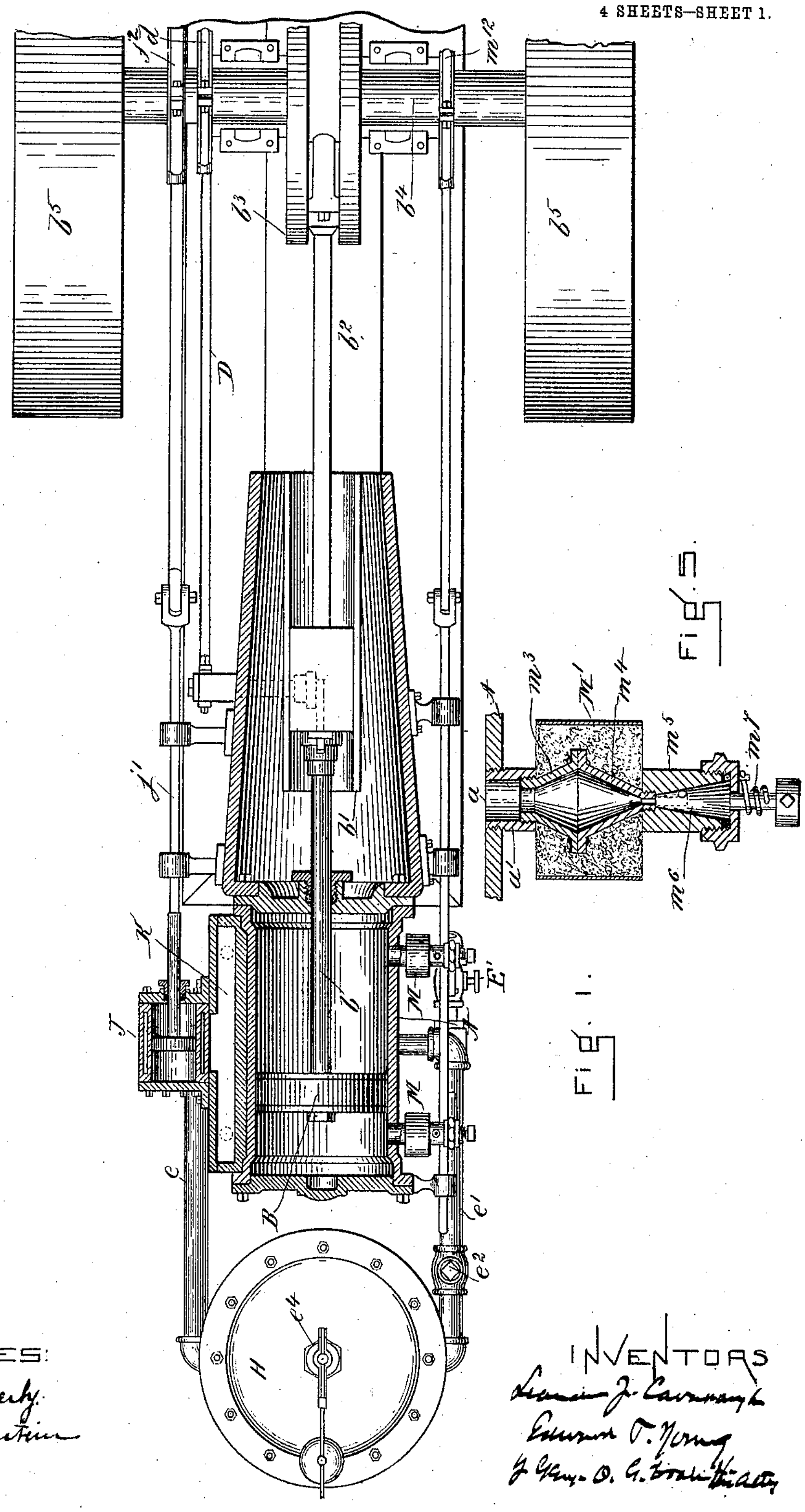
L. J. CAVANAUGH & E. T. YOUNG.

