A. W. SHEPHERD.

INTERNAL COMBUSTION ENGINE.

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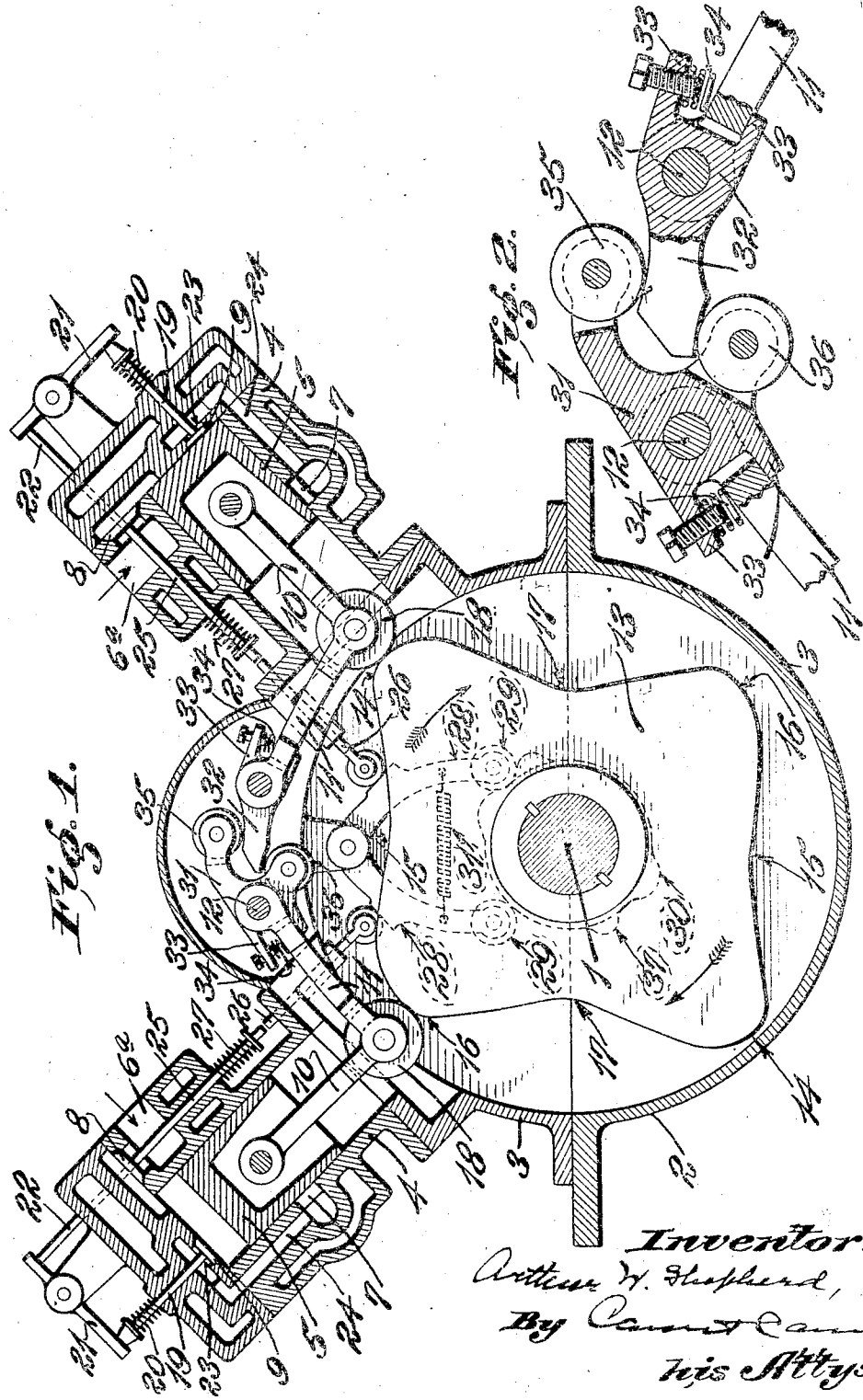


Fig. 1.

Fig. 2.

