Aug. 17, 1948. J. J. CARROLL 2,447,314

INTERNAL-COMBUSTION ENGINE

Filed Sept. 17, 1942 4 Sheets-Sheet 1

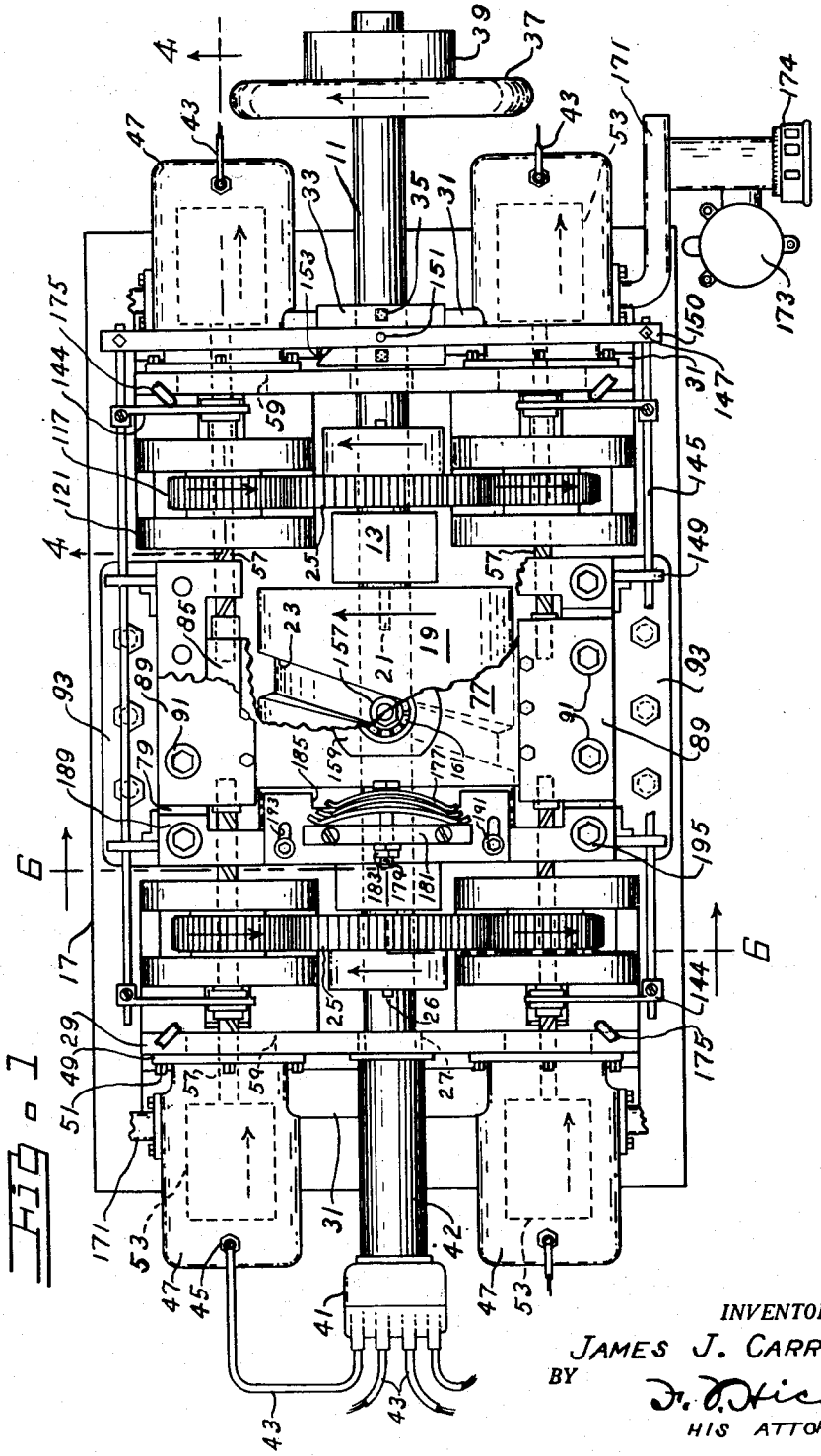


FIG. 1

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INTERNAL-COMBUSTION ENGINE

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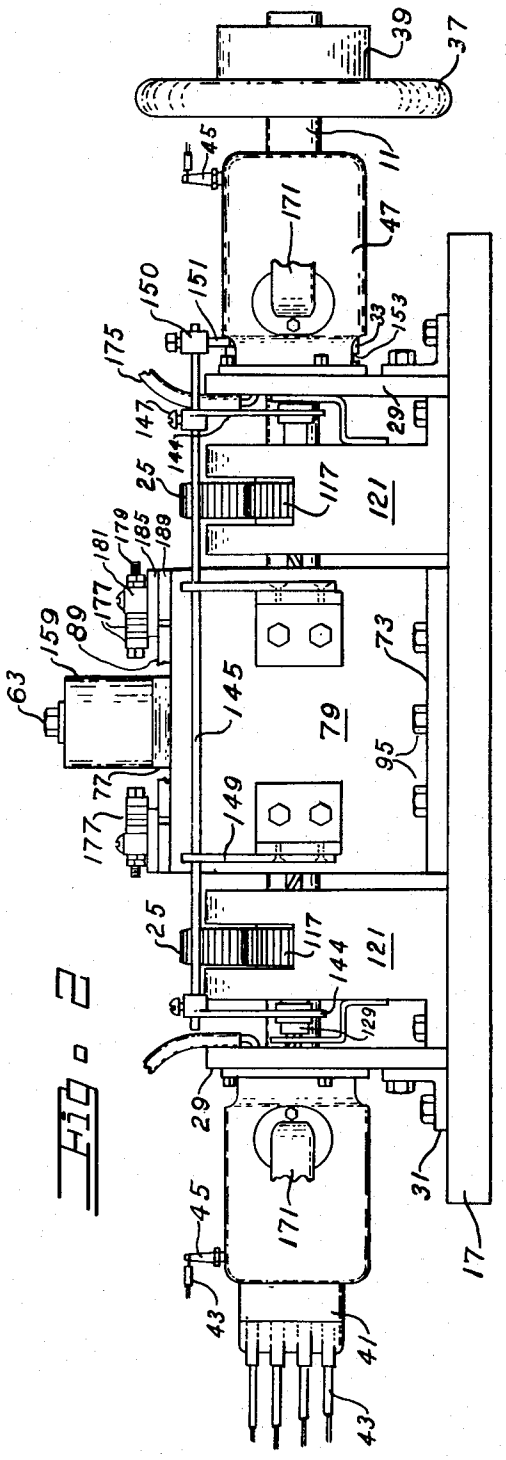



