H. LEMP.

METHOD OF REGULATING THE PRODUCTION OF STEAM.

APPLICATION FILED NOV. 3, 1902.

1,015,043.

Patented Jan. 16, 1912.

3 SHEETS—SHEET 1.

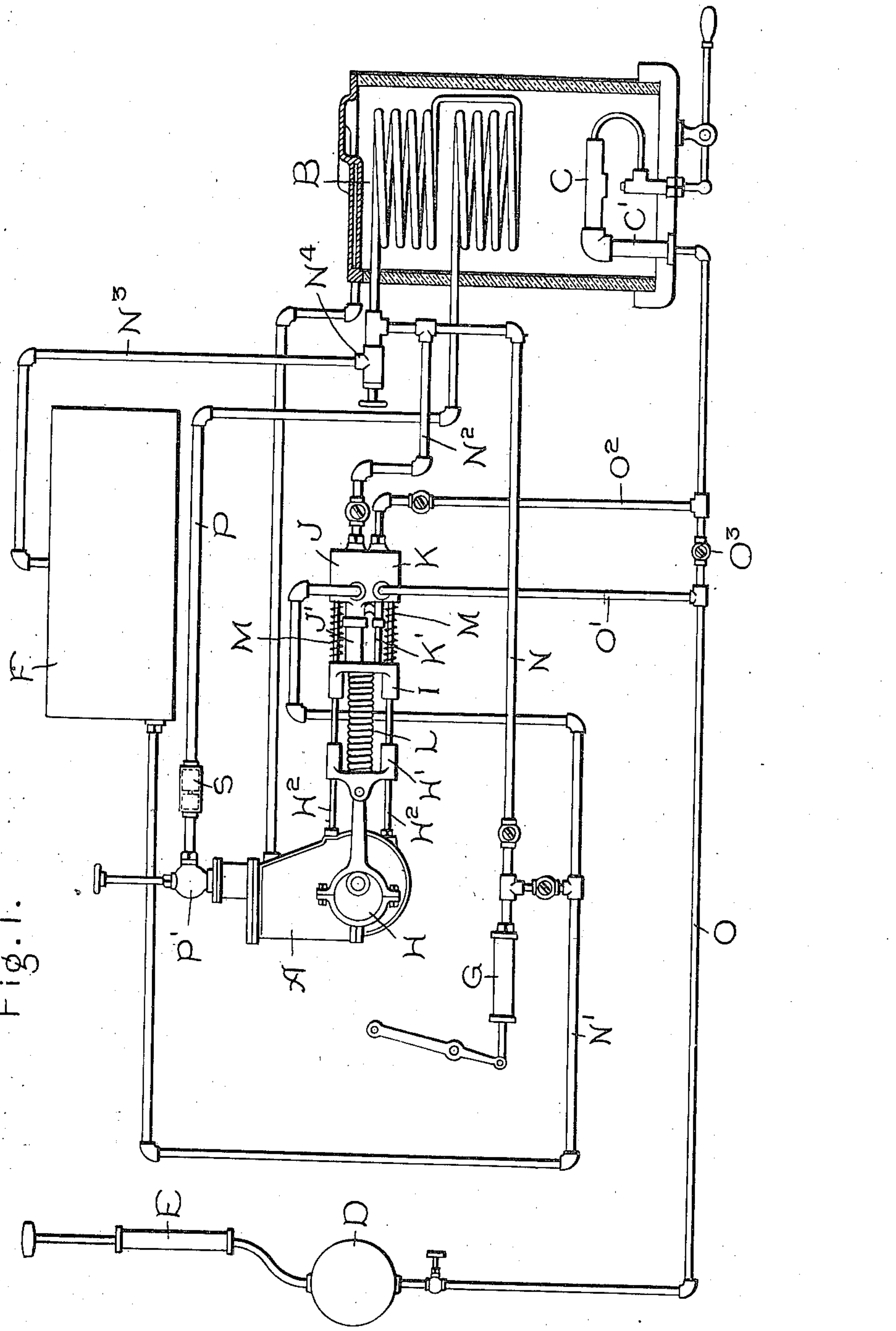


Fig. 1.

Witnesses:

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Alex. F. Macdonald.

