

July 31, 1923.

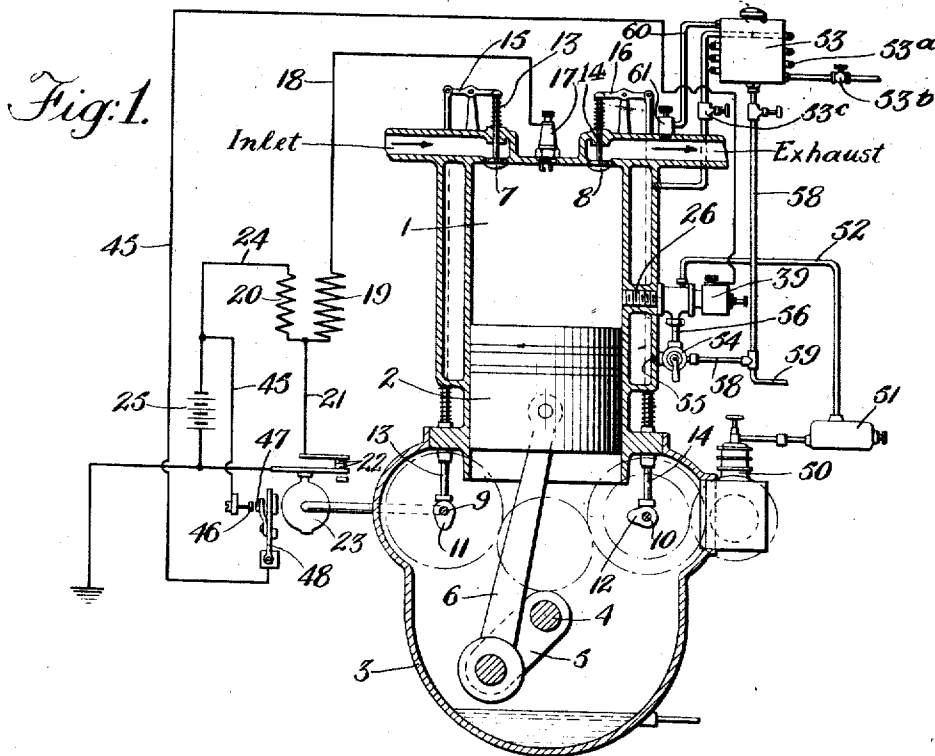
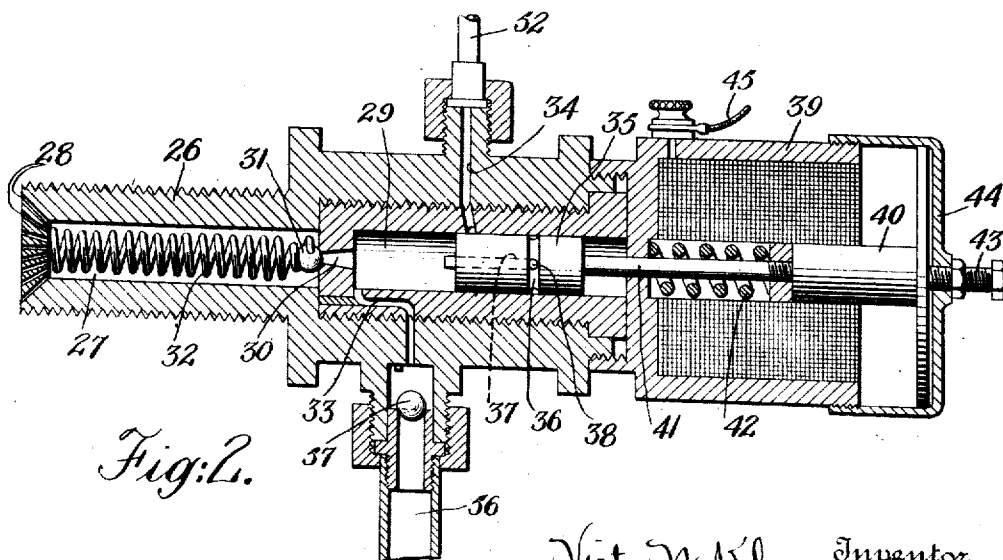
1,463,586

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INTERNAL COMBUSTION ENGINE

Filed Aug. 30, 1919

6 Sheets-Sheet 1



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By his Attorneys
Metcalf & Prewitt

July 31, 1923.

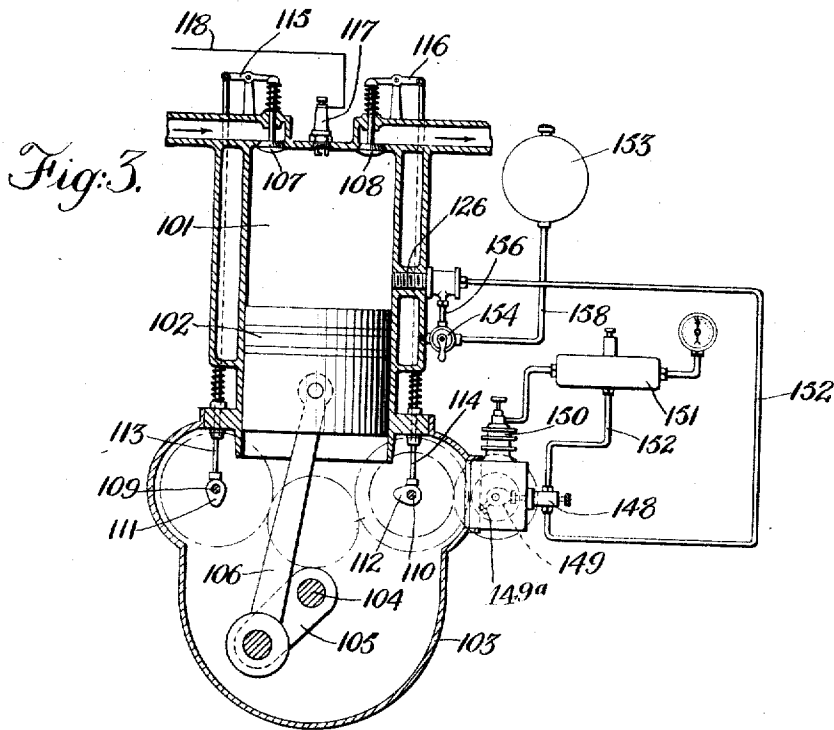
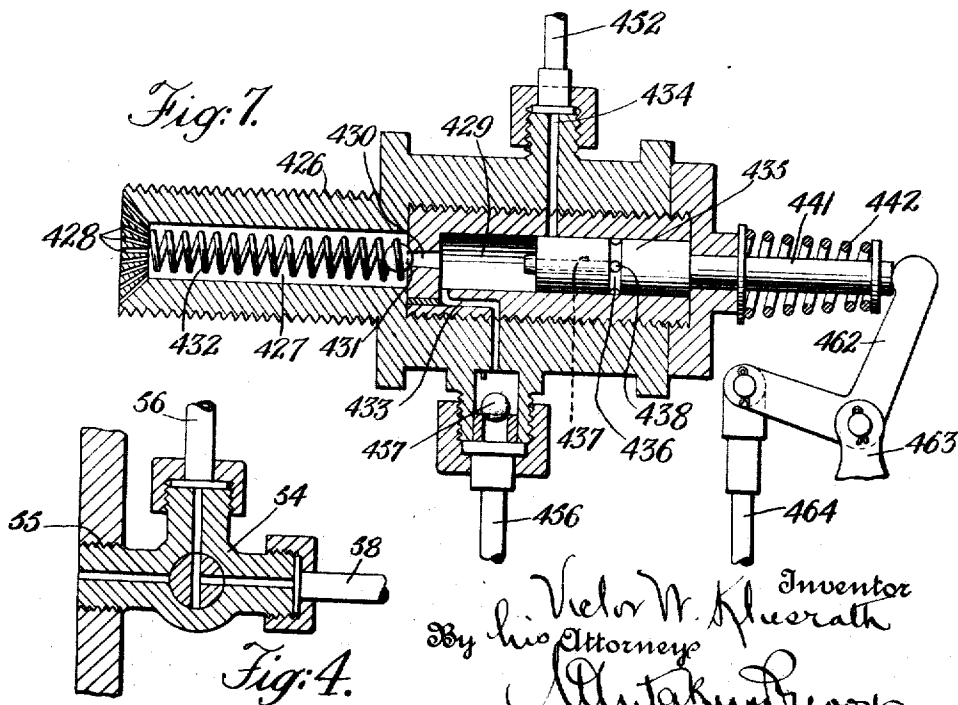
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INTERNAL COMBUSTION ENGINE

Filed Aug. 30. 1919

6 Sheets-Sheet 2



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INTERNAL COMBUSTION ENGINE

Filed Aug. 30, 1919

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Fig. 8.

