L. M. ELLIS.

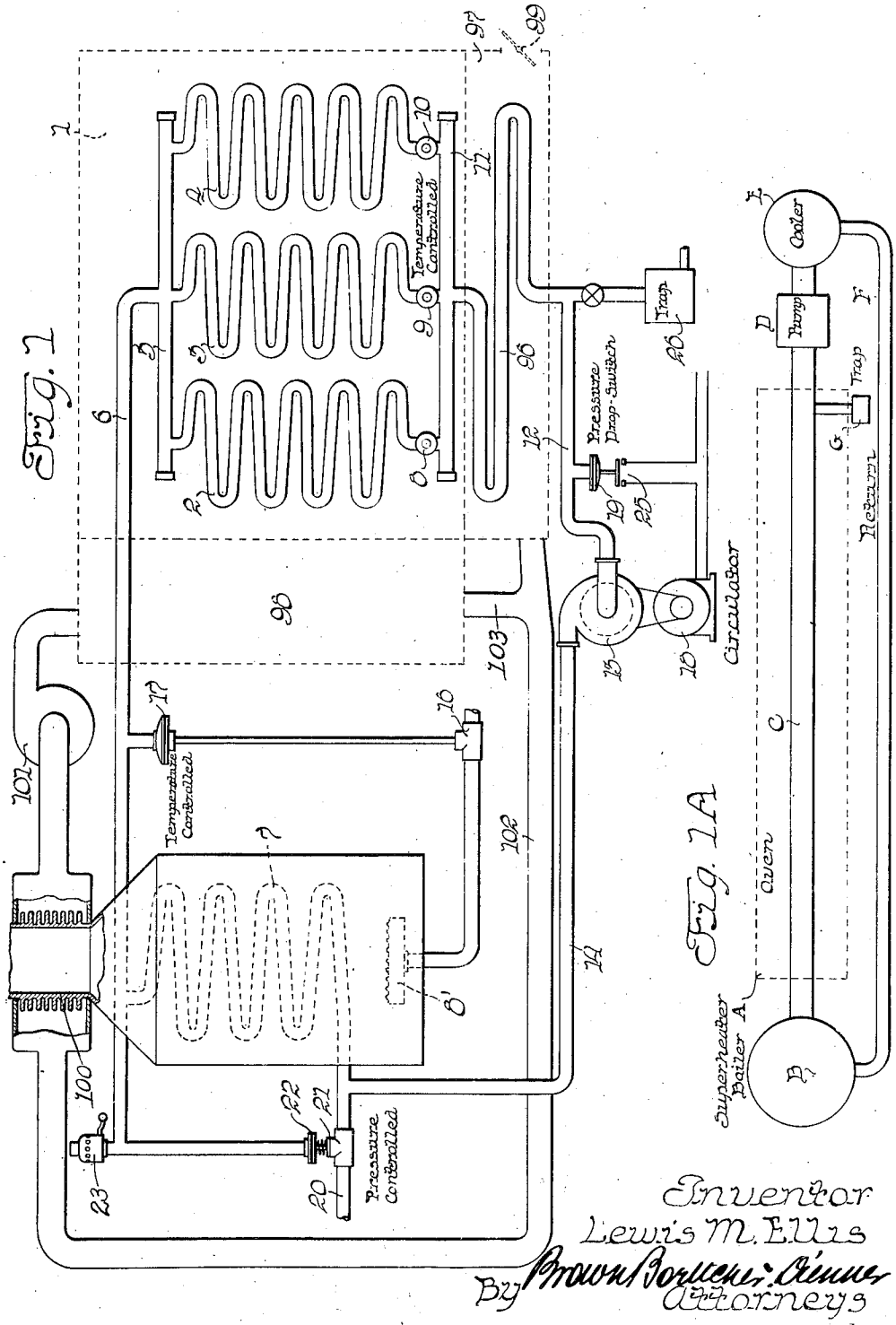
HEATING SYSTEM.

APPLICATION FILED DEC. 23, 1920.

