(No Model.)

G. H. BABCOCK.

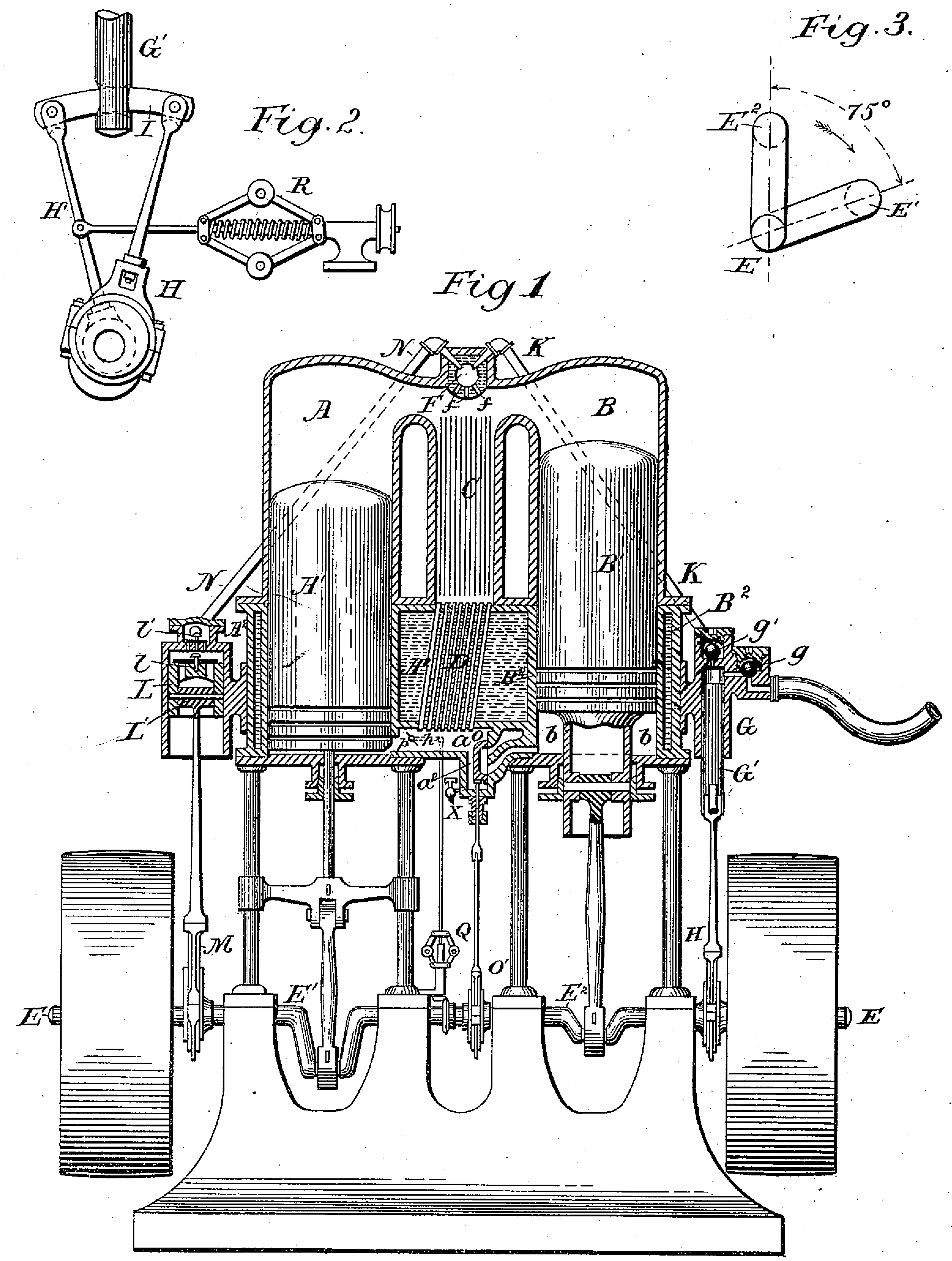
OPERATING AIR AND GAS ENGINES.

No. 334,155. Patented Jan. 12, 1886.

Fig. 2.

Fig. 3.

Fig. 1



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UNITED STATES PATENT OFFICE.

GEORGE H. BABCOCK, OF PLAINFIELD, NEW JERSEY.

OPERATING AIR AND GAS ENGINES.

SPECIFICATION forming part of Letters Patent No. 334,155, dated January 12, 1886.

Application filed June 29, 1885. Serial No. 170,120. (No model.)

