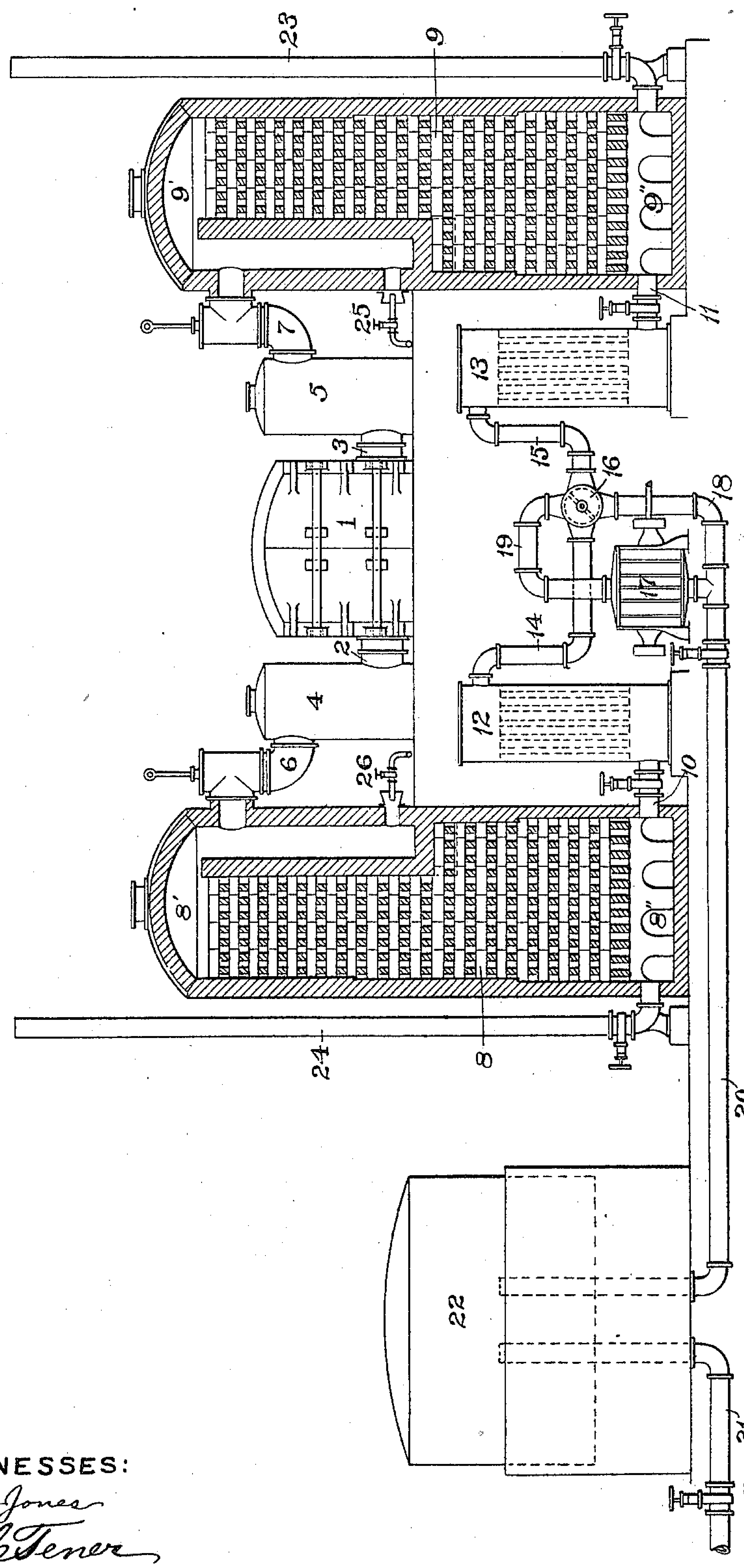
No. 680,781. Patented Aug. 20, 1901.

W. J. KNOX.

METHOD OF MAINTAINING SPECIFIC ATMOSPHERES AND TEMPERATURES.

(Application filed Apr. 25, 1900.)

(No Model.)



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METHOD OF MAINTAINING SPECIFIC ATMOSPHERES AND TEMPERATURES.

