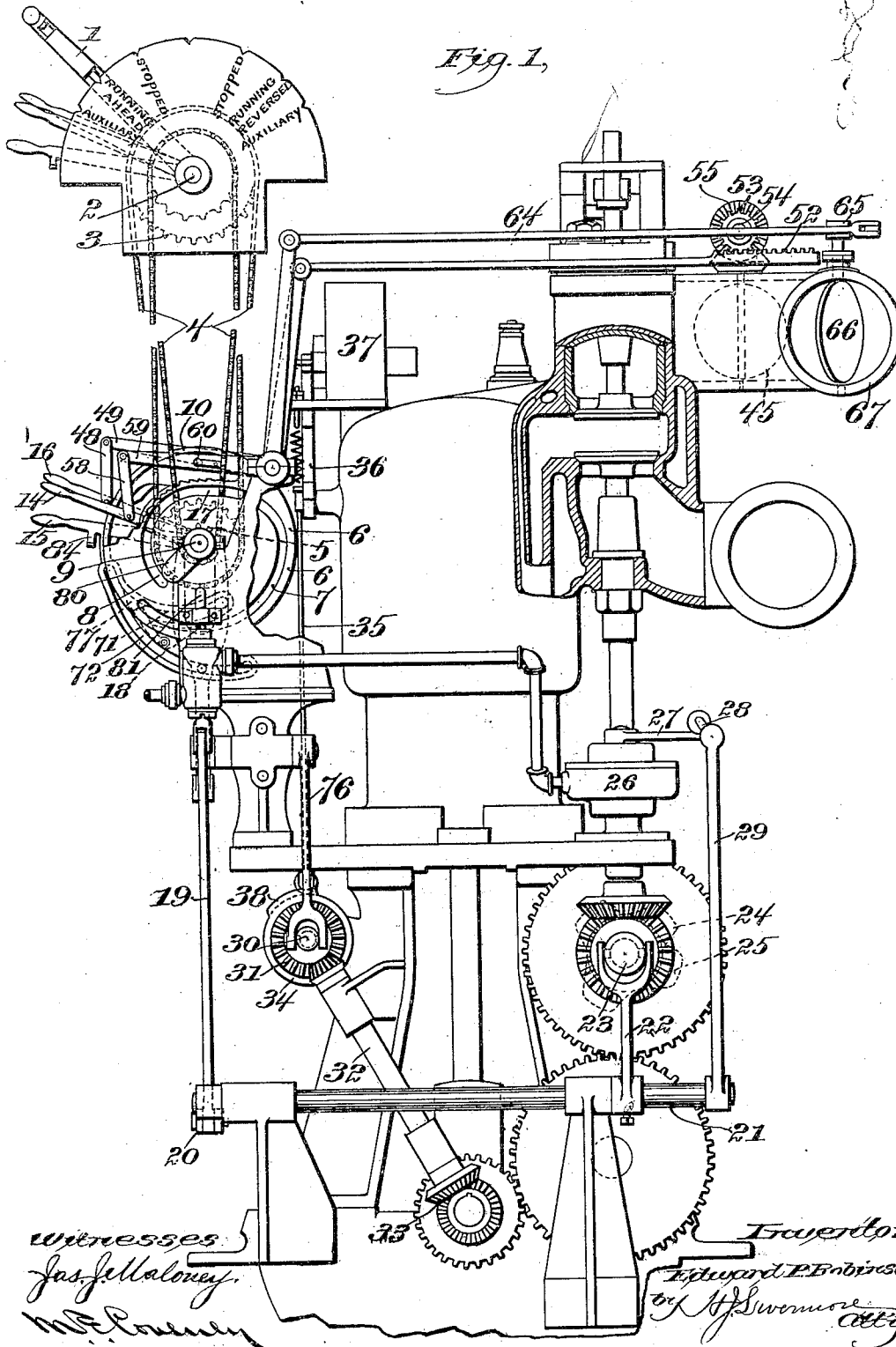


E. P. ROBINSON.  
INTERNAL COMBUSTION ENGINE.  
APPLICATION FILED JUNE 9, 1911

1,040,018.

Patented Oct. 1, 1912.

4 SHEETS—SHEET 1.

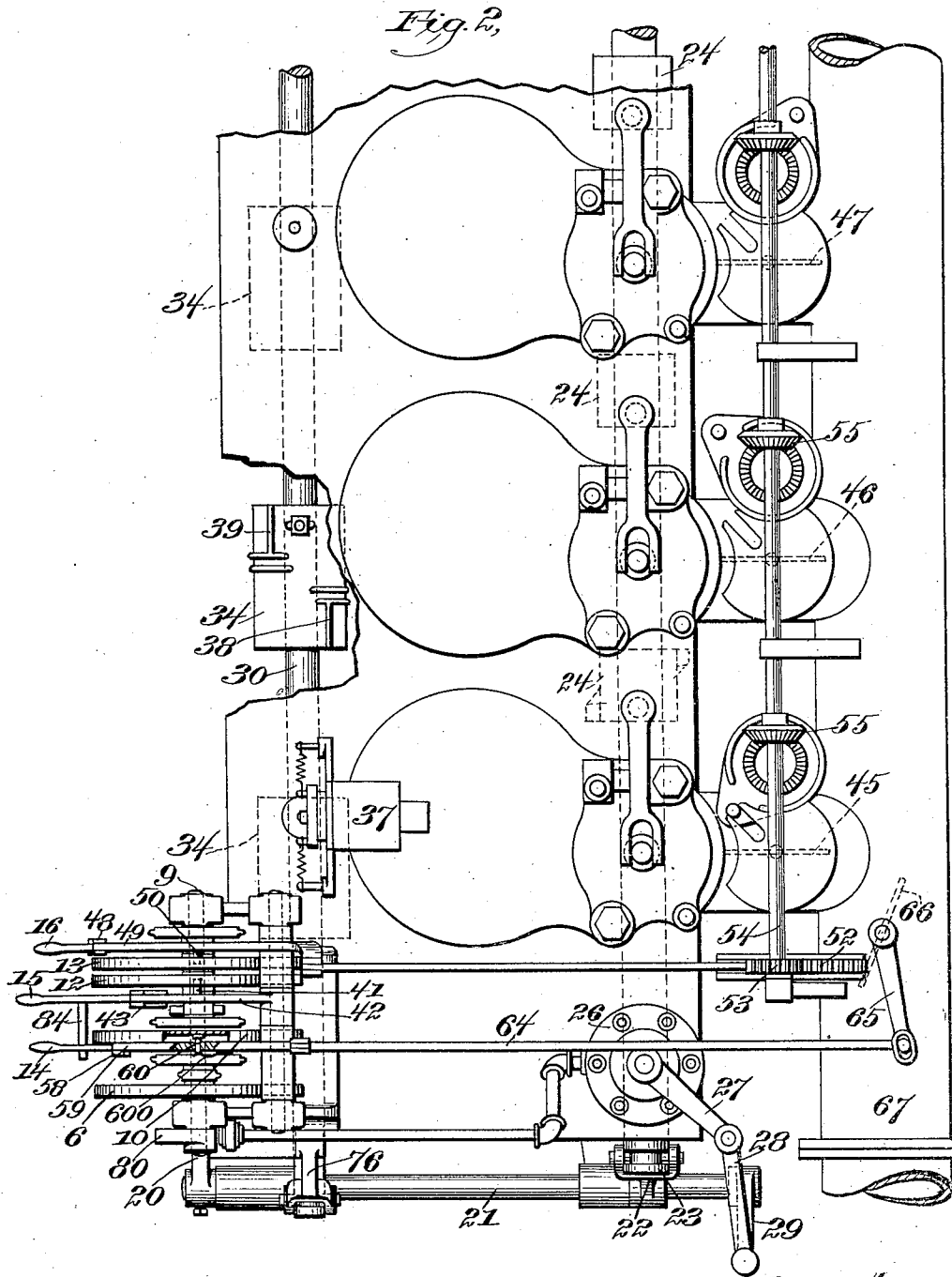


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4 SHEETS—SHEET 2.



witnesses:  
Jas. J. Maloney  
[Signature]

Inventor:  
Edward P. Robinson  
by [Signature] Atty.

