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CLOSED FEED SYSTEM FOR BOILERS

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2 SHEETS.—SHEET 1

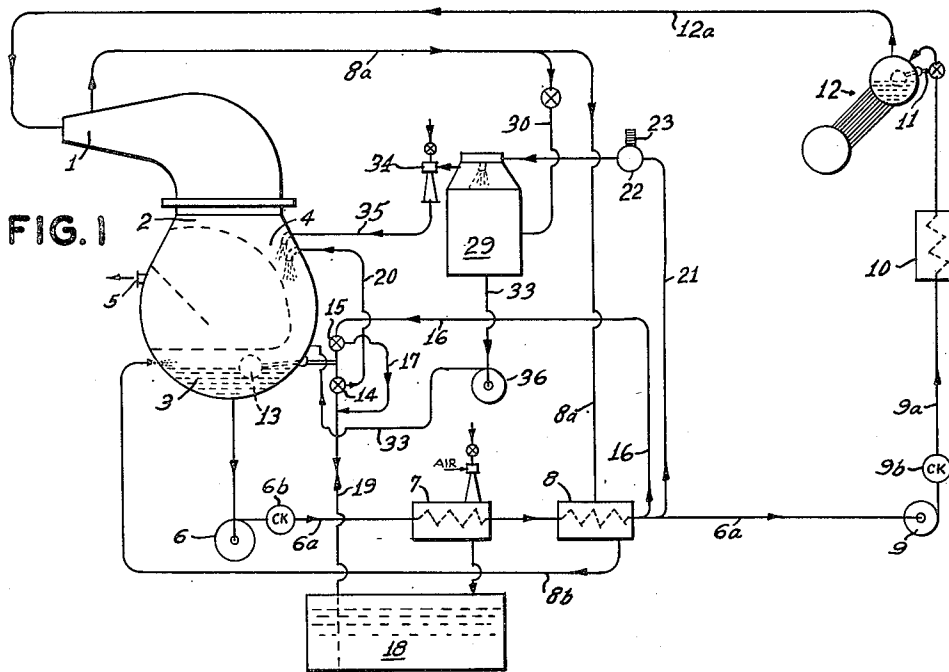
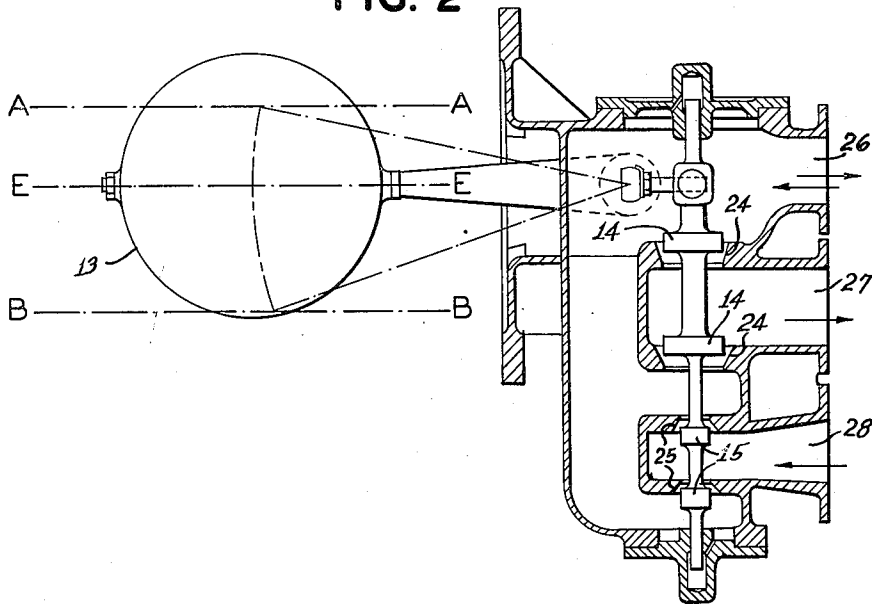


