March 11, 1930. S. BROWN 1,750,035

DEAERATOR

Filed Nov. 19, 1926 4 Sheets-Sheet 1

Fig. 1.

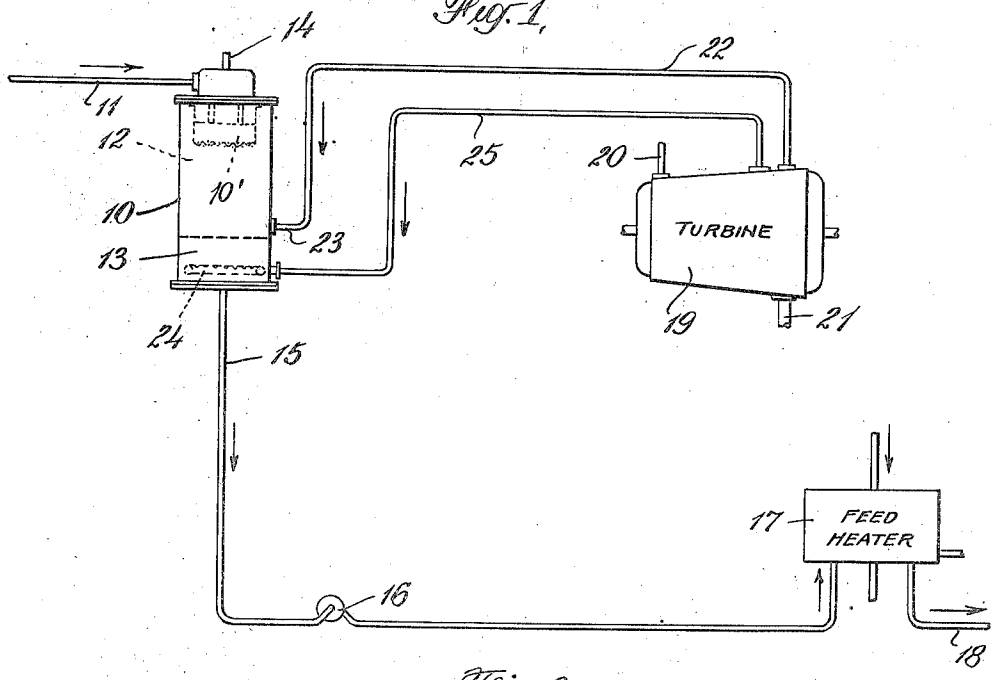
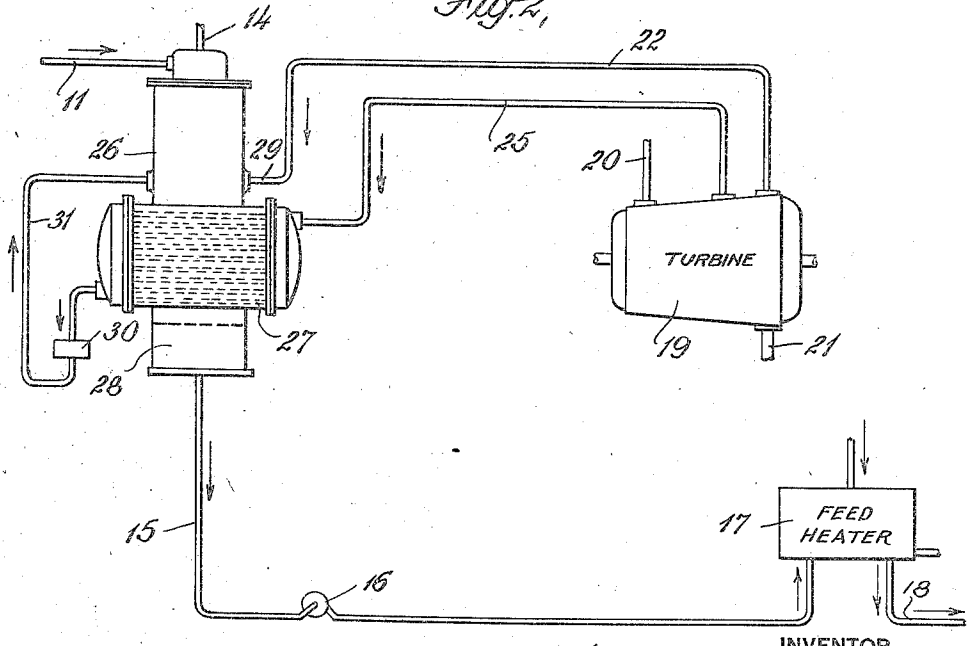


Fig. 2.



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DEAERATOR

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Fig. 3.

