N. B. WALES.

HEATING APPARATUS.

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1,079,381.

Patented Nov. 25, 1913.

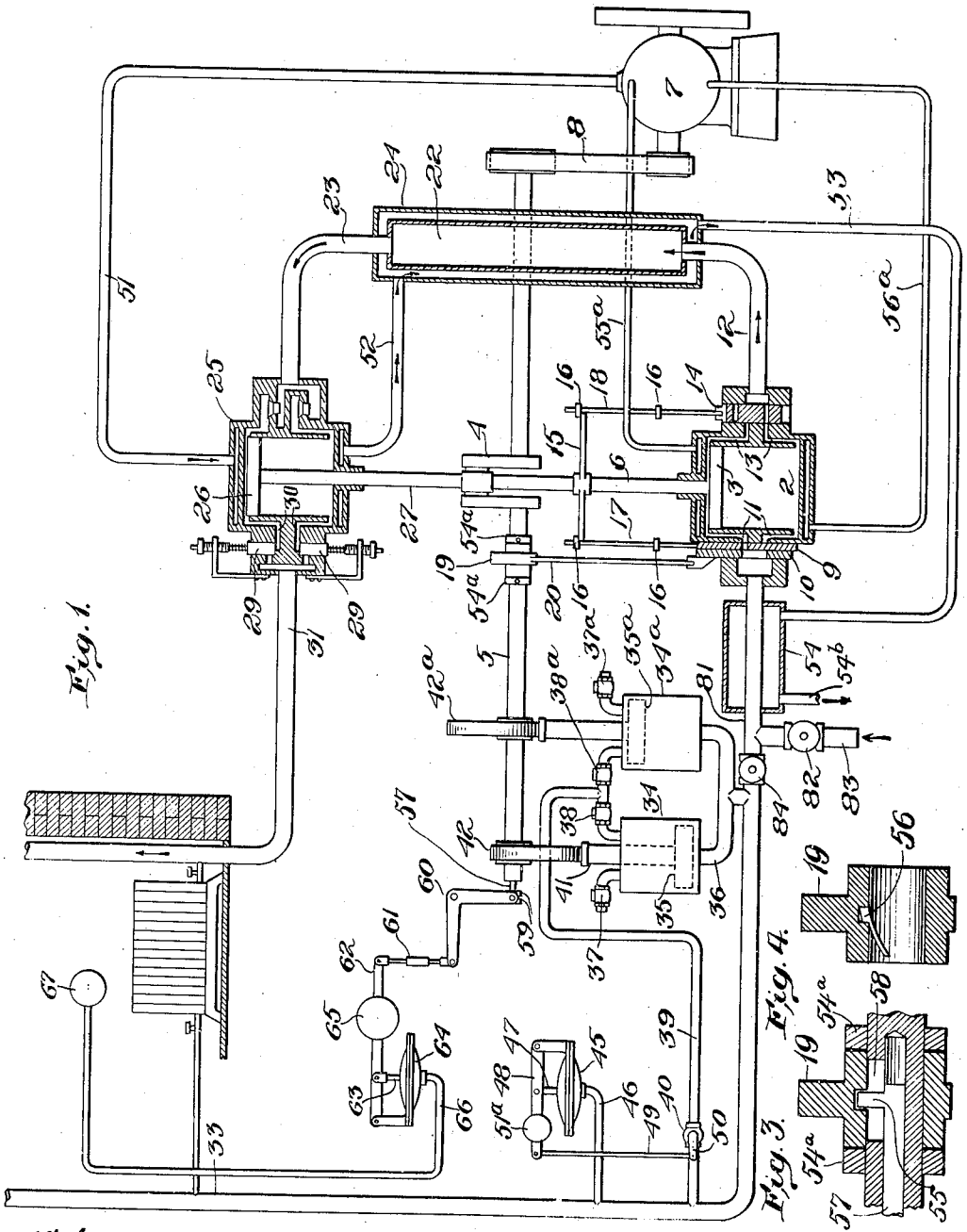


Fig. 1.

Fig. 4.

Fig. 3.

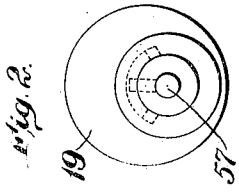


Fig. 2.

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UNITED STATES PATENT OFFICE.

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HEATING APPARATUS.

1,079,381. Specification of Letters Patent. Patented Nov. 25, 1913.

