

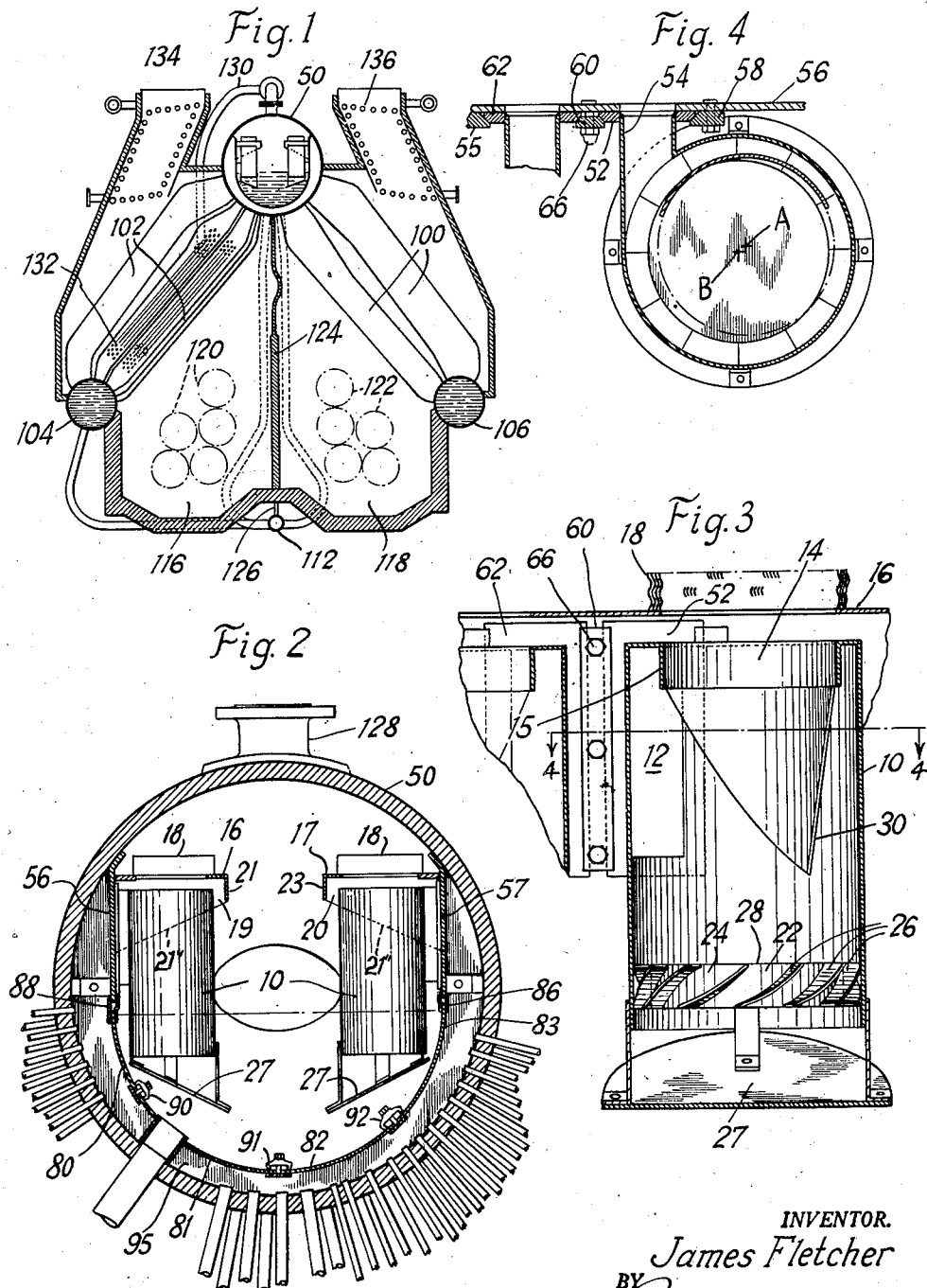
June 18, 1946.