1,399,052.

Patented Dec. 6, 1921.

3 SHEETS—SHEET 1.



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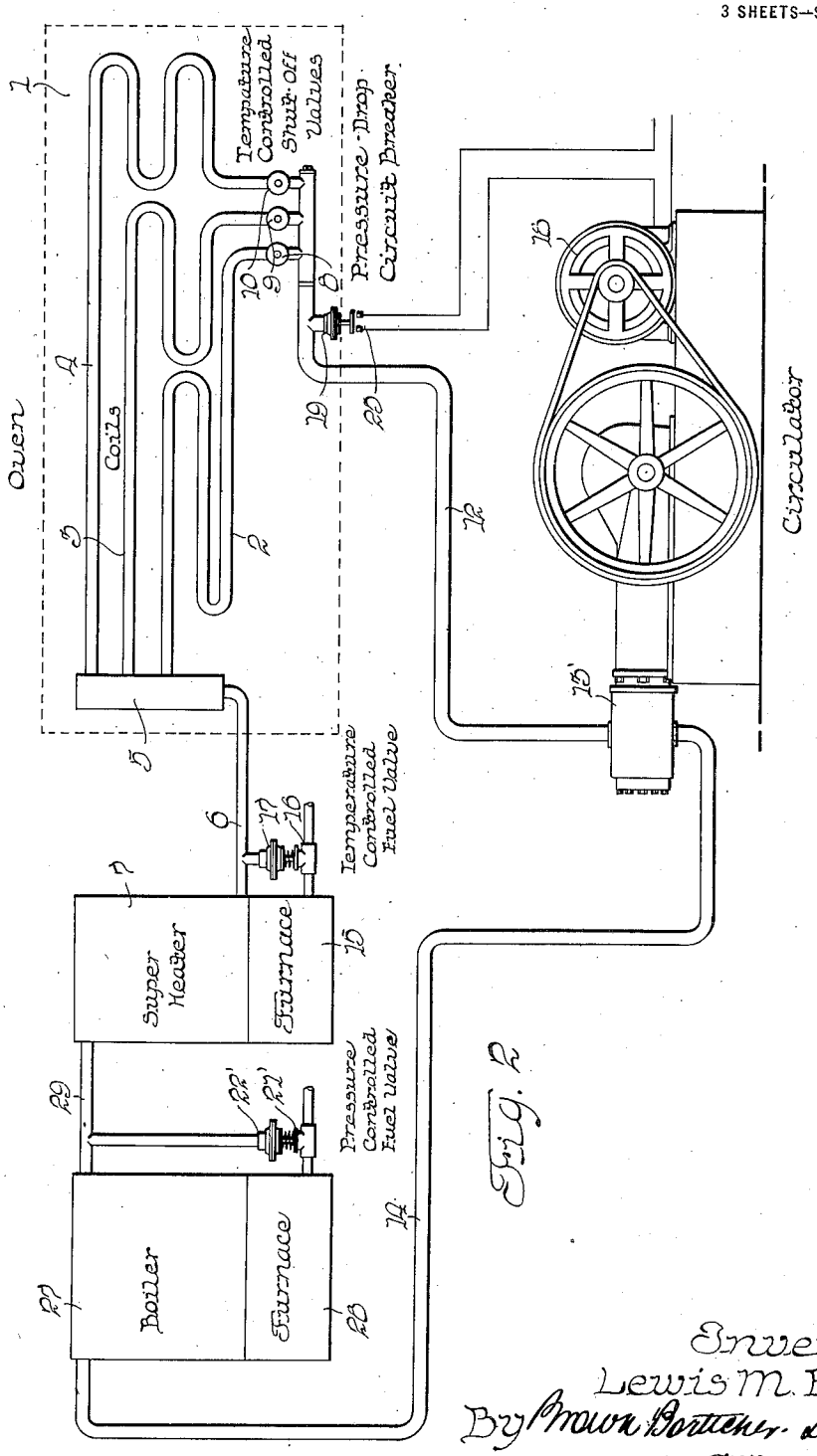


Fig. 2

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3 SHEETS—SHEET 3.

