W. B. S. WHALEY & A. L. GALUSHA.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED OCT. 7, 1907.

1,039,865. Patented Oct. 1, 1912.

2 SHEETS—SHEET 1.

Fig. 1.

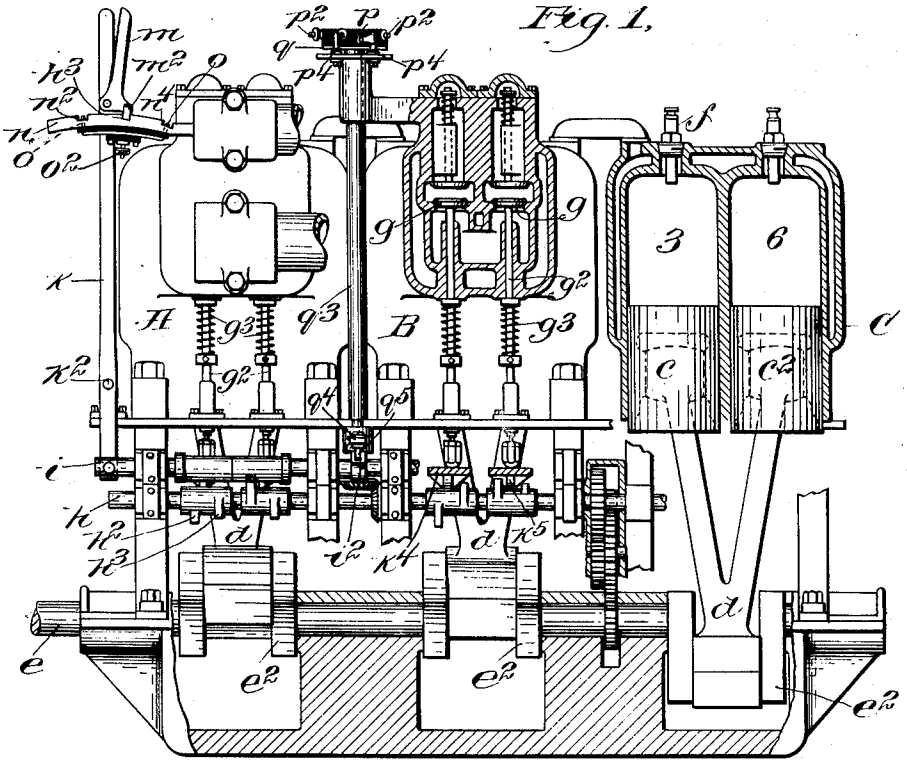
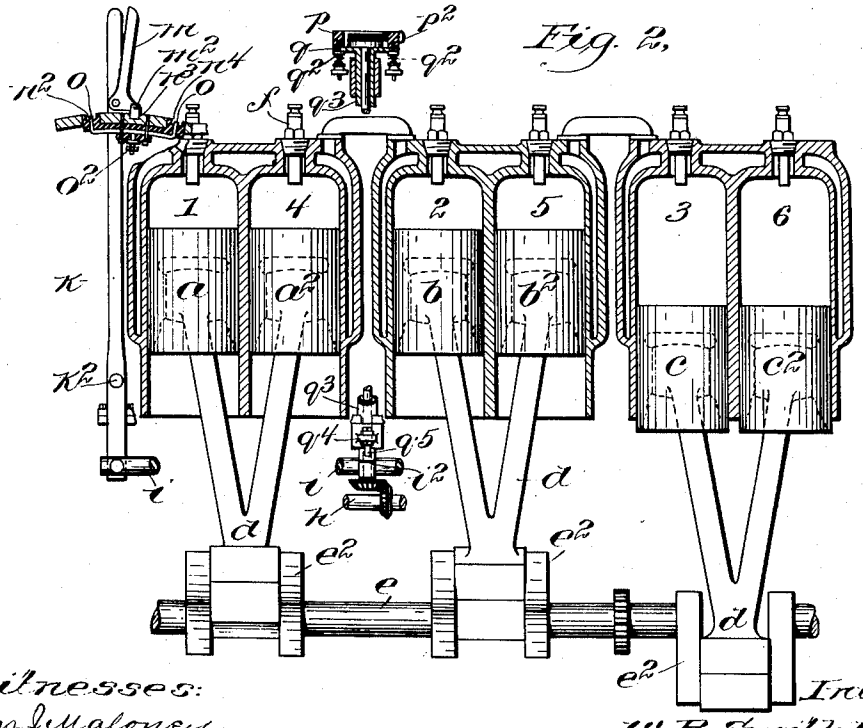


Fig. 2.



