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STEAM DRYING APPARATUS

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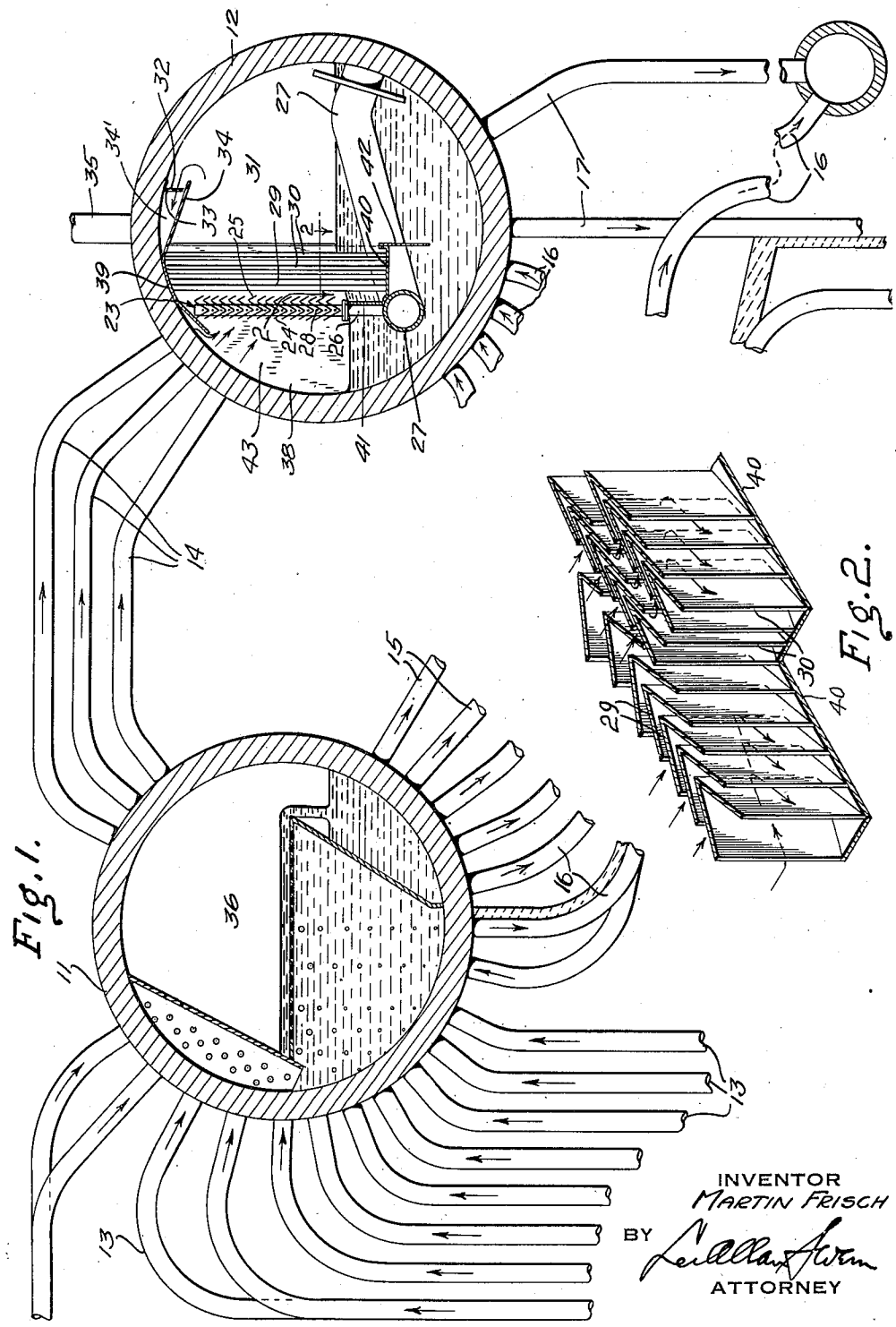


Fig. 1.

Fig. 2.

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STEAM DRYING APPARATUS

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1 Claim. (Cl. 183—109)

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This invention relates to steam generators, and pertains to the purification of the steam generated therein. More particularly, the invention provides novel means for removing entrained circulating water from the steam and drying the steam.

In one form of the invention, the circulation of the steam generator is arranged so that all the steam generated is delivered to one of a plurality of upper drums in which novel means are employed for separating water from the steam released in the drum, both above and below the water level therein. From this drum, the separated steam and relatively steam-free water pass through separate groups of circulator tubes to a second upper drum which is otherwise connected with the circulatory system of the unit only by downcomer tubes. The steam entering the second drum, flows through a novel steam washer in which any of the originally entrained moisture remaining in the steam, and which ordinarily has a high concentration of solids, will be removed by fresh feed water of a relatively low solid concentration. Thereafter the washed steam is dried by passing it through a novel drying device before leaving the drum. It will be understood that the invention is not limited to this particular multi-drum arrangement. Apparatus embodying the invention may be employed in only one upper drum, and in this case one or more of the steam purifying steps referred to may be omitted if desired, depending upon the operating conditions and requirements of a given installation.

