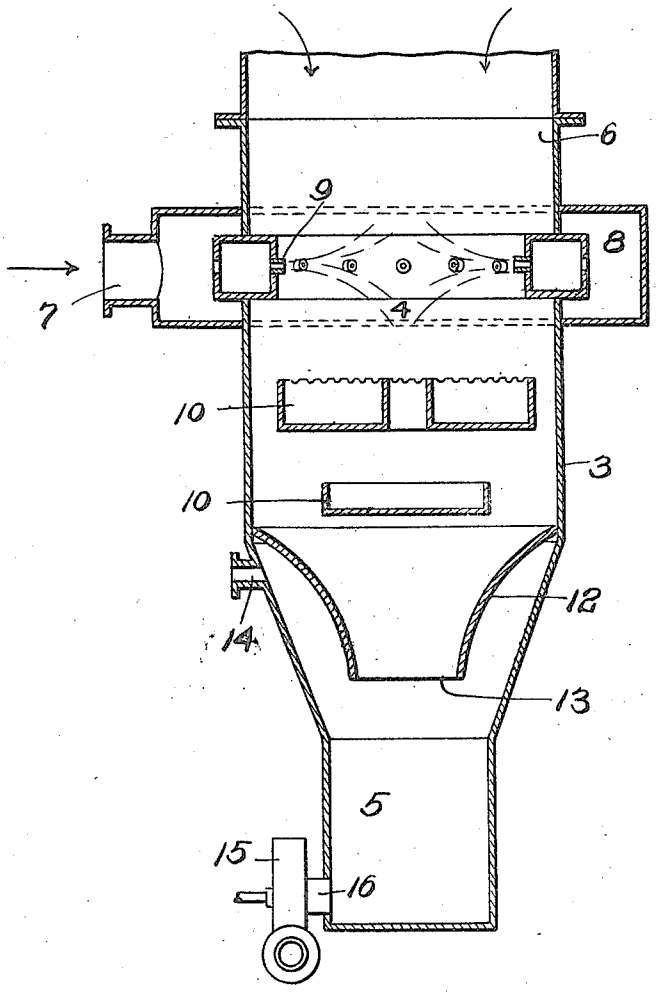
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J. A. POWELL

COMBINATION HEATER

Filed Aug. 18, 1920



WITNESSES

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INVENTOR

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UNITED STATES PATENT OFFICE.

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COMBINATION HEATER.

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To all whom it may concern:

Be it known that I, JAMES A. POWELL, a citizen of the United States, and a resident of Reading, in the county of Berks and State of Pennsylvania, have made a new and useful Invention in Combination Heaters, of which the following is a specification.

This invention relates to feed water heaters and has for an object the production of a heater which will operate effectively under widely varying conditions of steam and water flow without occasioning waste of steam.

A further object is the production of a heater having all the advantages of a jet type and also of a tray type heater and which eliminates the objectionable features of both these types of heaters.

A further object is the production of an improved feed water heater in which improved means are employed for venting the heater for the purpose of discharging the air or non-condensable vapors, which may be delivered thereto with the steam or water.

These and other objects which will be made more apparent throughout the further description of the invention are attained by means of a heater embodying the features herein described and illustrated. In the single sheet of drawings accompanying and forming a part hereof, I have diagrammatically illustrated a heater embodying my invention.

