Aug. 4, 1931. L. IMBLUM 1,817,375

INTERNAL COMBUSTION ENGINE

Filed May 2, 1929 3 Sheets-Sheet 1

Fig. 1.

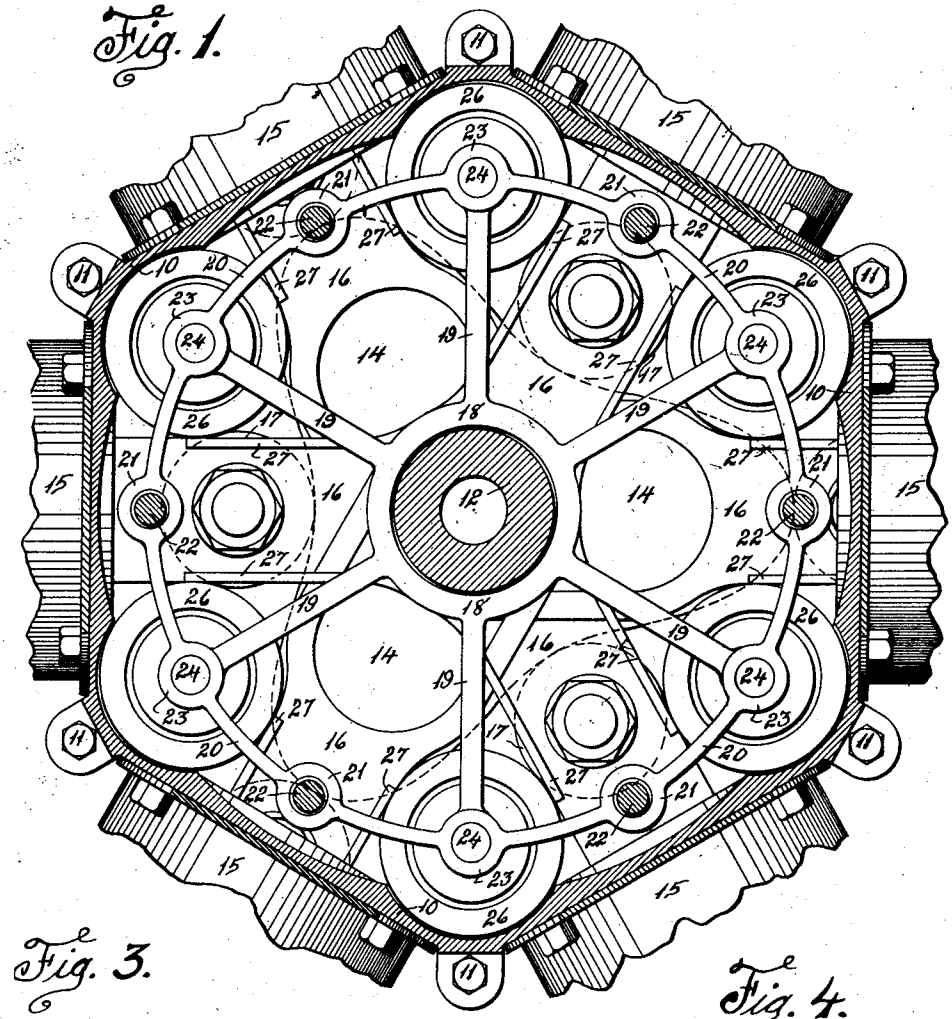


Fig. 3.

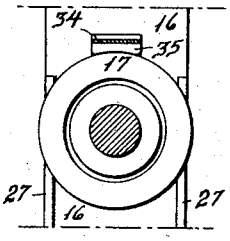
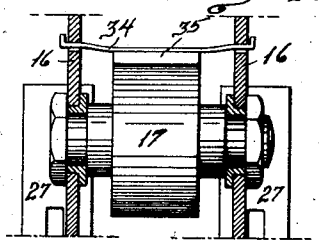


Fig. 4.



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INTERNAL COMBUSTION ENGINE

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Fig. 2.