POWER GENERATOR.

APPLICATION FILED AUG. 26, 1901.

976,547. Patented Nov. 22, 1910.

4 SHEETS—SHEET 1.



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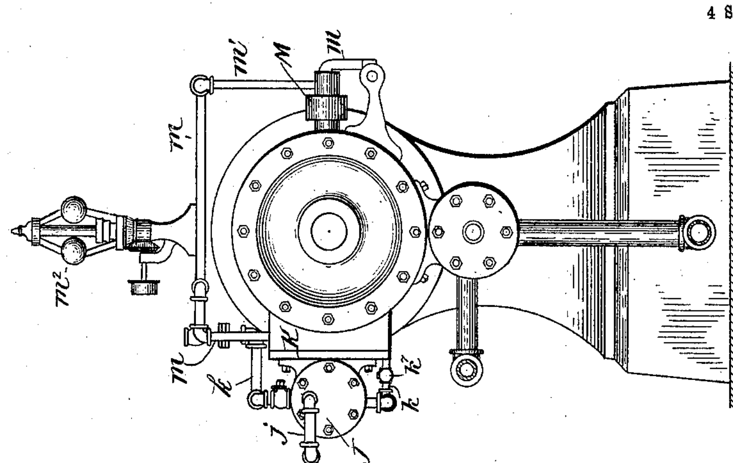

Fig. 3.

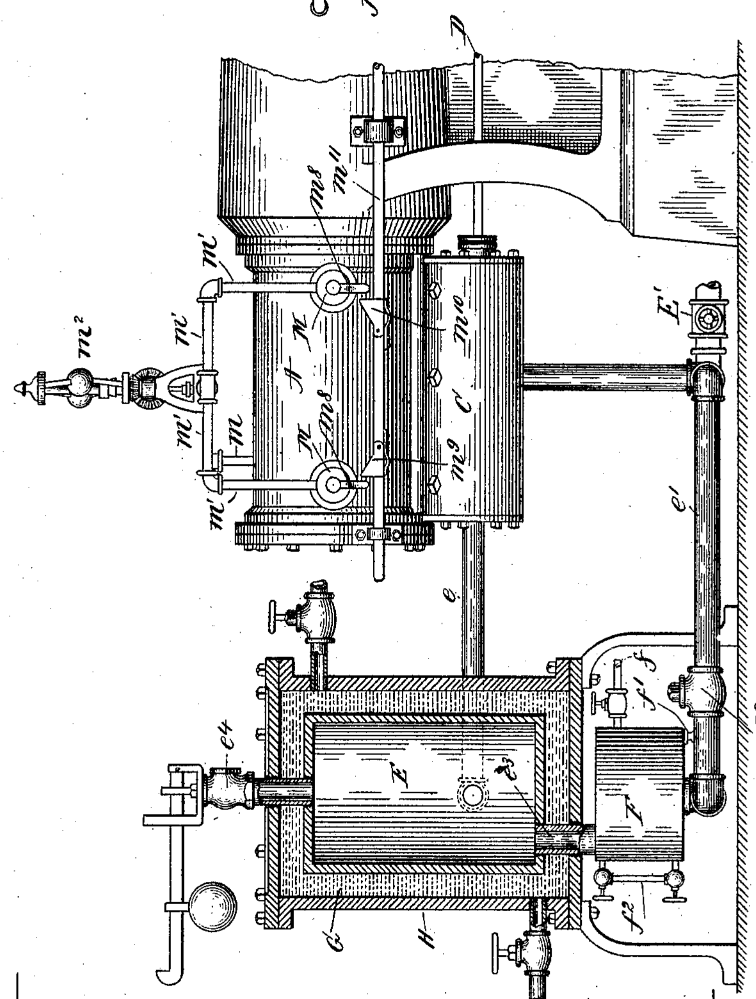

Fig. 2.