FIG. 2



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2 SHEETS—SHEET 2

FIG. 3

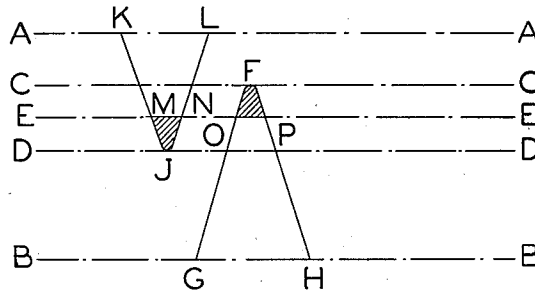
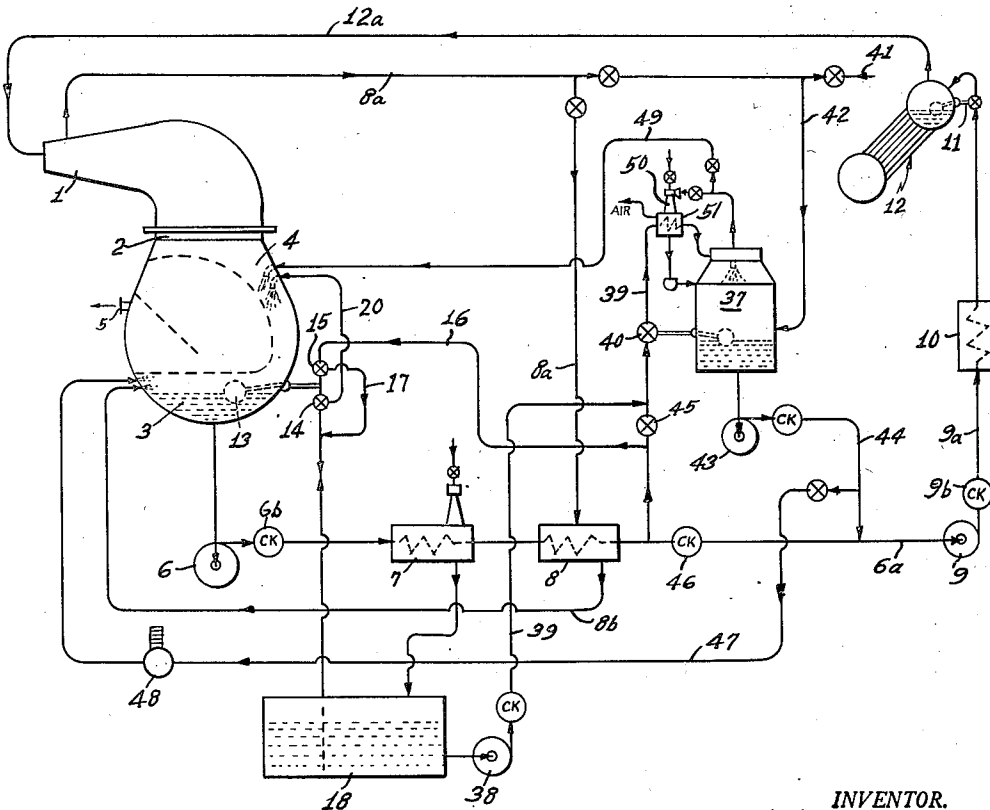


FIG. 4



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CLOSED FEED SYSTEM FOR BOILERS

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4 Claims. (Cl. 257—24)

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This invention relates to boiler feed systems incorporating apparatus for removing gaseous impurities from feed water for boilers.

It is known to make use of a deaerating or steam regenerative type condenser for the purpose of deaerating all condensate passing through such condenser, the condensate being thence conveyed to the boiler or boilers through a closed feed system in which the pressure on the discharge side of the condensate extraction pump is maintained substantially above atmospheric pressure so as to avoid any possible ingress of contaminating air.

During standing conditions and starting up, and, on board ship, during rapid maneuvering and port conditions, circumstances may arise in which the deaeration of the feed water obtained is not as thorough as during steady normal operating conditions. Further, the extremely high boiler pressures which are now becoming more commonly used necessitate deaeration of the feed water to the greatest possible extent under all conditions of operation, whether standing, in port, warming up, maneuvering or in steady operation.

The present invention provides an improved boiler feed system in which a proportion of the feed water is recirculated and subjected to repeated deaerating action except during periods when the boiler feed pump demands an abnormal supply of feed water. The feed water may be returned from the discharge of the main condenser extraction pump direct to the main condenser, or by way of a deaerating vessel to the main condenser, with the object of passing such water into the condenser or via a deaerator into the condenser so that it is subjected to the deaerating action of the condenser and the deaerator before passing again into the suction of the condenser extraction pump.