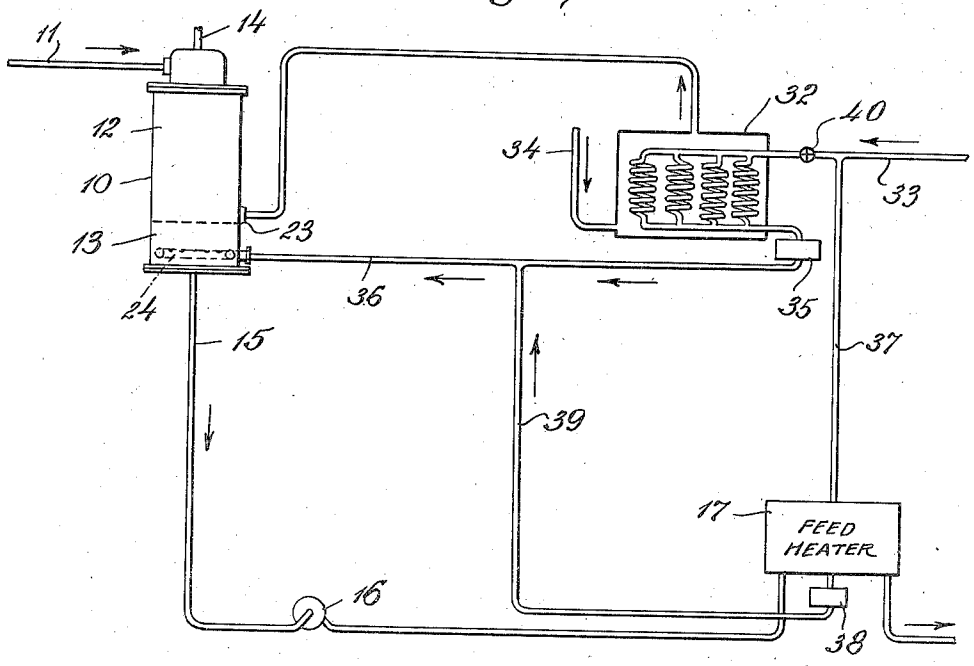
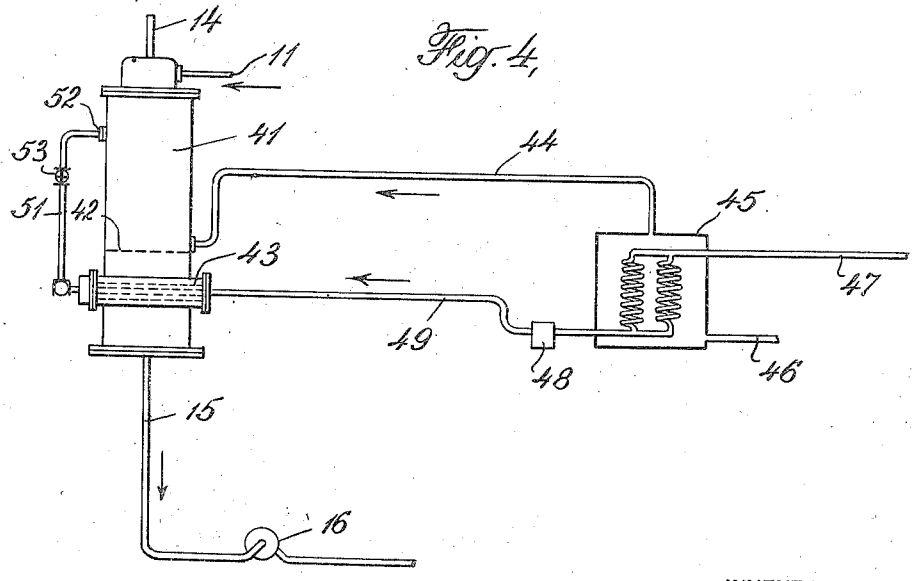


Fig. 4.



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DEAERATOR

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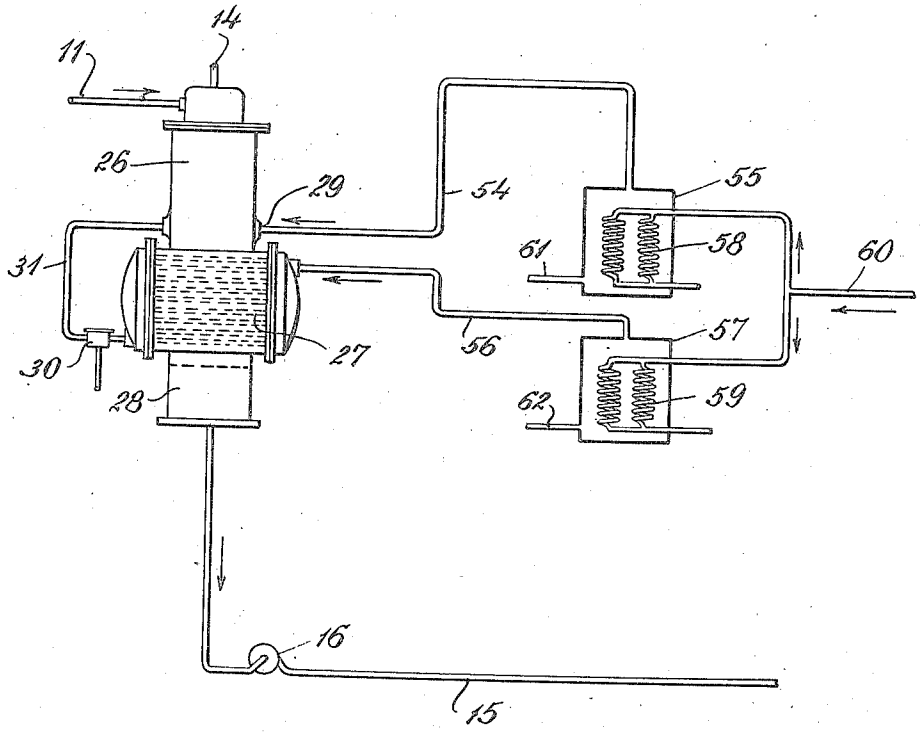
Fig. 5,