It is well established that the overall efficiency of a power plant is increased by heating the feed water before it is delivered to the boilers. To accomplish this most economically it is necessary to avoid a waste of heat in the expulsion of air or non-condensable vapors from the heater. Two losses are occasioned by improperly venting heaters: First, the heat carried away from the heater with the air or non-condensable vapors occasions a loss; and second, the increased pressure in the heater, occasioned by an excessive amount of air present, causes the auxiliary apparatus, exhausting into the heater, to operate at a materially increased back pressure and consequently the economy of the auxiliary apparatus will be much poorer than would be the case if the heater were properly vented. It is usual in power house practice to heat the feed water with steam exhausted from one or more of the steam driven auxiliaries. It is well understood that the flow of water to a heater is governed by the load on the main power generating unit, while the flow of steam from the auxiliaries is more constant. With heaters now in use, it is considered best to so proportion the auxiliaries delivering steam to the heater that the heater will perform economically at the most constant load on the main generating unit. With loads above or below this most constant load, there will be a loss of efficiency due, under an abnormal load, to improper venting of air, or, under a subnormal load, to excess steam. The load on the auxiliaries of a power plant is usually substantially constant; consequently, each auxiliary delivers a substantially constant amount of exhaust steam per unit of time. In proportioning the delivery of steam to the heater, the approximate amount of steam necessary to accomplish the desired preheating is ascertained and the requisite number of auxiliaries are connected so as to exhaust into the feed water heater. Under such conditions, the amount of exhaust steam delivered to the heater is substantially constant; whereas, as has been said, the delivery of water to the heater varies with the load on the main units. This occasions temperature fluctuations within the heater, and a consequent loss when the temperature is above or below the most economical temperature, which is governed by the flow of steam and water with constant pressure within the heater. With feed water heaters, such as are now in use, the range of permissible temperature fluctuations is limited, and in addition, the heaters are so constructed that they not only waste steam under conditions of low water flow, but actually accentuate the waste by occasioning an increase in the delivery of heating steam to the heater under conditions of low water flow. This increase in the amount of heating steam delivered is occasioned by the fact that the decrease in the amount of feed water delivered to the heater decreases the capacity of the heater to absorb heat and thereby condense the steam delivered to it. The surplus steam in the heater increases the back pressure on the auxiliaries and this in turn makes it necessary for the auxiliaries to receive more steam in order to accomplish the work required of them. As a result, the governing mechanisms of the auxiliaries automati-

cally deliver more steam to the auxiliaries and the auxiliaries exhaust more steam into the heater. The surplus steam delivered to the heater must be discharged therefrom and it is ordinarily vented to the atmosphere with a resultant waste of heat and also of water. The waste of heat reduces the efficiency of the entire plant and primarily of the feed water heater. The accompanying waste of water may be exceedingly objectionable particularly on ship board or in localities where water suitable for feed water purposes is scarce.

One of the objects of my invention is the production of a feed water heater, which overcomes the above enumerated disadvantages of the present commercial heaters and which operates with high efficiency under widely varying conditions of water flow.

Referring to the drawings:

In the drawings, I have illustrated in vertical section a heater embodying my invention. The casing 3 encloses a heating chamber 4 and also a collecting chamber 5, which receives preheated feed water combined with the condensate resulting from the condensation of steam within the chamber 4. The casing is also provided at or near its upper end with a steam admission port 6, through which steam is delivered to the heating chamber. This port may communicate with the exhaust ports of one or more auxiliaries or it may communicate with any suitable source of steam supply. As shown, water to be heated is delivered through a port 7 to an annular chamber 8, which surrounds the cylindrical casing 3. This chamber is adapted to deliver water to spray nozzles 9, which are arranged in a series around the internal wall of the chamber 8 and are constructed to break up the jets of water issuing from them into a mass of separate drops or sprays and to discharge the spray in such a way that it is intimately mixed with the steam entering the port 6 and passing through the chamber 4. As shown, the spray nozzles 9 are adapted to discharge the water in substantially horizontal jets toward the center of the casing 3. With this arrangement, a barrier composed of water spray or a mass of separate drops of water is interposed between the port 6 and the chamber 4 during normal conditions of water flow; consequently, all the steam entering the heater will be intimately mixed with the spray and will not only give up its heat to the water in its passage through the heater, but will be condensed. Under conditions of low water flow, the nozzles 9 are not capable of delivering a sufficient amount of water to form the necessary spray barrier and consequently, the mixing of the steam and water is not as effective, nor is the complete condensation of the steam accomplished. It is, therefore, necessary to provide means for accomplishing the necessary heat transfer from the steam to the water under conditions of low flow. In the heater illustrated, I have provided trays 10 in the heating chamber 4 so located and arranged that water issuing from the nozzles 9 will be received by the trays under all conditions of water flow. With this arrangement, the feed water will not only be retained in the heater in contact with the steam, but will be broken up into a mass of drops or thin curtains in overflowing from one tray to another and finally to the collecting chamber 5. The upper tray 10 may be an annular tray so disposed within the heating chamber that it will receive the smallest quantity of water issuing from the spray nozzles 9. It may also be provided with notches 11 for the purpose of insuring a substantially uniform delivery of water around its overflow edges, and also for insuring a breaking up of the overflow into a mass of separate drops or minute streams. Any number of trays may be employed, and they will preferably be so arranged that the lower trays receive at least a portion of the water overflowing the upper trays. With such an arrangement, the feed water is not only retained for an appreciable period within the heating chamber, but it is broken up into sheets, curtains, or minute streams as it falls through the heating chamber toward the collecting chamber 5. As shown, I have interposed a converging annular apron or baffle 12 between the heating chamber and the collecting chamber 5. This apron is so arranged that all water issuing from the chamber 4 and striking it is deflected toward the center of the casing 3 and enters the collecting chamber through a port 13, which is materially less in area than the cross sectional area of the heating chamber 4. The apron surrounds what may be termed a combining passage, which tends to more or less unite the separate streams of water falling through the chamber 4 and to render the water more effective as an air entraining medium. The apron 12 also shields an air offtake port 14, through which air and non-condensable vapors accumulating in the heater are discharged. Any suitable means for exhausting the heater may be employed, and if the heater is designed to operate with an internal pressure less than atmospheric pressure, it may be equipped with an air pump or air ejector which communicates with the port 14. It will, of course, be apparent that the port 14 may communicate directly with the atmosphere, if the conditions are such that the normal pressure within the heater is above atmospheric pressure.