FIG. 2

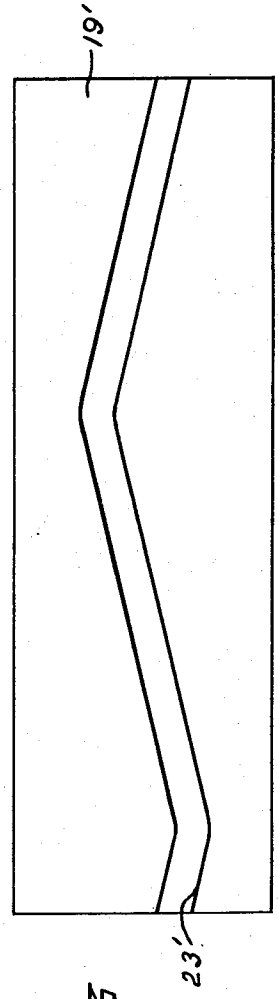



FIG. 3

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INTERNAL-COMBUSTION ENGINE

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Fig. 4.

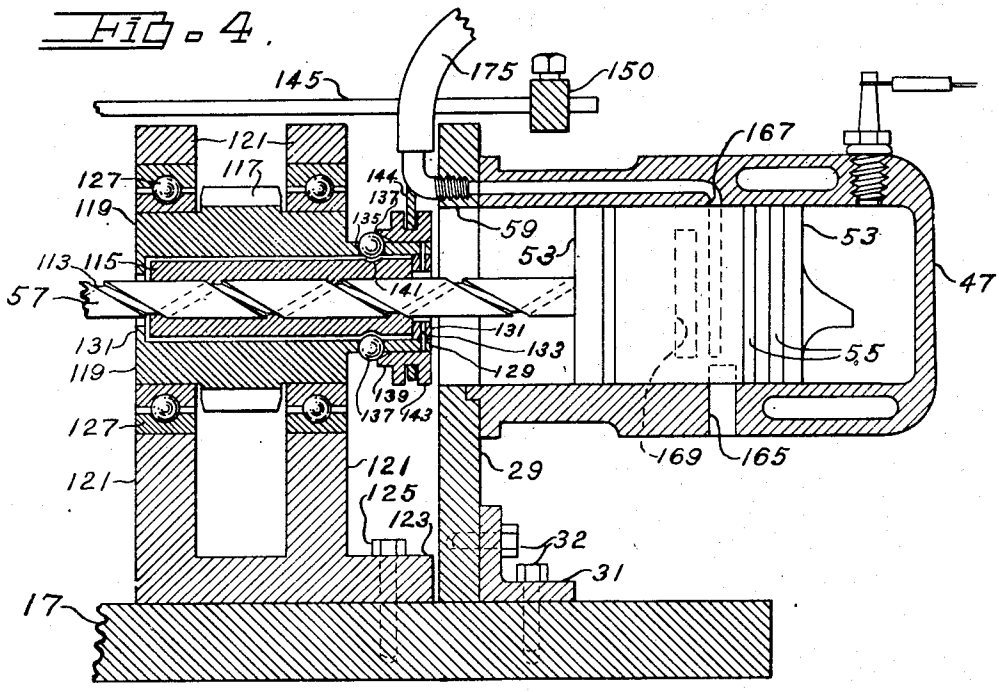
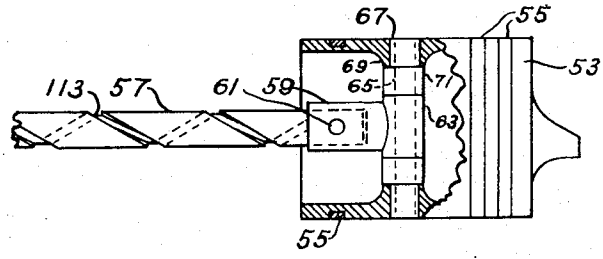



Fig. 5.