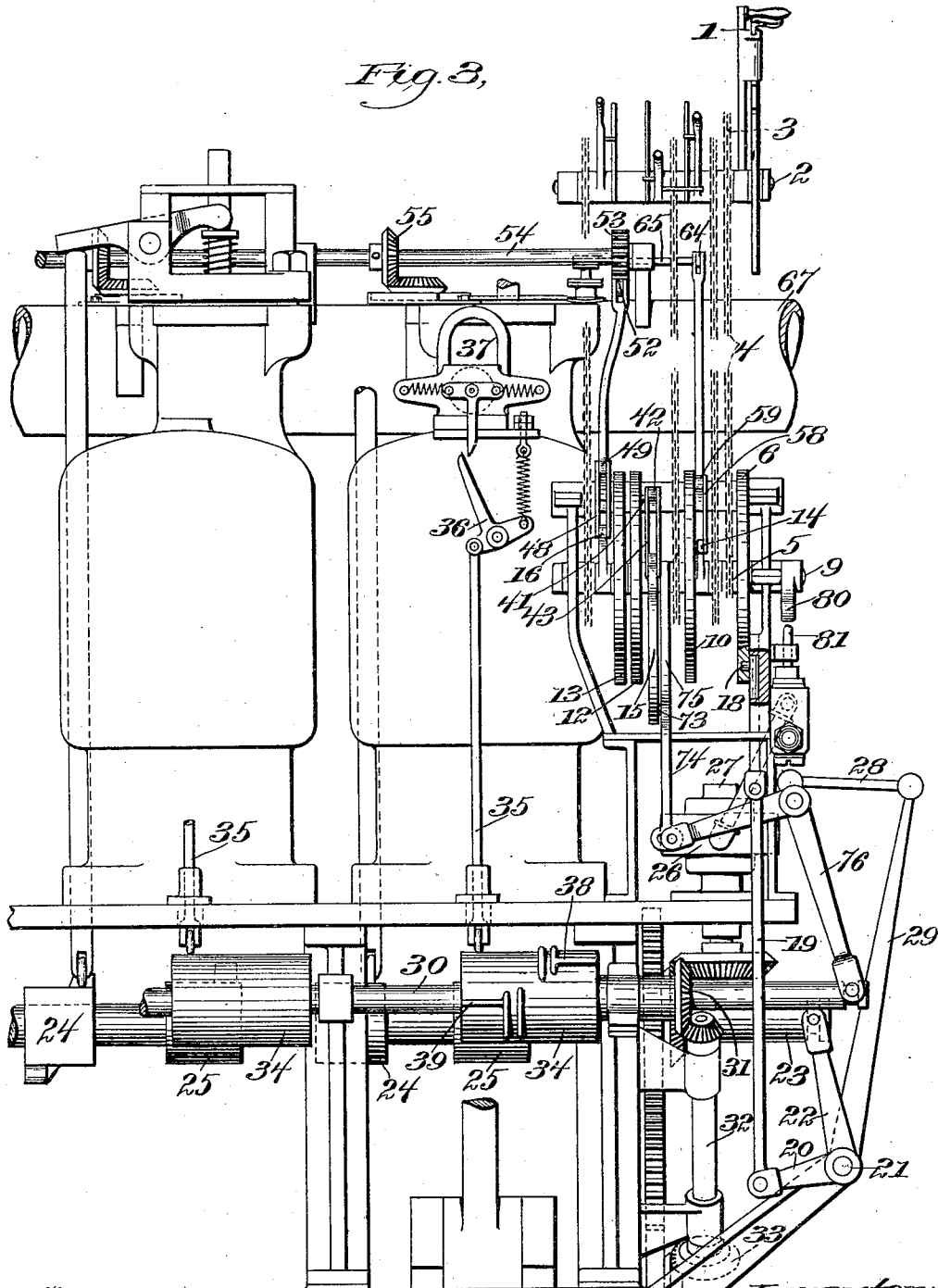
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4 SHEETS—SHEET 3.

Fig. 3,



witnesses:

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W. P. Connelley

Inventor:

Edward P. Robinson  
by H. J. Swannell  
att'y.

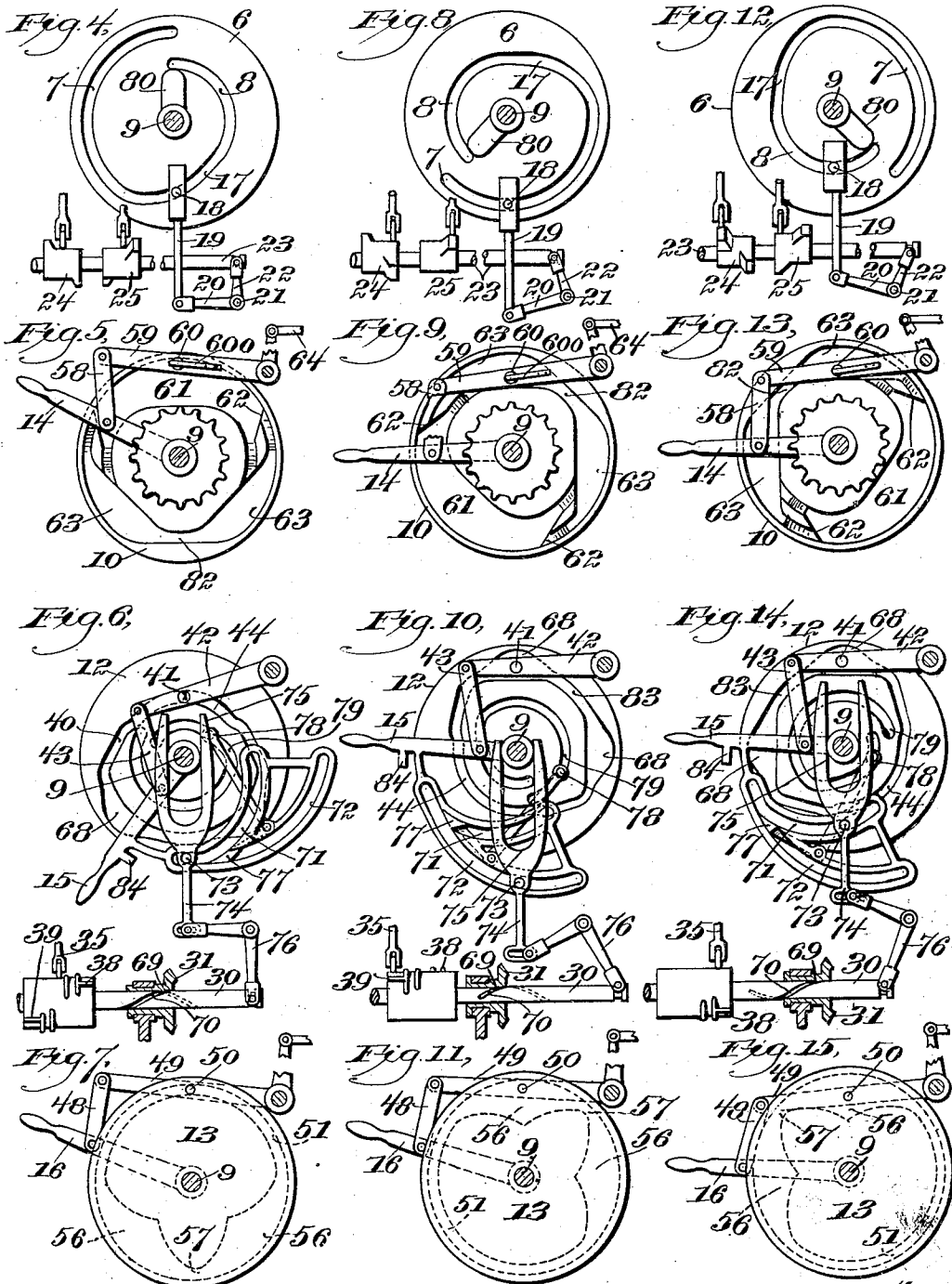
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4 SHEETS—SHEET 4.



