W. W. MACFARREN AND T. W. GRAY.

GAS ENGINE.

APPLICATION FILED MAR. 3, 1919.

1,370,503.

Patented Mar. 1, 1921.

2 SHEETS—SHEET 1.

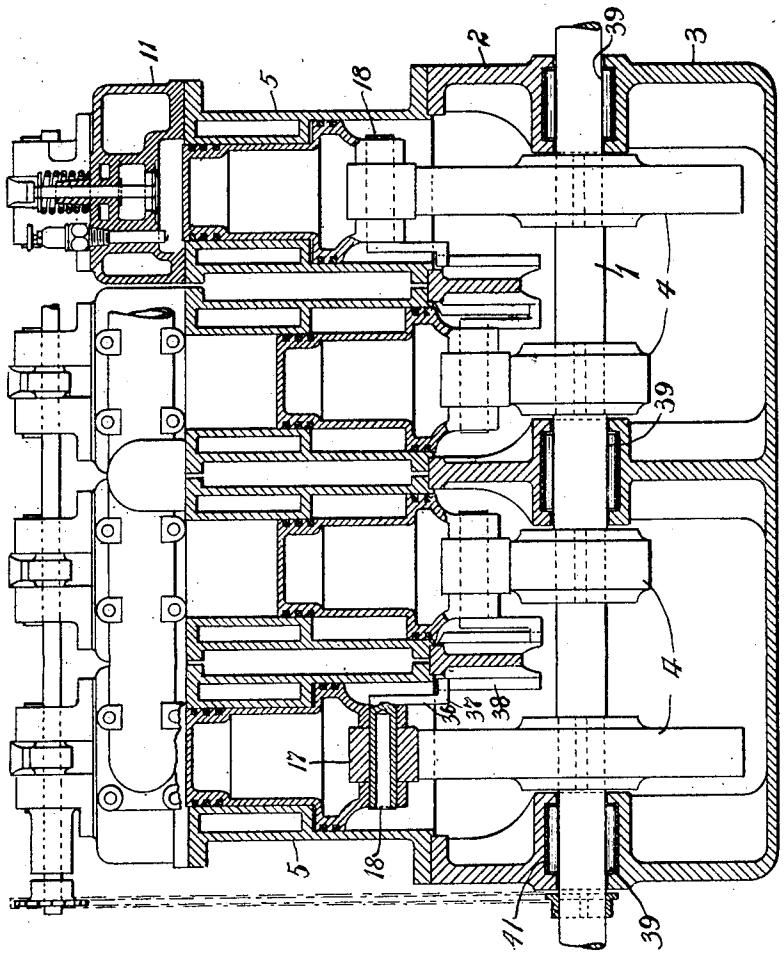


FIG. 1.

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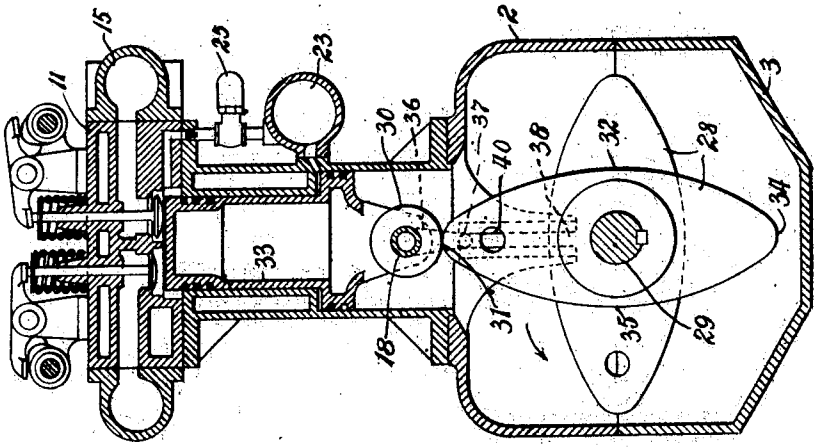


FIG. 3.