SPECIFICATION forming part of Letters Patent No. 680,781, dated August 20, 1901.

Application filed April 25, 1900. Serial No. 14,296. (No specimens.)

To all whom it may concern:

Be it known that I, WILLIAM JOHN KNOX, a citizen of the United States, and a resident of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented certain new and useful Improvements in Methods of Maintaining Specific Atmospheres and Temperatures, of which the following is a specification.

My invention relates to a process for maintaining any desired atmosphere within a vessel and at the same time also maintaining any desired temperature therein. The process may be practiced by the circulation of the desired atmosphere through an apparatus consisting of a reacting vessel, connections from it to the hot ends of two regenerative chambers, a connection between the cold ends of these regenerative chambers and a fan or equivalent device interposed in this latter connection for causing the circulation of said atmosphere in either direction through the closed circuit thus formed. Vessels containing coke or an easily-oxidizable metal, such as copper, may be interposed between the hot ends of the regenerators and the reacting vessel for maintaining a constant reducing atmosphere within the vessel, and economizers or vertical boilers may be placed between the cold ends of the regenerators and the fan for utilizing the heat passing from said cold ends and for assisting to maintain thereat a constant low temperature.

The processes involved in the application of this apparatus comprehend the treatment of materials for the purpose of altering their physical or physico-chemical characteristics—such, for instance, as the malleableization of iron, the annealing of iron, as ordinarily understood, acieration or hardening, especially as applied to armor-plate, desiccation, as of fruits or woods, and all operations in which it is desired to maintain a certain specific atmosphere and to control temperatures. The process is also applicable for subjecting materials to the action of heat when they are inclosed in a box or retort through which heat can be conducted to them by continuously conveying heat to the chamber containing the box or retort by circulating therethrough a heated reducing-atmosphere, such as will not injuriously affect the material of the retort.

The construction of the apparatus and its operation will now be described in connection with the accompanying drawing, which diagrammatically illustrates the invention.

In the drawing, 1 is a brick-lined vessel or chamber in which the material to be treated is to be placed. This chamber is connected by pipes 2 and 3 to vessels 4 and 5, in which coke or other reducing material will be placed when necessary for the operation for the purpose of breaking up any carbonic anhydrid or aqueous vapor that may be present in the circulating atmospheric heat-carrier before it enters the chamber 1. Pipes 6 and 7 connect vessels 4 and 5 with respective regenerative chambers 8 and 9 at their top ends. In future reference herein to these ends they will be designated "hot ends" 8′ and 9′, respectively. These regenerative chambers may be similar in construction to the well-known blast-furnace type of air heating-stove filled with refractory checker-brickwork for storing heat communicated to them. Pipes 10 and 11 connect the bottom ends of stoves 8 and 9 with vertical boilers or economizers 12 and 13. In future reference herein to the bottom ends of these stoves they will be designated as "cold ends" 8″ and 9″, respectively. The boilers 12 and 13 are connected by pipes 14 and 15 to opposite sides of a reversing deflecting-valve 16, the purpose of which latter is to deflect the circulating atmosphere in either direction through the circuit as may be desired. The deflecting-valve 16 is also connected by pipes 18 and 19, respectively, to the inlet and outlet of a blower 17, which is to produce the circulation of the atmosphere contained in the apparatus. A pipe 20 leads from the inlet of blower 17 to a gas-holder 22, which latter receives its supply of the required gaseous atmosphere through a pipe 21 from any convenient source.

In the foregoing description of apparatus all mention of valves has been omitted, as their introduction at various points in the apparatus and their operation will be readily understood. For instance, suitable valves may be interposed in the pipes leading from the regenerative chambers for the purpose of cutting out these regenerative chambers from the circuit, so that they may be restored to the proper heat condition by burning gas therein, such gas being admitted through suitable injectors 25 and 26, for instance, the proper amount of air for supporting combustion being simultaneously admitted at the injectors. Valves may be introduced in the chimneys 23 and 24, through which the products of combustion escape to the air when the chambers are being heated. Valves may also be provided at the burners for the purpose of closing the regenerative chambers from the atmosphere when they are subsequently cut into the circuit again. A valve may also be introduced into each of the pipes 20 and 21 for controlling the passage of gas through them.

