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H. RICHARDSON ET AL

METHOD OF AND APPARATUS FOR GENERATING THERMODYNAMIC ENERGY

Original Filed May 3, 1921 2 Sheets-Sheet 1

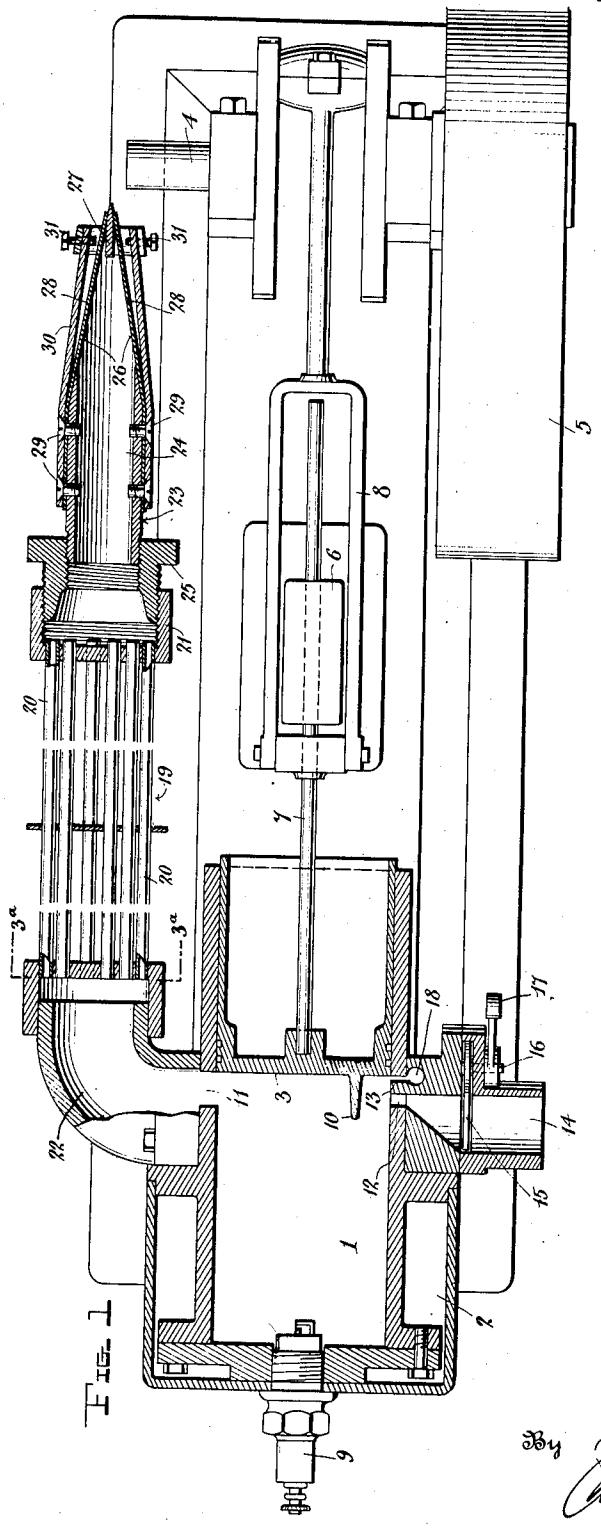

Fig. 1

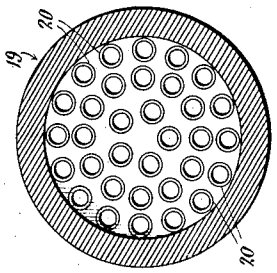

Fig. 3a

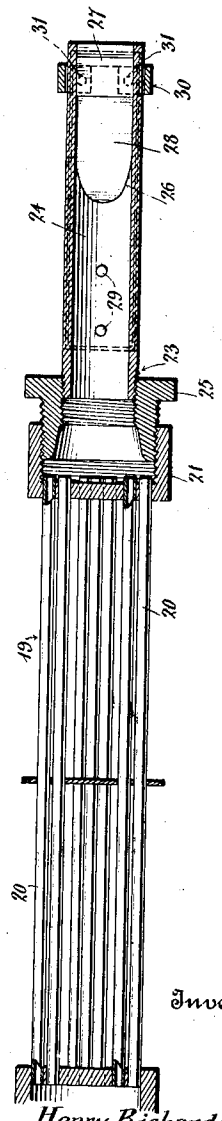

Fig. 3

