P. W. HODGKINSON.

ENGINE STARTER.

APPLICATION FILED APR. 8, 1912.

1,056,418. Patented Mar. 18, 1913.

Fig. 2.

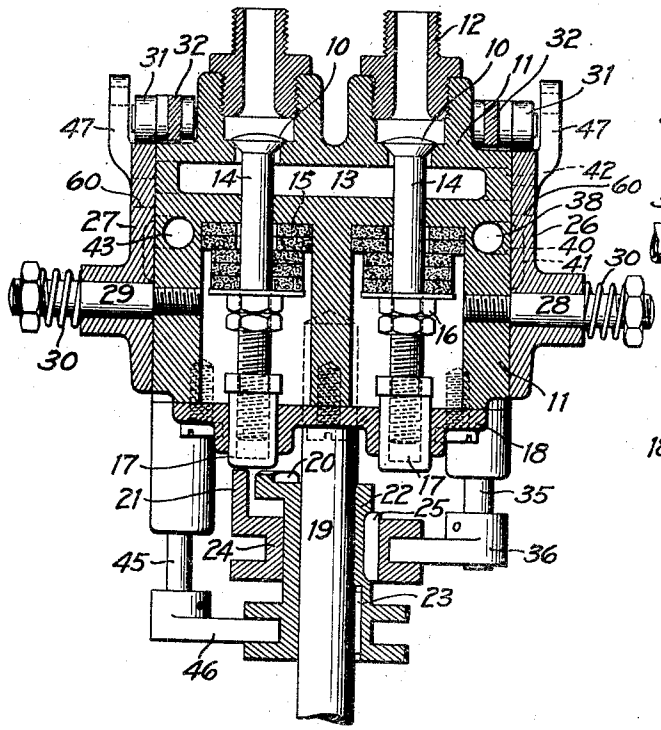


Fig. 1.

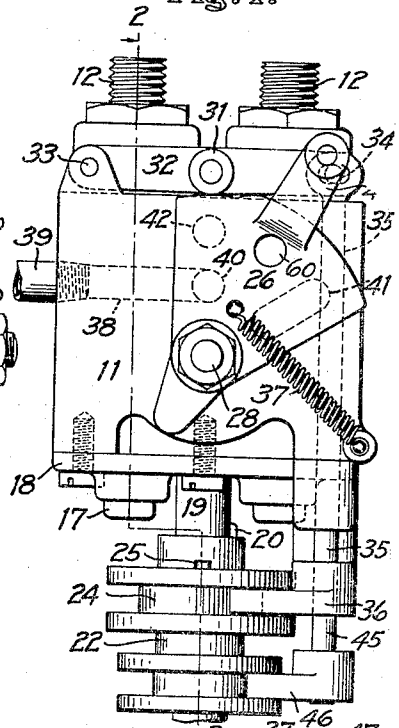


Fig. 4.

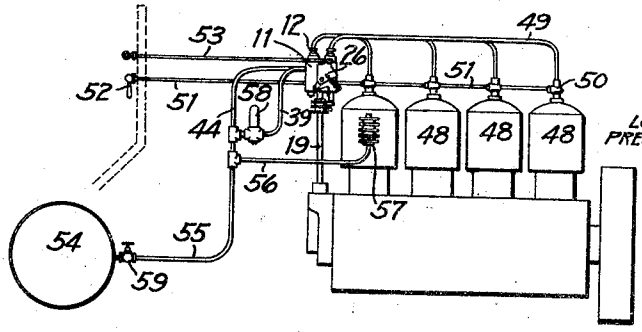
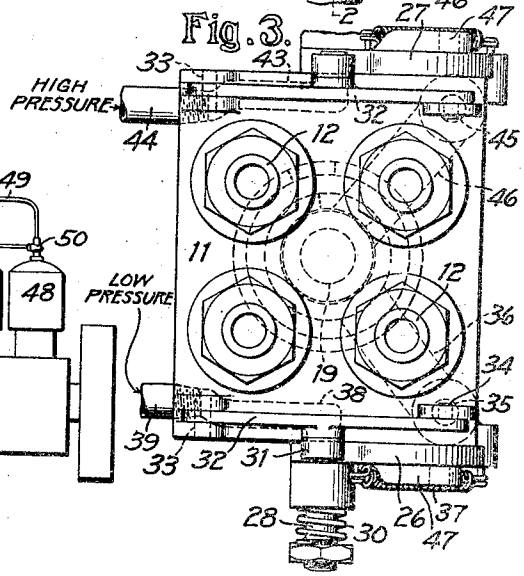


Fig. 3.