J. FLETCHER

2,402,154

FLUID SEPARATOR

Original Filed July 30, 1940 2 Sheets-Sheet 1



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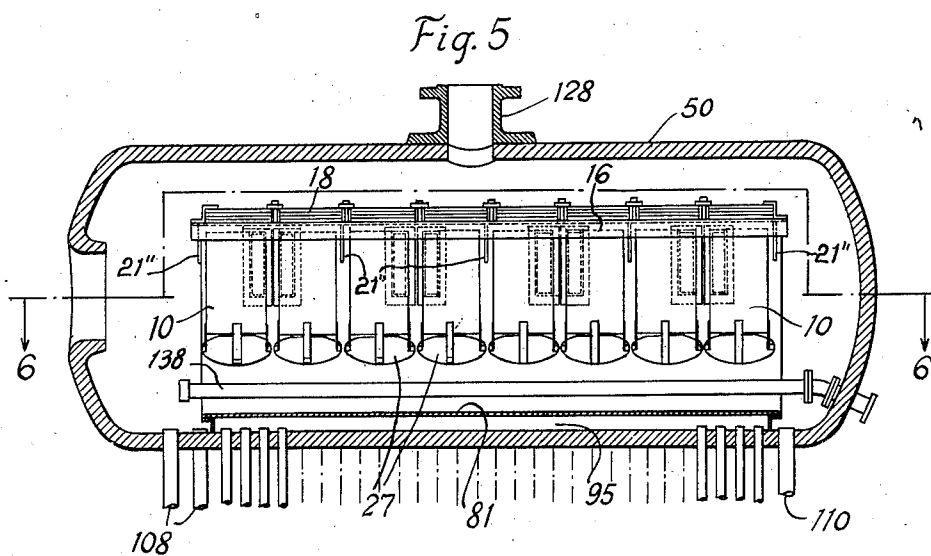
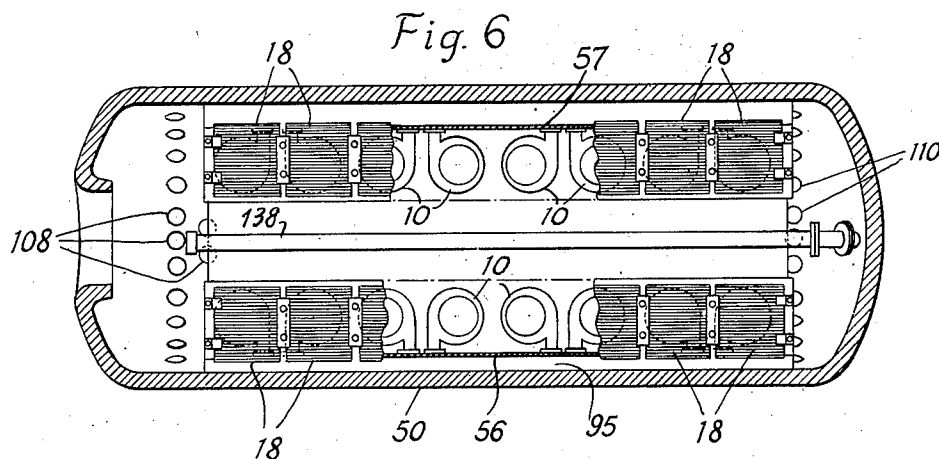
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FLUID SEPARATOR

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8 Claims. (Cl. 122-488)

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This invention relates to steam generators having steam and water drums in which centrifugal separators are employed. The invention is also particularly concerned with a system involving centrifugal means for effecting the separation of fluids of different densities.

The invention involves a circular whirl chamber into which a mixture of steam and water is directed tangentially at a high velocity, this action setting up a whirling motion of the fluid within the chamber. In this chamber, the steam is separated from water, and the former passes from the chamber through an upper circular outlet which is arranged eccentrically with reference to the whirl chamber. The separated water is discharged through another outlet preferably disposed at the bottom of the chamber.

With the whirl chamber inlet near the top of the whirl chamber and a steam outlet arranged at the top of the chamber and eccentrically thereof, there is a maximum annular width or space between the outside edge of the steam outlet and the adjacent whirl chamber wall in the zone of the inlet. With a whirl chamber of a given diameter and with a steam outlet of a given diameter, the eccentric relationship of the steam outlet and the whirl chamber improves fluid separation and increases the capacity of the whirl chamber while at the same time minimizes space requirements in the arrangement of a plurality of the illustrative whirl chambers within a separator chamber. This is particularly important in the steam and water drums of high pressure steam generators, where, on account of the high cost of drums for high pressures, it is necessary that drum space and drum diameters be minimized.