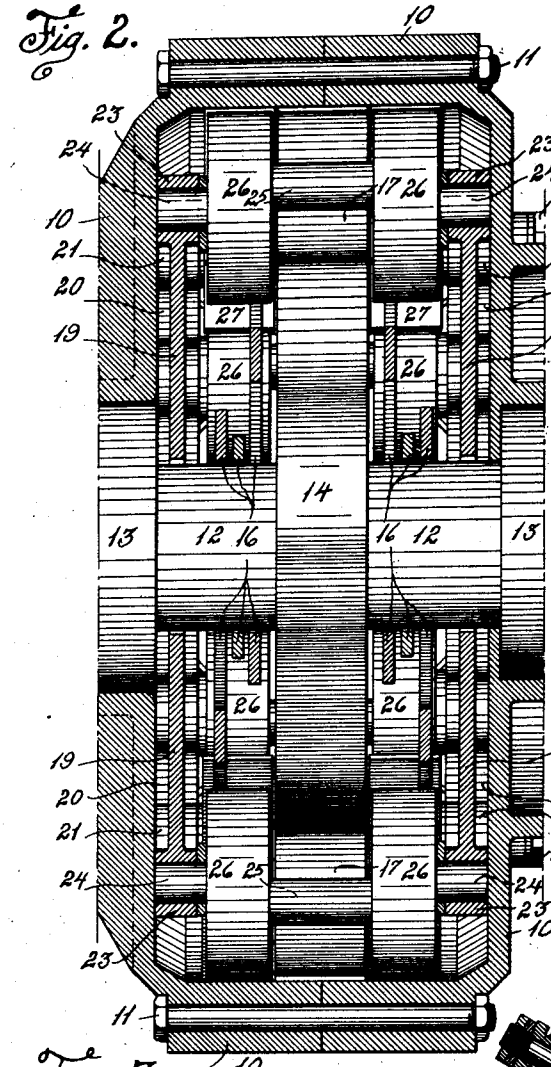


Fig. 6.

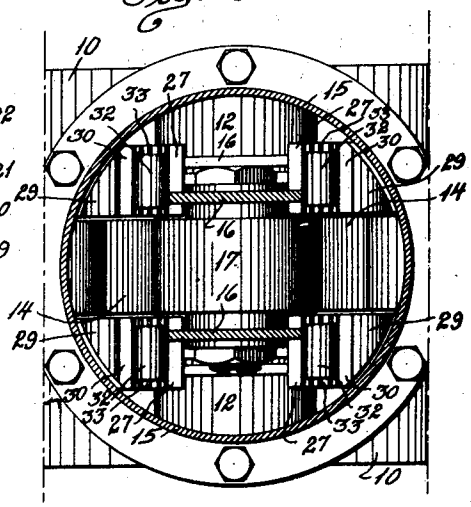


Fig. 5.

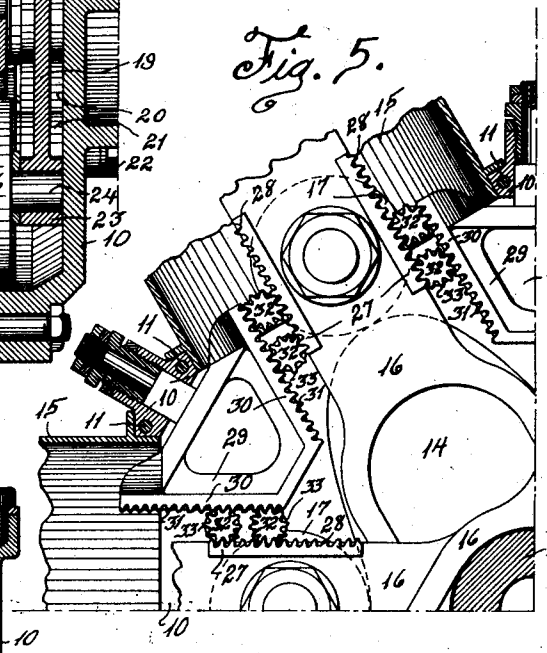
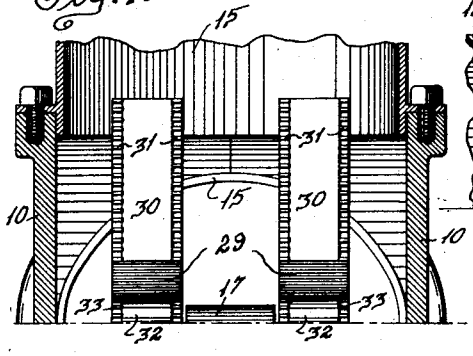


Fig. 7.



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INTERNAL COMBUSTION ENGINE

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Fig. 8.