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2 SHEETS—SHEET 2.

Fig. 3.

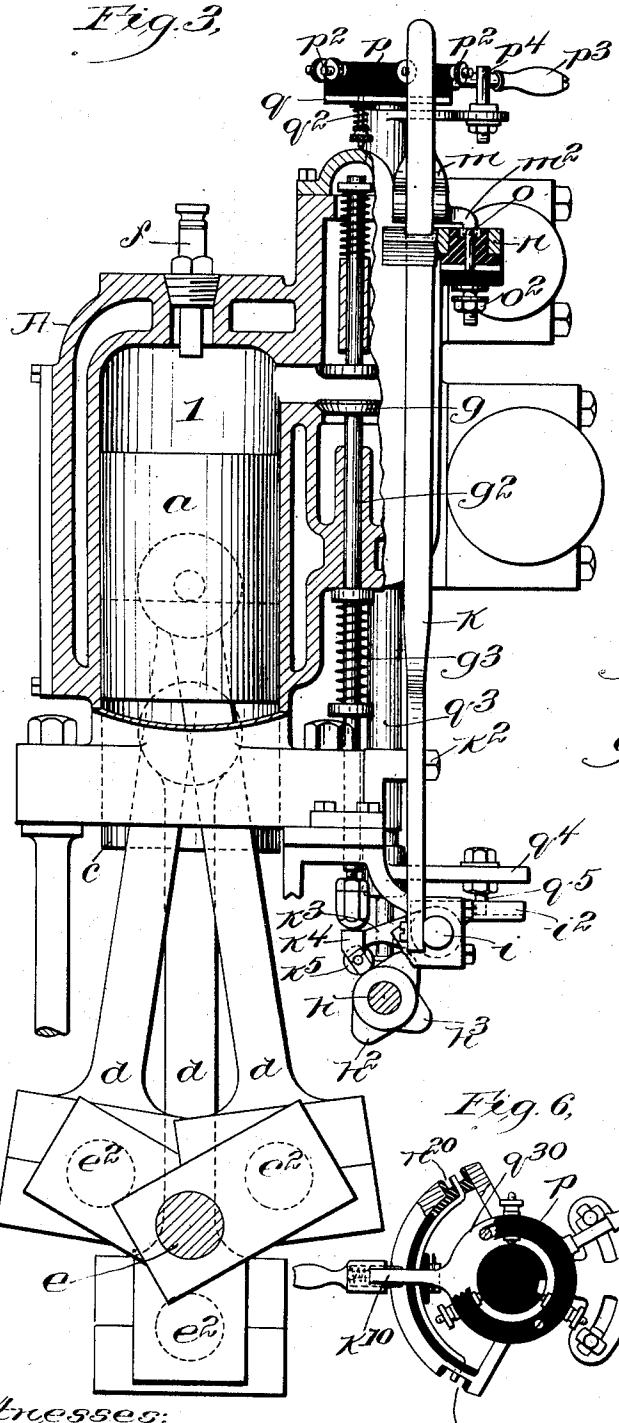

Fig. 4.

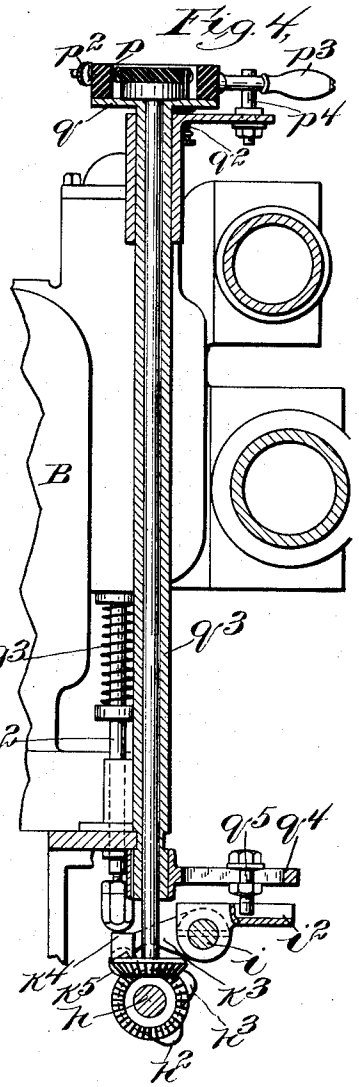

Fig. 5.

