

Sept. 1, 1931.

B. AMES

1,821,685

RECIPROCATING APPARATUS

Filed April 3, 1929

3 Sheets-Sheet 1

Fig. 1

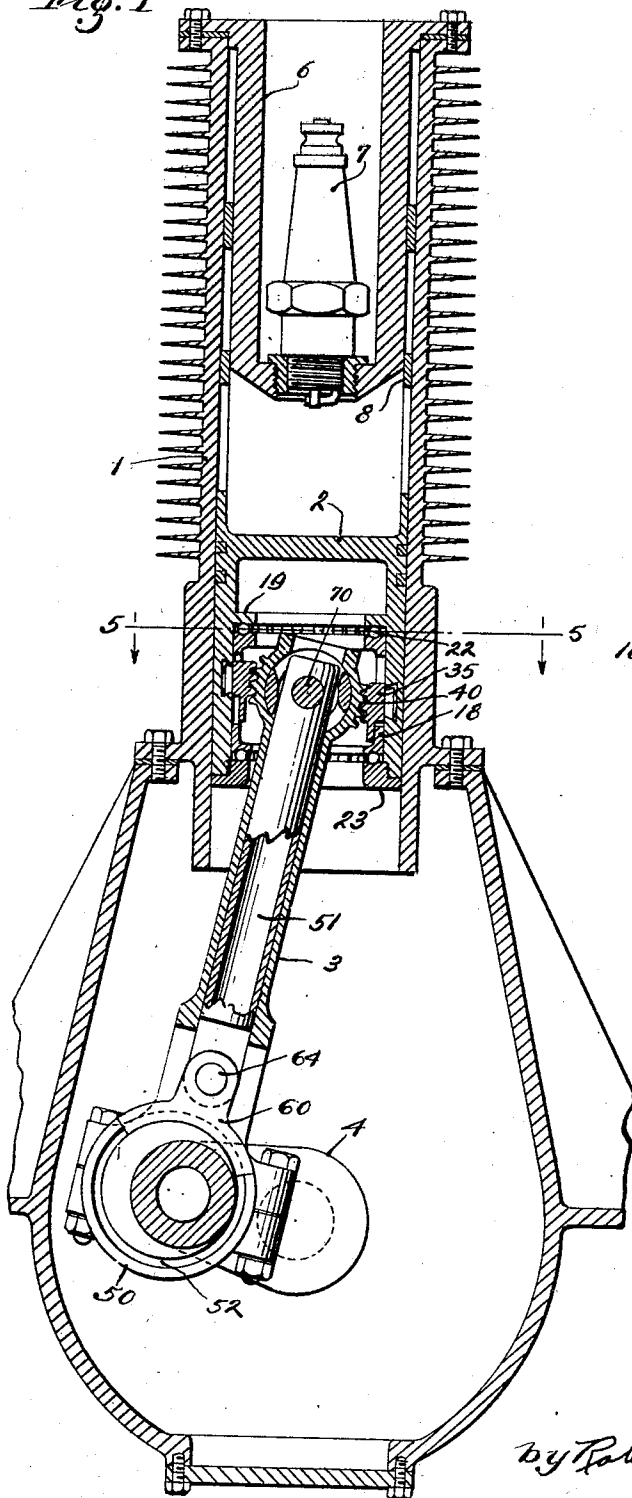


Fig. 2

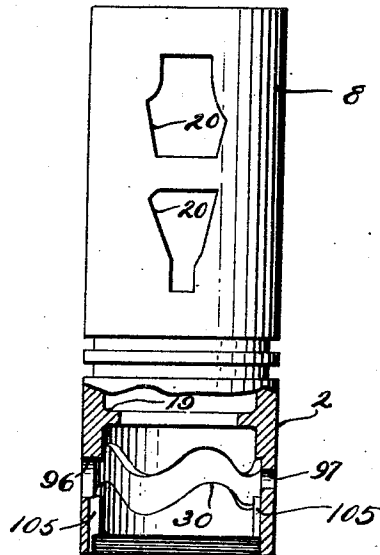
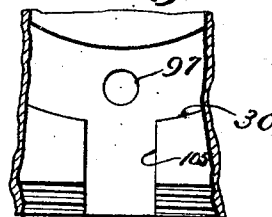
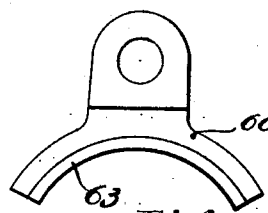


