April 20, 1954 L. D. WATKINS ET AL 2,675,789

INTERNAL-COMBUSTION ENGINE

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Fig. 1

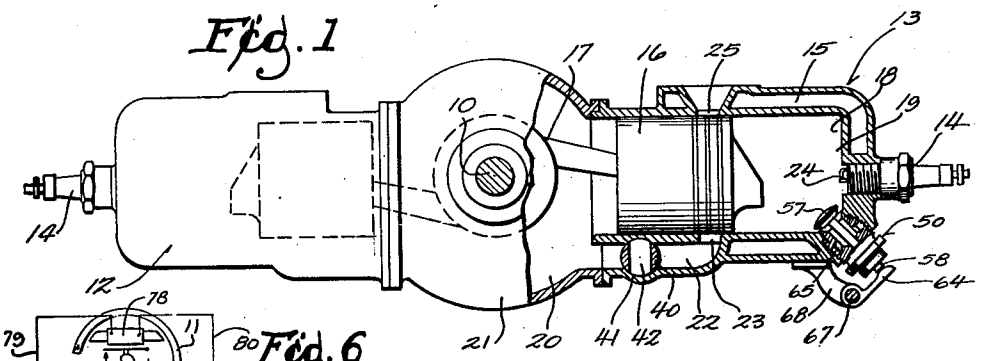


Fig. 6

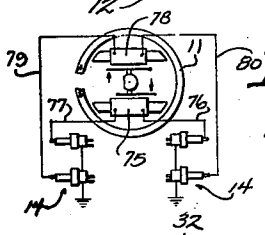


Fig. 2

Fig. 4

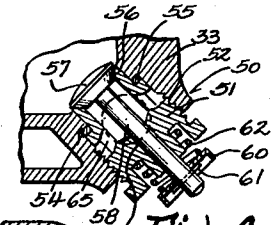


Fig. 5

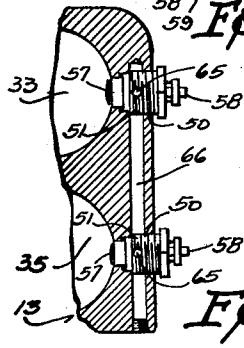
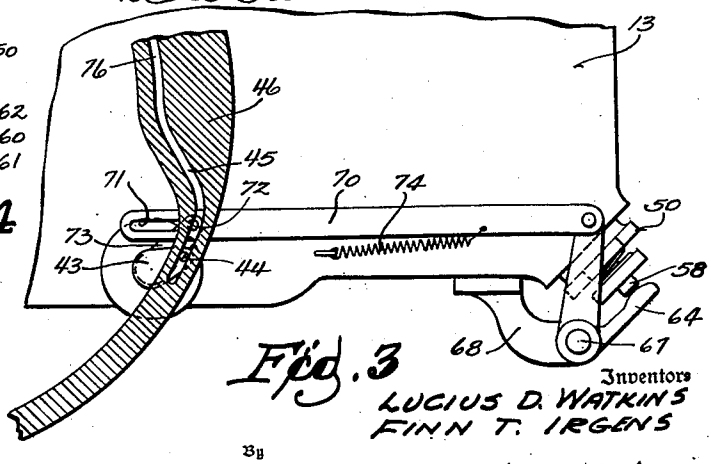


Fig. 3



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INTERNAL-COMBUSTION ENGINE

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10 Claims. (Cl. 123—41.13)

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Our invention relates to improvements in internal combustion engines.

More particularly stated our invention relates to the alternative operation or idling of certain cylinders of a multi-cylindered two-cycle engine so that only certain of the cylinders receive fuel and are worked, while others receive no fuel and are scavenged.

