R. H. WHITE.

MULTICYLINDER INTERNAL COMBUSTION ENGINE.

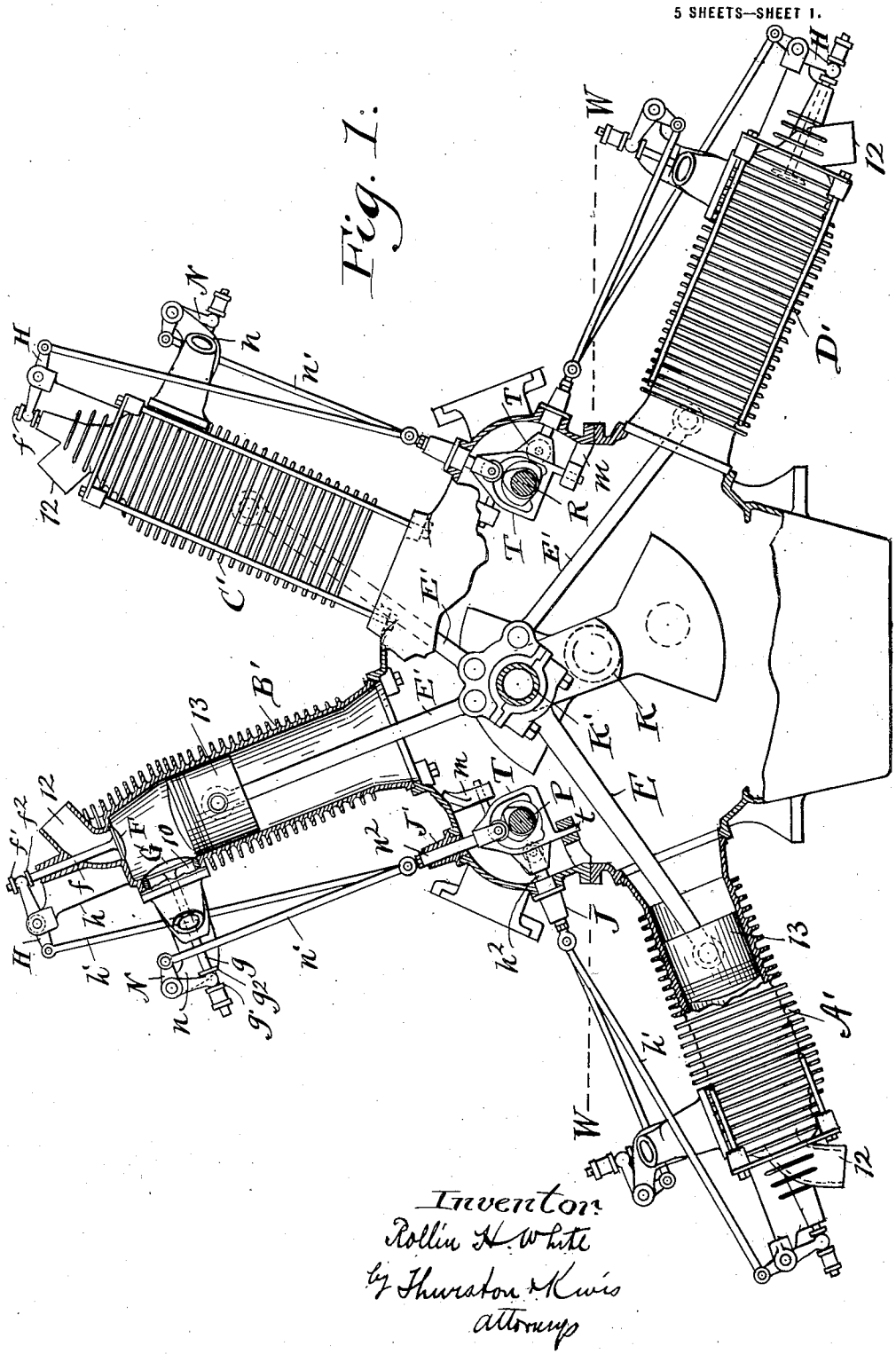
APPLICATION FILED JAN. 10, 1916.

1,285,861.

Patented Nov. 26, 1918.

5 SHEETS—SHEET 1.

Fig. 1.



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5 SHEETS—SHEET 2.