To all whom it may concern:

Be it known that I, GEORGE H. BABCOCK, a citizen of the United States, residing at Plainfield, in the county of Union and State of New Jersey, have invented certain new and useful Improvements in Methods of Operating Air or Gas Engines, of which the following is a specification, reference being had therein to the accompanying drawings.

My invention relates to the same general class of air or gas engines as those shown and described in my applications Nos. 129,504 and 129,574, filed April 28, 1884, and to that embraced by my application No. 170,119, filed simultaneously herewith, the present invention relating more particularly to a certain method of energizing a volume of actuating-fluid, which is repeatedly used within the engine, by introducing hot products of combustion into said fluid at intervals and cooling said fluid between the intervals of introduction of the said hot products.

This application is a division of my application No. 129,574, above referred to, and although the mechanism whereby my present invention is carried into effect is herein shown as being the same as that described in my said application No. 129,574 I do not wish to be understood as limiting the use of my invention to the particular construction of engine hereinafter described, although such engine embraces what I consider to be the best means for carrying my invention into effect.

In all of my applications above referred to I have claimed certain features of invention different from that which is hereinafter described, and I hereby disclaim in this application all inventions claimed in my other said cases.

In the drawings forming part of this specification, Figure 1 is a vertical sectional view of an engine for carrying my invention into effect; and Figs. 2 and 3 are detail views, which will be hereinafter referred to.

A is a cylinder, which I call a "changing-cylinder," and A′ a plunger working within said cylinder freely, but nearly air-tight.

B is a working-cylinder, in which the plunger B′ is fitted to work tightly.

These plungers are made in the well-known manner of similar engines, having a deep portion filled with some non-conducting substance to protect the wearing-surface from the direct action of the heated fluid. The lower portions, A^2 and B^2, of these cylinders are surrounded by water-jackets for conveying away the surplus heat thereof and keeping the surfaces sufficiently cool to admit of lubrication.

C is what is known as a "regenerator," consisting of a collection of plates of iron or other material with small interstices, through which the fluid passes on its way to and from the hot end of the cylinder, which regenerator serves the purpose of retaining a portion of the heat of the hot gases and restoring the same to the cold gases in a manner well known in similar engines.

D is a refrigerator, consisting of a series of small tubes surrounded by water, through which the air passes on its way to the cold end of the cylinder, for the purpose of taking out such heat from the air as has not been absorbed by the regenerator. This is also a well-known device.

E is the crank-shaft, having two cranks placed at an angle to each other and connected in the ordinary way to the two pistons A′ and B′, transmitting their power and controlling the time of their motions. Fig. 3 shows the relation of these cranks one with the other. I find in practice that the angle of seventy-five degrees gives the best results; but this may be varied as circumstances require.

F is a furnace wherein the combustion takes place, and having passages or ports *f*, connecting it with the interior of the cylinders A and B. This furnace F may be of any size and burn any fuel as is found to be practicable; but I prefer to make it, as shown, quite small, and to burn therein some form of hydrocarbon fuel, as hereinafter described.

G is a pump automatically operated by a connection with the engine, and here shown as connected with an eccentric, H, on the main shaft E, for the purpose of supplying the fuel to the furnace F. The connection of this pump G with the shaft is shown more fully in Fig. 2, in which the eccentric H is connected to one end of a link, I, the other end of which is jointed to a distance-rod, H′, attached to the shaft or any other convenient stationary point. It will be seen that by the variation of the position of the link I relative to the plunger G′ any amount of stroke may be given to the plunger G′, from the full throw of the eccentric to nearly or quite none. The length of the distance-rod H′ bears such relation to the plunger G′ and the eccentric H that the plunger G′ is caused to approach to nearly the inner end of the barrel of the pump G at each stroke, whatever may be the length of the stroke.

Instead of varying the stroke of the pump G, the same object may be attained by connecting therewith a vessel containing a piston or other means of varying the size thereof, into which vessel a portion of the gas within the pump G may be allowed to expand as it is compressed, and the amount of fuel pumped into the engine may thereby be reduced. The position of the piston within this vessel or supplementary chamber may be determined by a governor, so as to automatically control the amount of gas delivered, while the stroke of the pump remains constant.

The valves g and g' are of ordinary construction, and need not be specifically described. A pipe, K, leads from the pump G to the furnace F.

L is an air-pump for the purpose of supplying air for the proper combustion of the fuel within the furnace F. It is of ordinary construction, having valves l l' and plunger L, and is driven, preferably, by an eccentric, M, on the main shaft. The stroke of this pump L may be made to vary in the same manner as the pump G; or the amount of air delivered therefrom may be otherwise varied, as above described in connection with the said pump G; but I prefer that it should have a constant stroke, as shown.

