June 30, 1936. F. J. HOLMES 2,045,599

INTERNAL COMBUSTION ENGINE

Filed Dec. 11, 1934 2 Sheets-Sheet 1

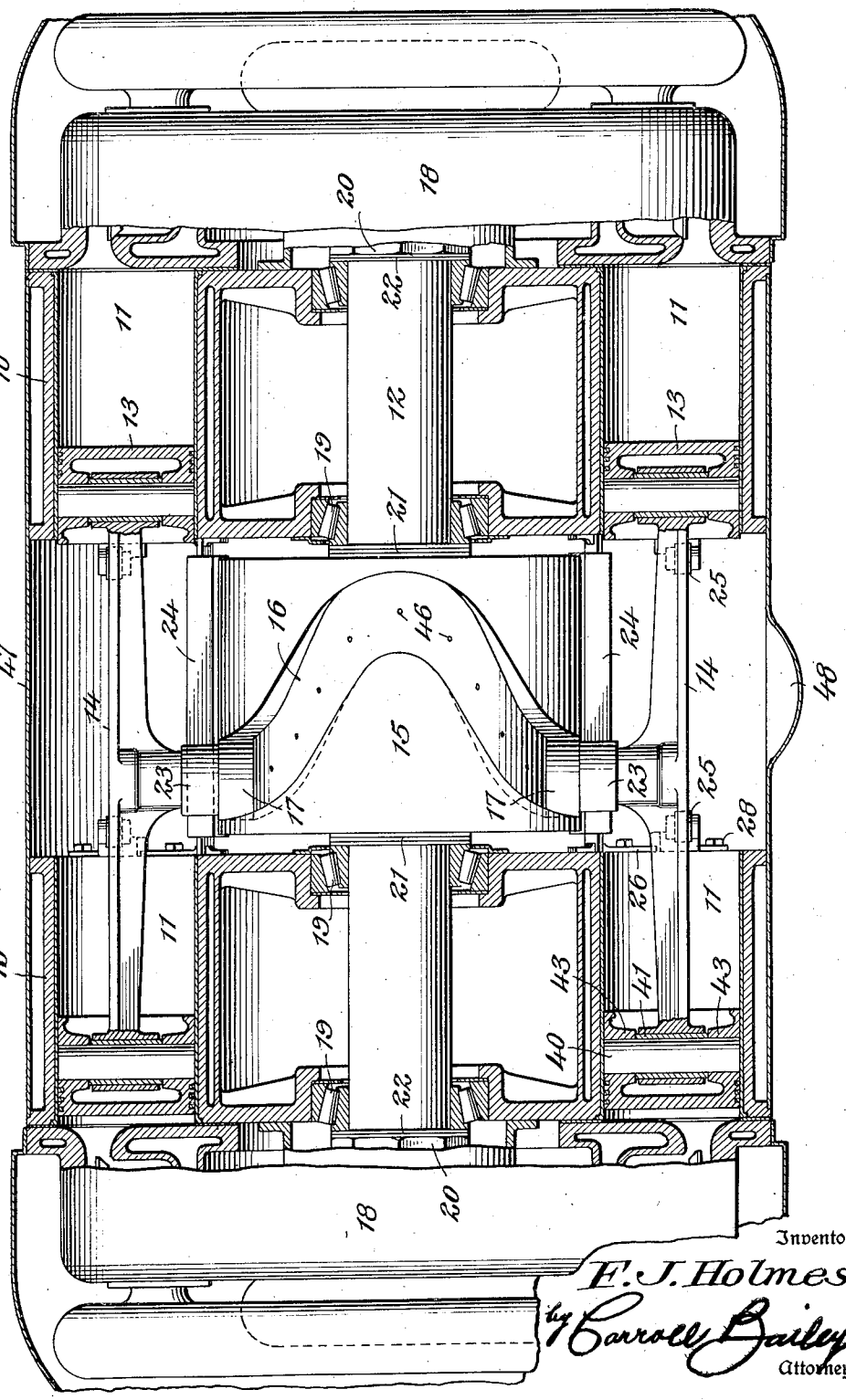

Fig. 1.

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Fig. 2.