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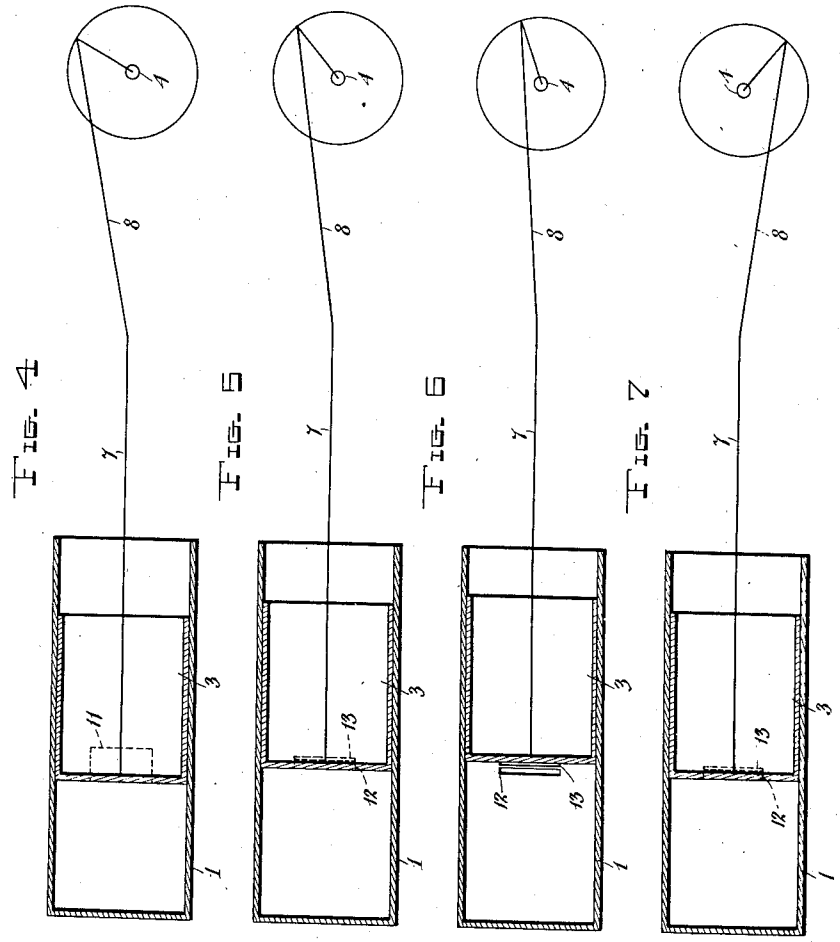
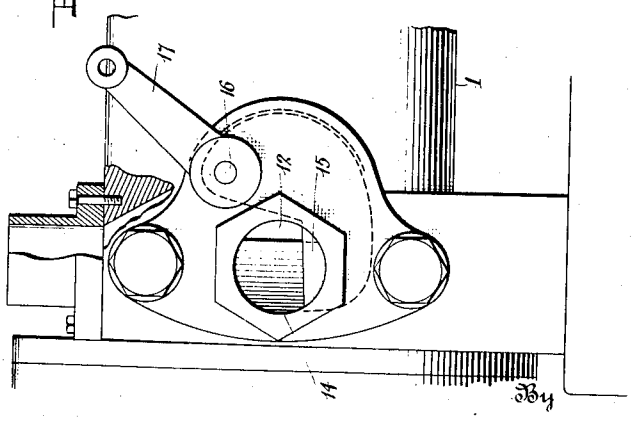


Fig. 2



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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR GENERATING THERMODYNAMIC ENERGY.

Application filed May 3, 1921, Serial No. 466,439. Renewed November 14, 1927.