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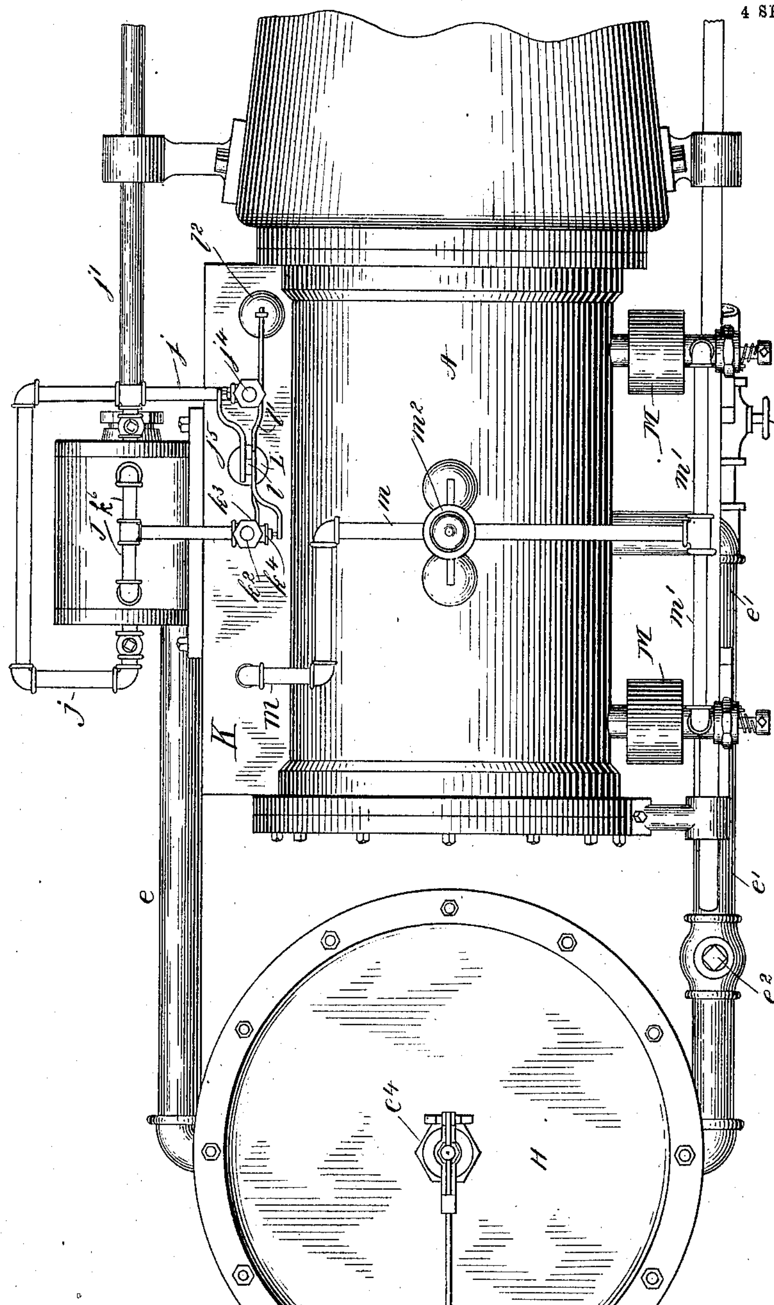

FIG. 4.

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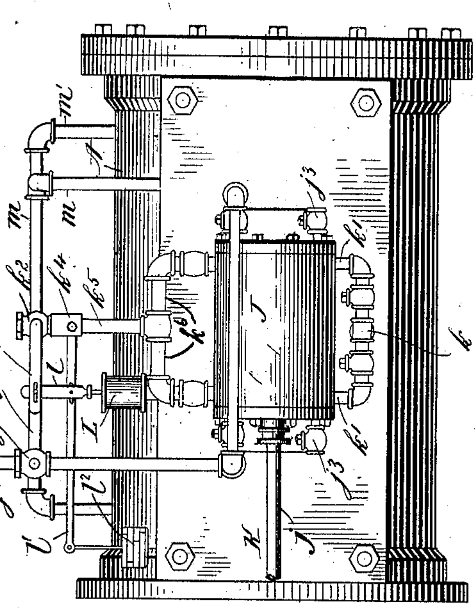

FIG. 6.

