C. E. DURYEA.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED SEPT. 17, 1914.

1,313,276.

Patented Aug. 19, 1919.

2 SHEETS—SHEET 1.

Fig. 2.

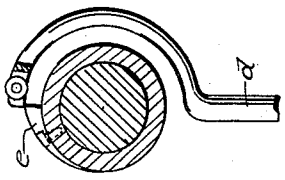


Fig. 3.

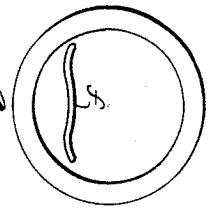
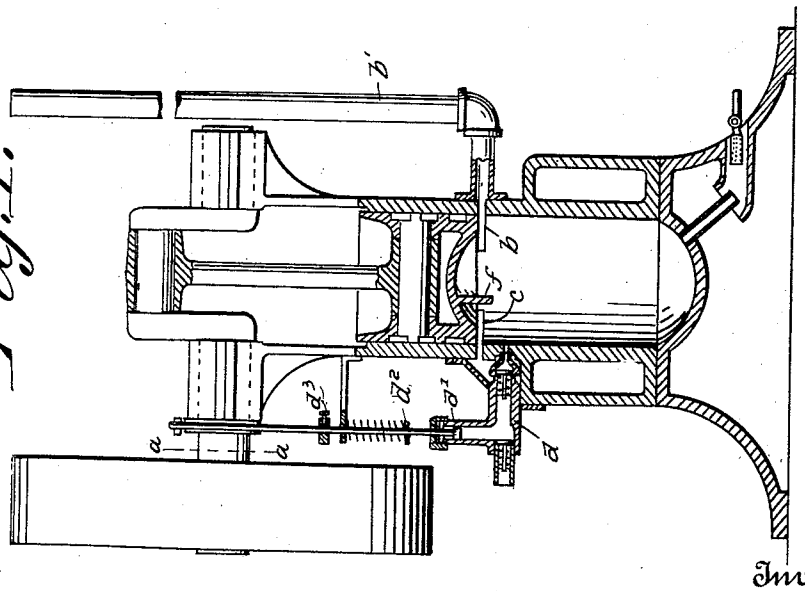


Fig. 1.



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2 SHEETS—SHEET 2.

Fig. 6.

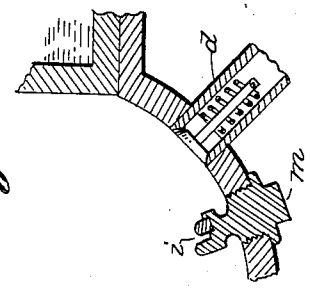


Fig. 5.

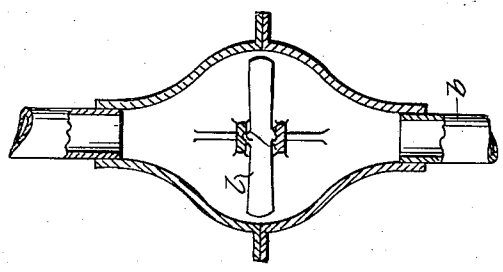
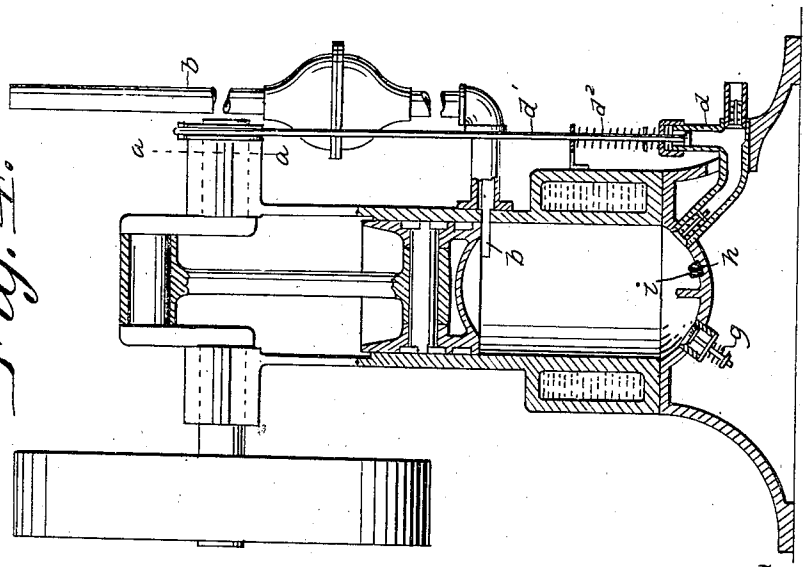


Fig. 4.