In the drawings, I have shown a pump 15 arranged to withdraw the heated feed water from the collecting chamber 5. As shown,

the inlet 16 of the pump communicates directly with the collecting chamber.

The operation of the heater is, in general, as follows: The condensate or water available for feed water purposes is delivered to the port 7 under a head, which will promote sufficient flow through the nozzles 9 to break up the streams issuing from the separate nozzles into a mass of separate drops or sprays. The spray so formed encounters or is encountered by the heating steam entering the heater through the port 6. The intermingling of the steam and water occasions a heat transfer from the steam to the water and a resultant condensation of at least a portion of the steam. Even under normal conditions of water flow, the trays 10 receive water issuing from the nozzles 9, and function to retain the water in the heating chamber and discharge it in the form of curtains, or a multiplicity of streams downwardly through the heating chamber and the combining passage, into the collecting chamber 5. Consequently, any steam which passes the ring of nozzles 9 is subjected to the cooling action of the water retained within the trays 10 and also of the water falling from the trays through the chamber 4. It may be desirable to so proportion the trays that they will accomplish 25% of the heating under normal conditions of flow. This, of course, means that the nozzles will be so arranged and constructed that the jets issuing from them will accomplish 75% of the heating under normal operating conditions. It will be apparent that a decrease in the flow of water through the nozzles will materially incapacitate the nozzles; first, because the heat absorbing capacity of the water will be decreased due to the fact that less water is delivered; and second, because the nozzles will be incapable of adequately breaking up the water into a mass of separate drops or sprays. The water issuing from the nozzles under such conditions will be less intimately mixed with the incoming steam and will be less effective in taking up heat from the steam. If the trays 10 were not interposed in the path of incoming water, the water would fall directly through the heating chamber into the collecting chamber, and as a result, a decrease in the flow would occasion a material reduction in the heat absorbing capacity of the water. The trays, however, retain the water, are subjected on all sides to the steam within the heating chamber 4, and are so located and arranged that the water overflowing from them falls in a subdivided condition from one tray to the next as it progresses toward the collecting chamber. This materially minimizes the loss occasioned by a reduction in water flow and, as a matter of fact, produces a feed water heater which will operate effectively and efficiently throughout a wide range of variations in water flow. It will, of course, be apparent to those skilled in the art that as the spray issuing from the nozzles 9 becomes less effective as a heat absorbing and steam condensing medium, the trays become more effective. This results from the fact that under normal operating conditions, the temperature within the heating chamber is low, whereas, the temperature in this chamber increases as the water flow decreases. This increasing temperature increases the difference in temperature between the steam and the water and consequently, increases the heat absorbing capacity of the water contained within and overflowing the trays 10. In addition, the decreasing flow through the jets increases the length of the period during which the water is retained in the trays.