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To all whom it may concern:

Be it known that I, NATHANIEL B. WALES, citizen of the United States, and resident of Braintree, county of Norfolk, Massachusetts, have invented certain new and useful Improvements in Heating Apparatus, of which the following is a specification.

The invention relates to a heating apparatus and its object is to provide an improved system by which the heat required for heating buildings or for other heating purposes may be economically secured and utilized. The heat conveying medium utilized in this system for conveying the heat to the place or places where the heating is to be done is preferably air although other elastic fluids might be used as such medium.

In practising the invention the air or other heat carrying fluid is taken into the system from the atmosphere or other source of fluid supply until the system contains the requisite quantity or weight of fluid and then communication between the atmosphere or other source of fluid supply is cut off and the fluid thus taken in is repeatedly circulated through the system. In passing through that part of the system where the heat in the air is to be utilized for heating purposes and which for convenience I term the circulating conduit, some of the heat of the air within the system is given up. The cooler air coming from the circulating conduit is again passed through that part of the system where a fresh supply of heat is supplied thereto and is then again passed through the circulating conduit. In a system of this sort working under practical conditions there will be a gradual leakage or loss of air from the system and one of the important features of my invention consists in providing means for automatically supplying or introducing fresh air to the system to compensate for such loss and maintain the requisite quantity or weight of air within the system.

A further feature of the invention consists in a closed system of the general character above set forth in which the air after passing through the circulating conduit is expanded and then compressed and delivered to the circulating conduit, heat being supplied to the air between its admission to the expanding mechanism and its admission to the compressing mechanism.

In embodying these features in an efficient form and arrangement of apparatus I have utilized various other features of invention which will be referred to hereinafter and set forth in the claims.

For the purpose of illustrating the various features of my invention I have shown diagrammatically in the accompanying drawings a heating system embodying the various features of my invention.

In these drawings—Figure 1 is a diagrammatic view of the system. Figs. 2, 3 and 4 are details of parts of the devices for regulating and governing the amount of compression effected in the operation of the apparatus.

In the apparatus shown in the drawings the air coming from the circulating conduit is taken into an expanding mechanism where it is expanded to a degree which may be regulated according to the conditions under which the apparatus is to operate. In expanding the temperature of the air falls so that the air is in condition to absorb low temperature heat or heat at a lower temperature than it would absorb had it not been expanded. The air is also by its expansion not only rendered capable of absorbing lower temperature heat but is also rendered capable of absorbing a greater quantity of higher temperature heat than it could absorb had it not been expanded. After having been expanded the air is delivered to a compressing mechanism by which it is compressed and delivered to the circulating conduit. After the admission of the air to the expanding mechanism and before it enters the compressing mechanism, heat is supplied to the air. This heat may be supplied to the air during the expansion or after the expansion or both during and after the expansion and may be thus supplied in any manner which is the most economical and advantageous according to the conditions under which the apparatus is being run. By the action of the compressing mechanism upon the air the temperature of the air is raised and a quantity of heat suitable for heating purposes is obtained which is materially greater than would have been obtained had the air not been expanded and heat supplied thereto.

By reason of the fact that the air after passing through the circulating conduit is redelivered to the expanding mechanism the quantity of heat which must be supplied to

the air in passing through the expanding and compressing mechanism and intermediate conduits is merely that which has been given up by the air in passing through the circulating conduit and consequently an efficent and economical system is provided and one which requires a small amount of power for operating purposes.

As shown in the drawings the expanding mechanism is in the form of a cylinder 2 within which reciprocates a piston 3. The piston is reciprocated by a crank 4 carried by a shaft 5 and connected with the piston rod 6. The shaft 5 is driven from a gas or hydrocarbon engine indicated at 7 through a belt 8.

The intake pipe 81 of the expansion cylinder communicates through a valve 82 and branch pipe 83 with the atmosphere and also communicates through the valve 84 with the return pipe 33 from the circulating conduit. In starting up the apparatus the valve 84 is closed to shut off communication between the intake of the expansion cylinder and the circulating conduit and the valve 82 is opened to establish communication between the intake of the expansion cylinder and the atmosphere. After the apparatus has been operated until the desired pressure within the circulating conduit is secured, the valve 82 is closed to shut off communication between the intake of the compression cylinder and the atmosphere and valve 84 is opened to establish communication between the circulating conduit and the intake of the expansion cylinder.

