

July 6, 1926.

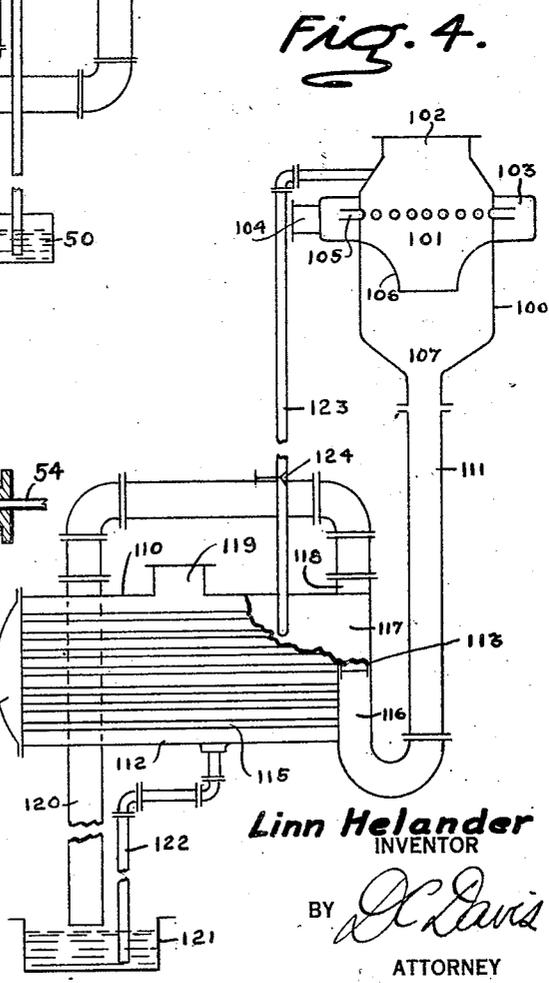
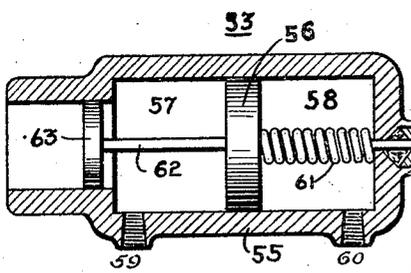
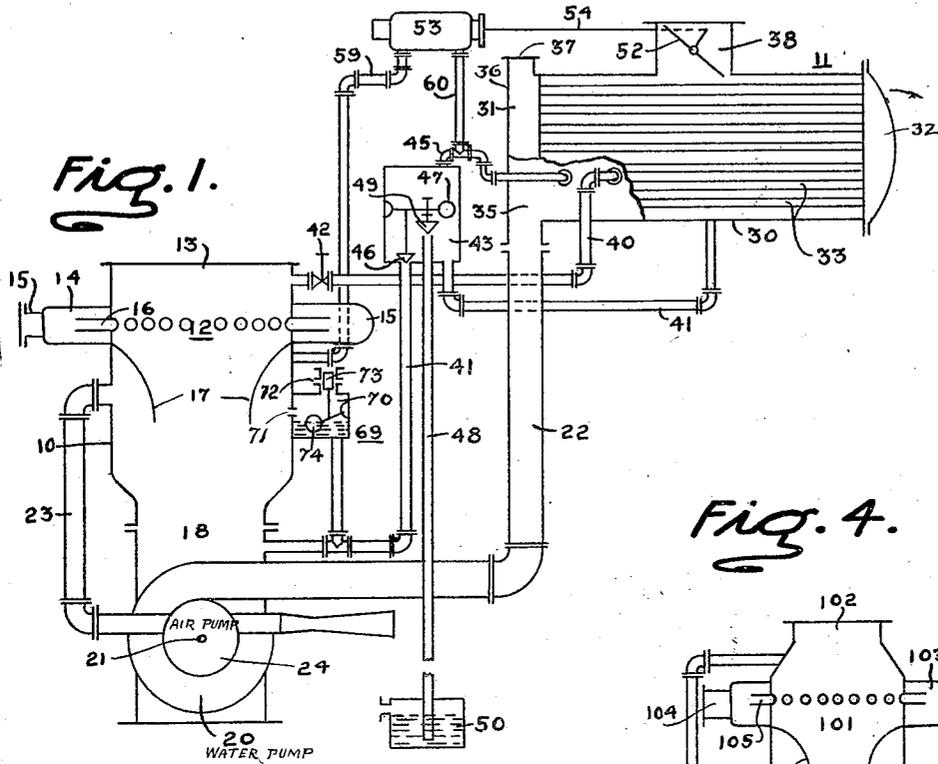
1,591,822