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Fig. 6

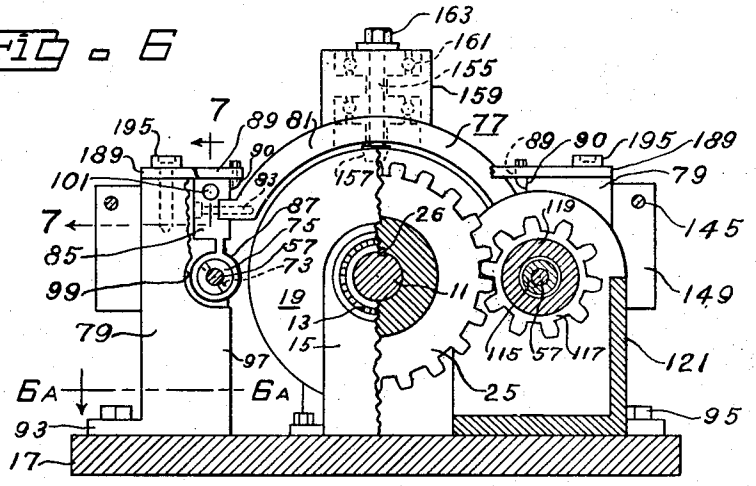



Fig. 7

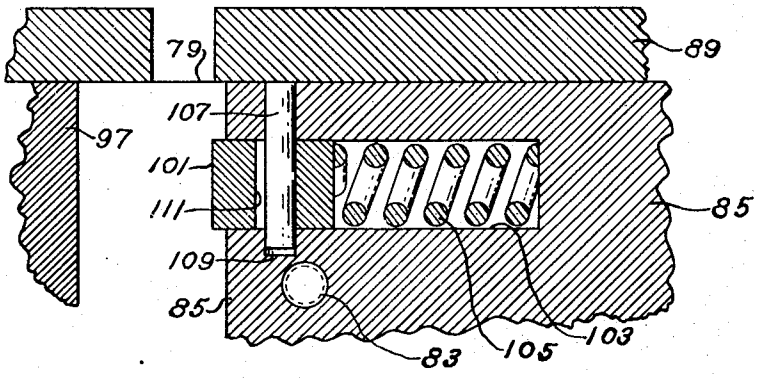
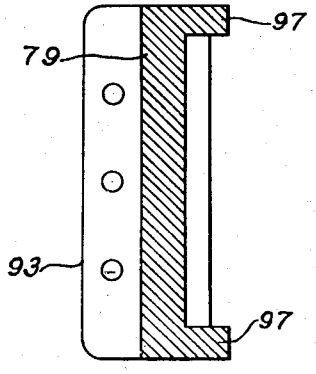



Fig. 6A




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Patented Aug. 17, 1948

2,447,314

# UNITED STATES PATENT OFFICE

2,447,314

## INTERNAL-COMBUSTION ENGINE

James J. Carroll, Grosse Pointe Park, Mich.

Application September 17, 1942, Serial No. 458,619

10 Claims. (Cl. 123—58)

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My invention pertains to power plants and more particularly to internal combustion engines.

It is an object of my invention to provide an internal combustion engine of an improved, compact, simplified construction.

It is also an object of my invention to provide an internal combustion engine having improved efficiency of operation and fuel economy with less weight for a required power capacity.

It is a further object of my invention to provide an improved internal combustion engine wherein the peak pressures delivered on the piston at the time of the explosion are promptly made effective to deliver a power impulse to the main shaft of the engine with the maximum mechanical advantage of application which remains constant throughout the power stroke instead of the mechanical advantage varying throughout the power stroke, as in conventional engines, in such a way that it is a minimum at the time when the pressures are a maximum and by the time the mechanical advantage has increased to a maximum the pressure has expanded to a minimum.

Another object of my invention is to provide an internal combustion engine which will have improved efficiency in a compact simplified construction providing for enonomy of material in construction, and providing for economy of space in installation and economy of fuel required to be stored or carried for operation.

A further object of my invention is to provide such an internal combustion engine having the rotative elements arranged so that these may be very conveniently journalled upon friction reducing ball or roller bearings having the respective races thereof formed in one piece for minimum friction and maximum durability.

Further objects and advantages are within the scope of my invention, such as relate to the arrangement, operation and function of the related elements of the structure, to various details of construction and to combinations of parts, elements per se, and to economies of manufacture and numerous other features as will be apparent from a consideration of the specification in conjunction with the drawings disclosing specific embodiments of my invention, similar reference characters being applied to corresponding elements throughout, and in which:

Fig. 1 is a plan view of one embodiment of my improved internal combustion engine;

Fig. 2 is a side elevational view thereof;

Fig. 3 is a diagrammatic view showing a development of the slotted or cam surfaces of the timing drum;

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Fig. 4 is an enlarged fragmentary sectional view taken on line 4—4 in Fig. 1 showing a piston push rod with the associated overrunning clutch and driving gear and also showing the associated piston and cylinder;

Fig. 5 is an enlarged detail view showing the attachment of one end of a piston push rod into a piston;

Fig. 6 is a cross-sectional view through the engine on line 6—6 in Fig. 1;

Fig. 6A is a cross-sectional view on line 6A—6A of Fig. 6; and

Fig. 7 is an enlarged fragmentary sectional view on line 7—7 in Fig 6 showing a compressed helical recoil spring and plunger, of which four are provided in the crosshead.

Referring more specifically to Fig. 1 of the drawings, I have illustratively disclosed an embodiment of my improved internal combustion engine which comprises a simple straight main shaft 11 rotatively journalled in bearings 13 mounted on brackets 15 rising from a rigid base plate 17. Although the bearings may be simple bearings these are preferably conventional friction reducing ball or roller bearings having solid one piece races which, in accordance with my invention, may very conveniently be installed upon the simple main shaft in a manner which is not possible with the usual crank type of main shaft. Mounted rigidly upon the main shaft between the bearings is a timing drum 19 which is secured to the shaft, in any suitable manner, as by means of a key 21 for example. The peripheral surface of the timing drum has an endless slot 23 cut therein and extending inclined from end to end and providing camming surfaces for deriving power from the rotating main shaft 11 to return the reciprocating parts in properly timed relation, as will be described in detail subsequently. Fig. 1 also shows, mounted upon the main shaft at points just outside of the main bearings 13, two driving gears 25 which may have axially elongated hubs providing for secure and rigid attachment of the gears to the shaft by keys 26 or in any suitable manner. The ends of the main shaft 11 extend outwardly and pass freely through apertures 27 in two cylinder plates, or end riser plates 29, which are secured rigidly and firmly upon the base plate, as by angle irons 31 secured to both as by bolting, riveting or welding. The two cylinder plates 29 are secured in a spaced parallel relation.

As viewed in Fig. 1, the end of the main shaft 11 extending to the right hand side, carries and operates a clutch actuating cam drum 33 which

actuates clutches in proper timed relation for applying power impulses to the main shaft, in a manner to be more fully described. The clutch operating cam drum 33 is secured to the main shaft 11 in such a manner that the angular position thereon may be conveniently adjusted to suit operating conditions, and for this purpose set screws 35 or other suitable securing means may be utilized. As shown, this same end of the main shaft 11 also has secured thereon a balance wheel 37 which, as usual, is designed with sufficient weight in the rim for providing a suitable moment of inertia to carry the rotation of the main shaft between power impulses and to provide a suitably uniform velocity for the purposes for which the power is to be applied from the engine. The timing drum having appreciable mass, also serves to provide such momentum and therefore in some installations the flywheel may be omitted, if desired. A belt pulley 39 is shown in connection with the balance wheel, but it is to be understood that any suitable power take-off may be provided in connection with the main shaft to suit the specific installation where the engine is to be used.