The connection through which the water is recirculated back to the main condenser is provided with means whereby the flow of water through such connection is automatically shut off during periods of abnormal demand for feed water by the boiler feed pump, satisfactory operation of the closed feed system being thereby ensured at all times.

A separate deaerating plant may be provided for operation when the main condenser is shut down so that deaerated water is supplied to the boiler feed pump at such periods, and such deaerating plant may be so contrived that, when the main condenser is in operation, the deaerating plant will take water from the discharge of

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the condenser extraction pump and deliver this water, after it has passed through the said deaerating plant, to the suction of the boiler feed pump, a non-return valve being interposed between the off-take of the condenser extraction pump discharge and the deaerator extraction pump delivery into the boiler feed pump suction. With such an arrangement the boiler feed pump is preferably supplied with water which has passed through the deaerating vessel up to the limit of the capacity of the deaerator. With greater feed requirements the non-return valve will open and permit the condenser extraction pump to discharge water direct into the boiler feed pump suction in parallel with the discharge from the deaerator extraction pump.

For smaller feed flows there is provided a connection which permits a portion of the deaerator extraction pump capacity to deliver water back to the main condenser direct or through a further deaerating vessel, the said recirculating connection to the main condenser being provided with means whereby the flow of water to the condenser is stopped when the boiler feed pump requires the said water.

The deaerating vessels mentioned may be supplied with heating steam for heating the feed water in its passage through the deaerating vessels. Air and non-condensable gases may be evacuated from the deaerating vessels to the main condenser or other suitable place. The deaerating action in the deaerating vessels may be limited to the atomization of the feed water in passing through the deaerator, the air and non-condensable gases being evacuated by suitable means, one means preferred for this operation being an ejector which discharges into the main condenser.

The means for controlling the flow of recirculated water to the main condenser may comprise a spring-loaded valve which closes when the pressure in the line between the condenser extraction pump and the boiler feed pump falls to a predetermined pressure which is preferably substantially above atmospheric pressure to avoid ingress of contaminating air into the closed feed system. The recirculated water may be subject to a float control whereby water in recirculation is permitted to pass into the main condenser when the water level in the main condenser is above a predetermined level but is cut off when the water level in the main condenser falls below a predetermined level. Water recirculated from the discharge of the deaerator extraction pump may pass to the main condenser through a spring-loaded valve set to close when the dis-

charge pressure of the deaerator extraction pump falls to a predetermined value; or a float may be provided in the base of the deaerator to operate a valve whereby the flow of water recirculated to the main condenser is cut off when the water level in the deaerator falls to a predetermined level.

In general, condenser extraction pumps and boiler feed pumps are provided for a maximum capacity substantially in excess of the maximum evaporation of the boilers. Provision may be made to ensure that the quantity of water recirculated shall be approximately equal to the difference between the maximum feed flow capacity of the boiler feed pump and the maximum evaporation of the boilers; or the quantity of water recirculated may be increased. In either case provision is made to stop the flow of water recirculated when the demand of the boiler feed pump exceeds the difference between the maximum feed capacity of the condenser extraction pump and the quantity of water in circulation.

It will be understood that in a closed feed system in accordance with the invention, in normal operation, there will be a substantial quantity of water recirculating from the discharge of the condenser extraction pump or deaerator extraction pump back to the main condenser, and that such water is being subjected to the repeated deaerating action of the main condenser. The lower the load on the boiler or boilers, the greater is the proportion of water subjected to such deaerating action, so that on light loads the proportion being recirculated is large in relation to the quantity of water going to the boilers, and the repeated deaerating action is a maximum at a time when, as experience has shown, the normal deaeration is liable to be deficient.

The base of the main condenser is normally provided with a well which contains a substantial quantity of water, and recirculation in accordance with the invention ensures that this water in the base of the condenser is maintained in a thoroughly deaerated condition, so that on a sudden demand for increased feed adequately deaerated water is immediately available from the base of the condenser from which it is drawn by the condenser extraction pump and discharged to the boiler feed pump for delivery to the boilers.