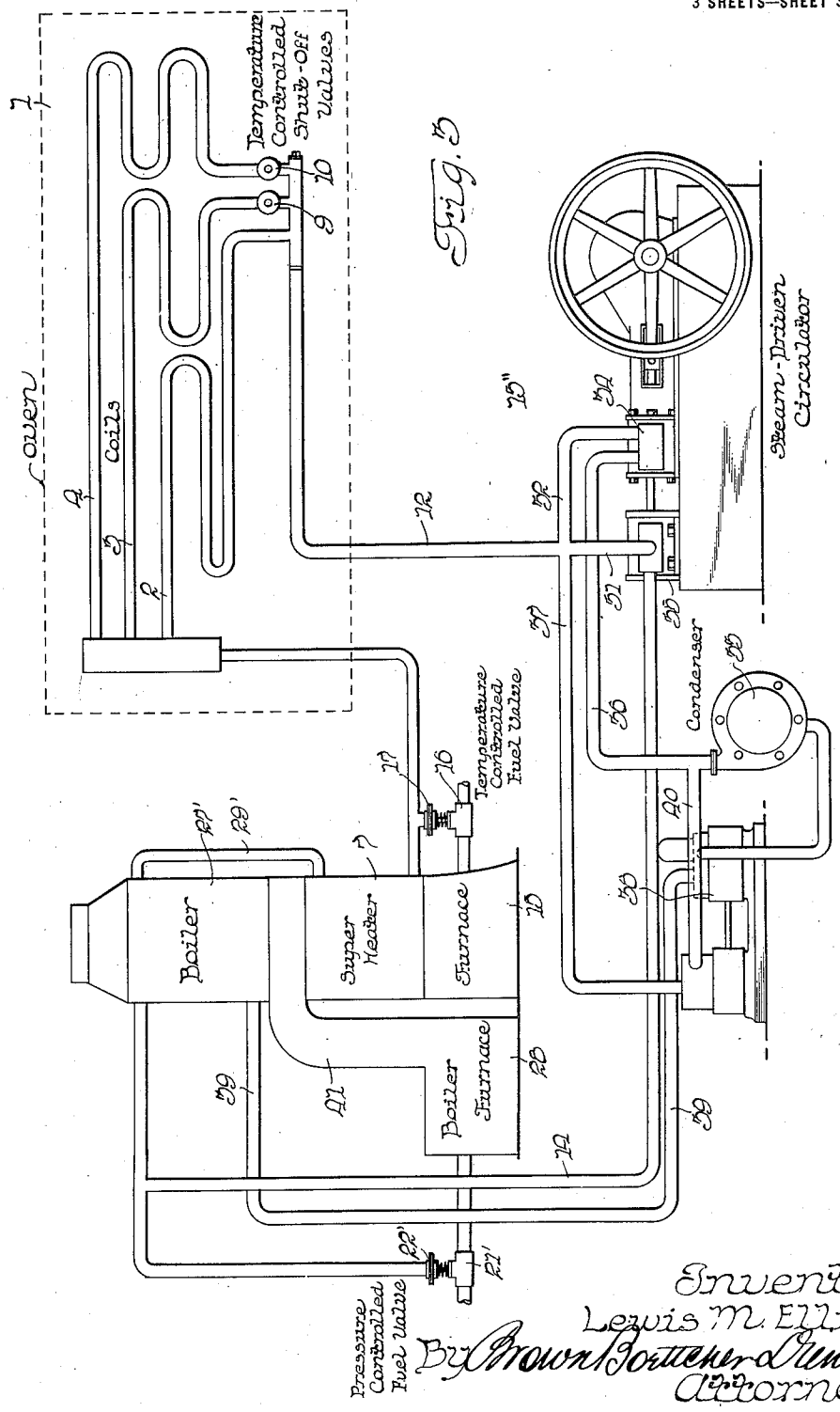


Fig. 5

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UNITED STATES PATENT OFFICE.