The admission of the air to either side of the piston 3 of the expansion cylinder is controlled by a main valve 9 and a cut-off valve 10 which control the communication between the intake pipe 81 and the intake ports 11. The expanded air is delivered from the expanding cylinder 2 to a delivery pipe 12 through ports 13, the opening and closing of which is controlled by a delivery valve 14. The main valve 9 and the delivery valve 14 are shifted at each end of the stroke of the piston by means of arms 15 projecting from the valve rod 6 and arranged to operate upon tappets 16 carried by the valve rods 17 and 18. The cut-off valve 10 is operated to cut off communication between the intake pipe 8 and the ports 11 at the proper point in the stroke of the piston in either direction by means of an eccentric 19 carried by the shaft 5 and connected with the valve by an eccentric strap and rod 20.

During a portion of the stroke of the piston 3 in either direction, air is taken into the cylinder back of the piston through the intake pipe 81, valves 9 and 10, and port 11, and then the supply of air is cut off by the closing of the valve 10. During the remainder of the stroke of the piston, the air back of the piston expands, the amount of expansion depending upon the point at which the cut off valve is operated. On the return stroke of the piston this expanded air is delivered through one of the ports 13 to the delivery pipe 12. The incoming air as it passes through the intake pipe 81 is subjected to the action of a heating agent by means of a heating device 54 through which the hot exhaust products from the engine 7 are circulating and absorbs heat from this heating agent. During the expansion of the air it is also subjected to the action of a heating agent circulated through a jacket formed around the expanding cylinder and absorbs heat from this heating agent so that the expansion of the air is approximately isothermal. The expanded air is conducted from the expansion cylinder to the expanding mechanism through the pipe 12, receiver 22 and pipe 23, the air as it passes through this conduit being subjected to the action of a heating agent which is circulated through a jacket 24 surrounding the receiver 22. Thus the air in its passage from the expanding mechanism to the compressing mechanism absorbs heat from the heating agent in the jacket 24 and will or may be delivered to the compressing mechanism at a temperature higher than that at which it entered the expanding mechanism.

The compressing mechanism in the form shown consists of a cylinder 25 within which reciprocates a piston 26. The cylinder 25 is arranged on the opposite side of the crank shaft 5 from the expansion cylinder 2 and the piston 26 is connected with the crank pin 4 by the piston rod 27 which forms a continuation of the piston rod 6. With the compressing and expanding mechanisms thus connected the expansion of the air in the expanding cylinder acts to force the piston 26 forward during its compression stroke, thereby reducing the power required to be furnished by the engine 7 in operating the compressing mechanism.

Air is supplied to the compression cylinder from the pipe 23 through intake valves, which may be ordinary puppet valves, one of which opens to admit air back of the piston immediately the piston starts forward, remains open during the entire stroke of the piston in this direction, and immediately closes as the piston starts on its stroke in the opposite direction. The air is delivered from the compression cylinder through valves 29 which control the communication between the ports 30 leading from opposite ends of the cylinder and the delivery pipe 31 which leads to or forms a part of the conduit through which the air is circulated. The valves 29 are valves which may be set to open when the pressure in front of the piston reaches a predetermined point. As the piston advances therefore the expanded

air delivered to the cylinder through the pipe 23 on its stroke in the opposite direction, is compressed until its pressure reaches a predetermined point when the valve 29 opens and this compressed air is delivered into the pipe 31. In thus compressing the air a certain amount of heat is imparted to it by reason of the work done upon it during the compression and the temperature of the air which contains the heat absorbed on its way to the compression mechanism is raised to a temperature level suitable for use for heating purposes. Thus a large quantity of heat suitable for heating purposes is secured by doing a comparatively small amount of work upon the air. The compressed air with its large quantity of heat suitable for heating purposes is delivered through the pipe 31 and may be circulated through radiators or heating coils of a heating system or may be utilized to transfer its heat to the hot water of a hot water heating system or may be otherwise used for heating purposes. After having given up a certain amount of its heat the air is delivered from the circulating conduit through the pipe 33 to the intake of the expanding mechanism to be again supplied with heat and passed through the circulating conduit.

In order that the quantity of air within the system may be automatically maintained to compensate for any leakage and thus maintain a substantially uniform operation, means are provided for automatically supplying air to the system to compensate for such loss. Any suitable means may be employed for this purpose and the means employed may be regulated and controlled in any suitable manner and may be arranged to introduce the air into any part of the system. I prefer however to employ for this purpose a compressing mechanism which forces air into the system and I also prefer to control the operation of this compressing mechanism by the pressure in the system so that when the pressure within that part of the system to which the controlling devices are connected falls below a predetermined point, the compressing mechanism is thrown into operation and operates to supply air to the system until the pressure is restored.