In a closed feed system incorporating a deaerating vessel for use on board ship, in port, for example, such deaerating vessel can be used at sea to subject a portion of the feed water up to the capacity of such deaerator to an additional deaerating action before the feed water passes into the boiler or boilers. In the system according to the invention, whenever the boiler feed pump requires less water than the capacity of such deaerator, the balance is recirculated into the main condenser to be subjected to further deaerating action in the recirculation circuit.

In the accompanying drawings:

Fig. 1 is a diagrammatic view showing an arrangement of a boiler closed feed system including means for recirculating feed water in accordance with the invention. Fig. 2 shows float-controlled apparatus for controlling the quantity of feed water in recirculation from the water level in the condenser. Fig. 3 is a diagrammatic view showing the range of water levels in the condenser well, and Fig. 4 is a view similar to that of Fig. 1 showing a closed feed system incorporating a deaerating vessel in parallel with a closed feed system provided with means for recirculation in accordance with the invention.

Referring to Fig. 1, the turbine 1 exhausts its

operating steam into the condenser 2 in which the steam is condensed, condensate passing to the base of the condenser in which is a well 3. A steam passage 4 permits steam to pass from the top to the bottom of the condenser where it can pass freely across the bottom of the condenser, so that all condensate must pass through such steam before reaching the well 3. Air and other non-condensable gases are drawn off through the air off-take 5 arranged substantially remote from the water level in the base of the condenser so that a negligible air pressure exists on the surface of the water in the well 3. All condensate passing through the condenser is thus subjected to the deaerating action of the steam in the base of the condenser before it is withdrawn by a condensate extraction pump 6. The condensate extraction pump 6 discharges through a pipe 6a, provided with a non-return valve 6b, connected through heat exchange apparatus such as the air ejector condenser 7 and the feed heater 8 to the boiler feed pump 9 which delivers through a pipe 9a, provided with a non-return valve 9b, connected through the feed heater 10 and the feed regulator 11 to the boiler 12. Steam from the boiler passes through a line 12a to the turbine 1.

The well 3 in the condenser 2 is provided with a float 13 which operates make-up and overflow valves 14 and 15, respectively. A rise in the water level in the well 3 opens the overflow valve 15 and allows water to pass from the condensate discharge line beyond the outlet from the heater 8 by way of the pipe 16, the overflow valve 15 and the pipe 17 to the external feed tank 18. When the demand of the feed pump 9 is in excess of the amount of condensate being formed in the condenser 2, the water level in the base of the condenser will fall and the float 13 will open the make-up valve 14, enabling water to pass from the feed tank 18 by way of the pipe 19, the make-up valve 14 and the pipe 20 into steam passage 4 of the condenser 2 where the water is sprayed and deaerated. The make-up water passing into the condenser 2 will fall to the base of the condenser from which the extraction pump 6 will discharge it into the closed feed system.

Heating steam, which may be bled steam from the main turbine, exhaust steam from auxiliary turbines, or heating steam from any suitable source, may be supplied to the heat exchanger 8. Steam may be bled from the turbine 1 through a line 8a to the heat exchanger 8 and the resulting condensate conducted in this heat exchanger through a line 8b and delivered into the condenser 2.

A pipe 21 is connected from the condensate extraction pump discharge line 6a preferably beyond the heat exchangers 7 and 8 into a separate deaerating vessel 29, in which the water is sprayed to effect a deaerating action. A control valve 22 provided with a spring loaded device 23 is arranged in the pipe line 21 to limit the amount of water which can pass through this pipe to a predetermined maximum. The water sprayed into the deaerating vessel 29 may be heated by means of a supply of heating steam bled from the turbine or other suitable source and conducted from the pipe 8a through a valve pipe 30 into the deaerating vessel 29. Air and non-condensable gases are evacuated from the deaerating vessel by means of a steam-operated ejector or other similar ejection apparatus 34 which acts to withdraw air and non-condensable gases from the deaerating vessel 29. The resulting mixture of

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air, steam, and water is discharged from the apparatus 34 through a pipe 35 to the condenser 2.