The objects of our invention are:

To improve the starting efficiency of a multi-cylindered internal combustion engine; to improve the slow speed operation of such an engine; to provide controlled adequate scavenging with predetermined "drag" in an idle cylinder of an operating internal combustion engine; to expend and waste no fuel through an idle cylinder or set of cylinders in a multi-cylinder two-cycle internal combustion engine; to automatically "cut-out" certain cylinders of a multi-cylindered engine at a predetermined lower speed of operation of the engine and at the same time automatically relieve or cut out fuel and compression loss as to those cylinders; to provide easier starting of a multi-cylindered internal combustion engine by cutting out certain cylinders and at the same time reducing compression in the idle cylinder and thus reducing the electric resistance across the points of a spark plug in such idle cylinder especially in an engine in which a plurality of spark plugs are in series connection in a plurality of cylinders for simultaneous spark; to provide in a two-cycle internal combustion engine having a pair of cylinders with pistons operating oppositely with respect to a single crank case chamber a bypass port valve so positioned as to close the port for one cylinder and force the concentration of the entire fuel mixture through the bypass port of the opposite cylinder for easier starting and better slow speed operation; to provide in a multi-cylindered engine a compression release involving no objectionable noisy operation; and to provide valve means for control of coolant for a multicylinder engine in combination with a control for idling certain of the cylinders whereby the idle cylinders may not be excessively cooled during the idling period of such idled cylinders.

In the drawings:

Figure 1 is a plan view of the top pair of cylinders and the intervening crank case of a four-cylinder two-cycle engine embodying our invention, one of the cylinders and part of the crank case being shown in horizontal section to exhibit a fuel shut-off valve and a scavenging valve used in carrying out our invention.

Figure 2 is a front elevation of a four-cylinder

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two-cycle engine embodying our invention, the fuel mixture transfer by-pass to one of the cylinders being broken away to show our air valve to control the by-pass; a portion of the flywheel being broken away to show our engine speed control inter-lock for coordinating our cylinder cut-out with engine speed; and a portion of the cooling jackets being broken away to show our coolant control means.

Figure 3 is an enlarged detail showing our speed and cut-out inter-lock.

Figure 4 is an enlarged section through one of the valves for scavenging control.

Figure 5 is a section through portions of the cylinder walls of adjacent cylinders and showing a compression release or scavenging intercommunicating duct, the valve cages at either end thereof being shown in side elevation.

Fig. 6 is a diagrammatic view in reduced scale showing the ignition system of our engine.

Like parts are designated by the same reference characters throughout the several views.

It will be understood from the following description of our invention that certain features of our improvement are adaptable to all multi-cylindered internal combustion engines. However, in our description herein the invention is shown and described as it is adapted to a multi-cylindered two-stroke cycle engine.

Our invention is especially adapted for use with and incorporation in a multi-cylindered two-cycle internal combustion engine wherein cylinders are arranged in sets, one of the sets comprising at least a pair of cylinders which may be "cut out," or rendered inactive in their combustion cycle while the remaining cylinders or sets of cylinders continue their combustion cycles and provide continued power for operation at idling or reduced speed.

Many multi-cylindered two-cycle engines do not "idle" well, and, after having idled, do not pick up speed in a satisfactory manner due to accumulation of heavy ends of fuel mixture in the crank case, and spark plugs tend to become fouled.

In the following description, we shall describe our invention as applied to a four-cylinder, two-cycle internal combustion engine such as the engine used in the power head of an outboard motor.

As shown in the drawings, an outboard motor power head includes a vertically disposed crank shaft 10 on the upper end of which is a fly-wheel 11 and radially from which are disposed sets of cylinders 12 and 13 which may be cast integrally. The engine shown in the drawings is a four-

cylinder engine with two cylinders in each set. The cylinders are disposed horizontally and each of them is provided with a spark plug 14. Each of the cylinders is water jacketed as indicated at 15 in the manner well known in this art, and each of the cylinders has a piston, such as the one shown at 16 connected to crank shaft 10 by means of connecting rod 17 so that the piston 16, in the operation of the engine, reciprocates to and from a firing chamber 18 at the head end 19 of the cylinder. When the piston is taken to its inner-most position toward the crank shaft, fuel gases are compressed in crank case chamber 20 of crank case 21 and a fuel by-pass 22 provides a supply of fuel gas from crank case chamber 20 to firing chamber 18, when piston 16 reaches its inner-most position and uncovers ports 23.

When, in the rotation of the crank shaft 10, the piston is forced to head dead center, the gases in the firing chamber are compressed and are fired by a spark across the points 24 of the spark plug 14, and the piston is again driven inwardly toward the crank shaft so that it may again uncover ports 23 for a new fuel charge. At the same time exhaust ports 25 are opened for the release of spent gases.