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HEATING SYSTEM.

1,399,052. Specification of Letters Patent. Patented Dec. 6, 1921.

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To all whom it may concern:

Be it known that I, LEWIS M. ELLIS, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Heating Systems, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to heating systems.

There is a great demand in the art for a simple, reliable and economical heating system which will maintain ovens, kilns, etc., at temperatures in the neighborhood of 350° F. to 800° F., which is above that found possible with saturated steam. For instance, in enameling ovens with which I am familiar, it is desirable that an even temperature of about 500° F. to 600° F. be maintained throughout the kiln.

To do this with saturated steam would require a prohibitive pressure. Electric heating is now practised, but it is too expensive, both in first cost and also in cost of current for operation. Furthermore, with electric heating it is necessary to run the heating elements red hot in order to get any efficiency from them and this increases the fire hazard and danger of damage to the product.

It has even been proposed to use a liquid of higher boiling point than water, such as mercury, or oil with a high flash point, for forming the fluid heat transmitting medium. Mercury, however, is too expensive and is too dangerous to use. The oil is not satisfactory because of the deterioration in use and danger from leakage and also from the low efficiency of a liquid for heat transfer purposes.

I provide a system in which superheated steam is used, as a heat transfer medium and I obviate the difficulties heretofore encountered, due to condensation, by mechanically moving the steam or other medium through a closed circuit. The superheated steam is moved with great speed through the radiator or heating coil. The circuit includes a superheater for adding heat to the steam, an oven, kiln, or other heat absorbing means and a pump, compressor, or the like used as a circulator for moving the steam from the oven coils back to the boiler or superheater. The circulator is placed at a point where it will assist in the rapid movement of the steam through the oven coil and it prevents any condensation from taking place in the oven coil. A boiler or other source of steam or vapor is employed for making up the losses incurred in running and for supplying the initial body of fluid medium. The temperature of the steam normally does not drop below the saturation point in the oven coil and preferably throughout the circuit, and as a consequence, the circulator may be operated at high speeds and the difficulties heretofore caused by condensation do not appear. Furthermore, the efficiency of an installation of this character is high because of the speed with which the fluid is moved through the circuit and because of the relatively greater specific heat of steam as compared with air, gas or other mediums.

A basic feature of the invention is the use of superheated steam in the radiating coils and the rapid movement of the steam through the said coils whether the steam be returned to the boiler or superheater in that condition or otherwise.

Along with the main idea of circulating an elastic fluid medium held always above the condensation temperature, I provide means for exercising suitable control over the operation of the system. I also provide improved heating means and auxiliary apparatus.

In order to acquaint those skilled in the art with a specific manner of making and practising my invention, I shall now describe in connection with the accompanying drawings a specific embodiment of the invention. In the drawings:

Figure 1 is a diagrammatic layout of a system embodying my invention;

Fig. 1A is an elementary diagram showing the theory of operation;

Fig. 2 is a similar diagram of a modified form of apparatus and arrangement of the circuit;

Fig. 3 is a similar diagram of a further modified form of apparatus and arrangement of the circuit.

In Fig. 1A I have indicated diagrammatically the preferred manner of operating a high temperature oven.

A superheater boiler B provides superheated steam at the proper temperature and pressure and this steam is discharged at high velocity through the pipe or coil C which is

the heating element for the oven A. A pump D which may be of the rotary or the reciprocating type aids in maintaining a high velocity in the said pipe C and serves as a separating device between the coil C and any region of condensation. After the steam passes the circulator D it is immaterial how it is treated so far as the operation of the coil C is concerned. Its pressure may be raised or lowered in the cooler E. It may be employed at E as a preheater for heating air supplied to the oven A or in fact its heat may be employed in any manner which will assist in the convenient or economical operation of the plant. The steam either as steam or water is returned by the return pipe F to the superheater boiler A. A trap at G is provided for removing any condensate which forms when the coil C is first started up.