If electrical ignition is to be utilized instead of compression ignition, the other end of the main shaft which extends to the left hand side, in Fig. 1, is provided with an ignition head and distributor 41, which may be the double ignition type as commonly used on the engines of a well known automobile. The ignition head and distributor 41 are supported in any convenient manner, as by means of a tubular support 42 attached to the adjacent cylinder plate 29 and of a larger diameter than the shaft 11 which passes concentrically therethrough. Insulated high tension cables 43 extend from the ignition distributor head to a spark plug 45 in each respective cylinder 47 for firing the explosive charges in properly timed relation, as will be understood, and the spark advancing and retarding means usually provided on such an ignition head may also be advantageously utilized for obtaining the most effective operation of the engine.

The cylinders 47 are firmly attached to the outer sides of the rigidly supported cylinder plates 29 by means of marginal flanges 49 on the open ends which are secured to the outer sides of the cylinder walls 29 as by screws 51 passing into the plates. Although I have shown a conventional type of cylinder having a jacket for liquid cooling, it is to be understood that the useful principles of my invention may also be advantageously utilized in an engine provided with air cooled cylinders. The cylinders 47 are preferably mounted on the cylinder plates 29 with the axes of the cylinders spaced from and disposed substantially parallel to the axis of the main shaft.

As shown dotted in Fig. 1, each cylinder 47 encloses a piston 53, which may be any conventional piston equipped with sealing piston rings 55 and arranged for operative sliding movement in the usual manner. Secured to each piston is a piston push rod 57 extending axially from the open end of each cylinder through a large aperture 59, shown dotted, in the riser plate.

The attachment of one end of each piston push-rod 57 to its piston 53 may be accomplished by various arrangements. One such arrangement provided which has proven satisfactory, as shown in Fig. 5, comprises a T connection 59 the stem of which is suitably drilled at the end for receiving one end of the push-rod. The piston push-rod is secured in the stem of the T connection by



means of a pin or bolt 61 passed transversely through suitable apertures provided in the push-rod and the connector. The T connector has a suitably drilled or tubular cross-piece 63 through which the mid-portion of the regular wrist pin 65 of the piston is snugly disposed. The ends of the wrist pin are secured or journalled in suitable bearings 67 provided in bosses 69 on the side walls of the piston, in the usual manner. Spacers 71 may be provided on the wrist pin for centering the T-connector.

As may be seen in Fig. 1, the other end of each piston push-rod extends from the piston and is secured, as by a pin or bolt 73, shown in Fig. 6, into a bushing 75 secured into a reciprocatable cross-head 77 which is slidably supported and firmly guided in its movements in stationary cross-head guides 79.

In this manner the pistons 53 are all joined together in spaced apart relation by a rigid reciprocatable interconnecting structure. The lengths of the piston push-rods 57 and the attachment thereof into the cross-head 77 is selected to space the pistons 53 so that as one piston, or set of pistons, is pushed into associated cylinder adjacent the cylinder head the other piston, or set of pistons, is moved to its maximum expansion position and vice versa. As viewed in Fig. 1, the pistons 53 toward the right hand side of the engine constitute one set of pistons, and these are spaced in a predetermined relation from the pistons on the left hand side of the engine, which constitute the other set of pistons. As represented by the dotted arrows, the pistons all move simultaneously in the same direction.

The cross-head 77, as may be seen in Fig. 6, comprises a heavy rigid piece 81 of metal, which may be either a casting or a thick rolled plate, of a cylindrical or arcuate curved shape having a radius slightly greater than the radius of the timing drum over which it reciprocates. The two side edges of the arcuate piece 81 are provided with outwardly projecting flanges, as by welding fabrication or by turning and forming the edges outwardly. Secured firmly to each out-turned flange of the cross-head, as by screws 83, is a runner or shoe 85 of a substantially rectangular cross-section fitting and sliding snugly against corresponding guiding surfaces provided in the stationary cross-head guides 79. The piston rod bushings 75 are secured into the cross-head in bosses 87 provided depending from the lower sides of the runners or shoes 85. A cover plate 89, secured on top of each cross-head guide by screws 91, serves to hold the cross-head runner or shoe 85 firmly in its position as it reciprocates in the stationary guides. A flange 90 depending from the inner edge of the cover plate 89 engages the upper portion of the inner surface of the cross-head runner 85. Each stationary cross-head guide bracket 79 is secured firmly upon the base plate, as by lateral flanges 93 through which screws 95 are passed. As shown in Fig. 6A, each stationary guide is provided at the ends with inturned flanges 97, and these are provided with open portions 99 surrounding each piston push rod 57, as shown in Fig. 6.

To aid in reversing the movements of the reciprocating structure of pistons, rods and cross-head, and to cushion this operation, a spring pressed recoil plunger 101 is provided slidably in an aperture 103 in the cross-head shoe 85. This is shown in Figs. 6 and 7, and in more detail in the latter, showing the heavy helical spring 105 compressed into the aperture and continuously urg-

ing the plug outwardly. The outward movement of the plug is limited by a pin 107 disposed in suitable apertures 109 in the cross-head shoe 85 and a transverse aperture 111 through the plug. As shown, the transverse aperture 111 in the plug is substantially larger in diameter than the inserted pin 107, or it may be an elongated slot, permitting a certain amount of slack motion of the plug in the cross-head.

The recoil plunger 101 is selected of such a length and is so disposed that the outer end strikes against the inturned flange 97 at the end of the stationary guide bracket 79 just before the cross-head reaches the end of its stroke. Both ends of both cross-head shoes 85 are similarly arranged for providing recoil reaction, making a total of four compressed helical recoil springs and plungers which may be utilized in the cross-head.