Inventor:
Arthur W. Shepherd,
By Cameron & Cameron
his Attys.

UNITED STATES PATENT OFFICE.

ARTHUR W. SHEPHERD, OF ST. LOUIS, MISSOURI, ASSIGNOR OF ONE-HALF TO ALBERT H. HAMEL, OF ST. LOUIS, MISSOURI.

INTERNAL-COMBUSTION ENGINE.

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To all whom it may concern:

Be it known that I, ARTHUR W. SHEPHERD, a citizen of the United States, and a resident of the city of St. Louis and State of Missouri, have invented a new and useful Improvement in Internal-Combustion Engines, of which the following is a specification.

My invention relates to internal combustion engines and has for its principal objects to provide for a comparatively low speed of the engine shaft, to provide for variation in the length of stroke of the piston, to dispense with direct mechanical connection between the piston and the engine shaft, and to secure other advantages hereinafter stated. The invention consists principally in providing a cam or cams on the engine shaft in a position to receive the thrust of the pistons; it also consists in shaping said cams so that the piston will have a return stroke that is alternately long for scavenging and short for compression; it also consists in providing a forward stroke shorter than the power stroke so as not to uncover the relief port; it also consists in minimizing the number of parts and in obviating the necessity for much work of precision; it also consists in correlating the surface of the cam to the timing system so that there will be more than one complete cycle of operation of the pistons for every revolution of the engine shaft; it also consists in a mechanism for mechanically correlating the movements of the two pistons of a pair so as to insure the proper relation of each to the cam on the engine shaft; it also consists in the combinations and arrangements of parts hereinafter described and claimed.

In the accompanying drawing, wherein like reference numbers refer to like parts wherever they occur,

Figure 1 is a cross section through two cylinders of an engine embodying my invention; and

Fig. 2 is a fragmentary detail illustrating the tappet action by which each piston is made to maintain a proper mechanical relation to the cam on the main shaft.

In the construction illustrated in the accompanying drawing, the main shaft 1 of the engine is journaled in a suitable framework 2, which is preferably made in the form of a horizontally split housing 3 which completely incloses the main shaft and the parts mounted thereon together with most of the other moving parts of the engine. Mounted on this housing are the engine cylinders 4, which are arranged radially with respect to the main shaft and preferably at an angle of 90° with respect to each other. Each cylinder contains a piston 5 and is provided with an admission port 6, a release port 7, an admission valve 8, a scavenging valve 9 and with any usual type of ignition system.

Each piston is provided with a piston rod 10 pivotally connected thereto at one end; but instead of the outer end of the piston rod being pivotally connected to a crank arm on the shaft, it is pivotally connected to a link 11 which in turn is pivotally mounted on a shaft or arbor 12 mounted on the housing parallel with the main shaft. The shafts upon which the piston rod links turn are adjacent to each other and are so disposed that the medial position of each link is substantially at right angles to the corresponding piston rod, by which arrangement the piston rod is made to have a substantially straight motion.

Mounted on the main shaft in the plane of the piston rods is a cam 13 whose periphery is formed with a major rise or peak 14 followed by a minor depression 15 and then by a minor rise or peak 16 of less height than the rise first mentioned and then by a major depression 17 which reaches closer to the axis than said first mentioned depression and then by a major rise or peak 14 of the same height as the initial major rise or peak, and then by a depression and so on in repetition to the point of beginning. In other words, the periphery of the cam is shaped with alternating rises and depressions, the alternate rises being respectively higher and lower and the alternate depressions being shallower and deeper respectively for a purpose hereinafter specified. In the construction illustrated in the drawing, one half of the periphery of the cam is a repetition of the other half; but if desired, the cam might be designed to produce even a larger number of repetitions. It is to be understood, however, that the curvature of the cam is correlated with the positions and actions of the pistons and that a change in the number of repetitions of the curvatures of the cam will require a change in the angular positions of the cylinders relative to each other.