One form of air compressing device suitable for the above purpose is shown in the drawings. As shown this device comprises a cylinder 34 within which reciprocates a piston 35. The lower end of the cylinder is connected by means of a pipe 36 with the pipe 33 which leads from the circulating conduit to the expanding mechanism. The upper end of the cylinder 34 communicates through an intake valve 37 with the atmosphere and communicates through a delivery valve 38 with a pipe 39 which leads from the pipe 33. The pipe 39 is provided with a valve 40 which serves to open and close communication between the upper end of the cylinder 34 and the delivery pipe 33 of the circulating conduit. The piston 35 is connected with a piston rod 41 the upper end of which is arranged to be acted upon by a cam 42 secured to cam shaft 5.

By reason of the fact that the piston rod 41 is connected to the upper side of the piston 35 the effective area of the lower side of the piston is greater than the effective area of the upper side of the piston and a given pressure below the piston will therefore cause the air above the piston to be compressed to a higher pressure.

Assuming that the valve 40 is open the operation of the device will be as follows: On the down stroke of the piston air will be drawn in through the valve 37, the valve 38 being held closed by the pressure within the system. As the cam 42 releases the piston the pressure on the under side of the piston will force it upward, the valve 37 closing to prevent the escape of air from above the piston. The air above the piston will therefore be compressed until the pressure is greater than the pressure within the system when the valve 38 will open and the air above the piston be forced into the system through the pipe 39. On the next down stroke of the piston the valve 38 will close and the valve 37 open to allow a fresh supply of air to enter the upper end of the cylinder above the piston when the operation will be repeated. Thus so long as the valve 40 remains open the pump will operate to supply air to the system and to build up the pressure therein. When the valve is closed the piston 35 will be forced downward to the lower end of its stroke each time the cam 42 revolves and when released by the cam will return until the pressure within the upper end of the cylinder and pipe 39 balances the pressure below the piston when the piston will remain at rest until again depressed by the cam.

In order to secure a substantially constant supply of air to the system during the time that the air supplying device is in operation a second cylinder and piston 34^a and 35^a may be provided and the piston may be operated by a cam 42^a arranged upon the shaft 5 at an angle of 180 degrees to the cam 42.

The device for opening the valve 40 and thus throwing the compressing device into operation when the pressure within the system falls below a certain amount, comprises a casing 45 which is connected by means of a pipe 46 with the pipe 33 leading from the circulating conduit. Within the casing 45 is a diaphragm (not shown) which is connected by means of a link or pin 47 with a lever 48. The lever is connected by means of a link 49 with an operating arm 50 which is connected with the valve 40. An adjust-

able weight 51ª is mounted upon the lever 48 and this weight may be adjusted to regulate the pressure required to operate the diaphragm and through it to operate the lever 48.

In adjusting the apparatus for any given conditions the weight 51ª is so adjusted that the lever 48 will be supported in raised position by the pressure on the under side of the diaphragm in the casing 45 so long as the desired pressure is maintained in the circulating conduit and pipe 33. So long as this pressure is maintained the valve 40 remains closed. Should the pressure in the pipe 33 fall below the predetermined pressure the lever 48 will be moved downward by the weight 51ª thus operating the valve 40 and opening communication between the upper ends of the cylinders 34, 34ª and the pipe 33. Air will now be forced into the system until the pressure in the pipe 33 is restored when the lever 48 will be raised to close the valve 40. Thus the requisite quantity of air will be automatically maintained in the system and fresh air supplied to compensate for any leakage.

The heating of the air after expansion may be effected in any suitable manner and in some cases it may be found most desirable to expand the air so that its temperature is below the temperature of the outside atmosphere so that heat may be supplied to the expanded air from the atmosphere. The heating at this stage and at other stages during the passage of the air through the apparatus may be economically done in cases where gas or hydrocarbon engines are used for operating purposes by utilizing the waste heat from the motor as the heating agent and in the drawings an arrangement for thus utilizing the waste heat from the motor is illustrated.

As shown the exhaust products from the engine 7 are led through pipe 51 to the jacket of the compression cylinder 25, thence through a pipe 52 to the jacket 24 of the receiver 22, thence through a pipe 53 to the heating device 54 and exhausted through pipe 54ᵇ. The heating agent for acting upon the air during its expansion in the expanding cylinder is the water circulated through the jacket of the combustion cylinder of the engine 7. This water is led from the water jacket of the engine through a pipe 55ª to the jacket of the cylinder 2 and is returned to the water jacket through a pipe 56ª.