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DEAERATOR

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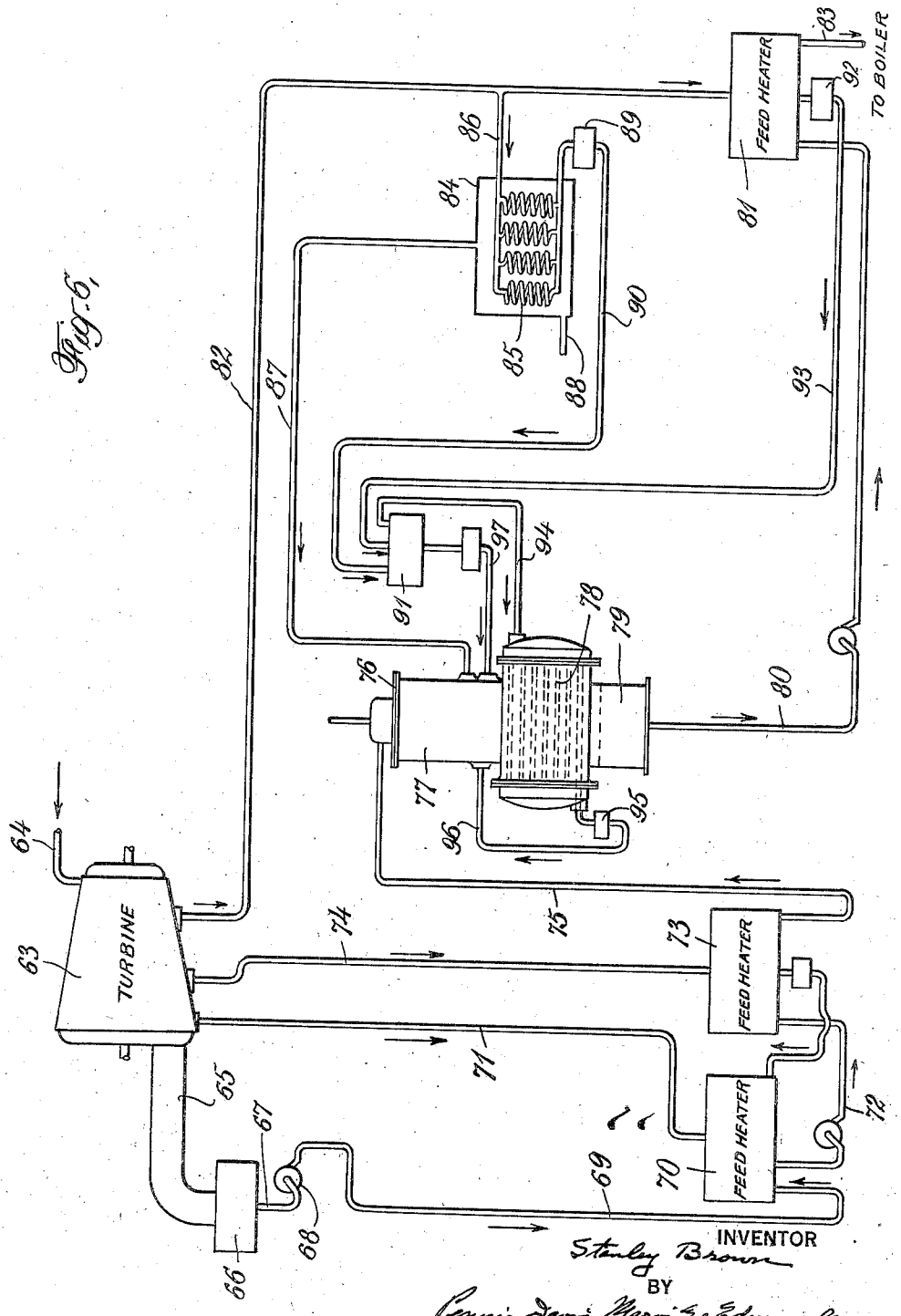
Fig. 6.



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Patented Mar. 11, 1930 1,750,035

UNITED STATES PATENT OFFICE

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DEAERATOR

Application filed November 19, 1926. Serial No. 149,327.

This invention relates to the deaeration or degassing of feed water used in steam power systems, and to the association or combining of deaerating apparatus with steam power systems, such for example as steam plants for producing electricity and plants for producing steam and/or power for industrial use.

In the operation of steam power systems it has been found that the feed water contains certain amounts of dissolved gases, such for example as oxygen, carbon dioxide and other constituents of air. These gases, particularly the oxygen are present in sufficient quantity to produce a corrosive action upon the metal of the boiler, and other apparatus included in the system, at high temperature operation. The extent of this corrosive action has led in recent years to the more or less general inclusion of deaerating apparatus in steam power systems so as to supply substantially gas-free water to that apparatus of the system which operates at high temperature.

Deaeration of the water is accomplished by passing it into a suitable vessel and heating to the temperature corresponding to the pressure within the vessel. Deaeration may be carried on at almost any desired temperature and pressure. Thus deaerating apparatus may be operated at pressures far below atmospheric, at atmospheric pressure, and at pressures considerably above atmospheric pressure. It has been found desirable, however, to carry on the deaeration at comparatively high temperatures because at such temperatures the water has less affinity for the gases and they are therefore more readily separated.

Furthermore, in the study of the problem of deaeration it has been found advantageous to treat the water in two zones. In the first zone of treatment substantially complete deaeration is effected by contact heating of the water with steam in sufficient quantity and at such temperature as to produce the desired temperature of the water. In the second zone of treatment the water is subjected to a temperature higher than that of the steam supply for the first zone and higher than the final temperature of the completely deaerated water. The action of this second zone of treatment is to prevent the enrichment of the water with air or gas from the vapor in the first zone, and also to carry the deaeration further on, providing a sort of secondary deaerating effect.

The apparatus for carrying out deaeration in this way comprises an elongated vertical chamber into which the water to be deaerated is supplied at the top. Steam or vapor at appropriate temperature is introduced into contact with the water within the chamber, and to bring the water and steam into more intimate contact means such as trays or baffles are usually provided within the chamber for finely dividing the water into drops or rain so that the largest possible surface of water will be presented to the action of the steam, thus effecting rapid heating of the water and condensation of the steam.

