Jan. 25, 1955 M. FRISCH 2,700,376

APPARATUS FOR PURIFYING STEAM

Original Filed Jan. 24, 1941 4 Sheets-Sheet 1

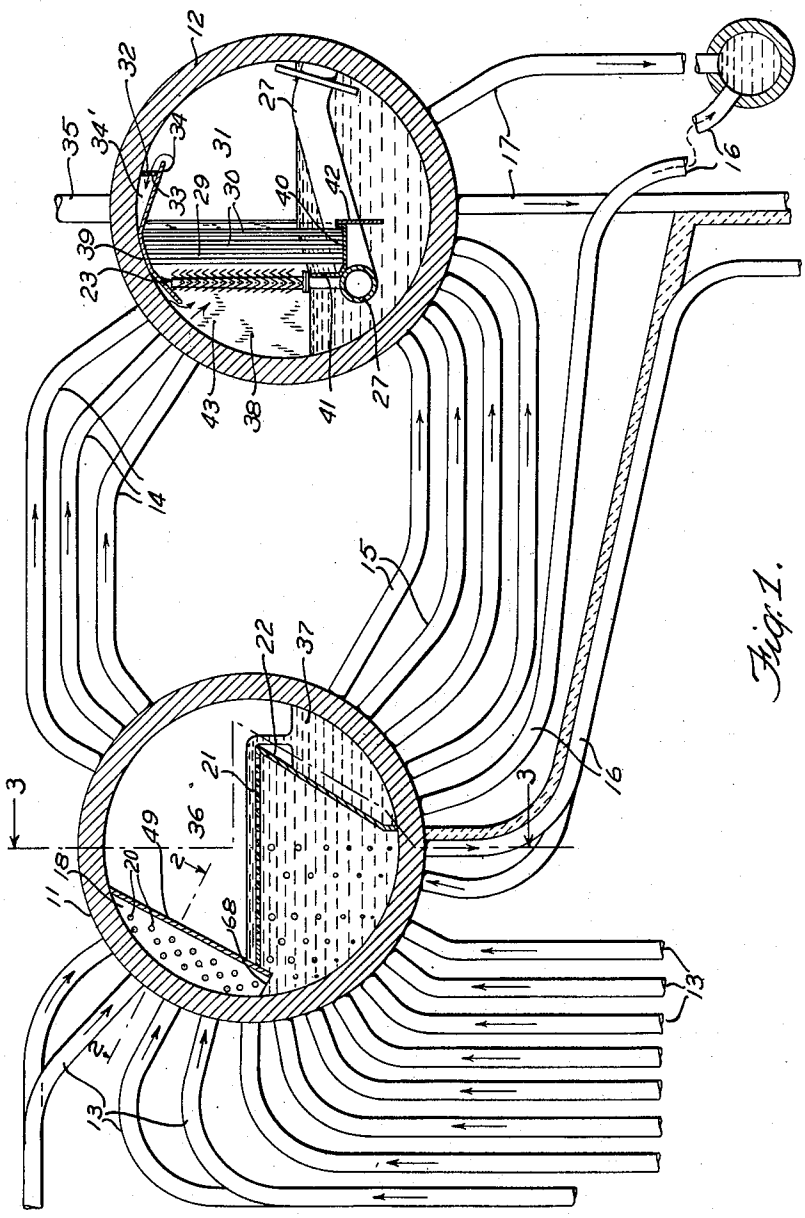


Fig. 1.

Inventor
MARTIN FRISCH

By

Attorney

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Fig. 2.