In the two-cycle motor of the type shown in the drawings, the crank case 21 is divided into an upper half 30 and a lower half 31. The chamber 20 of the upper half is associated with the upper cylinder 32 of set 12 and the upper cylinder 33 of set 13 and the cranks and connecting rods of these pistons in their respective cylinders are positioned to draw the pistons equally and oppositely toward the chamber 20. The pistons, connecting rods and the throws of the crank shaft in lower cylinders 34 (set 12) and 35 (set 13) are timed 180 degrees apart from the upper cylinder equipment so that when the pistons of the upper cylinders are at head dead center, the pistons in the lower cylinders are at crank dead center.

Because of the timing of the upper pair of cylinders as contrasted by the lower pair of cylinders in the two-cycle engine, when the upper cylinder in set 13 is under highest compression, the lower cylinder in set 13 is exhausting spent gases and receiving a new fuel charge.

From the above description, it will be seen that each set of cylinders 12 or 13 comprises an alternate firing two-cylinder, two-cycle engine which can operate as a power unit without assistance from other sets of cylinders, but if one of the sets of cylinders, for instance the set 13, is not exploding its charge of gases, the cycle of gas interchange through the by-pass 22 of each cylinder may be interfered with, and gas conditions in chambers 20 and 31 of crank case 21 may, and in most cases would be unsatisfactory.

Therefore, in carrying out our invention which contemplates the "cut out" of power operation of set 13 of cylinders, we make the following structural changes. As to each of the by-passes 22 in set 13 cylinders, we provide a rotary valve 40 extending vertically through a bore 41 which intersects by-pass passages 22. Rotary valve ports 42 extend through the rotary valve and are of sufficient capacity to pass all of the gases of which the by-passes 22 are capable of passing to their respective ports 23 and their respective cylinders which they are intended to feed.

At the upper end of the rotary valve 40, I provide rotary valve crank 43 and a rotary valve operating pin 44 which extends into a cam track 45 in magneto cam plate 46 for purposes to be described below. The rotary valve 40 may be rotated from a position in which passages 22 are wide open to a position as shown in Figure 1 in which passages 22 are closed. When closed, these passages, of course, can pass no gases to the cylinders in the set 13 and the cylinders in set 13 may be "cut out" without disturbing fuel gas conditions in the crank cases, it is then possible to run the engine merely with the cylinders of set 12 working.

Of course, the operation of the engine shown in the drawings at a time when valve 40 is closed would be impractical if the firing chambers 18 of the cylinders in set 13 are gas tight, therefore, we provide a compression release valve 50 for each of the cylinders; and we interconnect the operating mechanism for valve 40 with the operating mechanism of valves 50 so that when the valve 40 is closed valves 50 are open, as will now be described.

Each of the compression release valves 50 as shown in enlarged section in Figure 4 includes a valve cage 51 received into threaded engagement at 52 with its cylinder 33 or 35. The cylinder wall 33 is bored and counter-bored so as to provide a shoulder 54 against which the cage may abut. A sealing gasket 55 is disposed between the cage and the shoulder as indicated.

The cage has a seat 56 for valve head 57, and a valve stem 58 extends through bore 59 in the cage. A spring retainer washer 60 secured to the valve stem by key 61 holds a compression spring 62 carried in annular pocket 63 of the cage and this compression spring 62 holds the head 57 against seat 56 in typical poppet valve construction. An arm 64 (see Figure 1) bears against the end of the stem 58 to open the valve and when the valve is open gases may pass through the cage 51 and through the relief ports 65 which are in communication with a compression relief duct 66 extending between the two cylinders 33 and 35 (see Figure 5).

Since each of the cylinders 33 and 35 has a compression release valve (Figure 5), we have provided means of simultaneously opening these valves and attention is directed to Figure 2 where it will be seen that a compression release rocker shaft 67 carried by brackets 68 acts simultaneously to move rocker arms 64 for each of the valves. A crank 69 on the rocker shaft 67 has a connecting link 70 with a slot 71 to receive release pin 72 providing a connection with lever 73 forming part of the rotary valve assembly as shown clearly in Figures 2 and 3. A tension spring 74 connected between link 70 and the outside wall of the cylinder 33 holds the various parts in position to prevent vibration. It will be understood that spring 74 is not sufficiently strong to overcome springs 62 of the valves 50.