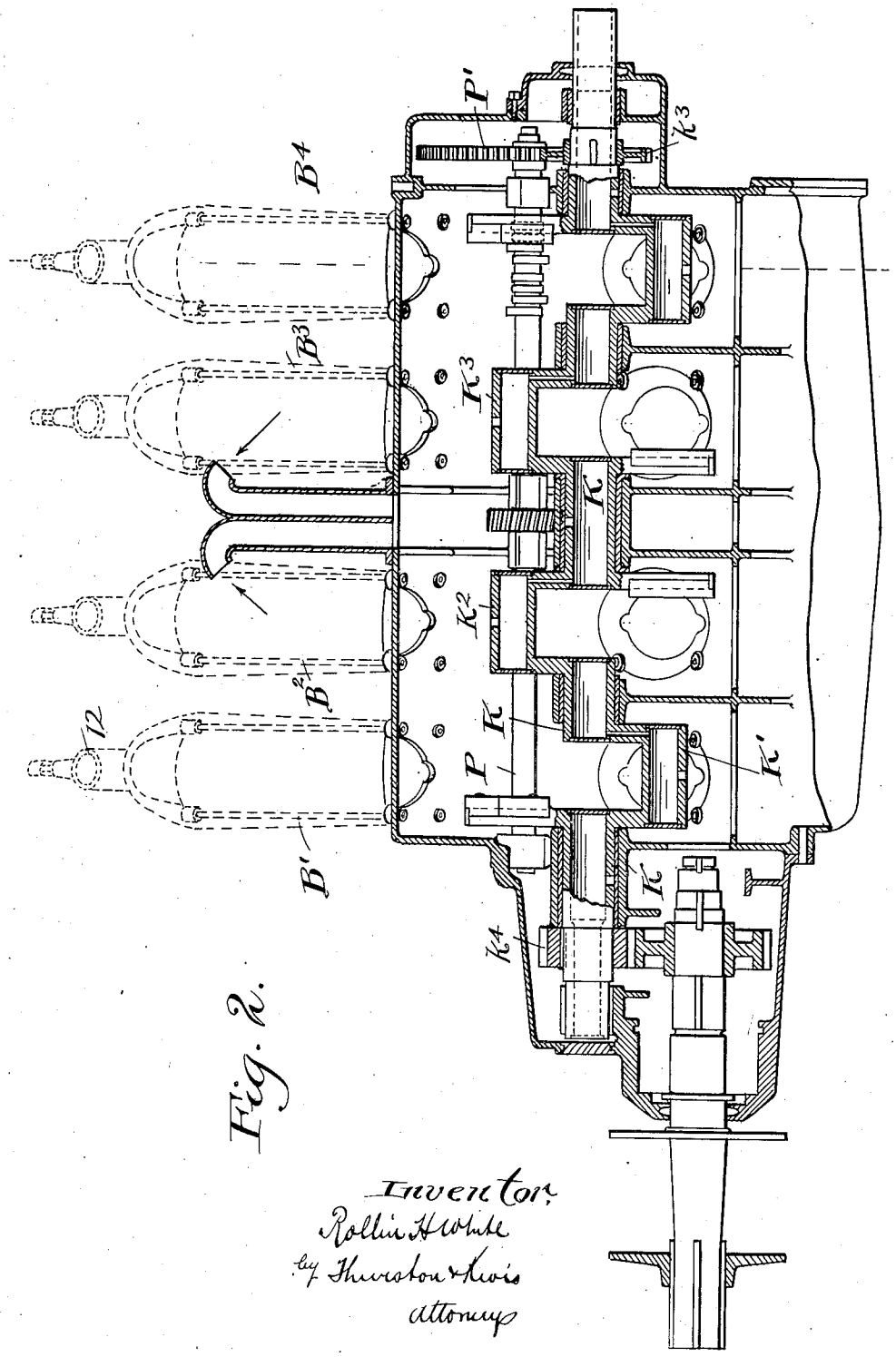


Fig. 2.

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5 SHEETS—SHEET 3.