L. HELANDER

HEATER

Filed Sept. 12, 1923

2 Sheets-Sheet 1



WITNESSES  
*W. R. Wakefield*

**Linn Helander**  
 INVENTOR  
 BY *J. Davis*  
 ATTORNEY

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HEATER

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2 Sheets-Sheet 2

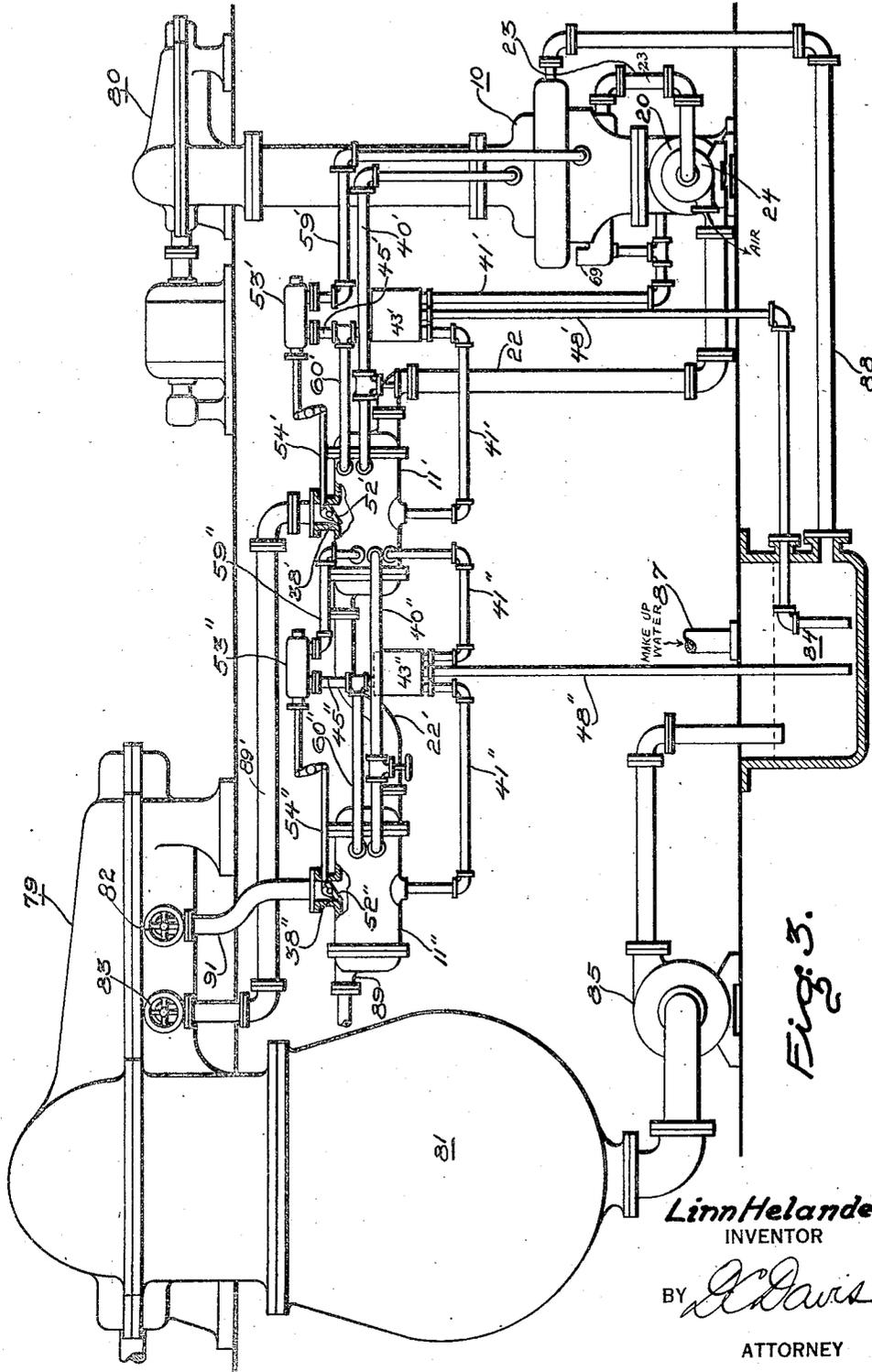


Fig. 3.

Linn Helander  
INVENTOR

BY *[Signature]*

ATTORNEY

# UNITED STATES PATENT OFFICE.

LINN HELANDER, OF EAST PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

## HEATER.

Application filed September 12, 1923. Serial No. 662,349.

This invention relates to multiple stage heaters, more particularly to heaters in which steam is utilized for heating water for industrial processes, boiler feed, and the like, and it has for an object to provide a heater of the character designated which shall utilize the heat of the steam more economically than has been possible heretofore in heaters of this character. It is a further object of my invention to provide means in connection with an apparatus of the character designated which shall insure the primary steam consumer, as for example, a steam turbine from which the steam for process heating is taken, from injury due to flooding of the heaters and the steam connections leading thereto.