Thus the operation of rotary valve 40 to shut off gas supply to cylinders 33 and 35 is accomplished simultaneously with the opening of compression relief valves 50 of these cylinders, and when the compression relief valves are open, there is relatively rapid gas interchange between the cylinders 33 and 35 and particularly between their firing chambers. When the engine equipped in this manner is operated at moderate speeds with the valves open for interchange of gas between cylinders 33 and 35, the size of the compression relief duct 66 and its connecting passages is such that there is some "drag" upon the pistons in these "idle" cylinders. This is an important feature of our improvement since a free floating piston substantially free of such "drag"

is not conducive to good, smooth operation while the engine is operating on the power of the active cylinders 32 and 34.

Attention is directed to the position of valve heads 57 of the compression relief valves. It will be clear that upon compression release for a cylinder, such as cylinder 33, gas from this cylinder is passed rapidly through the valve 50 pertaining to cylinder 35. A rush of gases is thus directed at the points 24 of spark plug 14 in that particular cylinder and will necessarily cool and clean the points so as to prevent fouling thereof.

To facilitate operation of the valves 50 and the rotary valves 40, we have connected the coordinating links and other connections of these valves, and this coordination will now be described.

Somewhat conventionally in the construction of outboard motors, the fly-wheel 11 is provided with a magneto and the stationary parts thereof are mounted upon a magneto plate 46 which underlies the fly-wheel and which may be moved under manual control to determine the timing of spark whereby to determine the speed at which the internal combustion engine is to operate. Under these circumstances, the speed is in part controlled by adjusting the timing of the spark. In our internal combustion engine, cam track 45 is formed in the magneto plate 46 and is contoured as shown to actuate our valves in coordination with the adjustment for increased or decreased speed of engine operation. Cam track 45 is so shaped and so disposed that in the position shown in Figure 3 the rotary valve operating pin 44 is in the open position of rotary valve 40 and the closed position of valves 50, however, when the cam plate and magneto plate are moved to the position for low speed operation of the engine, the rotary valve operating pin will occupy a position shown at 76 in Figure 3. This means that the rotary valve operating pin has been swung through an arc of 90 degrees from the position shown in Figure 3. At the same time that such motion takes place with respect to the rotary valve and its operating pin 44, the compression release pin moves from one end to another of the slot 71, and, in the last few degrees of such movement, tensions link 70 to rotate crank 69 to depress valve stems 58 against the bias of springs 62 and move the valves 50 to open position.

Upon closure of rotary valve 40 and the opening of the compression release valves 50, the cylinders 33 and 35 of set 13 are "cut out," meaning that they no longer function to produce power and no combustion of fuel gases takes place in their firing chambers, but it will be understood by those acquainted with the art pertaining to two-cycle internal combustion engines, that the cylinders of set 12 continue to operate.

Since no fuel mixture is being fed to the cylinders 33 and 35, the only liquid accumulation in these cylinders will be that of a lubricating nature, which is brought into the cylinder by the pistons rubbing upon the cylinder walls. If, during long operation at slow speeds, the engine tends to accumulate a small quantity of lubricant or heavy ends of fuel mixture in the cylinders 33 and 35, there is no opportunity for fouling of the spark plugs 14 because of the rapid interchange of gases between the cylinders and through the passage 66 which directs jets of fast moving gas across the points 25 of the spark plugs as above described. It is, therefore, clear as demonstrated by repeated operation of an engine

made in accord with our invention that upon reestablishment of normal high-speed operation with the valves 50 closed and the rotary valves 40 opened, the cylinders 33 and 35 may resume their working operation, it being understood that at no time is the electrical cycle of operations for generating a spark at points 24 interrupted.

