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Carnavos et al.

[11] **3,712,272**

[45] **Jan. 23, 1973**

[54] COMBINED MOISTURE SEPARATOR AND REHEATER

[75] Inventors: **Theodore C. Carnavos**, Danbury, Conn.; **William S. Hubble, Kenneth K. Woods**, Cape Elizabeth, Maine

[73] Assignee: **General Electric Company**

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[52] **U.S. Cl.** **122/483**, 165/78

[51] **Int. Cl.** **F22g 1/00**

[58] **Field of Search** 122/32, 483; 165/78

[56] **References Cited**

UNITED STATES PATENTS

3,472,209	10/1969	Roffler	122/483 X
3,508,527	4/1970	Durrer	122/483
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3,667,430	6/1972	Hubble et al.	122/483

FOREIGN PATENTS OR APPLICATIONS

931,235	7/1963	Great Britain	122/483

Primary Examiner—Kenneth W. Sprague

Attorney—William C. Crutcher et al.

[57] **ABSTRACT**

A combined moisture separator and reheater for a steam turbine-generator power plant has moisture separating elements and first- and second-stage heating elements disposed longitudinally in a pressure-tight cylindrical shell. The reheating elements each comprise a transverse header with a vertical partition, the tube sheets forming part of the header wall. Tube bundles designed to be supplied with substantially saturated steam are comprised of tubes extending the length of the pressure vessel from one side of the header, forming a U-bend at the opposite end in a horizontal plane and extending back to the other side of the header. The tube bundles are supported on side rails which are arranged to slide on side rails supported by the pressure shell.