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ENGINE-STARTER.

1,056,418. Specification of Letters Patent. Patented Mar. 18, 1913.

Application filed April 8, 1912. Serial No. 689,431.

To all whom it may concern:

Be it known that I, PERCY W. HODGKINSON, a citizen of the United States, and resident of Rochester, in the county of Monroe and State of New York, have invented certain new and useful Improvements in Engine-Starters, of which the following is a specification.

This invention relates to means for starting the operation of internal-combustion engines without the application of manual power thereto, and particularly to devices of this kind in which compressed air or other motive-fluid is employed to furnish the requisite power, this motive-fluid being introduced directly into the cylinders of the engine under the control of suitable selector-mechanism.

In four-cylinder, four-cycle internal-combustion engines, as usually constructed, all of the cranks lie in one plane, so that it is possible for the engine to stop in a position in which all of the cranks are at or near dead-center. In such a case it is difficult, and often impossible, to start the engine by the mere introduction of compressed motive-fluid into the cylinder in which the piston is on the expansion-stroke, for the reason that this piston may be so near the end of the stroke that sufficient momentum cannot be applied through it to the engine to carry the parts past dead-center and for the further reason that the valve-mechanism is usually adjusted to open the exhaust-passage from the cylinder before the end of the expansion-stroke is reached.

In a previous application filed November 23, 1911, Serial No. 662,074, I have disclosed an engine-starter of the pneumatic type in which I propose to overcome the difficulty just described by introducing compressed-motive-fluid first into a cylinder in which the piston is on the in-stroke or compression-stroke, thus moving the parts of the engine backwardly so as to bring another piston into a position favorable for the starting-operation. The present invention relates to improvements upon the apparatus disclosed in said application.

One object of the present invention is to render the preparatory backward movement of the engine-mechanism more certain in its extent and results. To this end I employ, in the present apparatus, motive-fluid at two different pressures. The high pressure is employed in the motive-fluid which is used to start the engine in a forward direction. The lower pressure is employed in the motive-fluid which is used for the preliminary operation of moving the engine-mechanism backwardly to bring it into a position favorable for starting. This arrangement has the advantage that the lower degree of pressure can be so selected that it is quite sufficient to produce the required movement of the engine-mechanism, while at the same time it is not sufficient in any case to move the engine parts too far, and thus bring them to or near the dead-center opposite to that which they originally occupied.

Another object of the invention is to improve the construction and operation of devices of the kind in question in various details which will be pointed out in connection with the following description of the illustrated embodiment of the invention.

In the accompanying drawings the invention is illustrated as employed in connection with a four-cylinder engine.

Figure 1 is a side-elevation of the selector-mechanism; Fig. 2 is a vertical section on the line 2—2 in Fig. 1; Fig. 3 is a plan-view of the selector-mechanism; and Fig. 4 is a diagrammatic side-elevation showing the connections between the engine and the starting-apparatus.

In the illustrated embodiment of the invention the motive-fluid is directed selectively to the several cylinders of the engine by means of a selector shown particularly in Figs. 1, 2 and 3. This device is provided with four puppet-valves 10 controlling outlets from a valve-casing 11. These outlets discharge through nipples 12 by means of which connections are made with the respective engine-cylinders. Within the valve-casing, and below the valves, is a chamber 13 which is charged with the compressed motive-fluid. The valves have stems 14 passing downwardly through the valve-casing, and each valve-stem is surrounded by washers 15 of rubber, or other elastic material, which serve the double purpose of springs to hold the valves normally closed, and packing to prevent the leakage of motive-fluid around the valve-stems. The de-

gree of compression of the washers is controlled by adjusting-nuts 16 on the valve-stems.

Upon the lower end of each valve-stem a cap 17 is screwed, this cap having a sliding bearing in a plate 18 closing the lower end of the valve-casing. The caps 17 serve the purpose of cam-followers through which the valves are actuated, as will be presently described, and, owing to their threaded connection with the valve-stems, they may be adjusted longitudinally thereon to regulate the amount of opening of the valves.

