Jan. 24, 1956 E. E. COULTER 2,732,028

STEAM PURIFIER

Filed Jan. 6, 1953

Fig. 1.

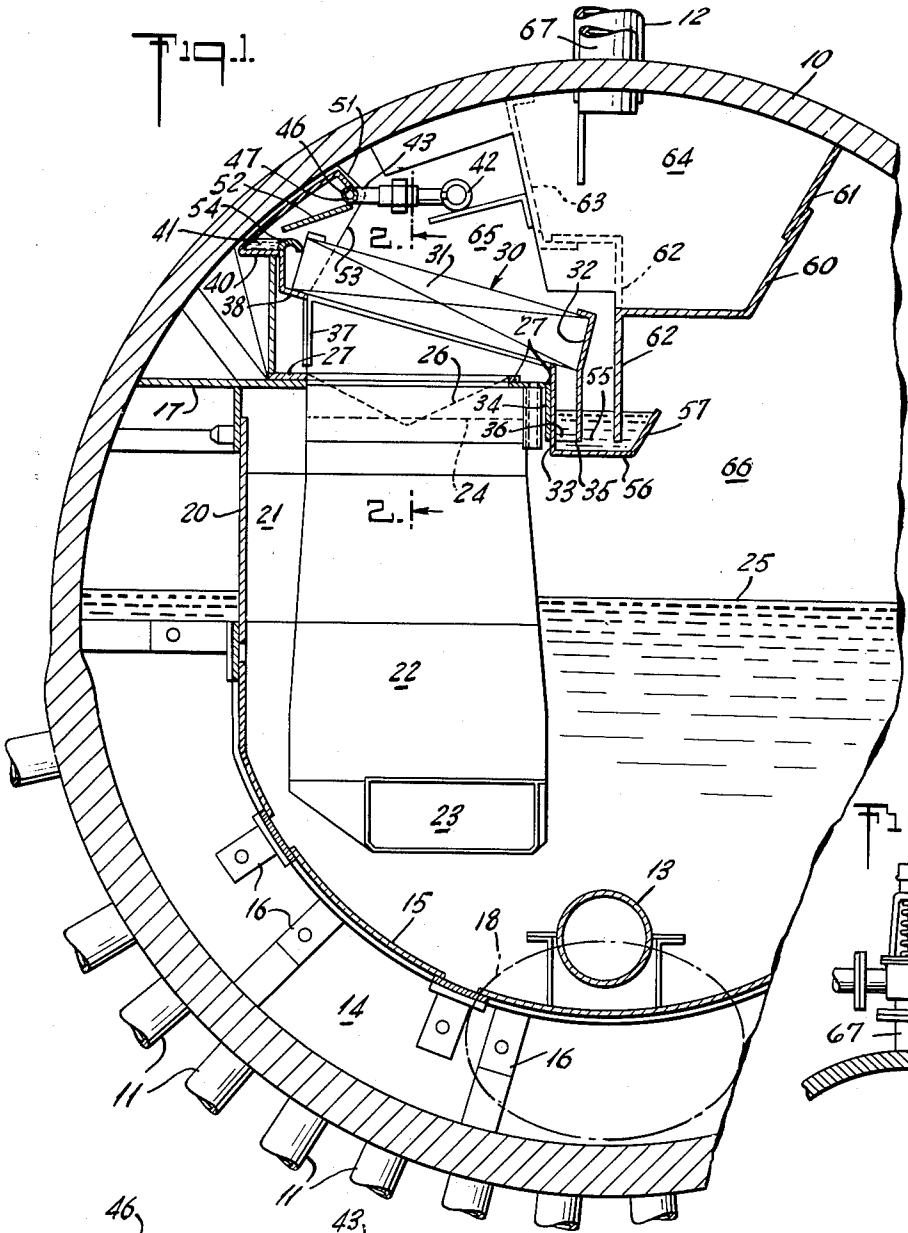
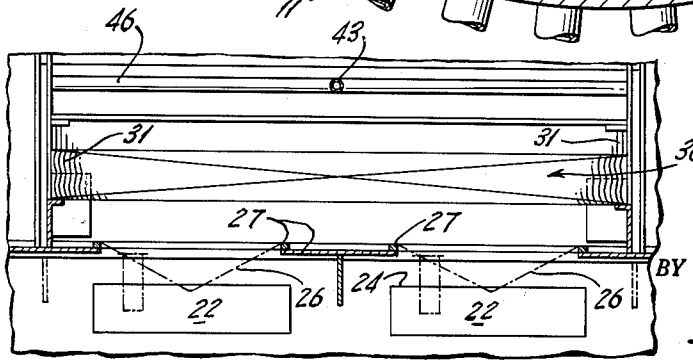


Fig. 1A

Fig. 2.