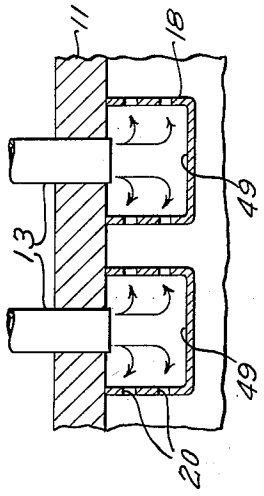
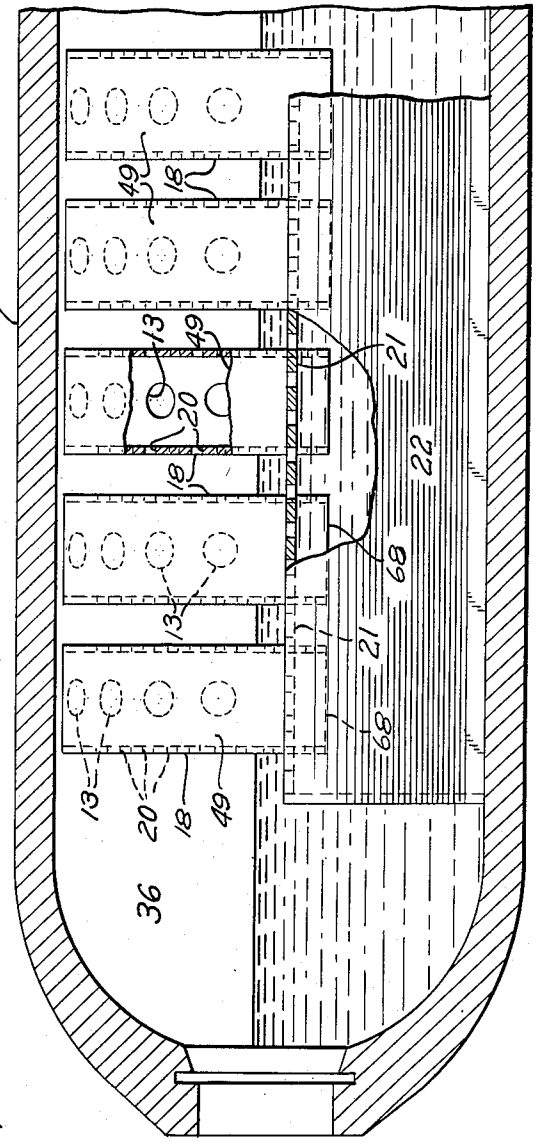


Fig. 3.



Inventor
MARTIN FRISCH

By

Attorney

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Fig. 4.

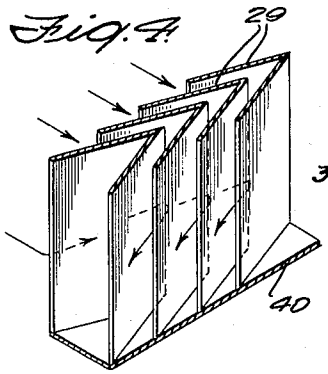


Fig. 5.

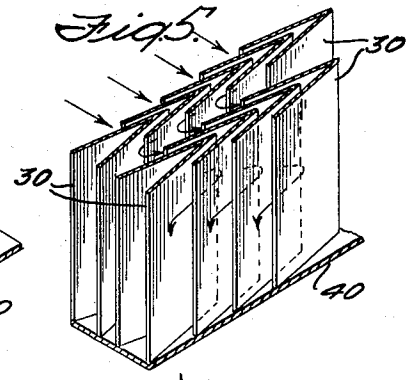


Fig. 6.