Witnesses:  
Jas. J. Maloney.  
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Inventor:  
Edward P. Robinson  
by J. S. Swann, Attorney.

# UNITED STATES PATENT OFFICE.

EDWARD P. ROBINSON, OF MALDEN, MASSACHUSETTS, ASSIGNOR TO REVERSIBLE GAS-  
ENGINE COMPANY, A CORPORATION OF MAINE.

## INTERNAL-COMBUSTION ENGINE.

1,040,018.

Specification of Letters Patent.

Patented Oct. 1, 1912.

Application filed June 9, 1911. Serial No. 632,159.

*To all whom it may concern:*

Be it known that I, EDWARD P. ROBINSON, a citizen of the United States, residing in Malden, in the county of Middlesex and State of Massachusetts, have invented an Improvement in Internal-Combustion Engines, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

The present invention relates to the controlling and regulating mechanism of an internal combustion engine, and is embodied in a structure which can be used to advantage in connection with any internal combustion engine, although it is especially useful in connection with an engine which is provided with self starting and reversing mechanism.

The principal purpose of the invention is to provide the engine with means whereby it can be started and stopped by the operation of a single actuating device which performs automatically all the preliminary operations which are necessary to place the engine in condition to start and to continue operating.

In order that an internal combustion engine may be safely and surely started, either automatically, by its own ignition, or by an independent starting device mechanically or otherwise operated, and that it may continue to run without racing, it is necessary that certain preliminary adjustments should be made, whereby the timing of the ignition and the quantity of fuel admitted to the cylinders may be such as to insure the desired result. If the engine is of the reversing type, it is also necessary that such mechanism as is employed for reversing should be operated before the engine starts, and if the engine is to be started on its own ignition, it is necessary to operate the igniting device after the preliminary adjustments have been made, but before the crank shaft has begun to turn. Furthermore, if an auxiliary starting device of any kind is used, it is necessary to put such device in operation if the engine has failed to start on its own ignition. It is the purpose of the present invention to provide the engine with means for positively and accurately causing all these preliminary operations to be performed automatically, so that there

is no possibility of a mistake on the part of the attendant in charge, as might easily be the case if the several adjustments were to be made separately, and each made by the attendant himself; and so that the time necessary to make the adjustments, one after another, is saved.

In accordance with the invention, therefore, the engine is provided with means for making all the preliminary adjustments which are necessary, and is further provided with a master controller for operating such means, which controller is adapted to be used only during the starting and stopping of the engine, and which is arranged so that it does not enter at all into the regulation, as to speed and power, of the engine while running. The said master controller, which consists of a lever, handle, or other suitable actuating device, is movable between differently located standing positions which may be referred to, respectively, as the "running position" and the "stopped position," and is provided with connecting mechanism whereby it coöperates with those parts which must be moved or adjusted in starting, so that the said parts are automatically operated by the master controller in the movement thereof between its standing position. The arrangement is such, furthermore, that those of the adjusting or regulating devices which are used in regulating the speed and power of the engine while running are solely operated by the master controller; when it is between running and stopped positions, and are wholly disconnected from said controller for independent regulation when the controller is in running position and the engine is operating; while those of the adjusting devices which are used only to place the engine in running condition are solely operated by the controller at all times.

In the engine which has been chosen to illustrate the invention, there is a reversing mechanism which is adapted to change the timing of mechanically operated valves, a throttle or equivalent device for regulating the supply of fuel to the engine, igniting mechanism provided with means for timing the ignition, the said igniting mechanism being also arranged so that it can be operated while the engine is not running, and an auxiliary starting device to be used if the engine

fails to start upon its own ignition. In this engine, the several functions of the master controller are as follows, it being understood that all these functions are performed during the movement of the controller between its standing positions:—First, to operate the reversing mechanism, whereby the engine is placed in a condition to run in either direction; second, to operate the fuel-regulating device so that in starting the engine the desired quantity of fuel will be admitted, while in stopping the engine the quantity of fuel admitted after ignition has ceased will be such as to leave the engine in favorable condition to start on its own ignition; third, to regulate the ignition timing mechanism; fourth, to cause, during the movement of the controller from stopped to running position, the operation of the ignition mechanism, in order to start the engine, if possible, on ignition; fifth, to prevent the ignition mechanism from being operated accidentally, or otherwise, while the controller is in stopped position; sixth, to operate an auxiliary starting device, if such is employed; and, if the engine is reversible, to reverse the auxiliary starting device prior to the operation thereof.

In the engine shown, in which reversing mechanism is employed as well as an auxiliary starting device, the master controller is shown as having four standing positions, that is, two stopped positions and two running positions, and, in the movement of the controller between the stopped positions, the reversing mechanism is wholly operated, and then left in its proper running position. The preliminary adjustments are then made by the movement of the controller from the stopped position to the corresponding running position, and if the engine starts on its own ignition it will begin to run as soon as the controller reaches the said running position. In this case, no further movement of the controller is necessary. The engine shown, however, is provided with an auxiliary starting device, and if the engine fails to start when the controller is in its running position, a further movement thereof in the same direction will operate the auxiliary starting device; after which the lever should be returned to its running position. The arrangement is such, however, that this return movement is not essential, since the auxiliary starting device will be automatically put out of operation as soon as the engine begins to run on its own ignition; but as it is desirable that the lever should not be left in the auxiliary starting position, the regulating devices are so arranged to be interlocked with the lever while it is in the said position, so that the engine cannot be regulated as to speed and power until the lever has been moved to its regular running position.