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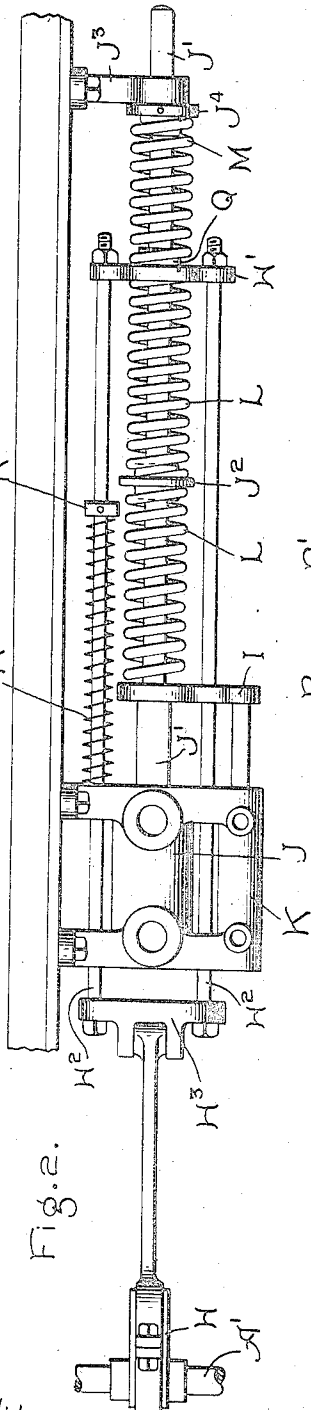

Fig. 2.

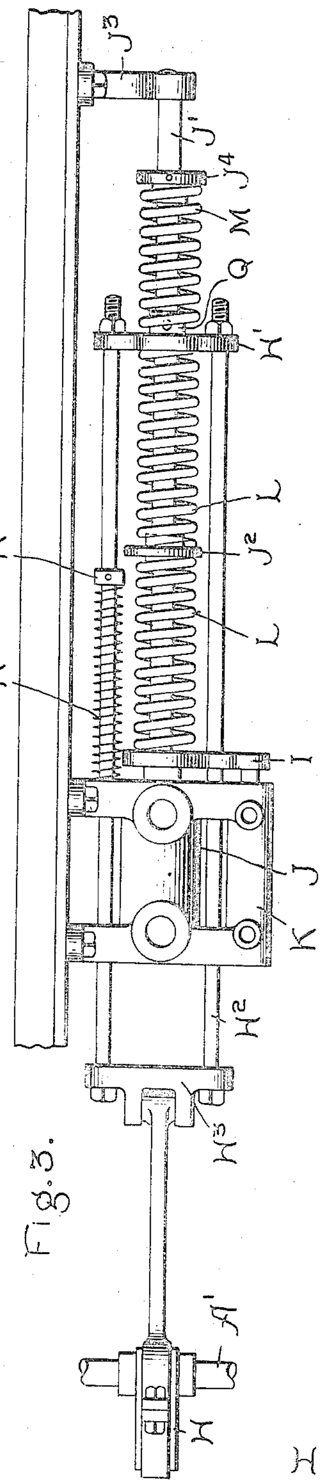

Fig. 3.

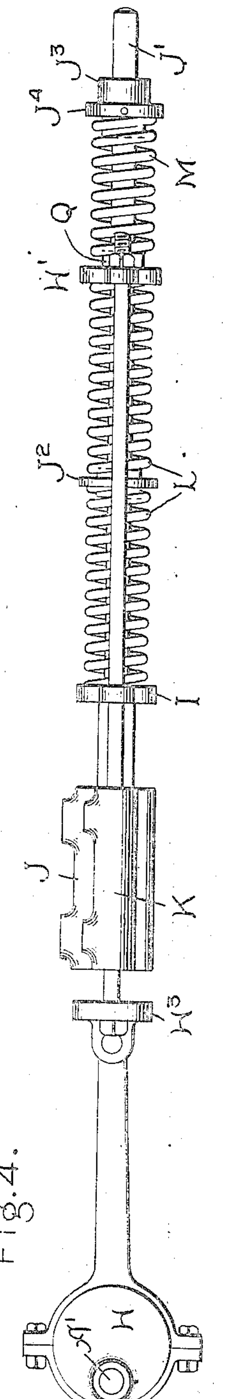

Fig. 4.