Journaled on a pin at the outer end of each piston rod is a roller 18 designed for coöperation with the edge of the cam 13 on the main shaft and serving by contact with said cam as a means of transmitting motion alternately from the piston to the cam and from the cam to the piston. The parts are so related that when one of the major peaks 14 of the cam is in contact with a roller, the corresponding piston is at the highest position of its stroke which, in the present instance, brings the piston almost into contact with the head of the cylinder. This position corresponds to the stage at which the piston has completed its scavenging stroke preparatory to charging the cylinder anew. When one of the minor rises or peaks 16 of the cam is in contact with a roller, the corresponding piston is at the limit of its return or compression stroke which position corresponds to the stage at which the charge has been compressed and is ready for explosion.

Each cylinder is provided with an inlet port 6 in its head or in its side close to the head. The inlet valve has a stem 25 that is disposed substantially parallel with the piston and that projects beyond the wall of the cylinder so as to terminate close to but normally out of contact with a reciprocatable rod 26 slidably mounted on the engine housing in alinement therewith. The projecting portion of the inlet valve stem is provided with a coil spring 27 whose ends bear respectively against the wall of the cylinder and a shoulder provided therefor on the valve stem, so that the spring normally holds the inlet valve against its seat. The inner end of the reciprocatable rod 26 is provided with a roller which bears against a lever 28 pivotally mounted on the framework and provided at its free end with a roller 29 in position to coöperate with an ordinary edge cam 30 provided for the purpose on the main shaft. the roller is resiliently held against said cam by means of a tension spring 31 attached to the lever for the purpose.

The cylinder is provided with a main relief port 7 located in the side thereof in position to be uncovered by the piston as it approaches the limit of its forward power stroke. In addition to this main relief port, each cylinder is provided with a scavenging port 23 located in the head thereof (or in the side wall close to said head) and controlled by a suitable valve 9. In the construction illustrated in the drawing, the scavenging valve 9 is seated in the valve seat provided therefor in a passage-way 24 leading from the scavenging port and opening into the atmosphere. This scavenging port is controlled by a valve 9 that opens inwardly into the cylinder and has a reciprocating stem 19 extending through the cylinder head. The valve stem is provided with a coil spring 20 whose ends bear against the cylinder head and against a shoulder on the valve stem respectively so as to normally hold said valve against its seat. Any suitable device of known type may be used for actuating this valve. For instance, a lever 21 mounted on the cylinder has one arm arranged to actuate the valve stem and the other arm operatively connected by a rod 22 provided with a contact roller to a suitable cam 37 on the main shaft to be actuated thereby.

The relation of the several parts just mentioned is such that when the piston is on its long return stroke, the cam 37 will move the lever arm 28, whose movement is communicated through the reciprocatable rod 22 and lever 21 to the scavenging valve 9, thereby opening the passage-way through the scavenging port in the head of the cylinder. The scavenging passage-way remains open until the piston reaches the limit of its long return stroke, whereupon the lever and reciprocatable rod resume their normal positions and the spring holds the scavenging valve to its seat. At this stage, the charging valve opens simultaneously with the forward stroke of the piston to admit the charge into the cylinder.

The following special provision is made for maintaining the piston rod rollers in contact with the cam on the main shaft. As stated above, the links 11 at the ends of the piston rods are pivoted close to each other. On the pivot pins of said links are pivotally mounted members 31, 32 that serve as extensions for the respective links. Each of these extension members is provided with a fork or bifurcated portion 33 which straddles the corresponding link. The throat or spread of the fork is wider than the link so as to afford play or lost motion between the link and said member. One leg of the fork is provided with an adjustable bolt on which is mounted a coil spring 34 whose ends bear against the link and one leg of the extension member respectively. The outer end of one of the members 31 is itself bifurcated and provided with bearing rollers 35, 36. The outer end of the other member 32 projects between said rollers and its opposite edges are curved in such form that both edges will continue in contact with the corresponding rollers at all times. This arrangement constitutes a yielding or resilient mechanical connection between the two links so that motion and power may be transmitted from one to the other as occasion may require, as when the engine is being started.