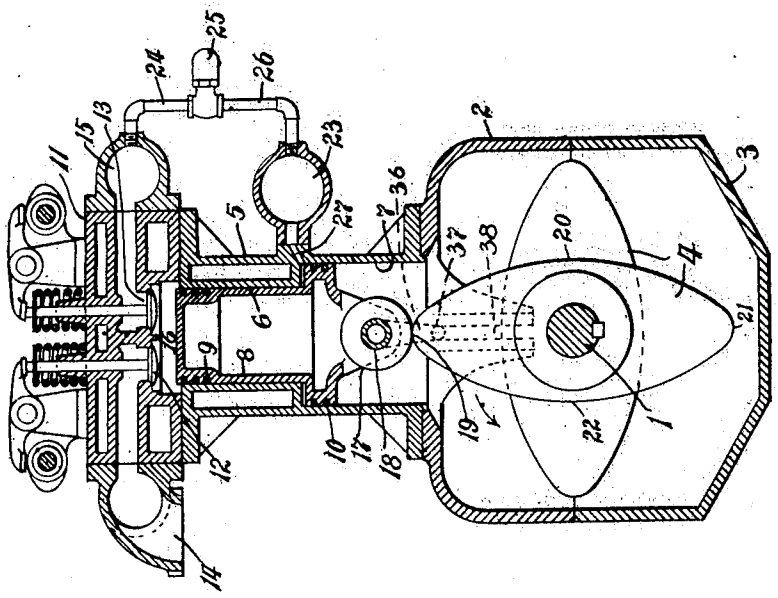


FIG. 2.

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UNITED STATES PATENT OFFICE.

WALTER W. MACFARREN, OF PITTSBURGH, AND THOMAS W. GRAY, OF HEIDLEBERG, PENNSYLVANIA, ASSIGNORS TO SAID WALTER W. MACFARREN, TRUSTEE.

GAS-ENGINE.

1,370,503. Specification of Letters Patent. **Patented Mar. 1, 1921.**

Application filed March 3, 1919. Serial No. 280,261.

To all whom it may concern:

Be it known that we, WALTER W. MACFARREN and THOMAS W. GRAY, citizens of the United States, residing, respectively, at Pittsburgh and Heidleberg, in the county of Allegheny, State of Pennsylvania, have invented certain new and useful Improvements in Gas-Engines, of which the following is a specification.

Our invention relates to internal combustion engines and more especially to those working on the four stroke cycle. Our improved engine may be constructed with any desired number of cylinders but is herein shown with four cylinders.

The objects of our invention are:

1st. To produce a 4 cycle engine in which each cylinder will fire at each revolution instead of once in every two revolutions as usual, whereby the power output is approximately doubled.

2nd. To increase the piston speed without increasing the speed of the shaft, whereby the heat loss to the water jacket is lessened and the efficiency increased.

3rd. To reduce the weight of the reciprocating parts by eliminating the connecting rods.

4th. To eliminate the crank shaft and substitute therefor a straight shaft which may be conveniently mounted in antifriction bearings.

5th. To substitute for the cranks, cams which may be designed to obtain more efficient control of the motion of the piston.

6th. To provide a direct contacting device between each piston and its cam by which power is transmitted from piston to shaft and vice versa.

7th. To provide a cushioning device to control the outer reversal of the piston.

8th. To provide a differential piston stroke whereby the lengths of the power, exhaust, inlet and compression strokes can be separately best adapted for their respective functions.

9th. To provide automatic means for maintaining the fluid pressure piston cushion at maximum effectiveness.

10th. And to provide various detailed improvements in the design and construction of such engines whereby they may be made more satisfactory and efficient.

Referring to the drawings: Figure 1 is a sectional side elevation of our improved engine. Fig. 2 is a transverse cross section of the same, and Fig. 3 is a view similar to Fig. 2, showing a modified form of engine.