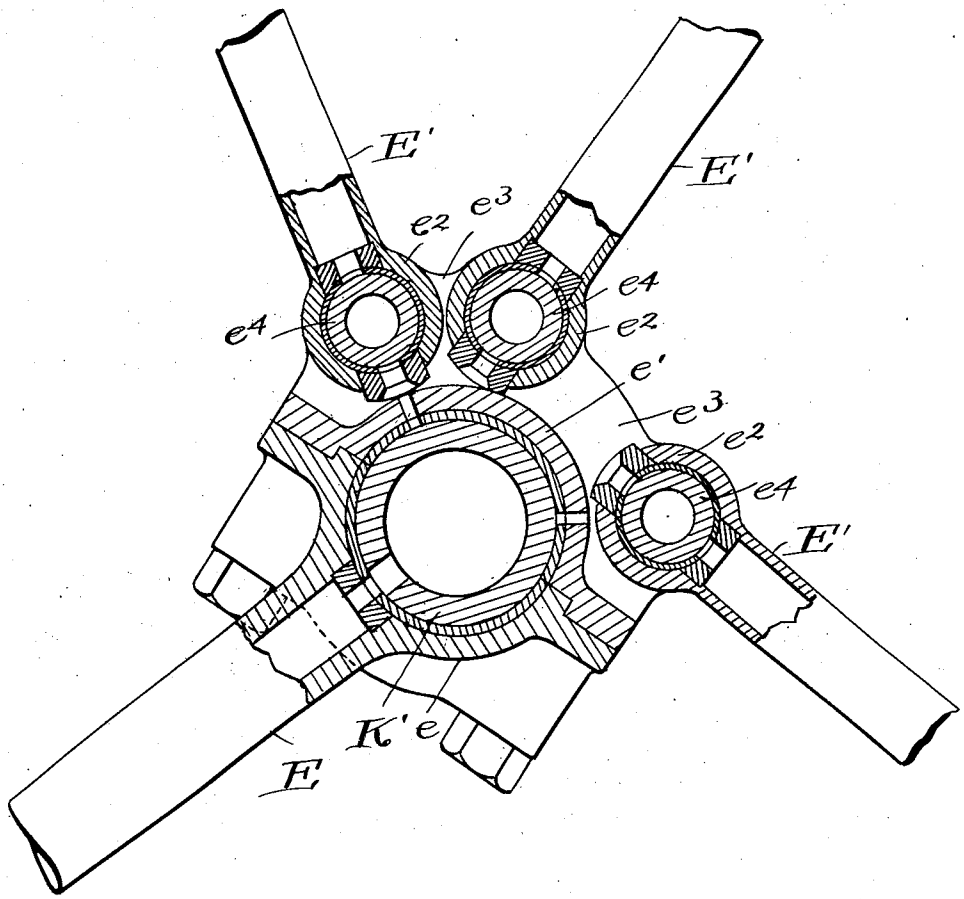


Fig. 3.

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5 SHEETS—SHEET 4.

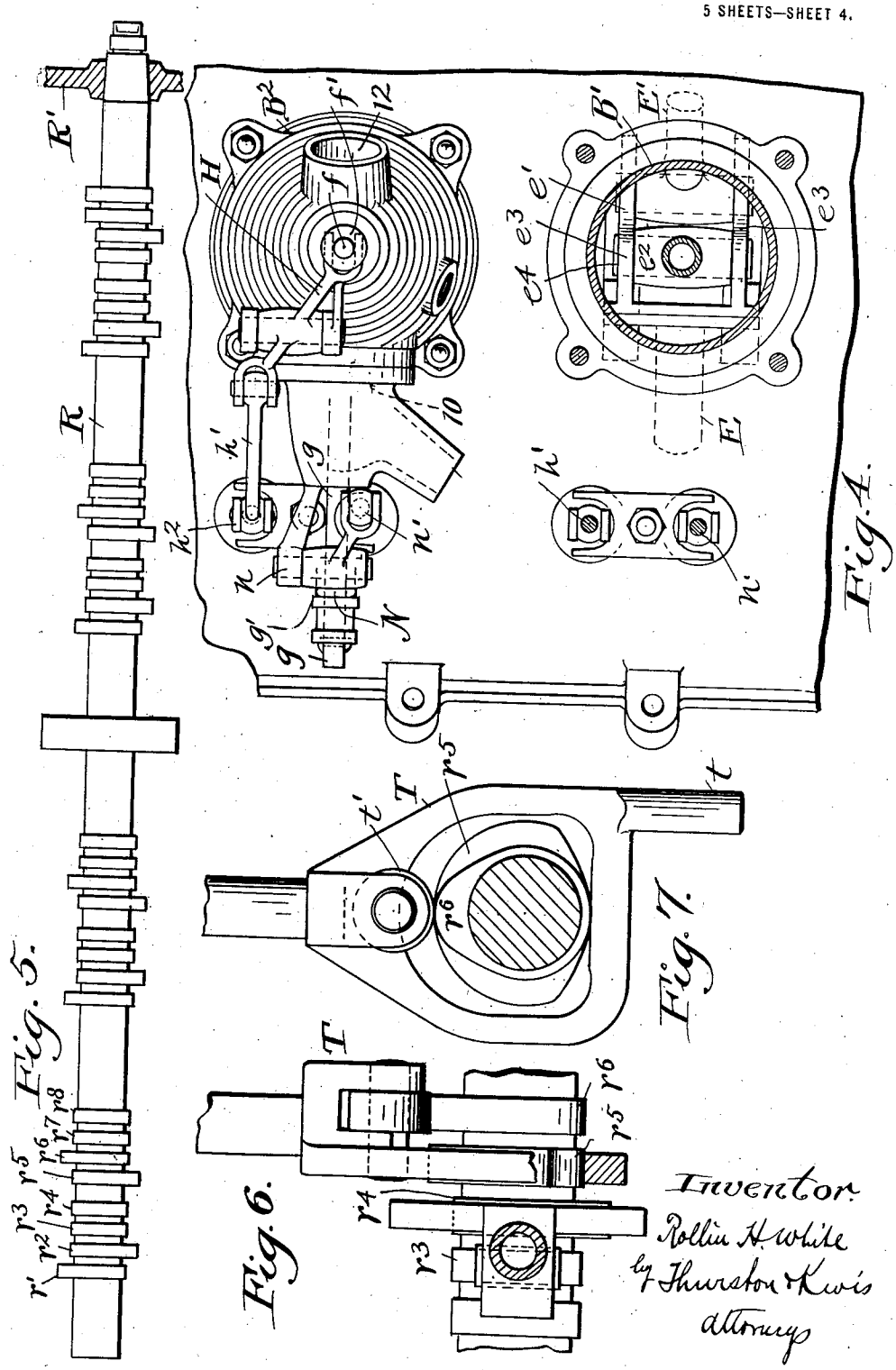


Fig. 5.