The valve-mechanism is actuated by connection with a rotative part of the engine, such, for example, as the usual half-time shaft 19, this shaft being illustrated as in vertical position and having a bearing at its upper end in the body of the valve-casing. The opening movements are imparted to the valves through the operation of two cam-projections 20 and 21 which are carried, respectively, by concentric sleeves 22 and 24. The sleeve 22 is loosely mounted on the shaft 19, so that it may slide longitudinally thereon, but is connected with the shaft by means of a spline 23 so as to rotate therewith. The sleeve 24 slides longitudinally upon the sleeve 22, but is connected therewith by means of a spline 25 so as to rotate with the sleeve 22 and thus with the shaft 19. In the normal position of the mechanism both of the sleeves are in their lower positions, as shown in Figs. 1 and 2, so that the cams 20 and 21 do not engage the caps 17, but rotate idly with the shaft 19 during the normal operation of the engine. When the apparatus is to be operated to start the engine, however, the sleeves and the cams are raised so as to bring the cams into operative engagement with one or the other of the caps. The means for so raising the cams comprise two valve-plates 26 and 27 which are pivotally mounted on studs 28 and 29, respectively, screwed into opposite sides of the valve-casing 11. Springs 30 surrounding the studs, and bearing against the valve-plates, press the plates firmly against the flat surfaces of the casing. The upper edge of each valve-plate constitutes a cam-surface, as shown particularly in Fig. 1, this cam-surface being engaged by a roller 31 journaled upon a cam-lever 32. Each lever 32 is pivoted, at its forward end, upon a stud 33 fixed in lugs projecting upwardly from the valve-casing, and the opposite end of each lever is connected, by a stud 34, with the slotted upper end of a rod which slides vertically in a bearing in the valve-casing. One of these rods, 35, is provided, at the lower end, with an arm 36 which engages an annular slot in the sleeve 24. The other rod, 45, is provided with an arm 46 which engages an annular slot in the sleeve 22.

Springs 37, connecting the valve-plates and the valve-casing, normally retain the former in the position shown in the drawings. Each valve-plate is provided, however, with an arm 47 by which it may be swung rearwardly against the opposition of its spring 37.

By the movement of the valve-plate just described the cam-surface, upon its upper edge, is caused to raise the corresponding roller 31, owing to the form of the cam-surface as illustrated in Fig. 1. This movement results in raising the corresponding rod 35 or 45, and thus raising the cam connected therewith into operative relation with the caps 17.

The cam 21 may be designated as the "reverse-cam" since it is the one which is employed in causing the reverse or backward movement of the engine hereinbefore described. Accordingly, the relative position of this cam with respect to the shaft 19 is such as to bring it always in position beneath the cap of whichever valve 10, in any particular position of the engine-mechanism, is connected with the cylinder in which the piston is in its compression-stroke. The cam 20, on the other hand, is the starting-cam, being so located with respect to the shaft as to lie always beneath the cap of whichever valve 10 is connected with the cylinder in which the piston is in its expansion-stroke.

In addition to their mechanical functions just described the valve-plates 26 and 27 act as valves to introduce motive-fluid into the valve-chamber 13. This motive-fluid is derived, from a suitable source of supply, through pipes 39 and 44 containing, respectively, low-pressure and high-pressure motive-fluid. The pipe 39 communicates with a passage 38 in the wall of the valve-casing, this passage being directed outwardly at its end so as to form a port 40 in the surface or seat upon which the valve-plate slides. Directly above the port 40 is a port 42 communicating with the chamber 13. These ports are normally both closed by the inner surface of the valve-plate 26, but when the valve-plate is swung rearwardly, that is, to the left in Fig. 1, a recess or passage 41 in the inner surface of the valve-plate is brought into communication with the ports 40 and 42, thus forming a passage through which motive-fluid may flow into the valve-chamber 13. A similar arrangement is employed in connection with the valve-plate 27. The motive-fluid from the pipe 44 flows through a passage 43, the valve-casing and the valve-plate being formed with ports similar to those just described.

After either of the valve-plates has been operated to introduce motive-fluid to the valve-casing, and thence to one of the engine-cylinders, it is desirable to exhaust the

spent motive-fluid before operating the engine in the opposite direction, and accordingly each valve-plate is provided with an exhaust-port 60 which registers momentarily with the port 42, thus affording an outlet to atmosphere from the valve-chamber 13 during each operative movement of the valve-plate.