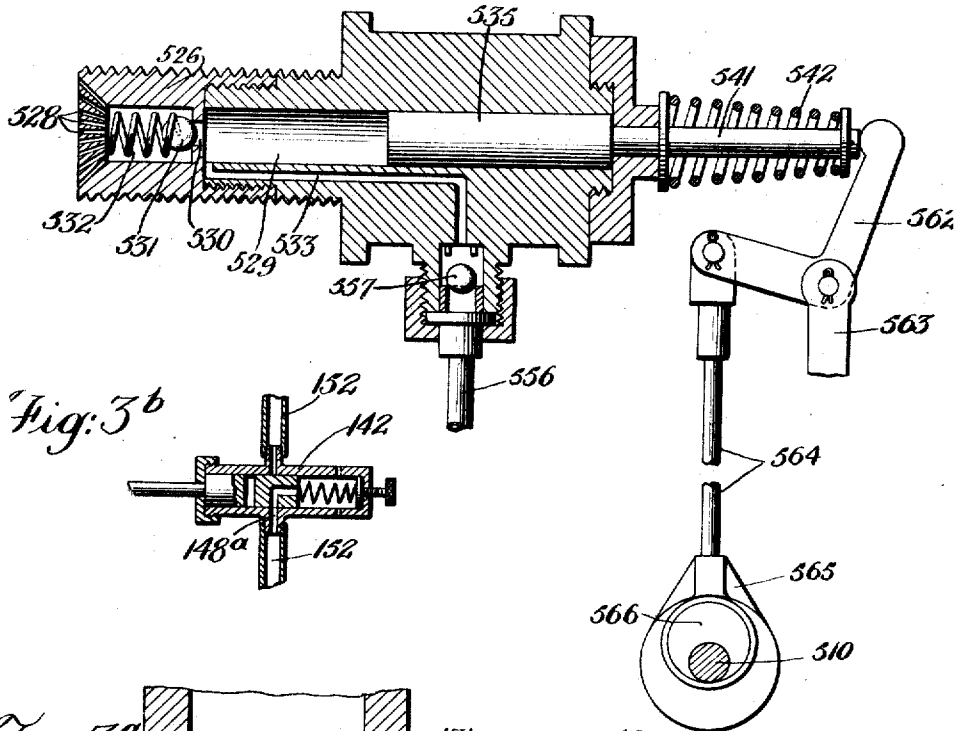


Fig. 3b

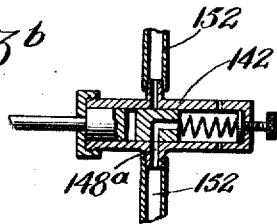
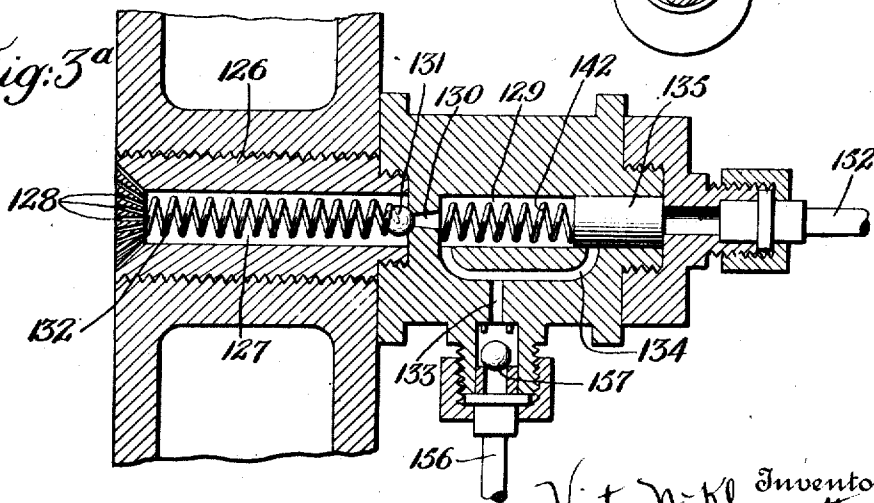


Fig. 3a



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INTERNAL COMBUSTION ENGINE

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6 Sheets-Sheet 4

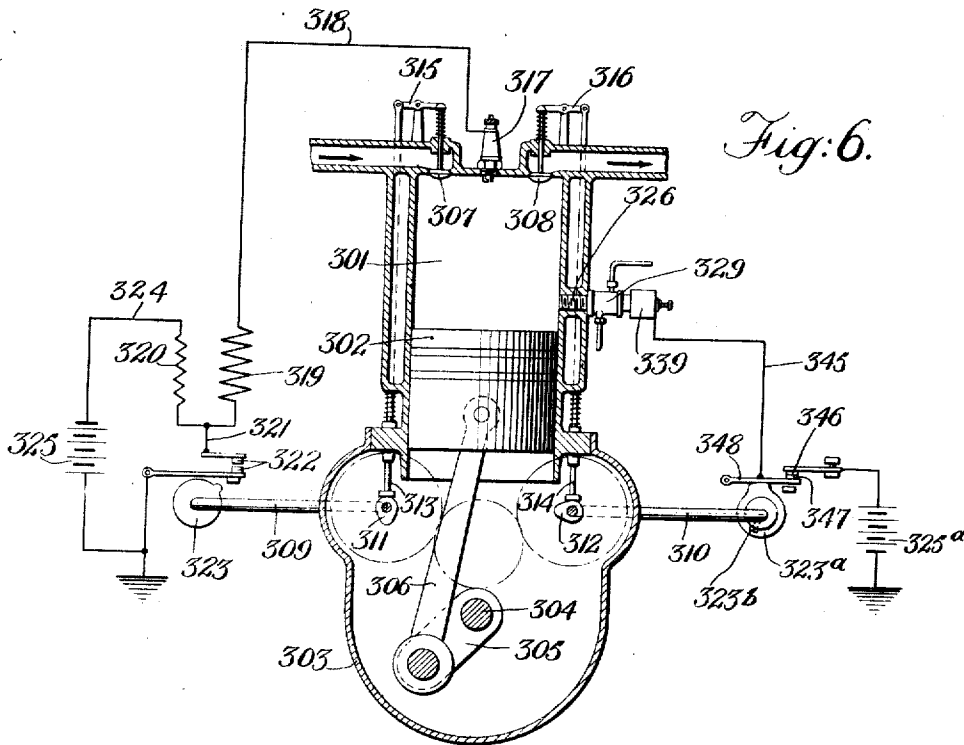


Fig. 6.

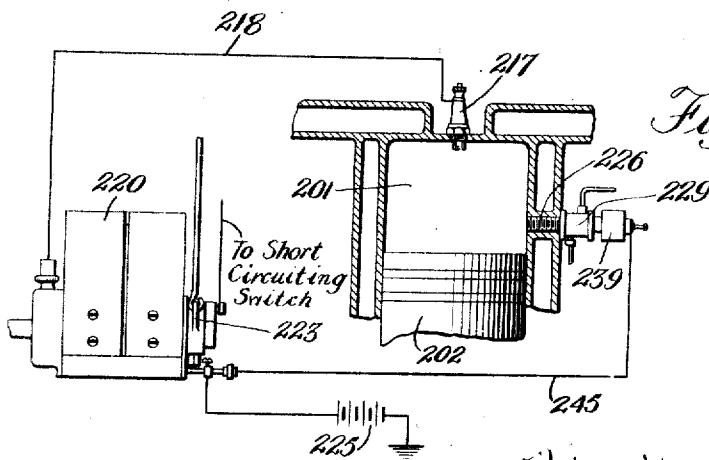


Fig. 5.

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Fig. 9.