Fig. 4.

Fig. 7.

Fig. 6.

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5 SHEETS—SHEET 5.

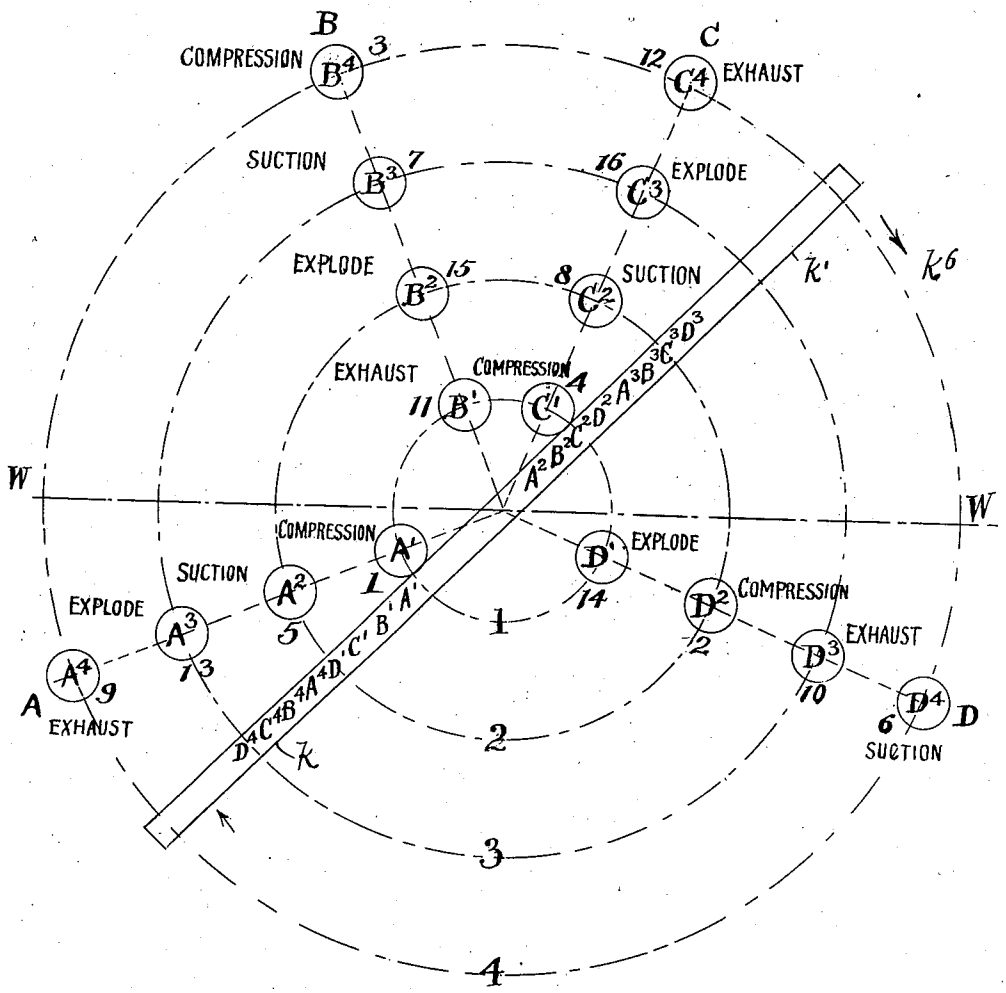


Fig. 8.

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UNITED STATES PATENT OFFICE.

ROLLIN H. WHITE, OF CLEVELAND, OHIO.

MULTICYLINDER INTERNAL-COMBUSTION ENGINE.

1,285,861. Specification of Letters Patent. Patented Nov. 26, 1918.

Application filed January 10, 1916. Serial No. 71,206.

To all whom it may concern:

Be it known that I, ROLLIN H. WHITE, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented a certain new and useful Improvement in Multicylinder Internal-Combustion Engines, of which the following is a full, clear, and exact description.

The object of this invention is to provide an efficient, light-weight, high-speed, multicylinder internal combustion engine especially adapted for use on aeroplanes. The invention is shown embodied in a 16-cylinder engine, whereof the cylinders are so arranged with respect to a single one-plane four-throw crank shaft that the engines will occupy relatively small space, that the cylinders will not make the engine top-heavy, and that the explosive impulses will be delivered in various directions to the crank shaft and at regular intervals of 45° of the revolution of said crank shaft.

These and other desirable characteristics are attained by the construction shown in the drawing and hereinafter described and definitely pointed out in the appended claims.

In the drawings, Figure 1 is a front elevation partly sectioned with the front cylinder in the B row shown in vertical section, with the front cylinder in the A row partly sectioned, and with the engine casing partly sectioned. Fig. 2 is a central longitudinal vertical section of the engine, the crank shaft being shown in a different position to that shown in Fig. 1. Fig. 3 is an enlarged section through one of the crank pins of the engine showing the parts associated therewith; Fig. 4 is a top view of two cylinders of the B-row of cylinders, one of said cylinders being sectioned below the piston therein; Fig. 5 is an elevation of one of the cam shafts; Fig. 6 is a transverse vertical sectional view of the cam shaft R, showing a part of the cam shaft, four cams thereon, and the parts which are associated with and are operated by said cams; Fig. 7 is a view from the left end of Fig. 6 showing one yoke and the operating cams therefor. Fig. 8 is a diagrammatic view of the 16 cylinders and the one plane four throw crank shaft.

