Feb. 27, 1934. T. O. LILES 1,948,526

PARALLEL STEAM ENGINE

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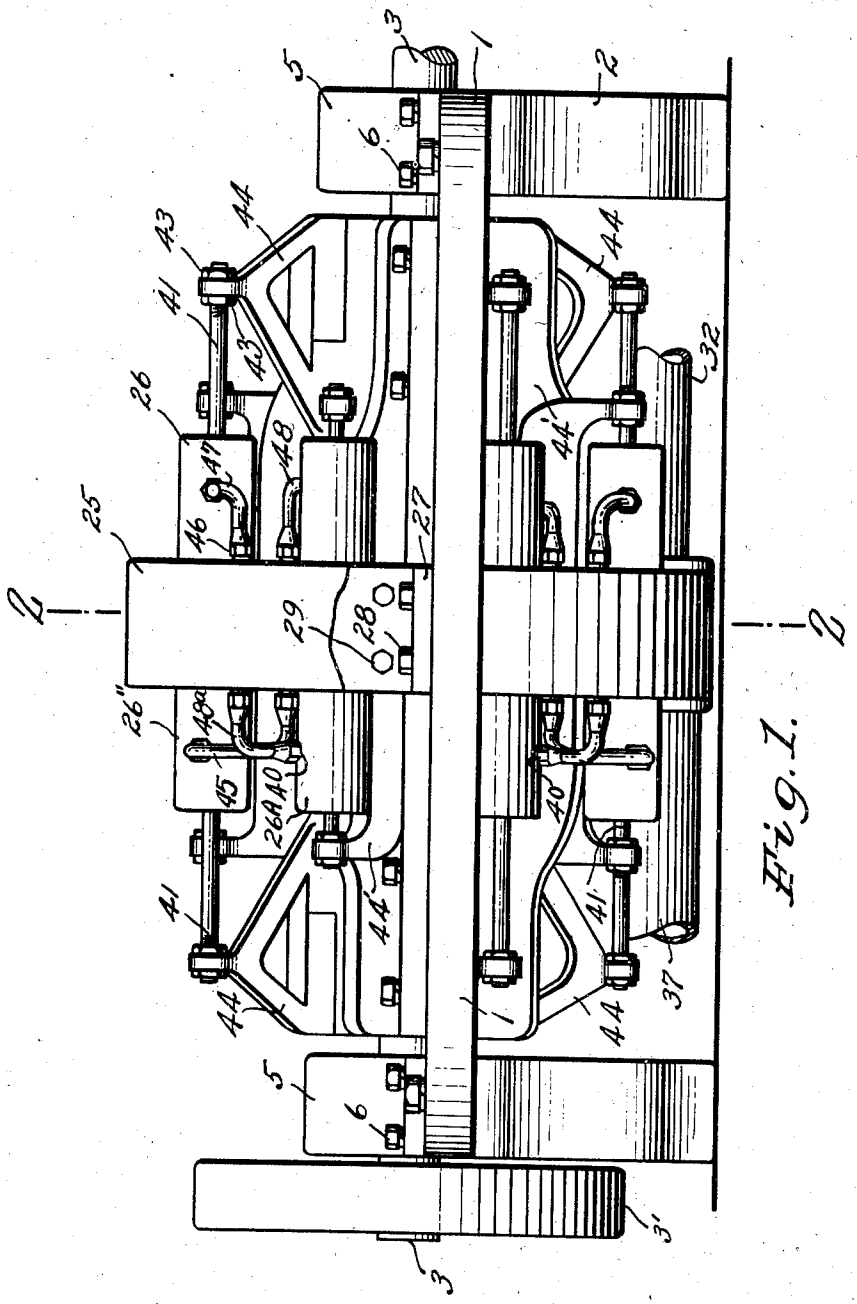


Fig. 1.

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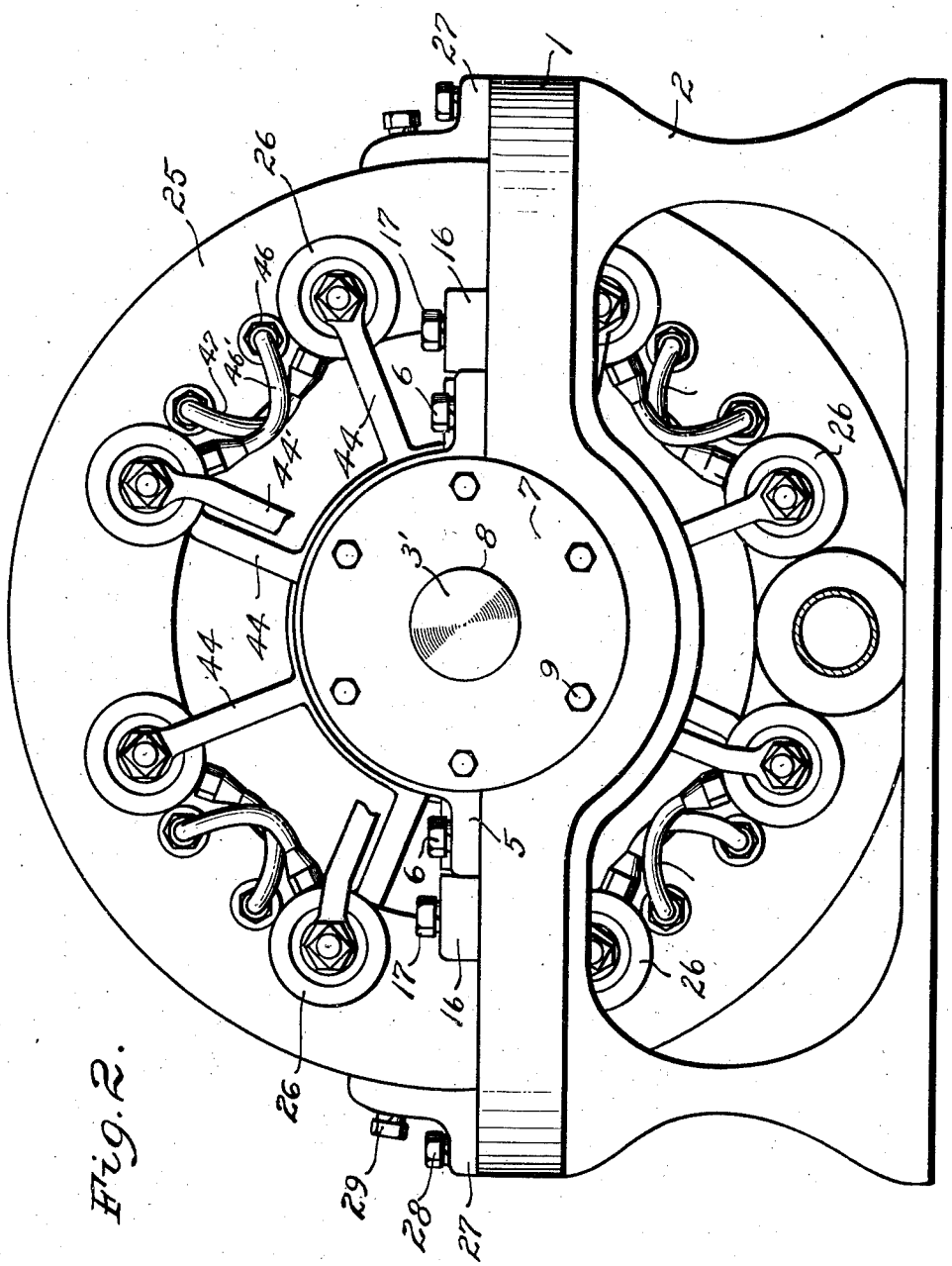


Fig. 2.