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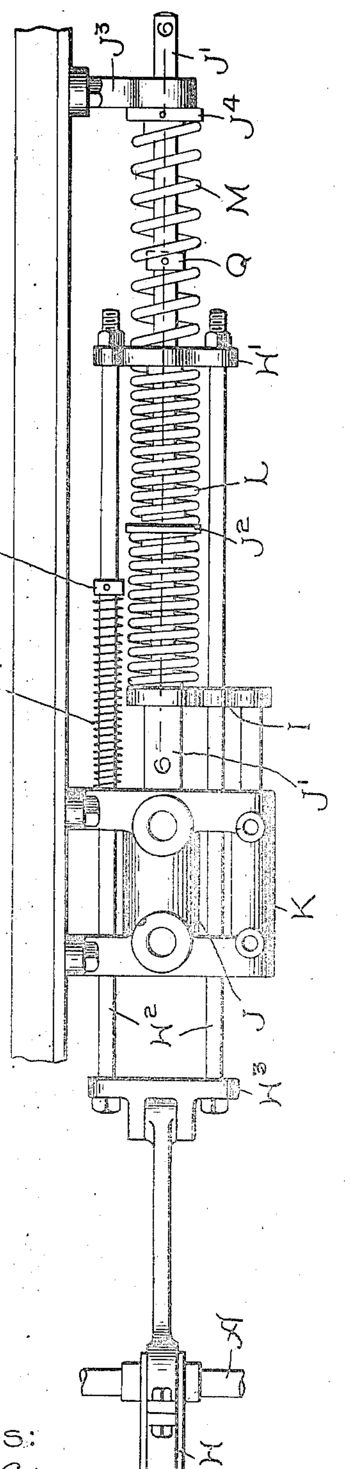


Fig. 5.

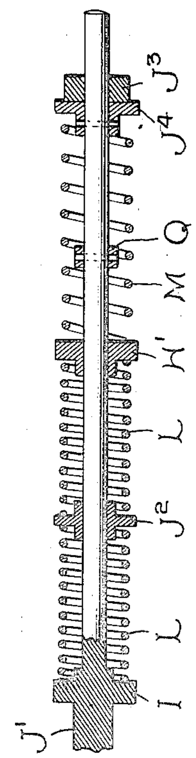


Fig. 6.

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# UNITED STATES PATENT OFFICE.

HERMANN LEMP, OF LYNN, MASSACHUSETTS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

## METHOD OF REGULATING THE PRODUCTION OF STEAM.

**1,015,043.** Specification of Letters Patent. **Patented Jan. 16, 1912.**

Original application filed February 28, 1900, Serial No. 6,806. Divided and this application filed November 3, 1902. Serial No. 129,859.

*To all whom it may concern:*

Be it known that I, HERMANN LEMP, a citizen of the United States, residing at Lynn, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Methods of Regulating the Production of Steam, of which the following is a specification.

The present application is a division of my prior pending application Serial No. 6,806, filed Feb. 28, 1900, covering the apparatus herein disclosed. The division is made under the requirements of Rules 41 and 42 of the United States Patent Office.

The present invention relates to the method of producing steam in power plants and more especially to those used on vehicles for supplying steam to its propelling engine. In such a plant the demand for steam varies through wide limits as the demand for power changes due to the character of the route traveled over, to the load on the vehicle and to its speed. Such a power plant or system, when utilizing coil boilers of the so-called "flasher" type and hydrocarbon burners, requires that the water to the boiler and fuel to the burner shall be supplied in regulated and proportional amounts, depending upon the demand of the engine for steam.

The present invention has for its object to provide an improved and efficient method of supplying liquid to a generator and fuel to a burner for heating said generator and of automatically increasing and decreasing said supplies as the demand for vapor energy changes due to any cause.

