

Sept. 20, 1949.

W. N. WRIGHT
ENGINE

2,482,136

Filed May 12, 1945

2 Sheets-Sheet 1

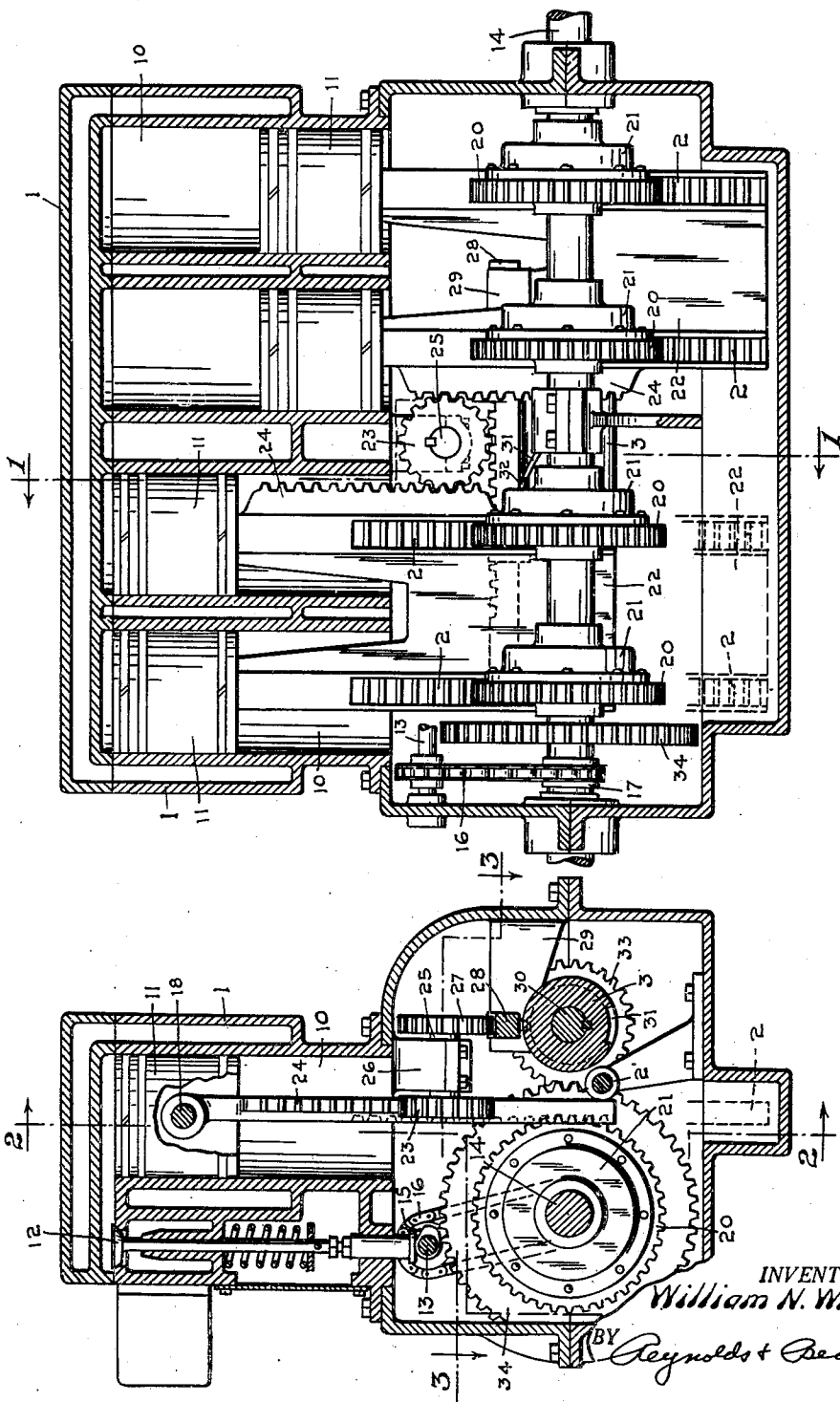


Fig. 1.

Fig. 2.