A pipe, N, leads from the air-pump L to the furnace F.

Any of the well-known means may be employed for igniting the fuel within the furnace; but when the interior of the furnace, which consists of a refractory substance, like fire-brick, has once become heated to incandescent temperature the fuel will ignite spontaneously upon coming in contact therewith. I provide a valve, O, in the passage a, through which the air passes to and from the cold end of the changing-cylinder A, which valve is operated by an eccentric, O′, mounted on the main shaft, or by other means. This valve O is similar to the slide-valve of a single-acting steam-engine, and admits a portion of the air or actuating-fluid from the passage a at each revolution into the annular space b, formed between the cylinder B^2 and the trunk of the plunger B′. This annular space may bear any desired proportion of area to the area of the cylinder B, to admit of any desired expansion to the portion of the air which is admitted thereto by the valve O. The passage a is formed with a depression or pocket, a^2, in which any water condensed from the products of combustion will accumulate, and in which the valve O is situated, so that when any water accumulates therein it will be blown out on the opening of the valve O. A petcock, X, is also provided for removing such water at will. I also provide the passage a with a throttle-valve, P, by closing which more or less the resistance of the passage of the air or gas from the cold to the hot end of the cylinder A, or vice versa, may be increased or diminished. The stem of this valve P extends out through a proper stuffing-box, and is connected through an arm, p, to a centrifugal governor, Q, whereby the valve P is caused to be operated automatically by the varying speed of the engine. Another centrifugal governor, R, Fig. 2, is connected to the distance-rod H′ in such a manner that when the speed of the engine increases the link I is drawn over to reduce the throw of the plunger G′, and thereby decreases the supply of fuel to the furnace F. This governor R, instead of being attached to the distance-rod H′, may be connected to a variable chamber communicating with the pump G, or with any other means for controlling the supply of gas to the furnace. I prefer to graduate the two governors R and Q relatively to each other in such a manner that the governor R shall have completed its action before the speed has increased to an extent to cause the governor Q to operate the valve P, so that in controlling the speed of the engine the amount of fuel supplied to the furnace F will be thus reduced to a minimum, and if that be not sufficient then the throttle-valve P will be brought into action to increase the internal resistance of the engine.

The operation of the engine is as follows: The interior of the cylinders A and B, the regenerator C, tubes D, and passage a and furnace F, all communicating, are first filled with a volume of atmospheric air or other gas at any desired pressure by a pump or otherwise. The engine being turned over by hand, or by any other convenient means, the plunger A is caused to descend and force the air which is below it through the refrigerator D and regenerator C into the upper portion of the cylinder A. At the same time the fuel-pump G and air-pump L deliver a portion of gas or other fuel, with the necessary oxygen for its combustion, into the furnace F, where it is ignited, and the products of combustion passing through the ports f mingle with the air or gas within the engine, causing the whole to become heated and the pressure thereof to increase. This forces the plunger B′ to descend, exerting the energy derived from such pressure upon the crank E^2. The plunger A′ now returns by the revolution of the crank-shaft and crank E′, forcing the heated air or gas in the upper part of the cylinder A down through the regenerator C, which absorbs the larger part of the heat therein through the refrigerator D, which takes away the balance of the heat into the lower end of the cylinder A^2, thus reducing the temperature and the pressure, when, by the revolution of the crank E^2, the plunger B′ is forced back into the cylinder B, driving all the air therein also through the regenerator C and refrigerator D into the lower part of the cylinder A^2. The valve O, having opened for a short time at the commencement of the return-stroke of the plunger B′, admitted a certain volume of the air from the passage *a* into the annular space *b*, and then closed, allowing the air which was thus admitted to *b* to expand and assist in the return of the plunger B′, this air admitted to space *b* being subsequently exhausted through valve O. Meantime the plungers of the pumps G and L have descended and taken in a fresh supply of gas and air. By the continual revolution of the shaft E the plunger A is now brought again to the lower end of the changing-cylinder, forcing the cold air therefrom around through the refrigerator D and regenerator C into the upper end of the cylinder A, in which passage it has taken up the heat which was stored in the regenerator C and been increased in pressure. At the same time the fuel-pump G and air-pump L have delivered another supply of fuel to the furnace F and the products of combustion from it have passed in and mingled with the air or gas within the engine, still further increasing its heat and pressure by which the plunger B′ is forced outward, as before. This cycle of operations continues regularly with each revolution. The valve O is so arranged that it will admit only a definite amount of air from the passage *a* into the annular space *b*, which volume is less than the volume of the pump L. It will therefore be seen that so long as the pressure within the passage *a* bears the same inverse ratio to the volume of air admitted into space *b* that the atmospheric pressure bears to the volume of the pump L the quantity of fluid within the engine will remain constant. It will also be seen, when the valve O is adjusted to admit into the annular space *b* a definitely smaller volume of air than the volume of the air-pump L, that if the pressure in the engine A B is such that this volume of air so admitted into *b* does not weigh the same as the volume of air which is pumped into the furnace F through the pump L the pressure in A B must increase with each stroke until the equilibrium between the amount of air delivered by the pump L and the amount of air removed by the valve O is secured.