Assume that the oven A is to be maintained at a temperature T. If now steam at a temperature $T+h$ is admitted at the intake end of the pipe C where h is the head in degrees required for supplying the necessary heat to the oven at the operating pressure, it will be necessary to move the steam through the coil so fast that it will not lose more than h degrees of temperature by contact with the sides of the cooling tube while passing therethrough. Thus the drop in temperature of the steam is controlled by the speed of movement of the steam and it is possible to hold the temperature of the coil very closely to a predetermined figure with only a small thermal head, and consequently an even distribution of heat.

In Fig. 1, I have indicated in the dotted inclosure 1 an enameling oven or the like in which it is desired to establish heat at a final temperature of say 500° F. to 600° F. This oven contains heat radiating coils shown for example by the three coils 2, 3 and 4, the coils being disposed in any suitable manner preferably but not necessarily coiled. These coils are connected to a manifold 5 at the hot end of the kiln or oven to have free communication with the steam inlet pipe 6 which connects the radiating coils or pipes 2, 3 and 4 with the delivery end of the superheater coil 7. The discharge or cold ends of the coils 2, 3 and 4 are connected through suitable temperature control shut-off valves 8, 9 and 10 to a common discharge manifold 11, which leads by way of pipe 12 to a circulator 13, which circulator returns the steam or other medium to the inlet end of the superheater coils 7 by way of the pipe 14. There is thus defined a closed circuit including the superheater coil 7, the radiating coils 2, 3 and 4, and the circulator 13.

The temperature control shut-off valves 8, 9 and 10 are controlled by the temperature at the cold end of the kiln, the kiln in this case being usually of a continuous kind in which the articles to be baked are fed in continuously at the cold end and discharged at the same rate at the hot end. These valves are controlled to shut off the flow of the heat transferring medium whenever the cold end of the kiln or the steam in that portion of the coils exceed a certain predetermined temperature.

The superheating coil 7 may be of any preferred character, as will be described more in detail later. The superheater is provided with a suitable burner 8′, in this case illustrated as a gas burner, although it is to be understood that any controllable source of heat may be employed. The gas burner 8′ is provided with a regulating valve 16 which controls the amount of fuel burned at the burner 15. The rate of heat delivery to the superheater coil 7 is controlled in accordance with the temperature of the heat transferring medium as it passes into the hot end of the kiln 1. For this purpose, I have provided a temperature sensitive element 17 for regulating the fuel control valve 16.

The circulator, in this case a pump of the rotary or centrifugal type, is driven by a motor 18, the operation of which is governed by a pressure sensitive element 19 connected to the pipe 12 between the circulator and the shut-off valves 8, 9 and 10.

To provide an initial supply of steam and also to make up such losses as are incident to operation, I provide a suitable source of steam supply which is in this case indicated merely by the pipe 20, but which may consist of a suitable boiler or vapor generating device of any suitable character which is connected to the lower end of the superheated coil 7 through a suitable pressure control valve 21, this valve being governed by a sensitive element 22 which is subject to the pressure prevailing on the discharge end of the superheater coil 7. If the steam is delivered from the superheater 7 at insufficient pressure, even though the temperature of the same is correct, it is obvious that more vapor should be injected into the system. A suitable pressure controlled relief valve 23 may be employed for discharging any excessive pressure.

The temperature control valve 17, instead of being subjected merely to the temperature of the steam delivered, may be subjected to the temperature of the hot end of the kiln if so desired, although I prefer to make this element strictly responsive to the temperature of the steam on the delivery side of the superheater 7.

The operation of the system shown in Fig. 1 is as follows:

A suitable supply of vapor is injected into the system to fill the system at the required pressure and temperature. Since the temperature control valve 17 opens the valve 16 wide when the temperature is low, the burner 15 will immediately heat up the

steam in the coil 7. At the same time, the cold end of the kiln being, at starting, below the maximum temperature will open the shut-off valves 8, 9 and 10 closing the circuit for the motor 18 at the switch 25 causing the circulator 13 to draw the steam from the manifold 11 and coils 2, 3 and 4 and discharge the same into the injection end of the coil 7.