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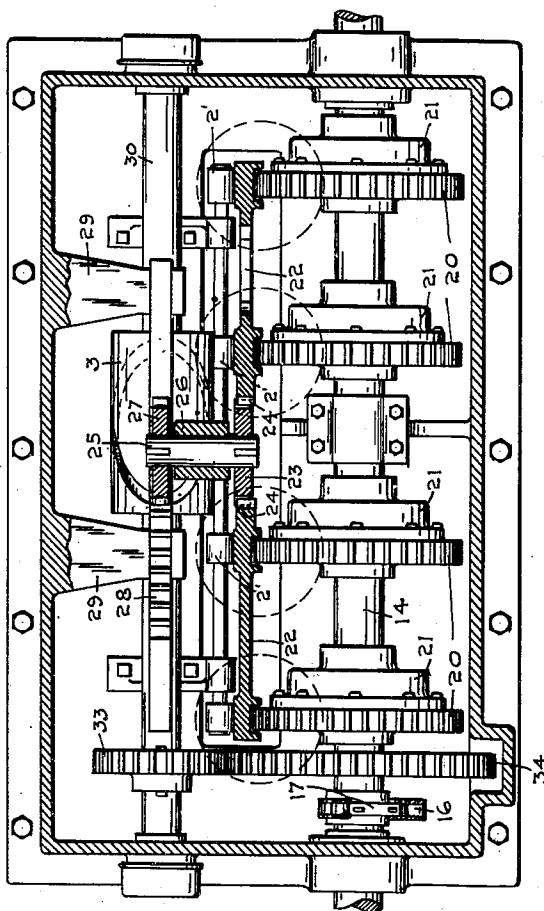


Fig. 3.

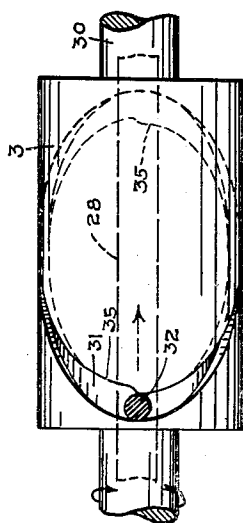


Fig. 4.

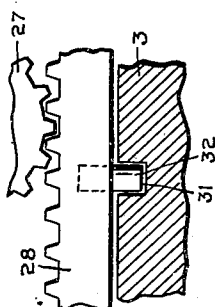


Fig. 5.

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2,482,136

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Application May 12, 1945, Serial No. 593,383

11 Claims. (Cl. 74-131)

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My invention relates to reciprocating piston engines of the internal combustion type, and more particularly to such engines employing drive connections between the pistons and power shaft which afford constant mechanical advantage in all positions of each piston lengthwise of its cylinder.

In conventional engines incorporating pistons reciprocating in cylinders, the pistons are connected positively to a crank shaft by connecting rods secured to crank arms of such shaft. Where such mechanism is employed, however, the lever arm of the force acting on the piston, and transmitted through the connecting rod to the crank shaft, varies. When the piston is at the top of its cylinder the effective lever arm is zero, and increases to a maximum when the crank shaft has rotated through approximately 90 degrees from the top position of the piston.

My invention is concerned particularly with mechanism which will afford a constant lever arm at which the piston force is applied to the power shaft. The type of mechanism which I prefer employs a rack bar for each piston engageable with a gear arranged to drive the power shaft. One difficulty in mechanisms of this general type which have been proposed previously, when applied to a multicylinder engine, was to coordinate properly the movement of the various pistons relative to each other and to the power shaft. In the case of a single cylinder engine the problem arose of insuring that the piston would always follow through its complete operating cycle.

A principal object of my invention, therefore, is the provision of novel coordinating mechanism capable of synchronizing the rotation of a power shaft with the reciprocation of one or more pistons of an internal combustion engine, to supply a force for rotating the power shaft. For accomplishing this object I provide simple and effective mechanism composed of few parts which are arranged compactly and which function reliably and effectively.

It is a further object of my invention to improve and to simplify the drive connection between the power shaft and the several pistons of a multicylinder engine, and in addition to include safety features which will reduce the possibility of engine failure.

Additional advantages of my engine which are inherent in the particular type of construction which I now prefer will be pointed out in the following description of a representative installation. It is to be understood, of course, that details of the features shown in the accompanying

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drawings and described hereafter may be varied to suit the preference of different designers, in accordance with the general principles of my invention.

Figure 1 is a vertical sectional view taken transversely through a representative form of engine, along line 1-1 of Figure 2, and Figure 2 is a vertical sectional view taken longitudinally through the engine, on line 2-2 of Figure 1.