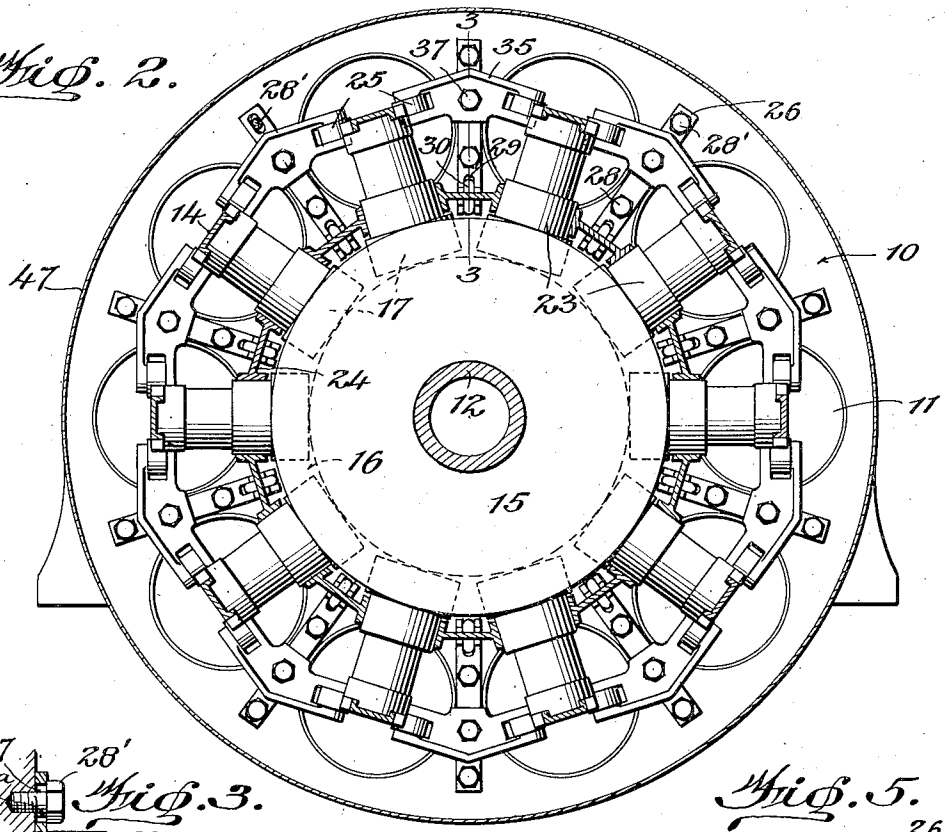


Fig. 3.

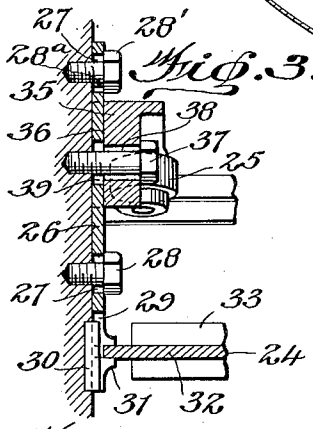


Fig. 4.

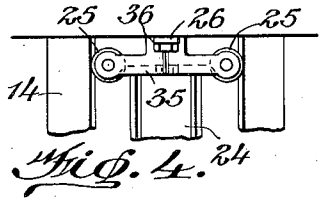


Fig. 5.

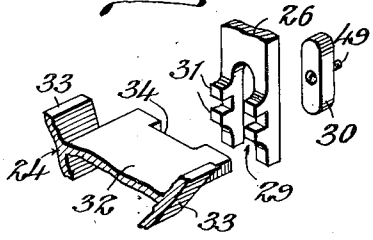


Fig. 6.

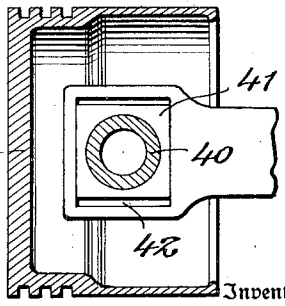
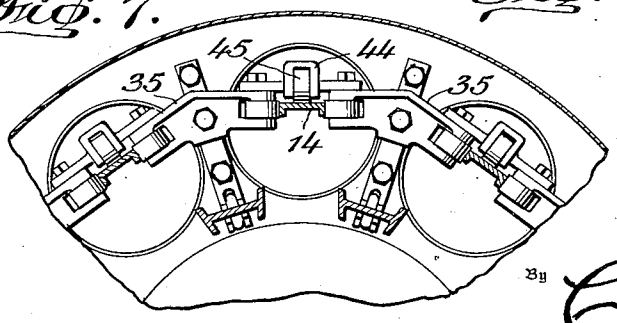


Fig. 7.