To derive power from each piston on the power stroke, and to adapt or convert the reciprocatory motion to rotary motion, each piston push rod 57 is provided with a screw groove or thread 113 cut helically in the outer surface from end to end. As shown in Fig. 4, each threaded piston push rod 57 passes in operatively engaging relation through a power adapter 115 which has a corresponding internal thread. The driving adapter 115 is disposed concentrically in the center of a driving gear 117 which has axially extending hubs 119 journalled rotatively in a pair of spaced bearing brackets 121. The bearing brackets 121 may be an integral casting provided with a bottom lug or flange 123 through which screws 125 are passed into the base plate 17. The bearing brackets 121 are each provided with friction reducing ball or roller bearings 127 having integral or one piece races so that the driving gear 117 rotates freely with a minimum of friction. At one end the gear hub 119 is provided with an extended clutch sleeve 129, or this may be a separate sleeve secured firmly into the gear. At both ends retaining flanges 131 are provided axially holding the driving or power adapter 115 within the gear. The retainer flange adjacent the cylinder is removable being secured by pins 133. The extended clutch sleeve 129 is provided with collet apertures 135 for receiving and housing steel balls 137 which are slightly larger in diameter than the thickness of the sleeve. A clutch ring 139, slidably disposed upon the extended sleeve, has in the inner end a converging or conical camming surface which rides over the balls 137 for pushing these in radially through the sleeve 129 to engage and grip the outer surface of the power or driving adapter 115, when the ring is pushed toward the gear. To more firmly lock with the balls, when these are pressed in, the adjacent outer surface of the adapter 115 is provided with depressions 141 of a similar radius to the balls, as is usual with clutches of this type. The clutch ring 139 is provided with two lateral flanges 143 spaced axially apart and providing a groove receiving the end of a control arm 144. The control arm 144 is preferably slotted or forked to fit operatively into the groove between flanges 143 in an arrangement which is usual with such control devices where relative rotation is to be permitted between the controlling and the controlled sliding and rotating member.

A driving connection is thus established between the driving adapter 115 and the driving gear 117, whereby a reciprocating movement of the piston push rod 57 causes the driving gear to rotate. The driving gear 117 is continuously in mesh with one of the driven gears 25, secured on



the main shaft 11, and with which it rotates freely at all times when power is not being applied therethrough. When a piston push rod 57 moves out of its cylinder on a power stroke, the associated driving gear 117 then applies power through the driven gear to the main shaft 11.

To close the clutch and provide a driving connection at the proper time phase in the engine operation, the control arm 144 is secured on a clutch control rod 145 by means of a set screw 147, as shown in Figs. 1 and 2, permitting adjustments to be made as desired. The clutch control rod 145 is slidably mounted in suitable apertures in vertically mounted bearing plates 149, the latter preferably being made of some self lubricating material which may be metal or a non-metal. In a multi-cylinder engine with cylinders 47 arranged in opposed pairs, as shown, the clutch control rod 145 is extended sufficiently to also actuate the clutch associated with the opposed cylinder of each pair, as may be seen in Fig. 1. In this arrangement the two clutches are actuated simultaneously, one clutch opening when the other clutch closes, and vice versa. When the engine is provided with a plurality of pairs of opposed cylinders, as shown in Fig. 1, a clutch control rod is provided for each pair of cylinders. The clutch rods 145 are moved axially in the supports 149 in proper timed relation to the rotation of the main shaft 11 by means of a clutch bar 150 extending across the end of the engine and having a pin 151 inserted into the curved slot 153 in the clutch cam drum 33 so that the curved side walls of the slot engage the pin and operate with a camming action. The timing may be adjusted by releasing the set screws 35 by which the clutch operating drum 33 is secured to the main shaft 11, and the clutches are preferably set to close just at the time when the explosion of the charge in the cylinder occurs.

In this manner the peak pressures applied on the piston at the time of the explosion are promptly made effective and a power impulse is applied through the threaded piston rod and the driving and driven gears with the maximum mechanical advantage which remains constant throughout the power stroke. This is a substantial advantage over conventional arrangements where the mechanical advantage of application of the pressures is at a minimum, or sometimes at zero, when the pressures are at a peak and then gradually increases to a maximum at the time when the gas pressures have reduced to a minimum due to expansion.

For returning power from the rotating main shaft 11 to return the pistons into the cylinders in properly timed relation to continue the proper operation of the engine, the cross-head 77 is provided with a timer pin 155 projecting down into the caming slot 23 in the timing drum 19. An enlarged groove engaging head 157 is preferably provided on the lower end of the timing pin 155 which extends up through a central aperture through a housing 159 which is secured to the upper side of the center of the arcuate member 81 of the cross-head, as by welding. For journalling the timer pin 155 with a minimum of friction, ball bearings 161 are preferably provided in the housing, as shown dotted in Fig. 6, the upper end of the pin being threaded to receive a nut 163 securing the pin therein. The inclined portions of the slot 23 in the timer drum have a pitch selected suitably according to the ratio of the teeth in the driving and driven gears 25 and 117 so that the pistons are returned into the cyl-

inder by the same amount of angular rotation of the main shaft 11 as occurred while the piston was moving out of the cylinder on the power stroke.

The arrangement as shown in Fig. 4, is for a simple conventional two cycle operation, the exhaust port 165, scavenging port 167, and the inlet port 169 being opened and closed by the piston. The inlet port 169 is connected through a conduit 171 to any suitable supply of air and fuel mixture, such as a conventional carburetor 173, and air entering through adjustable ports 174, or under pressure, if desired. The scavenging port 167 is connected through a hose 175 to any suitable source of air under pressure (not shown). Or a closed crank case may be utilized in the manner conventional with 2-cycle engines. The advantages of the improved mechanical arrangements embodied in my engine may also be realized in various other cycling arrangements besides 2-cycle, as will be readily understood. The gear ratio represented in Fig. 1 is one for the driving gears to two for the driven gears, but it is apparent that various other gear ratios may be utilized, if the pitch of the threads on the piston rods and drum are correspondingly changed.