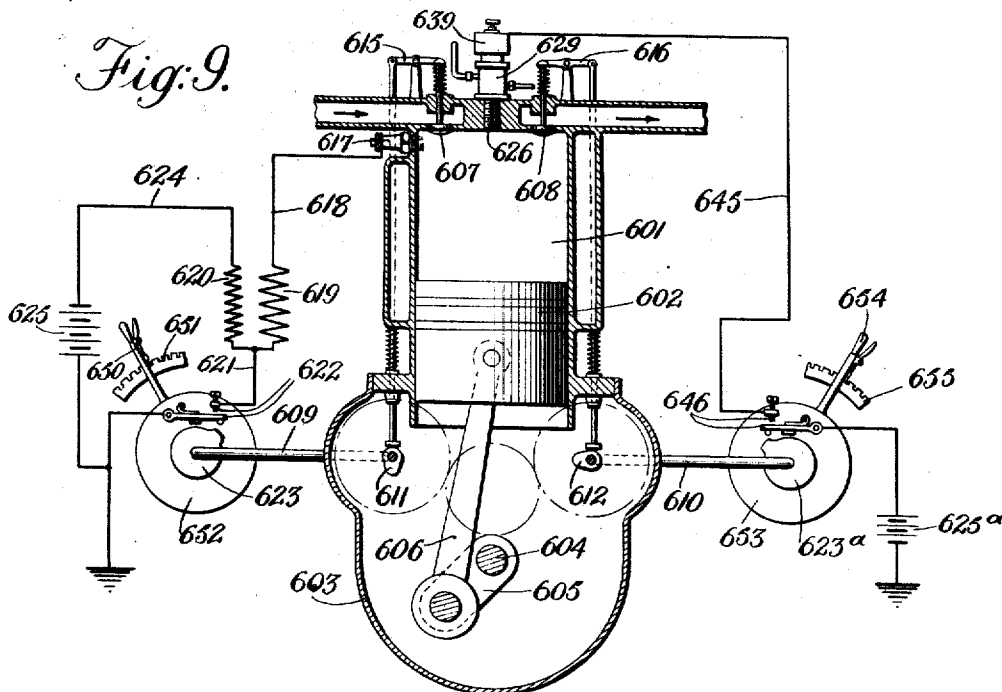
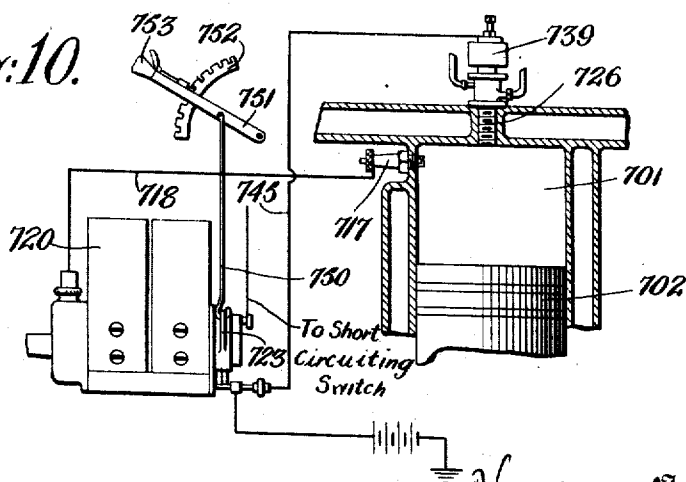


Fig. 10.



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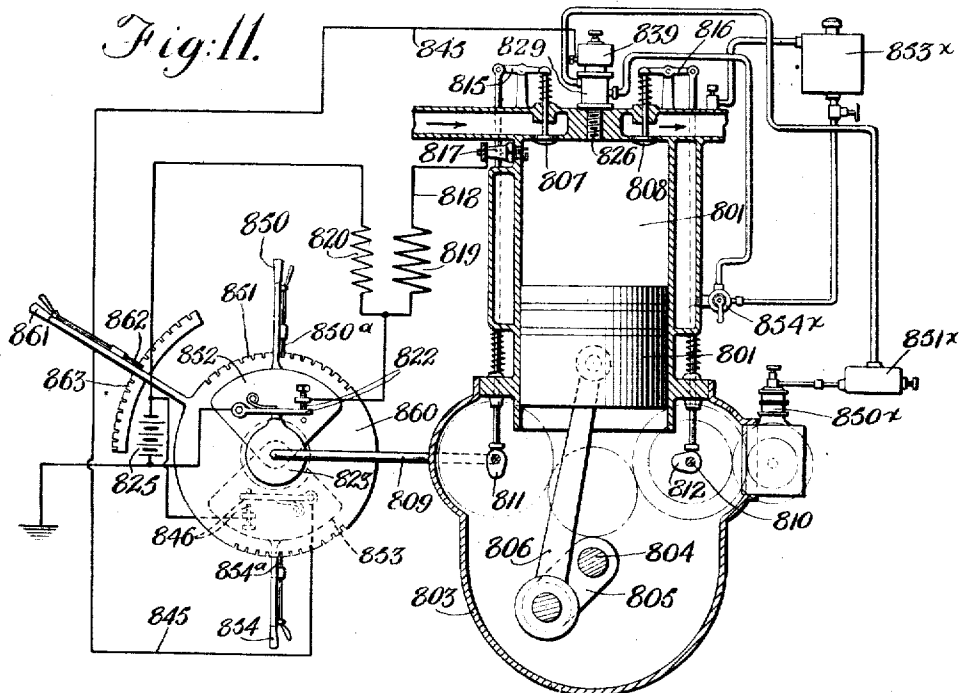
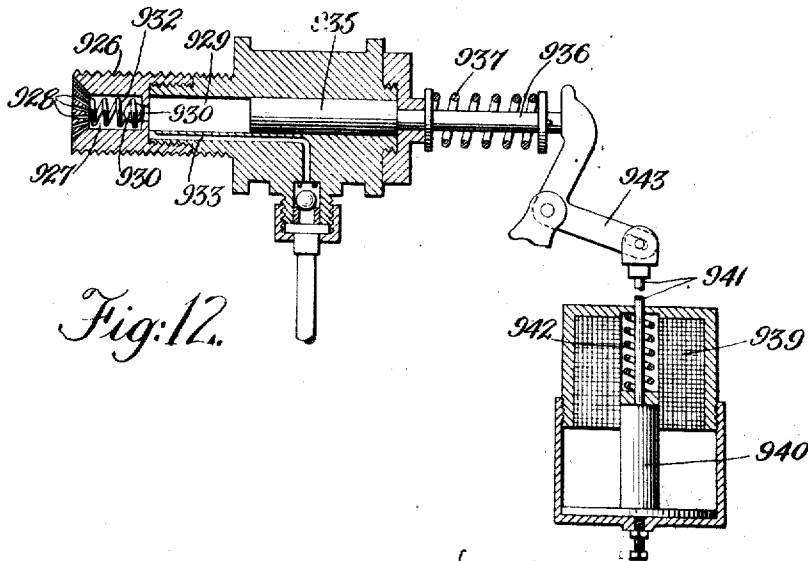
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V. W. KLIESRATH

INTERNAL COMBUSTION ENGINE

Filed Aug. 30, 1919

6 Sheets-Sheet 6



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Patented July 31, 1923.

1,463,586

UNITED STATES PATENT OFFICE.

VICTOR W. KLIESRATH, OF EAST ORANGE, NEW JERSEY ASSIGNOR OF ONE-HALF TO
CALEB S. BRAGG, OF CINCINNATI, OHIO.

INTERNAL-COMBUSTION ENGINE.

Application filed August 30, 1919. Serial No. 320,806.

To all whom it may concern:

Be it known that I, VICTOR W. KLIESRATH, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Internal-Combustion Engines; and I 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.

My invention consists in the novel features hereinafter described, reference being had to the accompanying drawings which illustrate several embodiments of my invention, selected by me for purposes of illustration, and the said invention is fully disclosed in the following description and claims.

This application is a continuation in part of my former application filed March 12, 1919, Serial No. 282,178.

