

[54] VERTICAL STEAM DRUM
[75] Inventor: Peter F. Sokolowski, Media, Pa.
[73] Assignee: Westinghouse Electric Corporation,
Pittsburgh, Pa.
[22] Filed: Aug. 31, 1971
[21] Appl. No.: 176,597

3,329,130 7/1967 Cochran 122/34
3,520,116 7/1970 Good 55/440

FOREIGN PATENTS OR APPLICATIONS

15,953 1/1961 Japan 55/DIG. 23

Primary Examiner—Dennis E. Talbert, Jr.
Attorney—A. T. Stratton

[52] U.S. Cl. 55/318, 55/423, 55/440,
55/452, 55/454, 55/457, 55/DIG. 22, 55/DIG.
23, 60/39.13 B, 122/34
[51] Int. Cl. B01d 59/50
[58] Field of Search 55/337, 456, 457,
55/440, 444, 445, 446, 447, 454, DIG. 23,
423, 452, DIG. 22, 318; 122/34, 488, 491;
60/39.13 B

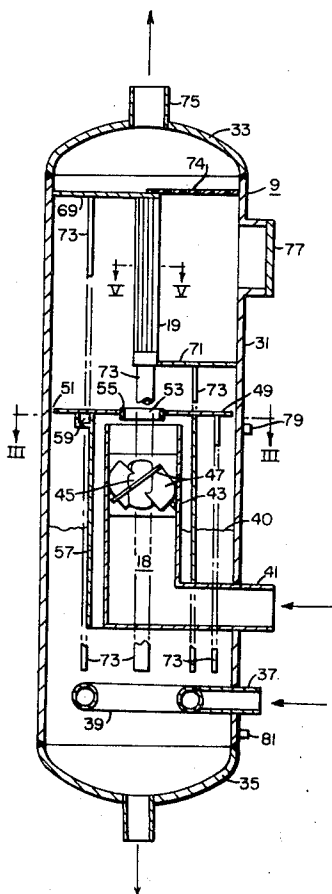
[56] References Cited
UNITED STATES PATENTS