The shaft 1 is mounted in a split crank case having an upper part 2 and a lower part 3, and is provided with a cam 4 for each cylinder. The cylinders 5 have each an upper bore 6 and a lower bore 7 in which there works a two diameter piston 8 with upper piston rings 9 engaging the upper bore 6 and lower piston rings 10 engaging the lower bore 7.

A cylinder head 11 is provided with inlet valves 12 and exhaust valves 13 both of which may be of any desired construction and operated in any desired manner. An inlet manifold 14 supplies gas to the cylinders and the exhaust passes out through an exhaust manifold 15. The clearance volume 16 above the upper piston 8 is the space in which the explosion takes place.

Power is transmitted from the piston 8 to the cam 4 through a roller 17 mounted on a pin 18 secured to the lower end of the piston 8. As shown in Fig. 2 the engine is on the dead center and may be supposed to be just starting a power stroke in either direction of rotation, it being understood of course that the cam 4 is carried around by the momentum of the connected moving parts.

As soon as the high point 19 passes the center line of the engine the piston 8 moves downward under the force of the exploding gases and the roller 17 exerts pressure on the cam 4 to turn it until the low point 20 is in contact with the roller 17, when the piston has reached the bottom of its stroke. As the cam continues to revolve the part between 20 and 21 bearing against the roller 17 will force it upward, thus giving the piston an up or exhaust stroke.

During the quarter turn from 21 to 22 the piston may travel downward again on its inlet stroke, and during the quarter turn from 22 to 19 the piston 8 will be forced upward by the cam 4 on its compression stroke.

In a vertical engine at slow speed the above described operation would take place by the force of gravity acting on the piston 8, but at high speed it requires an additional force to reverse the piston 8 at the upper limit of its travel on the exhaust stroke. It

is also of advantage to have a positive check on the upper motion of the piston during the compression stroke as in case of a valve sticking there would be no compression obtained.

To obtain this necessary force we have provided a cushioning device acting on the upper side of the enlarged lower portion of the piston 8, and comprising a manifold 23 which forms a small reservoir for compressed gas or air. This manifold as shown in Fig. 2 is supplied with pressure from the exhaust manifold 15 through a pipe 24 which leads through a reducing valve 25, to a second pipe 26 connected with the manifold 23. The reducing valve can be set to maintain a constant pressure in the manifold 23 below that of the exhaust from the manifold 15. A port 27 leads into the upper end of the enlarged bore 7.

As there is at all times a constant pressure in the manifold 23 the upward movement of the piston or pistons is resisted thereby, and it is a matter of designing skill to so arrange the area of the lower annular piston, and the pressure carried in manifold 23 in such proportion to the speed of the engine and the weight of the piston, as to keep the roller 17 at all times in contact with the cam 4.

When the engine is built with only one cylinder the manifold 23 is simply an air spring, the air passing in opposite directions through the port 27 as the piston moves up or down.

In the preferred construction of a multi-cylinder engine, having four cylinders as shown, two of the pistons move down as the other two move up, and thus the air is displaced by the upward moving pistons to supply the downward moving pistons. In either case there will be a certain amount of leakage past the rings 10, and to take care of this some pressure producing device is necessary. As the pressure of the exhaust is considerable this may in some cases be used as just described, and by the use of a reducing valve this pressure is made constant in the reservoir 23; as soon as there is any drop in pressure the valve admits more gas.

In Fig. 3 we have illustrated a similar arrangement in which the pressure is taken from the interior of the power cylinder itself instead of from the exhaust. By this means a much higher pressure can be obtained.

In passing it will be noted that by reason of the sealing effect of the rings 10 at the lower part of the piston 8, copious splash lubrication may be used in the crank case, as no considerable quantity of oil can leak upward past these rings due to the existence of a constant pressure above them.

In Fig. 2 we have shown the cams 4 as symmetrical and of substantially elliptical form. It will be understood, however, that since each quadrant of the cam represents a stroke of the piston it can be individually shaped to obtain the most advantageous action of the piston during such stroke.