Fig. 4 illustrates, as a whole, the system or arrangement by which the selector-mechanism previously described is employed in connection with an engine. An engine having four cylinders 48 is illustrated, and these cylinders are connected, respectively, through pipes 49, with the nipples 12 on the valve-casing. In each of the pipes 49 a shut-off cock 50 is introduced near the engine-cylinder, so that, during the normal operation of the engine, communication between the cylinders and the valve-mechanism may be interrupted, and these cocks may be conveniently operated by a rod 51 connected with all of them and provided with a handle 52, at any convenient point, by which it may be turned to open or close the cocks simultaneously. These shut-off cocks are not essential, but it is preferable to use them in order that hot gases from the engine-cylinders may not be forced backwardly into the pipes 49 during the operation of the engine.

As a convenient means for operating the valve-plate 26, Fig. 4 illustrates a rod 53 connected with the arm 47 on the valve-plate and extending rearwardly to a position in which it is conveniently accessible, the rod having a handle of any convenient form, on its rear end, by which it may be pulled. The valve-plate 27 is actuated by a similar device (not shown).

The motive-fluid employed in connection with the starting-mechanism may be either compressed air or compressed gases from the engine. In Fig. 4 I have illustrated a tank 54 adapted to contain a sufficient supply of compressed motive-fluid, and this tank communicates, through pipes 55 and 56, with one of the engine-cylinders so as to receive compressed products of combustion therefrom during the normal operation of the engine. The usual check-valve device 57 may be introduced in the pipe 56 to prevent the return flow of gases to the engine-cylinders. This device is not more particularly illustrated as it is familiar in connection with various well-known engine-starters. It will be understood that in place of deriving the motive-fluid from the engine-cylinder, pure air may be compressed by means of a pump of any ordinary or suitable construction, or that the motive-fluid may be derived from any other convenient source.

As already stated, the pipe 44 supplies motive-fluid under high pressure, while the pipe 39 supplies motive-fluid under a lower pressure. Accordingly, the pipe 44 is shown as communicating directly with the pipe 55, while between the pipe 39 and the pipe 55 a pressure-regulator or reducing-valve 58 is introduced, this device being adjusted to maintain a comparatively low pressure in the pipe 39. The construction of the reducing-valve 58 is not illustrated, as such devices are well known. A hand-operated shut-off valve 59 may be introduced in the pipe 55, so that in case the apparatus stands unused for a long period of time the leakage, or gradual escape, of motive-fluid may be prevented by closing this valve.

The operation of the apparatus as a whole will now be described.

A four-cylinder internal-combustion engine usually comes to rest with the pistons off dead-center, two of the cranks being on one side of the axis of rotation and two on the other, so that two of the pistons are on their suction-stroke and expansion-stroke, respectively, while the other two are on their exhaust-stroke and compression-stroke, respectively. Accordingly, one of the pistons is always on the expansion-stroke, with the corresponding inlet-valve and exhaust-valve closed, and this is the cylinder into which the starting-cam is adjusted to direct the motive-fluid. Providing the piston in question is at a sufficiently early point in its stroke the engine may be started by merely introducing the high-pressure motive-fluid into this cylinder, this operation resulting from the movement of the valve-plate 27 to its rearward position. As soon as the engine begins to rotate forwardly the cam-mechanism is rotated correspondingly by the shaft 19, so that the cam 21 raises the valves 10 successively, and thus transmits motive-fluid to the cylinders in order as the piston in each cylinder reaches its expansion-stroke. The engine may thus be operated continuously by the compressed motive-fluid until the induction and combustion of explosive mixture causes the engine to begin its normal operation. While it is usually sufficient, therefore, to operate the valve-plate 27, it frequently occurs that the engine stops in such a position that it is difficult or impossible to start it by introducing motive-fluid into the cylinder in which the piston is on the expansion-stroke. This is due to the fact that the engine may frequently come to rest in a position in which the piston in question is so near the end of the expansion-stroke that it will not operate with sufficient effect to move the engine over the succeeding dead-center. Accordingly, in case the engine fails to start when the valve-plate 27 is operated, the operator then allows this valve-plate to return and operates the valve-plate 26, thus moving the reverse-cam 20 into operative position. Low-pressure motive-fluid is now introduced into the cyl-

inder in which the piston is on the compression-stroke. Since this piston, under the circumstances in question, is necessarily near its innermost position, nearly a full stroke is available to move the engine backwardly. Accordingly, the engine-shaft is turned through nearly a half-rotation, thus bringing the parts into such a position that the piston on the expansion-stroke is near the dead-center at which this stroke begins. Accordingly, after this reverse movement, it is necessary only to return the valve-plate 26 to normal position, and then operate the valve-plate 27 again to start the engine with nearly a full effective stroke of one of the pistons.