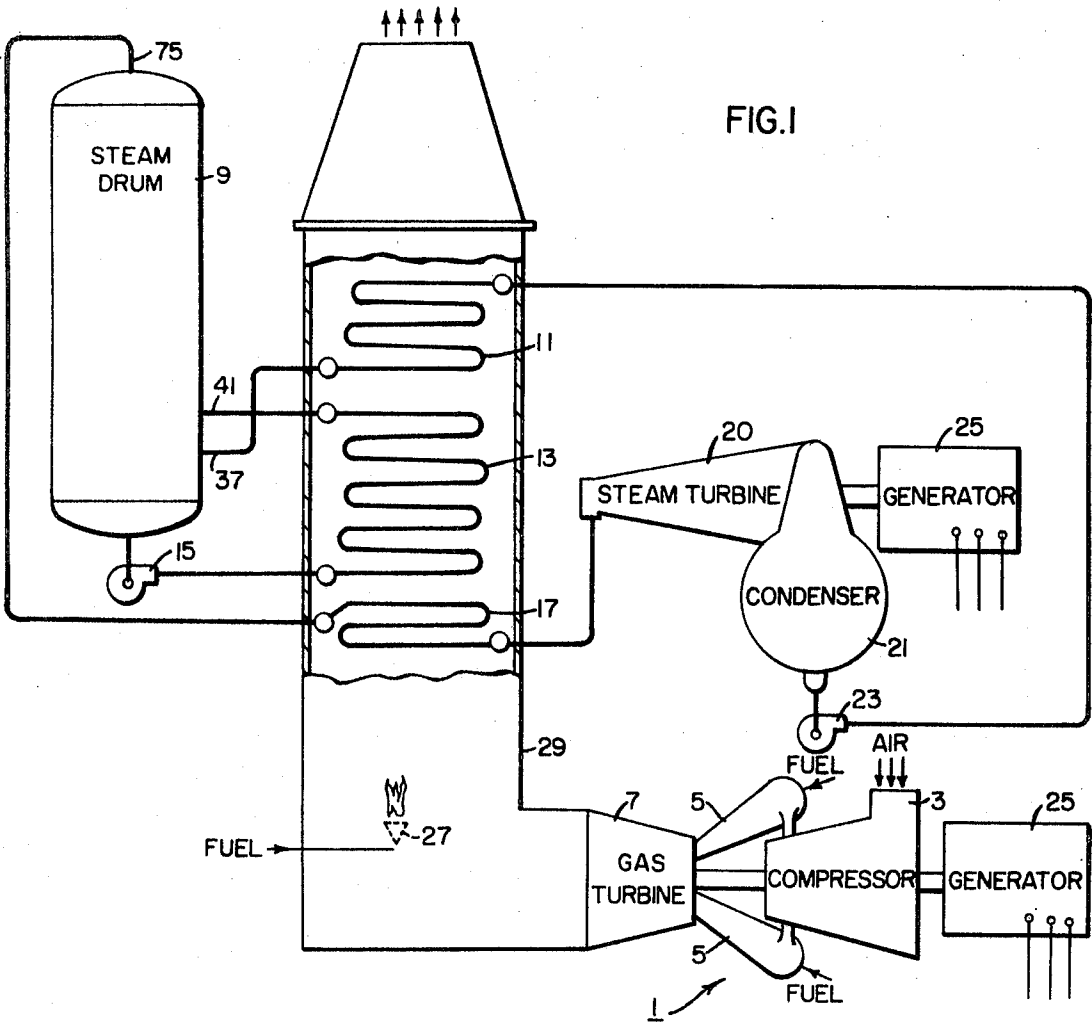
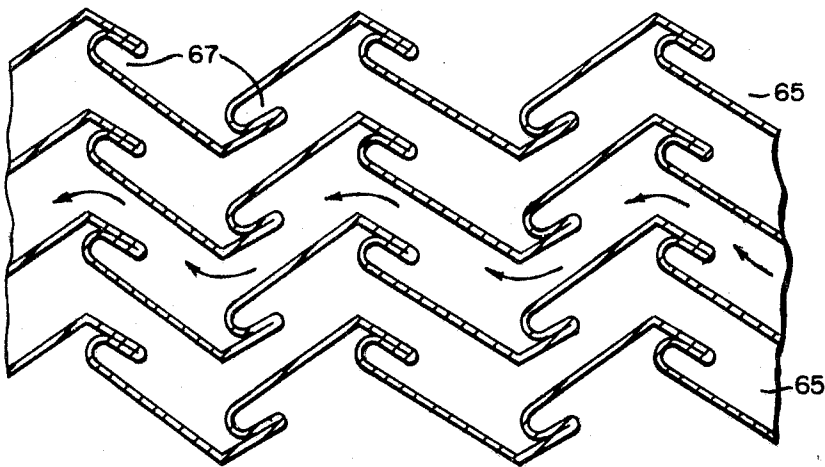
429,347	6/1890	Haskell	55/457 X
2,122,630	7/1938	Williams	55/454 X
2,648,397	8/1953	Ravese et al.	55/343
2,800,196	7/1957	Arant	55/456
3,195,515	7/1965	Blizard	122/34
3,213,833	10/1965	Cunningham et al.	122/34
3,296,779	1/1967	Daman et al.	55/337

[57] ABSTRACT

A vertical steam drum having two moisture separation stages, which cooperate to remove the majority of the water from moisture laden steam, is utilized in a heat recovery system, in which heat from the exhaust of a gas turbine produces superheated steam to operate a steam turbine. The first separation stage comprises a plurality of swirl vanes, which direct the moisture laden steam upwardly to form a swirling vortex of steam adjacent an orifice plate, a sleeve extending downwardly from the orifice plate, and tangential ducts disposed adjacent the upper end of the sleeve for discharging water from the swirling vortex of moisture laden steam. A chevron type separator disposed above the first separator forms the second separation stage to provide essentially moisture free steam to a superheater disposed in an exhaust duct of the gas turbine.