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Patented June 30, 1936 2,045,599

UNITED STATES PATENT OFFICE

2,045,599

INTERNAL COMBUSTION ENGINE

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Application December 11, 1934, Serial No. 757,033

16 Claims. (Cl. 74—57)

This invention relates to internal combustion engines, and has particular reference to improvements in internal combustion engines of the type in which opposed sets of cylinders and pistons are circumferentially spaced about a power shaft with the cylinders of each set equal in number to and axially alined with the cylinders of the other set and disposed parallel to the power shaft; in which each related pair of pistons of the two sets are connected together by a single rod, and in which the connecting rods are provided with abutments or cam followers cooperating with a cam on the power shaft between the two sets of cylinders, whereby reciprocation of the connecting rods effects rotation of the power shaft.

In engines of the character type mentioned the wedging action between the abutments or cam followers on the connecting rods and the cam on the power shaft results in strong lateral thrust being imposed on the connecting rods, and if this thrust is permitted to be transmitted through the connecting rods to the pistons, the engine is of low efficiency and possesses only a short life due to the excessive friction and wear which develops as a consequence of the lateral thrust of the pistons against the cylinder walls. Accordingly, one special object of the present invention is to provide novel and highly efficient means to resist side thrust of the connecting rods and to entirely relieve the pistons of such thrust, thus to contribute to high efficiency and longevity of the engine.

Another special object of the present invention is to provide a novel connection between each piston and its related connecting rod with a view to permitting radial and circumferential or lateral movements of the connecting rods relative to the power shaft either due to thrust or to adjustment of the thrust resisting means, and to avoid the transmission of such connecting rod movements to the pistons.

Another special object of the invention is to provide novel means whereby the power shaft may be adjusted longitudinally relative to the cylinders to equalize the size of the compression chambers of the two sets of cylinders.

With the foregoing and various other objects in view, which will become more fully apparent as the nature of the invention is better understood, the same consists in the novel features of construction, combination and arrangement of parts as will be hereinafter more fully described, illustrated in the accompanying drawings and defined in the appended claims.

In the drawings, wherein like characters of reference denote corresponding parts in the different views:

Figure 1 is a central, longitudinal section through an engine of the opposed cylinder type constructed in accordance with one practical embodiment of the invention.

Figure 2 is a transverse section through the engine showing particularly the means for resisting side thrust of the connecting rods.

Figure 3 is a detail section on the line 3—3 of Figure 2.

Figure 4 is a detail plan view of one end of one of the thrust resisting assemblies.

Figure 5 is a detail perspective showing a portion of one of the thrust resisting rails and its mounting means.

Figure 6 is a sectional view illustrating the connection between one of the pistons and its related connecting rod; and

Figure 7 is a fragmentary view similar to Figure 2 illustrating a slightly alternative form of the invention.

Referring to the drawings in detail, first with reference to the form of the invention illustrated in Figures 1 to 6, 10, 10 designate a pair of cylinder blocks which are disposed in end to end, spaced relationship and each of which has formed therein an annular series of cylinders 11 radially spaced equidistantly from the axis of a power shaft 12 which extends centrally through and is journaled in said cylinder blocks. As shown, the cylinders of the respective blocks are equal in number and are disposed in alined pairs parallel to the power shaft 12.

Within the cylinders 11 are pistons 13 and, as shown, each alined or related pair of pistons of the respective cylinder blocks are connected together by a connecting rod 14.

On the power shaft 12, between the cylinder blocks 10, 10, is fixed a cylindrical member 15 having a continuous peripheral cam channel 16, and carried by each connecting rod 14 and disposed within said cam channel is a roller 17, the cam channel being of such suitable shape that the cam, and consequently the power shaft, is rotated due to the coaction of the rollers 17 with the inclined side walls of the cam grooves when the connecting rods 14 are reciprocated.

At the outer ends of the cylinder blocks 10, 10 are cylinder heads 18 having valves suitably actuated from the power shaft 12 for controlling the admission of fuel and the escape of exhaust gases to and from the cylinders 11, while at the outer end of either or both of the cylinder blocks 10 is a

suitable timing device (not shown) for controlling the firing of charges admitted to the cylinders, the arrangement in this respect being such that each set of cylinders fire successively with the cylinders of one set firing in predetermined relationship to the cylinders of the other set so that there is a substantially continuous transmission of power from the connecting rods to the cam and the power shaft.

