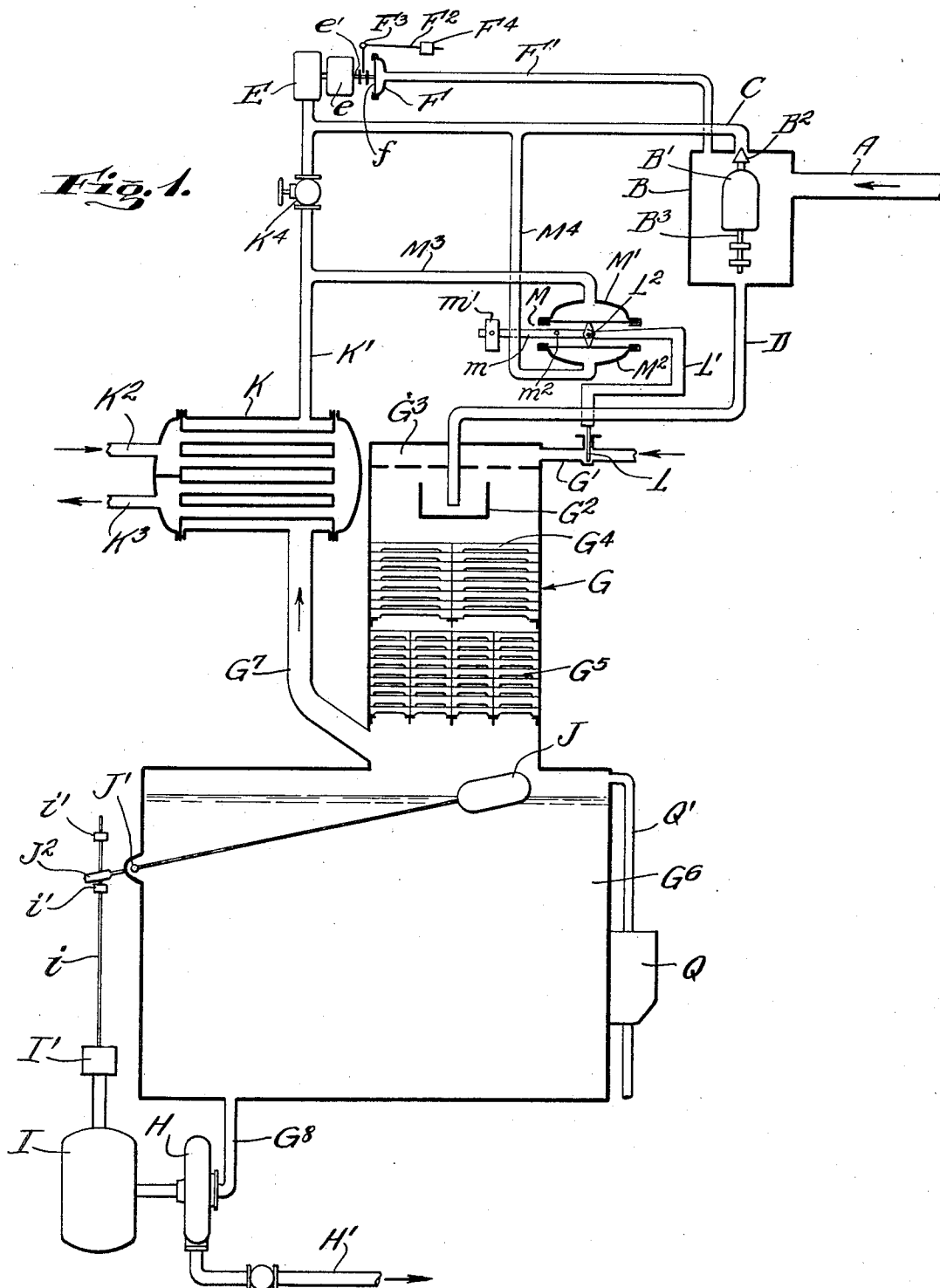


1,966,791

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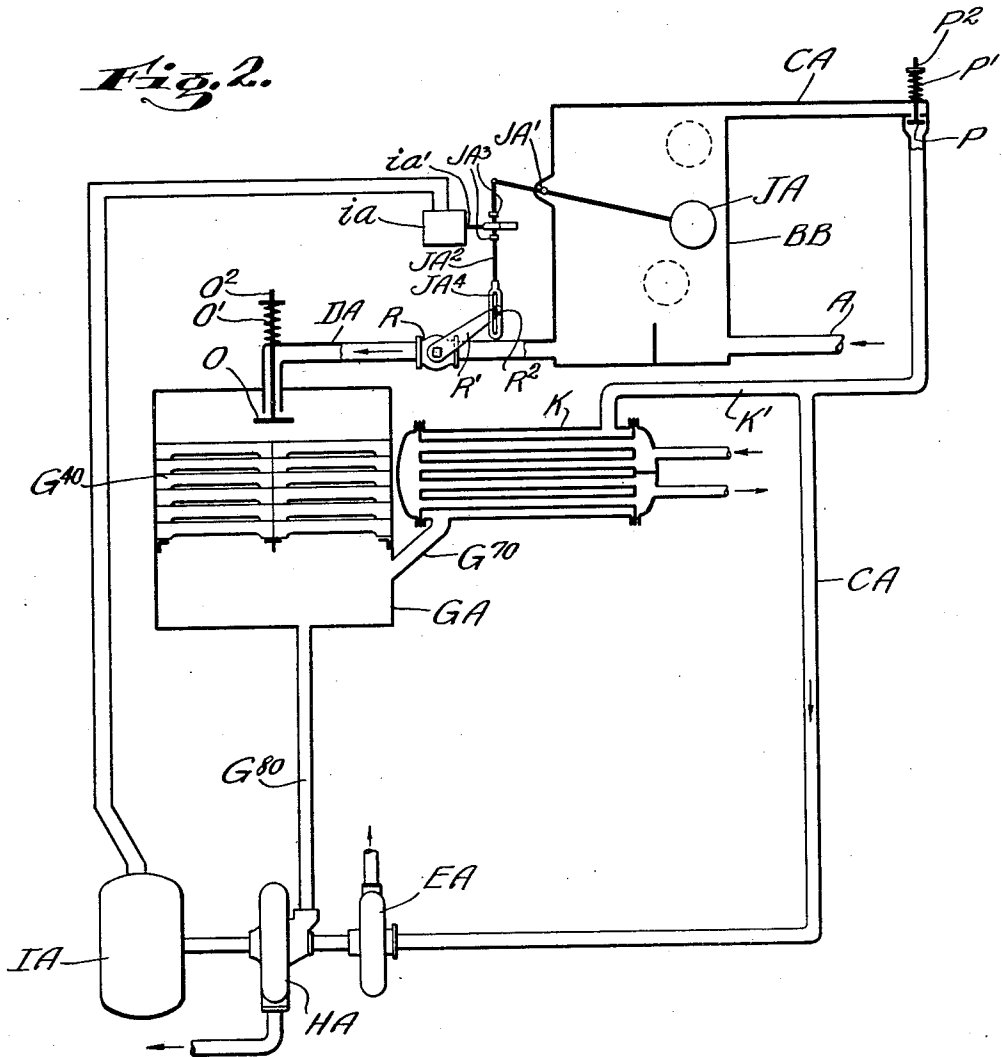
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METHOD OF AND APPARATUS FOR HANDLING HEATING SYSTEM RETURNS

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METHOD OF AND APPARATUS FOR HANDLING HEATING SYSTEM RETURNS

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The general object of our present invention is to provide an improved method of, and improved apparatus for, handling the so-called returns from vacuum steam heating systems and analogous liquid and gas mixtures. More specifically, the object of our invention is to provide a simple and effective method of and means for separating gases, both free and dissolved, from the return water or other liquid of a liquid and air mixture.

The returns from a vacuum or sub-atmospheric heating system comprise water, water vapor and gases, the latter being partly in admixture with the vapor and partly in solution in the water. The gases referred to are commonly referred to as "air" and will be so referred to hereinafter, as they consist wholly or largely of the gaseous constituents of ordinary atmospheric air, though not necessarily in the same proportions. Heretofore it has been customary to pass such returns through apparatus comprising one or more pumps or ejectors and an air and water separator to the end of building up the fluid pressure of the returns so that the free air may be discharged into the atmosphere and the water returned to the boiler or water heater of the heating system.