2 Claims, 6 Drawing Figures





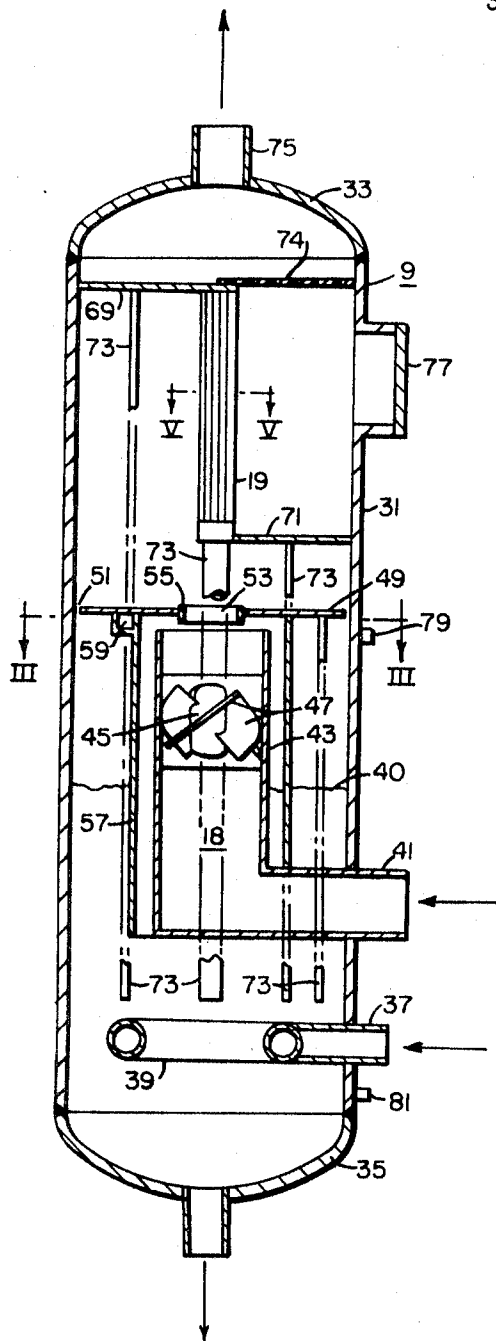


FIG. 2