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United States Patent Office 2,732,028 Patented Jan. 24, 1956

2,732,028

STEAM PURIFIER

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Application January 6, 1953, Serial No. 329,783

9 Claims. (Cl. 183—31)

The present invention relates to improvements in vapor generation, and more particularly to improvements in the internal arrangement of steam and water drums.

High pressure steam generated in and delivered by a boiler for power purposes ordinarily contains small amounts of impurities, such as silica, and other boiler water salts. These impurities are frequently deposited on the surfaces of blades and other internal parts of turbines requiring periodic turbine stoppage for cleaning purposes in order to maintain its efficiency.

The carry-over of the impurities by the steam to the turbine is generally considered to be by mechanical entrainment with the steam, by vaporization or solution in the steam, or by a combination of these phenomena. Mechanical entrainment in the steam can be reduced by separation of the liquid from the vapor through the use of centrifugal forces, providing the physical properties of the liquid-vapor mixture are conducive to mechanical separation. Impurities present in the steam as the result of incomplete separation by mechanical means, or in a vapor form or in solution in the steam, can be removed by washing as resulting from intimate contact between the steam and a relatively pure wash liquid.

One of the problems in mechanical separation of steam and water, and in the washing of the relative dry steam lies in the necessity for insuring treatment of all of the steam delivered by the generator. This can be accomplished in a number of ways, but simplicity of construction is essential to permit accessibility to the separating and washing elements for maintenance and repair.

In the present invention I provide means for dividing the steam space of a steam and water drum into separate compartments. One or more of the compartments open to the water space of the drum and to the necessary drum safety valves while one or more of the other compartments open to the steam and water separators of the drum and the saturated steam outlets. The dividing means of the drum include partitions provided with water seals which are effective in maintaining the separation of the drum compartments during normal operations, but are easily broken when the safety valves are opened.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described an embodiment of the invention.

Of the drawings:

Fig. 1 is a transverse view, in section, of a portion of the interior of a steam and water drum constructed in accordance with the present invention;

Fig. 1A is a transverse view, partly in section, of the upper portion of the drum shown in Fig. 1; and

Fig. 2 is a longitudinal view of a portion of the internal elements of the steam and water drum taken on the line 2—2 of Fig. 1.

As shown in Fig. 1 the steam and water drum **10** of a vapor generator is provided with a plurality of steam and water mixture delivery tubes **11** opening into the lower portion of the drum, and saturated steam discharge tubes **12** connected to the upper portion of the drum. A suitable feed water pipe, such as the pipe **13**, chemical feed pipe, safety and vent valves, as well as steam sampling tubes are also provided for the drum. The steam and water drum is also provided with necessary downcomer tubes connected into the circulatory system of the steam generator, where the downcomers may take the form of large diameter tubes connected to the ends of the drum, such as shown at **18**, or may be tubes connected along one side of the drum below the normal water level therein.

The mixture of steam and water entering the drum through the tubes **11** passes into a collecting chamber **14** which is formed by a series of curved plates **15** inwardly spaced from the lower segment of the drum wall. The plates are supported by brackets **16** attached to the drum wall. In addition, the collecting chamber is provided with end closure plates (not shown) and a series of top closure plates **17**. The upper portion of the collecting chamber **14**, above the horizontal center line of the drum, has a series of removable plates **20** provided with and supporting vertically elongated and horizontally extending guide ducts **21** each of which directs steam flow tangentially to a steam and water separator **22** of the cyclonic type.

The general construction of the cyclonic type of separator **22** and the collecting chamber **14** is disclosed in detail in the Fletcher U. S. Patent 2,368,211. As described in the patent and shown in Fig. 1, each separator **22** receives steam through an individual tangentially arranged duct **21** and is provided with a lower water outlet **23** and an upper steam outlet **24** for the separate discharge of steam and water therefrom. Ordinarily, the water level (indicated at **25**) within the drum is maintained approximately at the position of the drum horizontal center line. However, the water level may vary during the normal course of operation, but should not vary beyond the limits of the vertical height of a separator.

The steam leaving the outlet **24** of each separator **22** passes upwardly through a perforated plate formed as an inverted pyramid **26**. Each pyramid **26** depends from a base plate **27** having an opening therein corresponding in dimension with the base of pyramid, and is supported by suitable brackets associated with the supports of the cyclone separators **22**, including the plates **17**.