This diagram is primarily intended to facilitate the explanation as to how the one plane four throw crank shaft comes to receive an explosive impulse at every eighth of a revolution, *i. e.*, at angular intervals of 45° of the revolution of the crank shaft, and what order the explosions occur in the several cylinders; and it also shows what particular engine cycle is being performed in each cylinder at the moment when the crank shaft is in the position indicated.

As above stated, the engine includes 16 cylinders. Each cylinder of itself is of the ordinary four cycle variety, and is provided with a valve controlled inlet 10, a valve controlled outlet 12, a piston 13, and a connecting rod for connecting the piston with a crank pin on the crank shaft. The cylinders are arranged in four angularly disposed longitudinal rows which are indicated and will be hereinafter referred to as the A row, the B row, the C row and the D row. Each of these rows contains four cylinders. All of the four cylinders in the A row have their axes in a plane which is radial to the crank shaft and extends to the left downward below a horizontal plane (indicated by line W—W in Fig. 1) which is diametrical with respect to the crank shaft, at an angle of 22½° thereto. All of the four cylinders of the D row have their axes in a radial plane which extends to the right and downward below said diametrical plane at an angle of 22½°. The cylinders of the B row and the C row respectively have their axes in radial planes which extend upward to the right and left respectively at angles of 67½° to said horizontal plane. Therefore the angular distance between the planes of the A and D rows is 135°; between the planes of the B and C rows 45°; and between the A and B rows on one side, and the C and D rows on the other side, 90°.

Preferably the cylinders are also arranged in four circumferential rows which are indicated on diagrammatic Fig. 8 by the nu-

merals 1, 2, 3, 4. One of these circumferential rows is shown in Fig. 1. The cylinders themselves are indicated by obvious combinations of these letters and numerals, for example, the cylinders in the A row, from front to rear, are indicated by the reference characters A′, A², A³, A⁴; those in the B row by B′, B², B³, B⁴, etc.

The crank shaft K is a one plane four throw crank shaft, and it is mounted as usual in the crank case M. It has four crank pins, one associated with each circumferential row of cylinders; but two of these crank pins K′, K⁴, namely, the two associated with the front and rear, *i. e.*, first and fourth, circumferential rows are in alinement with each other. The other two crank pins K², K³, are also in alinement with each other, and are in the same diametrical plane as the two crank pins first mentioned, but are on the opposite side of the axis of said crank shaft; and they are associated with the cylinders in the two intermediate, *i. e.*, the second and third, circumferential rows. This crank shaft is therefore a one plane four throw crank shaft. It is a crank shaft having its four crank pins in the same diametrical plane on opposite sides of the axis; that is meant by the expression herein used, viz: one plane four throw crank shaft.

Associated with each of the four crank pins is a main connecting rod E which is connected with the piston 13 in a cylinder of the A row. This connecting rod is formed on its inner end with the usual yoke *e* and is associated with a cap *e′*,—which yoke and cap when secured together, embrace and have bearing upon the associated crank pin. Connected with each main connecting rod are three secondary connecting rods E′ which are respectively connected with the three pistons in the cylinder in the same circumferential row,—one from each of the three longitudinal rows B, C, D. The secondary connecting rods E′ have transverse sleeves e^2 on their inner ends; and each sleeve lies between and is pivoted to a pair of flanges e^3 on the cap *e′* by pivot pins e^4 which are parallel to the crank shaft.

The exhaust port 12 of each cylinder is in its outer end; and the inlet port 10 of each cylinder is through its side near its outer end. Associated with each exhaust port is an exhaust valve F; and with each inlet port is an inlet valve G. Said valves, which are of familiar form, are provided respectively with stems *f* and *g*, which are slidable endwise in the usual guideways from which the outer ends of said valve stems project.

There are two cam shafts P, R. These are parallel with the crank shaft and they are mounted in suitable bearings in the crank case, and are located, respectively, one to the left and a little above the axis of the crank shaft and between the A and B rows of cylinders; while the other is located to the right of and a little above the crank case and between the C and D rows of cylinders.

Gears P′, R′, on these two cam shafts are respectively engaged by a gear k^3 on the crank shaft and thereby both cam shafts are driven by the crank shaft at half the speed thereof. The left cam shaft P controls the movement of the inlet and exhaust valves of the cylinders in the A and B rows, while the right cam shaft G in like manner controls the valves associated with the cylinders in the C and D rows.