These and other objects, which are made more manifest in the further description of my invention may be attained by the apparatus herein described and illustrated in the accompanying drawings in which Fig. 1 is a diagrammatic view partially in section and partially in elevation of a multiple stage heater embodying my invention; Fig. 2 is a sectional elevation of a piston motor for controlling the supply of steam to respective pressure stages of the heater; Fig. 3 is a diagrammatic view of a modification of the construction illustrated in Fig. 1 employed in conjunction with a main turbine and a house turbine and Fig. 4 is a diagrammatic view of a still further modification of the construction illustrated in Fig. 1 in which barometric connections displace the pumps necessary to circulate the water to be heated through the heating system.

According to the present invention, I employ a jet heater of any suitable type, in construction similar to the ordinary barometric or jet condenser, as a first-stage heater, the water therefrom being discharged into the circulating passages of a surface heater of any ordinary construction. I have found it advisable to have at least one jet or contact heater arranged in the series because of its deaerating qualities. The discharge water from the surface heater may pass to one or more surface heaters, or directly to a device for utilizing the heated water. This arrangement is particularly adapted for use of low-pressure steam and permits the water to be heated by the absorption of heat from steam at a high degree of vacuum in the first-stage heater and to pass into the second and any succeeding heaters at an increased temperature, and there absorb further heat of steam at increasing absolute pressures. A further economy is attained by leading the non-condensable fluids from the last stage heater progressively through the several heaters, thus recovering both the heat and the water carried by the uncondensable fluids, and finally discharging the non-condensable fluids from the first-stage heater only after contact with the cold first-stage cooling water and after the heat and water vapor has been recovered therefrom as completely as possible. The invention further contemplates the conveying of condensate from the surface heaters to the first-stage jet heater so that, where pumps are necessary for removing the condensate and air, a single air pump and a single condensate pump, preferably mounted on the same shaft suffice for all heaters. Further means are provided for forming a liquid seal in a condensate pipe leading from the surface heaters and means for controlling the relative pressure conditions in the several heaters is also provided.

In Fig. 1, I show a multiple stage heater composed of a first-stage jet heater 10 and a second-stage surface heater 11. The jet heater 10 comprises a mixing chamber 12, a steam inlet 13, an annular water box 14 surrounding the mixing chamber and having an inlet 15 and nozzles 16 arranged to deliver sprays of water across the mixing chamber 12. The mixing chamber 12 is provided at its lower portion with a converging conoidal apron 17 which serves to direct fluid from the mixing chamber 12 to a well 18 disposed at the lower portion of the heater. A centrifugal water pump 20 mounted on a power shaft 21 is arranged to withdraw water from the well 18 and discharge it through a pipe 22. A non-condensable fluid pipe 23 leads from the upper portion of the well 18 to a pump 24 which is preferably mounted upon the same power shaft 21 as the pump 20, the discharged non-condensable fluids being delivered therefrom to the atmosphere.

The second-stage heater 11 may be of any well-known construction and as shown comprises a cylindrical shell 30, the ends of which are closed by water boxes 31 and 32. Tubes 33 traverse the space within the cylin-

drical shell 30 and are secured in the water boxes in the ordinary manner. The water box 31 is provided with an inlet compartment 35 with which the pipe 22 communi-  
 5 cates and an outlet compartment 36 from which the heated water is discharged through an outlet 37 to other heaters or to use. A steam inlet 38, adapted for connec-  
 10 tion with a source of steam supply, is centrally disposed in an upper portion of the shell 30.

The two heaters are connected one to the other through the water pipe 22, already de-  
 15 scribed, and also through a vent pipe 40 and a condensate discharge pipe 41. The vent pipe 40 leads from a central portion of the steam space within the cylindrical shell 30 to an upper portion of the mixing chamber 12, and is preferably provided with a valve  
 20 42. Interposed in the condensate discharge pipe 41 is a water sealing or regulating chamber 43, situated adjacent to and at the level of the bottom of the heater 11. The pipe 41 leads from the bottom of the steam chamber of the heater 11 into the chamber  
 25 43, and a second section of pipe 41 leads from the bottom of the chamber to the well 18 of the first-stage heater 10. A vent 45 connects the upper portion of the regulat-  
 30 ing chamber 43 to an upper portion of the steam chamber of the surface heater, so that the level of the condensate in the regulating chamber, is at all times the same as that in the heater 11. A valve 46 is arranged with-  
 35 in the regulating chamber 43 to control discharge of condensate therefrom to the well 18 of the first-stage heater, and is actuated by a float 47 in such manner that the valve 46 cuts off the flow of condensate when the  
 40 level of the condensate in the heater 11 falls to a predetermined low level.