This invention also involves whirl chambers arranged with tangential inlets, a characteristic which combines with the eccentric relationship of the steam outlet and the whirl chamber, to further improve the steam and water separating capacities of boiler drums and thereby minimize the drum space required for a given boiler, by making it possible to arrange a greater number of the illustrative whirl chambers within a steam and water drum.

The invention also involves such an arrangement and mounting of the individual whirl chamber units within a steam and water drum that periodic removal of the individual units to give access to boiler tube ends, is facilitated.

Among other objects, the invention is intended to provide means for maintaining the incoming mixture of steam and water relatively free from

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the disturbing influences arising from the impact of the swirling water after it has completed the major part of its first movement about the whirl chamber. An additional object is to effect this result without incurring undesirable reaction due to excessive deflection of the whirling mixture.

Another object is to so construct and arrange the components of the separator that the incoming stream of steam and water is subject to a minimum of flow resistance.

It is also an object of the invention to so arrange the steam outlet with reference to the whirl chamber that an optimum flow of separated steam may take place.

The invention contemplates the use of steam and water separators in a high pressure steam generator to improve circulatory conditions and enable the generator to operate at high water levels and still supply dry steam. The use of the illustrative separators in a steam and water drum of a steam generator is characterized by the fact that the high velocities of the steam and water mixtures are utilized in separating the component parts of these mixtures without subjecting the incoming mixture to excessive flow resistance. Each separator may be arranged to receive the combined discharge of several water heating, or steam generating tubes, and yet, be so arranged and constructed that it may be easily removed from its operative position for inspection of the related boiler parts as well as the separator itself.

Other objects of the invention will appear as the following description proceeds and the invention will be described with reference to an embodiment which is illustrated in the accompanying drawings.

In the drawings:

Fig. 1 is a vertical section of a steam generator utilizing the invention;

Fig. 2 is a detail view in the nature of a vertical section through the steam and water drum of the Fig. 1 installation;

Fig. 3 is a detailed view of one of the separators. This figure shows part of the separator in side elevation, and the lower part of the separator has its outer wall broken away so as to expose the inner construction.

Fig. 4 is a horizontal section on the line 4-4 of Fig. 3;

Fig. 5 is a vertical section through the steam and water drum showing the arrangement of a plurality of separators employed therein; and

Fig. 6 is a horizontal section on the line 6-6 of Fig. 5 of the drum showing the arrangement of the illustrative separators, in plan. This figure

is partly broken away to show the arrangement of the inlet nozzles for adjacent whirl chambers.

The illustrative separator includes a plurality of substantially circular whirl chambers 10 each having an inlet 12 through which a mixture of steam and water is discharged into the whirl chamber at high velocity.

Within each whirl chamber, steam, separated from the water, passes upwardly through a circular steam outlet 14 determined by the downwardly extending flange, or cylindrical structure 15 which is fixed to the top of the whirl chamber. The eccentric relationship of the whirl chamber and the separated steam outlet is indicated in Fig. 4 in which the center of the outlet is indicated at A while the whirl chamber center is indicated at B. Fig. 6 also shows this eccentric relationship.

When the whirl chambers 10 are arranged in rows as indicated in Figs. 5 and 6 of the drawings, they are supported so that their steam outlets are spaced downwardly from the horizontal shroud structures 16 and 17. These structures also provide support for a number of multiple plate separators, or scrubbers 18 disposed over the steam outlets of the whirl chambers. It is important that the separated steam be as free from water as possible and this condition is promoted by the provision of the steam discharge openings 19 and 20 between the shroud structures 16 and 17, respectively, and the tops of the whirl chambers. These openings permit communication between the drum steam space and the whirl chamber steam outlets, beneath the shroud side flanges 21 and 23 (which connect the transverse and end shroud flanges such as 21' and 21''). With this construction, pressure drop is reduced and the loading of the multiple plate separators is made more uniform.