One of the principal features of my invention is that the air or non-condensable vapors issuing from the heater are withdrawn from the heater at a point of minimum air saturation or point of greatest air pressure. This is advantageous, because it prevents a waste of steam and also because the air and vapors so withdrawn are heavier than would be the case if they were withdrawn from a portion of the heater subjected to the heat of the incoming steam. This last mentioned advantage is important where means, such as an ejector or an air pump is employed for accomplishing the discharge of air from the heater. It is usual practice to locate the air vent port of a heated at or near the top of the heater. Consequently, heating steam is discharged through these ports with the air. This occasions a waste of steam and a resultant reduction in the efficiency of the heater. Most heaters are so designed that this waste is maintained at a minimum under normal conditions of operation. It has, however, been stated that such heaters are ineffective under conditions of low water flow and that their ineffectiveness results in an increase in the amount of steam delivered to the heater and a material increase in the pressure within the heater. This pressure will relieve itself through the vent with a resultant waste of steam. In addition, the accumulation of air within the heater decreases the heat absorbing capacity of the heater, since the air acts somewhat as a heat insulator. Air is also objectionable because it occasions back pressure on the auxiliary supplying steam to the heater, and this back pressure is independent of the steam condensing capacity of the heater. Waste of steam is obviated with a heater embodying my invention, since under the worst conditions of flow, steam must pass around the trays and through at least one of the curtains of water dropping from the trays

and finally through the cone-shaped member 12, before it can pass through the port 14. As a result, a heater embodying my invention is effective and operates efficiently under wider ranges of flow variations than is the case with other heaters, and the back pressure decreases within the heater as the flow decreases up to a predetermined decrease in flow.

The water falling through the combining passage tends to entrain the air and non-condensable vapors and to deliver them to the collecting chamber partially compressed or at least reduced in volume by reason of the cooling action of the water. As a result, the heating chamber 4 is maintained relatively free of air under widely varying conditions of water flow.

Another feature of my invention is that it embodies the desirable characteristics of both the spray and the tray type heater. The spray heater is very efficient while operating under normal or moderate conditions of water flow but is exceedingly inefficient under conditions of low flow. On the other hand the tray type heater is efficient under conditions of low water flow. In addition, the trays of my heater are advantageous since they provide means for permitting the deposition of foreign material carried by the water and its subsequent removal, whereas all foreign material carried by the water must necessarily be delivered to the boiler with the feed water where the ordinary spray or jet type of heater is employed.

While I have illustrated and described what I now consider to be the preferred embodiment of my invention, it will be apparent to those skilled in the art that various changes, substitutions, omissions and additions may be made to the apparatus illustrated without departing from the spirit and scope of my invention as set forth by the appended claims.

What I claim is:

1. A feed water heater comprising a casing having a steam inlet port and a water inlet port near the upper end thereof, a water discharge port near the bottom thereof and an air discharge port between the steam inlet port and the water discharge port, in combination with nozzles located within the casing and communicating with the water inlet port for delivering water in the form of spray across the path of the steam entering the steam inlet port, and trays located below said nozzles and adapted to receive water delivered therefrom.

2. A feed water heater comprising a casing having a steam inlet port and a water inlet port located near the top thereof and a water discharge port and an air offtake port located near the bottom thereof, in combination with means communicating with the water inlet port for delivering a mass of spray across the interior of the chamber, trays located within the casing below said means and adapted to receive water therefrom, and a combining cone located between said trays and the air offtake and water discharge ports.

3. A feed water heater comprising a casing having a steam inlet port, and a water inlet port located near the top of the casing, an air offtake port and a water discharge port formed therein, means located within the casing and communicating with said water inlet port for discharging a water spray across the interior of the casing, means located within said casing below said first mentioned means for collecting water discharged therefrom and for delivering a multiplicity of streams of water through the interior of the casing, and a downwardly converging cone-shaped member between said means and said air offtake port.

4. A feed water heater comprising a casing having a steam inlet port adjacent the upper end, a water discharge port adjacent the lower end, and an air offtake port intermediate said inlet and discharge ports, a series of spray nozzles located within the casing and communicating with said water inlet port for discharging a water spray across the interior of the casing, a series of trays located within the casing between the nozzles and the air offtake port and adapted to receive water from said nozzles, and a converging combining cone located between said trays and said water discharge port and forming a shield for said air offtake port.

5. In a feed water heater, a casing having a steam port formed in the top thereof, a water inlet port, located adjacent said steam port, a water discharge port located near the bottom thereof, and an air offtake port between the water inlet port and the water discharge port, in combination with a series of nozzles communicating with the water inlet port and located within the casing adjacent said water inlet port, for discharging a spray of water across the interior of the casing, a series of trays located within the casing below said nozzles and a downwardly converging combining cone, located below said trays and above said air offtake port.

In testimony whereof, I have hereunto subscribed my name this 4th day of August, 1920.

JAMES A. POWELL.