Such treatment eliminates the free air constituent of the returns but leaves the return water with a content of dissolved air which is a maximum for the water temperature and pressure conditions. Water so saturated with air in solution is highly corrosive, particularly at the temperatures at which it leaves the above described apparatus, and valves and piping and other apparatus through which it is passed are subjected to objectionable corrosion.

In accordance with the present invention, we not only separate the free air and liquid constituents of the returns and then subject the latter to an effective deaerating action, but we do this in a simple manner and with relatively simple apparatus. A particular object of our invention is to accomplish such separation and deaeration by means consisting of a single air pump, and a single water pump which may also serve as the boiler feed pump of the system.

Another object of our present invention is to so combine the apparatus for the initial separation of the water and free air, with the apparatus for the deaeration of the water that a single vacuum pump may be employed to discharge to the atmosphere both the free air initially separated from the water, and the air and water vapor separated from the water in the deaera-

tion of the latter. For the purposes of our combination it is essential in general that the vapor pressure in the deaerating apparatus should be different from that in the free air and water separating apparatus, and a further object of our invention is to provide simple and effective means for automatically maintaining the proper vapor pressures.

Of the drawings:

Fig. 1 is a diagrammatic representation of an apparatus embodying one form of the present invention; and

Fig. 2 is a diagrammatic representation of apparatus embodying another form of our invention.

In the drawings and referring first to the arrangement shown in Fig. 1, A represents the return line from a vacuum heating system through which water and free air are discharged into an air and water separator B. The latter is provided with an upper outlet C for air which runs to an air pump E, and is also provided with a bottom outlet D for water which leads to the deaerating apparatus G. A float B' in the chamber B, and having a guide stem B³ at its lower end, carries at its upper end a valve B². The latter closes the air outlet C on an undue rise in water level in the chamber B and thus prevents water from being drawn out of the chamber B into the inlet of the air pump E.

The normal or desired sub-atmospheric pressure in the receiver B is automatically maintained by a vacuum regulator F. The latter, as diagrammatically illustrated, comprises a pressure chamber one side of which is a flexible diaphragm f subjected at one side to the pressure of the atmosphere and at the other side to the pressure transmitted to the regulator F from the chamber B through the pipe F'. The diaphragm f is shown as connected to the controller element e' regulating the speed of the motor e driving an air pump E. The tendency of the diaphragm to move in one direction under the action of the atmospheric pressure is opposed not only by the pressure transmitted by the pipe F', but also by the action of the lever F² pivoted at F³ and carrying an adjustable weight F⁴. The control apparatus described speeds up or slows down the air pump E accordingly as the vacuum in the chamber B decreases or increases, respectively.

The deaerating apparatus G of Fig. 1 is intended to subject the water entering it through the separator outlet D to the deaerating and heating action of steam supplied from some suitable source through the steam supply connection

G', and may be of any one of various known forms suitable for so deaerating and heating water. In the form shown the deaerating apparatus comprises an upper steam chamber G³ to which the steam supply pipe G' delivers steam. The chamber G³ has a perforated bottom wall through which steam passes with proper distribution into the inter-tray space of trays over which the steam and the water treated flow through tortuous passages insuring intimate and prolonged contact between the steam and water. In the known form or deaerating heater shown there are upper and lower banks of trays G⁴ and G⁵, respectively, and the water entering the apparatus G through the separator outlet pipe D is properly distributed by a water distribution box G² into which the water is delivered by the pipe D, and from which the water overflows onto the upper bank of trays G⁴.