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PARALLEL STEAM ENGINE

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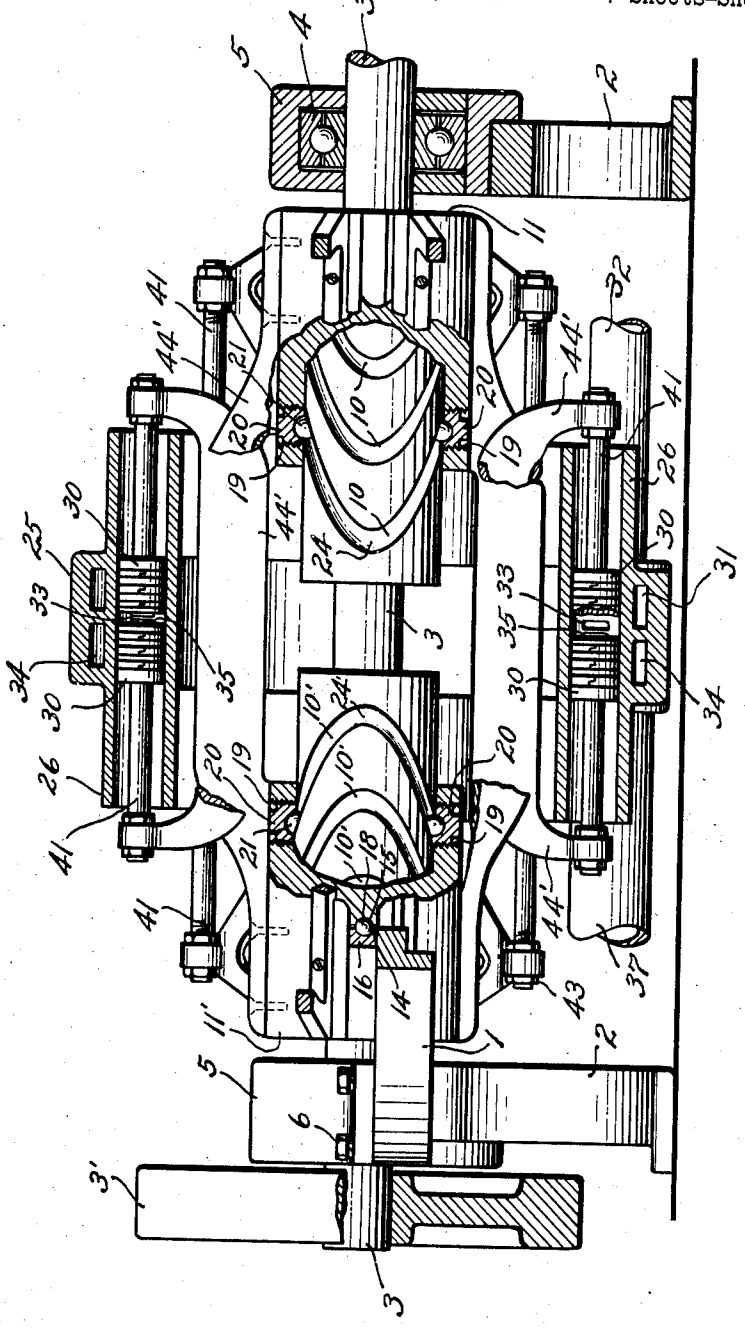


Fig. 3.

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PARALLEL STEAM ENGINE

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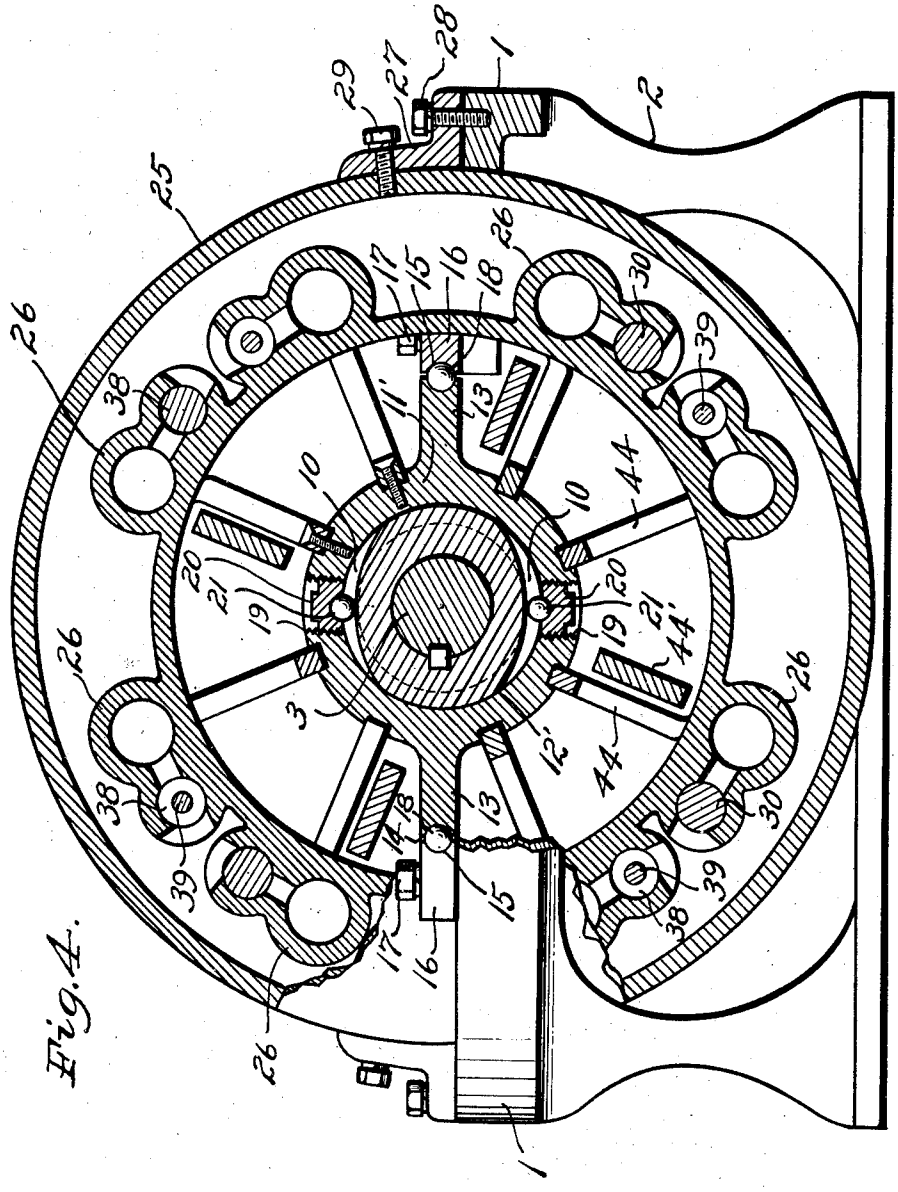


Fig. 4.