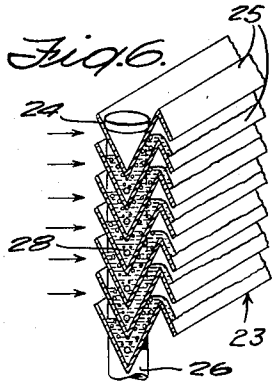
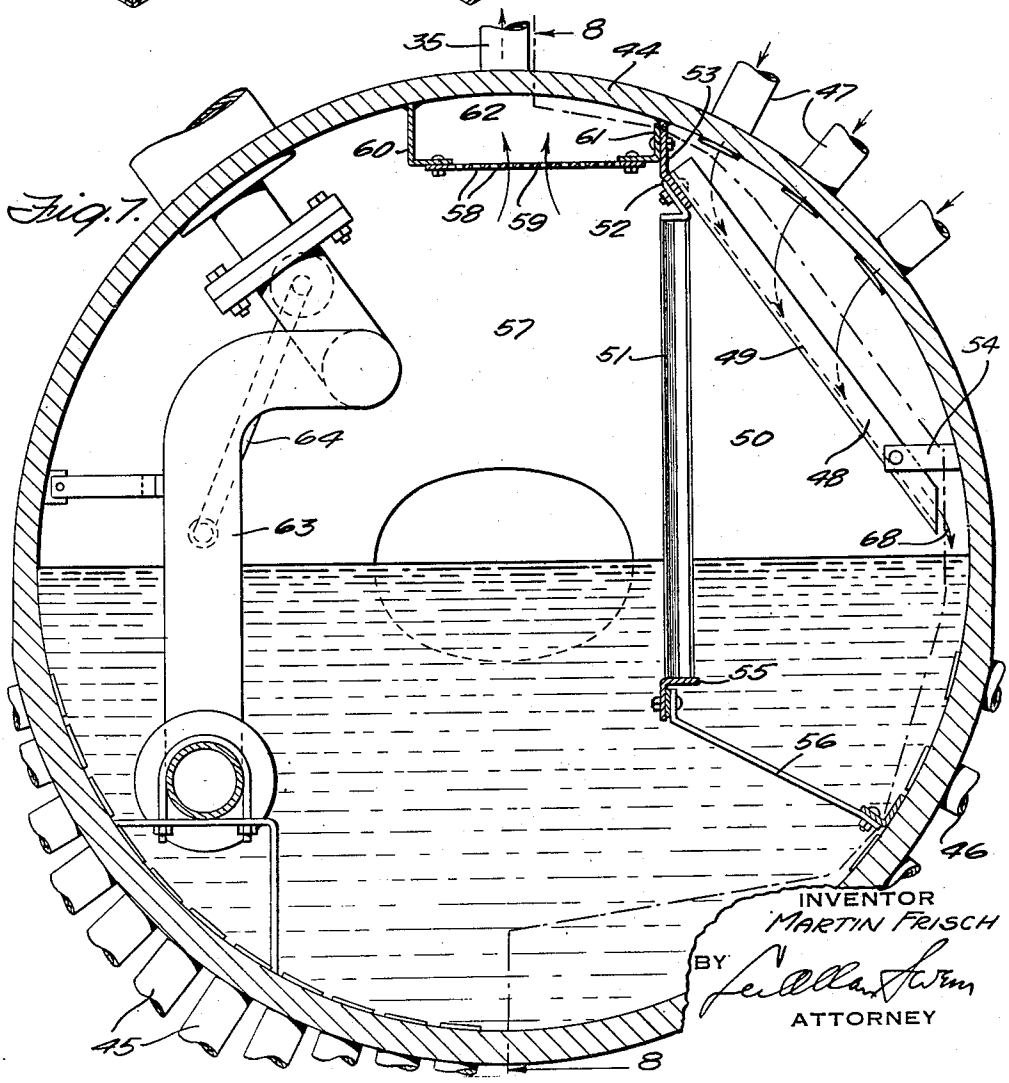


Fig. 7.