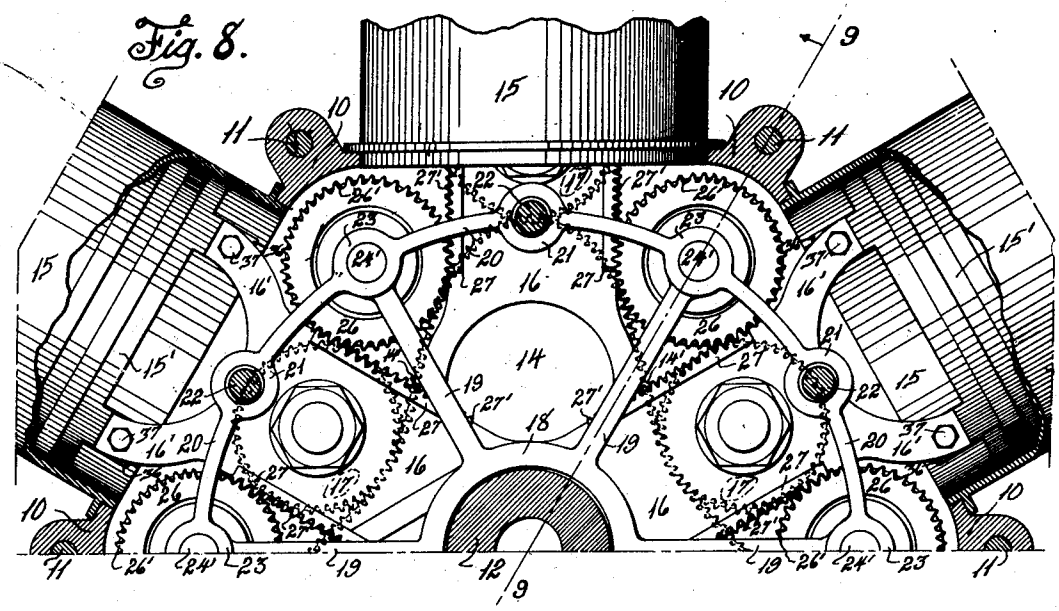


Fig. 9.

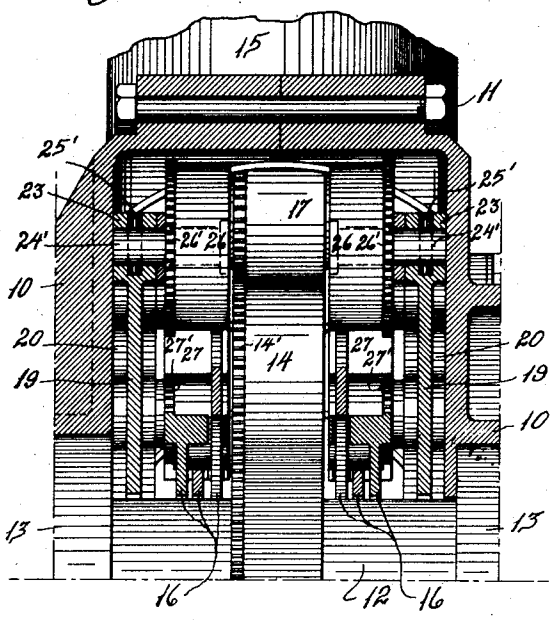
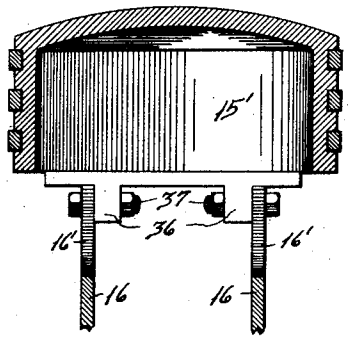


Fig. 10.



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Patented Aug. 4, 1931 1,817,375

UNITED STATES PATENT OFFICE

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INTERNAL COMBUSTION ENGINE

Application filed May 2, 1929. Serial No. 359,387.

An object of this invention is to provide an improved construction and arrangement of elements in cam type internal-combustion engines.

A further object of the invention is to provide an improved construction and arrangement of elements in an internal-combustion engine of a type wherein the piston connecting elements are limited to rectilinear reciprocation axially of the engine cylinders.

A further object of the invention is to provide improved means for eliminating piston side thrust in an internal-combustion engine of the type described.

A further object of the invention is to provide improved means for mounting piston side thrust eliminating means in an internal-combustion engine of the type described.

A further object of the invention is to provide an improved piston guide assembly in an internal-combustion engine of the type described.

A further object of the invention is to provide improved means for mounting a piston guide assembly in an internal-combustion engine of the type described.

A further object of the invention is to provide improved means for compensating the expansive effect of temperature differentials in certain elements of an internal-combustion engine of the type described.