As shown in Figs. 1 and 2, additional recoil means is also provided for engaging the sides of the timer pin housing 159 on top of the cross-head, which is preferably flattened slightly on the opposite sides. Such additional recoil means may comprise a set of semi-elliptical springs 177 clamped together by a bolt 179 passing through the middle of the spring leaves and through a bar 181 for clamping the spring leaves in firmly compressed relation with the ends of the leaves against the bar and the mid portions of the springs bowed toward the timer pin housing. By turning the nuts 183 on the threaded end of the bolt 181 the degree of compression of the springs 177 may be adjusted and locked. The semi-elliptical recoil springs are mounted in a proper position by securing the bar 181 to a plate 185 by means of screws, and the plate is in turn adjustably secured upon a cross-piece 189 by screws 191 passing through slots 193. The outer ends of the cross-piece 189 are secured on top of the stationary cross-head guide brackets 79 by screws 195 so that the recoil springs 177 are secured in any desired position for engaging the opposite sides of the timer pin housing 159 at proper times, and with the desired degree of compression to cushion and to aid in reversing the motion of the cross-head and the entire reciprocating structure at the end of each stroke.

The advantages of my improved internal combustion engine may be realized in a small engine with only one or a few cylinders, or with all the cylinders grouped around one end of the main shaft, as would be present in Fig. 1 if the cylinders at the left hand side were omitted, for example. The threaded piston push rod, clutch and driving gear arrangement being still effective in such an arrangement to transmit power promptly to the main shaft from the peak pressures applied to the piston at the time of the explosion and throughout the power stroke with the maximum mechanical advantage of application which remains constant during the stroke. At times the timing drum may also serve as a return power transmission means for applying and returning sufficient power from the rotating main shaft to return the piston or pistons into cylinder in properly timed relation.

However, for smoother operation and to minimize wear and vibration it is preferable to provide a plurality of cylinders arranged in opposed pairs. By providing a number of such opposed pairs of cylinders grouped around a main drive shaft, the maximum amount of power can be provided in a very compact unit of a simplified construction requiring a small amount of material and light weight while providing improved fuel economy.



Operation is as follows: Referring especially to Fig. 1, the pistons (shown dotted) are represented in mid-position with the piston push rods and the cross-head in corresponding positions, and the arrows on the gears, timing drum and fly wheel represent the respective directions of rotation. The two pistons on left-hand side moving out to the right, are being driven out of the associated cylinders on the power stroke, as represented by the dotted arrows, responsive to pressure applied on the pistons by a previous explosion. The associated piston push rods are also being driven out of the left hand cylinders on the power stroke, and the helical threads thereon are rotating the associated driving gears in the indicated directions. The associated clutches having been previously closed, are applying a power impulse through the adjacent driven gear on the main shaft, which is thereby driven in the indicated direction of rotation.

At the same time the two driving piston push rods from the left hand cylinders are pushing the cross-head which slides smoothly toward the right hand side on the cross-head guides. The cross-head serves as part of an interconnecting structure pushing the right hand piston push rods to the right hand side of the engine, and the connected pistons are thereby pushed into the associated cylinders, compressing an explosive charge of air and fuel therein. The energy for such operation may be regarded as being transmitted directly through the push rods from the left hand pistons until such time as the pressures on the left pistons, decreasing due to expansion and subsequent opening of the exhaust port, are less than the pressures increasing on the right hand pistons, due to compression. Thereafter energy for moving these reciprocating parts to the extreme right hand position, is derived from the rotating main shaft through the cam surfaces of the timing drum engaging the cross-head pin and also from the kinetic energy of moving parts. The timing drum serves to maintain a proper timed relation between the movements of the reciprocating and the rotating parts. As the right hand pistons reach the peak of compression, the ignition head, driven directly from the rotating main shaft, supplies a properly timed spark at the same instant to both of the spark plugs of the right-hand cylinders. Depending upon the rate of flame propagation of the fuel used, and other factors involved, the timing of the spark is carefully adjusted for optimum operation in a manner usual with such ignition heads on automotive engines.

As the reciprocating pistons, rods, and cross-head approach the end of the stroke, the kinetic energy of these reciprocating parts is partially expended upon compressing the combustible mixtures charged into the right hand cylinders. Also the shape of the portion of the caming groove then engaged by the pin, as more specifically shown in development in Fig. 3, is such as to stop the right-hand movement of the cross-head and connected rods and to reverse this movement. To further aid in cushioning and reversing the

movement of these reciprocating parts, the compressed recoil springs are engaged on the advancing side just before the end of the stroke. The strength and tension of the recoil springs is selected and adjusted suitably for supplying any additional force necessary for cushioning and reversing the movement of the reciprocating parts at the end of the stroke in order to provide smooth operation with a minimum of wear and vibration.

At the time when the spark is applied, or slightly thereafter, the clutch control cam on the main shaft pulls to the right hand side the clutch bar and rods which in turn open the clutches in the two left hand driving gears and simultaneously close the two clutches in the two right hand driving gears so that these are now connected to be rotated with the associated driving adapters which are driven and rotated by the piston push rods moving to the left on the power stroke and passing therethrough driven by the explosion pressures on the two right hand pistons. The high pressure peak of the pressures applied on the pistons at the time of the explosion in the combustion chamber is thereby promptly effective in applying a power impulse on the main shaft with the maximum mechanical advantage of application. This mechanical advantage of application of power from the piston to the main shaft remains constant throughout the power stroke.

As the right hand pistons move driving their push rods to the left on the power stroke, the cross-head moves to the left and in turn pushes the left hand push rods and pistons to the left admitting and compressing charges in the two left hand cylinders. In properly timed relation these charges are fired in the two left hand cylinders, as previously described with reference to the two right hand cylinders, and the reciprocating structure moves to the right, the two right hand clutches are opened and the two left hand clutches are closed, and power impulses are again applied to rotate the main shaft. This sequence of operations is repeated and continues so long as the engine is operated.

It is apparent that within the scope of the invention, modifications and different arrangements may be made other than herein disclosed, and the present disclosure is illustrative merely, the invention comprehending variations thereof. My improved mechanism for converting reciprocatory motion to rotary motion may also be advantageously utilized in steam, vacuum or compressed air engines.