Below the water heating and deaerating apparatus proper is a water receiving and storage chamber G⁶. When the latter is enclosed in the same shell with the heating and deaerating trays, as in the preferred construction illustrated, the air liberated in the deaerating apparatus G is withdrawn from the latter through a pipe G⁷ opening to the apparatus G at a level below the lower trays G⁵ and above the water level in the storage chamber G⁶. In the arrangement shown water is withdrawn from the chamber G⁶ through a water outlet G⁸. The latter leads to the inlet of a pump H, which ordinarily serves as a boiler feed pump, though it might be employed to deliver the water which it withdraws from the chamber G⁶ to other apparatus in which the water is to be stored or utilized. As shown in Fig. 1, the motor I which drives the pump H and which may be an electric motor, steam turbine or other suitable motor, is provided with a controller I'. The latter is operated by a float J to start and stop the pump H accordingly as the water level in the chamber G⁶ rises to a normal upper level, or falls to a normal lower level. Said levels are fixed in the arrangement shown by the adjustments of upper and lower collars i' carried by the stem i of the controller I. As the water level in the chamber G⁶ rises to its upper normal level, an arm J² carried by the rock shaft J' carrying the float J engages the lower collar i' and starts the pump H into operation. When thereafter the water falls to its lower normal level the arm J² engages the upper collar i' and stops the pump H.

The air passing away from the deaerating apparatus through the outlet G⁷ will be admixed with a considerable amount of water vapor. The elimination of this vapor or the major portion thereof from the vapor air mixture issuing through the vent outlet G⁷ may advantageously be effected by means of a vent condenser K. The latter, as shown, is of the surface condenser type having an outlet K' for air and any uncondensed vapor mixed therewith, and having an inlet K² and an outlet K³ for any available condenser cooling water. The vent outlet K' from the vent condenser is connected to the inlet of the air inlet pump E which withdraws free air from the separating chamber B through the connection C.

The introduction of steam into the deaerating apparatus G, and the heating of the water in that apparatus by the steam necessarily implies and requires a vapor pressure in the deaerating apparatus G which is higher than the vapor pressure in the receiver B. For the maintenance of desirable and desirably uniform conditions, the

difference between the two vapor pressures is advantageously maintained approximately constant. To that end the apparatus shown in Fig. 1 includes a valve K⁴ or other device in the connection K' leading from the air vent of the surface condenser to the air pump E for creating a normally constant excess of pressure in the condenser over the pressure at the inlet to the pump E. In addition, the apparatus of Fig. 1 includes means for regulating the steam supply through the connection G' to the deaerating apparatus as required to maintain an approximately constant pressure drop past the throttling device K⁴.

The regulating means shown in Fig. 1 for thus regulating the pressure drop at the throttling device K⁴ comprises a throttling valve L in the steam supply conduit G', the valve L being connected to an operating member L' which is subjected to the action of a differential pressure device M. As diagrammatically shown in Fig. 1, the differential pressure device M comprises two pressure chambers M' and M² having opposed flexible diaphragm walls, each of which is subjected at its outer side to the pressure of the atmosphere. The head L² of the member L' forms a thrust block through which the fluid pressure acting on the inner side of each of said diaphragms is opposed by the fluid pressure acting on the inner side of the other diaphragm. To the pressure chamber M' the pressure at the inlet side of the throttling device K⁴ is transmitted by a pipe connection M³. The pressure at the outlet side of the throttling device K⁴ is transmitted to the chamber M² by means of a pipe M⁴ shown as connecting the latter to the pipe C which is in communication with the pipe K' between the throttling device K⁴ and the inlet of the pump E.

As shown, the valve operating member L is yoke shaped, the head L² being above and in vertical alignment with the valve L and the latter exerts an increased or decreased steam throttling effect as it falls and rises, respectively. The gravitational action due to the weight of the parts L, L' and L² is suitably overbalanced by a counterbalancing lever m fulcrumed at m² and pivotally connected to the head L² and carrying an adjustable counterweight m'. With the described arrangement, the differential pressure device will be in equilibrium only when the pressure transmitted to the chamber M' exceeds the pressure transmitted to the chamber M² by an amount which corresponds to the resultant of the lifting effect on the valve L due to the action of the lever m, and the opposing action due to the weight of parts L, L' and L². This resultant, which may be varied by adjustment of the counterweight m' on the lever m, determines the normal pressure drop past the throttling device K⁴. When that pressure drop diminishes below its normal value, the counterweight m' raises the valve member L' and valve L, thereby increasing the steam flow into and the vapor pressure in the deaerating apparatus and thus restoring said pressure drop to its normal value. Conversely, when said pressure drop rises above its normal value, the valve L is depressed and the steam supply to, and the vapor pressure in the deaerating apparatus is reduced until the said pressure drop is restored to its normal value.