The engine chosen to illustrate the invention, which will be specifically described in connection with the drawings, shows no radical departure, so far as relates to the reversing mechanism, and the regulating devices, from the engines of this type now commonly employed, and it is to be understood that such specific construction and arrangement of these parts as is shown is not essential to the main features of the invention, and that any practicable form of reversing mechanism and fuel controlling or ignition timing devices may be employed, while other modifications may be made without departing from the invention.

Figure 1 is an end elevation, partly in section, of a portion of a six cylinder four-cycle internal combustion engine provided with the controlling and regulating mechanism embodying the invention; Fig. 2 is a plan view of the same; Fig. 3 is a side elevation; Figs. 4, 5, 6 and 7 are detail views showing the several cams which are mounted on a shaft capable of being oscillated by the master controller, the several parts shown in said figures being in the mid-gear position; Figs. 8, 9, 10 and 11 are similar views showing the parts in the position assumed when the engine is going ahead; and Figs. 12, 13, 14 and 15 are similar views, the parts being shown in the position assumed when the engine is going in the reverse direction.

In accordance with the invention, all the devices which must be operated or adjusted prior to the starting of the engine are connected or interlocked with a master controller; and, if desired, said controller may be located at a point remote from the engine, such, for example, as the deck, bridge or pilot-house of a boat, and in Figs. 1 and 3 the master controller 1 is indicated as located at a distance from the engine, being mounted on the shaft 2 having a sprocket wheel 3, through which the movement of the shaft 2 is transmitted by a chain 4, to a sprocket wheel 5 on the shaft 9 which carries the cams for automatically operating the throttle lever, the ignition lever, and the supplemental throttle lever, if supplemental throttles are used. In the construction shown, there are two sets of levers, one set being located at the engine and pivotally supported on the shaft 9, and the other set being remote therefrom, so that the engine can be controlled by the man in the engine room, or by the man at the remote station, the master controller, however, being shown as solely under the control of the man at the remote station. The controller may obviously be duplicated at the engine by connecting a handle directly or through gears with the cam shaft 9. In the construction shown in Fig. 1, the spark and throttle levers at the remote station are shown as

bearing on the shaft 2, and connected with the corresponding levers at the engine by sprocket wheels and chains.

The cam 6 mounted on and rotatable with the cam shaft 9 is provided with a cam groove 7 which operates, as will be more fully described hereinafter, upon the valve cam reversing mechanism and the reversing mechanism for the auxiliary starting device. In the construction shown, the cam shaft 9 is geared to the actuating shaft 2 in such relation as to make nearly a complete revolution, as the controller 1 is moved over the segment which is provided with the notches indicated in Fig. 1 as "running ahead," "running reversed," "stopped" and "auxiliary." This construction is not essential, but the cams can be constructed to better advantage if provision is made for nearly a full rotation of the shaft, while it is desirable to reduce the extent of movement of the controller necessary for performing its various functions.

The segment is provided with two notches marked "stopped," and in the travel of the controller 1, from one of these notches to the other, all the necessary reversing mechanism is operated, and during this movement the spark lever is locked, so that it is impossible to start the engine during this movement. If the engine, when going in either direction, is to be stopped, the controller 1 is moved to the nearer "stopped" position, and the reversing gear is not operated, since the controller does not act on the reversing gear, during the movement; but operates on the reversing gear only during the movement of the lever from one "stopped" position to the other. In either stopped position, however, and in all positions between them, the ignition mechanism is locked and is in a neutral position, so that it is impossible to cause ignition, even if the crank shaft is mechanically turned. The spark lever itself, under these conditions, is locked, so that it cannot be moved without a previous operation of the controller.

The cam shaft 9, operated as above described, also has keyed, pinned, or otherwise fastened thereon, cams 10, 12 and 13, which are adapted to operate respectively on the throttle lever 14, the spark-lever 15 and the supplemental throttle lever 16, which levers, although they may be for convenience mounted on the shaft, are movable independently thereof. These cams which rotate with the shaft are so arranged as to operate the respective levers during the rotation of the cam shaft 9 in either direction to start the engine and to leave the parts free to be operated for regulating the engine when running. The function of these cams is, first, to provide for the automatic setting of every part in a favorable position to start and run the engine, prior to the actual

starting thereof, so that the operator is not obliged to adjust the several regulating devices one at a time prior to starting; or to rely on his own judgment in making the adjustments; and, second, to control and properly set the parts when the engine is being stopped. The cam 10, which controls the throttle actuator 14, is so arranged as to act upon the throttle during the movement which results in stopping the engine, in such a way as to open the throttle before ignition ceases, so that the cylinders will receive full charges of fuel. This leaves the cylinders in the best starting condition; and it also tends to cause the pistons to stop in the most favorable starting position, since the compression is high and has the maximum effect in overcoming friction, inequality in balance, etc. When the engine stops, therefore, it is usually in condition to start readily on its own ignition. This feature is especially important in an engine having no balance wheel, because such an engine stops very soon after the power has been cut off. In conjunction with this automatic control of the throttle, the spark lever is also automatically controlled, and if it has been set in an abnormally late position prior to stopping the engine, it is automatically advanced to a favorable position with relation to the condition of the charge controlled by the opening of the throttle, thus insuring at least one effectual impulse before ignition ceases. The said cam also operates, when it is being moved in the opposite direction, in response to the starting movement of the controller 1, in such a manner as to set the throttle in the position which has been found best to keep the engine running after it is started, without immediate adjustment of the fuel controlling device and the ignition timing devices.

The cam 12, which controls the spark lever 15, is adapted, when the controller is moved from the stopped to running position, to operate said spark lever in such a way as to cause ignition to take place in the cylinder which is ready to be fired; and the spark lever in turn controls the ignition mechanism in such a way that the ignition can take place only on a firing stroke. The cam 12 also operates a mechanical switch or shifting device which is adapted to reverse the direction of movement of the spark lever, so that the same movement of the spark lever is employed in controlling the running of the engine, whether the engine is running ahead or is reversed.

The cam 13, which is also keyed on, and operated by, the shaft 9, operates on a supplemental throttle lever which is arranged to operate separately in connection with individual throttles applied to some of the cylinders, as will be described hereinafter, the function of the cam 13 being to open the

individual throttles wide during that movement of the controller 1 which stops the engine.

The several cams above described, their operation, and the operation of the several parts under their control, will be specifically described as they are reached in tracing the operation of the machine.