Fig. 3



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3 Sheets-Sheet 2

Fig. 4

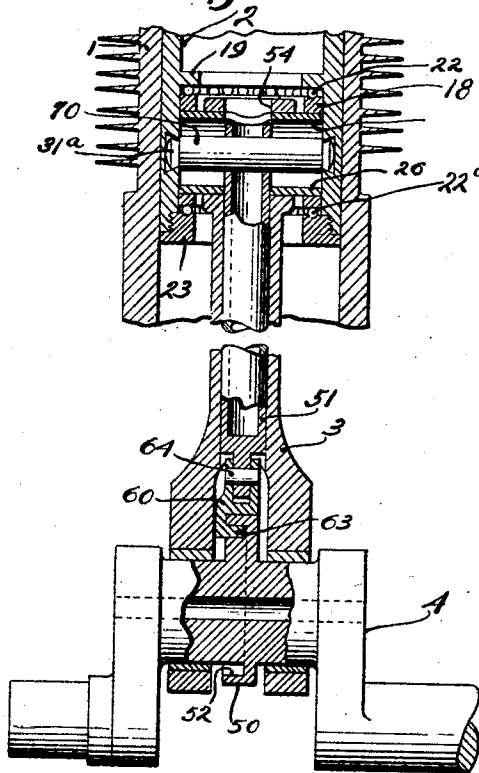


Fig. 5

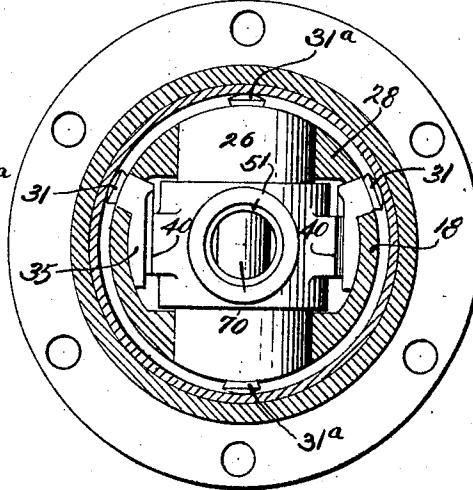


Fig. 6

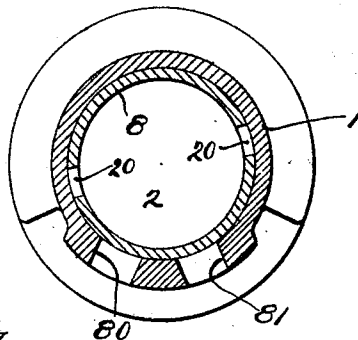
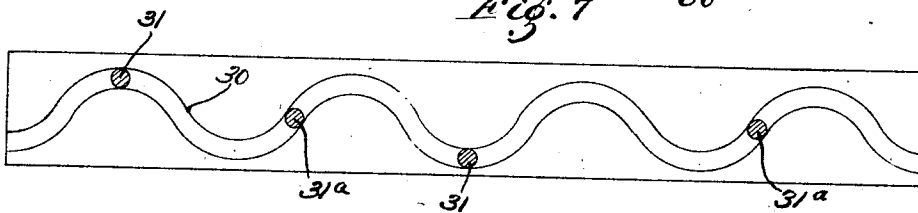