Since the fluid pressure in the deaerator G is higher than in the separating chamber B, the latter should be elevated above the deaerator sufficiently to insure the proper gravity flow of

water from the chamber B into the deaerator. The water storage chamber G⁶ is shown as provided with an overflow connection Q' leading to a suitable trap discharge device Q for limiting the maximum height of water level in the chamber G⁶. With control provisions for the boiler feed pump H of the character described, however, there is small need for such overflow provisions, and ordinarily they may be omitted.

The preferred mode of operation contemplated for the apparatus shown in Fig. 1, comprises the continuous inflow of water and steam into the deaerator G. The rate at which water enters the deaerator varies, of course, with the rate at which water passes into the receiver B through the return conduit A. The amount of steam required to properly heat and deaerate the water and thereby maintain the desired excess of vapor pressure in the deaerator G over the vapor pressure in the receiver B will vary in accordance with the amount of water entering the deaerator. The steam supply, as previously described, is varied by the operation of the regulator M on the valve L in the steam supply pipe G. The vapor pressure in the chamber B is normally maintained approximately constant by the regulator F and at the value determined by the adjustment of the regulator weight F⁴.

Any temporary disturbance in operating conditions resulting in an undue rise in water level in the chamber B will cause the float B' to move the valve B² against its seat closing the air vent outlet C from the chamber B. Such increase in vapor pressure in the chamber B will cause the regulator F to increase the speed of the pump E with the result of an immediate reduction in vapor pressure in the deaerator, particularly as the closure of the inlet to the conduit C tends directly to a reduction in the pressure transmitted through the pipe M¹ to the chamber M² of the regulator M. Such reduction in vapor pressure in the chamber G increases the flow of water into the deaerator G from the chamber B and thus quickly restores the normal water level in the latter. The chamber G⁶ is preferably made large enough to have a considerable storage capacity, so that the operation of the boiler feed pump need not be continuous but may be intermittent as is generally desirable. With this arrangement the receiver chamber B may be of relatively small capacity. A reduction in the size of the elevated receiver B, reduces its cost, and facilitates its mounting where the available space to receive it is restricted.

The apparatus disclosed in Fig. 1 is simple and reliable in operation and, for effective and adequate deaeration of the water passing through it, need be but little if any more bulky or inherently expensive to construct than apparatus heretofore employed for handling the same quantity of returns without deaerating the water. A special advantage of the apparatus shown in Fig. 1 arises from the fact that the deaerator constitutes an effective preheater in which exhaust or otherwise waste steam, when available, may be effectively utilized. The water employed as cooling water in the vent condenser K may come from any available source of supply. Usually in buildings or plants of the kind in which the apparatus of Fig. 1 will ordinarily be used, there is some readily available source of condensing cooling water. For example, in some cases water so used may be cold water passing to the hot water generator supplying the hot water service system commonly provided in such buildings or plants.

In the modified arrangement illustrated in Fig. 2, the returns pipe A delivers to a receiver or separator BB, which is provided with an upper vent outlet CA for free air separating from the liquid constituent of the returns in the chamber BB, and with a lower outlet DA for said liquid constituent. In Fig. 2 the air outlet pipe CA leads to the inlet of an air pump EA, and the liquid outlet DA leads to the water inlet of a deaerator GA. The latter, as shown, is a so-called flash deaerator in which a fluid pressure appreciably below the fluid pressure in the chamber BB is maintained so that a portion of the water passing through the pipe DA to the deaerator GA will flash into steam on entering the latter. The portion of the entering water not evaporated by the flash action flows downward over the trays G⁴⁰ of the deaerator GA.

The desired excess of pressure in the pipe DA over that in the upper portion of the deaerator GA is insured by the action of an inlet valve O. The latter opens and closes as the pressure in the pipe DA acting on the upper side of the valve rises and falls relative to the resultant of two forces tending to close the valve. One of the two valve closing forces is the fluid pressure in the deaerator GA which acts on the underside of the valve O, and the other force is that due to the action of an adjustable loading spring O' acting on the stem O² of the valve O.

The deaerated water is withdrawn from the deaerator GA through the bottom outlet G⁸⁰ by a boiler feed pump HA. The air vent G⁷⁰ from the deaerator GA is connected to the inlet of a vent condenser K which may be like the vent condenser first described, and which has its vapor outlet K' connected to the pipe CA leading from the air inlet of the separator BB to the air pump EA.