The present invention relates to improvements in the art of generating thermo-dynamic energy and it is applicable more particularly to internal combustion engines of the conventional forms employing a cylinder and cooperating piston, and especially to such engines which operate on the two-cycle principle.

The primary object of the invention is to provide a novel and improved means for generating thermo-dynamic energy from hydrocarbon or other suitable fuel which is mixed with air, compressed and exploded to drive the piston on its power stroke, whereby greater power may be obtained from a power unit of given dimensions by obtaining greater efficiency in the combustion of the fuel, avoiding loss of unburned fuel and by providing a fuller and more complete charge of explosive fuel for each explosion.

As applied to internal combustion engines of the usual types, the present invention insures substantially complete scavenging of the products of combustion remaining in the cylinder from the preceding explosion and the drawing in of a full fresh charge of explosive by the creation and maintenance of a vacuum pressure at the exhaust outlet of the engine, such vacuum acting, at the end of each working stroke of the piston, to not only draw the products of combustion from the cylinder, but also serving to first draw a current of air into and through the cylinder, sweeping before it and into the exhaust outlet any remaining products of combustion, and to subsequently draw a fresh charge of fuel or explosive mixture into the cylinder, preparatory to compression and the next following explosion. The invention may be applied with particular advantage, to two-cycle engines of the type having piston-controlled ports arranged in the side walls of the cylinder, as it insures substantially complete evacuation of the exhaust gases and the scavenging of any remaining exhaust gases and it also insures the induction of a full charge of fresh explosive mixture, and moreover, these results are attained without the necessity of employing crank-case compression or other means of compressing the explosive charge or either constituent thereof exteriorly of the cylinder, in order to introduce such charge into the cylinder, as has heretofore been found necessary, but which presents well-known objections.

The vacuum is created by condensation of the exhaust gases as they are discharged from the cylinder, and according to the presen invention, the escape of the exhaust gases to the atmosphere is regulated or controlled so that a vacuum will be produced at the exhaust outlet of the cylinder and any gases at the outlet end of the condenser which reach a pressure above atmospheric pressure will be immediately discharged into the atmosphere. By this method, the correct functioning of the engine with respect to the discharge of products of combustion, induction of air to scavenge the cylinder and the introduction of a fresh explosive charge can be attained with efficiency and in a manner which is simple and does not require further attention after it has been properly regulated.

The invention may be applied to or carried out by the aid of apparatus of different kinds, it being shown applied, in the accompanying drawings, to an internal combustion engine of the two-cycle type.

In these drawings:—

Figure 1 represents a section taken along the longitudinal axis of a two-cycle engine constructed to embody and to operate in accordance with the present invention;

Figure 2 is a detail enlarged view showing the inlets for the scavenging air and the fuel mixture;

Figure 3 is a detail view of the escape valve which regulates or controls the escape of the condensed products of combustion from the outlet end of the condenser to the atmosphere, and the condenser.

Fig. 3ª represents, on an enlarged scale, a section on the line 3ª—3ª, Fig. 1; and

Figures 4 to 7, inclusive, are diagrammatic views illustrating the cycle of operation of the engine shown.

Similar parts are designated by the same reference characters in the several figures.

The internal combustion engine shown in the present instance comprises a cylinder 1 which may be provided with the usual water jacket 2, a piston 3 which reciprocates in the cylinder, a crank shaft 4 provided with a flywheel 5 and, as shown, a guide 6 is provided for the outer end of the piston rod 7, the latter being operatively connected to the crank pin on the crank shaft, by the connecting rod 8. A spark plug 9, or equivalent ignition device, is provided for igniting the explosive charge within the cylinder,