The water which has been heated through this exchange of heat, and the condensed steam, collect and form a body of liquid in the lower part of the chamber. Submerged in this body of liquid is a bubble pipe or a surface heat transfer means, such for example as a tube bundle, and through one or the other of these instrumentalities steam at a higher temperature is supplied to effect the treatment in the second zone mentioned above. Instead of being submerged in the body of water at the bottom of the chamber, the tube bundle may be placed just above the liquid level, and the rain or spray of water will descend from the upper part of the chamber onto and through this tube bundle and collect at the bottom of the chamber. The spray tends to form films of liquid on the surfaces of the tubes but when the spray strikes these hot tubes a violent ebullition of the liquid in the film form is produced and a portion of the liquid is vaporized. This violent vaporization of a portion of the liquid, and the vapor resulting therefrom produces the final or secondary deaeration effect, removing the last remaining particles of air and other non-condensible gases. This will be referred to herein as the unsubmerged tube bundle type of deaerator.

When the bubble pipe or submerged tube

bundle is used ebullition and agitation of the body of liquid result and a moderate amount of vapor is released. All three of these actions, namely, the action of the submerged bubble pipe, the action of the submerged heat transfer means, and the action of the unsubmerged heat transfer means, serve to carry further on the deaeration which has been produced by the contact heating. In all three of these types of deaerators the outlet for the noncondensable gases is at the top of the rain chamber, and the vapor produced by the secondary deaerating effect joins the contact heating steam entering at the lower part of the rain chamber and the mixture of vapor and steam rises in the rain chamber in the opposite direction to the downward flow of the water undergoing deaeration. This counterflow of vapor carries with it the air and other noncondensable gases toward the outlet at the top.

The problem is to fit the deaerating apparatus into various steam power systems with as little disturbance or change in the layout of the particular system as possible.

The difficulty encountered in attempting to introduce a deaerating apparatus into a steam power system is caused by the fact that the steam to be supplied to the bubble pipe, or to the submerged tube bundle, or to the tube bundle placed above the surface of the liquid must be at a higher temperature than the steam conducted into the rain chamber or shell of the apparatus for contact heating. This latter steam may be called the primary or principal heating steam whereas the former steam, that is, the steam for the bubble pipe or tube bundles may be termed the secondary heating or secondary deaerating steam. It has been found by investigation that the secondary heating steam may advantageously be from about 2° F. to about 20° F. higher in temperature than the temperature of the principal heating steam for deaerators employing the bubble pipe type. With deaerators of the tube bundle type, whether employing a tube bundle above or below the liquid level, investigation has shown that the secondary steam should be in the neighborhood of 10° F. to 30° F. above that of the primary heating steam.

It has been customary heretofore to supply both the primary and the secondary steam from the same source, such for example as the vapor output of an evaporator. With this arrangement, although the amount of primary heat consumed in deaerating apparatus is far in excess of that of the secondary heat, the usual proportions being about 85 to 95% primary heat, and 5 to 15% secondary heat, nevertheless the evaporator is required under these circumstances to supply the total amount of steam consumed, at a temperature corresponding to that required by the secondary deaeration. In a steam plant operating a 50,000 k. w. turbine, the amount of primary steam condensed in the deaerating apparatus would perhaps be in the neighborhood of 20,000 to 30,000 pounds per hour, so that the maintaining of this amount of vapor or steam at say 10° to 25° higher temperature than necessary is an important consideration, necessitating the installation of an evaporator of much larger capacity than would be required if deaeration were not included in the system. In other words, the furnishing of the total quantity of steam required for deaeration processes at the maximum temperature which is determined by that necessary for the secondary steam subjects the source of deaerator steam to a penalty which is very likely to necessitate an undesired modification in other apparatus of the steam power system in order to accommodate the deaerating apparatus.

Accordingly the principal object of the present invention is to so associate a deaerating apparatus with a steam power system that the most economical kind or quality of steam may be consumed in the deaerator.

A further consideration is that of the large variety of steam power systems which are required to meet varying local or desired conditions in the output of the system. Some systems, for example, utilize steam for industrial uses which steam is not returned to the system, and consequently a large evaporator capacity must be installed in order to take care of the relatively large feed water make-up. In such a system it is necesary to return the heat of the evaporator vapor to the system and this may conveniently be done by means of the deaerating apparatus. In other steam power systems the amount of boiler feed make-up may be relatively small because little or no steam is taken from the system except by leakage and/or because the available supply of boiler feed water is relatively pure and uncontaminated. In systems of this kind the evaporator capacity would be comparatively small and it would then be necessary to revise the scheme for supplying heat to the deaerating apparatus, and in this case it might be found advantageous to supply this heat from the bleeder stage of a turbine.

These examples will serve to indicate a few of the many different hook-ups or connections of the various different apparatus used in a steam power system. A further object of the invention is therefore to adapt the deaerating apparatus to the scheme of various steam power systems with the least possible change in the layout of the system.

The invention will be better understood by referring to the accompanying drawings which illustrate by way of example a number of ways in which deaerating apparatus

may be used with steam power systems in accordance with the invention. These drawings are all diagrammatic. In these drawings

Fig. 1 is a view of a portion of a steam power system showing a deaerator of the bubble type receiving steam bled from a turbine;

Fig. 2 is a similar view showing a deaerator of the unsubmerged tube bundle type connected to a bleeder turbine;

Fig. 3 is a view showing a deaerator like that of Fig. 1 receiving heat from an evaporator and feed water heater;

Fig. 4 shows a deaerator of the type illustrated in Figs. 1 and 3 with the bubble pipe replaced by a submerged heating coil or tube bundle, the deaerator receiving its heat from an evaporator;

Fig. 5 shows an unsubmerged tube type deaerator supplied with heat from two separate evaporators; and

Fig. 6 shows a complete steam power system except for the boiler including a deaerator and bleeder feed water heaters.

Referring now to the accompanying drawings and particularly to Fig. 1, the deaerator here shown comprises a shell 10 into which the water to be deaerated is admitted through a pipe 11. The water entering through pipe 11 at the top of the deaerator descends through the upper portion of the shell 10 which forms a rain chamber 12 and collects in a body of liquid 13 at the bottom of the shell. Any form of trays, baffles or other distributing means may be provided within the shell 10 to cause the water to be finely subdivided as it traverses the rain chamber.