The operation of the apparatus is as follows: Chamber 1 having been charged with the material to be treated, regenerative chambers 8 and 9 having been properly heated up by burning gas, and air admitted at the injectors 25 and 26, so that the temperature at the hot ends is sufficient to impart to the gases passing through them toward the reacting-chamber 1 such a temperature as is suitable for the operation being carried out and so that the cold ends of the regenerative chambers are at a minimum temperature, and vessels 4 and 5 having been charged with coke or other suitable reducing material, valves are so adjusted that gas will flow in from the holder 22 through the pipe 20, thus putting the system under holder-pressure, and the deflecting-valve 16 is so adjusted that circulation will take place in one direction only. It will be readily seen that on setting the fan in motion a circulation of the gaseous contents will take place in one direction—for example, from the blower through economizer 12 into cold end of regenerative chamber 8, out of hot end of same, into and through reducing-chamber 4, reacting-chamber 1, reducing-chamber 5 into the hot end of regenerative chamber 9, and out of its cold end into the economizer 13, and through the deflecting-valve 16 and fan 17 to the economizer 12, continuously. The circulating gas thus passing into the cold end of the regenerative chamber 8 will continuously increase in temperature by the heat liberated to it by the successively-hotter brick as it passes upward through the chamber, finally leaving the regenerative chamber 8 at its maximum temperature. As the products of combustion which were in the stove at the beginning of circulation pass through the reducing-chamber 4 their content of carbonic anhydrid is converted by the coke or other suitable material in the reducing-chamber 4 into carbon monoxid and any accompanying aqueous vapor is converted into hydrogen and carbon monoxid. This reducing-atmosphere at the required temperature then passes into the reacting-chamber 1, where the materials to be acted upon will be raised to the requisite temperature and maintained at this temperature during the period of treatment by the heat liberated to them by contact with this hot gaseous atmosphere. After the material in chamber 1 has attained its maximum temperature no more heat will be abstracted from the circulating gas excepting a small amount required to supply the loss due to radiation from the walls. The hot circulating atmosphere passing from the reacting-chamber 1 passes through the reducing-chamber 5, in which material—such as coke, for example—will attain the temperature of the circulating gas and the gaseous atmosphere will pass thence into the hot end of the regenerative chamber 9. It will be seen that when the vessels 4, 1, and 5 and their contents have attained the temperature of the circulating gas there will be a very small drop in temperature in such gas passing from the hot end 8′ of the regenerative chamber 8 to the hot end 9′ of the regenerative chamber 9. The circulating atmosphere in passing downward through the regenerative chamber 9 to the cold end will, as it passes successively over the brick, which are continuously cooler in this direction, be continuously cooled and will pass out of the cold end 9″ at a minimum temperature. During the period of circulation in one direction the cold end 9″ of the regenerative chamber 9 will gradually rise in temperature by the absorption of heat carried downward by the circulating gas. In passing from the relatively cold end 9″ to and through the economizers 13 and 12 this increment of heat will be largely abstracted from the circulating gaseous medium. Passing from the economizer 12 at a low temperature it will cool the relatively cold end 8″ of the regenerative chamber 8, thus continually lowering the temperature of this cold end throughout the period of such circulation in one direction. The amount of heat that will be added to the water in the economizers 12 and 13 will depend largely upon the length of time of circulation in one direction, as it is evident that the gaseous heat-carrier will increase in temperature continuously, carrying more heat per mass of circulating medium per time unit at the end of such circulation in one direction than at the beginning. On reversing the deflecting-valve 16 and causing a circulation to take place in the opposite direction—namely, upward through the regenerative chamber 9 and downward through the regenerative chamber 8—the gas passing out of the cold end of regenerative chamber 8 to the economizer 12 will not increase in temperature to any extent until the brick in the cold end of the regenerative chamber 8 have been heated up to the temperature of the water in the economizers 12 and 13. After such temperature has been attained the gaseous heat-carrier will gradually rise in temperature until such time as another reversal takes place. The gaseous heat-carrier passing through the economizers 12 and 13 into the cold end of the regenerative chamber 9 will absorb heat from the brick in this relatively cold end and cool them to its minimum temperature. It will then be heated in passing upward through the hotter layers and pass from the hot end 9' through the reducing-chamber 5 and thence through the reacting-chamber 1 and reducing-chamber 4 at a practically constant maximum temperature. It will be seen that in apparatus of this description short periods of reversal of the circulating gas will maintain an evenly-graduated distribution of heat in the regenerative chambers and prevent excessive loss of heat due to rise in temperature of the gas passing between the cold ends. The regenerative chamber through which the gas passes upward on its way to the reacting-chamber will act as a heat-giver. Very little heat will be abstracted from the hot circulating gas in the vessels between the hot ends of the regenerative chambers after the contents of the former have attained the maximum temperature, and hence the major portion of the heat carried by the gaseous heat-carrier from the heating-stove will be carried into the opposite or heat-absorbing stove, where it will be stored up and on subsequent reversal will be carried by the fluid heat-carrier back again through the vessels situated between the hot ends of the regenerative chambers and restored to the original stove, which, having been reduced in heat energy, has a capacity for absorbing practically the same amount of heat that it previously gave up. There is thus a flow of heat energy alternately through the reacting-chamber from one regenerative chamber to the other, these regenerative chambers successively acting at one time as heat-giving devices and then as heat-absorbing devices. It may be well to point out that equal masses of fluid heat-carrier passing alternately through the system, first in one direction and then in a reverse direction through stoves heated to the same maximum temperature, will return to the heat-giving stove, when it is subsequently acting as a heat-absorbing stove, practically the same amount of heat energy that was carried from such stove in the previous circulation in the opposite direction.