In each whirl chamber, the separated water is discharged downwardly through circumferentially arranged outlets such as those indicated at 22 and 24. They are separated by successive vanes 26 arranged in an annular series between a bottom plate 28 and a wall of the whirl chamber. Below the outlets a baffle 27 directs the separated water toward the central portion of the associated drum.

The arrangement of elements is such that the steam and water inlet 12 communicates directly with the circumferential space between the flange 15 and the whirl chamber wall at a point where the flange is at a greater distance from the wall, due to the eccentricity of the whirl chamber and the wall 15 as indicated in Figs. 3 and 4. This arrangement offers a minimum of flow resistance and thus improves the circulation in the fluid system without additional space requirement for the separators. This is particularly important when the separators are utilized in boiler drums.

Means is also provided for preventing the flooding of the space adjacent the steam and water inlet and for minimizing the passage of water through the outlets 14 and the scrubbers 18 along with the steam, and this means is effective to accomplish these results without involving undesirable reaction arising from excessive deflection of the whirling stream within the chamber. This means includes, in each whirl chamber, a curved or segmental plate 30 spaced from the wall of the whirl chamber. It is secured in position by joining it at its upper edge, as by welding or brazing, to the flange 15.

The illustrative separators are preferably arranged in opposite rows within the steam and

water drum 50 in the manner indicated in Figs. 1, 2, 5, and 6 of the drawings, and, for this purpose, each whirl chamber is provided at its steam and water inlet nozzle with a heavy flange 52 for securement to upright plates 56 and 57 which are affixed to the drum in the positions indicated in Fig. 2. As indicated in Fig. 4 of the drawings the flanges 52, rigid with the whirl chamber inlet structures 54 have beveled edges which co-operate with similarly formed edges on the fixed bars 55 and 58 and the removable wedge bars 60 to facilitate the original assembly of a plurality of the illustrative whirl chambers within a drum and likewise facilitate the removal of the whirl chambers when access to the drum ends of the steam generator tubes is desired.

The whirl chambers are arranged in pairs with the tangential fluid inlets of each pair parallel to each other and normal to their supporting plate (either 56 or 57), as indicated in Figs. 4 and 6 of the drawings. In the installation of such a pair of whirl chambers, one of them with its inlet structure 54 is moved upwardly beneath the shelf 16 with the face of the flange against the plate 56 and the right-hand beveled edge (see Fig. 4) disposed within the groove formed by the plate 56 and the beveled edge of the bar 58. Then the adjacent whirl chamber is similarly disposed with its flange 62 facing against the plate 56 and its left-hand beveled edge fitting within the groove formed by the bar 55 and the plate 56. Thereafter, with the adjacent whirl chambers held in the positions indicated, the wedge bar 60 is placed in position with its opposite beveled edges in contact with the remaining beveled edges of the flanges 52 and 62 and the wedge bar is forced into operative position by the tightening of nuts 66 arranged upon bolts secured to the plate 56. Thus the inclined edges with the wedge bar 60 bear upon the inclined faces of adjoining nozzle (or inlet structure) flanges and co-operate with the fixed wedges (formed by the inclined surface of the bars 55 and 58) bearing upon the opposite inclined faces of the nozzle flanges to force the flanges into water-tight relationship with the plate 56 and to maintain it in such relationship.

In the above described action, it is to be noted that no access is necessary to the spaces between the plates 56 and 57 and the adjacent walls of the drum 50. It is only necessary to insert a socket wrench in the space between adjacent whirl chambers, this socket wrench engaging the nuts 66 to operate them and thus secure the whirl chambers in their operative positions. This manner of mounting the whirl chambers permits a close spacing of those chambers throughout the length of the drum and thus increases the steam and water separating capacity of the drum, per unit of drum length. The eccentric relationship of the steam outlets and the whirl chambers permits the tangential arrangement of the inlet nozzles or structures 54 which, in turn, permits such a closely spaced arrangement of the whirl chambers in pairs as indicated in Figs. 4 and 6, thus, these co-acting structural relationships combining to provide increased steam and water separating capacity for a given drum length, and to afford an improved manner of assembling and disassembling the illustrative separators within a steam and water drum.