Fig. 7



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3 Sheets-Sheet 3

Fig. 8

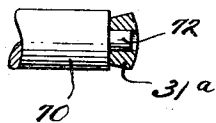


Fig. 10

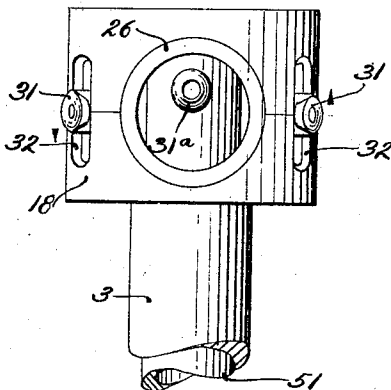


Fig. 9

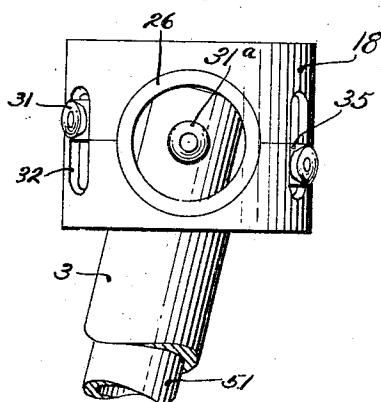


Fig. 12

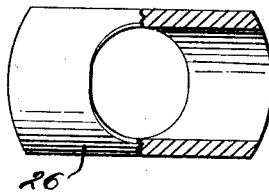


Fig. 11

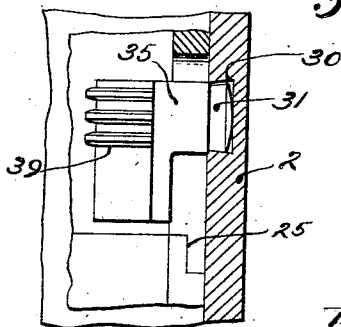


Fig. 13

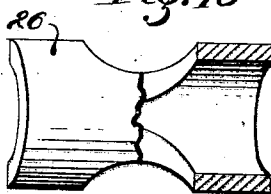


Fig. 14

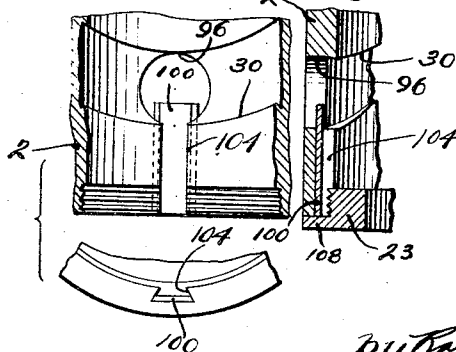
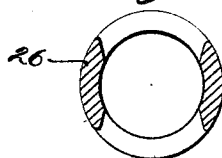


Fig. 15



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UNITED STATES PATENT OFFICE

BUTLER AMES, OF LOWELL, MASSACHUSETTS

RECIPROCATING APPARATUS

Application filed April 3, 1929. Serial No. 352,248.

This invention relates to reciprocating apparatus, such as steam or internal combustion engines, compressors, pumps or the like, of the general type that are characterized by a piston which rotates about its cylindrical axis while reciprocating along a path parallel or coincident with said axis, and which functions as a valve member to control the admission and emission of fluids through suitable ports in the cylinder wall and piston itself.

An engine of this general type is illustrated in Letters Patent of the United States, Nos. 1,363,547 and 1,363,548, while the same general type of apparatus is also shown in my copending application Serial No. 181,251, filed May 28, 1928.

By way of illustration of the invention herein described, I take, for example, a motor which, like that shown in my Patent No. 1,363,548, employs an extension portion of the piston as the fluid control valve member, and accordingly, I refer the reader to Patent No. 1,363,548 for an explanation of the structure and general functional relationship of the parts of the motors of this type. The chief object of that invention was to secure a rotation of the piston valve member at an angular velocity in constant ratio with the angular velocity of the engine shaft; in other words, to eliminate from the rotative movement of the piston valve any decelerations and accelerations within the cycle of one rotation thereof.

In accordance with the present invention, simplified mechanism is provided for affording a constant ratio of angular velocity between the crank shaft and the rotary piston; means being provided whereby the piston valve may be driven with the minimum of unnecessary friction, and whereby the driving means may be readily cooled and lubricated while being protected from the gases of combustion or the like.