In the operation under consideration the products of combustion were converted into reducing-gases containing nitrogen as the only diluent by means of the reducing material in vessels 4 and 5, and the system was in connection with the gaseous contents of the holder 22. The gas-holder in this case would be filled with ordinary producer-gas, and being in open connection with the circuit would maintain the system at all times under pressure equal to that of the gas in the holder. If it is desired to use other gases, such as hydrogen or water gas, the products of combustion remaining in the system when the apparatus is closed in from the atmosphere may previously to the closing in of the system be removed by the introduction of steam and the steam replaced as it condenses by gas from the holder 22 and the steam then removed from the system by condensation in the economizers or by causing its oxygen to unite with an active reagent, such as metallic copper, in the reducing-chambers 4 and 5, thus liberating hydrogen.

As many reacting-chambers as may be desired may be used with suitable valve connections, so that when the operation is completed on one charge of material the chamber containing it may be cut out of the system and another chamber or chambers freshly charged may be cut in. The material in the chamber that has been cut out may then be allowed to cool down slowly—as, for example, in annealing operations, where such slow cooling is necessary. Likewise, more than two stoves may be used, with suitable valve connections, so that the stoves may be cut out for the purpose of heating up and other heated stoves cut in, so that the operation may be carried on continuously. When the system has lost so much heat by radiation and by reason of the heat absorbed by the materials being acted upon, the regenerative chambers are again heated up in the manner already described. During the circulation of the gases for the purpose of imparting heat to the materials to be acted upon there may be some waste of gases, due to leakages, &c.; but, as already explained, this waste will be replaced by gas supplied from the gas-holder, which is in open connection with the system. The rate of circulation effected by the blower 17 is adjusted by means of the valve 16, which may be placed in any desired intermediate position between the extreme positions of reversal, and it is evident that the speed of circulation may thus be regulated from a maximum in one direction through all the intermediate stages to a maximum in the opposite direction. An increase in the speed of circulation of the gas causes the volume of gas passing per unit of time to increase, thus diminishing the time that it is exposed to the heating-surfaces, and it acquires less temperature, but may carry as much or even more heat energy per unit of time, and vice versa.