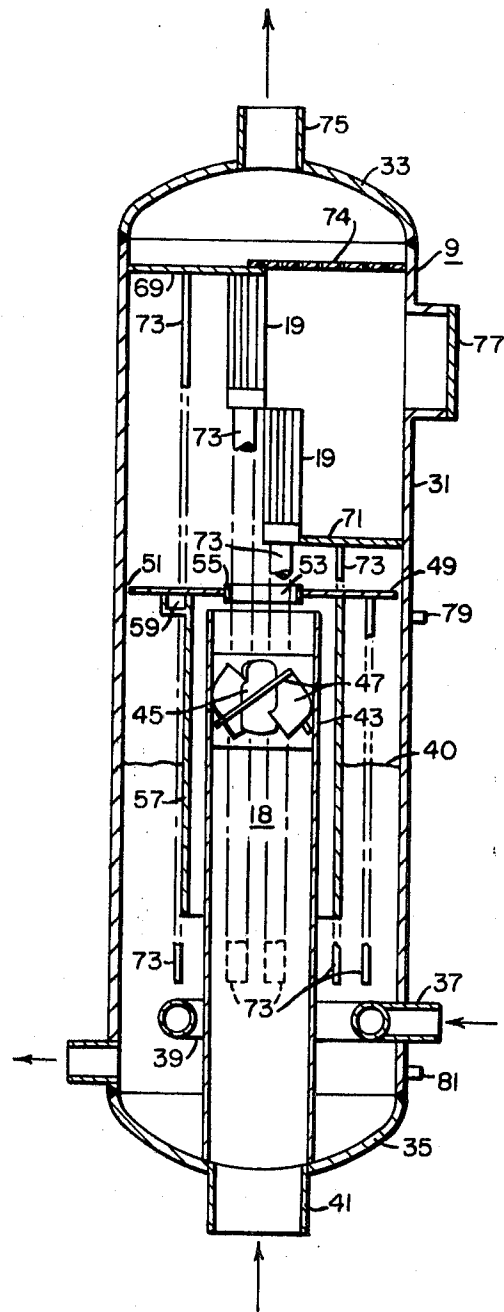
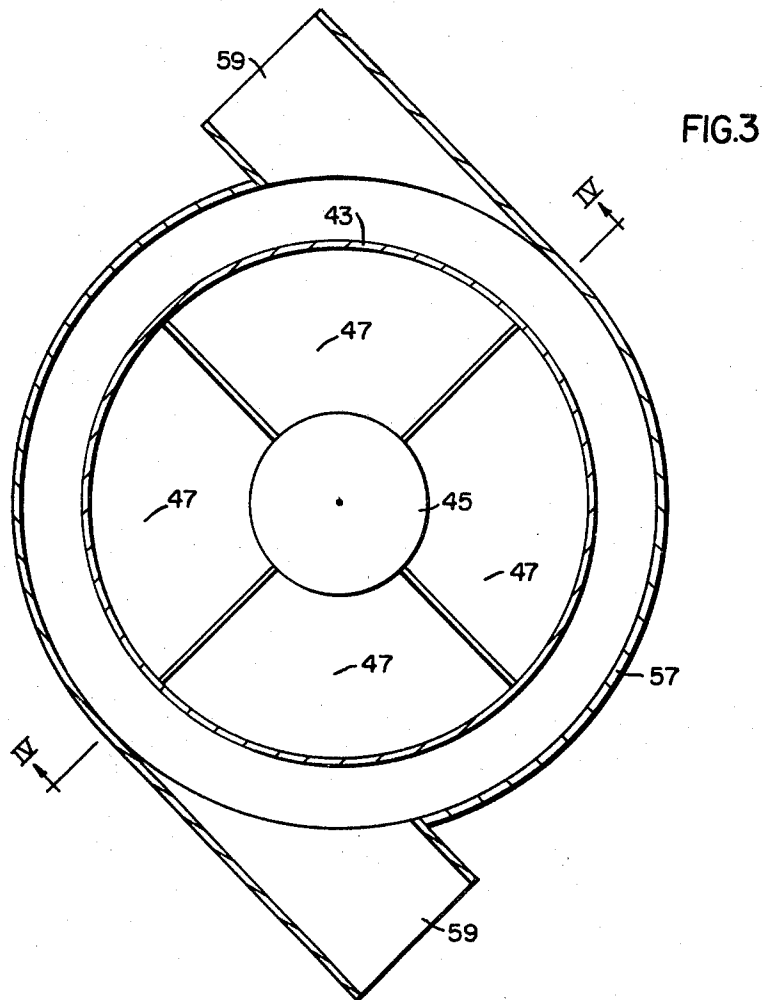
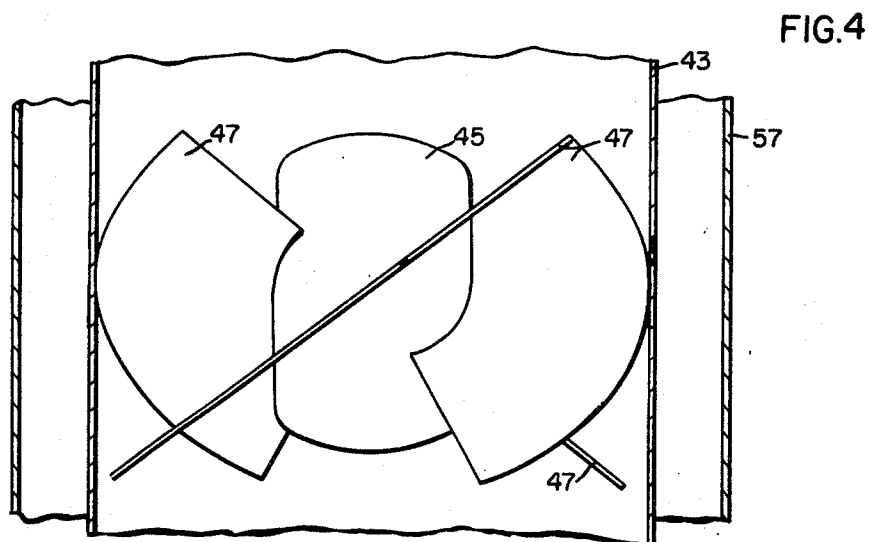