More specifically this invention provides a single cam factor which is associated with a plurality of actuators, the latter being so arranged that they impart substantially constant torque to the rotary piston. To this end I prefer to arrange a sinusoidal groove with-

in the piston skirt which is engaged by actuators that are driven by the oscillating movement of the upper end of the main connecting rod, and also by actuators which are actuated by an auxiliary connecting rod which may be driven by a secondary throw or eccentrically disposed element of the crank shaft that causes relative movement between the upper end of this connecting rod and the piston. The various actuating factors are so arranged in relation to each other and to the cam groove that the points of maximum driving effect of one or more of the actuators occurs at the time of the minimum driving effect of one or more of the other actuators.

In the accompanying drawings:

Fig. 1 is a vertical section perpendicular to the axis of crank shaft rotation of a motor in which my invention is embodied;

Fig. 2 is an elevational view of the piston with a portion of the skirt thereof broken away, more clearly to show the construction thereof;

Fig. 3 is an elevational detail of the shoe or follower which is associated with the auxiliary connecting rod;

Fig. 4 is a section through the piston and connecting rod assembly substantially parallel to the axis of the crank shaft, the connecting rod being shown at the upper end of its stroke in this view;

Fig. 5 is a section on line 5—5 of Fig. 1, the piston skirt being broken away along the cam groove;

Fig. 6 is a sectional view of a cylinder showing the arrangement of the ports therein;

Fig. 7 is a diagrammatic view showing a development of the cam groove and the relative spacing of the actuators in engagement with the same;

Fig. 8 is a detail view, partly in section, of one of the actuators;

Figs. 9 and 10 are elevational details of a portion of the piston and connecting rod assembly in various positions which they occupy during one revolution of the crank shaft;

Fig. 11 is a sectional detail of the piston,

showing an actuator engaging the cam groove and related parts;

Figs. 12 and 13 are views partly in elevation and partly in section of the main wrist pin;

5 Fig. 14 includes detail elevational, bottom, and vertical sectional views of the means for retaining the actuators in the cam groove;

10 Fig. 15 is a transverse section of the wrist pin; and

Fig. 16 is an elevation detail of a portion of the piston.

As indicated by Fig. 1 a motor constructed in accordance with this invention may comprise a cylinder 1 having a reciprocating and rotating piston 2 connected by a rod 3 with a crank shaft 4. The cylinder may be provided with a re-entrant head 6 in which is located a suitable spark plug 7. An integral sleeve portion 8 of piston 2 is received between the re-entrant head and the adjoining portion of the cylinder wall. Piston 2 is adapted to be rotated in relation to the cylinder and the connecting rod, a suitable bearing member or shell 18 being interposed between the wrist pin 26 and the piston to permit this rotary movement.

In order to impart a substantially uniform angular velocity to the piston, I provide a cam groove 30 in the piston skirt which may be of sinusoidal form, cooperating actuators engaging this groove to rotate the piston by means of the same. In the preferred embodiment of this invention, as shown, there are four upper and four lower dwells in the cam groove so that each actuator may pass two upper and two lower dwell portions, corresponding to the upper and lower ends of two strokes of the piston during each complete cycle of a four cycle engine, or, in other words, the piston may rotate at one-fourth the speed of the crank shaft. It is evident, however, that the number of dwells and consequently the ratio of crank shaft and rotational speed may be varied; for example, there may be two upper and two lower dwells so that the piston will rotate once for each two revolutions of the crank shaft rather than once during each four revolutions of the same. The provision of a cam groove of the character shown is advantageous, however, since it results in a lower rotational speed of the piston, and since it permits the provision of oppositely disposed ports 20 in the sleeve portion of the piston, and a resultant pneumatic balance.

In the approved form of my invention, 60 the shell 18 may be arranged to engage annular sets of balls 22 and 22^a which comprise thrust bearings between the upper and lower portions of the shell and annular flanges carried by the piston. For example, numeral 19 designates the upper flange

which may be integral with the piston skirt, and which engages the annular series of balls 22, while the annular collar 23 may be screwed into the lower end of the piston skirt providing a race for the lower set of balls 22^a, or any other suitable retaining means may be utilized. Preferably, as shown more particularly in Figs. 9, 10 and 11, the shell 18 may be formed of upper and lower portions which have rabbeted annular edges in interfitting engagement with each other, as designated by numeral 25. The ball bearings may take radial thrusts and/or the outer surface of the shell may perform this function.