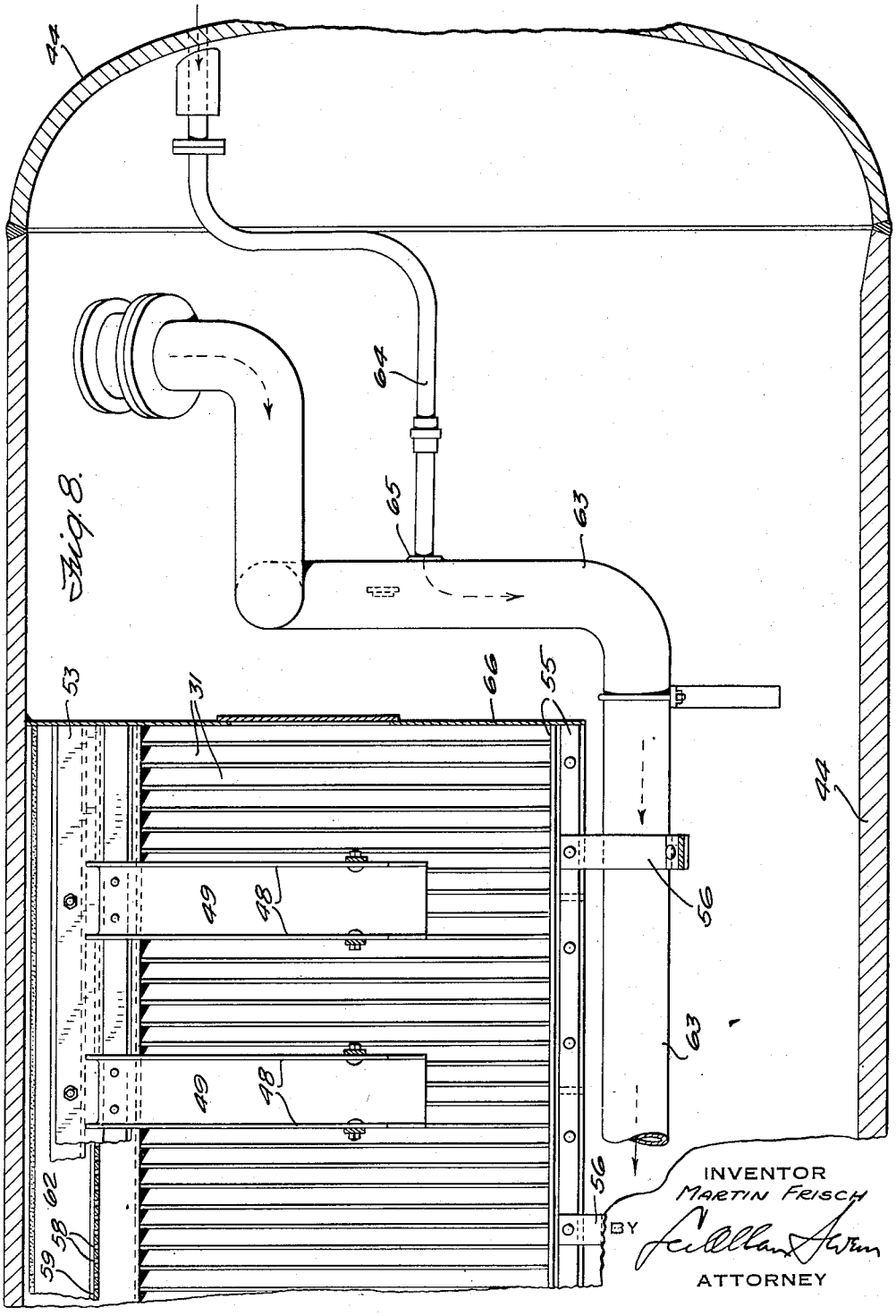


INVENTOR
MARTIN FRISCH
BY
ATTORNEY

Jan. 25, 1955 M. FRISCH 2,700,376

APPARATUS FOR PURIFYING STEAM

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2,700,376

APPARATUS FOR PURIFYING STEAM

Martin Frisch, New York, N. Y., assignor to Foster Wheeler Corporation, New York, N. Y., a corporation of New York

Original application January 24, 1941, Serial No. 375,735, now Patent No. 2,472,101, dated June 7, 1949. Divided and this application June 4, 1949, Serial No. 97,108

9 Claims. (Cl. 122—491)

This invention relates to steam generators, and pertains more particularly to means for removing entrained steam from circulating water.

This application is a division of application Serial No. 375,735, filed January 24, 1941, and issued June 7, 1949, as U. S. Letters Patent No. 2,472,101.

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 and steam from a mixture thereof introduced into the drum both above and below the water level therein. From this drum, the separated steam and relatively steam-free water pass, in said one form of the invention, 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;

Fig. 2 is an enlarged transverse sectional view of part of the apparatus, taken on line 2—2 of Fig. 1;

Fig. 3 is an enlarged, longitudinal, vertical sectional view having parts broken away, taken substantially on line 3—3 of Fig. 1;

Figs. 4 and 5 are fragmentary views in perspective of steam drying devices used with the invention;

Fig. 6 is a perspective view of part of a steam washing device used with the invention;

Fig. 7 is a transverse sectional view of an upper drum of a steam generator embodying another form of the invention, and

Fig. 8 is a longitudinal vertical sectional view taken substantially on line 8—8 of Fig. 7.

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

Referring to the drawings, particularly Figs. 1 to 6, 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.

Within the drum 11 and arranged to receive the mixture of steam and water which is discharged by the tubes 13 above the water level in the drum, are a plurality of spaced, parallel, dewatering channel members 18. These channels are disposed opposite the ends of the vertical rows of tubes 13, and are formed to fit the contour of the inner wall of the drum as shown in Fig. 1. The lower ends of the channels are spaced from the drum wall to provide water drains 68. The sides of the channels are provided with a plurality of perforations or orifices 20 through which the steam flows from the channels into the steam space of the drum. A horizontal perforated plate 21 extends longitudinally of the drum for substantially its length, and transversely thereof from a point adjacent the lower ends of the channel members to within a short distance of the opposite drum wall. A weir plate 22 has its upper end in contact with the free edge of the plate 21 and has its lower edge in engagement with the drum 11 between the rows of downcomer tubes 16. The weir plate 22 causes the mixture of steam and water delivered below the water level in the drum 11 by the tubes 13, to flow upwardly before spilling over into a water space 37 at the other side of the weir. This upward flow of the steam and water mixture permits the steam bubbles to disengage themselves from the water at the water line so that the water on the other side of the weir is practically free from steam. This results in a greatly increased density of the water entering the water circulators 16 and the downcomers, and hence a greatly improved boiler circulation.