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UNITED STATES PATENT OFFICE.

LEANDER J. CAVANAUGH AND EDWARD T. YOUNG, OF BOSTON, MASSACHUSETTS.

POWER-GENERATOR.

976,547. Specification of Letters Patent. Patented Nov. 22, 1910.

Application filed August 26, 1901. Serial No. 73,236.

To all whom it may concern:

Be it known that we, LEANDER J. CAVANAUGH and EDWARD T. YOUNG, both of Boston, in the county of Suffolk and State of Massachusetts, have invented a new and useful Improvement in Power-Generators, of which the following is a specification.

In making our present invention it has been our aim to provide means whereby with very slight changes a steam engine of otherwise ordinary construction may be operated by means of hot air or vapor other than pure steam, so that there may be not only economy in the original production of the motive power, *i. e.*, the fluid by the pressure and expansion of which the piston is moved, but also in the application of it to move the piston. We believe, however, that our invention is capable of wider application and hence do not mean to limit it to a mere steam engine attachment, although we have shown and shall describe it as so applied.

The theory on which our invention is based is that the heat of combustion acting upon gas of a given density or pressure expands that gas to a pressure as many times greater than the original pressure as the total heat compares to the heat required to double the given pressure, and our invention in its broadest form comprises means whereby intense heat, preferably in the form of a flame, is projected into a chamber on one side of a piston, which chamber is already filled with a compressed gas. This gas is expanded thereby so as to drive the piston before it, after which a corresponding action is caused to take place on the opposite side of the piston to return it to its original position. These alternate expansions are coupled with an exhaust action by means of which the expanded gas after it has driven the piston to the extreme of its stroke is allowed to escape as the piston returns. By condensing this exhaust which carries with it the products of combustion of the flame into a storage reservoir under pressure, substantially the same body of gas may be used over and over again as the working medium, so that the engine may be run by supplying the minimum amount of heat, thus resulting in great economy.

For convenience we shall speak of the products of combustion or fluid of motive power as the "gas," and as shown in the drawings it is fed to the cylinder of the engine and delivered therefrom by means of the ordinary valve mechanism used with steam. A condenser is provided connected at one end with the exhaust chamber and at the other end with a reservoir, which may be part of the condensing system and from which the gas is supplied in condensed form to the supply chamber of the valve mechanism, the gas in this reservoir being always under a pressure controlled by a suitable safety or relief valve.

Our invention will be understood by reference to the drawings in which—

Figure 1 is a plan view of an engine of well known type to which our invention is applied, the cylinder and fuel compressor being shown in horizontal section. Fig. 2 is a side elevation of the cylinder showing the condenser in vertical section, Fig. 3 being an end view of the engine. Fig. 4 is an enlarged plan of the cylinder and condenser. Fig. 5 is a longitudinal section of the burner, and Fig. 6 is a detail showing the pump in side elevation.

A is the cylinder containing the piston B, provided with a piston rod b, the free end of which is attached to a block which slides in ways b^1, and is connected by a connecting rod b^2 with a crank b^3 so as to rotate the shaft b^4. This shaft carries the fly wheels b^5, b^6, and also the eccentric d for the valve rod D.

C is the valve chest of such construction as is ordinarily used in steam engines to provide a supply and exhaust to the two ends of the cylinder in turn in the ordinary manner.

The motive power or gas as we have called it above, is led to the valve chest C by means of the pipe e from the reservoir E, the exhaust being led away from the valve chest by the pipe e^1. As is intimated above the gas through the expansion of which the piston is moved, gradually contains more and more of the products of the combustion by means of which its expansion is caused, and as it is desirable that certain of its impurities of a more solid character shall be removed, we prefer to lead the pipe e^1 into a separating or washing chamber F which may contain water or any chemical suitable for the purpose. As shown this chamber F is connected up with an inlet f and an outlet f^1 to provide it with a water supply, f^2 being a water gage to allow examination of the condition and height of the water.