In the operation and use of internal combustion engines a charge of explosive mixture is ignited in the combustion chamber or chambers in or communicating with the engine cylinder or cylinders, imparting a sudden and powerful impact against the piston or pistons, due to the rapid formation of large volumes of gas produced by the combination of the explosive charge, and accompanied by the evolution of intense heat. It follows that as the piston or pistons is or are moved outward by the impact of the gases, the pressure thereof rapidly decreases as the size of the combustion chamber is increased by the movement of the piston or pistons, and it has also been found necessary to eliminate a large proportion of the heat by radiation, in order to prevent overheating of the cylinders, pistons, and valves, and as a considerable amount of heat is lost through the exhaust, it is customary in this type of engines or motors to employ large masses of metal, in the formation of the cylinders, in order to facilitate the absorption and radiation of the heat, and also to provide additional means, such as water jackets, and extraneous radiators connected therewith, or other cooling means for the rapid radiation to the atmosphere of a large portion of the heat of the ignited charge, which is thus dissipated and lost. The object of my invention is to provide a process and apparatus for converting a large por-

tion of the heat evolved in the combustion of the explosive charge in internal combustion engines, into energy for the double purpose of increasing the efficiency of the engine, and for the elimination of a certain proportion of the evolved heat, which is thus converted into energy and transmitted to the crank shaft of the engine. In carrying out my invention, I inject into the cylinder or cylinders or combustion chamber or chambers, at a point in the cycle of operation between the time of ignition of the explosive charge and the time of exhausting the burnt gases, a substance which will absorb a considerable portion of the heat of the explosive charge, and by expansion, combustion, or otherwise, increase the pressure of the gases produced by the ignition of the normal charge, thereby increasing materially the effective stroke of the piston, and preventing the rapid decline of pressure which follows the ignition of an ordinary explosive charge. The substance which I prefer to inject into the cylinder or combustion chamber for the purpose specified, is water, which is preferably warmed to a point somewhere near the boiling point, or 212° Fahrenheit, as water absorbs large quantities of latent heat in its conversion into steam, and increases very largely in volume such conversion, thereby extracting heat from the ignited charge, while at the same time, it greatly increases the pressure within the cylinder, and thereby in a highly efficient manner converts a large portion of the heat of the ignited charge into useful energy, while lowering the temperature of the burning gases and the surrounding parts, holding them in confinement. I may, however, inject other substances of a gaseous, liquid, or solid character, in the same manner and for the same purpose. For example, I may inject a supplemental charge of an explosive mixture of gases, or a small quantity of liquid explosive material, or water containing explosive material, for example picric acid, or I may inject a finely divided solid such as, for example, a finely divided powder or picric acid or other explosive substance.

The time in the cycle of the engine at which the injection of the extraneous heat absorbing and pressure forming material is injected may be fixed with respect to the stroke of the piston, or the time of injection

may be regulated either manually or automatically with respect to the stroke of the piston, and if desired, it may also be regulated with respect both to the stroke of the piston and to the time of ignition. Some of the benefits and advantageous results of my invention in the construction and operation of internal combustion engines, may be stated as follows:—

- 10 a. It will allow of using higher compressions.
- b. It will permit the burning of lower grade fuel oils.
- c. It will permit the utilization of a greater extent in mechanical work of the heat of the explosive charge developed in the cylinder or cylinders, which is now wasted through the exhaust and by radiation.
- 15 d. It will eliminate the necessity for at least a large part of the cooling apparatus now necessarily employed in the operation of internal combustion engines.
- e. It will continue the pressure within the cylinder for a greater length of piston stroke, and lengthen the effective stroke of the piston.
- f. It will diminish the excessive heat action upon the cylinder, piston, and inlet and exhaust valves which have hitherto been to a great extent limiting factors as to the amount of heat which could be handled for the purpose of developing power in explosive combustion engines.
- 20 g. The motor will be more flexible, more free from vibration, and will have a more uniform torque.
- h. The motor will produce more power per unit of cylinder area.
- i. Higher speeds may be used for given ratios of cylinder dimension.
- j. Radiating surfaces and external cooling devices may be largely, if not entirely, dispensed with, owing to the elimination of a large part of the heat evolved by the ignited charge and its conversion into power or energy.

It will also be understood that my invention is applicable to engines of one or more cylinders, and to engines operating upon either the four cycle or two cycle system.

In the accompanying drawings,

Fig. 1 represents diagrammatically an embodiment of my invention applied to a one cylinder internal combustion engine, in which the injection of the heat absorbing and pressure producing material is effected by a pressure system under the control of an electromagnetically operated control valve operating in timed relation with the ignition mechanism.

Fig. 2 represents an enlarged view of one form of injector for carrying out my invention, and the electromagnetically oper-

ated control valve therefor, as shown in Fig. 1.

Fig. 3 represents a one cylinder engine embodying my invention, in which the pressure applied to the injector is controlled by a valve acting in timed relation with the engine shaft and therefore independent of the ignition mechanism.

Fig. 3^a is an enlarged detail view of the form of injector and measuring chamber shown in connection with Fig. 3.

Fig. 3^b is a detail of the control valve.

Fig. 4 is an enlarged detail view of a siphoning valve shown in Figs. 1 and 3 for supplying the injector with liquid either from the water jacket of the engine cylinder or from an extraneous source.

Fig. 5 is a diagrammatic representation of an embodiment of my invention similar to Fig. 1 in which the electromagnetically operated valve controlling the injector is operatively connected with and operates in timed relation with the magneto which supplies current for the ignition.

Fig. 6 represents an embodiment of my invention similar to Fig. 1 in which the electric circuit controlling apparatus for the injector is operated in timed relation with the engine, but independently of the ignition mechanism.

Fig. 7 represents a modification of the injector and its controlling mechanism, in which the pressure system is controlled by a valve operated mechanically by a part connected with the engine, and in timed relation therewith, without the use of an electromagnetic control for such valve.

Fig. 8 represents another modification of the injector in which the pressure system illustrated in connection with the other and preceding figures is dispensed with and the pressure necessary for injection is supplied mechanically by means of a plunger operated mechanically by and in timed relation with the part connected with the engine.

Fig. 9 is a view similar to Fig. 1 showing the injector located in the cylinder head, and also showing electromagnetically controlled means for independently adjusting the timing of the ignition and of the operation of the injector.

Fig. 10 is a detail view similar to Fig. 5 showing the injector in the cylinder head, and electromagnetically controlled, and a magneto combined therewith and constructed to enable the time of ignition and injection to be simultaneously advanced or retarded.

Fig. 11 is a view similar to Fig. 9 showing means for simultaneously advancing or retarding the time of ignition and injection and also means for separately and independently adjusting the timing of either or both.

Fig. 12 is a detail view of an injector of

the type shown in Fig. 8 showing the electro-magnetic control apparatus arranged to directly actuate the injecting plunger.

Referring to Fig. 1 of the accompanying drawings, which illustrates one embodiment of my invention selected by me for purposes of illustration, 1 represents an engine cylinder, 2 the piston working therein, 3 the crank case, 4 the crank shaft, 5 a crank, 6 the connecting rod from the piston to the crank, 7 the inlet valve, 8 the exhaust valve, 9 and 10 the cam shafts operatively connected with the engine shaft by gearing indicated diagrammatically in dotted lines and provided respectively with inlet and exhaust cams 11 and 12, for actuating the inlet and exhaust valves through the usual rods 13 and 14 and levers 15 and 16. 17 indicates the spark plug connected by wire 18 to the secondary coil 19 of the spark coil, having a primary winding 20, both windings being connected to ground by wire 21 through the separable contacts 22 of a periodic interrupter having a cam 23 on or driven by one of the cam shafts 9 or 10 (in this instance the shaft 9), as is diagrammatically illustrated in Fig. 1, the primary winding 20 being connected by wire 24 to a battery 25, which is in turn connected to ground. The foregoing parts represent a simple and known form of a one cylinder internal combustion engine in connection with which it will be convenient to describe the application of my invention thereto.