In the present instance the two cylinder blocks 10, 10 are provided with taper roller bearings 19 in which the power shaft 12 is journaled for free rotation, and said blocks are securely held against relative outward or longitudinal movement away from each other by nuts 20 threaded on the power shaft and cooperating with the respective outer roller bearings of said blocks. Between the inner roller bearing of each block and the adjacent end of the cam member 15 is arranged a plurality of washers 21, while between the outer roller bearing of each block and the related nut 20 is arranged a plurality of washers 22. Thus, obviously, by reducing or adding to the number of washers of the respective sets 21, 22, the cylinder blocks may be adjusted closer together or farther apart to decrease or increase the sizes of the combustion chamber at the ends of the cylinders, while on the other hand, by interchanging the washers of the respective sets 21, the cam member 15 may be shifted in one direction or the other relative to the cylinder blocks to equalize the areas of the combustion chambers of the two sets of cylinders regardless of the adjustment of the cylinder blocks toward or away from each other. In this connection, equalizing the areas of the combustion chambers of the cylinders in an engine of the present type is a very important consideration, especially from the standpoint of providing an engine which is smooth in operation, and obviously the present construction provides a very simple and practical arrangement whereby this may be accomplished.

Referring now to the means to prevent the side thrust imposed on the connecting rods 14 by the wedging action of the rollers 17 against the side walls of the cam channel 16 from being transmitted to the pistons 11, it will be observed that each connecting rod carries a second roller 23 disposed adjacent to and outwardly of the cam engaging roller 17, and that between the rollers 23 of each two adjacent connecting rods is a rail 24 extending longitudinally between the cylinder blocks 10, 10 and having its ends supported by said cylinder blocks, said rails having side faces engaged by the rollers 23 thereby to receive and resist any side thrust of the connecting rods.

Since the rollers 23 and the rails 24 with which they cooperate are located outwardly of the cam engaging rollers 17 and inwardly of the center lines of longitudinal thrust of the connecting rods 14, it is apparent that if the rails 24 constituted the sole provision for resisting lateral thrust of the connecting rods there would result, under the wedging action of the sides of the cam groove 16 against the rollers 23, lateral springing of the connecting rods with the setting up of torsional strains therein and undesirable pressure of the pistons 11 against the sides of the cylinder walls. Consequently, in order to hold the connecting rods against springing laterally, thereby to counteract the tendency of torsional strains to be set up therein, guide rollers are mounted at the inner end of each cylinder block, one to either side of each connecting rod, and constitute anti-friction or rolling abutments engaged by the sides of the connecting rods effectively holding them against springing laterally.

Novel means are provided for mounting the rollers 25 at the inner ends of the cylinder blocks 10, 10 and for mounting the rails 24 between said cylinder blocks, said means providing particularly for radial adjustment of said rollers and rails to bring the same into desired close cooperative relationship with the sides of the connecting rods and the sides of the rollers 23, respectively. At the inner end of each cylinder block, between each two adjacent cylinders 11, is bolted a flat bar 26 which extends radially relative to the power shaft 12 and which is longitudinally slotted as at 27 where the bolts 28 extend therethrough, whereby it is capable of longitudinal adjustment. At its inner end, each bar 26 is provided with a slot 29 or other suitable form of keyway in which is disposed a key 30 seated in a recess in the end of the cylinder block 10 whereby the bar if held accurately positioned radially with respect to the power shaft midway between the cylinders to either side thereof and at the same time is capable of longitudinal adjustment. Moreover, each bar 26 is provided near its inner end with a pair of inwardly projecting lugs 31 spaced apart corresponding to the thickness of the webs 32 connecting the flat side portions 33 of the rails 24, and each end of each rail web 32 is notched as at 34 and has its notched end engaged between the lugs 31 of the related bar 26 with the portions of said web to either side of the notch engaging the sides of the bar 26, whereby each rail is detachably interlocked at its ends with its related pair of bars 26. Thus, the rails 24 are supported between the two cylinder blocks 10, 10 for inward and outward adjustment with the bars 26, and since the side portions 33 of each rail converge inwardly as shown for flat contact with the cylindrical rollers 23, it is manifest that each rail constitutes, in effect, a wedge disposed between adjacent rollers 23 so that by inward or outward adjustment of the rails desired contact or clearance, as the case may be, may be provided between the rollers 23 and the sides of the rails. Moreover, it is apparent that the several rollers 23 and rails 24 collectively constitute a ring of side thrust resisting devices for the several connecting rods so that the several rails act cooperatively to resist side thrust of said rods.