FIG. 6



VERTICAL STEAM DRUM

BACKGROUND OF THE INVENTION

This invention relates to a heat recovery system and more particularly to such a system having a vertical steam drum with two stages of moisture separation disposed therein.

Horizontal drums have been utilized to separate water and steam in steam generating equipment for decades; however, horizontal drums do not provide ample space for multistage moisture separating devices necessary to efficiently remove moisture from the saturated steam. Increasing the drum diameter to provide additional space for separation is no solution as the stresses increase with the diameter requiring thicker walls, which increase the cost of the drum.

SUMMARY OF THE INVENTION

In general, a vertically disposed steam drum for separating water from moisture laden steam, when made in accordance with this invention, comprises a shell portion, an upper head portion, a lower head portion, a steam outlet, a water outlet, a level above the lower head portion to which the water will rise, when the drum is operating, a feedwater inlet, and a ring disposed below the water level for discharging the feedwater evenly into the drum. Such a drum also comprises swirl vanes for directing moisture laden steam in an upwardly spiraling path to cause the steam to form a swirling vortex, a tangential discharge for separating the water from the swirling vortex of moisture laden steam and a chevron type separator for removing additional water from the steam.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects and advantages of this invention will become apparent from reading the following detailed description in connection with the accompanying drawings, in which corresponding reference characters indicate corresponding portions in the various drawings and in which:

FIG. 1 is a schematic diagram of a heat recovery system made in accordance with this invention;

FIG. 2 is an enlarged vertical sectional view of a steam drum made in accordance with this invention;

FIG. 3 is an enlarged partial sectional view taken on line III—III of FIG. 2;

FIG. 4 is an enlarged partial sectional view taken on line IV—IV of FIG. 3;

FIG. 5 is an enlarged partial sectional view taken on line V—V of FIG. 2; and

FIG. 6 is a vertical sectional view of a modified steam drum.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings in detail, FIG. 1 diagrammatically shows a heat recovery system for recovering heat from the exhaust of a gas turbine 1, wherein air enters a compressor 3, is compressed, and the pressurized air flows to a plurality of combustion chambers or combustors 5, wherein the air is mixed with a fuel, such as natural gas, is ignited and burned raising the temperature of the mixture. The high temperature mixture or motive fluid is then expanded in a turbine unit 7. The exhaust gases leaving the turbine unit 7 still contain a large amount of heat energy and if exhausted to

the atmosphere, this heat energy would be wasted. The other equipment shown forms the heat recovery-steam generator portion of the system and comprises a vertical steam drum 9, an economizer heat exchanger 11 for heating feedwater or condensate being fed to the drum 9, an evaporator heat exchanger 13 for evaporating water pumped from the drum 9 by a circulating pump 15, and a superheater heat exchanger 17 for superheating steam flowing from the drum.

The steam produced in the evaporator is saturated steam and contains a large quantity of moisture, therefore to protect the superheater 17 from premature failure caused by scaling, which results from dissolved solids in the steam being deposited on the walls of the tubes forming the superheater as the entrained moisture in the steam is evaporated, it is necessary to remove as much moisture as possible from the steam before it enters the superheater. To accomplish this the steam drum is disposed vertically to provide for two stages 18 and 19 of moisture separation, as will be described in detail hereinafter.

Superheated steam produced in the superheater 17 flows to a steam turbine 20 and the exhaust steam from the steam turbine 20 is condensed in a condenser 21. A condensate pump 23 pumps the condensate back through the economizer 11 to the steam drum 9 forming a closed cycle.

FIG. 1 also shows a generator 25 coupled to each turbine, however, the turbines can be coupled to a single generator by providing gearing or other connecting means between the turbines.