To enable the air exhausting pump EA to simultaneously withdraw air as required from the receiver BB and deaerator GA, while maintaining a pressure in the flash deaerator chamber GA lower than the air pressure in the receiving chamber BB, a back pressure valve P is placed in conduit CA between the receiver BB and the point along the conduit at which the latter is connected to the conduit K'. The valve P is a spring loaded valve comprising parts P' and P² similar to the parts O' and O², respectively, of the flash or spray valve. To compensate for the effect of the water head on the inlet side of the flash valve O, the pressure drop due to the valve P should be greater than that due to the valve O.

In the arrangement shown in Fig. 2, the air pump EA and boiler feed pump HA are driven by a common driving motor IA the operation of which is regulated by a controller *ia*. The operating member *ia'* of the controller *ia* is adjusted to start and stop the motor IA accordingly as the water level in the separator chamber BB rises to a normal upper level or falls to a normal lower level. This effect is secured by means including a float JA resting on the water in the chamber BB and carried by the arm of the rock shaft JA'. The shaft JA' has a second arm external to the receiver BB from which is suspended a controller actuating a link or rod JA². The latter carries two spaced apart collars JA³. The upper collar JA³ engages the controller arm *ia'* and starts the motor IA into operation when the water in the receiver BB rises to a normal upper level. When the water level in the receiver BB falls to a normal lower level, the lower collar JA³ actuates the controller arm *ia'* and stops the motor IA.

Since in the normal operation of the apparatus shown in Fig. 2 the air pump EA, as well as the boiler feed pump HA, is operated intermittently, provisions are desirably made to prevent the passage of water from the receiver BB into the flash deaerator GA when the pumps are not in operation. Such provisions are diagrammatically illustrated in Fig. 2 as comprising a rotary cut-off valve R in the conduit DA having an operating arm R' which carries a pin R² received in a slot JA⁴ in the link JA. The slot JA⁴ is sufficiently elongated so that the valve R may be opened and closed when the controller arm a' is moved to start and stop the motor IA, respectively.

The general operation of the apparatus shown in Fig. 2 will be apparent to those skilled in the art from what has already been said. With the flash deaerator of Fig. 2, the temperature of the water withdrawn from the deaerator by the boiler feed pump is lower than the temperature of the water in the receiver BB, which is a disadvantage of serious practical importance in some cases. The apparatus of Fig. 2 possesses an advantage over that of Fig. 1 in that it requires but a single pump driving motor and a single motor controller. In general, the control mechanism employed in Fig. 2 in its entirety is simpler and less expensive to construct than the complete control mechanism required with the apparatus of Fig. 1. In the preferred arrangement and mode of operation of the apparatus of Fig. 2, the deaerator GA need have no water storage capacity, but in such case, the boiler feed pump HA of Fig. 2 should have sufficient capacity to withdraw the water from the deaerator GA as rapidly as water enters that chamber, so that there can be no significant or objectionable accumulation of water in the deaerator GA. The receiver BB should have suitable water storage capacity. It is not essential with the apparatus of Fig. 2, however, that the receiver BB should be located at a level above that of the deaerator GA. In general the pumps shown in Fig. 2 are started into operation only when the water space of the receiver BB fills, and their operation terminates as soon thereafter as the water level in the receiver is suitably lower and the receiver is suitably emptied.

While in accordance with the provisions of the statutes, we have illustrated and described the best forms of embodiment of our invention now known to us, it will be apparent to those skilled in the art that changes may be made in the forms of the apparatus disclosed without departing from the spirit of our invention as set forth in the appended claims, and that in some cases certain features of our invention may be used to advantage without a corresponding use of other features.

Having now described our invention, what we claim as new and desire to secure by Letters Patent, is:

1. The method of handling the water and air returns from a low pressure heating system which consists in passing said returns into an air and water separating chamber continuously in free communication with said system to receive said returns therefrom, passing water from said separator chamber into a deaerating chamber, and withdrawing air from both of said chambers by a common air withdrawing means as required to maintain definitely different air pressures in the two chambers.