*Reversing.*—The controller 1 is the only element which can be used in reversing the engine, and the said controller 1, not only performs the aforesaid function, but also prevents any independent operation of the engine or adjustment of its regulating or starting devices until the reversing operation has been completed. The operation of reversing the engine mechanism prior to starting, so that the operative parts thereof will be in condition to follow out the sequence of operations necessary for travel in the desired direction, is performed by the movement of the controller 1 from one to the other of the positions marked "stopped", in Fig. 1. In Fig. 4, the cam wheel 6 is shown in mid-gear, that is, in the position in which it stands when the controller is half way between the two "stopped" positions. Referring to Fig. 4, it will be seen that a pin or projection 18 is in engagement with a portion 17 of the cam groove 7, which portion is inclined from a part of the cam groove of larger diameter toward a part of the cam groove of smaller diameter, indicated by the reference numeral 8. The pin 18 is connected with a link 19 which, in turn, is connected with an arm 20 fastened to a rock-shaft 21, the said shaft having another arm 22 engaging the valve cam shaft 23. It is obvious, therefore, that a movement of the cam 6 sufficient to cover the distance between the part of the cam groove of larger diameter and that of smaller diameter will produce a longitudinal movement of the valve cam shaft, such movement being sufficient to shift the valve cams from the ahead to the reverse position. It is unnecessary to describe the valve cams 24 and 25, which are of the usual reversing type, each cam hub having two cams inclined reversely and set at such an angle that one cam on each hub will control the valve for the normal operation, while the other cam on the same hub will control the valve for the reverse operation, when the valve cam shaft is rotating in the opposite direction. The inclined portion 17 of the cam groove 7 is so related to the controller 1 that the said portion will travel its entire length over the pin 18, while the controller is being moved from one stopped position to the other. If, as is herein shown, an auxiliary starting device is employed, it is also necessary to reverse the functions thereof, and such reversal is also directly performed through the agency of the controller 1 during the move-

ment above described, as follows: The engine is herein shown as provided with a distributing air valve 26, Figs 1, 2 and 3, the construction and operation of which is not herein shown, since it forms no part of the present invention, the valve chosen for illustration, however, being substantially the same as that set forth and described in a joint application, Serial No. 450,687, filed August 28, 1908, by William B. Smith, Whaley and Edward P. Robinson. It is to be understood, however, that any suitable and practical reversible starting device might be used and operated for reversing and starting by the controller, without departing from the invention. In the valve chosen to illustrate this invention, the functions are reversed by shifting a movable port member, or its equivalent, and the member is shifted through the agency of a lever 27 which is herein shown as connected by means of a link 28 and an arm 29, with the rock shaft 21, connected, as before described, through the link 19 and arm 20, with the sliding head which carries the pin 18. The valve is also provided with a distributing member to connect the source of pressure to the cylinders successively and in the proper sequence, and the said distributing member may be driven directly from the valve cam shaft through bevel gears, as best shown in Fig. 1.

It will be seen from the foregoing description, that the movement of the controller which has been described, operates on all the parts which need a preliminary operation or adjustment in order to place the engine in condition for running in whichever direction is desired, such movement, however, performing no actual functions other than those recited. During the reversing movement, however, it is desirable to prevent absolutely the possibility of causing ignition, accidentally or otherwise, and to this end the parts are so arranged that the ignition mechanism is locked against independent operation during the reversing movement, and also when the controller is in either stopped position.

The ignition mechanism, together with the means for timing the ignition, are herein shown as having for the main operating member a rotatable shaft 30, shown as driven by a gear 31 through a bevel gear on a shaft 32 which, in turn, is geared to the crank shaft through a gear 33, the reduction being such that the timer shaft 30 travels half time with relation to the crank shaft, as is usual in four-cycle engines. The timer shaft 30 is capable of longitudinal movement with relation to its driving gear 31, and is so arranged that such longitudinal movement will also produce a rotary movement which is imparted to the ignition cam members 34, which are mounted on the

timer shaft and shown as adapted to operate lifters 35 which act through levers 36 on oscillating magnetos 37 which may be of any suitable or usual construction. It is obvious that any other type of ignition may be used, the cams being capable of operating make-and-break igniters, any form of electrical contacts, or the equivalent thereof; but it is practicable, with the arrangement shown, to produce an initial spark to start the engine from a standstill by the use of a magneto, or a make-and-break igniter in a battery circuit, since a manipulation of the timer shaft 30, while the engine is standing, causes a mechanical operation independent of that caused by the rotation of the engine shaft when the engine is running.

For reversing purposes, each cam member 34 is provided with two cams 38 and 39, oppositely disposed, the reversing of the ignition mechanism bringing one cam or the other into the path of the lifter 35 according to the direction in which the engine is to travel. During the operation of the controller which reverses the operating mechanism of the engine, however, the timer shaft 30 is held in mid-position with neither cam in the path of the lifter, which, at that time, stands mid-way between them, as best shown in Fig. 6.

The cam 12, which coöperates with the controller in preventing ignition during the main reversing process, is provided with a cam groove 40 which coöperates with a projection 41 on an arm 42 which is connected by a link 43 with the ignition controller 15, the construction and operation of which will be more fully described hereinafter. The cam groove 40 has a portion 44 curved on the arc of a circle, and of sufficient length to engage the projection 41 during that part of the movement which corresponds to the reversing movement of the controller, this part being so shaped as to hold the projection 41 in the position shown in Fig. 6, in which position the lever 15 is locked, and, through the lever, positively connected therewith, the ignition shaft 30 held in the mid-position shown.

While it is not essential to the invention, the engine is herein shown as equipped with an auxiliary throttle controlling device which consists of supplemental throttles 45, 46 and 47, located in the intakes from the manifold which lead, respectively, to three of the cylinders of the series, and which are capable of being successively closed, or nearly closed, in the continuous movement of the so-called supplemental throttle lever 16. This lever 16 is shown as connected by a link 48 with an elbow lever 49, having a projection 50 which enters the cam groove 51 in the cam wheel 13 and is connected with a rack 52 which operates a pinion 53 on the shaft 54. In the construction shown,

the throttles 45, 46 and 47 are operated by so-called Geneva gears which are illustrated in Fig. 3, and are thought to require no further description. It may be noted, however, that the several gears which are set for successive operations on the throttles are driven through bevel gears 55 on the shaft 54. In case any of the supplemental throttles should have been closed while the engine has been running, it is desirable that any so closed should be opened prior to stopping, so that every cylinder available during the travel of the engine by momentum shall receive a full charge of gas. For this purpose, the cam groove 51 is so shaped, as shown in Fig. 7, as to hold the lever 16 in the wide open position for all the supplemental throttles during every part of the movement of the cam 13, except that which places it in running position. The cam groove is provided with enlarged portions 56 to allow the lever 16 to be free for manipulation when the engine is in either running position, there being, however, a supplemental portion 57 corresponding to the main part of the cam groove which comes into operation during the movement of the controller 1 from the running position which operates the auxiliary starting device, which part of the operation will be more fully described in connection with the action of the ignition and throttle devices under the same conditions.

*Starting and stopping.*—In starting the engine by the movement of the controller 1, as above described, it is desirable that the main throttle should be moved to a favorable starting position prior to ignition, and that the ignition mechanism should not only be moved to its position for operation in either direction, but should also be operated to produce a spark during such movement. It is also necessary that at the end of this movement, the throttle and spark levers 14 and 15 and the auxiliary throttle lever 16, should be left free for manipulation to control the speed and power of the engine while it is running. As shown in Fig. 4, the configuration of the cam groove 7 is such that the movement of the controller 1 from stopped to running position, in either direction, will produce no further corresponding movement of the parts depended upon for reversing the engine, these parts, on the other hand, being locked by the cam in the proper position for running. The throttle lever 14, which is loosely mounted on the shaft 9, is, however, under the influence of the cam-wheel 10, the said lever being shown as connected through a link 58 with an arm 59 which has a projection 60 lying in a cam recess 61 in the cam wheel 10.