A further object of the invention is to be found in the provision of improved means for minimizing peripheral speed differentials of a rotatable cam and its roller followers.

A further object of the invention is to be found in the provision of improved means for minimizing slippage between a rotatable cam and its roller followers.

A further object of the invention is to provide means for clearing the bearing surfaces of cam roller followers of grit, chips and similar foreign substances that might damage said surfaces.

A further object of the invention is to provide an improved construction and arrangement of the reciprocating elements of an internal-combustion engine of the type described, whereby the inertia effects inherent in said reciprocating elements may be more effectively and advantageously utilized.

A further object of the invention is to provide improved piston connecting elements in an internal-combustion engine of the type described, whereby said pistons are arranged in axially-alined pairs to form rigid units diametrically-disposed relative to the engine cam for more effective and advantageous utilization of the inertia effects inherent in said pistons and connections.

My invention consists in the construction, arrangement and combination of elements hereinafter set forth, pointed out in my claims and illustrated by the accompanying drawings, in which—

Figure 1 is an elevation, partly in section, of the maincase portion of an internal-combustion engine to which my invention is particularly applicable, certain portions of the engine nonessential to an understanding of its operation being omitted to conserve space. Figure 2 is a vertical section of the construction and arrangement shown in Figure 1, certain parts being omitted as in the preceding figure. Figure 3 is a fragmentary detail view, partly in section, of one of the cam followers employed in the engine illustrated. Figure 4 is a fragmentary detail view, partly in section, of the showing of Figure 3 and at right angles thereto. Figure 5 is a detail view, partly in section, of a portion of the engine illustrated by Figures 1 and 2, showing a modified construction of piston guide. Figure 6 is a detail view, partly in section, of the modification shown in Figure 5 as viewed axially of one of the engine cylinders. Figure 7 is a detail view, partly in section, of the rigid members employed in the piston guide illustrated in Figure 5. Figure 8 is a half elevation, partly in section and similar to Figure 1, showing certain improvements and modifications of the construction according to said latter figure. Figure 9 is a vertical section on the indicated line 9—9 of Figure 8. Figure 10 is a detail fragmentary section of one of the pistons employed in the engine and a portion of the connecting elements employed therewith.

In the construction of the improvements illustrated, a cam type internal-combustion engine is indicated as comprising opposed maincase halves 10 suitably locked together by means of bolts 11 to form a housing about a substantially cylindrical, hollow interior; a main shaft 12 axially of said housing and journaled in bearings 13 carried by said maincase halves 10; a multiple-lobed cam 14 fixed to and rotatable with said main shaft within said housing; cylinders 15 disposed in axially-alined pairs radially of said main shaft about said housing and opening therethrough; pistons 15′ mounted for rectilinear reciprocation axially of said cylinders in a common manner; paired links 16 connecting pistons in each pair of alined cylinders, the links of each pair lying on opposite sides of the cam 14 and said links being formed with slotted central portions adapted to embrace and slide relative to the main shaft 12; and anti-friction roller follower assemblies 17 journaled between each pair of links 16 on opposite sides of the main shaft 12 in position for rolling engagement with the eccentric surface of the cam 14. From the showing and foregoing description it is obvious that pressures developed within the cylinders 15, however obtained, will act to move the pistons within said cylinders and the links 16 connecting said pistons, said piston motion being transmitted through the roller followers 17 to the cam 14 and rotating said cam, all of which is, for present purposes, strictly conventional and in itself no part of the instant invention, being only representative of an engine construction to which said invention is advantageously applicable.