The invention will be understood from the following description when considered in connection with the accompanying drawings forming a part thereof, and in which:

Fig. 1 is a vertical sectional view of an upper portion of a steam generator embodying one form of the invention, and

Fig. 2 is a fragmentary section view in perspective of a steam drying device of the invention taken on the line 2—2 of Fig. 1.

Like characters of reference refer to the same or to similar parts in both of the views.

Referring to the drawings, the steam generator illustrated has two upper steam and water drums 11 and 12. Connected to the drum 11 both above and below the normal water level therein, are steam generating or riser tubes 13, and extending from the drum 11 to the drum 12 are groups of steam circulating and water circulating tubes 14 and 15 respectively. Connected to the lower portion of the drum 11 are downcomer tubes 16, while other downcomer tubes 17 are connected to the lower portion of the drum 12.

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Within the drum as shown in Fig. 1, is dewatering apparatus which dewaters the steam and water mixture discharged by tubes 13 into said drum. Such apparatus does not form a part of the present invention but is included to merely illustrate a form of steam generator having an improved boiler circulation due to an increased density of water entering the water circulators.

In the drum 12, the steam delivered thereto by the circulators 14 is subjected to a washing action in a steam washer of the general type disclosed in applicant's United States Patent No. 2,380,424, granted July 31, 1945, generally designated 23. As illustrated in Fig. 1 of the drawings, the steam washer comprises a plurality of horizontally extending, vertically spaced, generally V-shaped trough members 24 which extend longitudinally of the drum 12. Each trough member 24 has a relatively short flange 25 which extends downwardly and outwardly from the upper end of the leg thereof which is remote from the steam circulators 14. The upper edge of the leg of each trough member having the flange 25 may be disposed at the same elevation or at a somewhat lower elevation than the upper edge of the other leg of the trough member. The trough members are disposed in nested, but spaced, relationship with the lower edge of each, excepting the lowermost, located at an elevation lower than the upper edges of the trough member immediately below. The flange 25 is sufficiently long to cause the steam leaving the washer to change its direction of flow abruptly to eliminate as much as possible of the water entrained in the steam. The troughs 24 are supported by a plurality of spaced, vertically extending stand pipes 26 which are connected at their lower ends to the horizontally extending portion of a feed water inlet conduit 27. As shown, the stand pipes 26 pass through openings in the trough members and they are provided with discharge orifices 28 located just above the lower ends of the troughs. Fresh feed water is supplied through pipe 27 at such pressure in excess of the drum pressure as will fill the stand pipes 26 and flow into the trough members 24 through the orifices 28. The water will fill the troughs and will flow over the flanged upper edges of the troughs as will presently appear.

Steam drying means are located adjacent the steam washer 23 in the drum 12. As shown, such means comprise a row of separate, spaced V-shaped plates 29 adjacent but spaced from the washer, and two rows of separate, spaced V-shaped plates 30 adjacent but spaced from each other and the plates 29. The included acute angle

between the legs of the plates 30 is smaller than the equivalent angle of the plates 29, as clearly indicated in Fig. 2. The plates 29 and 30 are disposed with their edges vertical and with the plates of each row in nested, but spaced, relationship as shown, with the edge at the apex of the angle of each plate located within the area defined by the next adjacent plate. The number of rows of drying plates utilized will depend upon the extent to which the steam is to be dried.

Beyond the drying means in the drum in the direction of flow of the steam, is a relatively dry steam space 31, from which the steam flows through apertures 32 in a vertically disposed distributing plate 33 which extends longitudinally of the drum in the upper portion thereof. Secured to the lower edge of the plate 33 is a horizontally inclined plate 34, which with the plate 33 and the inner wall of the drum forms a dry steam chamber 34' from which purified steam enters one or more outlet nozzles or superheater connections 35.

The steam washer 23 and the several rows of drying plates or water eliminators 29 and 30, are suitably supported at their upper ends by a plate 39 which is secured to the inner wall of the drum. At their lower ends the drying plates are supported by a horizontal plate 40, which is disposed a substantial distance below the normal drum water level, thus effecting a seal. A vertical plate 41 which extends from the feed water inlet conduit 27 to a point just below the trough members 24 prevents steam from flowing below the washer. A skirt baffle 42 which extends downwardly from the inner edge of support plate 40, causes the circulating water entering the drum through circulators 15 to flow towards the inlets of the downcomers 17. The assembly of the steam washing and steam drying devices is enclosed adjacent each end of the drum by vertical closure plates 43, one of which is shown in Fig. 1, to prevent the by-passing of steam entering the drum 12, around either end of the washing and drying assembly.

In operation, the steam and water mixture entering the drum 11 will be dewatered in said drum, the separated water flowing through the circulators 15 to the water space of drum 12, while the dewatered steam will flow from the steam space 36 in the drum 11 through the circulators 14 to the steam space 38 in the drum 12.