Since it is immaterial whether the throttle be manipulated or not during the reversing movement, the cam space 61, as shown in

Fig. 5, is left wide in that part where the projection 60 lies during the reversing movement. In moving the controller 1, however, from the stopped to the running position in either direction, the cam-wheel 10 is turned with relation to the pin 60, and in so turning causes one of the cam surfaces 62 to engage the pin 60 and move the arm 59 to such a position as to open the throttle a predetermined extent; that is, to the position which has been found best for keeping the engine running after starting, without further regulation. The throttle lever is shown in this position in Figs. 9 and 13. This occurs just prior to the operation of the ignition device, and the completed movement to running position brings a second enlarged portion 63 of the cam groove into the proper position with relation to the projection 60 to admit of the free movement of the lever 14, as shown in Figs. 9 and 13 (ahead and reverse running positions). Thus the throttle is automatically placed in proper position for starting and left free for manipulation while the engine is running. It is obvious that any automatic control of the throttle which may be found necessary or desirable can be provided for by shaping the cam to produce the proper movements; and that, if desirable, the control of the throttle in starting the engine reversed can be made to differ from the control of the throttle in starting the engine ahead. Furthermore, the throttle adjusting cam can be arranged so that when the engine is running and the throttle lever is under the control of the operator, the cam will prevent the throttle from being fully closed. In the construction shown, the arm 59 constitutes part of an elbow lever connected by a link 64 with an arm 65 on the stem of a butterfly valve 66 located in the manifold intake passage 67 after the usual construction.

For the purpose of operating the throttle, as previously described, while the controller 1 is being moved from "running" to "stopped" position, the inner wall of the enlarged cam space 63 is inclined outward toward the periphery of the cam wheel, so that in the movement of the cam wheel, said inner wall engages the pin 60 and moves the throttle lever to the position shown in Fig. 5. In this operation, the pin 60 rides over the cam surface 62, the cam groove at the end of the enlarged space 63 being upwardly inclined as indicated by the shading. In the reverse movement, *i. e.*, from "stopped" to "running," the pin is engaged by the cam surface 62, and is thereby moved to the position shown in Fig. 9. The cam surface 62 terminates in a groove or channel having an upwardly inclined surface, as shown, whereby the pin is lifted over the inner wall of the space 63. This channel

is substantially equal in width to the diameter of the pin 60, and, therefore, will carry the throttle lever to the desired position from any position in which it may have been placed while the engine was idle. The pin 60 is shown as longitudinally movable in the lever 59, being pressed toward the surfaces of the cam-wheel by a spring 600, so that it yields as it rides over the inclined surfaces, and then snaps back to be acted upon when the cam wheel is turned the other way.

In order to start the engine on its own ignition, as is usually possible, the controller 1 is arranged to operate positively upon the igniting device, during the movement from stopped to running position, the construction and operation of said igniting device having been previously described. For this purpose, the cam groove 40 is so shaped, as shown in Fig. 6, as to produce a movement of the spark-lever 15 and a consequent longitudinal movement of the shaft 30 as the said cam groove travels through the influence of the controller 1 in being thrown to the running position. As shown in Fig. 6, the cam groove 40 is inclined materially at each end of the part 44 so as to produce a considerable longitudinal movement of the shaft 30 during the relatively small movement of the controller from stopped to running position. This causes a sufficient longitudinal movement of the shaft 30 in one direction or the other to bring one or the other of the igniter cams, 38 or 39, under the lifter 35, at the same time turning the shaft 30 so as to bring the cam into such relative position to the lifter as to cause ignition, and also to carry the cams to the position in which ignition will be retarded in the firing of the successive cylinders when the engine starts, so as to obviate any chance of pre-ignition.

In the construction shown, the lifter cams 38 and 39 are made relatively narrow, and in order to insure ignition, the said cams are shown as provided with one or more elongated projections, two being shown, which, during the longitudinal movement of the shaft 30 will operate the lifters, the purpose of having two or more of these supplemental cam surfaces being to provide for a plurality of sparks during the longitudinal starting movement of the shaft, in order to insure ignition, if possible. It has been found, in practice, that several successive sparks will sometimes cause ignition, when a single spark fails, (especially if the compression is light, or the mixture not perfect.)

The actual movement of the shaft 30, which produces the initial spark, as described, is accomplished through the direct agency of the member which is provided with the spark-lever 15, this member being moved, as above described, through the cam 12 in starting the engine, but being free to

move independently after the engine has been started. The cam 12 is then in such a position that one or the other of the enlarged spaces 68 of the cam groove 40 receives the projection 41 so that there is nothing to control or confine the arm 42 or the lever 15 connected therewith. The enlarged spaces, however, are so proportioned that it is impossible to move the spark-lever far enough to prevent ignition while the engine is running, although the ignition may be advanced or retarded within such limits as may be found best in manipulating the engine.

The elongated cam projections for the cylinders which fire successively when employed, as shown, in a six-cylinder, four-cycle engine, are of sufficient length to overlap, so that it is impossible to move the ignition cam-shaft from "stopped" to "running" position without operating the lifter for the cylinder which is ready to fire, no matter where the crank-shaft may have stopped.

The timing of the ignition after the engine has been started is accomplished by the longitudinal movement of the shaft 30 through the agency of the lever 15, the said longitudinal movement causing the shaft to rotate in one direction or the other through the agency of a spline or feather 69 connecting the driving gear 31 with the shaft 30, the spline groove 70 in the shaft 30 being spirally formed, so that while the shaft is connected to be rotated by the gear, it is also capable of being turned with relation thereto in response to a longitudinal movement. The ignition cams 38 and 39 are of sufficient length to remain under the igniter lifters throughout such longitudinal movement of the shaft 30, as is required for timing, the rotation of the shaft relatively to its driving gear obviously causing the said cams to reach the lifters early or late with relation to the revolution of the crank shaft, since the relation of the driving gear to the crank-shaft is unchangeable. This, so far as relates to the operation of the lifters, is the same operation as that already described in connection with starting the engine; but after the engine is running, the spark lever is manipulated instead of the controller.

In order to avoid confusion or possibility of error on the part of the operator when the ignition timer is under manual control, it is desirable that the spark-lever 15 should always be moved in the same direction to advance the spark, regardless of the direction of movement of the engine, such a movement, of course, being always characteristic of the throttle lever. To this end, the shaft 30 is operated in its longitudinal movement through the agency of inclined cam surfaces or channels 71 and 72 which are carried by the lever 15, the said channels being oppositely curved or inclined with re-

lation to the axis on which said handle turns. It is obvious that the channels need not be symmetrical with each other, but may be shaped to afford any control of the ignition which may be desired. In marine engines, it may, for example, be of advantage to have a different control of the ignition when the engine is reversed, from that employed when the engine is running ahead. These channels cooperate with a pin 73 on a longitudinally movable actuating member 74 which is shown as having a forked projection 75 which, in conjunction with the cam shaft 9, constitutes a guide, the said member 74 being connected through an elbow lever 76 with the shaft 30.