The main wrist pin 26 is tubular and has its ends fitting into internal bosses 28 upon the shell 2 (Fig. 5). Disposed at a suitable position in relation to the wrist pin are a pair of vertically extending slots 32 in the wall of the shell (Figs. 9 and 10). These slots are arranged to receive and form guide-ways for actuator elements which reciprocate in relation to the same. The actuators 31 which engage the cam groove may conveniently comprise frusto-conical rollers mounted upon pins that are carried by reciprocating blocks 35 which are guided by the sides of the slots 32; these blocks have inner toothed portions 39 which may comprise short racks engaging segmental toothed portions 40 formed upon the upper end of the connecting rod. Thus, angular movement of the upper end of the connecting rod about the wrist pin axis causes a movement of these toothed portions 40 along definite arcs, and the vertical reciprocation of the blocks 35 in the guide slots 32. Since the blocks 35 carry the actuators 31, the latter are moved along the cam groove 30 to impart rotary movement to the piston.

Since the actuators 31 as arranged will arrive at dwell portions of the cam groove at substantially the same time, it is necessary to provide additional actuators to insure the continuous impartation of uniform torque to the rotary piston; for this purpose, I provide a secondary throw element or eccentric element 50 upon the crank shaft which is adapted to actuate a secondary connecting rod 51. As shown for example, the lower end of the main connecting rod 3 may be split, and the crank throw which is engaged by the same may carry an eccentric portion 50 between the bearings of the rod that engage the crank throw. This eccentric has a groove 52 which is eccentric to the axis of the crank throw; preferably, the axis of this groove is spaced outwardly from the axis of the crank shaft rotation at a distance somewhat greater than is the axis of the main crank throw so that the auxiliary connecting rod 51 which is actuated thereby may have a stroke which is somewhat greater than the stroke of the main connecting rod.

In order to permit the rod 51 to be actuated by the element 50, I provide an arcuate shoe 60 having a flange 63 engageable in the groove 52 and having a pivotal connection 64 with the lower end of the auxiliary connecting rod. Preferably, the main rod 3 may be tubular and the auxiliary rod reciprocates therein. The wrist pin 26 is hollow and its intermediate portion has openings through which the oscillating upper end of auxiliary rod 51 may extend and move. The upper portion of the wrist pin bearing of the connecting rod is similarly provided with a recess or opening 54 to permit the relative movement of the upper end of the auxiliary connecting rod in relation thereto. The upper end of rod 51 carries an auxiliary wrist pin 70 having reduced end portions 72, one of which is shown more particularly in Fig. 8, upon which actuator rollers 31^a may be rotatably mounted. It is evident that the pin 70 may be at the upper and lower portions of its stroke in relation to the piston when the actuators 31 are in the intermediate portions of their strokes so that with the parts properly arranged, one pair of actuators will be imparting a maximum rotational effect to the piston, while the other pair of actuators is imparting substantially no rotational effect to the same.

Fig. 5 illustrates the preferred angular arrangement of the actuators 31 and 31^a in relation to the rotational axis of the piston; while Fig. 7 which may be considered in this connection illustrates the positioning of the various actuators in relation to the cam groove. Obviously, the actuators 31^a are spaced at 180° from each other since they are at opposite ends of the pin 70. Accordingly, as seen in Fig. 7, these elements may be at their mid-strokes, i. e., at the point of maximum inclination of the cam groove where they are imparting their maximum driving effect, when the actuators 31, which preferably are located at 67½° from the axis of the pin as shown in Fig. 5, are at the upper and lower dwells of the cam groove, it being evident that this arrangement permits the movement of the actuators 31 to their point of maximum effectiveness as the other actuators 31^a arrive to the upper and lower dwell of the cam groove. Thus, it will be understood that the sinusoidal groove 30 has a maximum ordinate dimension substantially corresponding to the path of reciprocation of both the actuators 31 and 31^a, and it is further evident that the maximum rotative impulse derived from one pair of these actuators may be obtained when that pair is in the mid-portion of its path between the dwells of the cam groove, or, in other words, in position of actuators 31^a as shown in Fig. 7, while the other actuators are at a top or bottom center, for example in the position occupied by actuators

31 in Fig. 7. Accordingly, the aggregate effect of the rotative impulses received by the piston from the actuators, results in a substantially uniform angular velocity of the piston, or in other words, one pair of actuators carries the piston over the dead point for the other pair of actuators.