At some point, preferably in the side wall of the cylinder 1 between the extreme inner and outer positions of the piston therein, as may be desired, I locate my improved injector nozzle 26, one form of which is shown enlarged in Fig. 2. The exterior of the nozzle is preferably threaded so as to be screwed into a threaded aperture in the cylinder wall in substantially the same manner in which the spark plugs are ordinarily inserted in the cylinder head, and where a water jacket is employed in connection with the cylinder, as shown in Fig. 1 for example, the nozzle 26 will preferably be made of sufficient length so that its inner end will be almost in line with the inner faces of the cylinder wall. The nozzle 26 is provided with an internal chamber 27 and is also provided at its inner end with a discharge aperture or apertures 28. I prefer to provide the inner end of the nozzle with a plurality of discharge apertures of very fine bore, disposed at increasing inclinations to the axis of the nozzle from the center outward towards the periphery so that the liquid or other material injected shall be sprayed into the ignited charge at the proper time in as finely divided and separated condition as possible, so as to instantly absorb heat therefrom and be converted into steam or gaseous form. At its outer end the nozzle is

provided with a valved measuring chamber 29 with which the injector passage 27 communicates by a small aperture 30 normally closed by a ball check valve 31 actuated by a spring 32. The measuring chamber 29 is provided with an inlet or siphoning port 33 and with a pressure inlet port 34, each of which communicates with a threaded nipple, and the chamber itself, which is cylindrical in form, and is provided with a piston valve 35 having an annular groove 36 surrounding the same, and a longitudinal bore or passage 37 communicating with said groove by a transverse passage 38, the said annular groove being adapted to register with the pressure inlet port 34 when the valve is in its innermost position, said port being closed by the piston valve when the valve is in its retracted position.

In the form of invention shown in Figs. 1 and 2, the piston valve 35 is adapted to be actuated by an electromagnetic control device which comprises in this instance a solenoid 39 provided with an armature core 40 directly connected to the valve by a stem 41, a retracting spring 42 surrounding said stem being employed to retract the valve, the outer position of the valve being regulated by a set screw 43 in a cap 44 secured to the outer end of the solenoid casing which is in turn conveniently applied by means of screw threaded portions, to the outer end of the valved measuring chamber. As shown, the solenoid is connected by a wire 45 with the battery 25 through normally separated contacts 46—47, the movable contact 47 being carried on a cam actuated lever 48, actuated by a projection on cam 23, which also operates the contacts of the periodic interrupter of the ignition circuit. The lever 48 is so located with respect to the cam 23 that a circuit through the solenoid 39 will be made at the desired period after the operation of the igniter to fire the charge, which interval may be made more or less as desired. The cam projections on the cam 23 for operating the ignition contacts and the injector contacts will be arranged on the cam, out of alignment with each other, so that each projection will actuate only the movable contact of the pair for which it is specially provided, as will be readily understood.

In the embodiment of my invention shown in Figs. 1 and 2, I have shown a pressure system for applying pressure to the injector at the desired time in the cycle of the engine. This pressure system, as shown in Fig. 1, comprises a pump or compressor, indicated at 50, driven from the engine, in this instance from the cam shaft 10 by gearing indicated in dotted lines and arranged to compress fluid, as air into an equalizing chamber 51, connected with the compressor 50, the equalizing chamber being connected

by pipe 52 with the pressure inlet port 34 of the valved measuring chamber 29. The pressure required for the operation of the injector may be as required. I have found that from two hundred and fifty pounds per square inch upwards is ample for the purpose of injecting a liquid into an ignited charge against the pressure thereof, and in some cases a much lower pressure may be employed.

The liquid to be injected in this case is water, and may be conveniently obtained either from the water jacket, in which case it will be obtained under a fairly high temperature, or it may be obtained from an extraneous reservoir such as is illustrated, for example, at 53, and I prefer to employ the three-way siphoning cock so that the water may be supplied to the injector in either way, although this is not necessary. The liquid contents of the tank or reservoir 53 may be heated in any desired way if desired. I have shown the tank 53 surrounded by a heating coil 53^a through which the heated water from the water jacket of the engine may be circulated, the circulation pipes being provided with valves 53^b and 53^c so that the circulation can be stopped when it is not desired to preheat the injected liquid. In this instance 54 represents the three-way cock which is illustrated in detail in Fig. 4, the said cock being connected at 55 to the water jacket and by a pipe 56 to the nipple communicating with the water inlet port 33 of the valve measuring chamber. The pipe 56 is preferably provided with a ball check valve 57. The siphoning valve 54 is connected by a pipe 58 with the tank 53, the pipe 58 being also preferably connected by a pipe 59 to the bottom of the radiator (not shown), and for the purpose of applying additional pressure to the surface of the water in the tank 53, I prefer to connect it with the exhaust passage of the engine by means of a pipe 60, and adjustable check valve 61. The three-way cock 54 may be set so as to take water from the water jacket or from the tank, or both as may be desired, and in case the water is taken from the water jacket, it will be replaced into the radiator by means of the branch pipe 59 from the tank 53. As a matter of fact, the amounts required to be injected are very small.

In the operation of the embodiment of my invention shown in Figs. 1 and 2 in which the engine operates on a four cycle system, a normal charge of explosive mixture is drawn into the cylinder through the inlet valve, is compressed in the usual manner, and ignited, effecting the ignition of the charge, and imparting the customary impact to the cylinder, which commences the outward stroke. At the predetermined period after the ignition takes place and

before the piston reaches the end of its stroke, the cam 23 will close the circuit through the battery and solenoid 39, hereby causing the core 40 and the connected valve to move inward. The measuring chamber 29 will be filled with water from the water jacket or the tank 53, the water being warmed to a temperature approximating that of steam and the forward movement of the piston valve 35 will force this water into the chamber 27 in the nozzle. When the valve 35 is moved far enough to bring the annular groove 36 into registration with the pressure inlet port 34, the accumulated pressure in the pressure equalizer 51 of the pressure system will enter said groove and pass through the transverse aperture 38 and the longitudinal passage 37 in the valve, and thence into the injector nozzle, forcing the water in the form of a fine spray through the distributing ejector passages 28, into the ignited charge. The finely divided water particles are instantly converted into steam, absorbing a large quantity of heat from the ignited charge, and greatly increasing the pressure at the time within the cylinder, which has been somewhat reduced by the outward movement of the piston, and imparting this increased pressure to the piston, thus converting the absorbed heat into energy and lengthening the effective stroke of the piston, as previously set forth. As soon as the controlling contacts 46—47 for the magnet separate, the spring 42 will withdraw the valve 35, thus closing the pressure passage. The ball valve 31 of the injector being seated as the valve withdraws, water for the next injection, in measured quantity will be drawn by suction through the pipe 56 and water inlet port 33 into the measuring chamber 29, when the parts are in position for the next operation following the next ignition of an explosive charge in the engine cylinder.

In Figs. 3 and 3^a I have shown an embodiment of my invention which differs somewhat in the manner of controlling the admission of pressure to the injector. The parts shown in Fig. 3 which are identical with those shown in Fig. 1 are given the same numerals plus one hundred, as cylinder 101, piston 102, etc., and the ignition mechanism for controlling the supply of current to the spark plug, which may be of any preferred type, is omitted in Fig. 3. In this instance the electromagnetic control for the pressure valve is dispensed with, and the injector nozzle 126 is provided with a measuring chamber 129, having therein a movable piston valve 135 normally held in its outermost position by spring 142. In this outer position the valve 135 closes by pass 134 communicating with the water inlet port 133 and the pressure is admitted

by pipe 152 from the pressure equalizer 151 directly in rear of the piston valve 135, so as to actuate the same. The pipe 152 is provided with a cut off valve 148 normally closed, and adapted to be opened by a cam 149 on a shaft driven by the engine and in timed relation therewith, in this instance located on the shaft of the compressor 150, which is driven at the same speed as the cam shaft 110 of the engine, but such cam may be located on any other shaft and driven in proper time from the engine. When the cut off valve 148 is open, the pressure fluid will be placed in communication with the valve measuring chamber of the injector, driving the piston valve 135 forward, compressing the spring, and uncovering the by pass 134, and expelling the water and other fluid in the measuring chamber 129 into the nozzle chamber 127. As soon as the by pass is uncovered, the pressure fluid is admitted to the inlet port 133, and thence to the nozzle, so as to inject the fluid into the ignited charge, in the manner hereinbefore described with reference to Fig. 1. As soon as the valve 148 is permitted to close (a retracting spring not shown being employed for this purpose which normally maintains the valve in closed position), the piston valve 135 is retracted by its spring 142, closing the by pass 134, and drawing a fresh charge of water or other fluid from the water jacket or from the external water tank 153, as the case may be, according to the position of the three-way siphoning cock. In Fig. 3 the pressure reservoir is provided with a gauge to indicate the pressure employed, and such a gauge may be used in any of the forms of my invention in which pressure is employed, if desired. The cut off valve 148 is provided with means for exhausting the piping between the valve and the measuring chamber as soon as it is returned to closed position, a cut off valve suitable for the purpose being shown in Fig. 3^b. The exhaust passage is here indicated at 148^a. It will be understood that by adjusting the cam 149 with respect to its shaft, for which purpose a set screw 149^a is shown in Fig. 3, for example, the interval between the ignition of the normal charge and the introduction of the fluid or other material into the cylinders can be regulated.