From the steam space 38, the steam enters the washer 23 and flows therethrough and into the space between the washer and the first row of drier plates 29. The submerged apex of each trough member 24 will force the steam in the space 38 to flow downwardly into the water in the trough below. The fresh feed water delivered to the washer troughs through the apertures 28 in the stand pipes, is discharged from these apertures at a relatively high velocity with the result that the water in the washer troughs normally is not quiescent. Due to the fact that the washer extends substantially from the water level to the upper wall of the drum and for at least the greater part of the length of the drum, a large flow area is provided over which the steam may enter the washer troughs, so that the velocity of flow of the steam through the washer will be relatively low. Thus the time of contact of the steam with the fresh feed water will be relatively long, and the normal agitation of the water in the troughs which is increased by the entrance of the steam into the water and the somewhat higher velocity of the steam in passing

through the troughs as compared with the velocity in the steam space 38, will provide thorough contact between the steam and water and an adequate washing of the steam. The flow of steam through the washer will cause the water to flow from the washer over the flanged upper edges of the troughs and downwardly into the water in the lower part of the drum. The steam leaving the water in the troughs will impinge against the flanges 25 and will be forced to change its direction of flow abruptly from an upwardly inclined to a downwardly inclined direction, thus eliminating a substantial quantity of the water entrained in the steam. This eliminated water will flow downwardly into the water in the bottom of the drum. As the steam enters the space between the washer and the drier plates 29, the velocity of the steam is reduced due to the increase in the area available for the passage of the steam, and entrained water will drop out of the steam by gravity in this space before the steam enters the drier.

The washed steam flows into and through the passages between the drying plates 29, and in its flow through these passages, it is forced to change its direction of flow abruptly upon entering these passages and also in the zone between the apices of the plates. The entrained water will impinge upon and be deposited on the plates 29 in the areas adjoining the zones where the abrupt changes in direction of flow occur, and this water will drain down the plates without being re-entrained in the steam, due to the relatively low velocity of the steam through the drier and to the cohesive properties of the water and its adherence to the surfaces of the plates. The steam leaving the passages between the plates 29, flows into the space between the plates 29 and the adjacent row of plates 30, and in this space water will drop out of the steam by gravity. Thereafter the steam flows into and through the passages between the first row of plates 30, into the space between the rows of plates 30, and into and through the passages between the second row of plates 30. Entrained water will be eliminated in the same manner as described in connection with the plates 29 and the space between the washer and the drier plates 29, the only difference being that in flowing through the passages between the plates 30, the change in direction of flow of the steam is more abrupt. It will be perceived that the flow of steam is substantially at right angles to the flow of the water on the plates, the steam flowing horizontally and the water draining downwardly to the water in the bottom of the drum.

From the second row of drying plates 30, the steam flows into steam space 31 where it changes its direction of flow again, removing therefrom entrained moisture, and thence through the orifices 32 in the distributing plate 33 into the dry steam space 34'. In flowing through the plate 33, entrained moisture will impinge against the plate and will be removed from the steam. The distributing plate 33 causes the steam to be withdrawn from the steam space 31 substantially uniformly over the length of this space, and insures that the steam leaving the washers 23 will be distributed substantially uniformly over all the drier plates. From the steam space 34', the steam is withdrawn from the drum through the outlet nozzles or superheater connections 35.

With steam washers and with the driers embodying the invention, the velocity of the steam through and between these devices will be of the

order of magnitude of from one to three feet per second. A satisfactory washer for the purpose will be composed of troughs having a width of two inches between the outer ends of the legs, and a height (apex to base line) of two inches, and with the troughs spaced on a pitch of one inch. The drier plates 29 may have a width of two inches between the outer edges of the legs, and a depth (horizontal distance from apex to base line) of three inches. The drier plates 30 may be the same as the plates 29 excepting that their width will be one inch. The drier plates 29 and 30 may be spaced on a pitch of one and one half inches. It will be understood that these dimensions are given by way of example and are not to be construed as limiting the invention because other sizes of washer troughs and drier plates arranged on different pitches may be employed.

It will be understood that changes may be made in the form location and relative arrangement of the several parts of the apparatus disclosed herein without departing from the principles of the invention. For example, any one instrumentality such as the dewatering channels, the weir and apertured plate, the washer, or the drier, may be employed in the purification of steam alone or in combination with one or more of the other instrumentalities. In view thereof, it will be apparent that the invention is not to be limited excepting by the scope of the appended claim.

What is claimed is:

In steam generating apparatus having a drum and means for introducing steam into the drum, and means for drying the steam in the drum comprising a plurality of spaced, substantially parallel rows of separate vertically extending V-

shaped plates horizontally spaced, with the apex edge of one plate within the area bounded by the next adjacent plate in the same row, the included angle between the legs of the plates in one row being different from the corresponding angle of the plates of another row, the plates being disposed in the drum so that the steam to be dried flows in a substantially horizontal direction through the passages between the plates.

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