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PARALLEL STEAM ENGINE

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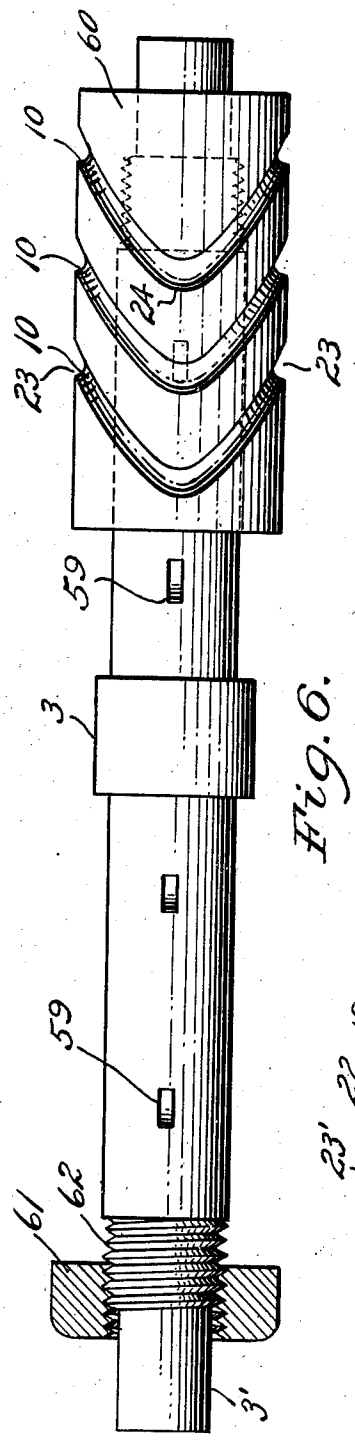


Fig. 6.

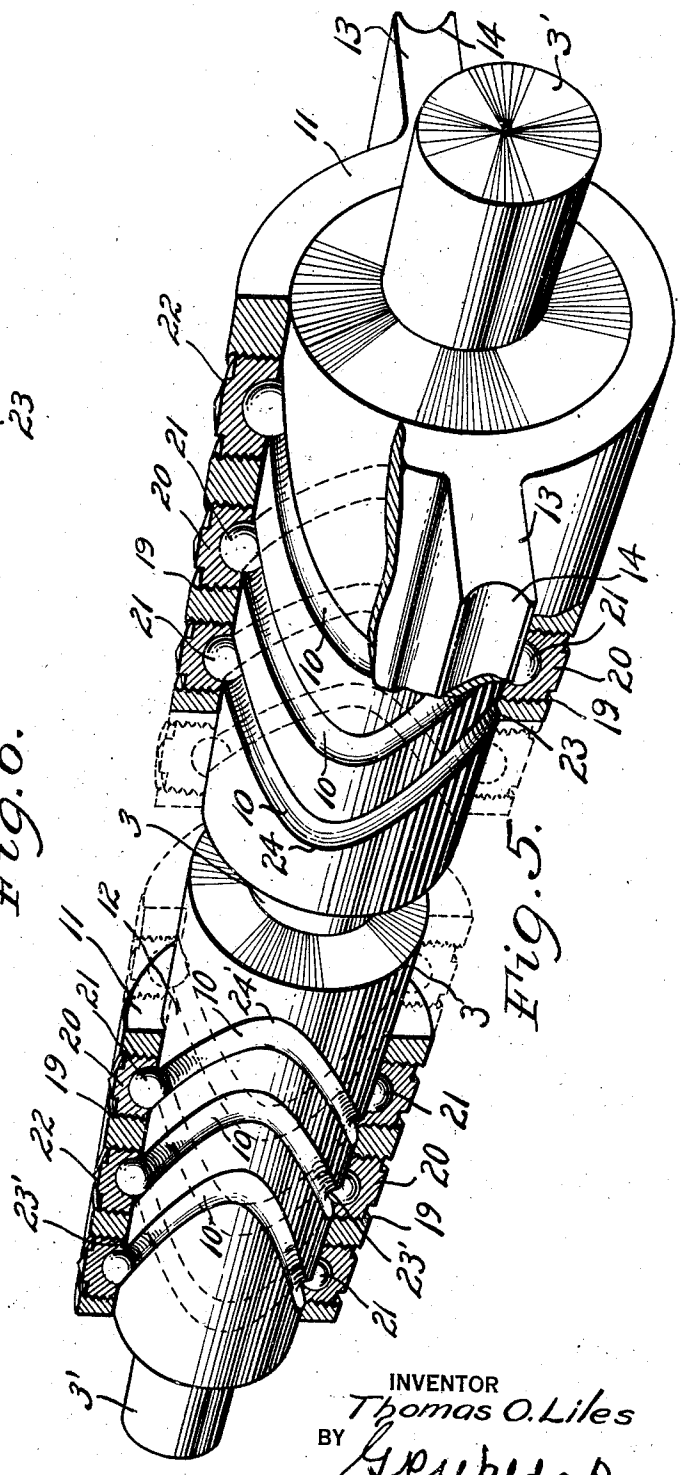


Fig. 5.

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PARALLEL STEAM ENGINE

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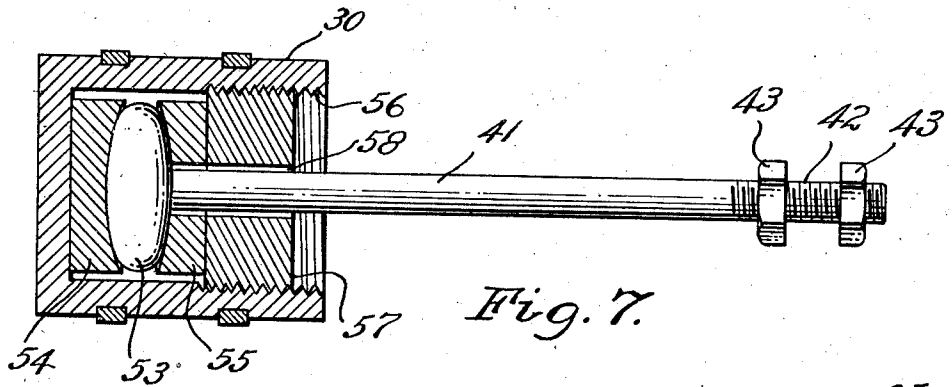


Fig. 7.

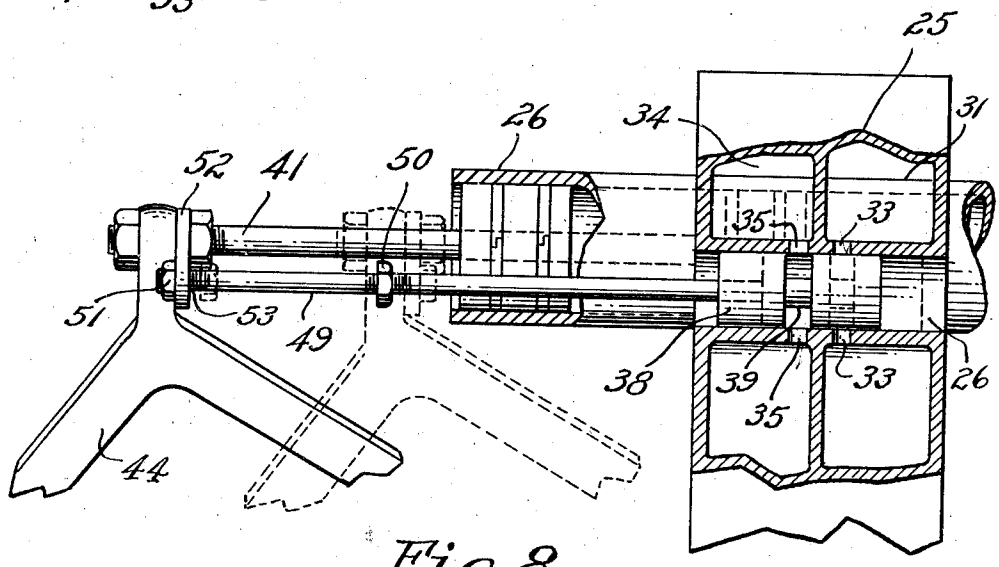


Fig. 8.