I claim:

1. In combination in an internal combustion engine, a main shaft, means rotatively journalling said main shaft, a plurality of cylinders, means mounting said cylinders with the axes thereof spaced from and substantially parallel to the axis of said main shaft, a piston in each cylinder a piston push rod secured to each piston, each piston push rod extending from the associated cylinder in a spaced substantially parallel relation to the main shaft, conventional means associated with the cylinders for controlling inlet and exhaust in accordance with the movements of the pistons for performing the usual cycles of an internal combustion engine, power transmission means independently operative between each piston push rod and the main shaft for applying power impulses to rotate the shaft with a predetermined direction of rotation as each piston push rod moves out of its respective cylinder on power strokes, additional power transmission means for transmitting power from the main shaft to the piston push rods for returning the pistons into their respective cylinders successively in a predetermined timed relation, and resilient recoil means arranged for cushioning and aiding in the reversal of the movements of the reciprocating pistons and push rods at the ends of stroke movements.

2. In an internal combustion engine, the combination according to claim 1 and further characterized by said first mentioned power transmission means comprising, each piston push rod having external threads thereon, a driving adapter threaded on each push rod, a driving gear disposed concentrically relative to each driving adapter, stationary bearing means rotatively journalling each driving gear, a clutch for engaging or disengaging each driving adapter to or from operative driving relation with its gear, driven gear means secured on said main shaft and operatively meshing with said driving gears, the threads of the piston push rods being arranged respectively right handed or left handed so that as each piston moves out on its power stroke the driving gear on its respective push rod rotates suitably for driving the main shaft in a predetermined direction of rotation, and clutch actuating means operated from the main shaft for closing each clutch to connect its driving adapter with its driving gear at times while its associated piston and push rod are moving out on the power stroke.

3. A recoil opposed internal combustion engine comprising, a main shaft, means rotatively journalling said shaft, a pair of cylinders, means mounting said pair of cylinders in a spaced apart opposed relation with the heads apart, a piston slidably disposed in each cylinder, a cross-head, an interconnecting push piston rod extending from each piston and secured to said cross-head for joining said pistons in a rigid spaced relation such that when one piston is pushed into its cylinder adjacent the head the other piston is moved to its maximum expansion position and vice versa, power transmission means operative between each said interconnecting push rod and said main shaft for applying power impulses to rotate the shaft with a predetermined direction of rotation as the interconnecting road reciprocates, inlet means, exhaust means, said inlet and exhaust being associated with said cylinders and actuated in accordance with the movements of the pistons for operation as an internal combustion engine, cross-head guiding means for guiding the movements of the cross-head as it reciprocates with the pistons, timing means for controlling the movements of said cross-head to predetermined linear positions corresponding to simultaneous angular positions of rotation of said main shaft, and resilient recoil means for cushioning and reversing the movements of the interconnected cross-head, push rods and pistons at either end of the stroke.

4. In a recoil opposed internal combustion engine the combination in accordance with claim 3 wherein the power transmission means comprises external threads on each push rod, a driving adapter on each push rod, a driving gear disposed concentrically relative to each driving adapter, stationary bearing means rotatively journalling each driving gear, a clutch for engaging or disengaging each driving adapter to or from operative driving relation with its gear, driven gear means secured on said main shaft and

operatively meshing with said driving gears, the threads of the piston push rods being arranged respectively right handed or left handed so that as each piston moves out on its power stroke the driving gear on its respective push rod rotates suitably for driving the main shaft in a predetermined direction of rotation, and clutch actuating means operated from the main shaft for closing each clutch to connect its driving adapter with its driving gear at times while its associated piston and push rods are moving out of the cylinder on the power stroke and at suitable speeds for driving the shaft.

5. In combination in a recoil opposed internal combustion engine, a main shaft, means rotatively journalling said shaft, a pair of cylinders, means mounting said pair of cylinders in a spaced apart opposed relation with the heads apart, a piston slidably disposed in each cylinder, interconnecting push rods extending from each piston and joining said pistons in a rigid spaced relation such that when one piston is pushed into its cylinder adjacent the head the other piston is moved to its maximum expansion position and vice versa, power transmission means operative between said interconnecting push rods and said main shaft for applying power impulses to rotate the shaft with a predetermined direction of rotation as the interconnecting rods reciprocate, said power transmission means comprising external threads on each push rod, a driving adapter on each push rod, a driving gear disposed concentrically relative to each driving adapter, stationary bearing means rotatively journalling each driving gear, an over-running clutch for engaging or disengaging each driving adapter to or from operative driving relation with its gear, driven gear means secured on said main shaft and operatively meshing with said driving gears, the threads of the piston push rods being arranged respectively right handed and left handed so that as each piston moves out on its power stroke the driving gear on its respective push rod rotates suitably for driving the main shaft in a predetermined direction of rotation, clutch actuating means operated from the main shaft for closing each clutch to connect its driving adapter with its driving gear at times while its associated piston and pushrod are moving out of the cylinder on the power stroke at suitable speeds for driving the shaft, and resilient recoil means for cushioning and reversing the movements of the interconnected push rods and pistons at either end of stroke.

6. In combination in an opposed recoil internal combustion engine, a base member, a pair of cylinder plates secured to said base member and rising therefrom in a parallel spaced relation, a main shaft, bearing means on said base member between the cylinder plates for journalling the main shaft parallel to the base member and perpendicular to the cylinder plates, an even number of cylinders, means mounting said cylinders on the outer sides of said cylinder plates in an opposed paired relation with the heads outward, said cylinders being mounted upon the cylinder plates with the axes thereof spaced from and substantially parallel to the axes of the main shaft, a piston slidably disposed in each cylinder, movable interconnecting means extending through said cylinder plates secured to and joining said pistons in a unitary reciprocable structure, said pistons being joined in a spaced relation such that when one piston of each pair is pushed into its cylinder adjacent the head thereof the other piston of said pair is moved to its maximum expansion position, power transmission means operatively engageable between said interconnecting means and said main shaft for applying power impulses to rotate the shaft with a predetermined direction of rotation as the interconnecting means reciprocates, additional power transmission means for transmitting power back from the main shaft to the respective pistons for returning the pistons into their respective cylinders in a predetermined timed relation, and resilient recoil means arranged in cooperative relation to said interconnecting means as the latter reciprocates for cushioning and aiding in the reversal of the movement thereof at either end of the stroke.