A barometric overflow pipe 48 having an admission valve 49 may also communicate  
 45 with the regulating chamber 43, the arrangement being such that the valve is opened by the float 47 upon an excessive rise of condensate therein. The excess condensate is conveyed through the pipe 48 to a water seal  
 50 50 disposed at such level with respect to the regulating chamber as to maintain a barometric head in the pipe 48.

It may be desirable under certain condi-  
 55 tions to regulate the steam supply of the second stage heater in response to pressure conditions within the first-stage heater. To accomplish this, I place a valve 52 in the steam inlet 38 of the second-stage heater, which valve is arranged to be operated by a piston motor 53 through a rod 54. As  
 60 shown in Fig. 2, the piston motor 53 has a casing 55 divided by a piston 56 into a first-stage pressure chamber 57 and a second-stage pressure chamber 58 connected respectively through pipes 59 and 60 to the first  
 65 and second-stage heaters. The piston 56 is

subjected on the side to which the rod 54 is secured to the pressure prevailing within the second-stage heater and to a supple-  
 70 mental variable pressure by a suitable spring 61. On the opposite side, it is subjected to the pressure prevailing within the first-stage heater 10. Rigidly secured to the piston 56 by a rod 62 is an auxiliary piston 63. This auxiliary piston, which may be of different  
 75 diameter than the piston 56, is subjected on one side to the pressure prevailing within the first-stage heater and on its opposite side to the pressure of the atmosphere. Should it be desired to operate the heaters  
 80 10 and 11 at pressures above atmosphere, hydraulic pressure may be employed to act upon the outer face of the auxiliary piston 63. The difference in pressure between the atmosphere and that of the first-stage heater determines the amount of force exerted by the auxiliary piston 63 through the rod 62 upon the piston 56.

The first-stage heater is preferably provided with a vacuum breaker 69 of any well-known construction so arranged as to place  
 85 the heater in communication with the atmosphere upon an excessive rise of water in the well 18, in order to stop the flow of water through the nozzle 16, and thus to prevent the flooding of the steam connections leading to the heater. As shown, a chamber  
 90 70 communicates with the upper portion of the well 18 through a port 71 and with the atmosphere through a port 72. A valve 73 controls the port 72 and is operatively connected to a float 74, the arrangement being such that upon water in the well 18 reaching  
 95 the level of port 71 the chamber 70 is immediately filled with water, the float 74 raised to open the valve 73, thus placing the interior of the heater 10 in communication with the atmosphere.

The operation of the apparatus is readily understood from the above description. Steam at a low absolute pressure, prefer-  
 100 ably exhaust steam from a prime mover, enters the first-stage through the inlet 13. The water to be heated enters the water box 14 through the inlet 15 and is sprayed into the steam in the mixing chamber 12 through  
 105 the nozzles 16. Within this chamber, the steam is condensed and the temperature of the water raised. The heated water falls into the well 18 whence it is conveyed by the pump and the pipe 22 to the second-stage surface heater 11. The partially heated water makes two passes through the tubes 33 of the surface heater 11 and is discharged therefrom through the port 37. The second-stage heater is supplied with steam at  
 110 higher pressure and temperature than the first-stage heater and consequently further heats the water passing through the tubes 33 thereof.

Since steam normally contains a small 130

amount of air and other non-condensable fluids, a certain quantity of these non-condensable fluids collects in each of the heaters. These fluids are economically removed and the heat largely recovered by venting them from the surface heater to the jet heater where they mingle with the incoming steam and are thus brought into intimate contact with the spray jets of cold water which condenses the entrained condensable vapors and absorbs the heat of these fluids. The non-condensable fluids from both heaters are then withdrawn from the first-stage heater through the pipe 23 and are discharged by the pump 24 into the atmosphere.

The condensate from the steam utilized in heating the water in the surface heater 11 is preferably conveyed to the well 18 of the heater 10 by means of the pipe 41, in order that a single pump 20 may serve to withdraw the water from both heaters. Since the pressure in the heater 11 is higher than that in the heater 10, it is necessary to interpose a sealing means in the condensate pipe 41 to prevent incompletely condensed steam from passing from the surface heater into the jet heater. The sealing means employed in the construction illustrated in Fig. 1 comprise a chamber 43 in which a certain level of water is at all times maintained. When the water is at a higher level a float 47 operates to open the valve 46 and permits the flow of condensate from the regulating chamber 43 to the well 18. If for any reason an excessive amount of water should collect in the chamber 43, the valve-controlled barometric overflow 48 drains away the excess and thus prevents the heater 11 from being flooded.