In carrying out the method of my invention, I employ a constantly driven pump, and vary its stroke by means of suitable springs. These springs are so proportioned and arranged that as the water pressure on the boiler rises the stroke of the pump is decreased, and vice versa. When the boiler pressure is below a certain predetermined value the pump, which is driven by the engine, works on full stroke, as does the eccentric driving the pumps; but as the pressure rises the stroke of the pump decreases, the eccentric meanwhile continuing to make a full stroke at each revolution of the engine. As the pressure rises and the pump piston meets with more and more opposition the eccentric acts on the springs and, in the simplest form, changes the tension or compression as the case may be, until the stroke of the pump entirely ceases and the eccentric or other source of driving power, works directly against the spring or springs. The spring or springs act to oppose the forward stroke of the eccentric or other source of power, and consequently absorb energy, which however is given out by them on the return stroke, so aside from the friction losses the pump, when bearing this particular relation to the other parts, does not consume any energy, and consequently any intermediate stage in the operation consumes an amount of energy in accordance therewith.

In practice I prefer to mechanically connect the fuel and water pumps, since it is desirable to correspondingly vary the amounts of fluid supplied thereby, but for the sake of simplicity in the above description I have not referred to the fuel pump, but will do so later.

In the operation of a steam vehicle, the changing of the amount of power required to drive the pumps forms an important consideration, for when the vehicle is traveling at a high rate of speed, the demand on the pump may be comparatively small, or even nothing at times, as when coasting.

Referring to the drawings, Figure 1 is a diagrammatic view showing the steam generating and driving parts of a steam-propelled vehicle; Fig. 2 is a plan view of a combined fuel and water pump, showing the parts in a position of rest; Fig. 3 is also a plan view of the pumps showing the pistons at the end of the stroke; Fig. 4 is a side elevation of the pump with the parts as shown in Fig. 2; Fig. 5 is a plan view of the pumps showing the springs compressed in such a manner that the pistons have no movement; and Fig. 6 is a sectional view taken on the line 6—6 of Fig. 5.

Referring to Fig. 1, A represents an engine of any suitable type, receiving steam from the flash boiler B, and is adapted to be connected to the driving wheel or wheels in any desired manner. The boiler is surrounded by a casing and is heated by a burner C, which burner is designed to receive vapor from a suitable vaporizer $C^1$. The liquid fuel is contained in a tank D, and a small hand pump E is employed to give an initial pressure thereto. The water is contained in a tank F, and a small foot pump G is employed to force water into the boiler at the moment of starting. On one end of the engine shaft is an eccentric H which is connected by a rod with the sliding cross-head $H^1$ working on guides $H^2$. This I have found to be a desirable arrangement, but any other of the well-known equivalents may be employed. Mounted on the same guides is a second cross head I to which are secured the piston rods $J^1$ and $K^1$; the former is connected to the piston of the water pump J, and the latter to the piston of the fuel pump K. For simplicity the cylinders for the two pumps have been made in a single casting, but the pumps may be made separate and operated by separate eccentrics or other well-known equivalents. Between the two cross-heads is located a compression spring L, and between the cross-head I and surrounding the guides $H^2$ are two compression springs M. The manually actuated water pump G is connected with the boiler by pipe N, and with the water tank by pipe $N^1$. The engine-driven water pump is connected with the boiler by the pipe $N^2$ and with the water tank by the pipe $N^1$. Extending to the water tank from a point between the boiler and the pump is a pipe $N^3$ containing an adjustable relief valve $N^4$ through which any excess water delivered by the pump may be returned to the tank. The fuel tank is connected with the burner by a pipe O, and located in this pipe between the pipes $O^1$ and $O^2$, which convey fuel to and from the power pump, is an adjustable by-pass valve $O^3$. By adjusting the valve $O^3$ the amount of fuel flowing in the by-pass circuit can be regulated, and in this manner the relation between the amounts of fuel and water delivered by the pumps can be adjusted. This valve is constructed to permit fuel to pass directly from the tank D to the burner, and to prevent a local circulation through the pump and pipes $O^1$ and $O^2$. Steam is conveyed from the boiler to the engine by the pipes P, and the engine is controlled by the throttle valve $P^1$.