In our multi-cylindered two-cycle engine, cylinders 32 and 33 fire simultaneously and as shown in Figure 6, the spark plugs 14 of these two cylinders are connected in series with the high tension coil 75 either end of which is connected by leads 76 and 77 to the respective lugs. Each of the spark plugs is of course grounded as indicated in the diagram. The same type of circuit prevails with respect to the spark plugs 14 in the respective cylinders 34 and 35. These are in series with a coil 78 through leads 79 and 80. It is well known that high compression of gases in the firing chamber of an internal combustion engine provides higher resistance to the passage of high tension current across the points of the spark plugs in such a compression chamber, whereas a lesser pressure approaching atmospheric pressure provides much less resistance. It is also well known that a magneto such as that shown in Figure 6 develops less voltage at slower speeds of rotation of the flywheel such as that shown at 11 and which carries the permanent magnets used to generate the current required for the coils 75 and 78. Thus when our engine is operated at reduced speed and the compression is reduced in cylinders 33 and 35 by opening of compression release valves 50, the lessened compression in these cylinders reduces the resistance in the high voltage spark circuit. The resulting spark ignition in the cylinders 32 and 34 is intensified so as to increase the dependability of operation of our engine at low speeds. When the engine is increased in speed by reason of the closure of the valves 50 and the opening of rotary valve 40, the timing of the magneto plate 46 is advanced with resultant increase of speed of operation and increase of voltage to take up the increased resistance across the points of the spark plugs in the cylinders 33 and 35.

When our engine is adjusted for slow speed operation in accord with the closure of valve 40 and the opening of valves 50, it is obvious that the cylinders 33 and 35 will be cool by reason of the absence of combustion therein. Jackets 15 of these cylinders receive cooling water from a duct 85 through which water is pumped by the usual outboard motor water pump (not shown). We therefore provide as an extension upon the rotary valve member 40 a water controlling extension 86 ported at 87 so that when the rotary valve member 40 is in the position shown in Figure 2 the duct 88 intended to feed cooling water to the jackets of cylinders 33 and 35 is closed. The duct 89 extending to the jackets of cylinders 32 and 34 remains open and all of the water moved by the relatively slow moving pump at this time is passed to these working cylinders. As soon as the motor is adjusted for high speed operation and the rotary valve member 40 is moved to open position, the port at 87 is aligned with the water passage 88 and the cylinders 33 and 35 are cooled in the usual manner. We thus provide protection against excessive cooling and condensation in the idle cylinders 33 and 35 during slow speed operation.

It will be clear from the above description that effort required to start our improved engine is minimized. Even though an engine has many

cylinders, it is possible to cut out certain of them and thus reduce the effort required to compress gases in them during starting operations. The engine can be started on the basis of a few of the cylinders and when there is sufficient speed of operation the remaining cylinders may be "cut in." Not only is the required effort for starting purposes minimized, but there is also an augmented charge of mixed fuel gases passed to the cylinders during the starting operation. Simultaneously there is the advantage of intensified spark in the cylinders used at the time of starting thus making the conditions ideal in the few working cylinders. As soon as conditions of operation at the lower speed are determined to be satisfactory, the engine is ready for high speed operation merely by changing the position of the magneto plate 46 which with its cam track 45 will move the rotary valve 40 and the valves 50 to the proper positions for putting the idle cylinders to work.

We claim:

1. A multi-cylindered internal combustion engine in which each cylinder has a firing chamber and a spark plug, a duct providing intercommunication for gases between the firing chambers of adjacent cylinders, and a valve controlling the duct, said valve having a gas deflecting surface directed toward said spark plug whereby gas flowing through said duct and deflected by said surface against the spark plug wall cools and cleans said spark plug, said cylinders being arranged in opposed pairs and said duct connecting the firing chambers of corresponding cylinders of said pairs, means for interrupting flow of fuel to said interconnected cylinders and means for opening said duct valve when said fuel is interrupted whereby gas will flow through said duct.

2. In an internal combustion engine having plural cylinders, cooling fluid jackets about said cylinders, a source of coolant and a coolant passageway leading from said source and having branches to said jackets, a control for selectively cutting out one of said cylinders whereby one of said cylinders is active and another of said cylinders is idle, coolant valve means in a branch leading to the jacket of the cylinder which may be cut out, and means interconnecting said control with said coolant valve means for actuating said control and said valve means concurrently to limit passage of coolant to the jacket of the cut out cylinder while it idles and to restore coolant to the jacket of said last cylinder when it ceases to idle.