The oxygen, air and other non-condensible gases are withdrawn from the deaerator through the outlet pipe 14 by any suitable means (not shown). The completely deaerated water is withdrawn from the apparatus at the bottom through pipe 15 by means of a feed pump 16 and may be passed through a feed heater 17 and thence through pipe 18 to the boiler or other appropriate part of the system.

The system includes a turbine 19 which receives steam through pipe 20 and which is provided with an exhaust pipe 21. The primary or principal source of heat for the deaerator 10 consists of steam which is bled from one of the lower stages of the turbine through pipe 22 at a relatively low temperature and pressure, the position of the bleeder stage being chosen to give steam at the desired temperature. This steam enters the rain chamber 12 at the point 23 just above the liquid level and serves to heat the water as it descends in finely divided form through the rain chamber. As the steam contacts with the falling water it condenses and is added to the body of water 13. The bubble pipe 24 consists of a pipe positioned near the bottom of the shell 10 having perforations in its surface so as to allow steam to be ejected through these perforations directly into the body of liquid. This bubble pipe is supplied with steam through a connection 25 from a different stage of the turbine 19 where the steam is at a higher temperature than that supplied by the pipe 22.

The heating of the water in the rain chamber by means of the principal heating steam entering at 23 causes the air and other gases to be released from occlusion in the water to such an extent that the water in the body of water 13 is substantially completely deaerated. The steam discharged through the apertures of the bubble pipe 24 causes a violent agitation or ebullition of the body of liquid 13 both on account of the velocity with which is emerges through the apertures and also because of the additional heat which it imparts. This agitation and further boiling of the liquid prevents the enrichment thereof with gases by contact of the body of liquid with the vapor and gases in the rain chamber. It furthermore carries the deaeration a little farther or adds a final deaeration kick before the deaerated liquid is withdrawn through the pipe 15.

The total quantity of steam bled from the turbine through pipes 22 and 25 is so proportioned by means of valves (not shown) to the amount of water entering the deaerator through pipe 11 as to produce a temperature of the mixture which is the same as that of the primary steam supplied through pipe 22, but by far the greater amount of steam comes through the primary supply pipe 22 from the low pressure low temperature source, namely the lower stage of the turbine where the greater part of the energy in the steam has been extracted by the turbine in doing mechanical work.

Thus according to the invention the principal heating steam for the deaerating apparatus is taken from a relatively low temperature source of supply in relatively large quantity, and the secondary heating steam is taken from a relatively high temperature source of supply in relatively small quantity. This permits the employment as the primary heating means of the most economical kind or quality of steam. If the steam for both the primary and secondary supplies to the deaerating apparatus were taken from the same source, it would be necessary to take it all from the higher stage of the turbine where the pipe 25 is connected, in order to provide the desired temperature for final deaeration.

Referring now to Fig. 2 of the accompanying drawings, the arrangement shown here is similar to that shown in Fig. 1 aside from the type of deaerator employed. This form of deaerator comprises a shell 26 having a comparatively large tube bundle 27 arranged at its lower part but above the level of the body

of liquid 28. The principal heating steam enters at the point 29 from the lower stage of the turbine and heats the water in the rain chamber by direct contact therewith as above described in connection with Fig. 1.

In its downward fall through the deaerator the finely divided water attains most of its temperature rise by the heat imparted from the primary source (through line 22) and is brought to its final temperature by the heat imparted from the secondary source (through the line 25) in heat transfer relation through the tube bundle. The result of this heat transfer is the intense ebullition in film form of the water traversing the bundle, through which action a moderate percentage of the water is evaporated, which vapor carries off the last remaining particles of air. The vapor thus evolved commingles and coacts with the primary source of steam in its contacting with and heating of the falling water in the rain chamber.

Condensate from tube bundle 27 passes into a trap 30 and thence through pipe 31 it is led into the rain chamber where it assists to some slight extent in heating the liquid, and is itself subjected to deaeration.

With this type of deaerator the advantages arising from the present invention are somewhat greater than with the type of deaerator shown in Fig. 1 since with this form of deaerator the secondary steam will be supplied at a greater difference in temperature from the primary steam.

In Fig. 3 of the drawings a deaerator like that shown in Fig. 1 is furnished with steam from two sources of supply at different temperatures in a somewhat different manner. Here the primary heating means for the deaerator which is led into the rain chamber at point 23 is the vapor from an evaporator 32. The heating coils of this evaporator are supplied with steam at any suitable higher temperature and pressure through a pipe 33 from any suitable source. The water supply to the evaporator enters through pipe 34. The evaporator coil drains pass into a trap 35 and thence through a pipe 36 to the bubble pipe 24 of the deaerator.

If it is desired, the feed heater 17 may be supplied with steam through a pipe 37 from the same source as that which feeds evaporator 32. The coil drains from this feed heater, after passing through a trap 38, may be led through a pipe 39 to join the coil drains in pipe 36 from the evaporator.

When the deaerating apparatus is supplied with separate sources of heating steam derived from an evaporator in accordance with the invention I have just described, the temperature of the principal heating steam supplied from the evaporator shell may be regulated by varying the amount of steam fed to the evaporator through valve 40. The saturated temperature of the steam in the heating chamber, i. e. the coils of the evaporator will usually be 35 to 45° F. higher than the evaporator shell pressure and the temperature corresponding to the pressure in the deaerator shell so that the contained heat in the drains from the evaporator heating chamber will on entering the collected water 13 in the deaerator impart an appreciable amount of heat which in the form of flash will cause considerable agitation. The heating drains from heater 17 will act in a similar manner. There will preferably be no control valve in evaporator vapor line 23 because the evaporator capacity may be entirely controlled by valve 40 in the evaporator heat supply line, so that at all times the pressure and temperature of the evaporator vapor will exactly correspond with the pressure in the deaerator. For this reason there will be no lessening of the preferred operating temperature difference in the evaporator.