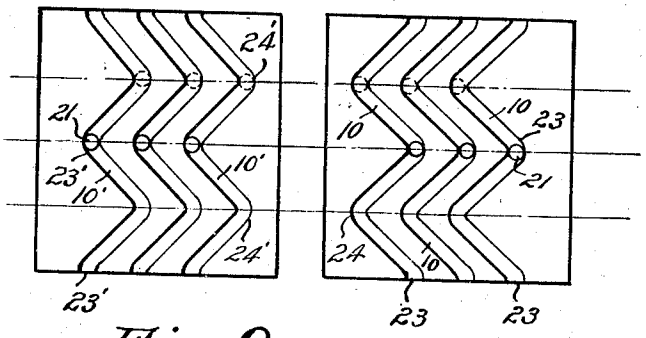


Fig. 9.

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PARALLEL STEAM ENGINE

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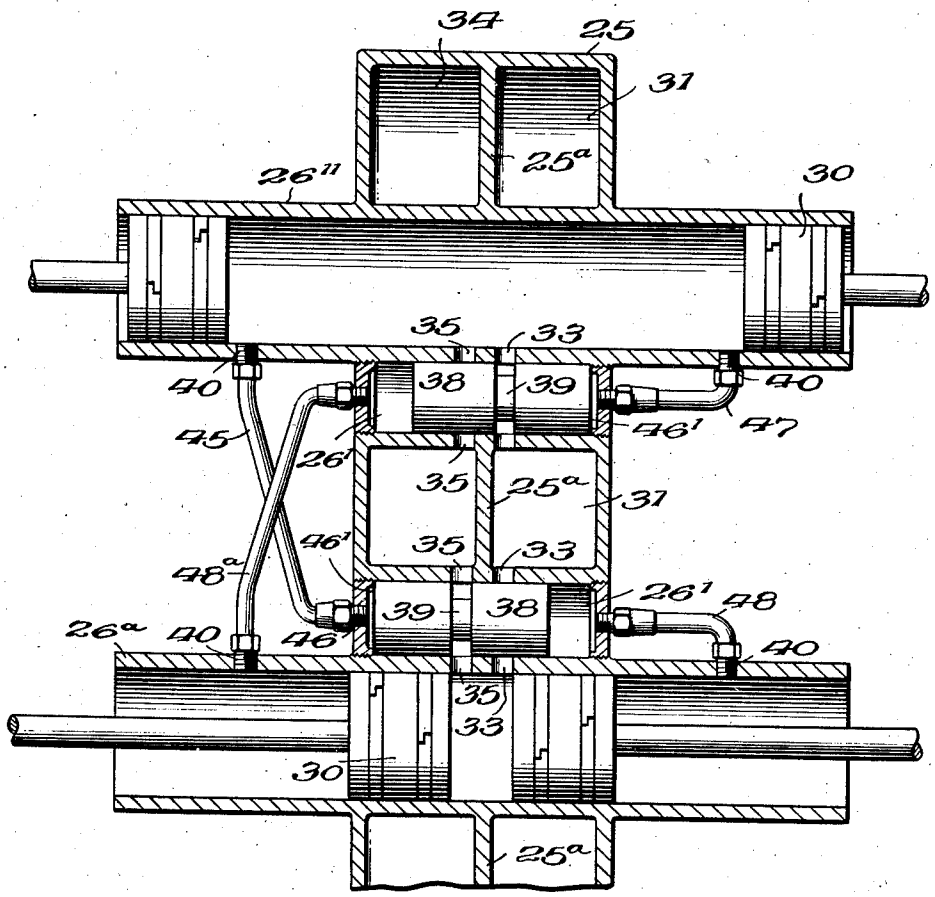


Fig. 10.

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Patented Feb. 27, 1934 1,948,526

UNITED STATES PATENT OFFICE

1,948,526

PARALLEL STEAM ENGINE

Thomas O. Liles, Dallas, Tex., assignor to Lilesmotor Corporation, a corporation of Texas

Application October 17, 1932. Serial No. 638,132

14 Claims. (Cl. 121—119)

This invention relates to engines of the reciprocating piston type having a plurality of cylinders parallel with each other and with the power shaft, which latter is disposed centrally of the group of pistons.

An object of the invention is to provide an harmonious balancing of parts; more particularly to provide a balanced relation between the parts and to have their several and various movements counterbalance each other.

It is a further object to provide an engine in which the power impulses are so synchronized and related that the stress, friction, and tendency to create vibration of one impulse is counteracted by another impulse of equal force and at the same instant, to the end that vibration and friction are reduced to a minimum and in a great measure eliminated.

Another object is to provide an engine in which the conventional crankshaft and crank action is eliminated.

A further object is to provide an engine of few parts, minimum number of bearings and ready accessibility for making repairs and adjustments.

Other novel features of my invention will appear from the description herein and the drawings herewith.

In all crankshaft and crank type engines, great power loss is occasioned due to the fact that the maximum energy from the power impulse is delivered to the piston either at or near dead center—that is, the instant when the center of the piston, the connecting rod, and the throw or crank of the shaft, and the center of the shaft are in a single plane. This condition is more particularly true of internal combustion type engines than with steam, although it is common practice to close the intake valve of steam engines before the maximum leverage point is reached—that is, before the crank has turned to a position at right angles to the plane in which the piston, rod, crank and shaft were in at dead center.

In other type of engine, a cylinder head receives a power thrust equal to that applied to the piston and transmits the same through the cylinder and main bearings and crankshaft to offset the working thrust of the piston. My invention enables me to capture this thrust, which I do through a second piston and convert it into useful work, rather than setting up needless friction and vibration. This generally is in accordance with the theory that such practice gives the exploded fuel time to fully expand and develop its maximum pressure by the time dead center is reached.

In steam engines, the intake valve is opened about the dead center point.

I have found in practice over a long period of years that on the power stroke or cycle of a reciprocating crankshaft type engine the crank must travel several degrees of the circle about the axis of the crankshaft before sufficient leverage is gained, that the energy applied against the piston head produces sufficient useful work to overcome the friction of the engine and begin to deliver usable power—torque—to the shaft. Some engineers claim that in certain internal combustion types of engines sufficient leverage is not gained to overcome the friction of the engine and its necessary correlated parts, such as generator, fan and water pump, until the crank has traveled about sixty degrees and the piston made one third of the power cycle, at which point more than one third of the initial or maximum pressure has been dissipated. Maximum leverage is not reached until approximately half way of the power stroke at which time the force of the explosion of the fuel is about three fourths spent.

In steam engines, the intake valve may be kept open until the maximum leverage point or further is reached, at a great loss of economy of operation, but in no event in a crank type engine is there other than a single point at which maximum leverage is attained—leverage starting at zero and increasing to maximum and then decreasing to zero.

In crank type engines (other than those provided with crossheads) the force delivered to the head of the piston, due to the side thrust of the connecting rod as it travels about a circle with the crank, drives the piston against one wall of the cylinder. On the exhaust cycle the piston is driven against the opposite wall of the cylinder, and where suction or intake and compression cycles are used, this further side wear of piston against cylinder walls is accentuated. This side thrust wears cylinders and pistons out of round, causes much friction and resultant heat, requires much lubricating oil and energy and shortens very materially the useful life of the engine.