A steam scrubber **30** is positioned above the pyramid **26** and is supported by suitable extensions from the braces and structural supports of the separators **22** and the pyramids **26**. The scrubber **30** is formed from a series of rectangular imperforate corrugated plates **31** (see Fig. 2) which are assembled in groups so that the plates are upright and in closely spaced parallel relationship to define sinuous or undulating steam flow channels therebetween. Each plate corrugation is parallel to the long dimension of the rectangular plate **31**.

The scrubbers **30** may be rectangular or square in plan section, and are arranged side by side in a longitudinal row above the separators **22** and the pyramids **26**. As shown in Fig. 2, a convenient arrangement includes a scrubber of rectangular plan section arranged to receive steam from two adjacent cyclone separator units. In the illustrated embodiment, the scrubbers are arranged with the edges of plates **31** lying in planes which are normal to the longitudinal axis of the drum **10**. The scrubbers are inclined at an angle of approximately 15° with respect to the horizontal from a position adjacent the drum wall toward the longitudinal axis of the drum **10**.

The individual scrubber plates are supported at their

lower edge by a clamp plate **32** which extends longitudinally of the drum to enclose the row of scrubbers, and projects downwardly below the upper edge of the separators **22**. The lower end of the clamp plate **32** is spaced from a parallel member **33** by a flat bar **35** which is provided with a spaced series of ports **36** therein for the discharge of wash water from the lower end of the scrubbers **30**. The upper edge of the scrubbers **30**, adjacent the wall of the drum **10**, is supported by an upstanding member **37**, having an inclined plate shoulder portion **38** and an upright upper end portion attached to a horizontally disposed shelf **40**. The shelf **40** is positioned intermediate the height of the scrubbers **30** and defines the bottom of a wash water reservoir **41**.

Wash water, which is obtained from an external source, enters one end of the drum through a pipe **42**, which extends longitudinally of the upper portion of the drum **10**. From the entrance pipe **42**, branch connecting pipes **43** extend horizontally toward the wall of the drum and connect to distributors **46** each of which is of a length equal to the length of the individual scrubber element **30**. Each distributor **46** is provided with a spaced series of apertures **47** in the wall thereof which project jets of water in a generally horizontal direction against a curved deflector **50** which extends from a juncture with an inclined baffle **51** attached to the upper side of the distributor **46** to a position merging with the shelf **40**. A baffle plate **52** is attached to the lower side of the distributor **46** and extends downwardly and toward the drum wall to direct the water discharged from the distributor **46** toward the shelf **40**. The structure described provides a distributed flow of wash water to a series of reservoirs **41** positioned adjacent the outer edge of the scrubbers **30**. End plates **53** separate each of the reservoirs **41** and the corresponding scrubbers **30** from the adjacent reservoirs and scrubbers.

The wash water discharges from the reservoir **41** over a distributor **54** to the plates **31** of the scrubber **30**. The distributor may be formed from a threaded pipe, which is longitudinally cut along the axis thereof, with one edge welded to the shelf **40** and the other edge positioned adjacent the edge of plates **31**, intermediate the height of the scrubber. The distributor is located in a level position so that the inner apex of each thread on the pipe is in alignment with a plate **31**. Thus, the threaded pipe of the distributor forms a plurality of weirs corresponding with the plates of the scrubber.

With the distributor **54** positioned near the top of the scrubber plates **31**, the wash water will flow in film form along the surfaces of the plates to the lower discharge end of the scrubber. The upper surfaces of the corrugated plates serves as a separator for any large drops of moisture entrained by the steam passing through the lower wetted wall portion of the scrubber. The drops collected on the scrubber surfaces also flow downwardly along the plates to the discharge end of the scrubber.

The wash water may originate as steam condensate obtained from a closed feed water heater included in the steam generator and turbine installation. Under such circumstances the wash water will be of high purity. Alternately, the wash water may originate in the boiler feed water. Under these circumstances the wash water will not be as pure, but will have a higher purity than that of the water in the steam and water drum of the boiler. With the wash water having a higher degree of purity than the moisture in the steam passing in intimate surface contact therewith, the steam will be effectively washed and its quality improved by the absorption of the contaminants into the wash water.

The wash water and the impurities therein discharge from the lower end of the scrubbers **30** into a trough **55** which is disposed longitudinally of the drum adjacent the upper portion of the separators **22**. The trough **55** is defined by the member **33**, and a flat bottom plate **56** which is connected on opposite edges with member **33**

and an upwardly inclined plate **57**. The opposite ends of the trough **55** are closed, so that a pool of water is maintained in the trough to the height of the upper edge of the plate **57**. The overflow of wash water from the trough, with the impurities therein, discharges to the water space of the drum **10**.