The furnace F may be heated up before starting the engine by building a fire within the same, or by a gas-jet, or by introducing a live hot coal just before starting the engine. It may also, in some cases, be made sufficiently large to receive a quantity of solid fuel, in which case the pump G can be dispensed with, the pump L furnishing air for the combustion of the fuel within the furnace as rapidly as the needs of the engine require.

The advantages due to my invention are: The heat, being applied directly to the gases within the engine, is all utilized, with the exception of the small proportion (usually about one-tenth) which is rejected through the refrigerator D, or is lost by radiation. That portion of the fluid which is removed by the valve O and annular space *b*, it will be noticed, is taken from the cold end of the engine after it has passed through the regenerator C, wherein a large portion of its heat has been stored or trapped. This air therefore carries off none of the heat supplied to the engine, as does the exhaust of an ordinary gas-engine or any form of the "Cailey" engine, heretofore known. By the use of the same fluid in the engine, stroke after stroke, it requires but a small proportion of the highly-heated products of combustion to be mingled therewith in order to impart the required amount of heat. The air-pump L is therefore small in proportion to the capacity of the engine, and the loss from compressing a large amount of air at each stroke is saved, and the cost of compressing the air compressed by the pump L is nearly repaid by the expansion of the air in the annular space *b*. It is evident that this annular space *b* can be replaced by an independent piston working in another cylinder, or it could be replaced by inclosing the lower portion of the pump L; but I prefer to employ the annular space, as shown.

A difficulty which attends nearly all air and gas engines exists in consequence of the resistance of the compression of the air in the cylinder in some portion of the revolution, and this difficulty increases greatly in engines in which a high pressure is used.

One of the advantages due to my invention is, that the engine may be started at atmospheric pressure with little resistance, and after a few revolutions the pressure will accumulate in consequence of the pump L putting in more air than the valve O lets out, which will continue until the proper pressure is attained and the engine is ready to work at its full load.

In practice it will probably be found best to employ two such engines as herein described, working upon opposite cranks or through beams, so that the normal pressures upon the working-pistons will balance each other, and the working-piston B′ will therefore not be compelled to be forced back against the back-pressure by the momentum of the fly-wheel. I have preferred, however, to represent it in this case as a single engine, for the sake of simplicity in the drawings.

I claim as my invention—

1. The method herein described of operating an air or gas engine by intermittingly mingling hot products of combustion into a volume of actuating-fluid within the engine, expanding the same directly against a working-piston while thus heated, afterward cooling said fluid in the intervals between the introduction of hot products of combustion, and removing from the engine the water which may be condensed from the products of combustion, substantially as set forth.

2. The method herein described of operating an air or gas engine by intermittingly mingling hot products of combustion with a volume of actuating-fluid within a hot cham-

ber, expanding said fluid in the development of power directly against a working-piston, transferring a part or all of said fluid to a cool portion of the engine, compressing it therein while cool, and removing from the engine the water which may be condensed from the said products of combustion, substantially as set forth.

3. The method herein described of developing power for operating air or gas engines, consisting in partly heating the actuating fluid, which is repeatedly used within the engine as it is passed from the cool to the hot part of the engine, further heating the said fluid, and thus fully energizing the same, by mingling hot products of combustion therewith, utilizing its developed energy by expanding the heated fluid directly against the working piston or plunger, afterward cooling said fluid as it is passed from the hot to the cool part of the engine, and while thus cooled removing therefrom the water which may be condensed from the said products of combustion, substantially as set forth.

4. The method herein described of operating an air or gas engine and of regulating the pressure of the actuating-fluid thereof by intermittingly mingling hot products of combustion with the actuating-fluid, utilizing the developed energy thereof by expanding in its heated condition the same directly against a working piston or plunger, cooling the said actuating-fluid thereafter and between the intervals of introduction of said hot products of combustion, and intermittingly removing a certain desired portion of the cooled fluid, together with the water condensed from said products of combustion, substantially as set forth.

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

GEO. H. BABCOCK.

Witnesses:
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