The bars 26 serve also as means for properly positioning the rollers 25 between the connecting rods 14. In this connection, it will be noted that the rollers 25 are mounted in pairs on individual brackets 35 and that each bracket is associated with a related bar 26 and includes a body portion having a channel 36 in its rear face neatly receiving the bar 26 whereby the bracket is held against lateral movement relative to the bar but is permitted to be adjusted therealong. Each bracket is secured to its related cylinder block by a bolt 37 which extends through alined slots 38, 39 in the block and the related bar 26, respectively, whereby the blocks are inwardly and outwardly adjustable. Moreover, the rollers 25 of each block are cylindrical and are mounted in arms extending from the sides of the block, and have their axes converging toward the axis of the power shaft 12, whereby their side faces engage flatly against the flat side faces of the connecting rods 14, and whereby they may be caused to have desired contact or clearance with or from the sides of the connecting rods by inward or outward adjustment of the brackets. Obviously, as in the case of the rollers 23 and the rails 24, the brack-

ets 35, the rollers 25 carried thereby and the connecting rods 12 constitute a ring of connecting rod side spring or thrust resisting devices so that the several connecting rods, rollers 25 and brackets 35 act cooperatively to resist side spring of the rods and therefore serve to avoid the setting up of torsional strains therein.

As a further means of preventing lateral thrusts of the connecting rods 14 from being transmitted to the pistons 13 and through the pistons to the cylinder walls, and also of preventing binding of the pistons within the cylinders due to any slight disalinement of the cylinders within assembly tolerances, a novel connection is provided between each piston and the adjacent end of its related connecting rod. As shown in Figure 1, each piston is provided with a transverse wrist pin 40 which may be either fixed or rotatable, as desired, and which has closely fitted thereon a block 41 of rectangular cross section. On the other hand, as indicated in Figure 6, each end of each connecting rod 14 is provided with a rectangular opening 42 which, in the direction of the length of the connecting rod, is equal in width to the block 41 and which, in a right angular direction or transversely of the piston, is of greater width than the block 41. In addition, the width of each connecting rod at its ends in the direction of the wrist pins 40 is less than the width of the space between the inner ends of the piston bosses 43 in which are formed the openings accommodating the ends of the wrist pins. The rectangular blocks 41 are disposed within the rectangular openings in the ends of the piston rods. It is apparent, therefore, that while the pistons and connecting rods are, in effect, rigid respecting transmission of longitudinal movements of the pistons to the connecting rods, nevertheless the piston rods are capable of limited lateral movement along the wrist pins and also limited lateral movement in a right angular direction transverse with respect to the wrist pins. Thus, substantially floating connections are provided between the pistons and the connecting rods whereby the pistons are permitted to reciprocate freely within the cylinders without being pressed laterally against the walls thereof even though the cylinders of the respective blocks may not be exactly alined and even though the connecting rods may be moved relative to the power shaft either inwardly or outwardly or in a right angular direction.

While it is not deemed essential to provide means to hold the connecting rods 14 against outward movement relative to the power shaft, Figure 7 of the drawing illustrates that simple means effective to accomplish this purpose may be provided if found to be necessary or desirable. In other words, as illustrated in Figure 7, brackets 44 may be fastened to adjacent brackets 35 so as to span the spaces therebetween outwardly of the connecting rods 14, and said brackets 44 may be provided with rollers 45 to engage the outer faces of the connecting rods, thus to hold them against outward movement.

While lubricant may be supplied to the cam channel 16 and the rollers 17 in any suitable manner, preferably the shaft 12 is hollow and is in communication with the cam groove 16 through small openings 46, whereby lubricant which may be delivered to the shaft in any preferred manner, is supplied to said cam groove and said rollers, either under pressure or under the action of centrifugal force, or both. A casing 47 surrounds the space between the cylinder blocks 10, 10 and is formed with a sump 48 into which excess lubricant delivered to the cam and the cooperating rollers may collect to be returned in any suitable manner to the shaft 12.