The steam passing from the separators **22** and the inverted perforated pyramids **26** through the scrubbers **30** to the steam outlet tubes **12** will be of an advantageously high purity. To attain the advantageous effects of the scrubbers **30**, all of the steam discharged through the tubes **12** should pass through the scrubbers. This is accomplished by fluid tight dividing means positioned within the drum to separate the drum steam space so that the steam discharging to the outlet tubes **12** is separated from the main steam space of the drum directly above the water level **25**. The fluid tight dividing means includes an angle shaped member **60** having its upper leg portion attached to a depending flange **61** which is welded to the inner surface of the drum **10** on the side of the steam discharge tubes **12** opposite to the row of separators **22**, and having its horizontally extended leg portion welded to an upright member **62** projecting downwardly into the trough **55**. The lower edge of the member **62** is spaced from the bottom **56** of the trough and is submerged in the pool of wash water maintained in the trough. The parts **60** and **61** of the dividing means extend longitudinally of the drum through the intermediate length thereof, while the member **62** extends substantially the full longitudinal length of the drum. At the opposite ends of the member **60**, the member **62** extends upwardly as shown in dotted lines in Fig. 1 to intersect a depending plate **63** which is welded thereto and attached to the upper surface of the drum **10** above the scrubbers **30**.

A transverse plate **64** connects the members **60**, **61** and **63**, while separate transverse plates (not shown) are positioned adjacent the ends of the drum to close the drum space defined by a segment of the drum **10**, the base plate **27** and the members **62** and **63**.

The space **65** above the scrubbers **30** will be at a lower pressure than the drum space **66** and the water level in the trough **55** on the scrubber side of the member **62** will be higher than on the opposite side. However, the pressure difference between the steam spaces **65** and **66** will be small, compared with the total pressure in the drum. The steam vents **67** connect the drum with the customary safety valves, such as valve **69** shown in Fig. 1A, which are positioned adjacent the ends of the drum and open directly into the space **66**. With the opening of the safety valves the differential pressure between the spaces **65** and **66** will be sufficient to break the water seal of the trough, so that the space **65** would also be vented.

In the operation of the apparatus described, the steam and water mixture discharged from the steam generating tubes **11** passes through the chamber **14** into the rows of cyclonic separators **22**. The water separated in the separators is discharged through the outlets **23** while the steam is discharged upwardly through the pyramids **26** into the scrubbers **30**. Substantially, all of the water is removed from the steam by the separators **24** and pyramids **34**, but any moisture retained with the steam may be laden with contaminating matter. The wash water films passing over the plates **31** of the scrubber **30** are intimately contacted by the steam passing in a sinuous path between the plates, with the wash water films thereon capturing the contaminating matter by adhesion and absorption. The wash water, with captured contaminants, discharges from the scrubbers **30** into the trough **55** and thence by overflow over the plate **57** into the steam space **66** of the drum.

While in accordance with the provisions of the statutes I have illustrated and described herein a preferred embodiment of the invention, those skilled in the art will understand that changes may be made in the form of

the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. In a vapor generator, a drum having an upper vapor space and a lower liquid space and having inlet means for a vapor and liquid mixture and separate outlets for vapor and liquid, vapor and liquid separating means within said drum and having a vapor discharge opening to the vapor space and a liquid discharge opening to the liquid space of said drum, partition means for dividing the vapor space of said drum into compartments, safety valve means in said drum, at least one of said compartments opening to said vapor outlet and at least one compartment opening to said safety valve means, and liquid seal means connected with said partition means, the opening of said safety valve means breaking said liquid seal means and interconnecting all of said compartments.

2. In a vapor generator, a drum having an upper vapor space and a lower liquid space and having inlet means for a vapor and liquid mixture and separate outlets for vapor and liquid, vapor and liquid separating means within said drum and having a vapor discharge opening to the vapor space and a liquid discharge opening to the liquid space of said drum, partition means for dividing the vapor space of said drum into compartments, safety valve means in said drum, at least one of said compartments including said vapor and liquid separating means and the vapor space communicating with said vapor outlets, at least one of said compartments communicating with the liquid space of said drum and to said safety valve means, and a liquid seal connected with said partition means, the opening of said safety valve means breaking said liquid seal and interconnecting all of said compartments.