All these adverse conditions and results are overcome by my invention.

Furthermore, in eliminating the crankshaft, I have provided an engine which has only a point for dead center, and upon rotating the power shaft as little as one to one and one half de-

grees, I attain the maximum leverage and continue with a maximum of leverage throughout the working stroke.

My invention may be readily understood by those skilled in the art from the following description together with the accompanying drawings, which form a part of this specification in which:

Fig. I is a side elevational view of my engine;

Fig. II is an end elevational view;

Fig. III is a fragmentary elevational view with parts broken away to show interior construction and arrangement of parts;

Fig. IV is a sectional view along line 4—4 of Fig. I, with part of frame attached;

Fig. V is a detail view of power shaft and associated elements with parts broken away;

Fig. VI is a modified form of power shaft shown in Fig. V;

Fig. VII shows the piston and related parts;

Fig. VIII shows a mechanically operated valve and the relation of the latter to the cylinder, intake and exhaust ports and manifolds;

Fig. IX shows the grooved sections of the shaft in Fig. V developed on a flat surface;

Fig. X shows in detail, partially sectional, valves and method of operation, depicted in Figs. I and II.

In the several views, like numerals refer to similar parts.

Proceeding now with the description:

1 is a frame to which supporting legs 2 are secured by conventional means, as by studs; or the frame 1 and legs 2 may be formed integrally. Transversely of the frame 1, power shaft 3 is mounted and revolubly secured thereto by bearings 4 which are held to the frame by caps 5 and studs 6. To secure the bearings 4 against end play they may be provided with covers 7 provided with openings 8 through which the reduced end sections 3' of shaft 3 project. The covers may be secured to the frame by studs 9, shown in Fig. I, or may be formed integrally with caps 5—shown in Fig. III.

It is, of course, well understood that conventional ball bearings or roller bearings may be employed which, set in the frame, engage the shaft in such manner as to secure it against undesired end play or motion, but which permit it to rotate freely. The ordinary type of friction bearing might also be employed if desired. However, my preference is the ball or roller bearing which is more nearly frictionless. The shaft 3 is provided with a series of grooves 10 and 10', to be more particularly described hereinafter.

It will be observed that shaft 3, Figs. III and V, is provided with reduced end portions 3' to be received by bearings 4, and that a central portion of the shaft is of a lesser diameter than the respective sections of largest diameter in which latter the grooves are formed.

Crossheads 11 and 11' are formed with openings 12 and 12' therethrough to receive but not to engage shaft 3 directly, that shaft 3 may be free to rotate within the crossheads and the latter free to move longitudinally of shaft 3. Crossheads 11 and 11' are provided with webs 13, in the outer faces of which grooves or channels 14, are provided registering with grooves 15 in straps 16, shown particularly in Fig. IV. Said straps being secured to frame 1 by studs 17. The grooves 14 and 15 forming a ball race to receive balls 18. Grooves 15 may be formed in the frame 1 if desired. Or straps 16 may be provided with elongated openings for receiving studs 17, which latter threadedly connect into frame 1 to provide for adjustment of strap 16 and its groove 15 toward or away from the center of shaft 3. It being the purpose of balls 18 to provide means for securing crossheads 11 against rotary motion about the axis of shaft 3 and at the same time provide comparatively frictionless support and guidance of said crossheads in their movement longitudinally of shaft 3.

Crossheads 11 are provided with threaded openings 19 for receiving threaded sockets 20, which latter carry balls 21 for engaging with grooves 10 and 10' of shaft 3. It will be noted in Figs. III, IV and V that sockets 20 and their corresponding balls 21 are disposed upon diametrically opposite sides of shaft 3, and that furthermore, they are disposed on each side of shaft 3 in line with its axis. It will further be observed that sockets 20, being threadedly engaged with crossheads 11 in seats or openings 19 provide means whereby balls 21 may be adjustably seated into grooves 10 and 10' as desired. Means being provided such as shouldered heads 22 on sockets 20 for rotating the latter in the threaded seats 19 in crossheads 11. The grooves 10 and 10' in shaft 3 are formed to receive approximately one half of ball 21, and the socket 20 is formed on its side adjacent the shaft 3 and groove 10, to receive approximately the other half of ball 21. As heretofore explained, sufficient space or openings are provided between crossheads 11 and 11' and shaft 3 for purposes heretofore described and purposes later to appear.

It will be observed that there are two sets of grooves, one designated 10 and one designated 10', Figs. III, V and IX, the grooves of each group being formed in parallel relation to each other about shaft 3. The grooves are so formed that they have respective points 23—23 and 23'—23' further away from each other with respect to the length of power shaft 3 than points 24—24 and 24'—24'. The balls 21 are, through the medium of seats 20, carried by crossheads 11 as said crossheads are caused to move simultaneously toward each other and away from each other by the action of the pistons to be hereinafter described, and engage grooves 10 and 10'. When the balls are at points 23 and 23' of the grooves, the crossheads will be furthest away from each other along power shaft 3. The crossheads being secured against rotation by balls 18 in the race or guide 16 upon being actuated by the pistons toward each other will cause shaft 3 to rotate one quarter revolution as the crossheads move along shaft 3 to the dotted line position shown in Fig. V, and balls 21 will be in the position in the grooves at points 24 and 24'. Then, crossheads 11 will simultaneously be moved away from each other by another set of pistons a distance equal to the original movement toward each other, thus causing shaft 3 to rotate an additional quarter revolution and bringing balls 21 back to points 23 and 23' in grooves 10. The balls, however, will now be on sides of shaft 3 opposite their original positions, shaft 3 having rotated one half revolution or one hundred and eighty degrees.

While I have shown two sets of grooves, three in number, with balls 21 equidistantly spaced about the periphery of shaft 3 and engaging

with grooves 10 and 10' thereof, as the preferred arrangement for imparting one quarter revolution to the shaft at each stroke or cycle of the engine, but I may provide other arrangements of the balls 21 and corresponding grooves 10 and 10', as by cutting the grooves 10 and 10' to impart one sixth of a revolution per engine cycle I could use three groups of balls equidistantly spaced about the shaft, it being of course preferred that the balls at all times be arranged to engage the shaft at points equidistantly of the periphery of the power shaft so as to distribute the rotary effort equally about the shaft.

It will be understood that I can employ any number of grooves, one or more in each of the sets, without departing from the spirit of the invention. Likewise, I can vary the diameter of shaft 3 at its grooved sections, thus increasing the distance from the center of the shaft to its periphery, and thereby providing any leverage desired. Since the balls engage the grooved sections at the periphery of the shaft, I have only to consider the number of degrees of the circle taken up by the points 23 and 23' and 24 and 24' of the grooves as constituting the total part of the stroke or cycle of the engine, which is not at full or maximum leverage.

It will be further observed, that not only am I applying power to the shaft 3 at its periphery, thus taking advantage of the full leverage, but am also applying the power at an acute angle, thus gaining additional leverage. In the present disclosure, each stroke or cycle of the motor rotates the shaft one fourth revolution. In this manner, each piston delivers two power strokes to the power shaft 3 at each of its revolutions.

It will be further observed that balls 21 engage shaft 3 on opposite sides of the shaft, that is to say, at equally distant points about the periphery of shaft 3 so that the torque or rotative effort of the balls is applied equally at points about shaft 3 thus relieving friction, resistance and balancing the torque thrust as applied to shaft 3.