It is readily apparent that as the cam 14 is rotated and the followers 17 move along the eccentric surface or outline of said cam, a very considerable non-radial thrust is developed between said followers and cam tending to move said followers tangentially of said cam and consequently tending to displace the link assemblies carrying said followers laterally out of their normal path of travel, which thrust, if uncompensated, would produce undesirable side thrust between piston and cylinder walls and rapidly effect unequal wear between said latter surfaces with consequent lowering of engine efficiency. To compensate said thrust developed between the cam 14 and followers 17, and to preserve the link assemblies in their normal paths of travel and guide the pistons 15′ in their reciprocation within the cylinders, a piston guide assembly is constructed and arranged as hereinafter set forth. Spiders, in this instance two in number, though the number may vary in the application of the invention to engines of various constructions, are formed each with an annular hub 18 adapted to fit about and loosely embrace the main shaft 12, spokes 19, preferably equal in number to the number of cylinders 15, spaced uniformly about and radiating from the hub 18 and an annular rim 20, preferably of greater width than thickness for a purpose that will more clearly appear hereinafter, fixed to and connecting the ends of the spokes 19 in concentric relation with the hub 18. Apertured bosses 21 are formed on the spider rims 20 at uniformly spaced intervals midway of each pair of spokes 19, and said spiders are mounted in concentric relation with the main shaft 12 on each side of the cam 14 within and immediately adjacent the maincase halves 10, the apertures of the bosses 21 registering with holes in said maincase halves to the end that bolts 22 may be passed through said apertured bosses and registering holes to securely clamp said spiders at regular intervals to said maincase halves, said bolts being so positioned as to bring the spokes 19 of the spiders midway between the intersecting planes containing the axes of the engine cylinders. Apertured bosses 23 are formed on the spiders at the point of intersection of each spoke 19 with the rims 20 and, according to the showing of Figures 1 and 2, shafts 24 are fixed at each end in registering apertures of the bosses 23 and extend in axially parallel relation with the main shaft 12 across the space within the housing between the spiders, said shafts 24 in this instance having radially offset central portions 25 to allow of free rotation of the cam 14. The shafts 24, thus disposed, perpendicularly intersect the planes of the links 16 midway between adjacent margins of adjacent links and anti-friction rollers 26 are mounted for rotation on said shafts 24 in the extended planes of said links 16 and in position to marginally contact with and roll relative to the adjacent edges of adjacent links, relatively wide bearing plates 27 being formed on said adjacent margins of the links to provide adequate bearing surface for contact with said rollers 26. The rollers 26, as clearly shown, are arranged in pairs on each shaft 24, one roller 26 on each side of the cam 14. In the modification according to Figure 9, the rollers 26 are shown mounted on stub shafts 24′ instead of the shafts 24, the offset portions of said latter shafts being eliminated, said stub shafts 24′ being mounted in the apertured bosses 23 of the spiders in opposed, axially-alined pairs and secured in said bosses in any desired manner, as for example by means of dowel pins 25′ in registering holes in said stub shafts and bosses, and the opposed, inner ends of said stub shafts 24′ are provided with suitable retaining means, such as heads, to prevent axial displacement of the rollers 26 relative to said stub shafts. It is of course obvious that the stub shafts 24′ may be formed directly on the spiders, if desired, in which case suitable

retaining means would be removably and replaceably mounted on the inner ends of said stub shafts for the same purpose as the heads indicated above. It is apparent that in the engine construction illustrated, when such engine is in operation, the motion of any one link 16 will be equal in speed and opposite in direction to the motion of its adjacent links, hence the rollers 26 may simultaneously contact adjacent bearing plates 27 without danger of speed differentials or slippage; however, since the links 16 change direction of motion rapidly with consequent reversals of the direction of rotation of the rollers 26, it may well be expedient to provide positive engaging means between the plates 27 and rollers 26 to overcome the reversal-resisting inertia of said rollers and positively prevent slippage between said rollers and plates, one such means being illustrated in Figures 8 and 9 as comprising marginal gear teeth 26′ on and about the peripheries of the rollers 26, the pitch lines of said teeth 26′ being coincident with the outlines of the bearing surfaces of their respective rollers, said teeth 26′ meshing with similar teeth 27′ forming marginal racks on the bearing plates 27, the pitch lines of the teeth 27′ being coincident with the planes of the bearing surfaces of said plates 27, so that free rolling contact is had between the bearing surfaces of said plates 27 and rollers 26, the intermeshing teeth 26′ and 27′ serving only to preserve synchronism of speed and direction of said bearing surfaces. In like manner, the cam 14 may be provided with a row of teeth 14′ on and about its eccentric outline in position to mesh with similar teeth formed on the roller followers 17, to the end of preserving speed synchronism between the engaging surfaces of said cam and followers, as is clearly shown in Figures 8 and 9.

It is to be noted that the spokes 19 are arranged diametrically of the spiders to form, through the hubs 18, rigid connections between opposite shafts 24 or 24′, so that, under the influence of heat developed in the operation of the engine, the spokes 19 expand or contract in conformity with the expansion and contraction of the links 16 and other related parts and thus the correct relation of parts is at all times assured, any difference in expansive or contractive effect between the maincase and the interior elements being compensated through the relative flexibility of the rim 20 between the bolts 22, to preserve which flexibility the said rim is preferably narrower radially of the spider than it is axially thereof, as above set forth.