Figure 3 is a horizontal sectional view through the engine on line 3-3 of Figure 1.

Figure 4 is a plan view of a cam drum constituting an element of the coordinating mechanism, and Figure 5 is a fragmentary sectional view through a portion of such cam drum and parts cooperating with it.

As has been pointed out above, my invention is concerned particularly with mechanism for coordinating the rotation of a power shaft with the reciprocatory movement of one or more internal combustion engine pistons. It will be understood, therefore, that the piston and cylinder construction and arrangement may be conventional, and the drawing merely shows generally a representative type of engine in which my mechanism is incorporated. It is preferred, however, that the cylinders be arranged in line rather than radially.

A typical engine may include an engine block 1, defining cylinders 10, in which pistons 11 reciprocate according to conventional practice. In an L-head type of engine valves 12, controlling intake and exhaust ports communicating with the cylinders 10, are operated by cams on a cam shaft 13 in the usual way. In an engine in which each piston is connected positively to a crank arm on the crank shaft by a connecting rod, it is mandatory that the crank shaft make a complete revolution each time a piston moves through an outward and inward stroke, or one-half a revolution for each piston stroke. Especially with high speed engines, it is therefore usually necessary to interpose speed reduction gearing between the crank shaft and the load, which decreases the overall efficiency of the installation to some extent.

In an engine incorporating my mechanism a connecting rack 2 replaces the usual connecting rod and meshes with a gear 20 carried by the power shaft 14. As each connecting rack is driven downward by a force applied to its piston, it will rotate such gear in the same direction as shaft 14 rotates, and at the same peripheral speed as the linear piston speed. It will be evident, therefore, that the speed at which the power shaft is thus rotated, as compared to the piston speed, will be a direct function of the size of gear 20. For a

given piston speed the larger the gear the slower will the power shaft 14 be rotated, so that the desired speed ratio may be obtained by selecting a gear 20 of proper size.

In the particular mechanism illustrated the stroke of connecting racks 2 is equal to one-quarter of the effective circumference of gears 20, so that each piston must make four strokes, two inward and two outward, for each complete revolution of shaft 14. Considered differently, the shaft turns one-quarter of a revolution for each piston stroke, half as much as in the conventional engine. During each rotation of the power shaft, therefore, each piston 11 executes one power stroke, assuming the engine to be of the four-stroke cycle type. Consequently if cam shaft 13 has a single cam to actuate each valve rod it would be necessary for such shaft to be rotated at the same speed as the power shaft 14. For this purpose the cam shaft may be driven by a sprocket 15 connected by a chain 16 to a sprocket 17 mounted on the power shaft. Such sprockets would, of course, be of equal size to effect rotation of the cam and power shafts at the same speed.

Each connecting rack 2 is held constantly in mesh with its gear 20 by a backing roller 2', as shown in Figures 1 and 3. Piston 11 is relieved of all tilting load transversely of the power shaft 14 by connecting the rack to it by a conventional wrist pin 18. This type of connection also guards against subjecting the connecting rack to bending loads, except those which are incidental to the compression stress in the rack.

Because each connecting rack 2 is thus maintained constantly in mesh with its drive gear 20, such gear must be oscillatable although power shaft 14 rotates unidirectionally. Each drive gear is therefore operatively connected to the shaft by a ratchet or overrunning clutch, or free-wheeling unit, 21 of any suitable type. Such unidirectional drive unit effects a driving connection with the shaft as its gear 20 is rotated by downward reciprocation of the associated connecting rack, whereas the shaft can overrun such gear, and it can be rotated in the direction opposite to the shaft's rotation as the connecting rack meshing with it moves upwardly, without retarding appreciably the rotative speed of the power shaft. Since various types of such unidirectional drive or overrunning clutch units suitable for this purpose are well known, it is not necessary to illustrate or describe such a unit in detail.

While each connecting rack 2 may be formed independently of all other such racks, either the bearing of the wrist pins 18 in the pistons and, in turn, the fit of the pistons in their cylinders, or special guide mechanism, would be relied upon to maintain the racks in proper registry with their coacting gears 20 lengthwise of the power shaft. I prefer that adjacent connecting racks be interconnected in pairs by rack webs or plates 22. The upper edge of each such plate is notched between the racks of its pair to receive the lower edges of the adjacent walls of the cylinders in which such racks, thus interconnected, reciprocate. Each plate insures that its racks and the two pistons connected to them will reciprocate precisely in unison.