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INTERNAL-COMBUSTION ENGINE.

1,313,276. Specification of Letters Patent. Patented Aug. 19, 1919.

Original application filed June 7, 1902, Serial No. 110,598. Patent No. 128,957. Divided and this application filed September 17, 1914. Serial No. 862,195.

To all whom it may concern:

Be it known that I, CHARLES E. DURYEA, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

My invention consists of certain improvements in the method of and mechanism for securing a cycle of operations through which the air and fuel and their products of combustion pass in the process of developing power in an internal combustion engine. The objects of my invention are to produce an engine having fewer mechanical parts, more simple construction, greater economy, of fuel, more frequent impulses, greater reliability of action and other minor improvements as will appear in the following specification.

It is a well-known fact that in all engines both gas and steam, as usually made, the working medium is not fully expanded. In gas engines it is the aim to expand the gases as far as practical and then to get rid of them. At the time of exhaust, these gases are turned loose with considerable energy remaining therein. Right at this "getting-rid-of" point my invention comes into action and utilizes what energy there is left in these gases to bring in the air or mixture for the next charge.

I accomplish these results by methods and mechanism shown in the accompanying drawings, in which—

Figure 1 is a sectional side elevation of a complete engine.

Fig. 2 is an end elevation of the pump operating mechanism on the line *a*—*a*.

Fig. 3 is a plan of piston head and partition for deflecting the incoming air.

Fig. 4 is a sectional side elevation of an engine showing different arrangement for securing the desired operation.

Fig. 5 is a rotary fan for assisting the exhaust.

Fig. 6 is an igniter detail.

Similar letters refer to similar parts throughout the several views.

This application is filed as a division of my application Serial No. 110,598, filed June 7, 1902.

My invention consists specifically in the method of and means for using the energy contained in the working medium at the moment the exhaust port is opened, to effect a complete evacuation of the firing chamber and cylinder; and to draw in and leave therein a volume of fresh air suitable for the reception of fuel with which and when compressed, it may be ignited and form a working charge, which, after performing its work on the piston has its remaining energy used to expel itself and draw in fresh air as before. That is, whereas heretofore engines have made use of the working impulse so far as practical but have always had left more or less energy not practical to use, which energy passed out the exhaust opening without doing further work and the energy stored in the fly wheel was called upon to expel the gases contained in the working cylinder and to introduce new air for the new charge or to introduce the new charge; by my method the energy stored in the fly wheel is not called on to produce such needless work because I can and do make use of the otherwise wasted energy still remaining in the exhaust. In other words, I have invented a method or gas engine cycle in which I not only secure greater simplicity of mechanism, but I secure greater economy and efficiency. I save a portion of the energy remaining in the gases as commonly exhausted. By this method the expulsion of the exhaust is followed by an admission of fresh air, both of which are accomplished in the time occupied by the crank shaft in passing that portion of its revolution at or near the upper dead center. The compression of the air is effected on each inward or return stroke of the piston, the ignition takes place at or near the time of each inward or lower dead center and the working impulse is imparted at each outward or upward movement of the piston under normal working condition.

Using the mechanism shown in Figs. 1, 2 and 3, the operation is more specifically as follows:—

The cylinder is provided with crank shaft and piston arranged to open the exhaust port *b* as it nears the outward end of its stroke and a little later an admission port *c*. An exhaust pipe *b'* connects with the exhaust port and is of a diameter somewhat larger than is commonly used with engines of like capacity of present construction. This exhaust pipe is preferably 10 to 25 or

more feet long and preferably extends upward. Under such conditions, it may be readily seen that with the piston in its uppermost position, the natural draft to be found in the exhaust pipe will cause air to pass into the air port c through the cylinder, purifying the same, and out through the exhaust port b and pipe b'. A fuel pipe d is provided leading into the cylinder at a point below the exhaust port and a means for operating the pump quickly is provided. A simple device is shown in Fig. 2 consisting of a cam e to slowly raise the pump plunger d' and then allow it to drop instantly under the impulse of the spring d^2 when the plunger drops off the cam e. A stop d^3 may be used to adjust the amount of fuel injected, or a governor of any well known form may be provided.

Some method of igniting the charge is provided, such as an electrical sparker; or a tube kept hot by a Bunsen burner y, as shown in Fig. 1.