The steam is therefore circulated through the closed circuit and the temperature of the kiln 1 will rise to the proper value. One distinctive feature of this invention is the continuous circulation of the medium, in this case superheated steam, at a temperature above the condensation point. When the system is first started steam from the main boilers of the power plant is introduced through the connection 20 into the superheater coil 7 and from thence with whatever additional heat the superheater may add is discharged into the heating coils of the oven 1 and since the oven coils may be started cold, the condensate is trapped at the trap 26 from which it may be withdrawn and returned to the main power plant or othewise disposed of. The circulator 13 at this time is not operated because of the condensation of the steam during the initial stage of heating up. As soon as the temperature of the oven is brought up to a point where steam above the saturation point is delivered from the cold end of the oven, the circulator is permitted to operate and the valve 21 closes off the further introduction of steam and the system begins to operate in the normal manner.

In order to obtain a satisfactory temperature of between 500 and 600 degrees F. in the oven 1, I supply steam at from 100 to 150 pounds pressure in the closed system delivering the steam from the superheater 7 at a temperature of approximately 750 degrees F. and discharge the steam from the cold end of the oven at a temperature of approximately 400 degrees, which is slightly above the saturation temperature. The saturation point for steam at 150 pounds pressure is approximately 368 degrees F. and the steam is kept sufficiently above the saturation point that it is moved throughout the system in the state of vapor without permitting condensation. This permits of very rapid circulation through the system and permits a small circulator or pump 13 to be employed.

The steam coming from the oven coils 2—3—4 may be hotter than desired for return to the boiler or superheater through the pump or circulator. I have provided a chamber 97 for further abstracting heat from the steam which is discharged from the heating coils. The steam is discharged through the coil 96 which heats the air in the chamber 97. The heated air thus obtained may be employed for preliminary warming as for instance in the ante chamber or vestibule 98 which communicates with the oven.

In a similar manner the superheater may be provided with economizing means 100 for taking up heat which would otherwise be wasted in the flue gases. These two economizing means may be combined as I have indicated by taking air into the heating chamber 97 through the controllable inlet 99 then moving the same through pipe 102 to the heater or stove 100 and then discharging the air into the vestibule or warming chamber 98. The air is circulated by means of the blower or fan 101. A portion of the warm air from the vestibule 98 discharges into the oven and the addition of more air is provided by the regulatable intake 99. A connection 103 is provided whereby the air in the vestibule 98 is circulated through the stove 100 to maintain a predetermined temperature of lower degree than that of the oven 1, in the vestibule 98. It is to be understood that the vestibule or warming chamber forms a transitional stage between the outside temperature and the oven temperature and there is communication between the outside of the oven and the inside of the same through this vestibule. A similar vestibule or cooling chamber may be maintained upon the discharge side of the kiln or oven 1.

The operation is not necessarily dependent upon the use of steam in this case since a gaseous medium under pressure might be employed but a much lower efficiency would be secured since the specific heat of water vapor is practically double that of any available gas of a fixed character. Consequently, other considerations being the same, a much smaller radiating surface in the oven may be provided where steam is employed.

In Fig. 2 I have shown a system similar to that of Fig. 1 employing a boiler 27 in the circuit, this boiler being itself the source of steam for charging and maintaining the system in filled condition. The boiler 27 is connected in the return pipe 14 and it in turn connects by way of the pipe 29 with the injection side of the superheater 7. The boiler 27 is provided with a furnace 28 employing a gas burner controlled by a fuel control valve 21′ governed by a pressure controlled element 22′. This corresponds to the pressure control valve 21—22 as shown in Fig. 1 for governing the injection of additional steam into the system when the pressure in the system drops below a predetermined minimum.