Flooding of the first-stage heater is also prevented by the provision of the vacuum breaker 70 which is designed to place the heater 10 in direct communication with the atmosphere upon a predetermined rise of water level therein. Each heater is thus provided with an independent means for preventing the flooding of the heater and the steam connections leading thereto, an important desideratum when the steam for heating is supplied from the exhaust or from bleeder passages of a prime mover.

The pressure control valve 52 serves to regulate the quantity of steam entering the second-stage heater in response to pressure conditions within the first-stage heater. Any increase of pressure in the first-stage heater will be transmitted to the first-stage chamber 57 of the piston motor 53. Within this chamber, the additional pressure moves the piston 56 to compress the spring 61 an amount sufficient to produce an equilibrium of forces. This movement of the piston 56 opens wider the valve 52, whereupon additional steam is admitted through the inlet

38 to the second-stage heater 11 until such time as the pressure builds up a sufficient amount to move the piston 56 to restrict the supply. In this manner, the relative pressures prevailing within the second-stage heater 11 are maintained at predetermined higher values than those prevailing within the first-stage heater 10.

The relative pressure values prevailing within the first and second-stage heaters may be represented by a straight-line graph. By selecting two relative pressure values such as 5 pounds absolute in the first-stage heater corresponds to 10 pounds absolute in the second-stage heater, and 10 pounds in the first-stage heater corresponds to 12 pounds absolute in the second-stage heater, a straight-line may be established. From this line, the relative pressures prevailing simultaneously in the heaters throughout the entire range of operation may be ascertained.

Should the level of the water in the first-stage heater reach a height sufficient to open the vacuum breaker, the first-stage chamber 57 of the valve motor 53 is placed in communication with the atmosphere. The additional pressure present therein moves the piston 56 to compress the spring 61 to open wider the valve 52, whereupon additional steam is admitted to the second-stage heater 11 until such time as the pressure prevailing therein is sufficient to throw the piston 56 together with the rod 62 and the auxiliary piston 63 to the left the required distance to completely close the valve 52 in the steam inlet of the second-stage heater. This operation is entirely automatic and when vacuum conditions have been re-established in the heater 10 the valve 52 is re-opened to permit steam to enter the second-stage heater as under normal operating conditions.

Water heating apparatus constructed as above described operates with a high degree of thermal efficiency, since all the heat of the steam is utilized as completely as possible, including the heat of the non-condensable fluids which is largely extracted during the passage of these fluids through heaters of progressive lower temperature prior to their withdrawal from the system. A further advantage arises in the need of but a single non-condensable fluid pump, and a single water pump, an arrangement which permits a considerable economy of motive power for the operation of the pumps and a reduced cost in the manufacture of the multiple stage heater.

In Fig. 3, I have illustrated a diagrammatic arrangement of apparatus similar to that above described in relation to Fig. 1 and for the purpose of this specification a detailed description thereof is deemed unnecessary. The arrangement of apparatus comprises a main turbine 79 with its con-

denser 81 and a house turbine 80 exhausting into a combined jet condenser and first-stage heater 10. A plurality of tubular surface heaters 11' and 11'' are arranged in series with the first-stage heater 10. The water to be heated is collected in a feed tank 84 which receives the condensate removed from the main condenser 81 by the pump 85. In addition thereto, make-up water is supplied through a suitable connection 87 which may, if desired, be provided with automatic regulating means for maintaining a predetermined level of water in the tank. The water is removed from the tank 84 and conveyed through the conduit 88 by means of the vacuum prevailing in the first-stage jet heater 10, in which it mingles with the exhaust from the house turbine 80. Within this combined heater and condenser, the exhaust steam is condensed and the temperature of the water is raised. The heated water is then conveyed by the pump 20 and conduit 22 to the second-stage heater 11' and thence through the conduit 22' to the third-stage heater 11''. The second and third-stage heaters 11' and 11'' are of the surface type, and may be of any well-known construction, but are preferably similar to that described in relation to the second-stage heater shown in Fig. 1. After being discharged from the third-stage heater 11'' at 89, the water may be utilized for feeding boilers, or, a portion thereof may be used for that purpose and a portion utilized for industrial purposes.

The temperature and pressure maintained in the second and third-stage heaters 11' and 11'' are relatively higher than that maintained in the heater preceding so that the temperature of the water is successively increased by being passed in series through the three heaters. Steam of a pressure slightly higher than that corresponding to the vacuum prevailing in the first-stage jet heater 10, is preferably supplied from a bleeding connection 83 provided in the main turbine 79, and conveyed through the conduit 89' to the inlet nozzle 38' of the second-stage heater 11'. Steam of still relatively higher pressure is taken from a second bleeding connection 82 provided in the main turbine 79, and conveyed through the conduit 91 to the inlet nozzle 38'' of the third-stage heater 11''.