The object in using a comparatively low pressure in the motive-fluid employed for the reverse movement of the engine is to prevent the engine from moving too far in a reverse direction. This is particularly important when the engine is started after having stood idle for a long time in cold weather. Under these conditions the lubricant in the cylinders becomes so stiff that considerable force is necessary to start the parts in motion. Where motive-fluid under high pressure has been used for this purpose I have found that the pistons would remain stationary until considerable pressure had accumulated in the cylinder into which the motive-fluid was introduced, and that then the engine would start suddenly into reverse movement with such momentum as to move it past the succeeding dead-center, and even cause it to perform a continuous reverse rotation. By properly adjusting the reducing-valve 58, however, according to the size of the engine and other conditions which vary more or less in each case, a pressure may be selected for the low-pressure motive-fluid which is sufficient to insure the reverse movement of the engine under all conditions, but not sufficient to carry the parts past dead-center against the normal compression occurring in the cylinders, and accordingly the reverse movement always terminates at a point in which the engine parts are most effectively positioned for the succeeding starting-operation.

My invention is not limited to the embodiment thereof hereinbefore described and illustrated in the accompanying drawing, but may be embodied in various other forms within the nature of the invention as it is defined in the following claims.

I claim:—

1. An engine-starter having, in combination, means for supplying compressed motive-fluid at two different pressures, and selector-mechanism adapted, in any given position of the engine which is to be started, to direct the motive-fluid at the lower pressure to one of the engine-cylinders in which the piston is on the in-stroke, to impart reverse movement to the engine-shaft, or to direct the motive-fluid at higher pressure to another of the engine-cylinders in which the piston is on the out-stroke, to impart a starting-impulse to the engine, the lower of said two pressures being insufficient to cause a movement of the engine-pistons past dead-center.

2. The combination, with a multicylinder internal-combustion engine, of an engine-starter comprising a source of supply of compressed motive-fluid at two different pressures, and a selector connected with said source of supply and with the respective engine-cylinders, the selector being operatively connected with the engine-mechanism and adapted, in any given position thereof, to direct the motive-fluid at the lower pressure to the engine-cylinder in which the piston is on the compression-stroke, to impart reverse movement to the engine-shaft, or to direct the motive-fluid at the higher pressure to the engine-cylinder in which the piston is on the expansion-stroke, to impart a starting-impulse to the engine, the lower of said two pressures being insufficient to cause a movement of the engine-pistons past dead-center.

3. An engine-starter having, in combination, a valve-casing with outlets adapted to be connected with the respective cylinders of the engine to be started, valves controlling said outlets, means for supplying motive-fluid under two different pressures to the valve-casing, and cam-mechanism for operating said valves, the cam-mechanism being adapted for connection with a moving part of the engine and being operative alternatively under manual control to operate the valves either to discharge low-pressure motive-fluid through one of said outlets, or to discharge high-pressure motive-fluid through another of said outlets, in any given position of the cam-mechanism.

4. An engine-starter having, in combination, a valve-casing provided with a plurality of outlets adapted to be connected with the respective cylinders of the engine to be started, a cam-follower connected with each valve, a shaft adapted to be connected with a rotative element of the engine-mechanism, two cams rotatively connected with said shaft so as to occupy definite positions with respect to each other and with the engine-mechanism in any position in which the latter may come to rest, said cams both having coöperative relation with said cam-followers but being normally out of engagement therewith, a source of supply of motive-fluid connected with the valve-casing, a manually-operable valve-member controlling the admission of motive-fluid to the valve-casing, mechanical connections between said valve-member and one of said cams whereby the cam may be moved into operative engage-

ment with one or the other of the cam-followers when the valve-member is manually operated, a second manually-operable valve-member controlling the admission of motive-fluid to the valve-casing, and mechanical connections between said second valve-member and the other cam whereby the latter may be moved into operative engagement with one or another of the cam-followers when said second valve-member is manually operated.

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