When water is used the gas may be led in at the bottom of this chamber F, a check valve e^2 being provided to prevent the water from sinking too far in the pipe e^1. This chamber F is not essential in all cases.

From the chamber F the gas is led by the pipe e^3 into the reservoir E where it is collected under pressure and from which it is forced through the supply pipe e to the valve chest C when the valve opens to allow it to enter either end of the cylinder. We prefer to provide a safety valve e^4 which may be set to blow off at any desired pressure to relieve the reservoir. Around the reservoir E is a jacket H containing water and forming a condensing chamber G by means of which the temperature of the gas is lowered. The pipe e^3 may be given a number of turns in the chamber G about the reservoir E before being connected therewith, if thought best.

The fuel to be used to expand the gas may be any one of the well known hydrocarbon mixtures adapted for the purpose, which may be mixed with air or not as thought best. It is furnished under pressure and for this purpose the feed pipe j leads from a suitable reservoir (not shown) to a pump J mounted on the side of a compression chamber K on the side of the cylinder A, this being a convenient arrangement of these parts. The pump rod j^1 is operated by an eccentric j^2 on the shaft b^4 in the same manner as the valve rod D. The pipe j branches, one branch leading into each end of the pump, each end of the pump being also provided with an air valve j^3 by means of which air is drawn into the pump in the quantity needed to mix with the hydrocarbon. Each branch of the pipe j is provided with a check valve to prevent back pressure therein.

From each end of the pump cylinder leads one branch k^1 of a pipe k which communicates with the compression chamber K, which chamber acts as a storage chamber for the fuel. To control the pressure in said chamber K, we prefer to provide the pipe j and a stand pipe k^5 provided with branches k^6, one leading to each end of the pump cylinder, with a valve j^4, k^2, each valve being moved by a lever j^5, k^3. Each lever is connected at its free end with a connecting rod l which is operated by a regulator L, projecting from and connected with the chamber K. Upon a collar k^4 on the pipe k^5 is pivoted one end of a lever l^1 which is also pivoted to the connecting rod l, and carries at its outer end a weight l^2, this construction being such that when the pressure in the chamber K reaches a predetermined point it lifts the piston in the regulator L which closes the valve in the feed pipe j and opens the escape valve in the pipe k^5 leading from the pump so that the supply of fuel to the pump is cut off, the pump thereafter being supplied with air only until the pressure in the chamber K again becomes nominal, the air entering by the air valves j^3 and escaping by the valve k^2 in the pipe k^5. The pipe k is provided with a check valve k^7 to prevent leakage from the chamber K. The weight l^2 can be adjusted so as to cause the valves to be operated at any desired pressure.

To utilize the fuel each end of the cylinder A is provided with a burner M connected with the fuel chamber K by means of a branch m^1 of a pipe m having a governor m^2 located therein. This governor is of ordinary construction, and as it is operated in the same way that all governors are operated, its connections are not shown. Its purpose is to control the supply of fuel to the burners M.

One of the burners M of the kind we prefer to use is shown in detail in Fig. 5. An opening a is made in the wall of the cylinder A into which screws a coupling a^1 connecting the burner with the cylinder. The burner itself as shown consists of a double cone shaped casing made in two parts m^3, m^4, quite small at its inlet end, which, in fact, is intended as the burner proper at which the flame may remain lighted at all times, the remainder of the structure serving as a hood or protection to the flame from back drafts.