In order to provide automatic means for maintaining the aforesaid relatively higher pressures in each succeeding heater in the series, I provide regulating devices 53' and 53'' and a vacuum breaker 69. The vacuum breaker is similar to that described in relation to and shown in Fig. 1, and by which the first-stage jet heater 10 is placed in communication with the atmosphere upon an excessive rise of water therein. The regulating devices 53' and 53'' control respectively

through rods 54' and 54'' the valves 52' and 52'' in the steam inlet nozzles 38' and 38'' of the heaters 11' and 11''. They are similar in construction to the regulating devices described in relation to and shown in Figs. 1 and 2 and serve to control the amount of steam entering the succeeding heater in response to the pressure prevailing within the heater preceding in the series. These pressures in the heaters are conveyed to the regulating devices through suitable conduits 59', 59'', 60' and 60''. The regulating device 53' also includes means for completely closing the valve 52' upon a functioning of the vacuum breaker 69, and the regulating device 53'' closes the valve 52'' upon a predetermined rise of pressure within the second-stage heater 11'.

The air and non-condensable fluids contained in the steam are economically removed from the heaters and the heat largely recovered therefrom by venting through the conduit 40'' the third-stage heater 11'' into the second-stage heater 11' in which a relatively lower pressure is maintained. This heater is in turn vented by means of the conduit 40' into the first-stage jet heater 10. The non-condensable fluids from both surface heaters and the jet heater are finally removed from the jet heater through the conduit 23 by means of an air pump 24 and discharged to the atmosphere. In this way, a single air pump is sufficient for all three heaters.

The condensate from the steam utilized in heating the water in the surface heaters is conveyed to the first-stage jet heater in a manner similar to the removal of the non-condensed fluids. Condensate from the third-stage heater 11'' is removed therefrom, by the second-stage heater 11' through the conduit 41'', and the first-stage heater 10 in turn removes the condensate from the second-stage heater 11' through the conduit 41'. Within the first-stage jet heater, it combines with the water to be heated and is removed therefrom by the pump 20 and discharged to the system. As the heaters are maintained at relatively lower pressures in the direction of flow of the condensate, sealing means, similar to that described in relation to and shown in Fig. 1, are provided in the conduits 41' and 41'' for preventing incompletely condensed steam from passing between the heaters. Each of the sealing or regulating chambers 43' and 43'' is vented by means of the conduits 45' and 45'' to the respective surface heaters 11' and 11'' from which it receives condensate, and may be so located as to maintain a predetermined level of water therein. In order to insure that this level of water may not reach such height as may endanger the main turbine 80, barometric overflow pipes 48' and 48'' may be provided similar to

that shown in Fig. 1. These pipes discharge into the feed tank 84 and have their outlet portions submerged therein.

The above outlined arrangement of apparatus provides a very efficient and highly economical method of heating water. It is especially adapted for installations which are required to produce a large amount of hot water for industrial processes in addition to that required for feeding the boilers. A considerable amount of water may be heated to any desired temperature by combining a sufficient number of surface heaters of required capacity, with the jet or contact heater. Irrespective of the number of heaters employed, a single air pump and a single water pump only are required, thereby entailing the expenditure of a minimum amount of energy for the operation of the auxiliary machinery.

The multiple-stage heater illustrated in Fig. 4 represents a modified construction which is particularly adapted for use where ample head room is available for the installation of the apparatus. In this construction, no removal water pump is required, water being withdrawn from the heater by barometric connections. The first-stage heater 100 is similar to the first-stage heater 10, above described, and, as shown, comprises a mixing chamber 101, a steam inlet 102, an annular water box 103 having an inlet 104, and nozzles 105 for discharging jets of water across the mixing chamber. The mixing chamber is provided in its lower portion with a converging conoidal apron 106 which serves to deliver the heated water to a well 107 at the lower portion of the heater.

A second-stage surface heater 110 is located at a considerably lower level than the heater 100 and receives water from the well 107 through a semi-barometric connection 111. The second surface stage heater 110 may be of any well-known construction. As shown, it consists of a cylindrical shell 112, water boxes 113 and 114, and tubes 115, the latter traversing the space within the cylindrical shell and secured to the water boxes in the usual manner. The water box 113 is provided with an inlet compartment 116 with which the pipe 111 communicates, and an outlet compartment 117 from which the heated water is discharged through an outlet 118. A steam inlet 119 is suitably disposed in the cylindrical shell 112. The water delivered from the outlet 118 of the heater 110 passes downwardly through a semi-barometric connection 120 to a pump sump 121, the lower end of the barometric connection 120 being immersed in the water of the sump. The condensate from the heater 110 may be withdrawn by any suitable means through a pipe 122. As shown, the pipe 122 may lead to the sump 121,

where the barometric head is sufficient to drain the condensate from the heater 110. The discharge portion of the pipe is immersed in the water of the sump. A vent connection 123 leads from an upper portion of the steam chamber of the heater 110 to an upper portion of the mixing chamber 101 and is preferably provided with a valve 124. Automatic control means similar to that shown and described in relation to Figs. 1 and 2 may be provided.