As one possible departure from the symmetrical arrangement shown in Fig. 2 we have illustrated in Fig. 3 cams 28 mounted on a shaft 29. The figure shows the piston 33 at the extreme upper end of its stroke with the roller 30 in contact with the upper end 31 of the cam. Assuming the stroke just completed to have been an exhaust stroke it will be seen that the piston has expelled by its movement practically all the products of combustion.

The following stroke will be an inlet stroke, during which the roller 30 will travel on the cam 28 from point 31 to point 32. This stroke will be of equal length to the exhaust stroke and will draw in a charge which will practically fill the piston displacement plus the clearance volume.

As the cam continues to revolve the roller 30 will travel from point 32 to point 34 and the piston 33 will move upward on a compression stroke. However, this stroke will be shorter than the exhaust and inlet strokes because the distance from the center of the shaft 29 to the point 34 of the cam is less than the corresponding distance to the point 31. On the following or power stroke the piston will travel downward and the roller will roll from point 34 to point 35. As shown the upper or longer half of the cam controls the inlet and exhaust strokes, and the lower or shorter half of the cam controls the compression and power strokes.

The advantages of this differential movement of the piston are well known, as the cylinder is completely scavenged of burned gases at each cycle, and draws in a full and unadulterated charge of fresh gas. The length of stroke required to give the proper clearance volume and compression, and the proper length of power stroke may be varied at will by changing the dimensions of the cam.

The cams 28 are also shown as being of substantial elliptical contour, but as before stated, each quarter of the cam may be made of any shape desired. It will be noted that the symmetrical cam shown at 4 is in perfect balance, whereas an unsymmetrical cam as shown at 28 is out of balance; this may be corrected however by forming an opening at 40 of such a size and at such a distance from the center as to make a running balance.

In the preferred construction of a four cylinder engine the outer two cams are placed at right angles to the inner two cams as shown in Figs. 1 and 2; thus the movement of the outer pistons is exactly the same and is opposed to the movement of the inner

pistons. As the pistons may be made of exactly equal weights, this produces a very efficient running balance. If in addition the cams are symmetrical or balanced with each other, the whole engine will be well balanced. Further, since the cams are of considerable size and weight, the necessity for a fly wheel may be in many cases dispensed with.

In order to prevent the rotation of the pistons and keep the roller pins 18 in proper alinement, a depending projection 36 may be formed on the end of the pin, the same being provided with a horizontal extension 37 which slides loosely in a groove 38 formed in the upper half of the crank case 2.

A further advantage of the construction herein described is the fact that a straight shaft is employed which may be mounted in roller bearings as illustrated at 39, the same having solid outer races 41. This is possible with crank shafts at the ends only, whereas with our construction a bearing may be put between each pair of cams if desired.

The valve mechanism, drive therefor, ignition system, and carbureter have not been described in detail, as they form no part of this invention.

The outstanding difference between this engine and other four cycle engines is the fact that a complete cycle of four piston strokes is obtained for each revolution of the shaft. By this means the power at the same shaft speed is approximately doubled, and if the scavenging effect illustrated in Fig. 3 is also used the power will be more than doubled. In addition to this, the efficiency will be increased by reducing the heat loss to the water jacket or other cooling means, this loss being to a great extent dependent upon the speed of the piston, it being well known that high speed engines lose a less proportion to the jacket than low speed ones.

It will be obvious to those skilled in the art that our improved engine may be built as a V type motor of eight cylinders by using two four cylinder blocks as illustrated and setting them at 90° with each other to operate on a single shaft having four cams, each cam receiving power from two cylinders. Twelve or sixteen cylinder motors could be similarly built on a four cam shaft.

We claim as our invention:

1. In an internal combustion engine, a power cylinder, a power piston working therein, a shaft, a cam on said shaft, a contacting device carried by said piston and engaging said cam, and a pneumatic cushioning device comprising an enlarged cylinder below the power cylinder and concentric therewith, an annular flange formed at the lower end of the piston and working in said enlarged cylinder, and a source of pneumatic pressure connected to the cushioning cylinder.