The plates 56 and 57 combine with the drum wall and the segmental plates 80-83 to form a compartment which receives the steam and water

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discharged into the drum by the steam generating tubes. These plates are preferably of such width that they may be passed through a drum manway, and the upper edges of the plates 80 and 83 are arranged with vapor-tight slip joint connections 86 and 88 with the lower edges of the plates 56 and 57, the adjoining edges of the plates 80—83 being united by the spanner clamps 90—92. This entire assembly is one which increases accessibility of the drum ends of the steam generating tubes, and this is of particular importance in connection with marine boilers where the internal drum chamber connecting with the whirl chambers must embrace almost the entire lower half of the drum due to the extent of drum connections of the steam generating tubes.

Steam and water mixtures are discharged into the internal drum chamber 95 by the steam generating tubes of two upwardly converging banks of tubes 100 and 102 which are in communication at their lower ends with the water drums 104 and 106, and, in the natural circulation boiler shown, the downcomers 108 and 110 connect the water space of the drum 50 with the drums 104 and 106.

The banks of tubes 100 and 102 are disposed above furnaces 116 and 118, respectively, the latter being fired by the sets of burners 120 and 122.

In the steam generator shown in Fig. 1 of the drawings, the furnaces are separated by a wall 124 which may include tubes 126 directly connecting the drum 50 with the header 112 which is connected into the boiler circulation.

Steam and water passes from the drum chamber 95 through the illustrative separators and the separated steam discharged from the separators, passes through the steam off-take 128, and through the superheater supply conduit 130 to a superheater 132, some of the tubes of which are preferably arranged between some of the tubes of the bank 102.

The feed water pipe 138 in the water space of the drum, is provided for adding water to replace that removed by the steam generated.

Furnace gases and other combustion products, after passing through the banks of the tubes 100 and 102 pass over the heat exchange surfaces of the economizers 134 and 136 and thence to one or more flues or stacks.

This application is a divisional application of the parent application 348,369 entitled Fluid separator, and filed July 30, 1940, but later abandoned.

What is claimed is:

1. In a steam generator, a steam and water drum, means including an upright diaphragm dividing the drum into inlet and outlet compartments, means discharging mixtures of steam and water into the inlet compartment, whirl chamber units having tangential inlet structures communicating with the inlet compartment, said units being arranged in the outlet compartment and along the diaphragm with their steam outlets within the drum steam space, a shroud including a shelf-like plate structure extending horizontally from said diaphragm over said steam outlets and spaced vertically from the whirl chambers, said shroud also including downwardly extending side and end flanges spaced laterally of the whirl chambers and disposed about the tops thereof, the shroud and said units being independently supported, and multiple plate separators supported by the shelf-like plate struc-

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ture across the upright path of steam flow from said steam outlets.

2. In a vapor and liquid system, means forming an exterior chamber adapted to have a liquid level therein, wall means co-operating with part of the first mentioned means to form an inlet compartment in the chamber, means maintaining in said compartment a vapor and liquid mixture at a pressure higher than the pressure in said chamber exteriorly of the compartment, a row of centrifugal fluid separators arranged so as to have their inlets in communication with said inlet compartment, the separators having vapor outlets at their upper ends in communication with the chamber space above such liquid level, a shroud including a unitary shelf-like plate structure spaced vertically from and extending over the vapor outlets of a plurality of said separators, said shroud structure being secured in position independently of the separators and presenting downwardly extending flanges spaced horizontally from said row of separators, and a row of multiple plate separators disposed on the shroud structure and superposed relative to said vapor outlets.

3. In a steam generator, a steam and water drum, means including an upright diaphragm dividing the drum into inlet and outlet compartments, said diaphragm extending longitudinally of the drum and along one side thereof, means whereby steam and water mixtures are discharged into the inlet compartment, a plurality of upright cylindrical steam and water separators secured to the diaphragm with their inlets communicating with the inlet compartment through openings in the diaphragm, the separators having steam outlets at their upper ends and outlets for separated water at their lower ends, a shelf-like construction secured to the diaphragm and extending horizontally over a plurality of the separators and spaced from their tops, said shelf-like construction being separately supported relative to said separators, multiple plate steam and water separators carried by said construction and disposed above said steam outlets, and upright walls extending downwardly from the ends and front of the shelf-like construction to direct water downwardly within the drum and confine the steam so that it will escape upwardly through the multiple plate separators, said upright walls and the shelf construction enclosing the tops of the first mentioned separators.