Referring to Fig. 6, it will be seen that if the lever 15 is moved toward the left, the member 74, through the pin 73, will be moved upward if the pin is in the cam groove 71, as shown in Fig. 14, or downward if it is in the cam groove 72, as shown in Fig. 10, so that the direction of movement imparted to the shaft 30 depends on which cam groove the pin 73 is in. Since the shaft 30 should move in one direction to advance the spark when the engine is going ahead, and in the opposite direction to advance the spark when the engine is reversed, the device is provided with means operated by the controller 1 for switching the projection 73 into one or the other of the cam grooves 71 and 72 in accordance with the direction of movement of the said controller.

In the construction shown, a mechanical switch or guide 77 is located at the junction of the two cam grooves 71 and 72, the said switch consisting of a pointed finger constituting one arm of an elbow lever, so that when the said lever is rocked on its pivot, the point of the switch will move across the junction of the channels, thereby closing one and opening the other. The opposite end of the elbow lever is provided with a projection 78 which enters a cam groove 79 carried by the cam wheel 12, this groove being so shaped that it will throw the switch 77 from one side to the other when the cam wheel is turned by the movement of the main controller 1 from one of the stopped positions to the other.

In an engine designed for marine work where the load or resistance varies mainly with the rate of speed, it is desirable that there should be a certain cooperation between the spark and throttle levers, so that if the ignition is quickly advanced to increase the speed, the throttle will be correspondingly opened, and, conversely, if the throttle is closed, the spark will be correspondingly retarded. For this purpose, the engine is provided with means whereby the spark and throttle levers will engage under such conditions, the spark lever 15 being shown as provided with a projection 84, Fig. 7.

1, which extends across into the path of the throttle lever 14, so that if the throttle lever is moved in the direction to close the throttle, it will produce a movement of the spark lever in the direction to retard the spark, and if the spark lever is moved in the direction to advance the spark, the throttle lever will be engaged thereby and the throttle correspondingly opened. This prevents the possibility of pre-ignition and consequent stopping of the engine which might take place if the operator suddenly advanced the spark with the throttle nearly closed and the engine running at low speed, or if the throttle were quickly closed so as to slow down the engine with the ignition advanced to such an extent that the charge might be fired before the end of the compression stroke.

*Auxiliary starting device.*—If the engine fails to start by the ignition of a charge produced by the above-described operation of the igniting device in the movement of the controller 1 from the stopped to the running position, the auxiliary starting device hereinbefore mentioned is brought into operation by a further movement of the controller 1 to the notch marked "auxiliary" in Fig. 1. This movement carries the finger 80 (Figs. 1 and 2) into engagement with a valve stem 81, or its equivalent, which controls a passage leading from any suitable source of fluid pressure, opening communication between said passage and the distributing valve 26. Since, as previously described, the main and auxiliary throttles, and the ignition actuating devices are all free to be independently regulated when the engine is in running position, it is possible that they might be moved accidentally or intentionally, if the controller were left in its running position after the engine had failed to start on ignition. To obviate the possibility in such a case of these parts remaining in the wrong position should the controller be subsequently moved to the auxiliary starting position to start the engine, the regulating devices in question are again interlocked with the master controller during the movement thereof from the running to the auxiliary starting position. For this purpose, the cam 10 is shown as provided with a cam groove 82 located between the enlarged spaces 63 which admit of the free movement of the throttle handle 14, when the engine is in either running position, this cam channel 82 reaching the engaging pin 60 when the controller 1 is moved from either running position to either "auxiliary" starting position. This sets the throttle in the most favorable position to take the required charge, the throttle being locked until the controller 1 has been moved back to its regular running position. This general arrangement of the

mechanism is of great importance, since it positively insures the starting of the engine in either direction, in case of an emergency, by one rapid and continuous movement of the controller. It is immaterial whether the engine starts on its own ignition or not, and in case the engine must be quickly and surely started, or, when running, must be suddenly reversed, it is only necessary for the operator to push the controller the whole distance in the desired direction. The auxiliary starting device will then cause the engine to run, and the fuel and ignition are then governed automatically, so as to cause the engine to continue running at a uniform speed, even if the controller is not returned to the regular running position. To vary the speed, after the engine is running, it is necessary to return the controller to the running position, in order to release the spark and throttle levers, but in emergencies the variation of the speed is a secondary consideration, and the controller can be moved back to running position as soon as conditions are normal.

Ordinarily, of course, the engineer will throw the controller to the running position desired, and the engine will usually start on ignition; but if it fails, he will push the controller over to bring in the auxiliary, and return it as soon as the engine starts. The engine will run, however, and deliver the necessary power, with the controller in either position, and when quick action is required, the controller is moved at once to the limit in either direction.

The cam wheel 12 is provided with a cam portion 83 on the cam groove 40 located between the two enlarged spaces 68, this portion being arranged to cooperate with the lever 15 and set the ignition timing device in the necessary retarded position. The cam 13 is provided with the cam space 57 between the enlarged portions 56, so as to carry the handle 16 to the position in which all the auxiliary throttles are wide open.

In the foregoing description, a thoroughly practicable embodiment of the invention has been specifically referred to throughout, in order that the invention may be clearly understood, but it is obvious that the construction actually shown and described may be modified without departing from the invention, which, in its broader features, is not directed to or limited by any specific details of construction and arrangement.

What I claim is:

1. In an internal combustion engine, the combination with regulating devices to control the quantity of fuel, the time of ignition, and the reversing mechanism, of means for making preliminary adjustments of the said regulating devices prior to starting the engine; a master controller having stopped and running positions; and connecting

mechanism whereby said means for making preliminary adjustments are operated solely by said master controller during the movement of the controller from one of its positions to the other.

2. In an internal combustion engine, the combination with regulating devices to control the quantity of fuel, the time of ignition, and the reversing mechanism; of means for making preliminary adjustments of the said regulating devices prior to starting the engine; a master controller having stopped and running positions; connecting mechanism whereby said means for making preliminary adjustments are operated solely by said master controller during the movement of the controller from one of its positions to the other; and means whereby said regulating devices are disconnected from said master controller for independent operation when said controller is in its running position.

3. In an internal combustion engine, the combination with regulating devices to control the elements which vary the power and speed of the engine while running; of a controller to be manipulated only in starting and stopping the engine; connecting mechanism whereby said regulating devices are operated solely by said controller in the movement thereof; and separate means for operating said regulating devices while the engine is running.

4. In an internal combustion engine, the combination with a fuel regulating device provided with a manually operated actuator; of a master controller adapted to operate said fuel regulating device only while the engine is being started or stopped; and means operated by said master controller for preventing said fuel regulating device from being moved by its actuator to a position to cut off wholly the supply of fuel while the engine is running.

5. In an internal combustion engine, the combination with ignition mechanism; of means cooperating with said ignition mechanism for timing the ignition; a master controller having stopped and running positions, and adapted to be operated only during the starting and stopping of the engine; and means for connecting the ignition timing means with said controller, whereby the ignition is timed solely by the operation of said controller except when said controller is in running position.

6. In an internal combustion engine, the combination with ignition devices; of a master controller having stopped and running positions, said ignition devices being timed and operated by said controller in the movement of the controller from stopped to running position; and means for releasing said ignition devices from the controller when the controller is in running position.