In order to completely eliminate side thrust between the pistons 15′ and cylinders 15 and to more effectively realize the inertia advantages of the piston and link assemblies, a rigid connection is provided between the said pistons 15′ and links 16, one such connection being illustrated in Figures 8 and 10 as comprising integral lugs 36 formed on and extending in spaced parallel relation axially of the inner end of each piston 15′, four such lugs being provided on each piston in this instance, to which lugs diverging terminal arms 16′ of the links 16 are secured by means of bolts 37 passing through registering holes in said diverging arms and lugs. Thus rigid, unitary assemblies are formed of the pistons in each pair of axially-alined cylinders and the links connecting said pistons and the weights of the constituent elements of each such assembly are combined to obtain maximum mass in each reciprocating unit. Due to this combined mass, which enhances the inertia of the reciprocating units, a considerable portion of the power generated by the expanding gases in the cylinders is used, in the early stages of the power stroke when such power is at its maximum, to overcome the inertia of the reciprocating units and is in fact stored in said units as potential energy to be utilized in the later stages of the power stroke when the expansive effect of the gases is on the wane due to heat losses, thus providing a smoother and more efficient flow of power throughout the power strokes and deriving maximum power from the expanding gases which is applied to turn the cam 14 after the force of said gases has been reduced through heat losses.

In the modification according to Figures 5, 6 and 7, the engine is in its main essentials the same as above described save that the spiders and rollers 26 are omitted and modified means, hereinafter set forth, substituted. As shown in the figures above noted, the bearing plates 27 carried by the links 16 are provided with parallel rows of gear teeth 28 on the long margins of their bearing faces, and a rigid member 29 is mounted within and fixedly or adjustably supported by the maincase between adjacent cylinders, said member 29 having bearing faces 30 parallel with, spaced from and in opposition to the bearing faces of the plates 27, said bearing faces 30 being provided with parallel rows of gear teeth 31 having the same pitch as the teeth 28 and being opposed thereto and spaced therefrom. Rollers 32, in this instance two in number, though the number may be varied as desired, each of a length equal to the width of the bearing surfaces 27 and 30 and each formed with gear teeth 33 on each end adapted to mesh with the teeth 28 and 31, are mounted between and in rolling engagement with each pair of opposed surfaces 27 and 30, the meshing of the teeth 33 with the teeth 28 and 31 serving to hold said rollers 32 in position without the need of retainers. It is to be noted that the pitch lines of the teeth 28 and 31 correspond with the surface lines of the surfaces 27 and 30, and that the pitch lines of the teeth 33 correspond with the circular

surface outline of the rollers 32, so that, when said teeth are in mesh as above set forth, there is no slippage between the surfaces in rolling contact and axial displacement of the rollers is precluded. When the members 29 are adjustably mounted, as shown, provision is made for careful spacing of the surfaces 30 relative to the plates 27.

Since the followers 17 normally bearing against the eccentric surface of the cam 14 are subject to rapid variation of their speeds of rotation, and since the inertia forces of the elements in operation tend to momentarily separate said followers from said cam at times, with consequent slippage and ill effect on the normally contacting surfaces, it is expedient that means be provided to limit the speed of rotation of said followers to that developed through contact with said cam, one such means having been above described as comprising the teeth 14′ on the cam meshing with similar teeth on the followers. An alternative means of limiting the speed of rotation of the roller followers to that developed through contact with the cam, which has the added function and advantage of clearing the contacting surfaces of the roller followers of grit, chips and the like, is shown in Figures 3 and 4, wherein a leaf spring 34 is mounted through and between each pair of links 16 and spaced from each follower 17 on the side away from the cam, said spring having a curvature in the direction of said follower and being provided with a block of friction-resistant, non-abrasive material 35 secured thereto in position to overlie and bear against the surface of said follower, the curvature of said spring serving to press the block 35 into close contact with the moving surface of said follower and exert a braking and wiping effect thereon, thus limiting the speed of rotation of said follower and minimizing the slipping effect between the cam and followers and at the same time wiping off grit, chips or other foreign matter that might adhere to said follower surface or be passed thereto from the cam surface and further smoothing out abrasions or distortions of the follower surface produced through the slight slippage that might occur.

Since many changes, alterations and modifications of the form and construction of elements shown and described may be had without departing from the spirit of my invention, and since the invention is applicable in various modifications to a variety of adaptations in a broad field, I wish to be understood as being limited solely by the scope of the appended claims rather than by the specific showing and foregoing description.