In the construction shown the valves are not associated with springs for closing them, as is a common construction, and as they might be if desired. They are positively opened and closed by mechanism which will be briefly described herein, but which is made the subject of another application, Serial No. 71,205 filed Jan. 10, 1916. Each exhaust valve stem *f* has on its projecting outer end two collars *f′*, f^2, between which projects the forked end of a valve rocker H which is pivoted to a bracket *h* fixed to the associated cylinder. The outer end of this rocker is connected by a link *h′* with a slide h^2 which is slidably mounted in and projects through a sleeve J fixed to the crank case. Each of the inlet valve stems *g* is provided on its projecting outer end with two flanges, *g′*, g^2, between which projects the forked end of a bell crank rocker N that is pivoted to a bracket *n* fixed to the cylinder. The other arm of this bell crank rocker is connected with a link *n′* with a slide n^2 similar to the slide h^2 before referred to and similarly mounted in a sleeve J. Suitable yokes T, T, are fixed to the inner ends of these two slides h^2, n^2, respectively. Each yoke has a guide finger *t*, which is slidable in a hole in a fixed bracket *m* in the crank case.

On each cam shaft are four groups of cams as shown in Fig. 5, which shows, for example, the cam shaft R. Each group contains eight cams, of which two are for opening and closing the inlet valve of the cylinder in the A row; two for opening and closing the exhaust valve of the same cylinder; two for opening and closing the inlet valve, and two others for opening and closing the exhaust valve of that cylinder of the B row which is in the same circumferential row as the cylinder of the A row last referred to.

In the specific construction shown the eight cams in the group of cams near the left front end of the cam shaft R shown in Fig. 5 are for the following specific purposes.

The cams *r′*, r^2, are respectively for open-

ing and closing the exhaust valve of the front cylinder in the row A, that is, the cylinder marked A′.

The cams r^7, r^8, are respectively for closing and opening the exhaust valve of the front cylinder in the B row, the cams r^3, r^4, are respectively for closing and opening the inlet valve of the front cylinder of the A row, while the two cams r^5, r^6, are respectively for opening and closing the inlet valves of the front cylinder in the B row.

In Fig. 6 are shown two of the yokes T, T, viz: those two yokes which engage the cams r^3, r^4, and r^5, r^6, respectively. All of these yokes are substantially alike and are as shown in Fig. 7.

In this figure it would appear that the yoke which is associated with the cams r^5, r^6, has a hole through it in which the cam r^5 lies and the bottom wall of this hole is so constructed that said cam r^5 may engage it and so draw the yoke in the valve closing direction. Each yoke carries also a friction roller t' which overhangs the cam r^6 and may be engaged thereby and may move the yoke in the valve opening direction.

The cams on the two cam shafts P and R are so placed that during two complete revolutions of the crank shaft the valves of the entire 16 cylinders will be opened and closed in such sequence and at such times with respect to one another that charges will be compressed and subsequently exploded in the cylinders in such wise as to impart to the crank shaft an explosive rotary impulse at each 45° interval in the rotation of said crank shaft.

In order that this may be clearly understood attention is called to diagrammatic view Fig. 8. In this figure lines A, B, C, D, represent respectively the radial planes which contain the axes of the cylinders in what has been termed the A, B, C, D, rows, which lines intersect at the point marked K^5 which represents the axis of the crank shaft. The dotted arcual lines 1, 2, 3, 4, represent respectively the vertical transverse planes which contain the axes of the circumferential rows of cylinders. The circles having their centers at the intersection of these radial and arcual lines represent the cylinders, and these bear reference characters that identify the cylinders; for example, the cylinders in the A line reading from the crank shaft outward represent the cylinders of the engine from front to rear,—all of which are disposed with their axes at the angle shown to the crank shaft, and to the horizontal diametrical line W, as shown in this diagram.

In this diagram also k and k' represent respectively the oppositely extended arms of the one plane four throw crank shaft; that is to say, the arm k represents diagrammatically the arms which carry crank pins K′, K^4, associated with the front and rear circumferential rows of cylinders, while the crank arm k' represents diagrammatically the arms which carry crank pins K^2, K^3, which are respectively associated with the two intermediate circumferential rows of cylinders. On these two arms k, k', respectively are reference characters which designate the cylinders whose pistons are connected with the crank pins with which those arms are associated as above stated. If the crank shaft occupies the angular position shown relative to the various longitudinal rows of cylinders, and is turning in the direction of the arrow K^6 certain parts of the four engine cycles are being carried on in the 16 cylinders, which cycle parts are as indicated by the notations adjacent the representations of said cylinders. For example, referring to the A row, the compression stroke is nearly completed in the cylinder A′, the exhaust stroke nearly completed in the cylinder A^4, the suction and explosion strokes nearly completed in the cylinders A^2, A^3, respectively. The corresponding notations alongside of the representations of the cylinders of the other three longitudinal rows indicate what cycle is being performed in said cylinders. Alongside of the circles representing the sixteen cylinders are numerals 1 to 16 inclusive, which indicate the order in which the compression strokes are completed, and therefore the order of the explosive impulses in the several cylinders. For example, during the first half revolution of the crank shaft from the position shown in this diagram, the compression strokes will be completed and explosions follow at regular intervals of 45° of movement of the crank shaft, in the cylinders A′, D^2, B^4, and C′, in the order stated, as indicated by the numerals 1, 2, 3, 4, adjacent the representation of said cylinder.