2. The method of handling the water and air

returns from a low pressure heating system which consists in passing said returns into an air and water separating chamber, permanently separating a portion of the air content of said returns from the water content thereof by withdrawing air from said chamber as required to maintain a predetermined sub-atmospheric pressure therein, passing water from said separating chamber into a deaerating chamber, withdrawing air from the deaerating chamber and supplying steam thereto as required to maintain a pressure therein differing by an approximately constant predetermined amount from the pressure maintained in said separating chamber.

3. The method of handling the air and water returns from a low pressure heating system which consists in passing said returns into a separating chamber having an air outlet and a separate water outlet, passing water from said separating chamber into a deaerating chamber provided with an air outlet and a separate water outlet, permanently separating a portion of the air content of said returns from the water content thereof by subjecting the air outlet of the first mentioned chamber to an air exhausting effect tending to maintain an approximately constant sub-atmospheric pressure in that chamber, subjecting the deaerating chamber to an air exhausting effect tending to maintain a pressure in the last mentioned chamber substantially higher than that maintained in the first mentioned chamber, supplying steam to the deaerating chamber as required to maintain the pressure therein in excess of the pressure in the first mentioned chamber by an approximately constant amount, and withdrawing water from said storage space.

4. The combination with an air and water separating chamber having a free inlet receiving air and water under low pressures and provided with an air outlet and a water outlet, a deaerating chamber receiving water from said water outlet and having an air outlet and a separate deaerated water outlet, an air pump connected to and drawing air from both of said air outlets, means for throttling flow through one of said air outlets, to thereby maintain the vapor pressure in said deaerating chamber at a different value from the vapor pressure in said separating chamber, and means passing said air and water under low pressures to said inlet at a rate independent of the water accumulation in said separating chamber.

5. The combination with an air and water separating chamber receiving air and water under low pressures and having an air outlet and a separate water outlet, a deaerating chamber receiving water from said water outlet and having an air outlet and a separate outlet for deaerated water, an air pump drawing air from both of said air outlets, the air outlet from the deaerating chamber being throttled, a steam supply connection to said deaerating chamber, and means jointly responsive to the pressures in said chambers for varying the steam supplied through said connection as required to maintain a predetermined difference between said pressures.

6. The combination with an air and water separating chamber having a lower water outlet and an upper air outlet, a deaerating chamber receiving water from said water outlet and having an air outlet and an air pump having its inlet connected to each of said air outlets, the connection to the deaerating chamber air outlet including a throttling device, controlling means for said air pump tending to maintain a constant sub-at-

mospheric air pressure in said separating chamber, a regulable steam supply connection to said deaerating chamber and regulating means therefor jointly responsive to the pressures in the two chambers for varying steam supplied to said deaerating chamber as required to maintain a pressure in the deaerating chamber exceeding that in the separating chamber by a predetermined and approximately constant amount.

7. The combination with an air and water separating chamber having a lower water outlet and an upper air outlet, a deaerating chamber receiving water from said water outlet and having an air outlet and an air pump having its inlet connected to each of said air outlets, the connection to the deaerating chamber air outlet including a throttling device, controlling means for said air pump tending to maintain a constant sub-atmospheric air pressure in said separating chamber, a regulable steam supply connection to said deaerating chamber and regulating means therefor jointly responsive to the pressures in the two chambers for varying steam supplied to said deaerating chamber as required to maintain a pressure in the deaerating chamber exceeding that in the separating chamber by a predetermined and approximately constant amount, said deaerating

chamber including a water storage space, a pump for withdrawing water from said space and means for starting and stopping said pump respectively as the water level in said space rises to a certain upper level and falls to a certain lower level.

8. The combination with an air and water separating chamber receiving air and water under low pressures and provided with an air outlet and a water outlet, a deaerating chamber receiving water from said water outlet and having an air outlet and a separate deaerated water outlet, an air pump connected to and drawing air from both of said air outlets, means for throttling flow through the first mentioned air outlet to thereby maintain a lower vapor pressure in said deaerating chamber than in said separating chamber, and means responsive to the accumulation of water in said separating chamber controlling said air pump to increase or decrease its air exhausting effect in accordance with a predetermined increase or a predetermined decrease, respectively, in the accumulation of water in said separating chamber.

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