Fig. 9 shows the position of the actuators 31 and the actuators 31^a when the piston is moving upwardly at substantially half stroke, one of the rollers 31 being substantially at the upper end of its reciprocating movement, and the other roller being substantially at the lower end of its path while the actuator 31^a is at mid-stroke, i. e., at the portion of the cam groove which has the maximum inclination.

Fig. 10 shows a position of the parts when the piston reaches upper dead center, the auxiliary connecting rod 51 and the rollers 31^a being at the top of their respective paths, and the actuators 31 moving in opposite directions but being at the points of maximum inclination of the groove.

It is thus evident that the rotative impulses of one set of actuators declines as that of the other increases the maximum of one coincident with the minimum of the other. The aggregate torque received, therefore, from the two sets of actuators is substantially uniform. On account of the momentum by the rotating piston very little restorative impulse is required to maintain its angular velocity of rotation while a dead point of either set of actuators is being passed. Consequently, there is very little friction, vibrations, or noise due to the rotation of the piston.

As shown in Fig. 6, the cylinder 1 may be provided with ports 80 and 81 in the same general manner as described in the above identified pistons, the ports being shaped somewhat differently in accordance with the now preferred mode of valve timing.

A pair of oppositely disposed vertical slots or grooves 104 and 105 may extend from diametrically opposed portions of the cam groove 30, i. e. from opposite lower dwells thereof, an opening 97 of a diameter slightly greater than that of pin extension 72 being located in the cam groove above the vertical groove 105. Preferably the latter has a width and depth substantially the same as that of the cam groove so that a roller 31 or 31^a may be slid upwardly through groove 105 to the cam groove. The opposite groove 104 preferably has a minimum width equal to that of pin extension 72 and is dovetailed to engage a retaining element 100, the depth of the groove 104 being somewhat greater than the depth of the cam groove. An opening 96 extends through the piston skirt at the juncture of the groove 104 and the cam groove, this

opening having a diameter equal to the width of the latter.

In the assembly of a motor of this character the lower half of shell 18 may first be dropped upon the connecting rod 3 and the tubular wrist pin then inserted in the upper end of the latter. The upper half of shell 18 may then be disposed in the piston. One of the blocks 35 with the roller 31 engaging the vertical groove 105 may be slid upwardly so that it engages the groove portion of the upper half of the shell with the roller disposed in the cam groove. The toothed portion of the connecting rod is then engaged with the toothed portion 39 of the block which has been so disposed, and the roller 31 upon that block is moved along the cam groove until the other block may be slid upwardly with its pin portion in groove 104 so that it may be meshed with the opposite toothed portion of the connecting rod which is swung away from this block. The roller for the second block may then be applied to the same through the opening 96. The lower half of sleeve 18 is thereafter brought into its permanent relation with the upper half thereof and the collar 23 may be secured in place to hold the parts assembled. While the secondary wrist pin 70 may be disposed within the main wrist pin 26 before the parts are thus assembled, preferably this pin is inserted through the opening 96 after the main wrist pin is disposed within the piston, the rotation of the pin 70 in relation to the cam groove permitting the application of a roller or rollers 31^a to the same after it is located within the piston. Opening 97 which is opposite opening 96 permits pin 70 to be removed when desired.

In order to prevent the movement of the actuator rollers out of the cam groove I provide the retaining strip 100 the edges of which engage the bottom of the dovetailed groove 104. This retaining strip is relatively thin so that its end is located outwardly of the outer face of the cam groove as shown at the right of Fig. 14. An annular flange 108 carried by the collar 103 may hold this retaining strip in place.