While the power impulses on the two connecting racks of each plate 22 will occur alternately, the combined guiding action of the two pistons and their wrist pins will prevent any appreciable tendency of the plate to tilt edgewise. Moreover each connecting rack is located precisely in alignment with the center of its piston, so that the

thrust force of the piston is transmitted directly to its drive gear 20. The only tendency of the rack plate 22 to tilt, therefore, would result from the drag of the piston moved downward on the intake stroke. A further advantage of such integration of adjacent connecting racks resides in the alternate emergency connection between each piston and the power shaft 14 thus afforded. If the overrunning clutch unit of one gear 20 should fail to operate properly, the thrust of the connecting rack meshing with it would be transmitted through plate 22 and the paired connecting rack integral with such plate to its gear 20.

On the compression stroke of an internal combustion engine piston considerable resistance to its movement occurs especially near the end of the stroke. When such a piston is positively secured by a connecting rod to the engine crank shaft, such crank shaft supplies power through the connecting rod to the piston to effect such compression. Since, in an engine incorporating my mechanism gears 20 rotate opposite to the direction of power shaft rotation during compression movement of each piston, however, the driving force required for such stroke can not be transmitted from the power shaft to the several connecting racks 2 directly through the overrunning clutch units 21 and their gears 20.

In my engine most of the force required to effect the compression stroke of each piston is transmitted to its connecting rack from a piston moving in its power stroke even more directly than in the conventional engine. In a four-stroke cycle internal combustion engine having four cylinders, such as illustrated in the drawings, two paired pistons, interconnected through the plate 22 carrying their connecting racks, are always moving inwardly on the exhaust and compression strokes, respectively, while the other two pistons, similarly interconnected, are moving outwardly on their suction and power strokes, respectively. The power developed by the piston moving outwardly on the power stroke may be transmitted to the inwardly moving piston on the compression stroke by directly interconnecting the two rack plates 22 to effect their conjoint movement in opposite directions.

The connection between plates 22 may be a coordinating gear 23 meshing with racks 24 formed on or secured to the adjacent edges of the two plates 22, and secured on shaft 25 journaled in a stationary bearing 26, as shown best in Figure 2. As one of the pistons at the right of Figure 2 is driven downward on its power stroke part of the thrust developed by it will be transmitted through the two racks 24 and the gear 23 meshing with them to drive upward at a corresponding rate the two pistons at the left of Figure 2, one of which will be executing its compression stroke.

It may at first be thought that no other interconnection between the oppositely moving pistons than that afforded by gear 23 and racks 24 would be required. Actually, however, in an efficiently operating engine the force necessary to complete the compression stroke of one piston exceeds that normally delivered at the same time by another piston near the end of its power stroke. While it is probable that the mass of the pistons, connecting racks, and rack plates 22 would usually afford sufficient momentum to complete the stroke of the piston moving to compress a new charge, despite the ability of shaft 14 to overrun the connecting racks, it is not safe to rely upon such operation.

To insure coordination of piston movement

with continual rotation of the power shaft 14 I provide emergency drive mechanism in the form of a supplemental drive between the power shaft and the coordinating gear 23. A control gear 27 is secured on the end of shaft 25 remote from gear 23 and meshes with a control rack 28. This rack is disposed parallel to power shaft 14 and reciprocates lengthwise of such shaft, being guided for such movement by channels, which embrace opposite ends of the rack, formed in fixed guide brackets 29 supported from the engine casing as shown in Figure 1. Reciprocation of the rack by the power shaft may be effected by any of several types of mechanism, but the cam drum 3 secured on a control shaft 30, which in turn is geared positively to shaft 14, has decided advantages.

Rack 28 necessarily reciprocates in synchronism with the pistons 11, so that, like each piston, this rack must complete two strokes in each direction while shaft 14 makes a single complete revolution, where the effective length of each connecting rack 2 is equal to one-quarter of the circumference of the gear 20. To effect such rack movement the cam drum 3 may have in it a single, substantially helical return groove 31, or equivalent surface, extending lengthwise of the drum over a distance equal to the stroke of rack 28. If coordinating gear 23 and control gear 27 are of equal size the stroke of the rack, and consequently the effective length of the cam drum, must be equal to the length of the piston stroke. The stroke of rack 28 may, of course, be altered to any degree desired by changing the relative sizes of gears 23 and 27. The cam drum groove 31 receives a follower pin or rollers 32 projecting downward from the bottom of the control rack 28. Preferably the cam drum is located directly beneath control gear 27, as shown in Figures 1 and 2, so that the forces will be transmitted most directly between the drum and gear.