In this system I have further illustrated the use of a reciprocating pump or compressor as a circulator as shown at 13′. This circulator is capable of handling either a vapor or a liquid at a relatively high speed and therefore, during the warming up period the

condensate is returned by the circulator to the boiler where the condensate is again vaporized when necessary to supply the heat transferring medium. In operation, the furnace 28 of the boiler 27 generates just sufficient heat to prevent the condensation of steam at this point unless through leakage or other causes the pressure drops in the system, whereupon, the furnace is activated to drive off vapor by a greater heat input and thereby restore the pressure in the system. The thermally controlled valve 16—17 always maintains the vapor at a certain temperature. Otherwise the operation of the system is identical with that described in connection with Fig. 1. It will be understood that in the operation of the system shown in Figs. 1 and 2 the circulator may be constantly driven if desired.

In the system shown in Fig. 3 the circulator is driven by a steam cylinder operated by a part of the steam discharged from the cold end of the oven. In this case one of the coils, for instance, coil 2 is not controlled by a temperature controlled shut-off valve, but is left constantly open so that a certain amount of steam may be discharged through this coil to the return pipe 12 which return pipe communicates with the compressor cylinder 35 of the circulator 13″ by way of a pipe 31, and communicates with the steam cylinder 34 by way of the pipe 32, the exhaust steam from the cylinder 34 being discharged by way of the pipe 36 through the condenser 33. The return pipe 12 also communicates by way of the pipe 37 with the steam pump 38 which pump returns the condensate from the condenser 33 by way of the pipe 39 to the boiler 27′. The exhaust steam from the steam pump 38 is also discharged by way of the pipe 40 to the condenser 33. The remainder of the circulating body of fluid which is to be circulated is returned to the boiler 27′ and from thence to the superheater 7 by way of the pipe 14. The top of the boiler 27′ communicates with the superheater 7 by way of the pipe 29′ in the same manner as indicated in Fig. 2. In this case, however, the boiler is superposed over the superheater 7 so that the waste heat from the superheater tends to keep the boiler 27′ hot. The boiler 27′ has its own furnace 28 which is connected by way of a flue 41 and which furnace is controlled by the pressure controlled valve 21′—22′. The operation of the superheater and boiler with the exception of the fact that the waste heat of the superheater is employed in the boiler is identical with that indicated in the diagram of Fig. 2.

The open connection, as for instance, the coil 2 from the superheater to the steam driven circulator 13″ permits this circulator to be constantly driven for maintaining a constant circulation throughout the closed system. A part of the energy of the steam is required to drive this circulator and so much of the steam as is imployed in driving this circulator is condensed in the condenser 33 and this condensate is returned to the boiler 27′. A certain amount of the steam is also required to drive the feed pump 38 for returning the condensate to the boiler. In other respects the operation of the system is the same as described in connection with the diagrams in Figs. 1 and 2.

It is apparent that the system may be charged with a certain amount of water for the beginning of operations, which amount of water will be sufficient to generate the required body of vapor at the desired pressure, and to compensate for even such leakage as may occur during an extended period of operation.

I am aware that vapor heating systems have been employed prior to my invention, but I wish to call attention to the fact that heretofore no one to my knowledge has been able to secure a relatively high temperature with low pressure in a manner sufficiently satisfactory to provide heat for enameling ovens and the like. The reason for this is that if the steam is allowed to condense in the heating coils the pressures which must be carried for a degree of heat comparable to enameling temperatures is commercially impracticable. If superheated steam is employed to heat the oven and the steam is permitted to condense in the coils, the oven will not be evenly heated due to the difference in temperature between the superheated steam and the saturated steam.

I claim:

1. A heating system comprising a closed vapor circuit, said circuit including a heater for superheating the vapor to a temperature above the temperature corresponding to the saturated vapor at the pressure prevailing in the system, a coil for giving off heat from the vapor and reducing the temperature of the vapor to a point above the corresponding temperature of saturated vapor at the same pressure and a circulator for moving the vapor from the coil back to the superheater while the vapor is still uncondensed.