The fuel is fed to each burner through its valve chamber m^5 containing a conical valve m^6, which valve is normally almost closed and held in that position by a spring m^7. The valve is turned to open it by a dependent lever m^8 operated by a wedge m^9, m^{10}, on a rod m^{11} operated like the ordinary valve rod by an eccentric m^{12} on the shaft b^4. After the lever m^8 has been turned by its wedge m^9, m^{10}, and has moved out of contact therewith, the spring m^7 immediately closes the valves. Each lever m^8 opens its valve only when turned in one direction. When turned in the opposite direction it has no effect on the valve. Thus when the rod m^{11} is moved to the left (see Fig. 2) the left-hand valve M will be opened by the engagement of the vertical edge of the wedge m^9 with the lever m^8 of that valve. When the rod m^{11} moves in the opposite direction the lever m^8 of that valve will slide over the slanting edge of the wedge m^9 and the vertical edge of the wedge m^{10} will engage the lever m^8 of the right-hand valve and open it. Thus these spring controlled valves are operated alternately to feed fuel first to one burner and then to the other, the eccentric m^{12} being so set on the shaft b^4 as to throw the rod m^{11} in the opposite direction to that in which the piston is moving and when the piston has moved about a quarter stroke, this being, we believe, the best adjustment. Any well known means for preventing back fire may be inserted at any proper point or points between the burners M and the chamber K. The use and construction of such means is so well known that further description is unnecessary.

We prefer to cover each burner with a removable asbestos casing M^1 to enable it to retain its heat as by this means should the valve close entirely so as to put out the flame, or the flame be put out in any other way, the heat of the burner will be maintained sufficiently high to ignite the next stream of fuel which is fed to it. If preferred, however, any of the well known electric igniters may be used for the purpose.

The operation of our engine as now seems best is as follows: To start it up it is necessary first to supply the reservoir with air under pressure; second, to start the pump by means of which the fuel is compressed in the compression chamber, and third, to heat the burners sufficiently to insure combustion when fuel is fed to the burners. It is evident that these three steps may be easily taken by operating a separate hand pump temporarily applied to the reservoir at the coupling E^1, by the turning by hand of the fly-wheel of the engine to work the compression pump and valves and at the same time by heating the burners by a Bunsen burner, or starting the igniter if an electric igniter be used. When the burners have become automatic in their action, and sufficient pressure is established in the compression chamber to feed them with fuel, the operation continues as follows: The supply valve in the valve chest being open a portion of the contents of the reservoir E passes through that valve into one end of the cylinder, it being under a pressure of say substantially 60 lbs. It there meets an explosive blast from one of the burners M which suddenly heats it, thus causing it to expand with great force and under great pressure and drive the piston before it, and at the same time absorb all the heat which otherwise would be wasted. The exhaust valve to the chamber on the opposite side of the piston is open and its contents passes back into the condenser and reservoir. When the piston has reached the end of its stroke the position of the supply and exhaust valves change and the same operation occurs on the other side of the piston, thus driving the piston back. The piston, therefore, while the engine is in operation, lies between two pressures, one the normal pressure of the reservoir, relieved by the condensation and circulation, the other the pressure due to the expansion of a gas under the influence of the explosive heat of the burner which gas was at an initial pressure also equal to or greater than the pressure in the reservoir, the effective force acting upon the piston thus being developed by the heat of the burner acting upon a body of gas at 60 lbs. or whatever the reservoir pressure may be.

One feature of economy of our engine lies in the fact that a given gas absorbs heat in proportion to its density or pressure, and expands with a force governed by its pressure and the amount of heat applied to it. By feeding gas under pressure to our cylinder and then applying the heat of a hydrocarbon jet injected into it, we get a greatly increased pressure governed by the original pressure and the amount of heat injected into it, this being obtained without the increased temperature which would result if the same heat were put into the gas at a lower pressure. This is owing to the fact that the greater the pressure or density of a given body of gas, the greater its power of absorbing heat. This heat in its absorption produces work in the form of expansion without the resulting extreme temperature, which would follow were the same gas used under less pressure so that by this means we have a great advantage over the ordinary gas engine in that all the heat is used in work being absorbed by the gas owing to its density, and there is no great amount of radiation to be carried off as is done by the water jacket in the ordinary gas engine. Moreover, by saving and condensing the contents of the chamber, *i. e.*, the original body of gas and the products of the explosion or combustion, we reduce its pressure somewhat and increase its density, storing it temporarily until it is again drawn upon by the cylinder to be expanded as before, thus causing it to circulate continuously through the engine as a working medium, with only such addition as may be made to it by the products of the explosion.