25, is a cylindrical or ring-shaped central portion of a cylinder block having eight cylinders, 26. The cylinders extend parallel with shaft 3 from both sides of the center, ring-like member 25. While I prefer to cast cylinders 26 and the central member 25 (which is hereafter referred to as the ring) in a single block, it will be understood that the ring member may be cast separately and that the cylinders may be cast separately as individual cylinders and assembled with the ring member, or the cylinders may be further cast into two sections each and then assembled in alinement with each other about the ring member 25.

The cylinder assembly is secured to frame 1 by bracket 27 which in turn has cap screws 28 passing through the bracket and into frame 1 and cap screws 29 passing through bracket 27 into the ring member 25. The center of the cylinders 26 being disposed equidistantly of the center of shaft 3. In each of the cylinders 26, a pair of pistons, 30, are disposed provided with conventional rings to effect liquid-tight seal between the pistons and the cylinders. The ring-like member 25 is divided into two sections each having an opening therein. The opening 31, Figs. III and VIII, serving as a steam chest into which steam is admitted through pipe 32. From this steam chest 31 ports 33 lead into cylinders 26. Likewise, the openings 34 having ports 35 leading from cylinders 26 thereinto, serves as an exhaust chamber from which steam is exhausted through pipe 37. The steam in leading from steam chest 31 to cylinder 26, passes through a cylindrical valve chamber 26'. Valves 38 shown in detail in Fig. VIII, are arranged parallel with each of the cylinders and are cylindrical in form, having a reduced central section 39, which reduced section is adapted to register with the ports 33 and 35 leading from the steam chest 31 through the valve chamber 26' and into the cylinders and then from the cylinders through ports 35 and again through the valve chamber 26' into the exhaust chamber 34. When the valve is in position that the reduced section 39 registers with the port 33, ports 35 will be closed and the steam admitted through ports 33 into cylinders 26 between the pistons of that cylinder, thus moving the pistons on the power stroke away from each other. When the pistons have reached the end of their working stroke or their outer position, the valve is moved to close ports 33 and to open ports 35 leading from the cylinder 26 through the valve chamber 26' and about the reduced section 39 of the valve, thus permitting the steam to exhaust from cylinder 26 into chamber 34 and out through pipe 37.

A preferred form of valve actuating mechanism is shown in Figs. I and II. Another form of valve actuating mechanism is shown in detail in Fig. VIII.

In the preferred form of valve actuating mechanism, I provide openings 40 in cylinders 26 which openings are spaced along the cylinder so that the pistons when they have been driven to the end or approximately the end of their working stroke will uncover openings 40, thus permitting steam to pass through said openings. Into each of the openings, I have fitted tubes or pipes and connected them with fluid-tight compartments in valve chambers 26' at the ends of the valve, one at each side of ring 25, the valve 38 being of such a length as to provide for its reciprocative movement in valve chamber 26' to effect opening and closing of the ports 33 and 35 as before mentioned. Further details of this action will be later described.

Referring to the several figures, it will be noted that pistons 30 are provided with piston rods 41, which rods have a threaded section 42 on their outer ends and are provided with a pair of nuts 43 by which means provision is made for adjusting the pistons toward or away from each other to regulate the space between the pistons in the cylinder.

While I have shown eight of the cylinders 26 in the present structure, and shall proceed with a detailed description of the operation of an eight cylinder, sixteen piston engine, it will be understood that the principle of my engine is worked out on the basis of a plurality of cylinders spaced about a power shaft, and that the power impulse is delivered between the pistons of equidistantly spaced cylinders; by which arrangement, supposing I have only four cylinders, two of the cylinders oppositely disposed of power shaft 3 will be, through their pistons delivering power impulses to the shaft 3, while the other pair of cylinders likewise oppositely disposed of power shaft 3 will be on the exhaust cycle. While if employing six cylinders, three equidistantly disposed cylinders would be on the

power cycle while the other three likewise equidistantly will be on the exhaust cycle.

In my eight cylinder engine described herein, I will have four of the cylinders on the working cycle arranged in respective pairs oppositely disposed of power shaft 3 while the other four cylinders similarly disposed will be on the exhaust cycle of operations. To each of the crossheads 11, one half of the total number of the pistons used in the engine are operatively engaged. What I will term short arms 44 are secured to crossheads 11 and rods 41 adjustably engaged therewith by nuts 43 carry the pistons at their opposite ends. These short arms 44 are secured to crossheads 11 by cap screws having threaded engagement with crossheads 11 and passing through arms 44, or arms 44 may be formed integrally with crossheads 11 as desired. These short arms extend at substantially right angles to the crossheads to which they are attached and engage with rods 41 providing the means whereby upon the introduction of steam into a pair or pairs of cylinders equidistantly or oppositely disposed of power shaft 3 and between the pistons of the respective pairs of cylinders the crossheads will be moved away from each other, thus causing the rotation of power shaft 3 a quarter of a revolution through the means heretofore detailed. Long arms 44' particularly shown in Fig. III, engage with the crossheads and pass within the opening of the circular cylinder block and engage with piston rods 41. The long arms of one crosshead engaging with the pistons in the ends of the cylinders opposite the crosshead to which they are attached, and the other long arms of the cooperative pairs engaging with the pistons in the ends of the cylinders likewise opposite from the other crosshead to which they are attached. By this means, the pistons in an opposed pair or in opposed pairs of cylinders operating through the short arms actuate the crossheads 11 to move them away from each other along power shaft 3 and cause it to rotate a portion of a revolution. This movement of the crossheads 11 away from each other simultaneously moves the pistons in oppositely disposed pair or pairs of cylinders through long arms 44' toward each other, thus exhausting the steam from those cylinders whose pistons move toward each other and bring them into position to receive the steam under pressure from steam chest 31 for a power stroke, whereupon, the pistons connected with the long arms begin moving away from each other and bringing the crossheads toward each other. While at the same time, the pistons which are connected to the short arms are being brought together on an exhaust stroke.

The pistons are arranged in two groups, one of the groups being directly operatively secured to each crosshead. Each group consists of one half the total number of the pistons, and viewed from the side of the engine the crossheads may be designated as one right hand and the other left, the ends of the cylinders also being considered as right and left hand ends. The group of pistons secured to the right hand crosshead will consist first of a piston in a right hand end of a cylinder and the next a piston in the left hand end of the adjacent cylinder, the next a piston in the right hand end of the next adjacent cylinder, and so on completely around the engine. The other group of pistons will be similarly arranged with respect to the left hand crosshead.

Now, referring particularly to Figs. I and III, and supposing, as illustrated in Fig. I, the crossheads are at their greatest distances away from each other, the pistons connected to the short arms 44 are at the end of their power stroke. Whereupon, openings 40 have been uncovered in cylinder 26'' and its oppositely spaced complementary cylinder of the pair, and of the other oppositely disposed pair of cylinders. It is sufficient to describe the action of the valves in a pair of cylinders which are disposed side by side, the pistons of one of which are connected to the short arms and the pistons of the other of which are connected to the long arms, in order to sufficiently disclose the valve action and its operating mechanism. Therefore, the action of cylinder 26'' and cylinder 26*a* being related to each other in that one has its pistons on the working stroke while the other is on the exhaust stroke will be detailed.