Starting with the piston in the upper position, as shown, the cylinder being washed out with air as described, and the pump ready to inject fuel, it is only necessary to turn the crank shaft to cause consecutively the piston to close the ports; the pump to inject the fuel, compression of the contained air and fuel by the piston; the ignition of the charge by the igniting device at the proper time and the expansion of the contained charge due to its combustion which causes the outward movement of the piston. This, as it nears the end of the stroke, opens the exhaust port and allows the inclosed charge to escape into and through the exhaust pipe with great force dependent upon its pressure at the time the exhaust port is opened. This pressure gives to the charge as it passes along the exhaust pipe, a very high velocity which increases until the pressure inside the cylinder is at or near the atmospheric point. The momentum of the gases in the exhaust pipe continues their movement until a partial vacuum is formed, by which time the piston has uncovered the inlet port and fresh air rushes into the cylinder and out the exhaust pipe. To insure a complete cleansing of the cylinder, large ports are provided and the exhaust pipe is of such length and size as will usually insure a quantity of air being drawn in equal to several volumes of the cylinder. As a further insurance of good cleansing, a partition is affixed to the piston near the inlet port which turns the incoming air downward into the firing chamber effectually washing out all products of combustion. This leaves the engine in condition to repeat the cycle under the impulse of the momentum of the fly wheel. It is evident that the pump may be so placed and the cam on the crank shaft so located that the fuel can be injected at any time during the revolution of the crank shaft.

In Fig. 1 the pump inlet is placed near the exhaust port end of the cylinder where it is closed by the piston before much compression has been accomplished. Thus locating the pump secures to the charge the benefit of the longest possible time in which to effect a mixture of the fuel and air before ignition. It will readily be seen that if the fuel is admitted before the exhaust port is closed, some of it may be carried by the current of air up the exhaust pipe and be wasted. It is well known that if the engine is cold or the ignition not strong, the mixture must be rich in fuel or else very evenly mixed to insure freedom from failure to ignite. This, and similar reasons, must decide at what point the pump entrance shall be made and at what point the fuel shall be injected.

In Fig. 4 another arrangement of the mechanical parts is shown, which accomplishes the desired result in a somewhat different manner, although it utilizes the same method. The inlet of the pump is placed below the lowest point reached by the piston and an inward opening valve g is placed in the head of the cylinder. The pump is arranged to spread the fuel (liquid fuel in this case being understood) so as to secure the most nearly perfect mixture quickly and so as to distribute a portion of the fuel on a wick h of gauze, asbestos or similar indestructible absorbent material placed in the head of the cylinder. To start the motor, the exhaust port is opened by turning the crank upward, and the air valve g is opened by the operator which allows a current of air to pass through the cylinder, washing it out and leaving it filled with air. A stroke or two of the pump by hand will saturate the wick h and surrounding air sufficiently to permit its being ignited by a flame held near the open air valve g which is then allowed to close, after which the wick will continue to burn until either the air in the cylinder is exhausted or until the fuel in the wick is burned out. Closing the exhaust port compresses the contents of the cylinder, while the combustion of the fuel in the wick and the contained air heats the charge and expands it, producing a slight working impulse. This escapes through the exhaust pipe when the exhaust is again opened, with sufficient force to open the light large inlet valve g admitting fresh air, the wick still remaining lighted. Further rotation of the crank shaft compresses this air; and at or near the lower dead center the pump injects fresh fuel, which mixing with the air, is ignited from the flame on the wick and produces the violent expansion desired,

after which the operation is continuous and the method the same as described with the outside igniter. To prevent the violent inrush of air from extinguishing the flame carried by the wick, a shield *l* is interposed between the valve and the wick. In this construction the ignition point is determined by the time of the fuel injection and, as before stated, the fuel must be distributed as widely as possible to secure a reasonably satisfactory mixture and consequent good combustion. One of the great advantages of this arrangement is that a constant flame carried by the wick insures certainty of ignition, even though the mixture be "poor," *i. e.* having but a small amount of fuel to a large volume of air. It is well known by engine constructors that a "poor" mixture gives greatest economy because it insures most perfect combustion; since there is ample air to properly combine with every atom of fuel and since a small amount of fuel will not heat the charge of air so excessively hot and produce so great a loss of heat through the walls of the motor as would a large amount of fuel. A "poor" mixture further insures that the wick flame has sufficient air to keep burning.