It will be seen that if the reservoir originally starts with atmospheric pressure, a pressure may be built up therein either by a hand pump as described or even by the explosion of the burners acting on the contents of the cylinder before the load is put on, the products of combustion being added to the original contents of the cylinder with each explosion. In this case a turn or two may be given to the engine by hand to start the valves. It will also be understood that the exhaust when condensed becomes thereby reduced in pressure and in density and enters the reservoir at a pressure sufficient to force its entrance and at the instant when the reservoir is being relieved by being drawn upon for a fresh supply. As the pressure in the reservoir becomes too great it is relieved by the safety valve.

As stated above, we do not mean to confine our invention to an engine of the ordinary type such as is used with steam, *i. e.*, one having a cylinder into which the motive power is introduced at each end, nor do we consider it merely as an attachment to such an engine. We believe it to be of wider application but we have shown it as an attachment or alteration of a well known type of engine for simplicity in construction and also because it now seems to us to be the best way in which to utilize it. It is evident that many of the details shown may be somewhat differently constructed without altering in any way the principle of the invention.

What we claim as our invention is as follows:—

1. In a power generator, a cylinder, a piston, and means for supplying said cylinder with an expansible gas and exhausting it therefrom, two burners, one located at each end of said cylinder, each burner being provided with a spring controlled valve normally substantially closed, in combination with a reciprocating rod and means whereby it is reciprocated, said rod being provided with means for engaging each of said valves in turn and throwing it, as and for the purposes described.

2. In a generator of the kind described, means for compressing and storing fuel comprising a pump and compression chamber, and a relief mechanism for said pump, whereby the pressure in said compression chamber may be controlled, in combination with one or more burners connected with said compression chamber to be fed therefrom, and a cylinder provided with openings located to receive the products of combustion from said burners, said cylinder containing a piston movable therein, means for supplying said cylinder with pressure on both sides of the piston whereby said piston when at rest will be subjected to equal pressure on each side thereof, said piston being adapted to be moved by the expansion of gas caused by heat ejected from said burners in turn, as and for the purposes described.

3. In a power generator, one or more burners, means for supplying fuel thereto comprising a compression chamber, means for supplying said compression chamber with fuel under compression and a governor operated by said power generator to control the supply of fuel to said burners from said compression chamber, as set forth.

4. In a generator of the kind described, a cylinder, a piston, means for supplying heat to said cylinder, a valve chest adapted to furnish a supply and exhaust passage to each end of said cylinder alternately, an exhaust pipe running from said valve chest, a reservoir connected thereto, a supply pipe connecting said reservoir with said valve chest and a separating chamber located in the line of said exhaust pipe and between said valve chest and said reservoir, as described.

5. In a power generator of the kind described, a reservoir adapted to receive, hold and deliver gas under pressure, a cylinder and piston, connections between each end of said cylinder and said reservoir whereby both sides of the piston are at all times under pressure greater than atmospheric pressure, means for injecting a flame into said cylinder, a valve chest having a supply inlet and exhaust outlet, separate connections connecting said supply and exhaust with said reservoir, in combination with means for condensing the contents of said exhaust connection, whereby the exhaust comprising the original gas delivered under pressure and the products of combustion are cooled to the initial temperature of said compressed gas, as described.

6. In a power generator of the character described, a cylinder, a piston working therein, means for providing said cylinder with gas under pressure greater than atmospheric pressure on both sides of the piston, and means comprising burners for producing combustion and injecting into said gas an intense heat while under pressure, whereby said piston will be moved by the products of combustion from said burners acting upon said gas under pressure as described.

In testimony whereof we have hereunto set our names this 22nd day of August, 1901.

LEANDER J. CAVANAUGH.
EDWARD T. YOUNG.

Witnesses:

GEORGE O. G. COALE,
M. E. FLAHERTY.