2. The method of heating which comprises heating a vapor to a temperature in excess of the temperature of saturation at the operating pressure to superheat the same, passing the superheated vapor into a radiator to give off some of the superheat and moving the vapor back to a heater before the temperature of the vapor has dropped to the saturation point.

3. In a heating system, a heater, a radiator connected to the heater in a closed circuit, a circulator for circulating an elastic fluid through said closed circuit, a heating device and means controlled by the tem-

perature of the elastic medium after it leaves the heater for governing the heating device.

4. In a heating system, a heater, a radiator connected to the heater in a closed circuit, a circulator for circulating an elastic fluid through said closed circuit, a heating device and means controlled by the temperature of the elastic medium after it leaves the heater for governing the heating device, and means controlled by the temperature of the cold end of the radiator for governing the circulator.

5. In a heating system, a heater, a radiator connected to the heater in a closed circuit, a circulator for circulating an elastic fluid medium through said closed circuit, a heat supplying device and means controlled by the temperature of the elastic medium after it leaves the heater for governing the heat supplying device, and means controlled by the pressure of the elastic fluid for injecting additional vapor into the closed circuit.

6. In a heating system, a heater, a radiator connected to the heater in a closed circuit, a circulator for circulating an elastic fluid through said closed circuit, and a source of vapor for maintaining substantially a predetermined pressure of vapor in the system.

7. In a heating system, a superheater, a radiator connected to the superheater in a closed circuit, a circulator for circulating an elastic fluid through said closed circuit, a source of elastic fluid for maintaining substantially a predetermined pressure of fluid in the system, a heat supplying device for the superheater and means controlled by the temperature of the elastic medium after it leaves the superheater for governing the heat supplying device.

8. In a system of the character described a closed vapor circuit comprising a superheater, a radiator, and a vapor circulator, and a boiler communicating with the closed circuit on the incoming end of the superheater for supplying additional vapor when the pressure of the system drops below a predetermined point.

9. The method of operating a steam heating plant which comprises circulating a superheated vapor through a heat radiating pipe and removing superheat only from the vapor passing through said pipe.

10. In a system of the character described, a superheater, a radiator connected thereto, and a circulator connected between the other end of the radiator and the superheater for returning the vapor from the radiator to the superheater while said vapor is still in superheated condition, and temperature controlled means subject to the temperature maintained by the radiator for governing the rate of flow of vapor through the system.

11. The method of controlling temperature which comprises, circulating a heating medium to maintain the temperature, and controlling the rate of flow as a function of the temperature of the heating medium after it delivers its heat.

12. The method of heating which comprises circulating a heating medium in a closed circuit without change of state, heating it to a predetermined temperature at one point and controlling the delivery of heat from said point by varying the rate of flow of the medium.

13. The method of heating which comprises, circulating a heating medium in a closed circuit, heating it to a predetermined temperature at one point, and controlling the delivery of heat from said point by varying the rate of flow of the medium.

14. The method of heating which comprises maintaining a mass of gas in a closed circuit at substantially constant pressure, and varying the temperature by the addition and removal of heat at different points in the circuit, maintaining a minimum temperature at any point in the entire circuit at all times above the liquefaction temperature.

15. In combination, a closed circuit, a source of vapor supply communicating with said circuit, and a means for circulating vapor through said circuit at temperatures varying at different parts of the circuit, the lowest temperature being higher than the liquefaction temperature.

16. In combination, a closed circuit, a liquid filled vapor generator communicating with said circuit, but not part thereof, a heater, a radiator and a circulator in said circuit, and control means for maintaining the temperature throughout the circuit well above the condensation point.

17. In combination, a closed circuit, a liquid filled vapor generator communicating with said circuit but not part thereof, a heater, a radiator, and a circulator in said circuit, control means for maintaining the temperature throughout the circuit well above the condensation point, and separating means interpolated between the radiator and the circulator for separating out condensate when the system is being started cold.

In witness whereof, I hereunto subscribe my name this 17th day of December, 1920.

LEWIS M. ELLIS.