It will be evident that if the drum 3 has in it a cam groove making only a single axial pass and return about its entire circumference, it will reciprocate control rack 28 once in each direction during a single revolution, whereas power shaft 14 rotates only one-half a revolution during such rack movement. The driven gear 33 carried by control shaft 30 therefore must be only one-half as large as the driving gear 34 meshing with it and carried by shaft 14. This gear ratio must, of course, be governed by the relationship between the piston stroke and the rotation of the shaft 14 as determined by the size of gears 20, the relative sizes of gears 33 and 34 being such as to effect one-half a revolution of shaft 30 for each piston stroke. If the cam groove 31 makes more than one pass axially of drum 3 around its circumference the rotative speed of the drum must be reduced correspondingly.

It is evident that pistons 11 cannot move at the same rate of speed at all times, because their direction of movement must reverse at the end of each stroke. In order to utilize the force on the piston moving through the power stroke to the best advantage, it is desirable for such piston to reciprocate sufficiently rapidly so that it will apply a torque to shaft 14 as early in its stroke as is consistent with the avoidance of excessive accelerations in the working parts. Because of the interconnection of rack plates 22 by coordinating gear 23 the reversal of movement of all the pistons must occur in the same period of time.

The contour of the cam groove 31 on drum 3 should conform to the type of piston movement

desired. At the beginning of the downward stroke the piston will be accelerating, and if the cam groove 31 corresponds exactly to the movement of the piston when correlated with rotation of power shaft 14, it would be possible for the piston to drive the power shaft through the control mechanism, including gear 27, control rack 28, cam drum 3, control shaft 30, and gears 33 and 34, instead of through the connecting rack 2 of the piston moving through its power stroke. In order to avoid any possibility of this operation, except possibly in the case of emergency, the cam groove 31 may be relieved slightly at each end, as indicated at 35.

The cam groove should, of course, be of true helical shape over the major portion of its length, so that the piston working on its power stroke will drive its gear 20 at a rotative speed equal to that of shaft 14. Adjacent to each end of the cam drum, however, such groove should be shaped to allow the pistons to slow down while reversing their movement, and while accelerating again at the beginning of their travel in the opposite direction. Nevertheless the cam groove should be able to contact the follower projection for the purpose of driving the pistons to the end of their strokes, if necessary, particularly to counteract the resisting force created on the piston moving through its compression stroke.

Assuming that the left piston 11, shown in Figure 2, is beginning its power stroke, it would drive the left connecting rack 2 downward to rotate its overrunning clutch 21, and consequently shaft 14, in a clockwise direction, as indicated in Figure 1. Simultaneously the two pistons at the right would be driven upward by the rotation of coordinating gear 23 in the counterclockwise direction, as seen in Figure 2. Also control gear 27, rotating conjointly with gear 23, would shift control rack 28 to the right in Figure 2 to move its cam follower 32 along the cam groove 31 of drum 3, in synchronism with rotation of such drum by gears 33 and 34.

As the resistance to upward movement of a piston at the right of Figure 2 increases because of the increasingly greater force required to compress the fresh charge after the exhaust port of the cylinder at the extreme left has opened, so that little further propulsive effort is produced, the speed of the pistons' travel will decrease and shaft 14 will overrun gears 20 at the left in Figure 2. If this tendency of the pistons to decelerate is greater than permitted by the contour of the cam groove 31 in drum 3, this drum, rotated by shaft 14 through gearing 33, 34, will exert a pressure on the follower of rack 28 tending to accelerate its lengthwise movement. This force will be transmitted through gears 27 and 23 to racks 24 for supplying the power deficiency necessary to complete the compression of the new charge and to drive the pistons to the end of their respective strokes.

As illustrated in the drawing, the engine is preferably constructed so that the entire power shaft assembly, including gears 20 and clutches 21 may be removed as a unit, and similarly shaft 30 and its cam drum 3 can be lifted out of the engine case as a single assembly. It will be understood that various conventional engine details, which would be the same in an engine incorporating my mechanism described above as in other engines, have not been illustrated or described.