I claim:

1. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a main rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising an eccentric cylindrical element upon the crank, a secondary rod pivotally connected to said element, and a cam and actuator factor between the upper end of the rod and the rotary piston, said eccentric element being spaced outwardly from the axis of the crank shaft at a

greater distance than the crank, whereby the secondary rod has a longer stroke than the main connecting rod and there is relative movement between the upper end of the secondary rod and the piston.

2. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a hollow rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising an eccentric element upon the crank, a secondary rod operatively connected thereto and slidably mounted in the hollow connecting rod, and a cam and actuator factor between the upper end of the secondary rod and the rotary piston, and a second cam and actuator factor synchronized with the first factor.

3. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart movement to the piston, whereby the ports are brought into registration with the openings, said means comprising a pair of eccentric elements upon the crank shaft, connecting rods actuated by each of said elements, cam and actuator means associated with the upper ends of each of the connecting rods and the piston respectively, whereby relative movement between said rod upper ends and the piston imparts rotary movement to the latter.

4. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising eccentric elements upon the crank shaft, connecting rods actuated with each of said throws, cam and actuator means associated with the upper ends of each of the connecting rods and the piston respectively, whereby relative movement between said rod upper ends and the piston imparts rotary movement to the latter, said actuators being arranged so that the maximum driving effect of one substantially coincides with the minimum of the other.

5. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising a pair of eccentric ele-

ments upon the crank shaft, main and secondary rods actuated by said elements respectively, cam means carried by the piston and actuators associated with the upper ends of each of the connecting rods and engaging the cam means, whereby relative movement between said rod upper ends and the piston imparts rotary movement to the latter, a non-rotary shell within the piston to which the main connecting rod upper end is articulated and about which the piston rotates, a block sliding upon the shell, an actuator carried thereby and means upon the main rod upper end to slide said block and thus to cause the actuator to impart movement to the cam means.

6. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising a pair of eccentric elements upon the crank shaft, connecting rods actuated by each of said elements, actuators associated with the upper ends of each of the connecting rods respectively, whereby relative movement between said rod upper ends and the piston may cause movement of the actuators, a common sinusoidally curved element upon the piston engaged by said actuators to receive rotary movement.

7. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising a sinusoidally curved cam groove upon the piston skirt, and a pair of actuators driven from the crank shaft, said actuators being so spaced in engagement with the cam groove and so driven in synchronism as to impart substantially uniform torque to the piston.

8. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a hollow rod connecting the crank and piston, the lower end of the rod being split and having spaced bearing portions engaging the crank, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising an eccentric element upon the crank between the bearings of the hollow rod, a secondary rod operatively connected to the eccentric and slidably mounted in the hollow connecting rod, and a cam and actuator factor

between the upper end of the secondary rod and the rotary piston, and a second cam and actuator factor synchronized with the first factor.

9. Apparatus of the type designated comprising a cylinder, a piston therein, a crank, a tubular connecting rod between the crank and piston, a secondary rod slidably mounted in the tubular rod, an eccentric element upon the crank for oscillating the second rod, the piston skirt having a sinusoidal cam portion, a hollow wrist pin engaged by the upper end of the tubular rod, a bearing shell engaging the ends of the wrist pin, the piston being rotatable about this shell, a secondary wrist pin secured to the secondary rod and disposed within the hollow wrist pin, and an actuator carried by said secondary pin and engaging the cam groove to rotate the piston.

10. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a main rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising an eccentric element upon the crank, a secondary rod operatively connected thereto and a cam and actuator factor between the upper end of the secondary rod and rotary piston, said element having a different eccentric relation to the axis of the crank shaft than the crank, a bearing shell to which the upper end of the main rod is articulated and about which the piston rotates, an element movably mounted in the shell and connected to the upper end of the secondary rod, the relative movement between the upper ends of the rods being effective in moving the element relative to the shell, the element carrying an actuator, and a cam surface upon the piston engaged by the actuator.

11. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising a sinusoidally curved cam groove upon the piston skirt, and actuators separately driven from the crank shaft said actuators being spaced and driven in synchronism continuously to impart a substantial torque to the piston.

12. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary move-

ment to the piston, whereby the ports are brought into registration with the openings, said means comprising a sinusoidally curved cam groove upon the piston skirt, and separate pairs of actuators, said pairs of actuators being separately driven from the cam crank shaft, and being arranged continuously to impart torque to the piston.

13. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising a single sinusoidally curved cam element carried by the piston skirt, separately driven actuators engaging the cam element, and actuators being spaced and driven in synchronism continuously to impart torque to the piston.

14. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising a pair of eccentric elements upon the crank shaft, main and secondary rods actuated by each of said elements respectively, cam means carried by the piston, actuators associated with the upper ends of each of the connecting rods and engaging the cam means, whereby relative movement between said rod upper ends and the piston imparts rotary movement to the latter, a non-rotary shell within the piston to which the main connecting rod upper end is articulated and about which the piston rotates, elements slidably mounted in the shell and carrying a plurality of teeth, teeth meshed therewith and mounted in segmental arrangement for movement about the axis of movement of the upper end of the main rod, and actuator parts associated with said slidable elements and engageable with the cam means.

15. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a hollow rod connecting the crank and piston, the lower end of the rod being split and having spaced bearing portions engaging the crank, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising an eccentric element upon the crank between the bearings of the hollow rod, a follower engaging the eccentric, a secondary rod pivotally connected to the eccentric follower and slidably mounted in the hollow connect-

ing rod, and a cam and actuator factor between the upper end of the secondary rod and the rotary piston, and a second cam and actuator factor synchronized with the first factor.

16. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising a sinusoidally curved cam groove upon the piston skirt, and separate pairs of actuators, said pairs of actuators being separately driven from the crank shaft and being arranged continuously to impart torque to the piston, said actuators including rollers engaging the surfaces of the cam groove and pins supporting said rollers, an opening in the piston permitting application of the rollers to the pins as the latter are moved along the cam groove and means to prevent accidental movement of the rollers out of this opening.

17. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising a sinusoidally curved cam groove upon the piston skirt, and separate pairs of actuators, said pairs of actuators being separately driven from the crank shaft and being arranged continuously to impart torque to the piston, said actuators including rollers engaging the surfaces of the cam groove and pins supporting said rollers, an opening in the piston permitting application of the rollers to the pins as the latter are moved along the cam groove and means to prevent accidental movement of the rollers out of this opening, said means comprising a dovetailed key, and a keyway for the same upon the outside of the skirt leading to the opening and means to retain the key with a portion thereof projecting into the opening.

18. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising cam means carried by the piston and actuators associated with the upper end of the connecting rod and engaging the cam means, whereby relative movement between said rod upper end

and the piston imparts rotary movement to the latter, a non-rotary shell within the piston to which the connecting rod upper end is articulated and about which the piston rotates, elements slidably mounted in the shell and carrying a plurality of teeth, and teeth meshed therewith and mounted in segmental arrangement for movement about the axis of movement of the upper end of the main rod, the actuators being carried by said slidable elements and engageable with the cam means.

19. Apparatus of the type designated, comprising a cylinder, a piston therein, a crank, a rod connecting the crank and piston, an extension of the piston providing ports, inlet and outlet openings in the cylinder wall, and means to impart rotary movement to the piston, whereby the ports are brought into registration with the openings, said means comprising cam means carried by the piston and actuators associated with the upper end of the connecting rod and engaging the cam means, whereby relative movement between said rod upper end and the piston imparts rotary movement to the latter, a non-rotary shell within the piston, a wrist pin with its ends mounted in the shell and its mid-portion engaged by the rod, whereby the rod is articulated to the shell, the piston being rotatable about the latter, elements slidably mounted in the shell and carrying a plurality of teeth, teeth meshed therewith and mounted in segmental arrangement for movement about the axis of movement of the upper end of the main rod, and actuator parts associated with said slidable elements and engageable with the cam means, said shell being split with portions of the slots in each of its sections, and means upon the piston for holding the sections in engagement.

Signed by me at Lowell, Massachusetts,
this twentieth day of March, 1929.

BUTLER AMES.