this spark plug or ignition device being timed by any suitable and well known arrangement to ignite a compressed explosive charge in the cylinder each time the piston is about to commence its out stroke. The piston is preferably provided with a fin or baffle 10 which projects a suitable distance toward the cylinder head, and the purpose of this baffle will be hereinafter described. In the present instance, the engine is of the type having its controlling ports arranged in the side walls of the cylinder, these ports being covered and uncovered at appropriate times in consequence of the reciprocating movements of the piston. As shown, an exhaust port 11 is formed in one side wall of the cylinder to be uncovered by the piston when the latter approaches the limit of its out stroke, and the opposite side wall of the cylinder is formed with an air inlet port 12 and an adjacently located fuel inlet port 13, the air-inlet port 12 being located nearer to the cylinder head and so arranged relatively to the exhaust port that the air-inlet port will be uncovered shortly after the exhaust port has been uncovered, and the fuel-inlet port 13 is arranged to be uncovered by the piston after the latter has moved past the air-inlet port on its out stroke. The baffle 10 on the head of the piston extends transversely of a plane between the exhaust port 11 and the air and fuel inlet ports 12 and 13, and it is arranged to be interposed between these ports when the piston has reached the points where it uncovers the air and fuel ports 12 and 13 respectively. The air-inlet port 12 may receive air from the atmosphere through an air inlet 14 and the amount of air introduced into the cylinder through the port 12 may be regulated or governed by a suitable valve, the valve shown in the present instance comprising a blade or vane 15 which is pivoted at 16 and is provided with an operating arm or handle 17, whereby the blade or vane may be set to adjust the size of the passage through which air is supplied to the air inlet port 12. The fuel inlet port 13 communicates with a passage 18 and this passage is connected to receive suitable fuel, such, for example, as one of the hydrocarbons commonly used as fuels in the operation of internal combustion engines, or a suitable combustible or explosive gas. This passage 18 may be connected to receive either fuel alone or it may receive a combustible or explosive mixture of fuel and air, in which latter case it will be convenient to connect a carbureter to such passage 18.

The exhaust port 11 is connected to an apparatus which will receive the products of combustion and will produce a vacuum at the exhaust outlet of the engine, which vacuum will function to withdraw the products of combustion resulting from each explosion, and to introduce a fresh explosive charge into the cylinder. In the engine shown, the vacuum will induce a flow of air through the cylinder from the air inlet 12, this current of air sweeping the remaining products of combustion through the cylinder and out through the exhaust 11 and it will draw a supply or charge of fuel into the cylinder through the fuel inlet port 13, these operations taking place in the order named during each revolution of the crank shaft and while the exhaust, air-intake and fuel-intake ports 11, 12 and 13 are uncovered by the piston. It will be understood that after these ports have been closed by the return or in-stroke of the piston, the mixture of air and fuel contained in the cylinder will be compressed and when the piston reaches the limit of its in stroke or substantially so, the spark plug or other ignition device will ignite the compressed explosive charge and the pressure thus developed will drive the piston on its immediately following out-stroke, the pressure of the exploded gases continuing to drive the piston until the latter uncovers the exhaust port 11, whereupon the exhaust gases will discharge from the cylinder, and air and fuel will be drawn successively into the cylinder through the ports 12 and 13, as before. The baffle 10 on the piston serves to deflect the current of air introduced into the cylinder through the port 12, so that this current of air will sweep around and through the combustion chamber at the head of the cylinder and thence out through the exhaust port 11, thus scavenging the cylinder of substantially all products of combustion remaining in the cylinder following the discharge of the bulk of these products of combustion, due to the opening of the exhaust port 11, and the vacuum pressure which acts to draw these products of combustion from the cylinder; and the baffle 10 also functions to deflect the fuel admitted through the port 13 toward the head of the cylinder, thus avoiding escape of fuel through the exhaust port 11.

The vacuum pressure which is created in the exhaust discharge is attained by cooling the highly heated products of combustion, thus reducing their volume considerably below the volume of the fuel and air mixture from which such gases resulted and by permitting the condensed products of combustion while above atmospheric pressure, to escape to the atmosphere under conditions which insure the production of the vacuum pressure at the exhaust port 11. Preferably and as shown, a condenser 19 is employed, this condenser comprising a suitable number of tubes 20 of appropriate diameter and length the ends of the tubes being fitted in headers 21. The header 20 at the inlet end of the condenser is attached to a fitting 22 which receives the products of combustion from the exhaust port 11. The other header at the outlet end of the condenser is con-