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 U. S. Patent No. 2,380,424, granted July 31, 1945, and generally designated 23. As illustrated in Figs. 1 and 6 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 as illustrated in Fig. 6. 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.

As shown, steam drying means of the general type disclosed in applicant's copending U. S. patent application Serial No. 375,735, filed January 24, 1941, are located adjacent the steam washer 23 in the drum 12. As shown, such means comprises 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 Figs. 4 and 5. 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, not shown, to prevent the bypassing 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 above the water level therein, will be separated into its components to a considerable extent by impingement against the surface 49 of the rear walls of the channel members 18. The separated water will drain down these walls to the water space of the drum, while the steam which is separated from the water in the channels will escape through the orifices 20 to the steam space 36. The steam and water mixture which enters the drum below the water level will be separated into its components by the perforated plate 21 and the weir 22 which causes the water to flow upwardly and through the apertures in the plate 21 thereby disengaging the steam bubbles from the water before the water enters the space 37 at the other side of the weir. Thus relatively steam-free water will flow through the circulators 15 to the water space of drum 12, while steam which has been dewatered by the channels 18 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 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.

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.

In the form of the invention illustrated in Figs. 7 and 8, the steam purification is accomplished without washing in a single upper drum 44. As shown, a group of steam generating and downcomer tubes 45, water circulating tubes 46, and steam circulator tubes 47 through which steam enters the drum, are connected to this drum. Disposed opposite the ends of the tubes 47 are a plurality of spaced, parallel, relatively shallow dewatering channels 48 similar to the dewatering channels 18, excepting that the sides of the channels 48 do not extend to, or conform with, the contour of the inner wall of the drum and they are not apertured. Water will be removed from the steam by impingement against the surfaces 49 of the channels, and will drain down to the water space in the drum through the gaps 68 between the drum wall and the lower ends of the channels, while the separated steam will flow between the sides of the channels to a steam space 50 inwardly of the channels. From this space, the steam will flow through a row of separate, spaced V-shaped steam drying plates or water eliminators 51, similar to the drying plates 29, Fig. 4. At their upper ends the plates 51 are supported by an angle 52 secured to a bracket member 53, which also supports the upper ends of the dewatering channels 48. The lower ends of the dewatering channels are supported in spaced relationship with the wall of the drum by brackets 54, while the lower ends of the eliminators are supported by an angle member 55 which is rigidly secured to the drum by means of brackets 56. The steam, after passing between the plates 51, enters the main steam space 57, from which it flows through orifices 58 in a plate 59 secured below the steam outlet connections 35 by means of angles 60 and 61 which are secured to the wall of the drum and form with the plate 59, a chamber 62 for the dry purified steam. Feed water is supplied to the drum through a conduit 63, together with a water treating chemical which is introduced through a conduit 64 connected to the conduit 63 at 65. The dewatering channels and water eliminators are enclosed at both ends by suitable closure plates 66 to prevent the steam from by-passing the channels and the eliminators.

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, the dewatering channels or the weir and apertured plate may be employed in the purification of steam alone without the washer or the drier. Moreover, washing or drying of the steam, or both, may be effected in the same drum with the dewatering of the steam. In view thereof, it will be apparent that the invention is not to be limited excepting by the scope of the appended claims.

What is claimed is:

1. Steam generating apparatus comprising a steam and water drum having a steam space in the upper part and a water space in the lower part thereof, steam generating tubes so connected to the drum that the discharge ends thereof are in communication with the steam space of the drum at points which at all times are above the water level therein, said points also being laterally spaced from one another axially of the drum, and a plurality

of channel members having opposite legs and a connecting member extending therebetween at one edge of the channel member, said channel members being laterally spaced from one another axially of the drum and disposed opposite the dischage ends of said tubes with the inner side of the channel connecting member facing said discharge ends of the tubes and so spaced therefrom that steam discharged from the tubes impinges on said connecting member, the channel members being positioned in the drum with the edges of the legs opposite said one edge extending toward the inner periphery of the drum and providing separated steam outlets located so as to discharge steam into the space between adjacent channel members, the channel members being so disposed in the drum that the connecting member extends downwardly at an angle from a point above the water level toward the inner periphery of the drum and said water level, the connecting member at its lower extremity being in spaced relationship with said inner periphery of the drum.