I claim as my invention:

1. In an engine having a plurality of pistons

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reciprocable in cylinders arranged in a row with their axes parallel, a plurality of connecting members secured, respectively, to the engine pistons, a power shaft, a plurality of rotative members carried thereby and engaged, respectively, with said connecting members, a plurality of overrunning clutches interposed between said power shaft and said rotative members, respectively, operable to effect rotation of said power shaft by rotation of said rotative members only in one direction, and a plate disposed substantially parallel to said power shaft and interconnecting two of said connecting members disposed in adjacent relationship to reciprocate in unison.

2. In an engine having a plurality of pistons reciprocable in cylinders arranged in a row with their axes parallel, a plurality of connecting racks secured to and aligned with the respective engine pistons, a power shaft, a plurality of gears carried thereby and meshing, respectively, with said connecting racks, a plurality of overrunning clutches interposed between said power shaft and said gears, respectively, operable to effect rotation of said power shaft by rotation of said gears only in one direction, and a rack plate disposed parallel to said power shaft and interconnecting two of said connecting racks disposed in adjacent relationship to reciprocate in unison.

3. In an engine having a plurality of pistons reciprocable in cylinders arranged in a row with their axes parallel, a plurality of connecting members secured, respectively, to the engine pistons, a power shaft, a plurality of rotative members carried thereby and engaged, respectively, with said connecting members, a plurality of overrunning clutches interposed between said power shaft and said rotative members, respectively, operable to effect rotation of said power shaft by rotation of said rotative members only in one direction, a plate disposed substantially parallel to said power shaft and interconnecting two of said connecting members disposed in adjacent relationship to reciprocate in unison, a second plate disposed substantially parallel to said power shaft and interconnecting two other of said connecting members disposed in adjacent relationship to reciprocate in unison, and coordinating means rotative about an axis disposed substantially perpendicular to said plates, interconnecting said two plates and operable to coordinate conjoint movement thereof in opposite directions.

4. In an engine having a plurality of pistons reciprocable in cylinders arranged in a row with their axes parallel, a plurality of connecting racks secured to and aligned with the respective engine pistons, a power shaft, a plurality of gears carried thereby and meshing, respectively, with said connecting racks, a plurality of overrunning clutches interposed between said power shaft and said gears, respectively, operable to effect rotation of said power shaft by rotation of said gears only in one direction, a rack plate disposed parallel to said power shaft and interconnecting two of said connecting racks disposed in adjacent relationship to reciprocate in unison, a second rack plate disposed parallel to said power shaft and interconnecting two other of said connecting racks disposed in adjacent relationship to reciprocate in unison, and located substantially coplanar with and adjacent to said first rack plate, edge racks carried by the adjacent edges of said rack plates, and a coordinating gear rotative about an axis disposed perpendicular to said rack plates, interposed between and meshing with said rack plate

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edge racks and operable to coordinate conjoint movement of said rack plates in opposite directions.

5. In an engine having a plurality of pistons reciprocable in cylinders arranged in a row with their axes parallel, a plurality of connecting members secured, respectively, to the engine pistons, a power shaft, a plurality of rotative members carried thereby and engaged, respectively, with said connecting members, a plurality of overrunning clutches interposed between said power shaft and said rotative members, respectively, operable to effect rotation of said power shaft by rotation of said rotative members only in one direction, plate means interconnecting two of said connecting members disposed in adjacent relationship to reciprocate in unison, second plate means interconnecting two other of said connecting members disposed in adjacent relationship to reciprocate in unison, coordinating means interconnecting said two plate means and operable to coordinate conjoint movement thereof in opposite directions, and control means separate from said overrunning clutches and operatively interconnecting said coordinating means and said power shaft for synchronizing movement of said coordinating means, and consequently of said connecting members, with rotation of said power shaft at all times.