The operation of the apparatus illustrated in Fig. 4 is similar to that already described in relation to Fig. 1. The water to be heated enters the first-stage heater through the inlet 104, water box 103 and nozzles 105, where it mingles with and condenses the steam admitted through the inlet 102 and then passes downwardly through the well 107 and barometric connection 111 to the surface heater 110. The water traversing the second-stage heater 110 is subjected to steam at a higher pressure and temperature than that delivered to the first-stage heater 100 and is finally discharged through the barometric connection 120 to the sump 121 from which the water is conveyed to use. The non-condensable fluids pass in a counter direction to the flow of water from the second-stage heater to the first-stage heater in order to utilize fully the heat of the steam. The condensate from the heater 110 may be mingled with the heated water or may be withdrawn independently for use if desired. It is to be understood that a plurality of surface heaters at successively lower levels may be utilized in the construction shown in Fig. 4, the heaters preferably receiving steam at successively higher pressures and temperatures so as to effect a gradual and constant heating of the water flowing therethrough.

While I have shown my invention in but three forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. A multiple-stage heater comprising a contact heater and a surface heater, means for delivering separate supplies of steam to each heater, means for passing water to be heated through the heaters in series, and means for venting the surface heater into the contact heater.

2. A multiple-stage heater comprising a contact heater and a plurality of surface heaters, means for delivering separate supplies of steam to each heater, the steam supplied to each successive heater being at a relatively higher pressure, means for passing

the water to be heated through the heaters in series, means for venting each heater, with the exception of the heater first in the series, into the heater of successively lower pressure, and means for withdrawing non-condensable fluids from the heater first in the series.

3. A multiple-stage heater comprising a first-stage contact heater and a second-stage surface heater, means for delivering separate supplies of steam to each heater, the steam delivered to the surface heater being at a higher pressure, means for passing water to be heated through the heaters in series, means for venting the surface heater into the contact heater, and means for withdrawing non-condensable fluids from the contact heater.

4. A multiple-stage heater comprising a first-stage contact heater and a second-stage surface heater, means for delivering separate supplies of steam to each heater, the steam delivered to the surface heater being at a higher pressure, means for passing water to be heated through the heaters in series, and means for delivering condensate from the surface heater into the contact heater.

5. A multiple-stage heater comprising a first-stage contact heater and a second-stage surface heater, means for delivering separate supplies of steam to each heater, the steam delivered to the surface heater being at a higher pressure, means for passing water to be heated through the heaters in series, means for delivering condensate from the surface heater into the contact heater, and means for withdrawing condensate from the contact heater.

6. A multiple-stage heater comprising a contact heater and a plurality of surface heaters, means for delivering separate supplies of steam to each heater, the steam supplied to each successive heater being at a relatively higher pressure, means for passing the water to be heated through the heaters in series, means for venting each heater, with the exception of the heater first in the series, into the heater of successively lower pressure, and means for delivering condensate from each heater, except the first in the series, into the heater of successively lower pressure.

7. A multiple-stage heater comprising a first-stage contact heater and a second-stage surface heater, means for delivering separate supplies of steam to each heater, the steam delivered to the surface heater being at a higher pressure, means for passing water to be heated through the heaters in series, means for delivering condensate from the surface heater into the contact heater, and means establishing a seal in said condensate delivering means for preventing the passage of steam therethrough.

8. A multiple-stage heater comprising a

contact heater and a plurality of surface heaters, means for delivering separate supplies of steam to each heater, the steam supplied to each successive heater being at a relatively higher pressure, means for passing water to be heated through the heaters in series, means for delivering condensate from each heater, with the exception of the heater first in the series, into the heater of successively lower pressure, and means establishing a seal in each of said condensate delivering means for preventing the passage of steam therethrough.

9. A multiple-stage heater comprising a first-stage contact heater and second-stage surface heater, means for delivering separate supplies of steam to each heater, the steam delivered to the surface heater being at a higher pressure, means for passing water to be heated through the heaters in series, means for delivering condensate from the surface heater into the contact heater, means establishing a seal in said condensate delivering means for preventing the passage of steam therethrough, said sealing means including a barometric overflow connection, whereby the level of condensate within the surface heater may be maintained within definite working limits.