In the next half revolution of the crank shaft the compression strokes will be similarly completed at regular 45° intervals in the cylinders A^2, D^4, B^3, C^2, in the order named. During the next complete revolution of the crank shaft compression strokes will be completed in the other cylinders, at regular 45° intervals, and in the order indicated by the numerals 9 to 16 inclusive. One may with this diagram easily trace out the above set forth sequential operation, and by so doing it will be noticed that the explosive impulse which will immediately follow the completion of the compression stroke in the cylinder A′ will be applied to the crank arm k; that, when the crank shaft has turned 45° and completed the compression in the cylinder D^2, the immediately following explosive impulse will be applied to the crank arm k'; that when the crank shaft will have moved

forward another 45° and the compression stroke will have been completed in the cylinder B^4, the immediately following explosive impulse will be applied to the crank arm k, that when the crank shaft has moved forward another 45° and the compression stroke shall have been completed in the cylinder C', the immediately following explosive impulsive will be applied to the crank arm k; that is to say, during this revolution the explosive impulses will take place successively in the A, D, B and C rows, and the first, third and fourth of the resulting explosive impulses will be applied to the crank arm k, while the second explosive impulse of this series will be applied to the crank arm k'. During the next half revolution the first, third and fourth of the explosive impulses delivered from cylinders in the A, B and C rows will be applied to the crank arm k', while the second of the explosive impulses of this series, delivered from a cylinder of the D row, will be applied to the crank arm k.

From the foregoing it will be understood that while the cams on the two cam shafts may be constructed for each cylinder as has been described, they must be fixed to or formed upon the two cam shafts in such wise as to produce such sequential operation of the valves as will result in the above described sequential carrying on in the several cylinders of the various engine cycles as above described.

Having described my invention, I claim:

1. In a multi-cylinder internal combustion engine, the combination of a one plane four throw crank shaft, a plurality of cylinders which are disposed radially with respect to said crank shaft in four longitudinal rows and in four circumferential rows,—two of said longitudinal rows of cylinders being extended to right and left respectively away from the crank shaft and downward at the angle of 22½° to a horizontal diametrical plane passing through the crank shaft, and the other two longitudinal rows of said cylinders being extended to right and left respectively away from said crank shaft and upward at the angle of 67½° to said horizontal diametrical plane, pistons in said cylinders, and four connecting rods operatively connected with each wrist pin of the crank shaft and with the pistons of the four cylinders in the associated circumferential rows of cylinders.

2. In a multi-cylinder internal combustion engine, the combination of a crank shaft having a plurality of wrist pins, a plurality of cylinders which are disposed radially with respect to said crank shaft in four longitudinal rows and in four circumferential rows,—two of said longitudinal rows of cylinders being extended to right and left respectively away from the crank shaft and downward at the angle of 22½° to a horizontal diametrical plane passing through the crank shaft, and the other two longitudinal rows of said cylinders being extended to right and left respectively away from said crank shaft and upward at the angle of 67½° to said horizontal diametrical plane, pistons in said cylinders, a main connecting rod connected with each wrist pin of the crank shaft and with the piston of one of the downwardly inclined cylinders in the associated circumferential rows of cylinders, and three supplemental connecting rods which are respectively connected with the pistons of the other three cylinders of the same circumferential row of cylinders and are pivotally connected with said main connecting rod.

3. In a multi-cylinder internal combustion engine, the combination of a crank shaft having a plurality of wrist pins, a plurality of cylinders which are disposed radially with respect to said crank shaft in four longitudinal rows and in as many circumferential rows as there are wrist pins on said crank shaft,—two of said longitudinal rows of cylinders being extended to right and left respectively away from the crank shaft and downward at the same angle to a horizontal diametrical plane passing through the crank shaft, and the other two longitudinal rows of said cylinders being extended to right and left respectively away from said crank shaft and upward at the same angle to said horizontal diametrical plane, pistons in said cylinders, four connecting rods operatively connected with each wrist pin of the crank shaft and with the pistons of the four cylinders in the associated circumferential rows of cylinders, two cam shafts which are rotatable at half the speed of the crank shaft and are respectively associated the one with the two left hand longitudinal rows of cylinders and the other with the two right hand longitudinal rows of cylinders, inlet and outlet valves for the several cylinders, valve operating mechanisms therefor, cams on the left hand cam shaft which engage and operate the valve operating mechanisms of the two left hand longitudinal rows of cylinders, and cams on the right hand cam shaft which engage and operate the valve operating mechanism of the two right hand longitudinal rows of cylinders.