6. In an engine having a plurality of pistons reciprocable in cylinders, a plurality of connecting racks secured, respectively, to the engine pistons, a power shaft, a plurality of gears carried thereby and meshing, respectively, with said connecting racks, a plurality of overrunning clutches interposed between said power shaft and said gears, respectively, operable to effect rotation of said power shaft by rotation of said gears only in one direction, a rack plate interconnecting two of said connecting racks disposed in adjacent relationship to reciprocate in unison, a second rack plate interconnecting two other of said connecting racks disposed in adjacent relationship to reciprocate in unison, and located substantially coplanar with and adjacent to said first rack plate, edge racks carried by the adjacent edges of said rack plates, a coordinating gear interposed between and meshing with said rack plate edge racks and operable to coordinate conjoint movement of said rack plates in opposite directions, means operatively connected to said coordinating gear to move therewith, means driven by said power shaft and rotatable therewith, and cam means operatively interconnecting said last two means and operable to synchronize movement thereof, and consequently to synchronize reciprocation of said connecting racks with rotation of said power shaft at all times.

7. In an engine having a plurality of pistons reciprocable in cylinders, a plurality of connecting racks secured, respectively, to the engine pistons, a power shaft, a plurality of gears carried thereby and meshing, respectively, with said connecting racks, a plurality of overrunning clutches interposed between said power shaft and said gears, respectively, operable to effect rotation of said power shaft by rotation of said gears only in one direction, a rack plate interconnecting two of said connecting racks disposed in adjacent relationship to reciprocate in unison, a second rack plate interconnecting two other of said connecting racks disposed in adjacent relationship to reciprocate in unison, and located substantially coplanar with and adjacent to said first rack plate, edge racks carried by the adjacent edges of said rack

plates, a coordinating gear interposed between and meshing with said rack plate edge racks and operable to coordinate conjoint movement of said rack plates in opposite directions, a control gear rotatable with said coordinating gear, a control rack meshing with said control gear and disposed generally parallel to said power shaft, a control shaft also disposed generally parallel to said power shaft, gearing interconnecting said control shaft and said power shaft to effect conjoint rotation thereof, a cam drum carried by and rotatable with said control shaft, and cam follower means carried by said control rack, engageable with said cam drum for synchronizing reciprocation of said control rack, and consequently of said connecting racks, with rotation of said power shaft at all times.

8. In an engine having a piston reciprocable in a cylinder, a power shaft, connecting means secured to such piston, unidirectional drive means interengaged between said connecting means and said power shaft, and operable to rotate said shaft by movement of said connecting means in one direction but inoperative to rotate said shaft by movement of said connecting means in the opposite direction, and control means separate from said unidirectional drive means operatively connecting said connecting means and said power shaft for synchronizing movement of said connecting means with rotation of said power shaft at all times.

9. In an engine having a piston reciprocable in a cylinder, a power shaft, connecting means secured to such piston, unidirectional drive means interengaged between said connecting means and said power shaft, and operable to rotate said shaft by movement of said connecting means in one direction but inoperative to rotate said shaft by movement of said connecting means in the opposite direction, and control means including a member operatively connected to said connecting means to move in synchronism therewith at all times, a member operatively connected to said power shaft to move in synchronism therewith at all times, and cam means operatively interconnecting said two members for synchronizing movement thereof at all times, and thereby synchronizing movement of said connecting means with rotation of said power shaft.

10. In an engine having a piston reciprocable in a cylinder, a power shaft, connecting means secured to such piston, unidirectional drive means interengaged between said connecting means and

said power shaft, and operable to rotate said shaft by movement of said connecting means in one direction but inoperative to rotate said shaft by movement of said connecting means in the opposite direction, a control shaft, drive means interconnecting said power shaft and said control shaft to drive the latter by rotation of the former, a cam drum secured to said control shaft for rotation thereby, a follower engaged with said cam drum and reciprocated by rotation of said cam drum, and means interconnecting said follower and said connecting means and operable to synchronize reciprocation of said connecting means with movement of said follower, and consequently with rotation of said power shaft.

11. In an engine having a piston reciprocable in a cylinder, a power shaft, connecting means secured to such piston, unidirectional drive means interengaged between said connecting means and said power shaft, and operable to rotate said shaft by movement of said connecting means in one direction but inoperative to rotate said shaft by movement of said connecting means in the opposite direction, a control shaft disposed parallel to said power shaft, drive means interconnecting said power shaft and said control shaft to drive the latter by rotation of the former, a cam drum having a cam groove therein and secured to said control shaft for rotation thereby, a rack disposed parallel to said control shaft and having a follower engaged with said cam drum to effect reciprocation of said rack by rotation of said cam drum, and means interconnecting said rack and said connecting means and operable to synchronize reciprocation of said connecting means with reciprocation of said rack, and consequently with rotation of said power shaft.

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