The heated and deaerated water falls to the base of the deaerating vessel 29 and is withdrawn therefrom by a deaerator extraction pump 36, which discharges the deaerated condensate through a pipe 33 into the condenser 2. If the water is heated in the deaerating vessel 29, the flashing of such heated water on entering the condenser 2 still further assists the deaerating action of the condenser 2. The recirculated water is thus subjected to the repeated deaerating action of the vessel 29 and the main condenser 2.

The capacity of the boiler feed pump 9 is usually substantially greater than the maximum steaming capacity of the boiler 12, and the maximum capacity of the condensate extraction pump 6 is equal to or greater than the maximum capacity of the boiler feed pump. The control valve 22 is so contrived that the quantity of water flowing through the control valve 22 is equal to or greater than the difference between the maximum capacity of the condensate extraction pump 6 and the maximum steaming capacity of the boiler 12, but the arrangement may be such that the control valve 22 will pass a greater or smaller quantity.

The condensate extraction pump 6 is designed for a discharge pressure which falls continuously from a maximum at zero flow to a minimum at maximum flow, the said minimum being substantially above atmospheric pressure to prevent any possibility of air obtaining ingress to the closed feed system between the condensate extraction pump 6 and the boiler feed pump 9, thereby avoiding contamination of water which has been deaerated in the condenser 2.

In normal operation, the boiler feed pump discharges to the boiler a quantity of water equal to or less than the maximum steaming capacity of the boiler, and a quantity of water will be in recirculation through the pipe 21, control valve 22, deaerating vessel 29, pipe 33, and main condenser 2, from which it will pass again into the suction of the condensate extraction pump 6 which will discharge it into the closed feed line to the boiler feed pump 9. The water in this circuit is in continuous recirculation under normal operating conditions, so that water drawn from the base of the condenser 2 will be subject to the repeated deaerating action of the deaerating vessel 29 and the condenser 2. The control valve 22 may be set to close at the required predetermined pressure by means of the spring loaded device 23 or other similar means.

In the event of an emergency and the boiler requiring more water than its steaming capacity, which may occur with maneuvering conditions, the pressure in the closed feed line 6a will fall and a spring-loaded device 23 or equivalent means is provided to close the valve 22 when the pressure in the closed feed system falls to a predetermined pressure, at which point the full capacity of the condensate extraction pump 6 will be available for supplying the boiler feed pump 9. It will be seen that there is a continuous recirculation of condensate from the closed feed system back into the condenser so that such water is subjected to a repeated deaerating action. The water in the well at the base of the condenser being in continuous recirculation, the maximum possible deaeration is obtained and the body of deaerated water in the base of the condenser is available at any time for discharge into the boiler. On light loads and when maneuvering, the quantity of

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feed water required by the boiler is generally small, so that the quantity in circulation through the recirculating system is large in proportion to the quantity of water delivered to the boiler, so that on light loads the condensate is being repeatedly subjected to the deaerating action of the condenser and deaerator by the action of the recirculation circuit, and such repeated deaerating action is a maximum when the normal deaeration is likely to be deficient.

Fig. 2 shows a detail of the float-controlled make-up and overflow valves as shown in the base of the condenser in Fig. 1, and the same reference numerals are used to designate the same parts. The float 13 controls the make-up valve 14 and the overflow valve 15, both of which are of the balanced type with two valve faces co-operating with their respective seats 24 and 25.

Make-up water from the pipe 19 enters by the branch 26 and flows through the make-up valve seats 24 to the branch 27 from which it passes by way of the pipe 20 to the main condenser 2. Overflow water from the pipe 16 enters by the branch 28, and passes through the overflow valve seats 25 from which it can flow through the branch 26 and pipes 17 and 19 to the external feed tank 18.

For the purposes of recirculating water for repeated deaerating action in the condenser, the make-up valve 14 and the overflow valve 15 are arranged to be both in the open position for a predetermined range of water level travel in the condenser well 3, and this arrangement is illustrated diagrammatically in Fig. 3, where the height AB represents the predetermined range of travel of the float 13, the line AA representing the water level at which the overflow valve 15 is full open and the line BB representing the water level at which the make-up valve 14 is full open.