In Fig. 5 I have illustrated more or less diagrammatically a modification of the parts shown in Fig. 1, in which the same form of injector nozzle, valve measuring chamber, and electromagnetic control for the valve is shown in connection with a magneto for supplying current to the igniter, and also the said electromagnetic valve operating means. In this figure the parts which correspond with those in Fig. 1 have been given the same numerals plus

200, as the cylinder 201, piston 202, etc. The injector nozzle 226 is provided with the form of measuring chamber 229 shown in detail in Fig. 2, the solenoid indicated at 239 being connected by wire 245 with a magneto 220, which is also connected by wire 218 to the spark plug 217. 223 represents the timing lever of the magneto, for shifting the cam of the periodic interrupter, in a well known way, to advance and retard the spark. The timing lever will preferably be provided with a separate cam in a manner similar to that shown in Fig. 1, out of alignment with that of the interrupter cam or cams for operating a movable contact (not shown), to make and break the circuit through the wire 245, and effect the actuation of the solenoid. The mechanism shown in Fig. 5 acts precisely like that with reference to Figs. 1, 2, and 3, except that the current for ignition and for actuating the controlling valve of the injector mechanism is supplied by a magneto, an auxiliary battery 225 being employed for starting, and as the application of my invention in this manner will be apparent to those skilled in the art, I have not herein specifically illustrated the slight change required in the magneto, i. e., the additional circuit breaker on the armature shaft, and contacts, as the same will be readily understood.

In this construction, as in the construction shown in Fig. 1, the injector will be actuated in a predetermined relation to the ignition, but the ignition may be advanced or retarded simultaneously with the operation of the injector, whereas in the form of my invention shown in Fig. 3, the timing of the injector action can be adjusted independently of the time of ignition, and my invention is as applicable in the one case as in the other.

In Fig. 6 I have shown another slight modification of my invention, in which the timing of the ignition is independent of the timing of the injector mechanism. In this figure I have shown more or less diagrammatically a one cylinder engine, the parts corresponding to those in Fig. 1 being given the same numerals plus 300, as the cylinder 301, piston 302, etc. In this figure I have shown the same form of injector mechanism as is shown in Figs. 1, 2, and 5, with the electromagnetically operated valve for controlling the admission of pressure, but in Fig. 6 I have disassociated the valve controlling mechanism from the ignition mechanism. The ignition mechanism shown in Fig. 6 is precisely the same as that shown in Fig. 1, and operates in the same well known manner. In this instance, however, I have shown a separate cam 323^a adjustably secured to the cam shaft 310 for operating the movable contact lever 348 carrying the movable contact 347 which is

interposed in the electrical connection 345 from the solenoid 339 to a separate battery 325^a. The cam 323^a is operated from the engine in timed relation therewith, and in timed relation with the cam 323 which controls the ignition mechanism and may be made to follow more or less closely the ignition of the charge by adjusting the cam 323^a upon the shaft 310 by means of the set screw indicated at 323^b. The operation of the apparatus will be exactly the same as previously described with reference to Figs. 1, 2, 5, except that the timing of the injector apparatus may be independent of the ignition mechanism, as is also the case in the form of the invention shown in Fig. 3.

In Fig. 7 I have shown another modification of my invention in which the same pressure apparatus hereinbefore described with reference to Fig. 1 is employed in connection with the injector nozzle, but in this case the controlling valve in the measuring chamber is directly operated mechanically by a part connected with and in timed relation with the engine. The form of the injector shown in Fig. 7 and the measuring chamber connected therewith is very similar to that shown in Fig. 2, and the corresponding parts have been marked with the same numerals plus 400, the nozzle being indicated at 426, the discharge orifices at 428, the valve measuring chamber at 429, etc. In this instance, however, the valve stem 441 projects outside of the measuring chamber and is provided with a retracting spring 442. The valve stem in this instance is actuated by a bell crank lever 462, pivoted on a suitable support or bracket indicated at 463, said bell crank being actuated by a connecting rod 464, driven in timed relation with the engine in any desired manner as by an eccentric or crank (not shown in Fig. 7), in a manner similar to that shown in Fig. 8, for example. In this instance it will be seen that the piston valve 435 will be positively actuated mechanically at the proper time in the cycle, following the ignition of the normal charge, by the connecting rod 464 and bell crank 462, thereby effecting the injection into the ignited charge of a measured quantity of the water or other liquid or fluid supplied from the water jacket or other source, as by means of the pipe 456, in exactly the same manner as previously described with reference to Fig. 1 of the drawing, except for such mechanical actuation of the injector controlling valve as may be necessary.

In carrying out my improved process by means of the various embodiments of my invention heretofore described and illustrated in Figs. 1 to 7 inclusive, I have employed a fluid under high pressure as the means for injecting the liquid or other material into the cylinder through the injector nozzle. I

do not, however, limit myself to the use of a pressure fluid for this purpose, as the measured quantity of water or other liquid, or other material may be injected by other means and in any other desired way. In Fig. 8, for example, I have illustrated a modification of my invention in which the pressure necessary to force the measured quantity of water or other material into the engine cylinder is furnished by mechanical means. In this figure the injector nozzle is indicated at 526, the discharge orifices at 528, the ball check valve at 531, and the nozzle is provided with a measuring chamber indicated at 529, which is cylindrical, and is provided with a piston 535 having a piston rod 541 extending outside of the chamber, and in turn provided with a retracting spring 542, which normally holds the piston at the outer end of its stroke. The measuring chamber is provided with the inlet passage 533 which connects by pipe 556 with the supply of water or other liquid or material, preferably from the water jacket, as before described, or from an extraneous reservoir or both, the communication between the pipe 556 and the inlet passage 533 being controlled by the ball check valve 557. In this instance I have shown a bell crank lever 562, mounted on a bracket, indicated at 563, one arm of said bell crank operatively engaging the outer end of the piston rod 541, and the other arm being connected by a rod 564 with an eccentric strap 565, surrounding an eccentric 566, mounted on a shaft 543 operated by and in timed relation with the engine, and being, for example, one of the cam shafts thereof. As the piston 535 is withdrawn by spring 542, a measured quantity of water or other liquid is drawn into the measuring chamber 529, and at the proper time in the cycle, after the ignition of a normal charge, determined by the position of the eccentric 566, on the shaft 543, the piston will be forced inward by the eccentric operating through the rod 564 and bell crank 562, thus positively expelling the liquid in the measuring chamber 529, and injecting it into the ignited charge.

It will be obvious that my invention is applicable to all types of internal combustion engines of whatever cycle, and that it is applicable also to engines having one or any number of cylinders. While I have shown several mechanical arrangements for carrying out my improved invention, and process, it will be understood that variations can be made in such apparatus within the scope of the following claims, without departing from the spirit of my invention, and that my invention may be applied and embodied in existing combustion engines, as well as in internal combustion engines manufactured with special reference to the embodiment therein of my invention. I believe that I

am the first to produce the herein described process and apparatus by which a quantity of material, gaseous, or liquid, as the case may be, capable of absorbing heat and producing increased pressure is injected into the cylinder or cylinders of an internal combustion engine between the ignition of the normal charge of explosive material and the end of the piston stroke produced thereby, and to provide means where desired for regulating the time of this injection with respect to the time of ignition, or with respect to the position of the piston, or both, and these features I broadly claim.

I wish it also to be understood that my invention is equally applicable to high compression internal combustion engines, for example, of the Diesel type, in which case the pressure employed for injecting the water or other material into the ignited charge whether produced by pressure fluid or by mechanical action, or otherwise, will be sufficiently high to overcome the increased pressure of the ignited charge within such high compression engine cylinders.