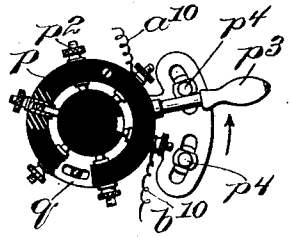

Fig. 6.

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UNITED STATES PATENT OFFICE.

WILLIAM B. SMITH WHALEY AND ALBERT L. GALUSHA, OF BOSTON, MASSACHUSETTS, ASSIGNORS, BY MESNE ASSIGNMENTS, TO THE REVERSIBLE GAS-ENGINE COMPANY, OF PORTLAND, MAINE, A CORPORATION OF MAINE.

INTERNAL-COMBUSTION ENGINE.

1,039,865. Specification of Letters Patent. Patented Oct. 1, 1912.

Application filed October 7, 1907. Serial No. 396,290.

To all whom it may concern:

Be it known that we, WILLIAM B. SMITH WHALEY and ALBERT L. GALUSHA, both of Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Internal-Combustion Engines; and we do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The present invention relates to an internal combustion engine, and is embodied in an engine which is capable of being started on its own ignition, and which may also be provided with reversing mechanism whereby the engine can be caused to run in either direction. The invention relates mainly to the controlling mechanism which is operated to start and stop the engine, the purpose of the invention being to provide the engine with means whereby all operations which must be performed to start the engine are performed by the movement of a single controller or actuating device.

The engine embodying the invention is provided with at least three cylinders with cranks at approximately 120° apart around the crank shaft, there being, preferably, a multiple of three, six being the best number, for example, when the invention is applied, as shown, to a four-cycle engine. With the pistons arranged in this way, the engine, after running, will usually come to a standstill when the explosions of gas cease, with two of the pistons or two pairs of pistons in successively operating cylinders substantially equi-distant from the cylinder heads, and the cranks belonging to said pistons at opposite sides of the center. Assuming, therefore, that the cylinders are charged with an explosive gas, the engine will start upon the ignition of the gas in either cylinder, the direction of movement depending upon the cylinder in which the charge is exploded.

In order to make the engine reversible, it is necessary to reverse the valve action prior to the starting of the engine and, in order to start the engine successfully it is also necessary to control the timing of the ignition so that the initial igniting effect in each cylinder will take place in the proper relation to the piston movement.

While the invention is applicable to any system of ignition the time of which is controllable, a jump spark ignition system is herein shown for purposes of illustration, the ignition being controlled by a timer of the usual construction, the said timer consisting of a continuously rotating element having a single contact which successively closes the circuit through stationary contacts leading to the spark plugs in the different cylinders. By "stationary," as hereinafter used in this connection, is meant relatively stationary, *i. e.*, as distinguished from the continually rotating member. The so-called stationary member, however, is adjustable between certain limits, for timing the ignition, as will be described. In this construction, it is obvious that the ignition takes place as soon as the rotating element comes in contact with the stationary element, there being, moreover, a material interval of time during which the spark is sustained owing to the necessary area of contact surfaces. It becomes necessary, therefore, in reversing the engine, to control the timer by moving one or the other of the contact members a sufficient distance to bring the initial engagement into the proper relation to the piston movement when the traveling contact member is moving in either direction. In the construction chosen for illustration, the normally stationary part of the timer is capable of being moved between certain limits, the movement being effected through the operation of the controlling device which establishes the circuit for starting the engine and shifts the valve gear, if the engine is reversible. Incidentally, this movement may be of sufficient extent to insure the establishment of the circuit through the proper timer contact simultaneously with the closure of the circuit through the operating device, so that no manipulation of the timer is necessary to start the engine.

It is further practicable, as will be hereinafter described, to provide means for an

independent manual control of the timer member for the purpose of controlling the spark while the engine is running.