In an apparatus of the character described the range of temperature through which the air should be raised by the compression mechanism in order to secure a given temperature in the air delivered, will vary with the conditions under which the apparatus is being used. In the form of apparatus shown, it is intended that the compressing mechanism should deliver the air at a substantially constant pressure after the apparatus has been once adjusted and the adjustment for varying conditions is effected by varying or regulating the amount of expansion effected in the expanding mechanism and consequently the amount of compression required to compress the expanded air to any predetermined pressure. When the apparatus has been adjusted or regulated so as to operate properly under the conditions existing at the time of its use, it is desirable that its operation should be automatically governed in conformity with the use to which it is put. For instance, it may be desirable to govern the operation of the apparatus so that a substantially constant temperature will be maintained in the apartments being heated and for the purpose of illustration a governing mechanism is shown adapted to govern the apparatus to maintain a substantially constant temperature at the place of use.

The amount of expansion effected in the expansion cylinder depends upon the point in the stroke of the piston 3 at which the cut-off valve 10 acts to cut off the supply of air through the intake pipe 81 and the point at which the valve thus acts depends upon the position of the eccentric 19 upon the shaft 5. The expansion effected in the expanding cylinder may therefore be regulated and governed by regulating and governing the position of the eccentric 19 upon the shaft 5. For this purpose the eccentric is loosely mounted upon the shaft between the collars 54ª and is held in position upon the shaft by means of a pin 55 which engages a spiral groove 56 formed in the bore of the eccentric. The pin 55 is secured upon the end of a rod 57 which is mounted within the shaft 5, the pin projecting through a longitudinal slot 58 formed in the shaft. The rod projects beyond the end of the shaft and is provided with two collars 59 which engage opposite sides of a pin projecting from one arm of a bellcrank lever 60. The other end of the bellcrank lever is connected by means of an adjustable link 61 with a lever 62. The lever 62 is connected by a link or pin 63 with a flexible diaphragm within a casing 64 and is provided with an adjustable weight 65 by which the pressure transmitted from the lever to the diaphragm may be regulated. The chamber within the casing below the diaphragm is connected by a pipe 66 with a thermostat 67 arranged within the building which is to be heated, and constructed in any usual or well known manner to vary the pressure within the pipe 66 according to the temperature of the thermostat.

By adjusting the weight 65 upon the arm 62 the pressure on the diaphragm in the casing 64 may be adjusted to counterbalance the pressure on the under side of the dia-

phragm corresponding to the desired temperature at the thermostat. By adjusting the link 61 the cut-off valve may be set to regulate the expansion to suit the conditions under which the apparatus is to operate at any particular time. After the eccentric has been thus set, the thermostat will operate to control the governing mechanism to maintain a substantially constant temperature at the thermostat. If the temperature at the thermostat falls, the eccentric will be shifted to cause the cut-off valve to operate at an earlier point in the stroke of the expansion piston. This will result in a greater expansion of the air and therefore a greater compression with the corresponding rise in the temperature of the air passing through the circulating conduit. If the temperature at the thermostat rises, the eccentric will be operated to cause the cut-off valve to operate later in the stroke of the piston. This will result in less expansion of the air in the expanding cylinder and consequently less compression in the compression cylinder with a corresponding fall in the temperature of the air in the circulating conduit.

It will be understood that the specific construction of the expanding mechanism, compressing mechanism and of the various devices and mechanisms forming parts of the apparatus, are not material and that the mechanisms and devices shown in the drawings are shown merely for the purpose of illustrating diagrammatically the general construction and mode of operation of an apparatus embodying the features of the invention.

Without attempting to point out in detail the various forms of apparatus in which my invention may be embodied, what I claim and desire to secure by Letters Patent is:—

1. A heating apparatus comprising fluid expanding mechanism, fluid compressing mechanism to which the expanded fluid is delivered, a prime motor for driving said mechanisms, means for supplying heat to the fluid between its admission to the expanding mechanism and its admission to the compressing mechanism, a circulating conduit to which the fluid from the compressing mechanism is delivered, devices for opening and closing the communication between the circulating conduit and the intake of the expanding mechanism and for opening and closing communication between said intake and a source of fluid supply.