Where the water or other liquid to be injected into an ignited charge of explosive material is obtained from an external supply tank or reservoir, it may be preheated by any desired means, as by waste gases from the exhaust, or otherwise. For example, in Fig. 1 I have shown the tank 53 provided with the heating coil 53^a, connected in this instance to the water jacket of the engine cylinder and provided with controlling valves 53^b for cutting it out when its use is not desired, but it will be understood that any other means of preheating the water in the tank may be employed.

In Fig. 9 I have shown an embodiment of my invention in which the injector nozzle is located in the head of the cylinder 601, as indicated at 626, and provided with the liquid measuring chamber 629 and electromagnetic control device 639, similar to those shown in Figs. 1 and 2, for example. The spark plug indicated at 617 is located in this instance in the side of the cylinder but it may also be located in the cylinder head if desired. In this figure I have shown independent means for advancing and retarding the time of ignition and the time of injection of liquid. 623 represents the ignition cam on the cam shaft 609, and the separable contacts 622 are shown located on a disc 652 concentric with the cam shaft and rotatable by means of a hand lever 650 which may be locked in adjusted position by means of a pawl engaging a stationary locking segment 651. It will be understood that other usual or preferred means for advancing or retarding the spark may be employed. The primary winding of the ignition mechanism is indicated at 620, the secondary winding at 619, and the battery at

625. In this figure I have shown the cam shaft 610 provided with a cam 623^a for closing the circuit through the electromagnetic control device for the injector, and the separable contacts 646 are shown as located on a disc 653 concentric with the cam shaft and adjustable rotatably by means of a hand lever 654 carrying a pawl engaging a locking segment 655. The battery for the electromagnetic control device is indicated at 625^a, and 645 represents the wire connecting one of the contacts 646 with the solenoid of the electromagnetic control device.

It is highly important that the time of injection of the liquid as before described may be varied with respect to the stroke of the piston and with respect to the time of ignition, so as to secure the best results under varying load conditions. If the injection follows too closely the ignition of the charge it may interfere with the complete combustion of the charge of explosive material, and if it is delayed too long the beneficial results of the liquid in augmenting the pressure in the cylinder and increasing the efficiency of the piston stroke will be impaired.

With the construction shown in Fig. 9, for example, the timing of the injection can be accurately regulated with respect to the time of ignition to secure the best results under all load conditions and the timing of either or both of the ignition and injection may be varied from time to time as the load condition varies.

In Fig. 10 I have shown a construction similar to that shown in Fig. 5, except that the injector here indicated at 726 is located in the cylinder head. In this instance a magneto 720 furnishes the current for both the ignition and the electromagnetic control for the injector through wires 718 and 745, extending respectively to the spark plug 717, and the electromagnetic control device 739, the injector being constructed and operating as shown in Fig. 2. The timing lever 723 carries two cams, forming parts of periodic interrupters of well known construction for producing electric impulses in the wires 718 and 745 at the proper times, the magneto being driven in timed relation to the engine in any usual or preferred manner. The timing lever is shown connected by a link or rod 750 with a control lever 751 which may be held in adjusted position by pawl 753 and segment 752. By moving the timing lever the timing of the ignition and the injector may be simultaneously advanced or retarded, as will be readily understood.

In Fig. 11 I have shown another modification of my invention which illustrates one way in which the timing of the ignition and injection may be simultaneously advanced or retarded, while at the same time

the timing of the ignition and injection may also be independently adjusted. In this figure 801 is the cylinder in the head of which is shown the injector 826, constructed and operating as shown in Fig. 2 and provided with liquid measuring chamber 829 supplied with liquid either from a tank 853 or the water jacket, according to the position of the valve 854*, and pressure for injecting the liquid being supplied by a pump 850* and equalizing chamber 851*, in the manner indicated and described with reference to Figs. 1 and 2. The electromagnetic control device for the injector is as shown in detail in Fig. 2, and includes a solenoid for admitting the fluid pressure to the measuring chamber, said solenoid being connected by wire 845 to one of the separable contacts 846 mounted in this instance on a disc or segment 853, concentric with the cam shaft 809, carrying the actuating cam 823. The disc or segment 853 is provided with an adjusting lever 854, and a pawl 854* which engages locking notches in an adjustable disc or segment 860.

The spark plug 817 is connected by wire 818 with the secondary winding 819 of the ignition mechanism, the primary winding of which is indicated at 820. The primary winding is connected to the battery 825 and both windings are grounded through separable contacts 822 carried on a disc or segment 852, concentric with the cam shaft 809, and adjustable by means of a lever 850, which can be locked with respect to the disc or segment 860, by a pawl 850* engaging notches 851 in disc or segment 860. The disc or segment 860 is adjustable together with and simultaneously with segments 853 and 852, by means of a hand lever 861, carrying a pawl 862, engaging a notched stationary segment 863. By this means the timing of the ignition and injection may be separately and independently advanced or retarded until the highest efficiency for a particular engine load is obtained and thereafter the lever 861 will enable the operator to simultaneously advance or retard the time of ignition and injection to meet variations of load and engine speed.

In Fig. 12 I have illustrated another slight modification of my invention in which the injector nozzle indicated at 926, is provided with a measuring chamber 929, provided with the siphoning port 933, connected to the liquid supply and having a piston 935 for forcing the measured quantity of liquid into the cylinder at the proper time under the action of an electromagnetic device. The piston 935 is provided with a stem 936 extending outside of the chamber and provided with a retracting spring 937. 939 represents the solenoid provided with an armature core 940, and retracting spring 942, and a stem 941, connecting the armature

core with a bell crank lever 943, one arm of which acts upon the piston stem 936, and forces the piston 935 inward to inject the liquid, when the solenoid core is actuated. In some instances I may desire to employ this construction in which the electromagnetic device directly effects the injection of liquid instead of operating a valve to admit a pressure fluid for the purpose as shown in other figures of the drawings.

What I claim and desire to secure by Letters Patent is:—

1. In an internal combustion engine provided with a cylinder and piston, and charge supplying and ignition mechanism, means independent of the normal charge supplying mechanism for introducing into the cylinder at a point in the cycle of the engine between the instant of ignition of a normal charge and the end of the piston stroke effected thereby, a quantity of material capable of absorbing heat from the ignited charge, and increasing the pressure thereof, including adjustable means for varying the timing of the admission of said material with respect to the piston between its inner and outer positions, whereby the timing of the admission of said material may be advanced or retarded with respect to the power stroke of the piston.

2. In an internal combustion engine provided with a cylinder and piston, and charge supplying and ignition mechanism, means independent of the normal charge supplying mechanism for introducing into the cylinder at a point in the cycle of the engine between the point of ignition of a normal charge and the end of the piston stroke effected thereby, a quantity of material capable of absorbing heat from the ignited charge and increasing the pressure thereof, including adjustable means for varying the timing of the admission of said material, a greater or less extent after the ignition of the normal charge.

3. In an internal combustion engine provided with a cylinder and piston, charge supplying and ignition mechanism, and adjustable timing mechanism for the ignition mechanism, means independent of the charge supplying mechanism for introducing into the cylinder at a point in the cycle of the engine between the point of ignition of a normal charge and the end of the piston stroke, effected thereby, a quantity of material capable of absorbing heat from the ignited charge and increasing the pressure thereof, including adjustable means for advancing or retarding the time of such admission of said material, whereby both the time of ignition and the time of admission of said material can be varied with respect to the piston stroke.

4. In an internal combustion engine provided with a cylinder and piston, and charge supplying and ignition mechanism, means

independent of the charge supplying mechanism for introducing into the cylinder at a point in the cycle of the engine between the point of ignition of a normal charge and the end of the piston stroke effected thereby, a quantity of material capable of absorbing heat from the ignited charge, and increasing the pressure thereof, means for varying the timing of the ignition mechanism, and means for varying the timing of the admission of said material, with respect to the time of ignition.

5. In an internal combustion engine provided with a cylinder and piston, and charge forming and ignition mechanism, an injector nozzle independent of the charge forming mechanism communicating with the cylinder, means for supplying a quantity of liquid to said nozzle, mechanism for injecting the liquid in said nozzle into the cylinder, electromagnetic controlling mechanism for said injecting mechanism, a circuit for said electromagnetic controlling mechanism, and means operating in timed relation with the engine for closing said circuit.