2. Steam generating apparatus comprising a steam and water drum having a steam space in the upper part and a water space in the lower part thereof, steam generating tubes so connected to the drum that the discharge ends thereof are in communication with the steam space of the drum at points which at all times are above the water level therein, said points also being laterally spaced from one another axially of the drum, and a plurality of substantially U-shaped channel members having opposite legs and a connecting member extending therebetween at one edge of the channel member, said channel members being laterally spaced from one another axially of the drum and disposed opposite the discharge ends of said tubes with the inner side of the channel connecting member facing said discharge ends of the tubes and so spaced therefrom that steam discharged from the tubes impinges on said connecting member, the channel members being positioned in the drum with the edges of the legs opposite said one edge extending toward the inner periphery of the drum and providing separated steam outlets located so as to discharge steam into the space between adjacent channel members, the channel members being so disposed in the drum that the connecting member extends downwardly at an angle from a point above the water level toward the inner periphery of the drum and said water level, the connecting member at its lower extremity being in spaced relationship with said inner periphery of the drum.

3. Steam generating apparatus comprising a steam and water drum having a steam space in the upper part and a water space in the lower part thereof, steam generating tubes so connected to the drum that the discharge ends thereof are in communication with the steam space of the drum at points which at all times are above the water level therein, said points also being laterally spaced from one another axially of the drum, and a plurality of channel members having opposite legs and a connecting member extending therebetween at one edge of the channel member, said channel members being laterally spaced from one another axially of the drum and disposed opposite the discharge ends of said tubes with the inner side of the channel connecting member facing said discharge ends of the tubes and so spaced therefrom that steam discharged from the tubes impinges on said connecting member, the channel members being positioned in the drum with the edges of the legs opposite said one edge extending into fluid-tight relationship with the inner periphery of the drum and with the connecting member engaging the inner periphery of the drum at the upper extremity of said member and extending to a point below said water level at the lower extremity of the member and in spaced relationship at said lower extremity with the inner periphery of the drum at least one of said legs having a separated steam outlet therein located above said water level.

4. Steam generating apparatus comprising a steam and water drum having a steam space in the upper part and a water space in the lower part thereof, steam generating tubes so connected to the drum that the discharge ends thereof are in communication with the steam space of the drum at points which at all times are above the water level therein, said points also being laterally spaced from one another axially of the drum, and a plurality of substantially U-shaped channel members having opposite legs and a connecting member extending therebetween at one edge of the channel member, said channel members being laterally spaced from one another axially of the drum and disposed opposite the discharge ends of said tubes with the inner side of the channel connecting member facing said discharge ends of the tubes and so spaced therefrom that steam discharged from the tubes impinges on said connecting member, the channel members being positioned in the drum with the edges of the legs opposite said one edge extending into fluid-tight relationship with the inner periphery of the drum and with the connecting member engaging the inner periphery of the drum at the upper extremity of said member and extending to a point below said water level at the lower extremity of the member and in spaced relationship at said lower extremity with the inner periphery of the drum at least one of said legs having a separated steam outlet therein located above said water level.

5. Steam generating apparatus comprising a steam and water drum having a steam space in the upper part and a water space in the lower part thereof, steam generating tubes so connected to the drum that the discharge ends thereof are in communication with the steam space of the drum at points which at all times are above the water level therein, said points also being laterally spaced from one another axially of the drum, and a plurality of channel members having opposite legs and a connecting member extending therebetween at one edge of the channel member, said channel members being laterally spaced from one another axially of the drum and disposed opposite the discharge ends of said tubes with the inner side of the channel connecting member facing said discharge ends of the tubes and so spaced therefrom that steam discharged from the tubes impinges on said connecting member, the channel members being positioned in the drum with the edges of the legs opposite said one edge extending toward the inner periphery of the drum to a point short of said periphery and providing separated steam outlets located so as to discharge steam into the space between adjacent channel members, the channel members being so disposed in the drum that the connecting member extends downwardly at an angle from a point above the water level toward the inner periphery of the drum and said water level, the connecting member at its lower extremity being in spaced relationship with said inner periphery of the drum.