The general operation of the machine is like that of an ordinary four cycle internal combustion engine; and it is considered unnecessary to go into detail in regard to such

common features as the timing and ignition features and the like. In the position illustrated in Fig. 1, the left hand cylinder is charged and ready to fire and the right hand cylinder has completed its scavenging action preparatory to receiving a new charge. The piston rod roller of the left hand cylinder is at the crest of the minor peak of the cam; and when the explosion occurs, the piston moves forward and the power is transmitted therefrom through the piston rod and the roller thereon against the edge of the cam. While the stroke of the piston is radial with respect to the main shaft, the tangent at the point of contact between the roller and the cam is not perpendicular to the radius of the shaft and consequently the applied force tends to rotate the cam and the shaft on which it is mounted. The low point in the cam corresponds with the limit of the forward stroke of the piston, the difference between the pitch circle at the crest of the minor peak of the cam and the pitch circle of the lowest point of the depression being the length of the effective piston stroke. Throughout its forward stroke, the pressure of the piston is effective to turn the cam. When the piston is at the forward limit of its stroke, the pressure therein is relieved through the relief port in the fore part of the cylinder which is uncovered in this position of the piston. The continued movement of the cam is transmitted to the piston and effects the return stroke of the piston. It is noted that this return movement of the piston is effected by the portion of the cam curve that begins at the bottom of a major depression and terminates at the crest of a major peak. As this major peak extends farther from the axis of the shaft than the minor peak, it causes the return stroke of the piston to be longer than the forward power stroke thereof. The purpose of this long return stroke is to thoroughly scavenge the cylinder and this action is aided by locating the scavenging port in the cylinder head. At the end of this scavenging stroke, the piston is in the position indicated at the right hand in Fig. 1. The forward movement of the piston from the position illustrated in Fig. 1 is effected through its mechanical connection with the piston of the other cylinder of the pair. Thus, referring to the positions indicated in Fig. 1, the forward movement of the left hand piston causes the link that is connected thereto to rock the extending yoke thereon and the roller on the lower arm of the extension bears against the under surface of the extension of the link connected to the piston rod of the right hand piston. By this arrangement, the forward or downward movement of the left hand piston is transmitted to the right hand piston to effect a forward and downward movement thereof. During this forward stroke of the right hand piston, it receives its charge and at the limit of its forward stroke its roller is in contact with the cam at the lowermost point of its minor depression. It is noted that the forward limit of this forward stroke is enough short of the limit of the power stroke to keep the relief port from becoming uncovered by the piston. As the cam continues to revolve, it bears against said roller and effects the return stroke of the piston until it reaches the crest of the minor peak corresponding to the position illustrated in Fig. 1. During this return stroke, the charge has been compressed and is ready for explosion, both pistons having completed their complete cycle of operation, while the shaft has made one half a revolution.

One of the great advantages of my invention is the fewness of its parts and the great simplicity of its organization. Thus, the valve mechanism is reduced to a minimum and that of the simplest form; in fact, the usual relief valve is dispensed with entirely. The contact connection between the piston and the shaft is of a very simple character and permits the piston to transmit a plurality of torque efforts for each revolution of the shaft; and the speed of the engine shaft is small compared with the speed of the piston. Also the speed of the engine can be controlled considerably by modifications of the cam. For instance, the forward or power stroke of the piston is effective throughout the angle that lies between the minor peak and the major depression; and by varying this angle, the relation of the speed of the piston to that of the engine is likewise varied. A convenient way of modifying this angle is to vary the rises of the cam itself, with corresponding variations, of course, in the angular positions of the cylinders.

Obviously the construction illustrated in the accompanying drawing admits of considerable modification without departing from my invention and I do not wish to be restricted to the exact construction shown.

What I claim is:

1. An internal combustion engine comprising a main shaft, a cam thereon, a plurality of cylinders disposed radially about said shaft, pistons in said cylinders and piston rods pivotally connected to said pistons at one end and having operative contact engagement with said cam at their other end, the curvature of said cam comprising a major peak, a minor depression, a minor peak and a major depression.