As will, of course, be understood, each rail 24 is intended to be maintained at all times rigidly assembled at its ends with its related pair of bars 26. Consequently, if and when the cylinder blocks are adjusted away from or toward each other to increase or decrease the areas of the compression chambers at the ends of the cylinder, shims either are inerted between the bars 26 and the inner ends of the cylinder blocks, or are removed, so that for any adjustment of the cylinder blocks toward or away from each other a rigid relationship is maintained not only between each rail and bar assembly, but between each such assembly and the cylinder blocks. In this connection it will be observed by reference to Figure 5 that a small screw 49 is provided to secure each key 30 to its related cylinder block and that it is primarily the bolt 28 near the inner end of each bar 26 and the bracket fastening bolt 37 which serve to secure each bar 26 to its related cylinder block, since the outermost bolt 28' of each bar 26 is primarily an adjustment element for slightly adjusting the bar laterally to thereby laterally shift the related bracket 35 and thus obtain desired contact or tolerance between the rollers 25 and the sides of the connecting rods 14. In other words, each bolt 28' is provided with an eccentric formation 28a disposed in the slot at the outer end of the related bar 26 as best shown in Figure 3 so that by turning said bolt in one direction or the other the bar 26 may be laterally shifted in one direction or the other for the purpose stated.

From the foregoing description considered in connection with the accompanying drawings it is believed that the novel features of the invention will be clearly understood. It is desired to point out, however, that while only certain specific mechanical structural embodiments of the invention have been illustrated and described, the same may be embodied in various other mechanical structures within the spirit and scope of the invention as defined in the appended claims.

I claim:

1. An internal combustion engine comprising a power shaft, opposed cylinder blocks each having a series of cylinders parallel to and spaced around said power shaft, bearings for said shaft carried by said cylinder blocks, a cam on the power shaft between the two cylinder blocks, interchangeable spacing elements separate from the shaft bearings between the inner end of each cylinder block and the adjacent end of the cam, nuts on the power shaft holding the cylinder blocks against relative outward movement, pistons within the cylinders, rods connecting alined pistons of the respective cylinder blocks, and cam followers on the connecting rods cooperating with said cam.

2. An internal combustion engine comprising a power shaft, opposed series of cylinders parallel to and spaced around said power shaft, a cam on the power shaft between the two series of cylinders, pistons within the cylinders, rods connecting aligned pistons of the respective series of cylinders, cam followers on the connecting rods cooperating with the cam, means connecting each bar to its pistons for movement with respect thereto radially with respect to the power shaft and in a right angular direction, a ring of antifriction devices mounted between the respective

series of cylinders and extending, respectively, between adjacent pairs of the connecting rods to hold them against lateral movements circumferentially with respect to the power shaft, said devices being adjustable radially relative to the power shaft, and means whereby radial adjustment of said devices varies the clearance between the sides of said devices and the sides of the connecting rods.

3. An internal combustion engine comprising a power shaft, opposed series of cylinders parallel to and spaced around said power shaft, a cam on the power shaft between the two series of cylinders, pistons within the cylinders, rods connecting alined pistons of the respective series of cylinders, cam followers on the connecting rods cooperating with the cam, means connecting each bar to its pistons for movement with respect thereto radially with respect to the power shaft and in a right angular direction, rollers on the connecting rods and a rail interposed between the rollers of each two adjacent connecting rods and mounted for inward and outward adjustment relative to the power shaft, each rail having inwardly converging side faces cooperating with its related rollers.

4. An internal combustion engine comprising a power shaft, two annular series of cylinders arranged around said shaft, corresponding cylinders of the respective series being axially alined, a piston within each cylinder, a bar connecting each related pair of pistons, a cam on the shaft, a connection between each bar and said cam whereby reciprocation of the pistons and bars effects relative rotation between the shaft and the cylinders, a roller carried by each bar, and a guide rail between the rollers of each adjacent pair of said bars cooperating with said rollers to resist lateral thrust imposed on the bars by the reaction of the connections of the bars with the cam, said guide rails being adjustable toward the shaft and cooperating with said rollers when so adjusted to take up looseness or play between the sides of the rollers and the sides of the rails.