Figure 1 is a side view, partly in elevation, and partly in section, of an engine embodying the invention; Fig. 2 is a longitudinal vertical section through the cylinders mainly for the purpose of showing the relative piston positions; Fig. 3 is an enlarged end elevation, partly in section, looking toward the left-hand side of Fig. 1; Fig. 4 is a vertical section along the timer shaft; Fig. 5 is a plan view, partly in section, of the timer; and Fig. 6 is a similar view showing a modification.

A, B, C, represent three pairs of parallel cylinders, supported in any suitable manner upon an engine bed or frame. Pistons a, a^2, b, b^2, c, c^2, are located in the cylinders and in the construction shown the pistons of each pair are connected by a forked connecting rod d with a single crank e^2 of the main driving shaft e, said pair of pistons moving in parallel as a single piston. In the drawing I have shown three pairs of cylinders, the three pairs of pistons driving the shaft e through the medium of the connections between the pairs of pistons and the three cranks e^2 of said shaft. This, it should be understood, is merely a matter of design, ignition taking place alternately in the cylinders of each pair. Igniting devices f and suitable valve mechanism are provided for the several cylinders and are so timed and operated, as hereinafter described, as to give successive firing in the various cylinders, so that in a four-cycle engine, the cranks will have six impulses for every two revolutions.

The several exhaust valves g are shown as provided with depending stems g^2 and springs g^3 on these stems serve to maintain the valves normally upon and reutrn them to their seats. Below the lower ends of the valve stems, a cam shaft h is mounted in the framework of the engine and carries several pairs of cams h^2, h^3, one pair of such cams, oppositely disposed, being provided below each valve stem and adapted to actuate the valves, through the medium of intermediate devices presently explained, to control the running of the engine in one direction or the other, said intermediate devices being part of the system which controls the stopping of the engine, and the starting of the same in either direction.

To produce the desired operation, a slide-member i is mounted between the cam shaft and the valve stems, and is capable of longitudinal movement. The movement of this slide-member is effected by means of a lever k pivoted at k^2 to the engine frame at one end thereof. A series of arms k^3 are connected with the slide member i so as to be capable of an oscillatory movement thereon, and correspond in number to the number of pairs of cams h^2, h^3, each of said arms being provided with a head k^4 of sufficient width to enable it to be shifted between the cam h^2 and the cam h^3 of a pair of cams without being moved out of alinement with the valve stem under which said head is disposed. Each head k^4 is recessed for the accommodation of a roller k^5 to be engaged by the cams, when in operation. The intermediate devices thus constructed and arranged constitute actuators for the valves, being adapted to operate the valves for forward running of the engine when shifted so as to be moved by one cam of each pair, or to operate the valves for reverse running of the engine, when oscillated by the other cam of each pair. The actuators will, of course, not be oscillated when they are caused to assume a position intermediate of two cams, so that at such time, the valves will not be operated and the engine will come to or remain at rest with all the exhaust valves closed.

In order to prevent ignition of the gases in the cylinders when the exhaust valves are put out of operation by the movement of the actuators to the intermediate position, the engine is also provided with means for also suspending the ignition. As herein shown, the usual jump-spark ignition system is used, and by breaking the electric circuits which include the sparkers, when the valve actuators are shifted to intermediate positions, such gas as may be drawn in through the intake is trapped in the cylinders without being ignited. Under these conditions, in a three or six cylinder engine with the cranks set at 120 degrees apart, the machine will come to rest with the pistons in two cylinders, or two pairs of cylinders, equidistant from the cylinder heads, and with the pitmen inclined in opposite directions, as best shown in Fig. 3, and the charge in the two cylinders under substantially equal compression. This is because the two trapped charges are practically equal in quantity and both under compression, so that the pistons will stop when the two charges come to a balance. The engine can, therefore, be started by merely selecting the cylinder in which the trapped charge is to be fired, according to the direction in which it is desired that the engine shall run.

It is desirable that common means be provided for making and breaking the electric circuit of the sparkers and for shifting the valve actuators, as the separate actuating of these devices would require very skilful manipulation, and the proper starting of the engine would depend rather upon the skill of the operator, than upon the surer and safer operation of the structural features of the machine, which is a matter of much importance in the operation of an engine of the type to which my invention relates. To provide means for the accomplishment of

the results above outlined, the devices now to be described have been found to be efficient.