4. In a steam generator, a steam and water drum having a water level below the drum steam space, means including an upright diaphragm wall disposed within the drum so as to provide separate inlet and outlet compartments within the drum, means discharging mixtures of steam and water into the inlet compartment and maintaining pressures therein higher than the pressure in the outlet compartment, whirl chamber units having substantially tangential inlet structures communicating with the inlet compartment, said units being arranged along the inlet compartment with their steam outlets within the drum steam space, a shroud including a fixed shelf-like structure disposed above said steam outlets and spaced vertically from the whirl chambers, said shelf-like structure being supported independently of the whirl chamber inlets, said shroud also including downwardly extending side and end flanges spaced laterally of the whirl chambers adjacent the tops thereof, and fixed separators supported by the shroud struc-

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ture in superposed relation to the steam outlets of the whirl chamber units.

5. In a vapor and liquid fluid system, means forming a gas and liquid chamber adapted in operation to have a liquid level therein, means including an upright wall dividing the chamber into inlet and outlet compartments, means whereby a gas and liquid mixture is discharged into the inlet compartment at a pressure higher than the pressure in the outlet compartment, a plurality of upright gas and liquid separators having whirl chambers secured to the wall with their inlets communicating with the inlet compartment through openings in the wall, the separators having gas outlets at their upper ends and outlets for separated liquid at their lower ends, a shelf-like construction secured to the wall independently of said separators and extending over and spaced from the tops of said separators, fixed auxiliary gas and liquid separators supported on said shelf-like construction and extending across the upright path of gas flow from said outlets, and upright walls extending downwardly from the shelf-like construction about the upper ends of the whirl chambers to direct liquid downwardly within the chamber and confine the gas so that it will escape upwardly through the auxiliary separators.

6. In a vapor and liquid fluid system, means forming an exterior chamber adapted in operation to have a liquid level therein, wall means co-operating with part of the first mentioned means to form an inlet compartment within the chamber but separate from the remainder of the chamber, means maintaining in said compartment a vapor and liquid mixture at a pressure greater than the pressure in said chamber exteriorly of said compartment, a row of whirl chamber gas and liquid separators having substantially tangential inlets in communication with said inlet compartment, the separators having whirl chamber gas outlets at the tops thereof, a shroud including a fixed shelf-like structure spaced vertically from and extending over the gas outlets of the whirl chambers, said shroud structure presenting downwardly extending walls spaced horizontally from the whirl chamber gas outlets and maintaining communication between

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the outlets and the chamber space above said liquid level, and multiple plate separators disposed on the shroud structure and superposed relative to said gas outlets.

7. In a steam generator, a steam and water drum, means including an upright wall separating the drum space into inlet and outlet compartments, said wall extending longitudinally of the drum, means whereby steam and water mixtures are discharged into the inlet compartment, a plurality of upright whirl chamber separators secured to said wall with their inlets communicating with the inlet compartment through openings in the wall, the separators having steam outlets at their upper ends and outlets for separated water at their lower ends, a shelf-like construction secured to the wall independently of said separators and extending horizontally over and spaced from the tops of said separators, fixed auxiliary steam and water separating means carried by said construction and disposed across the upright of steam flow from said steam outlets, and upright walls fixed to and extending downwardly from the shelf-like construction to direct water downwardly within the drum and confine the steam so that it will escape upwardly through the auxiliary separating means, said upright walls and the shelf construction being disposed around the tops of the whirl chamber separators.

8. In a fluid system, means forming a vapor and liquid chamber, a row of upright whirl chamber separators secured within said chamber, means whereby vapor and liquid mixtures are discharged tangentially into each separator whirl chamber at high velocity, each whirl chamber having a vapor outlet at its upper end and an outlet for separated liquid at its lower end, a shroud like construction secured within the drum independently of the whirl chambers and extending over said row of whirl chamber separators, and fixed auxiliary separators supported by said shroud above the whirl chamber vapor outlets, said shroud including downwardly extending upright walls spaced horizontally from and enclosing the tops of the whirl chamber separators.

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