Referring to Fig. X, the pistons 30 in cylinder 26*a* are just completing the exhaust cycle whereas the power cycle of cylinder 26'' is just completing, whereupon openings 40 of cylinder 26'' are uncovered by pistons 30 of that cylinder and steam passes through pipe 45 which is connected at 46 with a fluid-tight compartment 46' in valve chamber 26' at the end of valve 38 for cylinder 26*a* and moves valve 38 for cylinder 26*a* to the intake position, closing exhaust ports 35 and causing the reduced portion 39 of the valve to register with intake openings 33. At the same moment steam passes through pipe 47 into fluid-tight compartment 46' at the end of valve 38 for cylinder 26'' and moves valve 38 to the exhaust position, closing ports 33 and causing the reduced portion 39 of valve 38 to register with exhaust ports 35 of cylinder 26''.

When the power cycle of cylinder 26*a* has been completed the exhaust cycle of cylinder 26'' will also have been completed and openings 40 of cylinder 26*a* will have been uncovered, whereupon steam will pass through pipe 48 into fluid-tight compartment 46' at the end of valve 38 for cylinder 26*a* thus moving valve 38, closing ports 33 of cylinder 26*a* and opening exhaust ports 35 for cylinder 26*a*, which is the position shown in the drawing Fig. X. Likewise, steam will pass through pipe 48*a* into fluid-tight compartment of valve chamber 26' for cylinder 26'', moving valve 38 to the intake position, closing ports 35 and opening ports 33, which position of the valve is shown in Fig. X. The intake or steam pressure compartment 31 is separated from exhaust compartment 35 by partition wall 25*a*.

It will be understood that by this method, pistons are being actuated on working strokes in two oppositely disposed pairs of cylinders in my eight cylinder engine at the same time, and that other oppositely disposed pairs of cylinders are at the same time on the exhaust cycle, and that as the working cycle in one group of two oppositely disposed pairs of cylinders ends it begins in the other.

In another form of valve operating mechanism, detailed in Fig. VIII, a rod 49, operatively connects with valve 38, having nuts 50 and 51 threadedly engaged therewith so they may be spaced apart as desired and arms 44 and 44' each carry a strap 52 having an opening 53 therethrough, through which valve rod 49 loosely passes. The nuts 50 and 51 being so adjusted that as the piston approaches the end of the power stroke, Fig. VIII, valve 38 will be

moved so that its reduced section 39 registers with ports 35 leading from cylinder 26 into exhaust chamber 34. Whereupon, the piston shown in Fig. VIII begins its travel on the exhaust stroke and arm 44 is carried to the dotted line position shown and valve rod 49 and nuts 50 and 51 are carried to the dotted line position shown in Fig. VIII by which movement the valve 38 is actuated to the intake position. That is, the reduced portion 39 of valve 38 registers with ports 33 leading from the steam chest into the cylinder 26, and the exhaust ports 35 from the cylinder 26 are closed. It will be observed that in the valve mechanism, detailed in Fig. VIII, that one of the arms connecting with the piston at one end of the cylinder 26 actuates the valve for that cylinder and has no operative connection with the valve for an adjacent cylinder. However, in the preferred form of valve operating mechanism, the pressure from a cylinder on its working stroke serves to move the valve for that cylinder from the intake to the exhaust position and to move the valve for an adjacent cylinder from the exhaust to the intake position.

In Fig. VII, I show a preferred form of construction whereby piston rod 41 is adjustably and movably connected with piston 30, wherein the end of the rod 41 opposite from the threaded end 42 is provided with a ball head 53, and seats 54 and 55 having concave surfaces, and receive and cooperate with ball 53 of rod 41. It will be noted that the piston 30 is hollowed out and the section nearest the open end of the piston is provided with threads 56 into which boss 57 is threadedly seated. There is provided an opening 58 through the boss larger than rod 41, and seats 54 and 55 are of less cross section than the opening in the piston. Thus, the end of the rod 41 inside the piston may move radially of the piston and the threaded end of the rod 42 may move in any radial direction of the piston 30 through the action of the ball 53 and seats 54 and 55, thereby providing a flexible connection between the piston 30 and rod 41, by which means, I provide for relief of binding and friction which might occur in case any of the parts were not exactly alined in their truly intended position or in case any of the parts got out of adjustment for any reason.

If it is desired to cushion the stopping of the crosshead and the parts carried thereby at the end of the respective strokes, I so time the valves that the exhaust ports are closed slightly before the pistons reach the ends of the exhaust strokes in respective opposed pairs of cylinders. Thus, with the exhaust closed, some of the steam is trapped between the pistons and forms a cushion as the pistons come together, thus easing the mechanical shock on the balls 21 and grooves 10 and 10' in the sudden stop of the crossheads and their reversing directions. This adjustment is readily accomplished by adjusting the nuts 50 and 51 on valve rod 49 in Fig. VIII, or in positioning the openings 40 on cylinders 26 as desired.

In Fig. VI, is shown a modified form of construction of shaft 3, in which the shaft is provided with a central section larger than the body sections, the latter being provided with key seats 59 into which keys, not shown, are fitted and a pair of grooved sections 60 provided with a keyway to receive the keys, are pressed over the shaft sections and against the centrally enlarged portion of the shaft which acts as a spacer whereby the grooved sections are positioned longitudinally of the shaft. Nuts 61 are screwed up on threaded sections 62 of the shaft and brought firmly against grooved sections 60, whereby the latter are secured in operative relation on the shaft. This arrangement permits of a ready renewal of the grooved sections should they become worn.

For purposes of ready accessibility for repair, replacement, and adjustment, I provide bearing caps 5 and bearings 4 of greater diameter than power shaft 3. Upon removal of cap 5 and bearing 4 from one end of frame 1 and shaft 3, and the flywheel 3' from the shaft, and ball seats 20 unscrewed to relieve balls 21 from grooves 10 and 10', shaft 3 may be moved along the line of its axis and removed from the engine entirely without disturbing crossheads 11 and 11', connecting arms 44 and 44', piston rods 41, pistons 30, or cylinders 26. For replacement, the shaft 3 may be inserted in its original position, and bearing 4 and cap 5 replaced, and ball seats 20 adjusted against balls 21 in grooves 10 and 10', and flywheel 3', if it is to be used, remounted upon shaft 3. The engine is now ready for renewed service.

If the form of construction shown in Fig. VI is employed, grooved sections 60 may be removed and replaced by new ones; and in either form balls 21 and sockets 20 may be adjusted or renewed without disturbing any other element of the engine.

Summarizing the novel points of my invention, the following are included:

A multiple cylinder engine of which the cylinders are parallel with each other and with the power shaft, in which the moving, working parts are so synchronized as to movement and balanced as to weight or specific gravity that the engine is automatically and exactly counterbalanced with itself.

An engine in which all power thrusts are applied equally in opposite directions at the same instant.

An engine in which energy is applied to the power shaft in opposed directions and at points equidistantly spaced about the shaft at the same instant.

An engine in which the power shaft may be caused to turn a selective part of a revolution at each working stroke of the engine.

An engine in which the power shaft is rotatively engaged at points about its periphery by adjustable means.

An engine in which power impulses are simultaneously delivered to pairs of pistons in each of a group of equidistantly disposed cylinders, parallel of and about the power shaft.

An engine in which while a part of the pistons are on a power stroke or cycle, an equal number of pistons are on an exhaust stroke or cycle, and in which one half of the pistons of each group move in opposite directions to the other half.

An engine in which four or a multiple of four cylinders each provided with a pair of pistons are coactively synchronized with each other and in which pistons are flexibly connected with piston rods in which the pistons may be adjusted to and away from each other with relation to a coacting pair in a single cylinder.

And, an engine in which the valves may be so timed that a cushion is formed between opposed pairs of pistons in oppositely disposed pairs of

cylinders, thereby arresting the shock or vibration of sudden stopping of the reciprocating parts at the end of respective strokes.