By supplying the deaerator with steam from two sources in this manner, no change need be made in the size of the evaporator in order to accommodate the operation of the deaerator. If, however, the steam from the vapor space of the evaporator were sent both into the deaerator shell and into the bubble pipe, it would be necessary to operate the evaporator at a higher temperature in order to provide the desired action of the superior temperature of the bubble pipe. This would necessitate that the evaporator produce all of its vapor at a higher temperature, and, particularly when the tube bundle type deaerator is employed in place of a bubble pipe deaerator, requiring 10 to 30° F. higher temperature for the secondary steam, the size of the evaporator would have to be materially increased.

In Fig. 4 a third type of deaerator has been illustrated. This deaerator operates in a manner quite similar to the bubble type of apparatus shown in Figs. 1 and 3, the main difference being that the secondary heating steam transfers its heat to the body of liquid in the bottom of the deaerator through a surface transfer means such as a relatively small tube bundle, the condensate from this tube bundle being returned to the rain chamber of the deaerator.

This deaerator also comprises a shell having a rain chamber 41 at its upper portion and a secondary deaeration zone at its lower portion within which is the body of liquid 42. Submerged in this liquid is a relatively small tube bundle 43. The water to be deaerated enters as before at the top through the pipe 11 and the non-condensible gases are withdrawn through pipe 14. Also the deaerated water is withdrawn at the bottom through pipe 15 by means of pump 16.

The principal heating means is supplied through pipe 44 from the vapor space of an evaporator 45 as in the case of Fig. 3, the

evaporator being supplied with water through pipe 46. Relatively high temperature heating steam for the evaporator 45 enters through a pipe 47 and the coil drains pass out through a trap 48 and pipe 49 into the submerged tube bundle 43. The condensate from tube bundle 43 passes through pipe 51 and valve 53 to the rain chamber at 52. The function of valve 53 is by its variable restriction to impose an appropriate back pressure on said condensate so as to maintain it at a sufficiently high temperature for appropriate transfer of its heat through the walls of the tubes to the collected water. If the full temperature of the evaporator heating steam is desired in the tube bundle the trap 48 may be omitted and valve 53 may be omitted and a suitably positioned trap may be incorporated in line 51.

In operation the steam from the evaporator shell heats the incoming liquid in the rain chamber 41 by direct contact as in the case of the deaerators previously described, suitable trays or baffles being provided for distributing the water in a finely divided spray. The heated and deaerated water collects in a body 42 at the bottom, and is given a secondary deaeration by means of the tube bundle 43. In this case the mechanical agitation of the liquid in the body of liquid 42 which is produced by the velocity of the steam admitted by the bubble pipe in the deaerators of Figs. 1 and 3 is absent. However, sufficient agitation is produced by the ebullition of the liquid 42 by heat transferred through the tube bundle. This secondary heating thus prevents enrichment of the liquid 42 with gas as before, and provides a finishing step of deaeration.

Again the size of the evaporator 45 does not have to be increased in order to accommodate the deaerator in the system as would be the case if the steam both for contact heating and for the secondary heating were both supplied by the vapor from the evaporator, instead of being taken from independent sources of different temperature.

In many steam power systems a plurality of evaporators are included instead of merely a single evaporator, and deaerating apparatus can be readily associated with such a system in accordance with my invention. Ordinarily in such a system the lines from the vapor spaces of all of the evaporators of the plant would be joined together and connected both to the deaerator shell and tubes or bubble pipe. This necessitates that all of the evaporators be operated at a higher temperature than necessary in order to supply heat at the heat level required by the tubes or bubble pipe or, in other words, by the secondary heating. This required higher vapor pressure of evaporators not only in general greatly increases the expense of the necessary transfer surface but at times makes it necessary to heat the evaporators by steam from a still higher extraction point of the turbine which causes a significant power decrement to the power system.

In Fig. 5 of the accompanying drawings an unsubmerged tube bundle deaerator is shown connected with a pair of evaporators in accordance with the invention whereby the principal heating means for the deaerator is supplied by the vapor from one evaporator, and the secondary heating means is supplied by the vapor from the other evaporator. The deaerator here is similar to the one described in connection with Fig. 2, the water entering at the top through pipe 11 and descending through a rain chamber where it is brought into contact with the principal heating means.

Descending further, the water and condensed steam or vapor strike the tubes of tube bundle 27 which are maintained at a higher temperature, say for example some 12° above the temperature of the rain chamber. An intense ebullition of the films of liquid on the tubes is thus produced as previously described in connection with Fig. 2, and this filming ebullition and consequent evaporation of a portion of the water as it traverses the tube bundle produces the secondary or final deaeration. The vapor produced by the tubes 27 also forms a rising blanket of relatively clear vapor, that is, vapor free from gas above the body of liquid 28 which prevents the enrichment of this liquid with gas.

In this embodiment of the invention the principal heating steam is supplied to the rain chamber at the point 29 through pipe 54 which leads from the vapor space of an evaporator 55. The higher temperature steam or vapor for the tubes 27, that is, for the secondary heating, is fed through a pipe 56 from the vapor space of a second evaporator 57. The evaporator coils 58 and 59 may receive their steam through a common supply pipe 60 from any suitable source of steam at an appropriate temperature. The drains from these coils are led back into the boiler feed supply system at any convenient point. Water is supplied to the evaporators 55 and 57 through the pipes 61 and 62. The condensate from tube bundle 27 is conducted into the rain chamber of the deaerator through trap 30 and pipe 31.