The gas turbine 1 as shown has an open cycle, that is the motive fluid is not recirculated. An after burner 27 shown in the drawings provides additional heat for generating steam and controls the temperature at steam leaving the superheater 17. However, the use of the after burner 27 is optional and other means may be provided for controlling the temperature of the steam leaving the superheater.

Also, as shown in FIG. 1, the superheater evaporator and economizer heat exchangers are disposed in an exhaust duct 29 in series, and in the order set forth, so that the hottest exhaust gases flow over the superheater and the coolest exhaust gases flow over the economizer, to provide the maximum mean temperature difference for the respective heat exchangers.

As shown in FIG. 2, the vertical steam drum comprises a cylindrical shell or wall portion 31, an upper and lower head portion 33 and 35, and a plurality of nozzles disposed to allow steam and water to flow into and out of the drum 9.

A feedwater inlet nozzle 37 is disposed in the lower end of the shell adjacent the lower head 35 and is in communication with the economizer 11 and with a ring distributor 39 disposed within the shell 31. When operating, the drum 9 is partially filled with water to a generally constant level, normally referred to as the water level 40. The inlet nozzle 37 and ring distributor 39 are shown disposed below the water level 40, but can also be located above the water level.

Moisture laden saturated steam from the evaporator 13 enters the drum 9 through a steam-water inlet nozzle 41 and flows into the first stage separator 18, which comprises a tubular riser member 43 disposed vertically within the shell 31. A hub 45 as shown in FIGS. 2 through 4 is centrally disposed adjacent the upper end of the tubular riser 43 and a plurality of swirl vanes

47 spiral upwardly between the riser 43 and the hub 45 to define a plurality of generally equal upwardly spiraling flow paths, which cause the moisture laden steam to form a swirling vortex as it is discharged from the upper end of the riser 43.

A short distance above the riser is an orifice plate 49 transversely disposed within the drum and having an outer diameter smaller than the inner diameter of the drum to provide a space or annular opening 51 between the shell 31 and the outer periphery of the orifice plate 49 for steam to flow thereby. The orifice plate 49 also has an opening or orifice 53 axially aligned with the tubular riser 43 and slightly smaller in diameter than the riser. A collar 55 encircles the opening 53 and extends downwardly below the orifice plate and is seal welded to the orifice plate.

A sleeve member or downcomer 57 extends downwardly from the orifice plate 49 and encircles the tubular riser 43. The downcomer 57 extends down below the water level 40 so that during operation the lower end of the downcomer 57 is sealed.

The upper end of the downcomer 57 has a plurality of tangential ducts 59 disposed thereon. The ducts 59 allow the water from the vortex of moisture laden steam to be spun therethrough and into an annular chamber bounded by the shell 31 and downcomer 57 with the orifice plate 49 and water level 40 forming the ends thereof. Steam, which is discharged through the tangential ducts 59 with the water, can pass upwardly through the space 51 between the orifice plate 49 and the shell 31, while the water flows downwardly. Steam with a large portion of the water removed flows upwardly through the central portion of the vortex and through the orifice 53 to the second stage of separation 19.

As shown in FIG. 2, a chevron separator forms the second stage 19 of separation and is disposed above the orifice plate 49. The chevron separator 19 as shown in FIG. 5 comprises a plurality of generally vertically disposed directional or guide vanes 65 defining a plurality of zig-zag paths. Each vane 65 is formed from a single sheet of material and is bent to form a plurality of vertically extending flat vane sections, having a zig-zag cross section and liquid channels 67 at the downstream end of each vane section. The vanes 65 being so disposed, collect water droplets which impinge upon the surface of the vane sections as steam passes therebetween. The water droplets which collect on the vane sections are propelled toward the channels 67 by the steam and collect in the channels and flow by gravity down the channel 67 to drain. The guide vanes 65 are spaced apart and traverse the drum 9. An upper and lower closure plate 69 and 71, respectively cooperate with the vanes 65 to cause steam to flow upwardly and pass through the orifice 53 and between the vanes to remove additional moisture from the steam. Drain pipes 73 are appropriately disposed to drain water removed from the steam. The lower end of the drain pipes 73 are disposed to extend downwardly below the water level to form a seal.