6. Apparatus for separating steam and water from a mixture thereof generated in a steam generator having a steam and water drum with a steam space in the upper part and a water space in the lower part thereof together with steam generating tubes so connected to the drum that the discharge ends thereof are in communication with the steam space of the drum at points which at all times are above the water level therein, said points also being laterally spaced from one another axially of the drum, said apparatus comprising a plurality of channel members having opposite legs and a connecting member extending therebetween at one edge of the channel member, said channel members being laterally spaced from one another axially of the drum and disposed opposite the discharge ends of said tubes with the inner side of the channel connecting member facing said discharge ends of the tubes and so spaced therefrom that steam discharged from the tubes impinges on said connecting member, the channel members being positioned in the drum with the edges of the legs opposite said one edge extending into fluid-tight relationship with the inner periphery of the drum and with the connecting member engaging the inner periphery of the drum at the upper extremity of said member and extending to a point below said water level at the lower extremity of the member and in spaced relationship at said lower extremity with the inner periphery of the drum at least one of said legs having a separated steam outlet therein located above said water level.

7. Apparatus for separating steam and water from a mixture thereof generated in a steam generator having a steam and water drum with a steam space in the upper part and a water space in the lower part thereof together with steam generating tubes so connected to the drum that the discharge ends thereof are in communication with the steam space of the drum at points which at all times are above the water level therein, said points also being laterally spaced from one another axially of the drum, said apparatus comprising a plurality of channel

members having opposite legs and a connecting member extending therebetween at one edge of the channel member, said channel members being laterally spaced from one another axially of the drum and disposed opposite the discharge ends of said tubes with the inner side of the channel connecting member facing said discharge ends of the tubes and so spaced therefrom that steam discharged from the tubes impinges on said connecting member, the channel members being positioned in the drum with the edges of the legs opposite said one edge extending into fluid-tight relationship with the inner periphery of the drum and with the connecting member engaging the inner periphery of the drum at the upper extremity of said member and extending to a point below said water level at the lower extremity of the member and in spaced relationship at said lower extremity with the inner periphery of the drum at least one of said legs having a separated steam outlet therein located above said water level.

8. Apparatus for separating steam and water from a mixture thereof generated in a steam generator having a steam and water drum with a steam space in the upper part and a water space in the lower part thereof together with steam generating tubes so connected to the drum that the discharge ends thereof are in communication with the steam space of the drum at points which at all times are above the water level therein, said points also being laterally spaced from one another axially of the drum, said apparatus comprising a plurality of substantially U-shaped channel members having opposite legs and a connecting member extending therebetween at one edge of the channel member, said channel members being laterally spaced from one another axially of the drum and disposed opposite the discharge ends of said tubes with the inner side of the channel connecting member facing said discharge ends of the tubes and so spaced therefrom that steam discharged from the tubes impinges on said connecting member, the channel members being positioned in the drum with the edges of the legs opposite said one edge extending into fluid-tight relationship with the inner periphery of the drum and with the connecting member engaging the inner periphery of the drum at the upper extremity of said member and extending to a point below said water level at the lower extremity of the member and in spaced relationship at said lower extremity with the inner periphery of the drum at least one of said legs having a separated steam outlet therein located above said water level.

9. Apparatus for separating steam and water from a mixture thereof generated in a steam generator having a steam and water drum with a steam space in the upper part and a water space in the lower part thereof together with steam generating tubes so connected to the drum that the discharge ends thereof are in communication with the steam space of the drum at points which at all times are above the water level therein, said points also being laterally spaced from one another axially of the drum, said apparatus comprising a plurality of channel members having opposite legs and a connecting member extending therebetween at one edge of the channel member, said channel members being laterally spaced from one another axially of the drum and disposed opposite the discharge ends of said tubes with the inner side of the channel connecting member facing said discharge ends of the tubes and so spaced therefrom that steam discharged from the tubes impinges on said connecting member, the channel members being positioned in the drum with the edges of the legs opposite said one edge extending toward the inner periphery of the drum to a point short of said periphery and providing separated steam outlets located so as to discharge steam into the space between adjacent channel members, the channel members being so disposed in the drum that the connecting member extends downwardly at an angle from a point above the water level toward the inner periphery of the drum and said water level, the connecting member at its lower extremity being in spaced relationship with said inner periphery of the drum.

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