10. A multiple-stage heater comprising a contact heater and a plurality of surface heaters, means for delivering separate supplies of steam to each heater, the steam supplied to each successive heater being at a relatively higher pressure, means for passing water to be heated through the heaters in series, means for delivering condensate from each heater, with the exception of the heater first in the series, into the heater of successively lower pressure, and means establishing a seal in each of said condensate delivering means for preventing the passage of steam therethrough, each of said sealing means including a barometric overflow, whereby the level of the condensate within the surface heaters may be maintained within definite working limits.

11. A multiple-stage heater comprising a first-stage contact heater and a second-stage surface heater, means for delivering separate supplies of steam to each heater, the steam delivered to the surface heater being at a higher pressure, means for passing water to be heated through the heaters in series, means for delivering condensate from the surface heater into the contact heater, means establishing a seal in said condensate delivering means for preventing the passage of steam therethrough, said sealing means including a barometric overflow connection, whereby the level of condensate within the surface heater may be maintained within definite working limits, said sealing means including a closed chamber so disposed as to contain condensate at a level of the conden-

sate in the surface heater, a barometric overflow communicating with said chamber, and a float controlled valve for permitting discharge of condensate into said overflow when the condensate in the surface heater rises above a predetermined level.

12. A multiple-stage heater comprising a plurality of heaters, means for delivering separate supplies of steam to each heater, interconnecting means for passing water to be heated through the heaters in series, and means responsive to the pressure in each preceding heater for controlling the delivery of steam to the heater next in the series.

13. A multiple-stage heater comprising a plurality of heaters, means for delivering separate supplies of steam to each heater, interconnecting means for passing water to be heated through the heaters in series, and a device responsive to the pressure in each preceding heater for controlling the delivery of steam to the heater next in the series, said device including means for automatically shutting off the delivery of steam upon a predetermined rise in pressure in the preceding heater in the series.

14. A multiple-stage heater comprising a first-stage heater and a second-stage heater, means for delivering separate supplies of steam to each heater, interconnecting means for passing water to be heated through the heaters in series, and means responsive to pressure in the first-stage heater for controlling the delivery of steam to the second-stage heater.

15. A multiple-stage heater comprising a first-stage contact heater and a second-stage surface heater, means for delivering separate supplies of steam to each heater, means for passing water to be heated through the heaters in series, and means responsive to the pressure in the contact heater for maintaining predetermined greater pressures in the surface heater.

16. A multiple-stage heater comprising a first-stage heater and a second-stage heater, means for delivering separate supplies of steam to each heater, the steam delivered to the surface heater being at a higher pressure, interconnecting means for passing water to be heated through the heaters in series, means responsive to pressure in the first-stage heater for controlling the delivery of steam to the second-stage heater, means for venting the second-stage heater into the first-stage heater, and means for withdrawing non-condensable fluids from the first-stage heater.

17. A multiple-stage heater comprising a first-stage contact heater and second-stage surface heater, means for delivering separate supplies of steam to each heater, means for passing water to be heated through the heaters in series, and means responsive to

the pressure in the contact heater for controlling the delivery of steam to the surface heater.

18. A multiple-stage heater comprising a first-stage contact heater and a second-stage heater, means for delivering separate supplies of steam to each heater, means for passing water to be heated through the heaters in series, a vacuum breaker for the contact heater operable upon a predetermined rise of water level therein, and means operable when the vacuum breaker acts for shutting off the steam supply to the second-stage heater.

19. A multiple-stage heater comprising a first-stage contact heater and a second-stage surface heater, means for delivering separate supplies of steam to each heater, the steam delivered to the surface heater being at a high pressure, means for passing water through the heaters in series, a vacuum breaker for the contact heater operable upon a predetermined rise of water level therein, and a device responsive to the pressure in the contact heater for controlling the delivery of steam to the second-stage surface heater, said device including means for automatically shutting off the steam supply to the second-stage surface heater upon a functioning of the vacuum breaker.

20. A multiple stage heater comprising a first stage heater and a plurality of surface heaters, means for delivering separate supplies of steam to each heater, the steam supplied to each successive heater being at a relatively higher pressure, means for passing the water to be heated through the heaters in series, and means for venting each heater, with the exception of the heater of lowest pressure, into the heater of successively lower pressure.

21. A multiple stage heater comprising a first stage heater and a second stage surface heater, means for delivering separate supplies of steam to each heater, means for passing water to be heated through the heaters in series, means for venting the second stage heater to the first stage heater, and means for withdrawing non-condensable fluids from the first stage heater.

22. A multiple stage heater comprising a first stage heater and a second stage heater, means for delivering separate supplies of steam to each heater, the steam delivered to the second stage heater being at a higher pressure, means for passing water to be heated through the heaters in series, and means for venting the second stage heater into the first stage heater.

In testimony whereof, I have hereunto subscribed my name this 15th day of August 1923.

LINN HELANDER.