The lever k, by means of which the valve actuators are shifted as hereinbefore explained, is provided with a latch m provided with a toe m^2 to enter any one of a series of three notches n^2, n^3, n^4, in an arm or segment n secured to the engine. It is apparent that when the toe of the latch engages one of the notches n^2 or n^4 the valve actuators will be retained in proper position to cause the valve to be operated, either for forward running of the engine or the reverse and that when the lever k has been so moved as to cause the toe of the latch to engage the intermediate notch n^3, the valve actuators will be retained in position intermediate of the cams and the engine will be stopped.

Suitably insulated contact fingers project into the notches n^2 and n^3, and these contact fingers are included in electric circuits from any suitable source of electrical energy, with the sparkers in the cylinders and with the lever k and its latch m. A binding post o^2 serves as convenient means for attachment of one of the conductors of the sparker circuit, with the fingers o. The contact points or fingers o and the notches n^2 and n^4 are so proportioned, that before the toe of the latch is fully withdrawn from one of the said notches, the electric sparker circuit will be broken. As the contact fingers project only into the notches n^2 and n^4, of the segment n and as these fingers and the latch m are included in the sparker circuit, said circuit can be closed only when the lever k is thrown to shift the valve actuators, either for forward or reverse running of the engine, so that unless the toe of the latch is in either the notch n^2 or n^4, no explosions can occur in any of the cylinders.

From the above, it will be seen that as soon as the latch m is operated to withdraw the toe of the latch from either of the notches the sparking circuit will be broken, and by the time that the lever k can be shifted to the intermediate position, with the toe of the latch engaging the notch n^3, and the operation of the valves stopped, explosive charges will have entered the cylinders, but as the circuit of the sparkers has been opened, these charges cannot now be exploded and will be trapped in the cylinders, ready to be exploded as soon as the lever is thrown to one position or the other.

In order to cause the engine to start in response to the movement of the lever to the operating notch, it is necessary to provide means whereby the same movement will be imparted to the timer or equivalent igniting device. Owing to the balance of compression in two successively operating cylinders, the engine will come to rest with the pistons in the two cylinders which would act next in the cycle of operations, if the ignition had not been cut off, at points substantially equidistant from the cylinder heads, and each in a favorable position to receive an impulse if the charge in the cylinder is ignited. Since one of the pistons will stop during its inward movement while the other stops during its outward movement the cranks will be at opposite sides of the center, so that the engine will start in one direction or the other according to which cylinder is first acted upon. Assuming the stationary member of the timer to be in its normal position, the movable member of the timer will have passed the contact in one cylinder, but will not have reached the contact in the next cylinder, or, in other words, will stand somewhere between the two contacts so that no ignition can take place, even when the circuit is closed by the controlling lever, unless one or the other of the sets of timer contacts are brought together. To start the engine forward, therefore, it is necessary to move the normally stationary timer member forward, and to start the engine in a reverse direction it is necessary to move said member back. In order to make the operation positive, the stationary timer member, in accordance with the invention, is connected with the controlling lever k and is arranged to have a movement sufficient to throw it the distance between adjacent contact devices, while the starting lever is moved from either one of its operating positions to its intermediate position.

In the construction shown, the sliding member i is provided with a slotted projection i^2, which receives the end of an adjustable pin q^5 in an arm q^4, connected with the timer, as will be hereinafter described, so that the longitudinal movement of the slide-member is imparted to the normally stationary timer-member. Provision is also made for lost motion if the operating lever is moved farther in the same direction, the connection being a frictional one, however, so that if the operating lever is moved back it will carry the timer member with it.

In the construction shown, the stationary timer member p which consists, as usual, of a ring of insulating material containing the several contacts which lead to the spark plugs, is frictionally held upon a disk q by means of springs q^2 which hold the disk and the ring together, so that the movement of the disk will be imparted to the ring unless such movement is resisted. The disk q is mounted on a sleeve q^3 which is connected by means of the arm q^4 with the main actuating lever as above, the proportions being such that the movement of the main actuating lever from the middle notch n^3 to either of the operating notches will move the disk q a distance substantially equal to

the distance between the adjacent sides of the spark plug contact members. If the engine is being reversed from the direction in which it is running when stopped, the ring p will remain stationary; but if the engine is being started in the same direction, the ring p will be moved the distance between two contacts, as more fully described hereinafter.