7. In an internal combustion engine, the combination with a valve cam-shaft having two sets of cams for reversing purposes; of an ignition cam-shaft having two sets of cams; igniting devices operated by the cams on said ignition cam shaft; means for moving said shaft independently of its normal rotation to vary the timing of the ignition; a lever for actuating said means; and a master controller cooperating with the valve cam-shaft and with said lever, to place the engine in condition for starting and running in either direction.

8. A controlling mechanism for internal combustion engines, consisting of a master controller to be manipulated in starting and stopping the engine; said master controller having stopped and running positions; regulating devices to vary the speed and power of the engine while running; connecting mechanism between said controller and said regulating devices whereby the said regulating devices are operated solely by said controller during the movements thereof between stopped and running positions; an auxiliary starting device; and means for operating said auxiliary starting device by a continued movement of the controller beyond its running position.

9. A controlling mechanism for internal combustion engines, consisting of mechanism for starting and stopping the engine; a controller constituting the sole means for operating the said mechanism; regulating devices which control the elements which vary the speed and power of the engine while running; connecting mechanism between said controller and said regulating devices whereby the said regulating devices are operated solely by said controller during the movements thereof between stopped and running positions; an auxiliary starting device; means for operating said auxiliary starting device by a further movement of the controller in the same direction; and means whereby the regulating devices are connected with and operated by the controller during the movement thereof from the running position to the auxiliary starting position.

10. The combination with mechanism for starting and stopping an engine; of a controller constituting the sole means for operating said mechanism; regulating devices for controlling the elements which vary the speed and power of the engine while running independently of the operation of said controller; and cams operated by the controller and cooperating with the regulating devices to move said regulating devices to certain predetermined positions during the movement of the controller which operates the starting and stopping mechanism.

11. The combination with mechanism for starting and stopping an engine; of a

throttling device for regulating the engine while running; a controller adapted to operate the mechanism for starting and stopping the engine; a cam member operated by said controller; and a cam carried by said member and cooperating with said throttling device, said cam producing movements of said throttling device in different paths during the movements of the cam in opposite directions.

12. In an internal combustion engine provided with starting, stopping and reversing mechanism; of a controller constituting the sole means for operating the said mechanism; said controller having two running positions and being movable from one running position to the other in stopping, reversing and starting the engine; a throttle regulator; a cam member adapted to be moved by said controller during the entire movement of said controller from one running position to the other; cams of different configuration at opposite sides of the mid-position of said cam member; and means for operatively connecting said cams with said throttle regulator.

13. In a reversible internal combustion engine, the combination with the reversing mechanism; of a master controller having two stopped positions and two running positions, the reversing mechanism being operated by the said controller during its movement from one stopped position to the other; regulating devices independent of said controller, said regulating devices being adapted to control the elements which vary the power and speed of the engine; and connecting mechanism whereby said regulating devices are operated solely by said controller, except when said controller is in either running position.

14. In a reversible internal combustion engine, the combination with a reversing valve cam shaft; of a reversing ignition mechanism; a spark lever; a controller for the devices aforesaid; means whereby said spark lever is locked in a neutral inoperative position by said controller in the reversing movement of the controller; and means whereby said spark-lever is released from the controller when the controller is in running position.

15. In a reversible internal combustion engine, the combination with a reversing cam shaft; a reversing ignition mechanism; a lever operating said ignition mechanism; a master controller for the devices aforesaid having stopped and running positions; means whereby the lever operating the ignition mechanism is locked in a neutral inoperative position during the reversing movement of the controller, and is operated by said controller to cause properly timed ignition during the movement of the controller from stopped to running position;

and means whereby said lever is released from the controller when the controller is in running position.

16. In a reversible internal combustion engine, the combination with a reversing valve cam shaft, a reversing auxiliary starting device, and a spark lever, of a controller for operating all the said parts; means for connecting said spark lever with the timing mechanism through oppositely acting cam-surfaces; and a switch operated by the controller for shifting the connection from one of said cam surfaces to the other.

17. In a reversible internal combustion engine, the combination with reversible valve cam mechanism; of reversible ignition operating devices; a reversible auxiliary starting device; a controller cooperating with all the said reversible devices to position the same for operation in either direction; independent power and speed regulating devices; and means whereby said regulating devices are operated solely by the controller, except when said controller is in running position.

18. In an internal combustion engine, the combination with reversing mechanism; of a controller therefor having stopped and running positions; ignition mechanism adapted to be operated by said controller during the movement thereof from stopped to running position; an auxiliary starting device; and means for operating said auxiliary starting device by a movement of the controller in the same direction, beyond the running position.

19. In an internal combustion engine, the combination with reversing mechanism; of a controller therefor; mechanically operated igniting devices; an ignition cam shaft to operate said devices; a regulating device adapted to move said cam-shaft longitudinally; means whereby such longitudinal movement causes a rotary movement of the cam-shaft independent of its driving mechanism; and means for connecting the controller to the regulating device while the reversing starting and stopping movements of the controller are being made.

20. In a controlling mechanism for internal combustion engines, the combination with a controller having stopped and running positions; of regulating devices which control the elements which vary the speed and power of the engine when the controller is in running position; an auxiliary starting device; and means whereby all of the said regulating devices are automatically set to the desired position by the controller during the movement thereof between the stopped and running positions; and said starting device between the running and auxiliary starting positions, and released from the controller when the latter is in running position.

21. In an internal combustion engine, the combination with a controller having stopped and running positions; of a spark lever; an ignition cam shaft operated by said spark lever, and adapted to produce a spark while the engine is standing still; and means for connecting the said spark lever with the said controller, whereby said ignition mechanism is operated in response to the movement of the controller between said stopped and running positions.

22. In an internal combustion engine, the combination with ignition mechanism; of a lever to operate said ignition mechanism; an independent controller to operate said ignition mechanism in starting and stopping the engine, said controller having stopped and running positions; connecting mechanism between said controller and said lever, whereby said lever is operated by the controller during the movement thereof between the stopped and running positions and released therefrom when the controller is in the running position; and means operated in response to the reversing movement of the controller for shifting the connection between the lever and the part operated thereby, whereby the said lever may be moved in the same direction to advance the spark, regardless of the direction in which the engine is running.

23. In an internal combustion engine, the combination with reversing mechanism, ignition controlling mechanism and an auxiliary starting device, of a controller having six positions, two "stopped", two "running", and two "auxiliary starting", the

positions last named being at the ends of the range of movement of the controller, and the "running positions" being between the "stopped positions" and the "auxiliary starting" positions; means whereby said controller operates the reversing mechanism during its movement between the "stopped positions"; means whereby said controller coöperates with the ignition controlling mechanism during its movement between stopped and running positions, and means whereby said controller again coöperates with the ignition controlling mechanism in its movement to the auxiliary starting position.

24. In an internal combustion engine, the combination with a spark lever and a throttle lever; of a master controller having stopped and running positions; means for interlocking said master controller and said spark and throttle levers, whereby said spark and throttle levers are operated solely by said master controller in its movement between stopped and running positions, and released from said controller for independent operation; and connecting mechanism whereby the spark and throttle levers are caused to coöperate when under independent control, substantially as and for the purpose described.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses.

EDWARD P. ROBINSON.

Witnesses:

JAS. J. MALONEY,  
M. E. COVENEY.