3. The device of claim 2 in which said control comprises a fuel valve in further combination with means controlled by the fuel valve for supplying fuel to the active cylinder, said coolant valve being directly connected with said fuel valve for concurrent opening and closing movement.

4. A two stroke cycle internal combustion engine having four cylinders arranged in pairs of opposed cylinders, corresponding cylinders of said pairs being arranged in sets, the cylinders of one of said sets having open fuel inlet ducts for continuous operation and the cylinders of the other of said sets having inlet ducts provided with valves in said ducts movable to closed position to incapacitate said last mentioned set of corresponding cylinders, the corresponding cylinders of said last mentioned set having firing chambers fed by said ducts, an intercommunicating duct between said corresponding cylinders of the last mentioned set, and valve means to control gas flow between the last mentioned cylinders through said intercommunicating duct.

5. The device of claim 4 further provided with a speed control having a normal running speed setting and a predetermined low speed setting, said inlet and compression release valve means having coordinating connections with said speed control whereby the inlet duct valves are shut and the compression release valve means is open in the low speed setting of the speed control whereby fluid present in the firing chambers of the last mentioned set of cylinders is forced back and forth through said intercommunicating duct between the said respective firing chambers of the corresponding cylinders of said last mentioned set.

6. The device of claim 5 wherein the intercommunicating duct comprises a restricted passage to resist free interchange of fluid and impose a light load on the operating cylinders of the first mentioned set.

7. A two stroke cycle internal combustion engine having four cylinders arranged in pairs of opposed cylinders, corresponding cylinders of said pairs being arranged in sets, the cylinders of one of said sets having open fuel inlet ducts for continuous operation and the cylinders of the other of said sets having inlet ducts provided with valves in said ducts movable to closed position to incapacitate said last mentioned set of corresponding cylinders, the corresponding cylinders of said last mentioned set having firing chambers fed by said ducts, an intercommunicating duct between said corresponding cylinders of the last mentioned set, and valve means to control gas flow between the last mentioned cylinders through said intercommunicating duct, being further provided with a speed control having a normal running speed setting and a predetermined low speed setting, said inlet and compression release valve means having coordinating connections with said speed control whereby the inlet duct valves are shut and the compression release valve means is open in the low speed setting of the speed control whereby fluid present in the firing chambers of the last mentioned set of cylinders is forced back and forth through said intercommunicating duct between the said respective firing chambers of the corresponding cylinders of said last mentioned set, said speed control comprising a plate having a cam surface, said inlet valves having a cam follower arm engaged therewith and an actuating link from the compression release valve means connected for coordinated action with said cam follower, said cam surface having a slow speed setting in which the inlet valves are closed and the compression release valve means is open.

8. The device of claim 7 in which the connection of the actuating link and the cam follower includes lost motion for sequential operation of the inlet valves and compression release valve means whereby the inlet valves are fully closed before the compression release valve means is opened.

9. A two stroke cycle internal combustion engine having four cylinders arranged in opposed pairs, two corresponding cylinders of said pairs having an interconnecting duct, compression release valve means controlling said duct, said corresponding cylinders having fuel inlets and control valves therefor, and coordinating connections between said inlet valves and said compression release valve means, coolant connections to said cylinders comprising a branch connection

to said interconnected corresponding cylinders, and valve means controlling said branch, said coolant branch valve means having coordinating connections with said inlet valve means, a speed control having a cam, the coordinating connections of said inlet valves with said compression release valve means and said coolant branch valve means comprising a cam follower arm engaged with said arm, said speed control means having a normal running speed setting and a predetermined low speed setting in which said inlet valves and said coolant branch valve are closed and said compression release valve means is open, whereby fuel flow and coolant flow are interrupted and interchange of gases between said chambers through said interconnecting duct is effected.

10. The device of claim 9 in which each cylinder is provided with a spark plug and high tension electric spark circuits in which the plugs in said paired cylinders are in series whereby release of compression in said corresponding cylinders of said pairs increases the intensity of the spark in the other cylinders of said pairs.

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