being connected with the pistons which are in advance of a vertical plane which bisects the angle between the two rows of cylinders, and the other crank pins being connected with the pistons of the cylinders of the other row.

2. A crank shaft having four crank pairs each comprising two crank pins which lie on opposite sides of the crank shaft, crank cheeks connecting said crank pins with the crank shaft, and a long crank arm connecting said crank pins with each other,—the two crank pins of each crank pair being equally offset to the same side of a diametrical plane, the crank pins of one crank pair lying on one side and the crank pins of another pair lying on the opposite side of one diametrical plane, the crank pins of a third pair lying on one side and the crank pins of the fourth pair lying on the opposite sides of a diametrical plane at right angles to the diametrical plane first mentioned.

3. A crank shaft having four crank pairs each comprising two crank pins which lie on opposite sides of the crank shaft, crank cheeks connecting said crank pins with the crank shaft, and a long crank arm connecting said crank pins with each other, the two crank pins of each crank pair being equally offset to the same side of a diametrical plane, the crank pins of one crank pair lying on one side and the crank pins of another pair lying on the opposite side of one diametrical plane, the crank pins of a third pair lying on one side and the crank pins of the fourth pair lying on the opposite sides of a diametrical plane at right angles to the diametrical plane first mentioned, said crank shaft having five bearings located at the ends of the crank shaft and between the adjacent crank pairs.

4. In an internal combustion engine, the combination of two rows of cylinders which are inclined in opposite directions and are associated in pairs one cylinder from each row, with a crank shaft having four crank pairs arranged in approximately quartering positions, but with the crank pins of each crank pair offset equally to the same side of a diametrical plane to a degree equal to one half the angle between the two rows of cylinders.

5. In an internal combustion engine, the combination of two rows of cylinders which are inclined in opposite directions and are associated in pairs one cylinder from each row, with a crank shaft having four crank pairs arranged in approximately quartering positions, but with the crank pins of each crank pair offset equally to the same side of the diametrical plane to a degree equal to one half the angle between the two rows of cylinders, the crank pins of one pair being

on one side of a certain diametrical plane and those of the second pair on the opposite side of said diametrical plane, and the crank pins of the other two crank pairs being on opposite sides of a diametrical plane at right angles to the diametrical plane first mentioned.

6. The combination of an 8-cylinder engine of the V-type whereof each cylinder is offset lengthwise of the engine and is overlapped transversely with respect to the associated cylinder in the other row, with a crank shaft having four crank pairs arranged in substantially quartering positions, each crank pair comprising two crank pins which lie on opposite sides of the crank shaft but which are equally offset to the same side of a diametrical plane, the two crank pins of one pair being offset to one side of a certain diametrical plane and the two crank pins of another pair being offset to the opposite side of the same diametrical plane, the crank pins of the third pair being offset to one side of a diametrical plane at right angles to the diametrical plane first mentioned, and the crank pins of the fourth pair being offset to the opposite side of the last mentioned diametrical plane, pistons in said cylinders, and connecting rods connecting the pistons with the crank pins.

7. In an 8-cylinder engine of the V-type, the combination of two rows of oppositely inclined cylinders whereof each cylinder of one row is associated with a cylinder of the other row and is offset lengthwise of the engine and overlapped transversely with respect thereto, the first and third cylinders in one row being in advance of the corresponding cylinders of the other row, and the second and fourth cylinders in the first row being in the rear of corresponding cylinders in the other row, with a 5-bearing crank shaft having four crank pairs arranged in approximately quartering positions, each crank pair including two crank pins which lie on opposite sides of the crank shaft but are equally offset to the same side of a diametrical plane, the two end crank pairs, when the crank shaft is in a certain position being respectively offset the one to the right and the other to the left of a vertical diametrical plane, and the two crank pins of each of the two intermediate crank pairs being respectively offset above and below a horizontal diametrical plane, pistons in the cylinders, and connecting rods connecting said pistons with the several associated crank pins.

In testimony whereof, I hereunto affix my signature.

ERNEST L. WRENTMORE.