A perforated plate 74 is disposed generally horizontally in the flow path between the chevron separator 19 and a steam outlet nozzle 75 disposed in the upper head portion of the drum 9. The perforated plate 74 helps promote a uniform flow distribution across the face of the chevron separators 19. The steam outlet nozzle 75

is in communication with the superheater 17 and supplies steam thereto.

A manway 77 is provided in the shell 31 adjacent the upper head 33 to provide access to the drum and its internals to facilitate assembly and maintenance.

Level control and indicating nozzle 79 and 81 are disposed in the shell 31 above and below the water level 40 and are utilized in conjunction with a level controller and sight glass (neither of which is shown) to control and observe the level of the water in the drum 9.

FIG. 6 shows a modified steam drum in which the moisture laden steam from the evaporator 13 enters the steam inlet nozzle 41, which is disposed in the lower head 35, and the tubular riser member 43 extends upwardly from the lower head and is seal welded thereto. The second stage moisture separator is also shown to comprise two sets of chevron separators 19 one disposed above the other to allow parallel flow therethrough and to provide shorter directional vanes 65, which reduce the amount of water running down vanes and prevent re-entrainment of water in the steam passing thereby. This arrangement also permits the use of a smaller diameter drum.

Vertical steam drums, as hereinbefore described, provide sufficient space for two stages of water separation to remove essentially all of the moisture from the moisture laden saturated steam produced in the evaporator heat exchanger 13 so that the amount of dissolved solids deposited in the superheater portion of the heat recovery-steam generator system is minimal, thus increasing the life of the superheater and reducing maintenance necessitated by premature failure due to the build-up of solids, which adversely affect the heat transfer from the exhaust gases to the steam and cause hot spots.

What is claimed is:

1. A vertically disposed steam drum for separating water from moisture laden steam comprising:

a shell portion;

an upper head portion;

a lower head portion;

a steam outlet;

a water outlet;

a level above said lower head portion to which said water will rise when said drum is operating;

a feedwater inlet;

means for discharging water from said feedwater inlet into said drum, said discharging means being disposed below said level;

means for introducing moisture laden steam into said drum;

means for directing moisture laden steam in an upwardly spiraling path to cause said steam to form a swirling vortex; said steam directing means comprising:

a vertically disposed tubular member having a steam inlet disposed adjacent the lower end thereof,

a hub centrally disposed within said tubular member, and a plurality of upwardly spiraling vanes disposed between said hub and said tubular member, said vanes being disposed to define a plurality of generally equal upwardly spiraling flow paths for the steam;

means for separating water from said swirling vortex of moisture laden steam, said separating means being disposed above said steam directing means;

5

additional means for separating water from said steam, said additional separating means being disposed above said first-mentioned separating means and adjacent said steam outlet,

said first-mentioned moisture separating means comprising:

an orifice plate disposed above the steam directing means said orifice plate having an orifice disposed therein, a collar disposed within said orifice, the collar being axially aligned with the steam directing means and disposed to extend above and below the orifice plate, said orifice plate being transversely disposed in the drum and having a diameter smaller than the inner diameter of the drum, a sleeve member extending downwardly from said orifice plate and encircling the steam directing means; and a plurality of tangential ducts extending from the

6

upper end of said sleeve member.

2. A vertically disposed steam drum as set forth in claim 1, wherein the additional separating means comprises a plurality of generally vertical directional vanes defining a plurality of zigzag paths, each vane being formed from a single sheet of material and bent to form a plurality of vertically extending liquid channels for collecting water droplets, which impinge on the surfaces of the vanes as steam passes therebetween; and a pair of closure plates cooperatively associated with said additional separating means and said shell portion to cause said steam leaving said first mentioned separating means to flow through said additional separating means prior to being discharged through said steam outlet.

* * * * *

20

25

30

35

40

45

50

55

60

65