3. In a vapor generator, a drum having an upper vapor space and a lower liquid space and having inlet means for a vapor and liquid mixture and separate outlets for vapor and liquid, vapor and liquid separating means within said drum and having a vapor discharge opening to the vapor space and a liquid discharge opening to the liquid space of said drum, partition means for dividing the vapor space of said drum into compartments, safety valve means in said drum, at least one of said compartments including said vapor and liquid separating means and the vapor space communicating with said vapor outlets, at least one of said compartments communicating with the liquid space of said drum and to said safety valve means, and liquid seal means including liquid containing means with the lower edges of said partition means submerged in the liquid therein, the opening of said safety valve means breaking said liquid seal means and interconnecting all of said compartments.

4. In a vapor generator, a drum having an upper vapor space and a lower liquid space and having inlet means for a vapor and liquid mixture and separate outlets for vapor and liquid, vapor and liquid separating means within said drum and having a vapor discharge opening to the vapor space and a liquid discharge opening to the liquid space of said drum, partition means for dividing the vapor space of said drum into compartments, safety valve means in said drum, at least one of said compartments including said vapor and liquid separating means and the vapor space communicating with said vapor outlets, at least one of said compartments communicating with the liquid space of said drum and to said safety valve means, and liquid seal means positioned adjacent the upper edge of said vapor and liquid separating means and including liquid containing means with the lower edges of said partition means submerged in the liquid therein.

5. In a steam boiler, a horizontally elongated steam and water drum having an inlet for a steam and water mixture and separate outlets for steam and water, steam and water separating means, means for washing said steam by contact between wash liquid and the steam discharging from said separating means, partition means for dividing the steam space of said drum into compartments, safety valve means in said drum, at least one of said compartments including said steam and water separating means and said washing means and opening to said steam outlet and at least one other compartment including said water space and opening to said safety valve means, and water seal means connected with said partition means including a water seal replenished by water from said washing means.

6. In a steam boiler, a horizontally elongated steam and water drum having an inlet for a steam and water mixture and separate outlets for steam and water, steam and water separating means within said drum and having a steam outlet to the steam space and a water outlet to the water space of said drum, washing means for direct contact between wash water and the substantially dry steam discharging from said separating means, safety valve means in said drum, partitions dividing the steam space of said drum into compartments, a compartment intermediate the length of said drum containing said steam and water separating means and said washing means and opening to said steam outlet, at least one compartment adjacent an end of said drum opening to said water space and to said safety valve means, and water sealing means for said partitions comprising a trough within said drum positioned adjacent the upper portion of said separating means and arranged to receive the wash water discharging from the lower edges of said washing means, and the lower edge of said partitions submerged in the water in said trough.

7. In a steam boiler a horizontally enlongated steam and water drum having an inlet for a steam and water mixture and separate outlets for steam and water, cyclone means for separating the steam and water entering said drum, washing means for washing said steam by contact between wash water and the substantially dry steam discharging from said cyclone separating means, and dividing means in the steam space of said drum for separating the flow path from said steam and water cyclone separating means through said washing means to said steam outlet from the water space of said drum comprising a plate member in the upper portion of said drum with its lower edge submerged in a water seal defined by a trough containing water positioned adjoining the upper portion of said cyclone means and arranged to receive the wash water discharging from the lower end of said washing means.

8. In a steam boiler, a horizontally elongated steam and water drum having an inlet for a mixture of steam and water and separate steam and water outlets, steam and water separating means within said drum, a plurality of upright corrugated plates inclined downwardly toward the axis of said drum and positioned upwardly adjacent the steam outlet from said steam and water separating means, a trough extending longitudinally of said drum and positioned at the lower edge of said inclined corrugated plates, means for forming a film of water on said inclined corrugated plates with the water leaving said plates flowing into said trough, and partition means positioned in the upper portion of said drum and having its lower edges submerged in the water in said trough and its upper edge attached to said drum.

9. In a steam boiler, a horizontally disposed steam and water drum having upper outlet means for steam and lower outlet means for water, a row of cyclonic steam and water separators disposed along a longitudinal side of said drum intermediate the height thereof, and having an outlet in the upper portion thereof for the upward discharge of substantially dry steam therefrom, means for

tangentially delivering steam and water mixture to said cyclonic separators, a washer positioned above the steam outlet from said cyclonic separators for direct contact between a wash water and the steam discharging from said cyclonic separators, a trough extending longitudinally of said drum adjacent the upper portion of the row of cyclonic separators and arranged to receive the wash water discharging from the lower edge portion of the washer, and a plate member positioned in the upper portion of said drum with its upper edge attached to said drum and its lower edges submerged in the wash water within said trough.

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