For purposes of manipulation by advancing or retarding the spark when the engine is running, the member p is provided with a handle p^3, and this handle may be utilized in connection with adjustable stops p^4 to determine the amount of throw which is accomplished through the movement of the starting lever of the machine.

In order to explain more fully the operation of the timer, it may be assumed, first, that the circuit has been broken so as to allow the engine to come to rest, the result being that the pistons in two successively operating cylinders will finally stand substantially equi-distant from the cylinder heads and with the cranks at opposite sides of the shaft, as indicated in Fig. 3. Referring to Fig. 2, and assuming that the sequence of firing is as indicated by the numerals 1 to 6 in the cylinders, we may also assume that the engine has come to rest with cylinders 1 and 2 in firing condition, that is to say, the cylinders containing the pistons a and b, respectively. With the pistons in this position, the movable timer contact will have passed beyond the terminal leading to the spark plug in cylinder 1, since, under running conditions, the charge in said cylinder would have been exploded before the piston reached the position shown. At the same time, the timer contact would not have reached the member leading to the spark plug in cylinder 2, since, under normal running conditions, the movement of said piston would be upward in its action of final compression of the charge before the ignition thereof. Referring to Fig. 5, the conductor a^{10} may be regarded as controlling the spark plug in the cylinder 1, and the conductor b^{10} as controlling the spark plug in the cylinder 2. In the movement of the lever k, however, from the operative to the intermediate position, the timer member p has been shifted in the direction of the arrow, the said timer member being carried through its frictional connection with the disk q until the handle p^3 reaches the stop p^4, so that the said member p will stand in the position shown in Fig. 5 regardless of the extent of movement of the member q through the tendency of the lever k. If, therefore, during the running of the engine, the handle p^3 has been moved in the direction of the arrow for the purpose of advancing the spark, it will, upon stopping the engine, come in contact with the stop p^4 prior to the complete movement of the actuating lever, and will be properly positioned by said stop in the starting position. With the timer contact in the position shown in Fig. 5, if the circuit is closed, ignition will take place in the cylinder 2, thus giving an impulse to the piston b which will start the engine in the reverse direction. At the same time, the shifting movement of the timer member controlled by the stops has placed the successive contacts in such position as to explode the charges in the successive cylinders at the right time. When, therefore, it is desired to reverse the engine, the lever k is moved from the neutral notch to the reversing notch, the timer member remaining in the position shown in Fig. 5, owing to the action of the stop p^4 and the lost motion permitted by the frictional connection between the timer member and the sleeve q^3. In other words the movement of the sleeve q^3, responding to the movement of the lever k, has no effect on the distributing member p which remains in the position shown. If, on the contrary, it is desired to start the engine forward, the movement of the lever k back to the notch in which it originally stood will shift the timer member back to the other stop p^4, since there is nothing else in the path of the handle p^3 to prevent such movement, such distance being sufficient to bring the terminal of conductor a^{10} into contact with the back of the traveling terminal, thus causing an explosion in cylinder number 1, so as to start the engine forward. The shifting of the timer member thus not only serves to insure the making of the proper contact to start the engine in either direction, but also serves to compensate for the width of the terminals, so that the spark will be properly timed when the engine is traveling in either direction. Furthermore, the handle p^3 can be utilized to advance the spark as the engine speeds up, the position shown, as determined by the stop p^4, being the normal retarded sparking position for slow speed or starting.

In applying this principle to two-cycle engines, the starting lever k^{10} and the circuit controllers operated thereby will be connected directly to the timer member q^{30}, Fig. 6, which is the equivalent of the sleeve q^3, the said lever k^{10} coöperating with circuit controllers in notches n^{20} and n^{40}. The action of the timer is the same except that a little longer throw of the timer member is required owing to the fact that in a three-cylinder, two-cycle engine, the spark plug terminals are only three in number, and are 120, instead of 60° apart.

Claims:

1. In an internal combustion engine, a timer comprising a traveling contact and a series of contacts adjustable to advance or retard the spark, combined with a circuit

closer governing the ignition circuit; an actuator adapted to open one member of said circuit closer; and connecting mechanism between said actuator and said series of contacts whereby said series of contacts are placed in a predetermined position prior to the closing of the circuit.