nected to a device 23 through which the products of combustion discharge or escape to the atmosphere. The escape device 23 preferably comprises a valve which is so constructed that it will open when the pressure of the products of combustion exceed atmospheric pressure, to permit escape of such gases, but will quickly close when the pressure of the products of combustion in the condenser or evacuating chamber are at or below atmospheric pressure, thus insuring the maintenance, during this operation, of a vacuum pressure, at the exhaust port 11. This valve is also preferably adjustable, whereby the extent to which it opens may be regulated, thus enabling the degree of vacuum at the exhaust port 11 to be governed to insure correct and efficient functioning of the engine. Preferably and as shown, the valve comprises a tubular member 24 which may be connected by a plug 25 or otherwise to the header 21 on the outlet end of the condenser, this tubular body 24 being beveled on its outer end to form a pair of valve seats 26, and a bar or cross-piece 27 extends across the apex of the tubular body. A pair of flap valves 28, which are preferably composed of spring steel or other suitable resilient material of appropriate thickness are arranged to cooperate with the seats 26, these valves, owing to their resilience, having a tendency to normally form fluid-tight fits upon the seats 26 and thus prevent entrance of air from the atmosphere into the discharge end of the condenser, but such valves will be easily and quickly forced from their seats when the products of combustion at the outlet end of the condenser reach a pressure slightly above atmospheric pressure, the valves, however, immediately closing when such gases have been permitted to escape to the atmosphere. The valves 28 are shown secured to the opposite sides of the tubular body 24, by screws 29, the opposite ends of the valves, however, being free to vibrate, incident to the escape of the accumulated condensed products of combustion. Means is provided for regulating the amplitude of movement of the valves 28 and to thus govern the degree of vacuum maintained at the exhaust port 11. Preferably and as shown, a frame 30 is rigidly attached to the tubular body 24 of the valve and this frame is provided with adjusting screws 31 which are located opposite to the respective valves 28 and these screws may be set to provide variable limit stops which will regulate the amplitude of movement of the valves. These adjusting screws enable the degree of vacuum to be governed so as to insure correct and efficient functioning of the engine, and when once adjusted, should require no further manipulation.

The condenser is proportioned to the engine with which it is used, in order to attain the action above described, by which vacuum pressure is maintained at the exhaust port 11 and accumulated condensed products of combustion from the condenser are permitted to escape to the atmosphere without destroying the vacuum at the exhaust port 11. We have found that with a cylinder of 2 inch bore and 2 inch stroke, a condenser having 33 tubes about 8 inches in length and with an internal bore of $\frac{3}{16}$ inch produces high efficiency. Cylinders of larger sizes should be provided with condensers of appropriately larger dimensions. In using a condenser of the dimensions given with a cylinder of the dimensions given, it was found that the desired vacuum was obtained without the necessity of subjecting the condenser exteriorly to a cooling medium, other than the exposure of the condenser to the surrounding air at ordinary temperature, and it was also found that under such conditions, the condensed products of combustion were discharged from the condenser at substantially the temperature of the surrounding air.

The cycle of operation may be described briefly in connection with Figures 4 to 7 inclusive, as follows: Figure 4 shows the piston approaching the limit of its power stroke, the piston being about to uncover the exhaust port 11. As soon as the exhaust port 11 is uncovered, the products of combustion will discharge through the exhaust port 11 and in so doing will be assisted by the vacuum pressure which is produced and maintained during these operations at the exhaust port. The continued outward movement of the piston brings the same into a position to uncover the air inlet port 12, as is shown in Figure 5, and owing to the vacuum pressure existing at the exhaust port 11, a current of air will be drawn into the cylinder through the air port 12 and this current of air sweeping through the cylinder and its combustion chamber will carry before it the remaining products of combustion. Further movement of the piston on its out stroke causes it to uncover the fuel port 13, as is shown in Figure 6, the vacuum maintained at this time in the cylinder, due to the vacuum pressure at the exhaust 11 thereof, causing a charge of fuel or an explosive mixture to be drawn into the cylinder through this port 13. During the return stroke of the piston, the ports 13, 12 and 11 are closed in the order named, the air and fuel contained in the cylinder, as represented in Figure 7, being compressed during the in stroke of the piston, and when the piston reaches the limit of its in stroke, the compressed explosive charge is ignited by the spark plug or other ignition device and the piston is driven on its power stroke until it reaches the position represented in Figure 4, whereupon the cycle will be repeated, there being a power impulse for each revolution of the crank shaft.