In the usual installation of steam power systems the vapor spaces of all the evaporators are joined together and arranged to feed both the primary and secondary heating means of the deaerator so that all of the evaporators are subjected to the temperature hardship of being operated to produce heating steam for the deaerator at the higher temperature requirements of the secondary heating means. However, by connecting the evaporators and deaerator in accordance with the present invention only evaporator 57 need be

operated at the higher temperature. In the usual installation of the invention evaporator 57 need be but about one-quarter the size of evaporator 55 so that the major portion of the evaporator system may be operated at the lower temperature, and the temperature hardship is imposed upon only a comparatively small part of the system.

In present day practice in the installation of steam power systems it has been found extremely advantageous to heat the feed water to within substantially 75° to 100° of the vaporization temperature corresponding to the pressure at which the boiler of the system is operated before allowing the water to enter the boiler. This heating of the boiler feed water can be most economically accomplished in a plurality of separate heaters through which the feed water passes successively, the water thereby being heated in steps to successively higher heat levels or temperatures, instead of being heated to the final temperature at one operation in a single heater. In this way steam at different suitable temperatures for the individual feed heaters can be taken from different stages of the turbine after a portion of its energy has been removed in doing useful mechanical work in the turbine.

In associating a deaerating apparatus with such a system it must be done in such a way as not to interfere with the desired operation of the turbine, feed heaters and other apparatus of the system and in Fig. 6 of the accompanying drawings I have shown a deaerator of the unsubmerged tube type fitted in between the intermediate and high temperature feed heaters.

The turbine 63 receives its steam from the boiler (not shown) through a supply pipe 64. The exhaust from the turbine is led through a conduit 65 to the usual condenser 66 and the condensate is withdrawn from the condenser through pipe 67 by means of a boiler feed pump 68 and delivered through a pipe 69 to the first stage or low temperature feed heater 70.

Feed heater 70 is supplied with low pressure, low temperature steam through a pipe 71 which leads from a low pressure stage of turbine 63. The feed water, which enters this heater at about 85° F. is therefore raised in temperature to in the neighborhood of perhaps 140° F. at which temperature it leaves feed heater 70 through connection 72 and enters the next or intermediate stage heater 73.

Heater 73 is supplied with steam through a pipe 74 from an intermediate stage of the turbine where the pressure is for example, around 23 pounds absolute. The temperature corresponding to this pressure is 235° F. and the water therefore might issue from heater 73 at about 230° F. The water thus heated, is carried through line 75 to the top of the deaerator 76 which is provided with a rain chamber 77 and a tube bundle 78 above the liquid level of the body of liquid 79. The condensate from heater 73 after passing trap 101 is conveyed through line 102 to the shell of the first stage heater 70 where it contributes to the temperature rise of the feed water entering this heater through line 69.

Continuing our assumed figures, a desirable rise in temperature in deaerator 76 would raise the temperature of the deaerated water to around 270° F., and this water is led through line 80 to the third stage feed heater 81.

Third stage heater 81 receives steam through line 82 from a relatively high pressure stage of turbine 63. Assuming that this stage pressure is 121 pounds absolute, the saturated temperature corresponding thereto is about 342° F. and heater 81 will therefore heat the feed water to about 336° F. at which it is fed through pipe 83 to the boiler.

In associating the deaerator 76 with a stage heating system in accordance with my invention, an evaporator 84 is provided, the coils 85 of which receive the steam through a pipe 86 from line 82 and hence from the same source as feed heater 81. The vapor space of evaporator 84 is joined through line 87 with the rain chamber 77 of the deaerator and the principal heating means is therefore supplied by the evaporator vapor. The amount of steam delivered to the evaporator coils will be regulated in accordance with the percentage of make-up required. The temperature of the evaporator vapor and the temperature of the deaerated water will at all times be substantially equal. Water for the evaporator 84 is supplied through pipe 88 and it is in this way that the boiler feed make-up is added to the boiler supply.

The condensate or drains from the coils 85 which are at a relatively high temperature with respect to the evaporator vapor are led through a trap 89 and line 90 to a flash tank 91. The drains from feed heater 81 may, if desired, also be led through trap 92 and line 93 to the same flash tank 91 so that their heat is added to the heat of the drains from evaporator 84. The vapor space of the flash tank 91 is connected through pipe 94 with the tube bundle 78, and the discharge from this tube bundle passes through a trap 95 and pipe 96 into the rain chamber 77.

The drains entering the flash tank 91 from lines 90 and 93 being relatively hot water, a considerable amount thereof vaporizes or flashes into steam under the reduction of pressure in the flash tank. The transfer surface or tube bundle 78 is so proportioned with respect to the flash tank 91 that the temperature of the flash tank will be maintained at about 285° F., or some 15° higher than the rain chamber and outlet of the deaerator. The vapor passing through pipe 94 into the

tube bundle is therefore at the right temperature to effect appropriate secondary deaeration by means of the tube bundle. The hot water which does not flash to steam in the flash tank is conducted through pipe 97 and is added to the water in the rain chamber wherein it is subject to deaeration.

By this arrangement of the apparatus the principal heating means for the deaerator 76 comes from the vapor space of evaporator 84 which may conveniently be operated at the proper temperature to produce the desired rise in temperature of the feed water as it passes through the deaerator. Inasmuch as the drains from evaporator 84 and heater 81 are eventually added to the body of liquid 79 they contribute to a certain extent in raising the temperature of this liquid. The relative quantities of heat furnished by the coil drains and by the evaporator vapor are such, however, that the coil drains produce a relatively small proportion of the temperature rise. Thus, for example the total rise in temperature between the point where the water enters the top of the deaerator and the point where it leaves the deaerator is in the example given 40°, and of this temperature rise about 34° is supplied by the evaporator vapor, about 2° by the evaporator coil drains, and about 4° by the heater drains.