2. The combination with an internal combustion engine of valve controlling devices; means for shifting said valve controlling devices to time the valves for the operation of the engine in either direction; an ignition circuit; a circuit breaker included in the ignition circuit; an actuating lever common to said valve shifting means and said circuit breaker; and means whereby said circuit breaker must be operated prior to the movement of the actuating lever which operates the valve shifting means.

3. The combination with a multi-cylinder internal combustion engine; of an ignition timer; means for positioning the timer for ahead or reverse operation; means for controlling the operation of the cylinder valves; a circuit closer for the ignition circuit; and a common actuating handle for the means for positioning the timer, the means for controlling the operation of the cylinder valves and one member of the circuit closer, the relation of the circuit closing member operated by the handle to the other member of the circuit closer being such that the circuit can be closed or opened only by a manual operation of the controlling handle to and from a predetermined position.

4. In a reversible internal combustion engine, the combination with a valve gear, timer and shifting mechanism common to the said valve gear and timer; of igniting devices; and means whereby the igniting devices are controlled by said shifting mechanism so that no ignition can take place prior to the complete shifting of the valve gear and timer.

5. In a reversible internal combustion engine, the combination with a valve gear, timer and shifting mechanism common to said valve gear and timer; of a circuit closer governing the ignition circuit and controlled by said shifting mechanism whereby the ignition circuit can be closed only after the shifting movement of the shifting mechanism has been completed.

6. In an internal combustion engine, the combination with igniting devices for the several cylinders; of a timer; a shiftable contact member carrying the contacts which severally control the ignition in the several cylinders; stops limiting the movement of said contact member; an actuator to produce the shifting movement of said contact member; and a yielding connection between said actuator and said shifting member, substantially as and for the purpose described.

7. The combination in an internal combustion engine, of a cam shaft; longitudinally movable valve actuators; an actuating lever connected with said longitudinally movable valve actuators to shift the same relatively to the cams on the cam shaft, and a circuit closer for the ignition circuit operated by said actuating lever to positively close the circuit at the end of the movement of said actuating lever to running position, the circuit being broken when the actuating lever is in any other position.

8. The combination in an internal combustion engine, of a series of cams, valve actuators to be operated by said cams, a lever for shifting said actuators relatively to the cams, a segment having a series of three notches, contact fingers projecting into two end notches of the series and a latch carried by said lever and having a toe to enter one or another of said notches, said contact fingers and latch included in circuit with the sparker of the engine.

9. In an internal combustion engine, the combination with a plurality of cylinders, igniting devices and valves; of actuators for said valves; a timer in the circuit of the igniting devices; a circuit breaker also in the circuit of the igniting devices; and a single actuating handle common to the valve actuators, timer and circuit breaker, for operating the circuit breaker and shifting the valve actuators and the distributing contacts of the timer.

10. In an internal combustion engine, the combination with a series of cylinders provided with igniting devices and valves; of valve actuators, a longitudinally movable member to which said valve actuators are attached, a timer comprising a normally stationary member carrying a series of contacts, and a rotary member carrying a contact within the normally stationary member of the timer, a tubular shaft to which the normally stationary member of the timer is secured, an arm on said tubular shaft, a pin projecting from said arm, a slotted arm projecting from the longitudinally movable shaft and receiving said pin, a timer shaft passing through the tubular shaft and carrying the rotary member of the timer, means for driving said timer shaft, and means for moving the longitudinally movable shaft to shift the valve actuators and the normally stationary member of the timer.

11. In a reversible internal combustion engine, the combination with a valve gear and a distributing ignition timer member; of shifting mechanism for said valve gear and said timer member; and common means for operating said shifting mechanism and closing the circuit through the timer.

12. In an internal combustion engine, an ignition system including means for timing the ignition; a circuit closer for the ignition circuit; an actuator for said circuit closer;

and connecting mechanism between said actuator and the means for timing the ignition, whereby the operation of the said means for timing the ignition is completed prior to the closure of the circuit.

13. In an internal combustion engine, an ignition system including means for timing and operating the ignition; an actuator for said timing and operating means, having stopped and running positions; and connecting mechanism between said actuator and said timing means, whereby the ignition system is set for the retarded ignition by the movement of the controller from running to stopped position.

In testimony whereof, we have signed this specification in the presence of two subscribing witnesses.

WILLIAM B. SMITH WHALEY.
ALBERT L. GALUSHA.

Witnesses:
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