While I have described the operation of my invention as applied to a steam engine, the principles are equally adaptable to internal combustion engines of the ordinary spark ignition or Diesel type, and it is intended that the appended claims shall apply equally to either type of engine. The details of valves, ignition, oiling and cooling systems are being made the subject matter of another application.

What I claim is:

1. An engine having a multiple number of cylinders arranged about and parallel with a power shaft, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads, connections beteen one of the crossheads and one group of the pistons and connections between the other crosshead and the other group of pistons, the pistons being operatively connected with the crossheads to move the latter toward each other upon the application of a power impulse between pistons of the two groups in some of the cylinders and away from each other upon application of a power impulse between pistons of the two groups in other of the cylinders, and means carried by the crossheads engaging with and imparting rotary motion to the shaft upon movement of the crossheads along the shaft.

2. An engine having a multiple number of cylinders arranged about and parallel with a power shaft, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads, connections between one of the crossheads and one group of the pistons and connections between the other crosshead and the other group of pistons, the pistons being operatively connected with the crossheads to move the latter toward each other upon the application of a power impulse between pistons of the two groups in some of the cylinders and away from each other upon application of a power impulse between pistons of the two groups in other of the cylinders, and means carried by the crossheads engaging at equidistant points on its periphery and imparting rotary motion to the shaft upon movement of the crossheads along the shaft.

3. An engine having a multiple number of cylinders arranged about and parallel with a power shaft, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads, connections between one of the crossheads and one group of the pistons and connections between the other crosshead and the other group of pistons, the pistons being operatively connected with the crossheads to move the latter toward each other upon the application of a power impulse between pistons of the two groups in some of the cylinders and away from each other upon application of a power impulse between pistons of the two groups in other of the cylinders, and adjustable means carried by the crossheads engaging at equidistant points on its periphery and imparting rotary motion to the shaft upon movement of the crossheads along the shaft.

4. An engine having a multiple number of cylinders arranged about and parallel with a power shaft, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads, connections between one of the crossheads and one group of the pistons and connections between the other crosshead and the other group of pistons, the pistons being operatively connected with the crossheads to move the latter toward each other upon the application of a power impulse between pistons of the two groups in some of the cylinders and away from each other upon application of a power impulse between pistons of the two groups in other of the cylinders, and means carried by the crossheads engaging with and imparting rotary motion to the shaft upon movement of the crossheads along the shaft, some of the cylinders adapted to be on the power cycle while other of the cylinders are on the exhaust.

5. An engine having a multiple number of cylinders arranged about and parallel with a power shaft, a pair of pistons in each of the cylinders, the pistons arranged in two groups, a pair of crossheads each having a centrally disposed opening for receiving the power shaft, each crosshead being directly actuated reciprocally of the shaft by one of the groups of the pistons in opposite direction to the other crosshead and means carried by the crossheads engaging with and rotating the power shaft.

6. An engine having a multiple number of cylinders arranged about and parallel with a power shaft, a pair of pistons in each cylinder, the pistons being arranged in two groups, a pair of crossheads each having a centrally disposed opening for receiving the power shaft, each crosshead being directly actuated reciprocally of the power shaft by one of the groups of pistons, the crossheads being actuated simultaneously but in opposite directions and means coacting between the crossheads and the power shaft imparting rotary action to the latter upon movement of the crossheads along the shaft.

7. An engine having a multiple number of coacting groups of cylinders arranged equidistantly about and parallel with a power shaft, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads each having a centrally disposed opening for receiving the power shaft and actuated reciprocally of the latter but in opposite directions directly by one of the groups of the pistons and means coacting between the crossheads and the power shaft imparting rotary motion to the latter upon movement of the crossheads along the shaft.

8. An engine having a multiple number of coacting groups of cylinders arranged about and parallel with a power shaft, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads each having a centrally disposed opening for receiving the power shaft and actuated reciprocally of the latter but in opposite directions directly by one of the groups of the pistons and means coacting between the crossheads and the power shaft imparting rotary motion to the latter upon movement of the crossheads along the shaft, the weight and inertia of one of the crossheads together with its actuating group of pistons being equal to the weight and inertia of the other.

9. An engine having a multiple number of cylinders arranged in groups about and parallel with a power shaft, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads each having a centrally disposed opening for receiving the power shaft and each actuated reciprocally directly and in both directions of the power shaft by one of the groups of pistons, the movement

of the crossheads being simultaneous but in opposite directions, means carried by the crossheads engaging with and rotating the power shaft; the weight and inertia of one of the crossheads, together with its shaft engaging means and actuating pistons and assemblies being equal to the weight and inertia of the other, the energy impulses actuating the crossheads through the pistons being equal and being delivered to the crossheads equally from the pistons in cylinders equidistantly disposed about the power shaft.

10. An engine having a multiple number of equidistantly spaced coacting groups of cylinders arranged about and parallel with a power shaft, a valve for each of the cylinders and means for actuating the valves so that one of the groups of cylinders will be on the power cycle while another group of cylinders is on the exhaust cycle, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads, connections between one of the crossheads and one of the groups of the pistons and connections between the other crosshead and the other group of pistons, application of a power impulse between pistons of one group of the cylinders moving the crossheads toward each other and application of power between the pistons of another group of the cylinders moving the crossheads away from each other, and means carried by the crossheads engaging with and imparting rotary motion to the shaft upon movement of the crossheads along the shaft.

11. An engine having a multiple number of equidistantly spaced coacting groups of cylinders arranged about and parallel with a power shaft, a valve for each of the cylinders and adjustable means for actuating the valves so that one of the groups of cylinders will be on the power cycle while another group of cylinders is on the exhaust cycle, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads, connections between one of the crossheads and one of the groups of the pistons and connections between the other crosshead and the other group of pistons, application of a power impulse between pistons of one group of the cylinders moving the crossheads toward each other and application of power between the pistons of another group of the cylinders moving the cross heads away from each other, and adjustable means carried by the crossheads engaging with and imparting rotary motion to the shaft upon movement of the crossheads along the shaft.

12. An engine having a multiple number of cylinders arranged about and parallel with a power shaft, a pair of pistons in each of the cylinders, the pistons arranged in two groups, means to adjust the pistons toward or away from each other in the cylinders, a pair of crossheads, connections between one of the crossheads and one group of the pistons and connections between the other crosshead and the other group of pistons, the pistons being operatively connected with the crossheads to move the latter toward each other upon the application of a power impulse between pistons of the two groups in some of the cylinders and away from each other upon application of a power impulse between pistons of the two groups in other of the cylinders, and means carried by the crossheads engaging with and imparting rotary motion to the shaft upon movement of the crossheads along the shaft.

13. An engine having a multiple number of cylinders arranged about and parallel with a power shaft having oppositely pitched grooves about its periphery, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads, connections between one of the crossheads and one of the groups of the pistons and connections between the other crosshead and the other group of the pistons, and means adjustably carried by the crossheads engaging with the grooves at equidistant points about and imparting rotary motion to the power shaft upon movement of the crossheads along the shaft.

14. An engine having a multiple number of cylinders arranged about and parallel with a power shaft having oppositely pitched grooves about its periphery, a pair of pistons in each of the cylinders, the pistons being arranged in two groups, a pair of crossheads, connections between one of the crossheads and one of the groups of the pistons and connections between the other crosshead and the other group of the pistons, and balls adjustably carried by the crossheads engaging with the grooves at equidistant points about and imparting rotary motion to the power shaft upon movement of the crossheads along the shaft.

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