5 Claims, 5 Drawing Figures

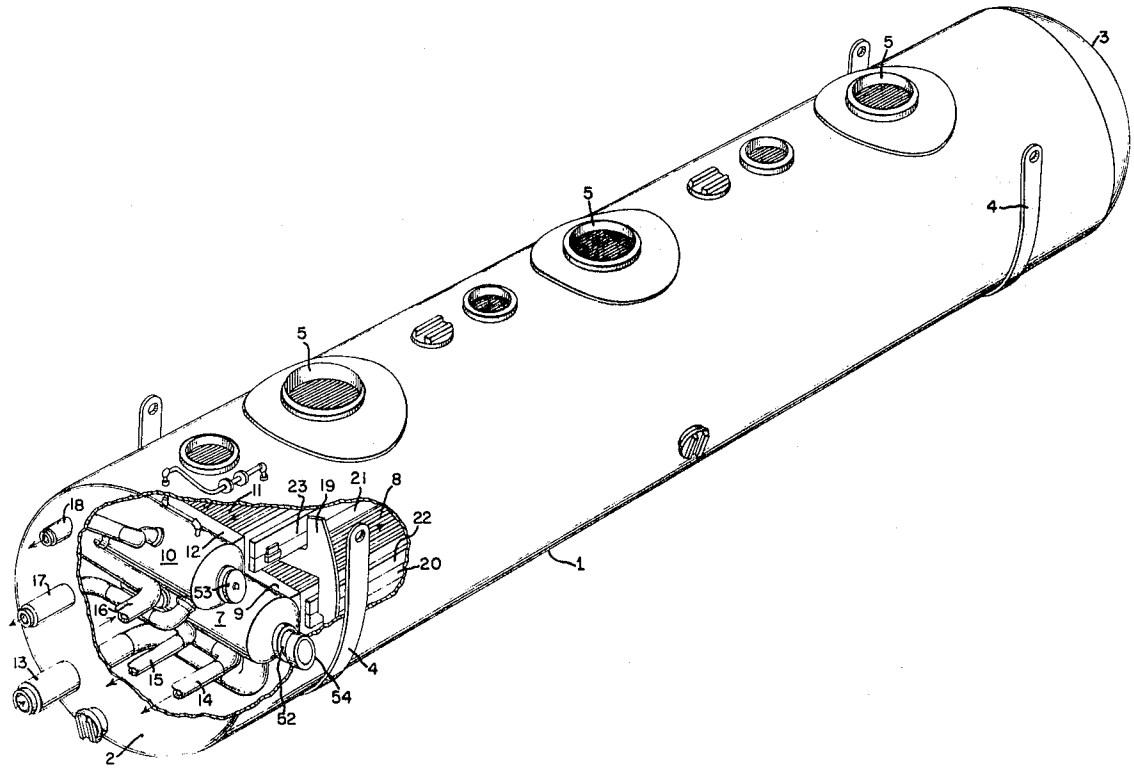


FIG.1

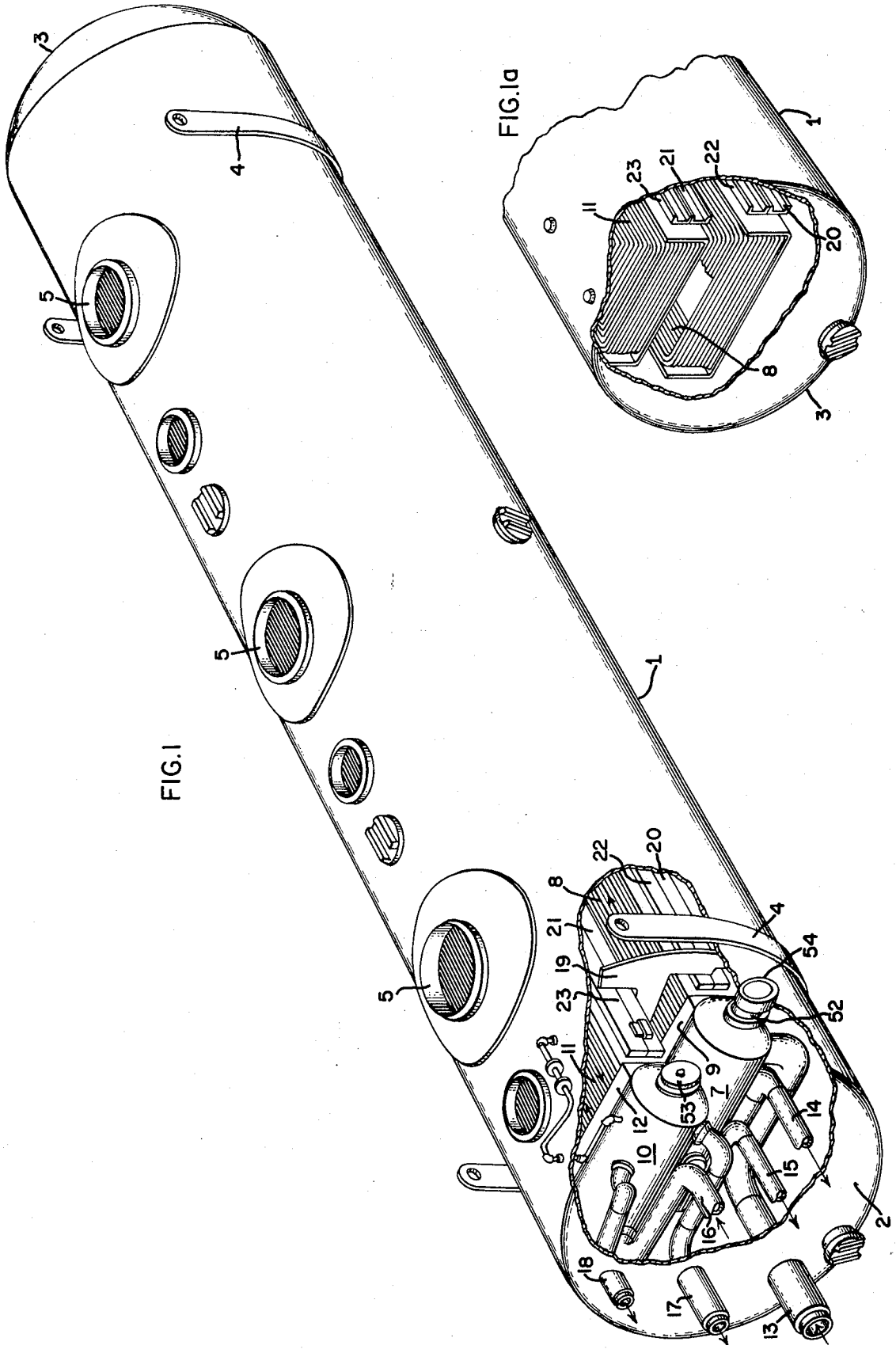

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5
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5
1
22
20
8
21
4
19
54
23
52
11
9
7
53
12
14
10
15
16
2
18
17
13