6. In an internal combustion engine provided with a cylinder and piston, and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, means independent of the charge forming mechanism for supplying a quantity of liquid to said nozzle, mechanism for injecting the liquid in said nozzle into the cylinder, electromagnetic controlling mechanism for said injecting mechanism, a circuit for said electromagnetic controlling mechanism, adjustable means operable in timed relation with the engine for closing said circuit, and means for advancing and retarding the operation of said adjustable means with respect to the cycle of the engine.

7. In an internal combustion engine provided with a cylinder and piston, and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, means independent of the charge forming mechanism for supplying a quantity of liquid to said nozzle, mechanism for injecting the liquid in said nozzle into the cylinder, electromagnetic controlling mechanism for said injecting mechanism, a circuit for said electromagnetic controlling mechanism, adjustable means operable in timed relation with the engine for closing said circuit, means for varying the timing of the ignition mechanism, and means for varying the timing of said adjustable circuit closing means for the injector operating mechanism.

8. In an internal combustion engine provided with a cylinder and piston and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, means independent of the charge forming mechanism for supplying a quantity of liquid to said nozzle, means separate from

and independent of the liquid supply means, for supplying fluid pressure to said nozzle, for injecting said liquid into the cylinder, a normally closed valve interposed between the fluid pressure supply and said nozzle, and means for opening said valve at a point in the cycle of the engine between the ignition of a normal charge and the end of the piston stroke effected thereby.

9. In an internal combustion engine provided with a cylinder and piston and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, means independent of the charge forming mechanism for supplying a quantity of liquid to said nozzle, means separate from and independent of the liquid supplying means, for supplying fluid pressure to said nozzle, for injecting said liquid into the cylinder, a normally closed valve interposed between the fluid pressure supply and said nozzle, means for actuating said valve to admit the pressure fluid to the nozzle, actuated by and in timed relation with the engine.

10. In an internal combustion engine provided with a cylinder and piston and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, means independent of the charge forming mechanism for supplying a quantity of liquid to said nozzle, means separate from and independent of the liquid supplying means, for supplying fluid pressure to said nozzle, for injecting said liquid into the cylinder, a normally closed valve interposed between the fluid pressure supply and said nozzle, means for actuating said valve to admit pressure fluid to the nozzle, by and in timed relation with the engine, and means for varying the timing of said valve actuating means.

11. In an internal combustion engine provided with a cylinder and piston and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, means independent of the charge forming mechanism for supplying a quantity of liquid to said nozzle, means for supplying fluid pressure to said nozzle, for injecting said liquid into the cylinder, a normally closed valve interposed between the fluid pressure supply and said nozzle, electromagnetic means for actuating said valve to admit the pressure fluid to the nozzle, an electric circuit for said electromagnetic actuating means, including normally open contacts and means operating in timed relation with the shaft of the engine for closing the said circuit.

12. In an internal combustion engine provided with a cylinder and piston and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, means independent of the charge forming mechanism for supplying a quantity of

liquid to said nozzle, means for supplying fluid pressure to said nozzle, for injecting said liquid into the cylinder, a normally closed valve interposed between the fluid pressure supply and said nozzle, electromagnetic means for actuating said valve to admit the pressure fluid to the nozzle, an electric circuit for said electromagnetic actuating means, including normally open contacts, a cam actuated in timed relation with the engine for closing said contacts, and means for adjusting said cam with respect to the cycle of the engine, to vary the time of operation of the injector.

13. In an internal combustion engine provided with a cylinder and piston and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, means independent of the charge forming mechanism for supplying a quantity of liquid to said nozzle, means for supplying fluid pressure to said nozzle, for injecting said liquid into the cylinder, a normally closed valve interposed between the fluid pressure supply and said nozzle, electromagnetic means for actuating said valve to admit the pressure fluid to the nozzle, an electric circuit for said electromagnetic actuating means, including normally open contacts, a cam independent of the ignition mechanism for closing said contacts, and means for adjusting said cam with respect to said ignition mechanism, to vary the operation of the injector with respect to the time of ignition.

14. In an internal combustion engine provided with a cylinder and piston, and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, means independent of the charge forming mechanism for supplying a quantity of liquid to said nozzle, means for supplying fluid pressure to said nozzle for injecting said liquid into the cylinder, a normally closed valve interposed between the pressure supply and said nozzle, electromagnetic means for actuating said valve to admit the pressure fluid to the nozzle, an electric circuit for said electromagnetic actuating means, and means operable in timed relation with the engine for closing said circuit.

15. In an internal combustion engine provided with a cylinder and piston, and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, means independent of the charge forming mechanism for supplying a quantity of liquid to said nozzle, means for supplying fluid pressure to said nozzle for injecting said liquid into the cylinder, a normally closed valve interposed between the pressure supply and said nozzle, electromagnetic means for actuating said valve to admit the pressure fluid to the nozzle, an electric circuit for said electromagnetic actuating

means, means operable in timed relation with the engine for closing said circuit, and means for advancing and retarding the operation of said circuit closing means with respect to the cycle of the engine.

16. In an internal combustion engine provided with a cylinder and piston, a water jacket for said cylinder, and charge forming and ignition mechanism, an injector nozzle communicating with the cylinder, a connection between said injector nozzle and the water jacket for supplying heated water to said injector, a fluid pressure supply for said nozzle, a normally closed valve controlling said fluid pressure supply, an electromagnetic device for operating said valve to open the same, an electric circuit for said electromagnetic actuating device, including normally separated contacts, and means operating in timed relation with the engine for closing said contacts.

17. In an internal combustion engine having a cylinder and piston, and charge forming and ignition mechanism, an injector nozzle communicating with said cylinder, a measuring chamber connected with said nozzle, means independent of the charge forming mechanism for supplying liquid to said measuring chamber, a movable piston valve in said measuring chamber, means for supplying pressure to said nozzle, normally closed by said piston valve, a spring for holding said piston valve in position to close said pressure supplying means, and means operated in timed relation with the engine for moving said piston valve, to force the measured quantity of liquid into said nozzle, and establish communication between said pressure supplying means and said nozzle, to inject said measured quantity of liquid into the ignited charge in the cylinder.

18. In an internal combustion engine having a cylinder and piston and charge forming and ignition mechanism, an injector nozzle communicating with said cylinder, a measuring chamber connected with said nozzle, means independent of the charge forming mechanism for supplying liquid to said measuring chamber, a movable piston valve in said measuring chamber, means for supplying pressure to said nozzle, normally closed by said piston valve, a spring for holding said piston valve in position to close said pressure supplying means, an electromagnetic device operatively connected with said piston valve, an electric circuit for said electromagnetic device including normally open contacts, and means operated in timed relation with the engine for closing said circuit, and effecting the operation of said valve to open position.

19. In an internal combustion engine provided with a cylinder and piston, a water jacket for the cylinder, and charge forming and ignition mechanism, an injector nozzle

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communicating with the cylinder, an external water reservoir, communications between the water jacket and said reservoir and the nozzle for supplying water thereto, a controlling valve in said connections, means independent of the said water supplying means for supplying compressed fluid to said nozzle, a normally closed valve controlling said compressed fluid supply, electromagnetic means for actuating said valve, a circuit for said electromagnetic actuating means, and means operable in timed relation with the engine for closing said circuit.

20. In an internal combustion engine provided with a cylinder and piston, charge supplying and ignition mechanism, means independent of the charge supplying mechanism, for injecting into the cylinder, at a point in the cycle of the engine between the ignition of a normal charge and the end of

the piston stroke, a quantity of liquid, and means for simultaneously advancing and retarding the time of ignition and injection.

21. In an internal combustion engine provided with a cylinder and piston, charge supplying and ignition mechanism, means independent of the charge supplying mechanism, for injecting into the cylinder, at a point in the cycle of the engine between the ignition of a normal charge and the end of the piston stroke, a quantity of liquid, means for independently advancing and retarding the time of ignition and time of injection, and means for simultaneously advancing and retarding the times of ignition and injection without interfering with the independent relative adjustment thereof.

In testimony whereof I affix my signature.

VICTOR W. KLESRATH.