Referring now to Figs. 2, 3 and 4, $A^1$ represents the engine shaft, and mounted thereon is an eccentric H which by means of a rod conveys motion to the cross-head $H^3$. The cross-head is secured to two rods $H^2$ which act as guides, and at the same time rigidly connect it with the cross-head $H^1$. The cross-head $H^1$ is sleeved on the rod $J^1$ which is an extension of the piston rod of the water pump J. Rigidly secured to the piston rod and to the right of the cross-head is a collar Q by means of which a right-hand movement is communicated to the piston. The fuel pump K and the water pump J have their cylinders formed in a common casting, and working within these cylinders are pistons which are rigidly connected to the cross-head I. Between the cross-heads I and $H^1$ and surrounding the extension of the piston $J^1$, are two coiled compression springs L having a sliding guide or collar $J^2$ located between them. I have found it preferable for certain reasons to use two springs instead of one between the cross-heads, but one spring may be used if desired. These springs normally tend to hold the sliding cross-head $H^1$ against the collar Q. The outer end of the piston $J^1$ works in a bearing $J^3$, and rigidly secured to the rod at or near this bearing is a collar $J^4$. Between the collar and the cross-head surrounding the piston rod is a compression spring M. All of the springs are under a certain amount of compression, but as the cross-head $H^1$ stands in Fig. 1 it is balanced between the two forces exerted by the springs. This is a very desirable arrangement, since I am enabled to obtain, for a given piston stroke, twice the compression obtainable where only a single spring is employed, providing that the compression or extension, as the case may be, is from zero to maximum.

Suppose, for example, that a single spring is employed, in order to start the compression at zero and work it up to the desired maximum; it would be necessary to start with the spring fully extended, and this would mean a large movement for the cross-head $H^1$ between the two extremes. Now by placing a second spring in opposition to the first, and giving both of them an initial compression, the cross-head $H^1$, being located between them, will assume a zero position. In other words, the cross-head will be pressed from one side by a definite force, and by a corresponding and equal force from the other. Both sets of springs being under stress, when the cross-head starts to compress one spring it is assisted in its work by the other spring. If it is desired, the compression of one spring can be made somewhat greater than the other and a stop provided to limit the movement of the cross-head in the direction of the weaker spring. A further modification would consist in making the scales of the springs different. In order to balance in a measure the friction of the moving parts, a compression spring R is coiled around one of the guides $H^2$ and engages at one end with the casting forming the water-pump cylinder, and at the other end with an adjustable collar $R^1$ mounted on the guide.

I have described the use of double springs as being a desirable one, but I do not desire to be understood as limiting myself to that, since I can employ a single spring and place it under an initial compression or not, as I please.

Fig. 3 illustrates the position of the parts when the pump is working full stroke and, as here shown, the piston is at the end of said stroke.

In Fig. 5 the parts are shown in the position which they occupy when the water pressure on the boiler is at a maximum and the piston is doing no work. That is to say, the water pressure on the boiler is greater than the force exerted by the springs L, so that while the cross-head H¹ and the eccentric H continue to move to and fro at full stroke between the position shown in this figure and the one shown in Fig. 2, it has no effect on the pump; it merely compresses the spring at one portion of its stroke, and the spring expanding assists the engine on the return stroke. In other words, the system is so arranged that the amount of water or fuel delivered by the pumps is automatically varied in accordance with the demands.

With systems of the character described, it is preferable to provide some device for restricting the amount of steam which can pass from the boiler to the engine, thereby preventing improper manipulation. Such a device is shown in Fig. 1 and consists of a disk S mounted in a suitable holder, and provided with a small opening through which the steam can pass.

Instead of using a separate steam-restricting or choking device, the throttle valve $P^1$ can be so arranged that it only has a certain definite and limited opening.

I have used the term "vehicle" in its broadest sense, as it is obvious that the apparatus could be used in connection with launches or other apparatus of a similar nature.

The operation of my invention is as follows: Assuming that it is desired to start the apparatus into operation, the hand pump E is operated until there is a pressure of approximately five pounds on the fuel tank D. This will force fuel to the burner C, which fuel will be vaporized by any suitable means; at the same time water is forced into the boiler by the foot-pump G. As soon as there is sufficient steam in the boiler, the throttle $P^1$ is opened and the engine is started into operation. At the moment of starting, the water pressure on the boiler is low and the fuel and water pumps operate at full stroke, but as soon as the water and fuel pressures increase to a predetermined point, a certain portion of the stroke of both pistons is taken up by the springs L, and as the pressure continues to increase, the compression on these springs increases until finally the maximum water and fuel pressure is reached, when the pistons will be in the position shown in Fig. 5. During all of this time the engine is supposed to be in operation and the eccentric H and cross-head $H^1$ moving at their full stroke.