2. An internal combustion engine comprising a main shaft, a cam thereon, a plurality of cylinders disposed radially about said shaft, pistons in said cylinders and piston rods pivotally connected to said pistons at one end and having operative contact engagement with said cam at their other end,

the curvature of sa[illegible] cam comprising repetitions of a curve consisting of a major peak, a minor depression, a minor peak and a major depression.

3. An internal combustion engine comprising a main shaft, a cam thereon, a plurality of cylinders disposed radially about said shaft in a common plane, pistons in said cylinders and piston rods pivotally connected to said pistons at one end and operatively engaging said cam at their other end, the curvature of said cam comprising a major peak and a minor peak arranged to be in alinement simultaneously with the respective cylinders.

4. A four-cycle internal combustion engine comprising a main shaft, a cam thereon, a plurality of cylinders disposed radially about said shaft, pistons in said cylinders and piston rods pivotally connected to said pistons at one end and operatively engaging said cam at their other end, said cam comprising repetitions of a curve consisting of a major peak corresponding to the scavenging stroke, a minor depression corresponding to the charging stroke, a minor peak corresponding to the compression stroke and a major depression corresponding to the power stroke, said cylinders having inlet and scavenging ports at or near the heads thereof and having their relief ports in the fore part in position to afford relief only when the piston is near the forward limit of its power stroke and the cylinders being so disposed as to be in simultaneous alinement with a major and a minor peak respectively.

5. In an internal combustion engine, a main shaft, a cam thereon, explosion cylinders radially disposed with respect to the shaft and angularly disposed with respect to each other, pistons in said cylinders, piston rods pivotally connected to said pistons and having their outer ends arranged for coöperation with said cam by mere contact therewith, links pivotally mounted on the framework adjacent to each other and pivotally connected to the outer portions of said piston rods respectively, and coöperating extensions on said links for coördinating the motions of said links and thereby maintaining operative contact of said piston rods with said cam.

6. In an engine of the kind described, a main shaft, a cam thereon, explosion cylinders radially disposed with respect to the shaft and angularly disposed with respect to each other, pistons in said cylinders, piston rods pivotally connected to said pistons and having their outer ends arranged for coöperation with said cam by mere contact therewith, links pivotally mounted on the framework adjacent to each other and pivotally connected to the outer portions of said piston rods respectively, and coöperating extensions on said links for coördinating the motions of said links and thereby maintaining operative contact of said piston rods with said cam, said extensions being yieldably mounted and interlocking with each other.

7. In an internal combustion engine, a main shaft, a cam thereon having major and minor peaks separated by depressions, explosion cylinders radially disposed with respect to the shaft and angularly disposed with respect to each other, pistons in said cylinders, piston rods pivotally connected to said pistons and having their outer ends arranged for coöperation with said cam, links pivotally mounted on the framework adjacent to each other and pivotally connected to the outer portions of said piston rods respectively, and coöperating extensions on said links for coördinating the motions of said links, said extensions being yieldably mounted, one of said extensions comprising a bifurcated member having one arm which normally clears the cam, but which extends across the path of the major peak of said cam when the corresponding piston is at the end of its return stroke.

8. An internal combustion engine comprising an explosion cylinder having a charging port at or near the head and a scavenging port at or near the head and a relief port in the fore part of the cylinder, and a piston in said cylinder whose forward stroke alternately passes and falls short of said relief port and whose return stroke is alternately of full length for scavenging and of shorter length for compression.

9. An engine of the class described comprising a cylinder having a relief port in its fore-part, a piston in said cylinder and means for varying the stroke of said piston so that on each alternate stroke said piston uncovers the relief port while on each intermediate stroke the piston keeps said port covered.

10. In an engine of the class described, a cylinder having an admission port and a scavenging port at or near the head thereof, normally closed valves for said ports, and a relief port in the fore-part of said cylinder, a piston in said cylinder and means for varying the stroke thereof, said means being adapted to open and keep open the scavenging valve until the piston reaches the limit of its long return stroke and then to close said scavenging valve and open the inlet valve.

Signed at St. Louis, Missouri, this 7th day of August, 1918.

ARTHUR W. SHEPHERD.