2. A heating apparatus comprising fluid expanding mechanism, fluid compressing mechanism to which the expanded fluid is delivered, a prime motor for driving said mechanisms, means for supplying heat to the fluid between its admission to the expanding mechanism and its admission to the compressing mechanism, heat utilizing devices to which the fluid from the compressing mechanism is delivered and from which the fluid is delivered to the expanding mechanism, and means for supplying fluid to the system whenever the pressure in the system falls below a predetermined point.

3. A heating apparatus comprising fluid expanding mechanism, fluid compressing mechanism to which the expanded fluid is delivered, a prime motor for driving said mechanisms, means for supplying heat to the fluid between its admission to the expanding mechanism and its admission to the compressing mechanism, heat utilizing devices to which the fluid from the compressing mechanism is delivered and from which the fluid is delivered to the expanding mechanism, and means for maintaining a substantially uniform quantity of fluid in the system.

4. A heating apparatus comprising fluid expanding mechanism, fluid compressing mechanism to which the expanded fluid is delivered, a prime motor for driving said mechanisms, means for supplying heat to the fluid between its admission to the expanding mechanism and its admission to the compressing mechanism, a circulating conduit to which the fluid from the compressing mechanism is delivered and from which the fluid is delivered to the expanding mechanism, and means controlled by the pressure in the system for supplying fluid thereto.

5. A heating apparatus comprising fluid expanding mechanism, fluid compressing mechanism to which the expanded fluid is delivered, a prime motor for driving said mechanisms, means for supplying heat to the fluid between its admission to the expanding mechanism and its admission to the compressing mechanism, heat utilizing devices to which the fluid from the compressing mechanism is delivered and from which the fluid is delivered to the expanding mechanism, and fluid compressing mechanism for forcing fresh fluid into the system to maintain a quantity of fluid therein.

6. A heating apparatus comprising fluid expanding mechanism, fluid compressing mechanism to which the expanded fluid is delivered, a prime motor for driving said mechanisms, means for supplying heat to the fluid between its admission to the expanding mechanism and its admission to the compressing mechanism, a circulating conduit to which the fluid from the compressing mechanism is delivered and from which the fluid is delivered to the expanding mechanism, and fluid compressing mechanism controlled by the pressure in the system for forcing fresh fluid into the system to maintain a quantity of fluid therein.

7. A heating apparatus comprising fluid compressing mechanism, a circulating conduit to which the compressed fluid is delivered and from which it is returned to the

compressing mechanism, and mechanism for supplying fluid to the system whenever the pressure therein falls below a predetermined amount.

8. A heating apparatus comprising fluid compressing mechanism, a circulating conduit to which the compressed fluid is delivered and from which it is returned to the compressing mechanism, and means controlled by the pressure in the system for supplying fluid thereto.

9. A heating apparatus comprising fluid compressing mechanism, a circulating conduit to which the compressed fluid is delivered and from which it is returned to the compressing mechanism, and fluid compressing mechanism controlled by the pressure in the system for forcing fresh fluid into the system to maintain a quantity of fluid therein.

10. A heating apparatus comprising fluid expanding mechanism, fluid compressing mechanism tc which the expanded fluid is delivered, means for supplying heat to the fluid between its admission to the expanding mechanism and its admission to the compressing mechanism, a circulating conduit leading from the compressing mechanism and delivering to the expanding mechanism, means for regulating the expanding mechanism, means for automatically governing the apparatus, and means for supplying fluid to the system whenever the pressure therein falls below a predetermined point.

11. A heating apparatus comprising fluid expanding mechanism, fluid compressing mechanism, a conduit for conducting the fluid from the expanding to the compressing mechanism, a circulating conduit leading from the compressing mechanism and delivering to the expanding mechanism, means for adjusting the apparatus to vary the amount of compression, governing mechanism for governing the apparatus to maintain a substantially constant temperature at the place of use of the heat carrying fluid, and means for supplying fluid to the system whenever the pressure therein falls below a predetermined point.

12. A heating apparatus comprising fluid expanding mechanism, fluid compressing mechanism to which the expanded fluid is delivered, means whereby the fluid is heated between expansion and compression, a circulating conduit leading from the compressing mechanism and delivering to the expanding mechanism, a governor for automatically controlling the amount of compression, and means for supplying fluid to the system whenever the pressure therein falls below a predetermined point.

In witness whereof, I have hereunto set my hand, this 10th day of December 1906.

NATHANIEL B. WALES.

In the presence of—
IRA L. FISH,
KATHARINE A. DUGAN.