It is evident of course that during the operation of the system as installed on an automobile the amounts of water and fuel delivered to the boiler and burner respectively will be greater or less depending upon the load and on the character of the road on which the vehicle is traveling. It is to be noted when the system is in operation, *i. e.*, the engine receiving steam from the boiler that the pressure on the water end of the boiler exceeds that of the steam end. This is due to the friction exerted by the wall of the boiler tube on the fluid passing therethrough. The value of the excess pressure at the water end will depend of course on the cross-section of the tubing and on the bends or turns therein, being greater with small tubing than with large. By using a regulator that is responsive to changes in the water pressure it will be quick and positive in its action.

During the time that the water and fuel pressures are rising to their maximum, the stroke on the pumps steadily decreases, assuming of course that the rise in pressure is a regular one; if, on the other hand, there is a sudden demand on the boiler which decreases the water pressure, the length of the pump stroke will automatically increase, irrespective of the length of the stroke which it formerly had.

Assuming that the vehicle is stopped after heavy duty, the steam pressure may rise and the relief valve $N^4$ will open slightly and permit the surplus of water to escape, sometimes carrying with it steam from the boiler. Under ordinary operation however this valve would not be used. As soon as the pump K starts into operation, it draws fuel from the tank D through the pipes O and $O^1$ and discharges it through pipe $O^2$, the check valve $O^3$ preventing the fuel from passing through the pipe $O^2$ to the pipe $O^1$ and thereby creating a local circuit.

It will be seen that I have provided a system in which the supply of water and fuel is automatically controlled in accordance with the demands on the apparatus, and that all the operator has to consider is the main throttle valve $P^1$ by which the speed of the engine is governed, and that no matter how rapid are the changes in speed of the vehicle, the pumps will automatically regulate their discharges in accordance with the demands.

From the foregoing it will be seen that the supplies of water to the boiler and fuel to the combustion chamber or burner will automatically vary in unison as the demand for superheated vapor changes, and substantially in the same degree, because the pumps are mechanically united and whatever affects the water pump piston must necessarily affect the fuel pump piston. The spring buffer between the driving means and the pump pistons readily compensates for all changes in load, no matter how small or how large they are. The water pump piston normally works against a pressure which may roughly be stated as 500 pounds, while a pressure of 50 pounds will be satisfactory for the burner. As the demand for vapor changes, so will the length of the pump strokes, and the changes will take place simultaneously and in the same degree with the variations in demand for fluid energy. The pistons of the pumps being rigidly connected and the bodies held stationary and controlled in their action by the condition of the steam as to pressure, which varies with the demand, such for example as changes in load, the supplies of fuel and water will vary in a definite quantitative relation with respect to said demand.

The boiler being of the flasher type, the water as it enters is gradually heated until it flashes into steam, and from this point to the end is gradually superheated. This means that there is only a small amount of water at the temperature of vaporization. As the load on the engine changes and consequently the demand for steam, the point of vaporization changes slightly. In one case it may be midway between the ends of the tube, and in another before or after the midway position. The boiler being made in sections and arranged as shown, water enters the upper end and flows toward the fire. The lower end of the upper section is connected to the bottom of the lower section, and from this point the flow of superheated steam is away from the fire. The upper section of the boiler, being remote from the fire, is cooler than the lower section, and hence the temperature difference between it and the entering feed water is not very great. This is conducive to long life of the boiler.

The construction of this boiler, together with its advantages are more fully set forth in a prior application filed by me.

In accordance with the provisions of the patent statutes I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof; but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States is,

1. The method of generating superheated vapor which consists in supplying liquid to a suitable generator at a substantially predetermined pressure, supplying a fuel for heating the generator, and varying both of said supplies in substantial accordance with the variations in pressure of the liquid supplied to the generator.

2. The method of generating steam which consists in forcing water under pressure into a coil boiler, and fuel under pressure to a burner for heating said boiler, and simultaneously increasing and decreasing the supplies of both water and fuel as the pressure of the water forced into the boiler increases and decreases.

In witness whereof I have hereunto set my hand this first day of November, 1902.

HERMANN LEMP.

Witnesses:
DUGALD McK. McKILLOP,
JOHN A. McMANUS.