I claim as my invention—

1. An internal-combustion engine of the character described, comprising, in combination, a main shaft, a cam fixed to and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links rigidly connecting said pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, opposed bearing plates on adjacent margins of adjacent links and rotatable piston guide means between and simultaneously engaging adjacent bearing plates of adjacent links.

2. An internal-combustion engine of the character described, comprising, in combination, a main shaft, a cam fixed to and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links rigidly connecting said pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, and rotatable piston guide means between and simultaneously engaging adjacent margins of adjacent links.

3. An internal-combustion engine of the character described, comprising, in combination, a main shaft, a cam fixed to and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links connecting said pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam and piston guide means engaging said links, said guide means comprising counterpart spiders concentric with said main shaft on each side of said cam, a plurality of spindles on said spiders and rollers carried by said spindles between and in position to engage adjacent margins of adjacent links.

4. An internal-combustion engine of the character described, comprising, in combination, a main shaft, a cam on and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links connecting said pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, opposed bearing plates on adjacent margins of adjacent links between said main shaft and cylinders, counterpart spiders concentric with said main shaft on each side of said cam and a plurality of rollers rotatably carried by said spiders between and in position to simultaneously engage the opposed bearing plates of adjacent links.

5. An internal-combustion engine of the

character described, comprising, in combination, a main shaft, a cam on and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links connecting said pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, opposed bearing plates carried by adjacent margins of adjacent links between said main shaft and cylinders, counterpart spiders concentric with said main shaft on each side of said cam, spindles uniformly spaced in opposed, axially-alined pairs about said spiders parallel with said main shaft between said bearing plates and rollers carried by said spindles between and in position to simultaneously engage the opposed bearing plates of adjacent links.

6. An internal-combustion engine, comprising, in combination, a main shaft, a cam on and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links connecting pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, opposed bearing plates on adjacent margins of adjacent links between said main shaft and cylinders, counterpart spiders concentric with said main shaft on each side of said cam, a plurality of rollers rotatably carried by said spiders between and in position to simultaneously engage the opposed bearing plates of adjacent links and interengaging speed synchronizing means carried by said rollers and bearing plates.

7. An internal-combustion engine, comprising, in combination, a main shaft, a cam on and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links connecting pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, opposed bearing plates on adjacent margins of adjacent links between said main shaft and cylinders, piston guide means including rollers between and in position to simultaneously engage the opposed bearing plates of adjacent links and interengaging speed synchronizing means carried by said rollers and bearing plates.

8. An internal-combustion engine, comprising, in combination, a main shaft, a cam on and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links connecting said pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam and piston guide means engaging said links, said guide means comprising counterpart spiders concentric with said main shaft on each side of said cam, a plurality of shafts parallel with said main shaft and connecting said spiders between adjacent links and rollers carried by said shafts between and in position to simultaneously engage adjacent margins of adjacent links.

9. An internal-combustion engine, comprising, in combination, a main shaft, a cam on and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links connecting said pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, opposed bearing plates on adjacent margins of adjacent links between said main shaft and cylinders, counterpart spiders concentric with said main shaft on each side of said cam, a plurality of shafts in parallel relation with said main shaft and connecting said spiders between adjacent links and rollers carried by said shafts between and in position to simultaneously engage the opposed bearing plates of adjacent links.

10. An internal-combustion engine, comprising, in combination, a main shaft, a cam on and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links connecting said pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, opposed bearing plates on adjacent margins of adjacent links between said main shaft and cylinders, a rigid member between adjacent links and presenting bearing surfaces parallel with and opposed to each of the bearing plates on said adjacent links and rollers between and simultaneously engaging each pair of opposed bearing surfaces and bearing plates.

11. An internal-combustion engine, comprising, in combination, a main shaft, a cam on and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, links connecting said pistons in each pair of axially-alined cylinders, cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, opposed bearing plates on adjacent margins of adjacent links between said main shaft and cylinders, parallel rows of

gear teeth on the outer margins of the bearing surfaces of said plates, a rigid member between adjacent links and presenting bearing surfaces parallel with and opposed to each of the bearing plates on said adjacent links, parallel rows of gear teeth on the outer margins of said bearing surfaces in opposition with the teeth on said bearing plates and rollers, each formed with an annular row of gear teeth adjacent each end, between and simultaneously engaging each pair of opposed bearing surfaces and bearing plates, the teeth on said rollers meshing with the teeth formed on said bearing plates and surfaces.