The areas through the make-up and overflow valves 14 and 15 are shown diagrammatically by FGH and JKL respectively in relation to the water level in the condenser well 3. The areas for flow through the make-up and overflow valves 14 and 15 are arranged to overlap, the line CC indicating the water level at which the make-up valve 14 closes and the line DD indicating the water level at which the overflow valve 15 closes. There is, therefore, a range of water level between CC and DD in which the overflow valve 15 and the make-up valve 14 are both partly open. Within this range of water level, water will be discharged from the condensate extraction pump discharge line through the pipe 16, the overflow valve 15, and then by way of the make-up valve 14 to the branch 27, from which the recirculated water can flow by way of the pipe 20 into the main condenser 2. For example, if the water level is at EE, the areas available for recirculation are represented by the areas FOP and JMN for the make-up and overflow valves, respectively.

In the event of the water level in the condenser falling below the level DD, the quantity of water in recirculation will be cut off and the whole of the condensate extraction pump capacity will be available to supply the boiler feed pump.

Whenever the boiler feed pump requires more water than the difference between the capacity of the condensate extraction pump 6 and the quantity passing through the recirculating circuit, the pressure in the discharge line between the condensate pump 6 and the boiler feed pump 9 will fall until the control device 22 closes at a predetermined pressure and cuts off the water in recirculation, thereby leaving the full capacity

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of the condensate extraction pump 6 available for the supply of water direct to the boiler feed pump 9, until normal conditions are restored when the control device 23 will open the valve 22 and permit recirculation again.

In Fig. 4 the same reference numerals are used to designate the same parts which they represent in Fig. 1.

Referring to Fig. 4, the deaerating vessel 37 is a separate deaerating apparatus which can be used when the main condenser 2 is out of action, when water can be drawn from the feed tank 18 by the supply pump 38 and discharged by way of the pipe 39, provided with a non-return valve, and the float-controlled inlet valve 40 to the top of the deaerator 37, where it is sprayed into the deaerator. Heating steam may be taken from any suitable source through the pipes 41 and 42 into the deaerator 37. A deaerator extraction pump 43 discharges by way of the pipe 44, provided with a non-return valve, into the closed feed line 6a between the condensate extraction pump 6 and the boiler feed pump 9. When the deaerating vessel 37 is in operation in port, heating steam can be supplied from the exhaust of auxiliaries such as a turbine boiler feed pump or other suitable source of heating steam by way of the pipe 41.

If desired, the said deaerating apparatus 37 can be put in operation when the main turbine 1 and condenser 2 are in operation by arranging the condensate extraction pump 6 to discharge water by way of the valved pipe 45, pipe 39 and float-controlled inlet valve 40 into the top of the deaerator 37, where it is sprayed for atomization and deaerating purposes. The deaerated water falling to the base of the deaerator is withdrawn by the deaerator extraction pump 43 and discharged through the pipe 44 to the suction of the boiler feed pump 9.

A non-return valve 46, which is normally held closed by the pressure of the deaerator extraction pump, is provided in the condensate extraction pump discharge line 6a, so that the condensate extraction pump 6 discharges into the deaerator 37 at all times when the capacity of the deaerator is less than the demand of the boiler feed pump 9 for water. Under these conditions, all water which has already been subjected to the deaerating action of the condenser 2 is still further subjected to the deaerating action of the deaerating vessel 37, before it passes into the suction of the boiler feed pump.

A connection is taken from the deaerator extraction pump discharge 44, and water is recirculated by way of the valved pipe 47 and control device 48 to the main condenser 2. Whenever the boiler feed pump requires less water than the capacity of the deaerator 37, the balance is recirculated by way of the pipe 47 and control device 48 to the main condenser 2, in which it is subjected to the further deaerating action of the main condenser 2. Air and non-condensable gases can be evacuated from the deaerator 37 to the main condenser through a valved pipe 49 under normal operating conditions, or they may be evacuated by an air ejector 50 which discharges into a condenser 51, cooled by the water in the pipe 39, from which the condensate is drained into the deaerator or the feed tank and the air discharged to atmosphere, this condenser 51 being in use when the main condenser 2 is not in operation. Whenever the boiler feed pump 9 requires water in excess of the capacity of the deaerating vessel 37, the con-

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densate extraction pump 6 discharges the balance of the water required through the non-return valve 46 direct to the suction of the boiler feed pump 9.