The above-described apparatus in operation might be termed a "reversible regenerative heat-cycle," in which one portion—namely, that comprised by the pipes and vessels between the hot ends of the stoves—is at a practically constant maximum working temperature, while the opposite side of the cycle—namely, that between the cold ends of the stoves—is maintained at a practically constant minimum temperature. The economy with which the heat is furnished to the system when it is stored in the stoves by burning gas or other fuel at one part, which I have designated the "hot end," depends entirely upon the temperature of the resulting products of combustion when they leave the other portion of the apparatus, which has been designated the "cold end," and pass by way of the chimney to the atmosphere. The distribution of heat in the stoves after they have been heated up in this manner may be said to taper in the form of an inverted wedge or cone, the large end of the wedge or cone representing the high temperature and large amount of heat energy contained in the layers of brick immediately adjacent to the flame and the small end of the wedge or cone that portion of the stove nearest the chimney or relatively low temperature and containing but a small portion of heat energy. In circulating the fluid heat-carrier passing upward through the stove cuts off and carries out of the stove heat energy from the sides or slope of the imaginary wedge or cone, successively reducing it in thickness at every point, and, likewise, as the fluid heat-carrier passes into the hot end of the other stove it is cooled down, and the heat energy which it has carried from the first stove will be added to the surface of the imaginary cone of the second, increasing its thickness continuously as it passes down toward its point. It will be readily seen that in removing heat from the imaginary heat-cone its apex will recede upward toward the base at the hot end and the corresponding cone in the other stove will lengthen, causing its point to protrude from the cold end of the stove and deposit heat in the vertical boilers. If the reversal of the direction of circulation is made at sufficiently short intervals, as determined by the temperatures at the cold ends, the distribution of heat in the stoves will remain practically constant and the amount of heat passing into the economizers will be relatively small. If the stove is so constructed that in heating up the maximum required temperature can be obtained in the hot end without largely increasing the temperature at the cold end, there will be very little transference of heat from the cold ends of the stoves to the economizers in the subsequent operation of the heat-cycle.

If ordinary annealing is the operation to be performed, a neutral or reducing atmosphere may be employed. For the purpose of malleableizing a carbon-monoxid atmosphere would be employed. Likewise in acieration or case-hardening of steel an atmosphere of carbon monoxid under pressure would be maintained around the materials under treatment. Its action would be as follows: The carbon-monoxid gas would penetrate the surface of the plate by diffusion and at the proper temperature cause what is known as "carbon deposition" to take place, successively converting a portion of the iron to a greater or less depth, depending upon the time employed, to carbid of iron. The material on removal may be subjected to a sudden cooling in oil, lead, or any other annealing bath.

It will be unnecessary to mention all of the applications and methods of employing this process, as it will be readily seen that all that would be required in a given case would be to reproduce and maintain the conditions that are generally known to be necessary for causing a given action to take place, and with the means employed it is possible to establish and maintain such atmospheric and heat conditions.

I claim as my invention—

1. The hereinbefore-described method of maintaining a high temperature which consists in continuously circulating a gaseous fluid through a closed circuit, heating the gaseous fluid at a point in the circuit before it enters the region where the temperature is to be maintained, abstracting heat from the gaseous fluid after it passes from that region, storing up such heat in such position as to be returned to the gaseous fluid when the direction of circulation of the fluid is reversed, and periodically reversing the direction of the circulation of the gaseous fluid through the circuit, thereby returning the heat thus abstracted to the gaseous fluid.

2. The method of conveying heat to a heating-chamber which consists in passing a gaseous fluid through a heating-stove into the heating-chamber, thence into a cooling-stove and thence again into a heating-stove and continuing the process until the temperature of the heating-stove has fallen below a predetermined degree and the temperature of the cooling-stove has risen above a predetermined degree and then reversing the process, thereby conveying more or less of the heat stored in the former cooling-stove into the heating-chamber and back into the former heating-stove.

3. The hereinbefore-described process of regulating the transmission of heat by means of gaseous fluid from one chamber to another which consists in passing the gas into the cool end of one chamber and out at its hot end into the hot end of the second chamber and out at its cool end and thence back into the cool end of the first-named chamber and in increasing the speed circulation of the gas for diminishing the temperature of the circulating medium passing from the first chamber to the second and decreasing the speed of circulation for increasing the temperature in passing from the first to the second chamber.

Signed at Pittsburg, in the county of Allegheny and State of Pennsylvania, this 23d day of April, A. D. 1900.

WILLIAM JOHN KNOX.

Witnesses:
J. A. ADAMS,
CHAS. F. MILLER.