4. In a multi-cylinder internal combustion engine, the combination of a crank shaft having a plurality of wrist pins, a plurality of cylinders which are disposed radially with respect to said crank shaft in four longitudinal rows and in as many circumferential rows as there are wrist pins on said crank shaft,—two of said longitudinal rows of cylinders being extended to right and left respectively away from the crank shaft and downward at the same

angle to a horizontal diametrical plane passing through the crank shaft, and the other two longitudinal rows of said cylinders being extended to right and left respectively away from said crank shaft and upward at the same angle to said horizontal diametrical plane, pistons in said cylinders, four connecting rods operatively connected with each wrist pin of the crank shaft and with the pistons of the four cylinders in the associated circumferential rows of cylinders, two cam shafts which are rotatable at half the speed of the crank shaft and are respectively associated the one with the two left hand longitudinal rows of cylinders and the other with the two right hand longitudinal rows of cylinders, inlet and outlet valves for the several cylinders, valve operating mechanisms therefor, cams on the left hand cam shaft which engage and operate the valve operating mechanisms of the two left hand longitudinal rows of cylinders, and cams on the right hand cam shaft which engage and operate the valve operating mechanism of the two right hand longitudinal rows of cylinders, said cams being arranged on said two cam shafts to cause such sequential operation of all of the valves that the explosive charges will be compressed and may be exploded in definite order one cylinder from each longitudinal row of cylinders in sequence and at substantially regular intervals until the entire number of cylinders have been included.

5. In a multi-cylinder internal combustion engine, the combination of a one plane four throw crank shaft, a plurality of cylinders which are disposed radially with respect to said crank shaft in four longitudinal rows and in four circumferential rows,—two of said longitudinal rows of cylinders being extended to right and left respectively away from the crank shaft and downward at the same angle to a horizontal diametrical plane passing through the crank shaft, and the other two longitudinal rows of said cylinders being extended to right and left respectively away from said crank shaft and upward at the same angle to said horizontal diametrical plane, pistons in said cylinders, and four connecting rods operatively connected with ~~each~~ wrist pin of the crank shaft and with the pistons of the four cylinders in the associated circumferential rows of cylinders, two cam shafts which are rotatable at half the speed of the crank shaft and are respectively associated the one with the two left hand longitudinal rows of cylinders and the other with the two right hand longitudinal rows of cylinders, inlet and outlet valves for the several cylinders, valve-operating mechanisms therefor, cams on the left hand cam shaft which engage and operate the valve operating mechanisms of the two left hand longitudinal rows of cylinders, and cams on the right hand cam shaft which engage and operate the valve operating mechanism of the two right hand longitudinal rows of cylinders said cams being arranged on the two cam shafts to operate the valves in such sequential order that the ignition of the compressed charges in the order of their compression will impart to the crank shaft eight substantially regularly spaced explosive impulses during each revolution thereof.

6. In a multi-cylinder internal combustion engine, the combination of a one plane four throw crank shaft, a plurality of cylinders which are disposed radially with respect to said crank shaft in four longitudinal rows and in four circumferential rows,—two of said longitudinal rows of cylinders being extended to right and left respectively away from the crank shaft and downward at the angle of $22\frac{1}{2}°$ to a horizontal diametrical plane passing through the crank shaft, and the other two longitudinal rows of said cylinders being extended to right and left respectively away from said crank shaft and upward at the angle of $67\frac{1}{2}°$ to said horizontal diametrical plane, pistons in said cylinders, a main connecting rod operatively connected with each wrist pin of the crank shaft and with the piston of one of the downwardly inclined cylinders in the associated circumferential rows of cylinders, three supplemental connecting rods which are respectively connected with the pistons of the other cylinders in the same circumferential row of cylinders, and are pivotally connected with the main connecting rod, two cam shafts which are rotatable at helf the speed of the crank shaft and are respectively associated the one with the two left hand longitudinal rows of cylinders and the other with the two right hand longitudinal rows of cylinders, inlet and outlet valves for the several cylinders, valve operating mechanisms therefor, cams on the left hand cam shaft which engage and operate the valve operating mechanisms of the two left hand longitudinal rows of cylinders, and cams on the right hand cam shaft which engage and operate the valve operating mechanism of the two right hand longitudinal rows of cylinders said cams being arranged on the two cam shafts to operate the valves in such sequential order that the ignition of the compressed charges in the order of their compression will impart to the crank shaft eight substantially regularly spaced explosive impulses during each revolution thereof.

7. In a multi-cylinder internal combustion engine, the combination of a one plane four throw crank shaft, a plurality of cylinders which are disposed radially with respect to said crank shaft in four longitudinal rows and in four circumferential rows,—said longitudinal rows of cylinders being arranged respectively in four planes which are radial with respect to the crank shaft and are so disposed that the angular intervals between them are 90°, 45°, 90° and 135° in the order stated, pistons in said cylinders, and four connecting rods op-

eratively connected with each wrist pin of the crank shaft and with the pistons of the four cylinders in the associated circumferential rows of cylinders, said longitudinal rows of cylinders being disposed in such angular relations to one another that at each 45° of arcual movement of the crank shaft one of the crank arms comes into plane with the radial plane in which one row of cylinders lie, and valve operating mechanisms which operate the inlet and exhaust valves of said cylinders to cause the completion of the compression stroke of a cylinder in said row.

In testimony whereof, I hereunto affix my signature in the presence of two witnesses.

ROLLIN H. WHITE.

Witnesses:
E. L. THURSTON,
L. I. PORTER.