The secondary heating means for the deaerating apparatus is supplied by the flash from high temperature drains at the appropriate temperature to produce the most efficient operation of the deaerator and yet no penalty in the form of increased temperature of operation of the evaporator, or increased size of the evaporator, is placed upon the power system.

If common practice were resorted to the high temperature drains would be passed directly into the rain chamber. If then the "shocking (i. e. secondary) deaeration" were undertaken by vapor from the evaporator the evaporator vapor would have to be maintained at a pressure corresponding to say 15° higher temperature which would necessitate a considerably larger evaporator. Furthermore, there would have to be a reducing valve or other control in the vapor line supplying the principal heating means so that the proper temperature relation would be present in the tubes in order to effect transfer therefrom.

I claim:

1. In a steam power system, a deaerating apparatus having a primary heating means and a secondary heating means, an evaporator having its vapor space arranged to deliver steam to said primary heating means, a flash tank, means for conducting the drains from the evaporator heating chamber to said tank, and means for conducting the vapor from said flash tank to said secondary heating means of the deaerating apparatus.

2. In a steam power system, a deaerating apparatus having a primary heating means and a secondary heating means, an evaporator having its vapor space connected to supply steam to said primary heating means, a flash tank, means for conducting the drains from the heating chamber of the evaporator to said tank, means for delivering the vapor from said tank to said secondary heating means, and means for delivering the water from said flash tank to the deaerating apparatus.

3. In a steam power system including an evaporator and a feed water heater, a deaerating apparatus having a primary heating means and a secondary heating means, means for conveying the vapor from the evaporator to said primary heating means, a flash tank, means for conveying the drains from the heating chamber of said evaporator and feed heater to said flash tank, and means for conducting vapor from said tank to said secondary heating means.

4. In a steam power system the combination of a turbine, a plurality of successive feed water heaters deriving heating steam at appropriate temperatures from various stages of said turbine, a deaerator arranged to receive water from one of said feed heaters and deliver it to the next higher temperature feed heater, said deaerator having a primary heating means and a secondary heating means, an evaporator supplied with steam from the same stage of the turbine as said higher temperature feed heater, means for conducting steam from the vapor space of said evaporator to said primary heating means, and means for conveying heat of the drains from said evaporator heating chamber to said secondary heating means.

5. In a steam power system the combination of a turbine, a plurality of successive feed water heaters deriving heating steam at appropriate temperatures from various stages of said turbine, a deaerator arranged to receive water from one of said feed heaters and deliver it to the next higher temperature feed heater, said deaerator having a primary heating means and a secondary heating means, an evaporator supplied with steam from the same stage of the turbine as said higher temperature feed heater, means for conducting steam from the vapor space of said evaporator to said primary heating means, a flash tank, means for conveying the drains from the heating chamber of said evaporator to said flash tank, means for conducting the vapor from said tank to said secondary heating means, and means for directing the water from said tank into said boiler feed system.

6. In a steam power system including an evaporator and a feed water heater, receiving heating steam at substantially the same temperature as the evaporator, a deaerating apparatus having a primary heating means and a secondary heating means, means for

supplying heating steam to said evaporator and to said feed heater, means for conveying the vapor from the evaporator to said primary heating means, and means for conveying the drains from the heating chamber of said evaporator under reduced pressure to said secondary heating means.

7. In a steam power system including an evaporator and a feed water heater, a deaerating apparatus having a primary heating means and a secondary heating means, means for supplying heating steam to said feed water heater and to said evaporator, means for conveying the vapor from the evaporator to said primary heating means, a flash tank, means for conveying the drains from the heating chamber of said evaporator to said flash tank, and means for conducting vapor from said tank to said secondary heating means.

8. In a steam power system the combination of a boiler feed system including a plurality of successive feed water heaters deriving heating steam at appropriate temperatures from various stages of said turbine, a deaerator arranged to receive water from said system and deliver it to one of said feed heaters, said deaerator having a primary heating means and a secondary heating means, an evaporator supplied with steam from the same stage of the turbine as said feed heater, means for conducting steam from the vapor space of said evaporator to said primary heating means, and means for conveying heat of the drains from said evaporator heating chamber to said secondary heating means.

9. In a steam power system the combination of a turbine, a boiler feed system including a plurality of successive feed water heaters deriving heating steam at appropriate temperatures from various stages of said turbine, a deaerator arranged to receive water from said system and to return it thereto after deaeration, said deaerator having a primary heating means and a secondary heating means, an evaporator supplied with steam from the same stage of the turbine which supplies heating steam to one of said feed heaters, means for conducting steam from the vapor space of said evaporator to said primary heating means, and means for conveying heat of the drains from said evaporator heating chamber to said secondary heating means.

10. In a steam power system the combination of a turbine, a boiler feed heating system including a plurality of successive feed water heaters deriving heating steam at appropriate temperatures from various stages of said turbine, a deaerator arranged to receive water from one of said heaters and deliver it to said boiler feed system, said deaerator having a primary heating means and a secondary heating means, an evaporator supplied with steam from a stage of said turbine, means for conducting steam from the vapor space of said evaporator to said primary heating means, and means for conveying heat of the drains from said evaporator heating chamber to said secondary heating means.

11. In a steam power system the combination of a turbine, a boiler feed heating system including a plurality of successive feed water heaters deriving heating steam at appropriate temperatures from various stages of said turbine, a deaerator arranged to receive water from said system and to deliver it to one of said feed heaters, said deaerator having a primary heating means and a secondary heating means, an evaporator supplied with steam at substantially the same temperature as the heating steam for said feed heater, means for conducting steam from the vapor space of said evaporator at said primary heating means, and means for conveying heat of the drains from said evaporator heating chamber to said secondary heating means.

In testimony whereof I affix my signature.

STANLEY BROWN.