One of the difficulties operating against reliable service from my invention is found at starting and is due to the fact that in cold weather the walls of the engine are quite cold, on which account the wick *h* may not ignite readily, or, if ignited, may be easily extinguished. This condition of affairs is likely to occur if the heavier liquid fuels, such as kerosene, are used and to overcome this, when necessary, I insert in the wall of the motor by screw threads, or in any manner, a plug *m* adapted to be heated red hot and then inserted in position, which plug, by its incandescence, will warm the wick or even ignite the charge without the use of the wick. This plug may be provided with a reduced portion connecting the projecting inside end with the part fixed in the wall, in which event the projecting inside end will remain hot much longer and be less chilled by the cold walls in which the plug is fastened. This plug may be inserted in proximity to the wick, or it may carry the wick of asbestos or gauze fixed in or on its inner end, as shown in enlarged detail Fig. 6. If the compression space is small so as to secure a high compression, but little heat is required to cause the gases to ignite and under the same conditions the plug will be kept hot enough by the burning gases surrounding it to ignite subsequent charges without the use of the wick or gauze, but the added reliability of the wick or gauze makes the use of the same preferable. Since it is evident that the wick must be of asbestos or similar non-burning material, metal gauze is usually preferable and if this is of fine platium wire, it serves both as wick for the oil and also assists ignition by its catalytic action which causes it to become incandescent when exposed to mixtures of fuel and air. This catalytic action is rendered quite rapid if the gauze is not allowed to become cold and mounted upon the heated plug secures this result. The platinum wire is quite able to resist heat and not likely to be destroyed by the rapid expansion or movement of the gases. Of course, other catalytic substances might be used if found to be more suitable than the platinum gauze.

It is evident that the shield *i* may be attached to the plug as readily as to the cylinder and in Fig. 6 the plug is so shaped that the wick or gauze is carried on one side of it next the fuel supply, while the other side of the plug serves as a shield. Modification of this method of shielding the flame or incandescent portion used for ignition may be made without departing from the spirit of my invention.

In both arrangements shown the method consists in causing the energy of the exhaust gases to draw in fresh air from outside of the cylinder in an amount at least sufficient to secure combustion of the next charge of fuel; then in compressing this air and injecting fuel into it, preferably during the compression stroke; and finally igniting and causing the energy produced to be converted into work.

While this motor as shown is primarily intended for the use of liquid fuel, gaseous or other fuels may be introduced in any proper manner conforming to this method. A governor or mechanical device for regulating the speed may be applied in any well known manner, but for service not too exact the spring-actuated pump *d*, as shown, serves for a governor in that if the speed of the engine is such that the piston closes the inlet before the full charge is injected, the partial charge cannot give full power and the leakage back around the valves allows the remainder of the charge to escape without entering the engine. It is also evident in the form having the inlet at a point not covered by the piston, that the increased pressure due to compression or to the ignition may be sufficient to prevent further entrance of the charge just as the action of the piston mentioned.

It will readily be understood that if there is an excess of air in the cylinder, a portion will be available to support the flame burning on the wick during the working stroke and during the early part of the exhaust, while fresh air will be drawn in during the latter part of the exhaust and will be plentiful during the compression stroke.

In both forms of mechanism shown, the fresh air is drawn in by the inertia of the exhaust gases and where a pipe of sufficient

length can be used, there will be found an excess of energy to effect this work, but in some places it is not possible to use the desired length of pipe, as for example, in an automobile; in which case a mechanical device arranged to utilize the energy of the exhaust and increase the suction may be added. Such a device is shown in Fig. 5 and consists of a rotary fan 1 mounted in the path of the exhaust gases and receiving motion from them at their highest speeds, while by its momentum it imparts motion to them at their lowest speeds.

When properly designed, the means first shown secures the most perfect results because there are no valves or similar resistances preventing the free passage of the air. In motors with variable speeds, the second means shown secures the best results because the automatic inlet valve is opened by atmospheric pressure whenever the pressure inside falls sufficiently low. It, therefore, permits the most complete cleansing of the cylinder possible at any good speed, whereas, with a fixed inlet port the exhaust gases at slow speeds would have escaped so fully before the inlet port opened that atmospheric pressure would have decreased their velocity, if not reversed it, while at high speeds the inlet port might open before sufficient time had elapsed to permit the exhaust gases gaining their highest velocity out through the exhaust pipe.