12. In an internal-combustion engine having a main shaft journaled in a housing, a cam on and rotatable with said main shaft within said housing, cylinders disposed in opposed, axially-alined pairs about said housing and radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, paired links on opposite sides of said cam and connecting pistons in each pair of axially-alined cylinders and cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, piston guide means comprising counterpart spiders concentric with and on each side of said cam, a plurality of uniformly spaced spindles carried by said spiders parallel with and spaced from said main shaft between adjacent pairs of links and rollers carried by said spindles in position to simultaneously engage adjacent margins of adjacent links.

13. In an internal-combustion engine having a main shaft journaled in a housing, a cam on and rotatable with said main shaft within said housing, cylinders disposed in opposed, axially-alined pairs about said housing and radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, paired links on opposite sides of said cam and connecting pistons in each pair of axially-alined cylinders and cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, piston guide means comprising counterpart spiders concentric with said main shaft on each side of said cam, each of said spiders comprising an annular hub loosely embracing said main shaft, a plurality of uniformly spaced spokes radiating from said hub and an annular rim connecting the outer ends of said spokes, a plurality of uniformly spaced spindles carried by said spiders parallel with and spaced from said main shaft and extending in opposed relation between adjacent pairs of links and rollers carried by said plurality of spindles in position to simultaneously engage adjacent margins of adjacent links.

14. In an internal-combustion engine having a main shaft journaled in a housing, a cam on and rotatable with said main shaft within said housing, cylinders disposed in opposed, axially-alined pairs about said housing and radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, paired links on opposite sides of said cam and connecting pistons in each pair of axially-alined cylinders, bearing plates on adjacent margins of adjacent pairs of said links and cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, piston guide means comprising counterpart spiders concentric with said main shaft on each side of said cam, each of said spiders comprising an annular hub loosely embracing said main shaft, a plurality of uniformly spaced spokes radiating from said hub and an annular rim connecting the outer ends of said spokes, said annular rim being secured to said housing at uniformly spaced points intermediate the outer ends of said spokes, a plurality of spindles on said spiders at the intersections of said spokes and rims in parallel relation with said main shaft and extending in opposed relation between adjacent pairs of links and rollers carried by said plurality of spindles in position to simultaneously engage opposed bearing plates on adjacent links.

15. In an internal-combustion engine having a main shaft journaled in a housing, a cam on and rotatable with said main shaft within said housing, cylinders disposed in opposed, axially-alined pairs about said housing and radially of said shaft and cam, pistons mounted for rectilinear reciprocation in said cylinders, paired links on opposite sides of said cam and connecting pistons in each pair of axially-alined cylinders, bearing plates on adjacent margins of adjacent pairs of said links and cam-followers carried by said links in position for rolling engagement with the eccentric surface of said cam, piston guide means comprising parallel rows of gear teeth on the longer margins of opposed bearing plates of adjacent pairs of links, rigid members fixed or adjustably secured to said housing between adjacent pairs of links and having bearing surfaces parallel with, spaced from and in opposition to the bearing surfaces carried by said links, parallel rows of gear teeth on the longer margins of said bearing surfaces in opposition to the teeth on said bearing plates and rollers, each formed with an annular row of gear teeth adjacent each end, between and simultaneously engaging each pair of opposed bearing surfaces and bearing plates, the teeth of said rollers meshing with the teeth carried by said bearing plates and surfaces.

16. In an internal-combustion engine having a main shaft, a cam on and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam, pistons mounted for rectilin-

ear reciprocation in said cylinders, paired links connecting pistons in each pair of opposed cylinders on opposite sides of said cam and cam-followers journaled between the links of each pair in position for rolling engagement with the eccentric surface of said cam, means for limiting the speed of rotation of said followers, said means comprising a leaf spring mounted between the links in each pair and bridging each follower, said spring having a normal tension towards said follower, and a friction block carried by said spring and tension held against the moving surface of said follower.

17. In an internal-combustion engine having a main shaft, a cam on and rotatable with said main shaft, cylinders disposed in opposed, axially-alined pairs radially of said shaft and cam and pistons mounted for rectilinear reciprocation in said cylinders, means for connecting the pistons in each pair of axially-alined cylinders to utilize and enhance the inertia effect of said reciprocating elements, said means comprising paired links disposed on opposite sides of said cam and connecting pistons in opposed, axially-alined cylinders, each of said links being formed with diverging terminal arms on each end engaging and rigidly secured to lugs on said pistons.

Signed at Colorado Springs, in the county of El Paso and State of Colorado, this 27th day of March, 1929.

LEO IMBLUM.