The control device 48 includes a valve in the line 47 and is set to close at a fall to a predetermined pressure in the deaerator extraction pump discharge line 44 so that the maximum capacity of the deaerator 37 is available at all times for the boiler feed pump 9. It will be seen that water recirculating through the connection 47 and control device 48 is subjected to the repeated deaerating action of the condenser 2 and the deaerating vessel 37. The maximum possible deaeration of the water in the well 3 at the base of the condenser 2 is thereby obtained and a body of fully deaerated water is available in the base of the condenser 3 at all times for discharging direct into the boiler feed pump 9 and the boiler 12. Water flowing through the pipe 47 may be caused to pass through a float-controlled valve influenced by changes in the water level in the deaerator to close at a predetermined level, whereby the recirculating flow is cut off when the boiler feed pump 9 demands an increased feed quantity.

On light loads and when maneuvering, the quantity of feed water required by the boiler 12 is generally small, so that the quantity of water discharged through the deaerating vessel 37 should be adequate to supply the boiler feed pump 9 and to maintain a quantity of water in flow through the recirculating system to the main condenser 2, thereby obtaining the maximum possible deaeration at times when, as experience shows, the normal deaeration of previously known closed feed systems is likely to be deficient.

The systems described ensure that under all normal operating conditions there is a recirculation of water through the main condenser whereby such water is subjected to repeated deaerating action with the object of obtaining the maximum possible deaeration of the water in the well of the condenser, and any water discharged to the boiler feed pump, particularly under light load conditions, is deaerated to the maximum possible extent.

It is to be understood that apparatus may be variously constructed in accordance with the invention and that the constructions illustrated and described herein are typical convenient forms. What is claimed is:

1. In a closed feed system for a steam boiler, the combination of a condenser for the condensation of steam initially generated in the boiler, a condensate extraction pump connected into the condenser, a boiler feed water pump connected into the boiler, a direct pipe connection between the outlet of the condensate pump and the intake of the boiler feed pump whereby the discharge from the condensate extraction pump has immediate access to the intake of the boiler feed pump, a deaerator having an inlet and an outlet, a conduit connecting said pipe with the inlet of the deaerator, means for passing deaerated condensate from the outlet of the deaerator to the intake of the boiler feed water pump, conduit means for delivering deaerated condensate from the outlet of the deaerator into the steam space of the condenser for further deaeration whereby deaerated condensate from the deaerator is recycled to the condenser and again returned to the deaerator by the condensate extraction pump, and control means in

said conduit means for automatically reducing the flow of condensate recycled from the deaerator to the condenser in response to an increase in the demand of the boiler feed water pump for feed water to be delivered to the boiler.

2. A closed feed system as claimed in claim 1 in which said means for passing water from the outlet of the deaerator includes a deaerator pump, a connection between the outlet of the deaerator pump and the pipe leading to the inlet of the feed pump, and a non-return valve in said pipe between said connection and the inlet of said conduit.

3. A closed feed system as claimed in claim 2 in which said control means includes a valve means in the conduit means for delivering deaerated condensate to the condenser downstream from the deaerator pump, said valve means being adapted to cut off the flow of deaerated condensate to the condenser when the pressure in said pipe at the inlet to the feed pump falls below a predetermined value.

4. In a closed feed system for a steam boiler, the combination of a condenser for the condensation of steam initially generated in the boiler, a condensate extraction pump connected into the condenser, a boiler feed water pump connected into the boiler, a direct pipe connection between the outlet of the condensate pump and the intake of the boiler feed pump, a deaerator having an inlet and an outlet, a conduit connecting said pipe with the inlet of the deaerator, a deaerator pump for drawing deaerated condensate from the outlet of the deaerator, a connection for passing deaerated condensate from the de-

aerator pump into said pipe between said conduit and the feed water pump for passage to the inlet of the feed water pump, a non-return valve in said pipe between the inlet of said conduit and the outlet of said connection, a second connection for passing deaerated condensate from said deaerator pump into the steam space of said condenser for further deaeration following which it is again passed to the deaerator by the condensate extraction pump, and a control means in said second connection for cutting off the flow of deaerated condensate to the condenser when the pressure in said pipe at the inlet to the feed pump falls below a predetermined value.

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