7. In combination in an opposed internal combustion engine, a base plate, a pair of cylinder plates secured to said base plate and rising therefrom in a parallel spaced relation, a main shaft, bearing means on said base plate between the risers for journalling the main shaft parallel to the base plate and perpendicular to the risers, an even number of cylinders, means mounting said cylinders on the outer sides of said risers in an opposed paired relation with the heads outward, said cylinders being mounted upon the risers with the axes thereof spaced from and substantially parallel to the axes of the main shaft, a piston slidably disposed in each cylinder, an aperture opening through each riser adjacent the open end of each cylinder secured thereon, a piston push rod secured to each piston and extending axially from the open end of the cylinder, external threads on each push rod, a driving adapter on each push rod, a driving gear disposed concentrically relative to each driving adapter, stationary bearing means rotatively journalling each driving gear, a clutch for engaging or disengaging each driving adapter to or from operative driving relation with its gear, driven gear means secured on said main shaft and operatively meshing with said driving gears, the threads of the piston push rods being arranged respectively right handed or left handed so that as each piston moves out on its power stroke the driving gear on its respective push rod rotates suitably for driving the main shaft in a predetermined direction of rotation, clutch actuating means operated from the main shaft for closing each clutch to connect its driving adapter with its driving gear at times while its associated piston and push rods are moving out of the cylinder on the power stroke and at suitable speeds for driving the shaft, and additional power transmission means for applying power back from the main shaft to the respective pistons for returning the pistons into their respective cylinders in a predetermined timed relation.

8. In combination in an internal combustion engine, a main shaft, means rotatively journalling said main shaft, a plurality of cylinders, means mounting said cylinders with the axes thereof spaced from the axis of said main shaft, a piston in each cylinder, a piston push rod secured to and extending from each piston, conventional means associated with the cylinders for controlling inlet and exhaust in accordance with the movements of the pistons for performing the usual cycles of an internal combustion engine, independent power transmission means operative between each piston push rod and the main shaft for applying power impulses to rotate the shaft with a predetermined direction of rotation as the piston push rods move out of their respective

cylinders on power strokes, the power transmission means comprising, each piston push rod having external threads thereon, a driving adapter on each push rod, a driving gear disposed concentrically relative to each driving adapter, stationary bearing means rotatively journalling each driving gear, a clutch for connecting or disconnecting each driving adapter to or from operative driving relation with its gear, driven gear means secured on said main shaft and operatively meshing with said driving gears, the threads of the piston push rods being arranged respectively right handed or left handed so that as each piston moves out on its power stroke the driving gear on its respective push rod rotates suitably for driving the main shaft in a predetermined direction of rotation, and clutch actuating means operated from the main shaft for actuating each clutch to connect its driving nut with its driving gear at times while its piston and push rod are moving out on the power stroke.

9. In combination in an internal combustion engine, a main shaft, means rotatively journalling said main shaft, a plurality of cylinders, means mounting said cylinders with the axes thereof spaced from the axis of said main shaft, a piston in each cylinder, a piston push rod secured to and extending from each piston, conventional means associated with the cylinders for controlling inlet and exhaust in accordance with the movements of the pistons for performing the usual cycles of an internal combustion engine, independent power transmission means operative between each piston push rod and the main shaft for applying power impulses to rotate the shaft with a predetermined direction of rotation as the piston push rods move out of their respective cylinders on power strokes, the power transmission means comprising external threads on each piston push rod, a power adapter threadably engaged on each push rod, means for restraining said adapter from axial movement so that it rotates when the push rod moves axially therethrough, a driving gear disposed concentrically relative to each adapter, clutch means controllable radially for connecting or disconnecting between the adapter and the gear, clutch actuating means operated automatically from the main shaft for establishing a driving connection between the adapter and the gear when the push rod is driven out of the cylinder on a power stroke, and gear means secured on the main shaft in meshing relation with each driving gear.



10. An internal combustion engine comprising, a main shaft, means rotatively supporting said main shaft, a cylinder, means mounting said cylinder with the axis of the cylinder spaced from the main shaft, a piston slidable in the cylinder, a piston push rod secured to said piston and extending axially from the cylinder, inlet and exhaust means associated with said cylinder for conventional operation in accordance with the movements of the piston for operating as an internal combustion engine, the piston push rod having external threads thereon, a driving adapter threadably engaged on the push rod, a driving gear disposed concentrically relative to the driving adapter, stationary bearing means rotatively journalling the driving gear, a clutch for connecting or disconnecting the driving adapter to or from operative driving relations with its gear, driven gear means secured on said main shaft and operatively meshing with said driving gear, the threads of the piston push rod being arranged so that as the piston moves out on its power stroke the driving gear on its push rod rotates suitably for driving the main shaft in a predetermined direction of rotation, clutch actuating means operated from the main shaft for closing the clutch to connect its driving adapter with its driving gear at times while its piston and push rod are moving out on the power stroke, additional power transmission means for transmitting power back from the main shaft to the piston push rod for returning the piston into the cylinder, and resilient recoil means arranged for cushioning and aiding in the reversal of movement of the reciprocating piston and push rod at the end of a stroke while balancing vibrations and providing fly-wheel momentum.

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## REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 697,649 | McLean | Apr. 15, 1902 |
| 851,293 | Lehberger | Apr. 23, 1907 |
| 1,076,179 | Whitehead | Oct. 21, 1913 |
| 1,291,642 | Elwell | Jan. 14, 1919 |
| 1,347,055 | Peterson | July 20, 1920 |
| 1,802,902 | Brau | Apr. 28, 1931 |
| 1,993,797 | Peterson | Mar. 12, 1935 |
| 2,269,281 | Michell | Jan. 6, 1942 |