5. An internal combustion engine comprising a power shaft, two annular series of cylinders arranged around said shaft, corresponding cylinders of the respective series being axially alined, a piston within each cylinder, a bar connecting each related pair of pistons, a cam on the shaft, a connection between each bar and said cam whereby reciprocation of the pistons and bars effects relative rotation between the shaft and the cylinders, a guide rail between each adjacent pair of said bars to resist lateral thrust imposed on the bars by the reaction of the connections of the bars with the cam, said guide rails being adjustable radially relative to the power shaft, and means whereby radial adjustments of said guide rails vary the clearances between the sides thereof and the sides of said bars.

6. An internal combustion engine comprising a power shaft, two annular series of cylinders arranged around said shaft, corresponding cylinders of the respective series being axially alined, a piston within each cylinder, a bar connecting each related pair of pistons, a cam on the shaft, a connection between each bar and said cam whereby reciprocation of the pistons and bars effects relative rotation between the shaft and the cylinders, means between and engaging each adjacent pair of said bars to resist lateral thrust imposed on the bars by the reaction of the connections of the bars with the cam, connections between said means and the series of cylinders providing for radial adjustment of said means relative to the shaft, and means whereby such adjustment of said first mentioned means compensates for wear between said first mentioned means and the bars.

7. An internal combustion engine comprising a power shaft, two annular series of cylinders arranged around said shaft, corresponding cylinders of the respective series being axially alined, a piston within each cylinder, a bar connecting each related pair of pistons, a cam on the shaft, a connection between each bar and said cam whereby reciprocation of the pistons and bars effects relative rotation between the shaft and the cylinders, a bracket mounted between each adjacent pair of bars for radial adjustment relative to the shaft, and rollers carried by said brackets engaging the bars.

8. An internal combustion engine as set forth in claim 7 in which a member connects each adjacent pair of the brackets and in which a roller is carried by each member and engages the face of the related bar remote from the shaft.

9. An internal combustion engine comprising a power shaft, two annular series of cylinders arranged around said shaft, corresponding cylinders of the respective series being axially alined, a piston within each cylinder, a bar connecting each related pair of pistons, a cam on the shaft, a connection between each bar and said cam whereby reciprocation of the pistons and bars effects rotation of the shaft, guide means engaging the sides, means mounting said guide means for radial adjustment relative to the shaft, means whereby radial adjustments of said guide means vary the clearances between the sides of said guide means and the sides of the bars, and means carried by said guide means engaging the outer faces of the bars.

10. An internal combustion engine comprising a power shaft, opposed series of cylinders parallel to and spaced around said power shaft, a cam on the power shaft between said cylinder blocks, pistons within the cylinders, rods connecting alined pistons, a roller on each rod cooperating with said cam, a bar fastened to the inner end of each cylinder block between each two adjacent cylinders, said bars being radially disposed with respect to the power shaft and being adjustable toward and from said shaft, rails carried by said bars and spanning the space between the cylinder blocks, one rail being disposed between each two adjacent connecting rods, and a second roller on each connecting rod cooperating with the rails to either side thereof.

11. An internal combustion engine as set forth in claim 10 including guide rollers engaging each side of each connecting rod outwardly of the guide rails.

12. An internal combustion engine comprising a power shaft, opposed series of cylinders parallel to and spaced around said shaft, pistons within said cylinders, rods connecting alined cylinders of the respective series, a member on the power shaft between the two series of cylinders, said member having a cam channel, rollers carried by the connecting rods and operating in said cam channels, the power shaft being hollow to contain a lubricant, and the member on said shaft having openings providing communication between said shaft and said cam groove.

13. An internal combustion engine comprising a power shaft, opposed series of cylinders parallel to and spaced around said power shaft, a cam on the power shaft between the two series of cylin-

ders, pistons within the cylinders, rods connecting alined pistons of the respective series of cylinders, a roller on each rod cooperating with said cam, a second roller on each rod outwardly of the first mentioned roller, guide rails spanning the space between the two series of cylinders and disposed, respectively, between the second mentioned rollers of adjacent bars, and guide rollers outwardly of said second mentioned rollers engaging the sides of the connecting rods.

14. An internal combustion engine as set forth in claim 10 in which the guide rails are of inwardly tapering cross section and are inwardly adjustable, and in which the guide rollers are mounted on inwardly and outwardly adjustable brackets guided for such adjustments by the rail carrying bars.

15. An internal combustion engine as set forth in claim 10 in which the guide rails have separable interfitting connections at their ends with the radially disposed radially adjustable bars.

16. An internal combustion engine as set forth in claim 10 including means for adjusting the rail carrying bars and consequently the rails circumferentially relative to the power shaft.

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