Other methods of getting fuel into the engine may be used and other methods of firing likewise. If the fuel is injected at or near the time of ignition, the engine may be constructed with a firing chamber of such small dimensions as to heat the air by compression to a point sufficiently high to ignite spontaneously any fuel injected into it.

If desired, both the port *c* and the inlet *g* may be used in the same motor, which arrangement avoids the necessity of lifting *g* in starting.

It is essential that the exhaust gases, after they leave the cylinder be confined, instead of being discharged directly into the open air, so that a portion of the gases from the cylinder will be converted from a comparatively quiescent state into a confined stream of comparatively small cross section, but of considerable length and great velocity, whereby this confined stream, once established, by its inertia will continue and effectually draw out the remaining gases and more or less of the newly drawn-in fresh air, thus thoroughly recharging the cylinder. As shown, the cubic capacity of the exhaust pipe is equal or greater than the cubic capacity of a major portion of the volume swept by a single movement of the piston, but this is not an absolute necessity. The length of the pipe required depends largely on the amount of energy remaining in the gases after they have expanded the major part of their energy doing work. At high speeds and with small engines, the pipe may be shorter than with large engines and slow speed. While two forms of engine construction are shown, the invention is applicable to other forms, the essential feature being that the energy remaining in the final portion of the burned gases or working medium be used to create momentum, which continuing without intermission creates a vacuum sufficient to bring in air or gas and air for the new charge. These shown forms are two of the common internal combustion type but the same economic method of introducing such air as is needed can be used also in engines less well known and commonly called hot air engines in which the air introduced is heated from the outside of the cylinder, the heat passing through the walls thereof. I, therefore, do not intend to limit myself to the particular constructions herein shown for carrying out my method.

What is claimed as new is:—

1. The method of recharging an internal combustion engine having no other means of recharging, by causing the burned gases to escape suddenly and continuously through an elongated passage with momentum sufficient to reduce the internal pressure below atmospheric and flush and recharge the cylinder with air.

2. The herein described method of scavenging and recharging the cylinder of an internal combustion engine, which consists in suddenly exhausting the used gases immediately following their woking expansion, moving them so as to cause the energy of the exhaust gases to impart to them sufficient momentum to form a vacuum and, unaided, discharge the contents of the cylinder and recharge with air.

3. The herein described method of scavenging and recharging the cylinder of an internal combustion engine having no other means of recharging by utilizing otherwise wasted energy, which consists in allowing the burned gases to suddenly escape immediately following their working expansion and immediately, without interruption, using the remaining energy of such exhaust gases to impart to them sufficient continuous momentum to discharge the contents of the cylinder and form and maintain therein a vacuum sufficient to recharge the same with air.

4. The herein described method of recharging the cylinder of an internal combustion engine which consists in exhausting the burned gases suddenly, producing a vacuum, and immediately, without interruption, causing the continuous momentum of the escaping gases, unaided, and by maintenance of such vacuum, to cause atmospheric air to enter the cylinder and scavenge and recharge the same with air.

5. The herein described method of recharging the cylinder of an internal combustion engine, consisting in utilizing the energy remaining in the working gases after they have been expanded to their practical working limit, by suddenly exhausting them through a pipe of some length, thereby converting said remaining energy into momentum and then immediately utilizing this momentum, unaided, during its continuity to create a vacuum within the cylinder and by said vacuum causing the new charge of air to enter the cylinder.

6. A method of effecting the cycle of an internal combustion engine, consisting in working the used gases down to their practical working limit of pressure and then utilizing their remaining energy to create momentum by discharge through a long open passage, and by this momentum, unaided, and during its continuity creating a vacuum sufficient to recharge the combustion chamber.

7. The method of recharging a two-cycle internal combustion engine by suddenly and continuously exhausting the burned gases through a momentum producing escape port and thereby reducing the pressure below atmospheric and drawing in a new charge of air.

8. In an internal combustion engine of the two-stroke cycle type, an admission port, a valve controlling the same opened by vacuum in the cylinder and arranged to automatically admit air at atmospheric pressure, a single exhaust port opened at the end of the expansion stroke, and a pipe communicating therewith at a point approximately at the outer end of the working cylinder space and of a length sufficient to permit the gases to attain a velocity such that their inertia causes them to aid in discharging the contents of the cylinder forming a vacuum therein sufficient to recharge.

In testimony whereof I affix my signature in presence of two witnesses.

CHARLES E. DURYEA.

Witnesses:

MERLE J. DURYEA,

GRACE L. DURYEA.