2. In an internal combustion engine, a power cylinder, a power piston working therein, a shaft, a cam on said shaft, a contacting device carried by said piston and engaging said cam, and a pneumatic cushioning device for cushioning the piston on its upstroke, including a reservoir and means for charging the reservoir with pressure generated in the power cylinder.

3. In an internal combustion engine, a power cylinder, a power piston working therein, a shaft, a cam on said shaft, a contacting device carried by said piston and engaging said cam, and a pneumatic cushioning device for cushioning the piston on its upstroke, including a reservoir, means for charging said reservoir with pressure generated in the power cylinder, and means for maintaining a substantially constant pressure in said reservoir.

4. In an internal combustion engine, a power cylinder, a power piston working therein, a shaft, a cam on said shaft, a contacting device carried by said piston and engaging said cam, and a pneumatic cushioning device including a reservoir, for cushioning the piston on its upstroke.

5. In an internal combustion engine, four parallel cylinders, a shaft, a power piston in each cylinder, an oval cam on the shaft for each cylinder, the two outer of said cams having their long diameters at a right angle to the long diameters of the two inner cams, and a contacting device for each piston engaging its cam, in combination with an enlarged cushioning cylinder below each power cylinder, a flange at the bottom of each power piston working in said enlarged cylinder, an air reservoir, and a port connecting each of said cushioning cylinders with said reservoir.

6. In an internal combustion engine, a cylinder, a piston, a shaft, a cam thereon, a contacting device on said piston engaging said cam, a pneumatic spring coöperating with said contacting device to cushion the piston on its upstroke, a source of pressure, and a connection between the same and said spring device.

7. In an internal combustion engine having four cylinders, each of said cylinders having a smaller and a larger bore, stepped pistons working in said cylinders, a shaft, a cam on said shaft for each of said cylinders, and a contacting device on each of said pistons to engage one of said cams, a fluid pressure manifold, and a port leading from the larger bore of each of said cylinders to the said manifold, the whole arranged so that two of said pistons move oppositely to the other two whereby the work done by the fluid pressure against two of said pistons is

balanced by the work done against the fluid pressure by the other two pistons.

8. In an internal combustion engine, a cylinder, a piston, a shaft, a cam on said shaft, a contacting device on said piston engaging said cam whereby the movement of the piston is determined by the contour of the cam, a fluid pressure device for maintaining the engagement of the contacting device with the cam, and a pipe connecting the combustion space in the cylinder with the fluid pressure device to supply the same with fluid pressure.

9. In an internal combustion engine having a plurality of cylinders, a piston for each cylinder, a shaft, a cam on said shaft for each of said pistons, a contacting device on each piston engaging its co-acting cam, whereby the movement of each piston is determined by the contour of its cam, a fluid pressure device for each piston to maintain the engagement of its contacting device with its cam, a manifold connecting the pneumatic devices for all the pistons, and a pipe connecting the combustion space in one of the cylinders with said manifold to supply pressure thereto.

10. In an internal combustion engine, a cylinder, a piston, a shaft, a cam on said shaft, a contacting device on said piston engaging said cam to drive the same, and a pneumatic cushioning device in line with said cylinder and coöperating with said piston to maintain the engagement of said cam with the contacting device on the piston.

11. In an internal combustion engine, a cylinder, a piston, a shaft, a cam on said shaft, a contacting device on said piston engaging said cam to drive the same, and a pneumatic cushioning device concentric with said cylinder and coöperating to maintain the engagement of said contacting device and said cam.

12. In an internal combustion engine, a plurality of cylinders, a shaft, a cam on said shaft for each of said cylinders, a piston for each cylinder, a roller on each piston engaging one of said cams, an individual pneumatic cushioning device for each of said pistons to maintain the engagement of said roller and said cam, and means for supplying pressure to said cushioning devices from a common source of supply.

In testimony whereof we hereunto affix our signatures in the presence of a witness.

W. W. MACFARREN.
THOMAS W. GRAY.

Witness.
A. M. GOODWIN.