In order to obtain efficient operation of the engine at low speed, the amount of air

admitted through the port 12 may be regulated as by the blade 15 so that efficient scavenging of the cylinder will be obtained, but a slight vacuum may exist in the cylinder after the exhaust port 11 is closed and the compression stroke has commenced, the weight of the explosive charge under such conditions being reduced to correspond with the amount of power to be developed by the engine.

The present invention provides a method of and apparatus for generating thermodynamic energy from suitable fuels whereby substantially complete withdrawal and scavenging of the products of combustion from the combustion chamber, immediately following each explosion, without loss of fuel, and the introduction of a full fresh charge of fuel into the combustion chamber are effected through the influence of a vacuum which is created and maintained during these operations at the outlet through which the products are discharged from the combustion chamber. A particularly advantageous feature of the cycle provided by the present invention is that the body of scavenging air precedes the fuel in entering the cylinder, and this body of scavenging air which is thus interposed between the exhaust port and the following and subsequently introduced body of fuel, prevents substantially the escape and loss of the subsequently introduced fuel through the exhaust port. By this cycle of operations, high efficiency is attained by insuring the introduction of a full and complete fresh explosive charge for each explosion, back-pressure on the exhaust discharge of the combustion chamber is reduced and the combustion chamber is cooled internally by the scavenging air which sweeps through it. These advantages render the invention particularly applicable to internal combustion engines of the so-called two-cycle type, as they not only cause an efficient explosion to be obtained at each revolution of the crank shaft, but they insure removal of substantially all of the products of combustion resulting from each explosion and the introduction of a full and complete fresh explosive charge substantially without loss of fuel and also without the complication and other disadvantages resulting from the use of crank-case compression or other forms of external compression as heretofore found necessary, and moreover, the successive or consecutive introductions of the scavenging air and fuel at definitely-timed periods or intervals to secure substantially complete removal of the products of combustion and the introduction of a full fresh fuel charge, without appreciable loss of fuel by its escape through the exhaust outlet, under the influence of the vacuum existing therein, can be accomplished easily and efficiently by arranging ports for the admission of the scavenging air and fuel adjacently and in proper order in the side wall of the cylinder so as to be opened and closed in proper order, and at the proper periods by the working piston.

We claim:—

1. In combination with an internal combustion engine embodying fuel admission and exhaust ports, a tubular member connected to the exhaust port for the discharge of the exhaust gases from the engine therethrough and having escape means to allow the gases while above atmospheric pressure to escape from said member to the atmosphere but relieving the remaining products of combustion in said member at or below atmospheric pressure of back pressure from the atmosphere, thereby causing the exhaust gases discharged into said member to create a vacuum therein which will induct a fuel into the engine through the fuel admission port, and means for controlling the operation of said escape means and thus governing the degree of vacuum acting on the fuel admission port.

2. In combination with an internal combustion engine embodying air, fuel admission and exhaust ports, a tubular member connected to the exhaust port for the discharge of the exhaust gases from the engine and having escape means to allow the gases while above atmospheric pressure to escape from said member to the atmosphere but relieving the remaining products of combustion in said member at or below atmospheric pressure of back pressure from the atmosphere, thereby causing the exhaust gases discharged into said member to create a vacuum therein which will successively induct first a current of air and then a fuel into the engine through said air and fuel admission ports respectively, and means for controlling the operation of said escape means and thereby governing the degree of vacuum acting on the air and fuel admission ports.

3. In combination with an internal combustion engine, a device connected to receive products of combustion exhausted therefrom and operative to produce a vacuum in such products of combustion, and an escape valve at the outlet of said device embodying a vibratory valve member arranged to open under the influence of pressure at said outlet, and means for regulating the amplitude of vibratory movement of the valve member.

In testimony whereof we have hereunto set our hands.

HENRY RICHARDSON.
ANTON HOLM.