FIG.1a

1
23
21
22
11
20
8
3

FIG.2

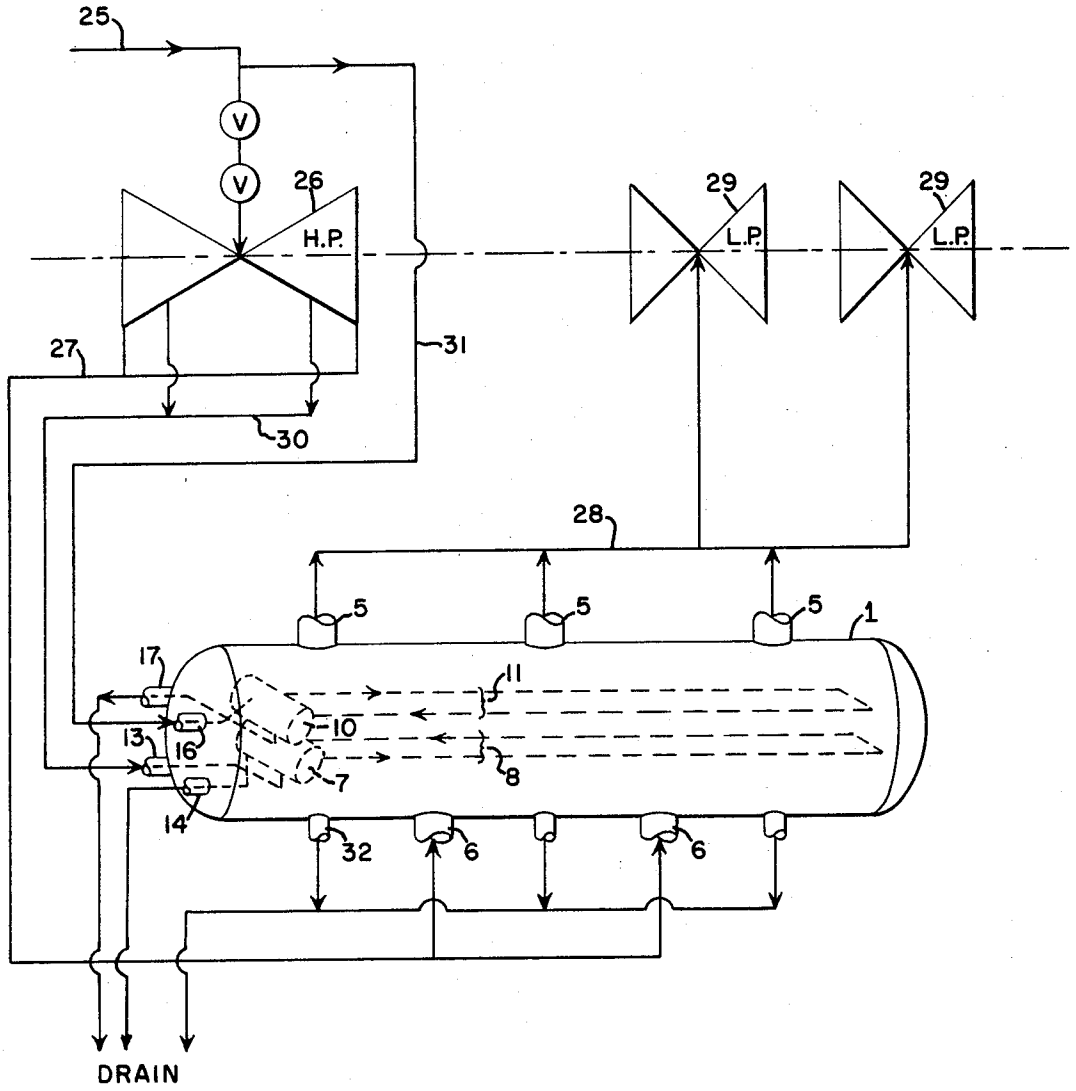

25
V
V
26
H.P.
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L.P.
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L.P.
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31
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11
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13
16
7
8
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32
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6
DRAIN

FIG. 3

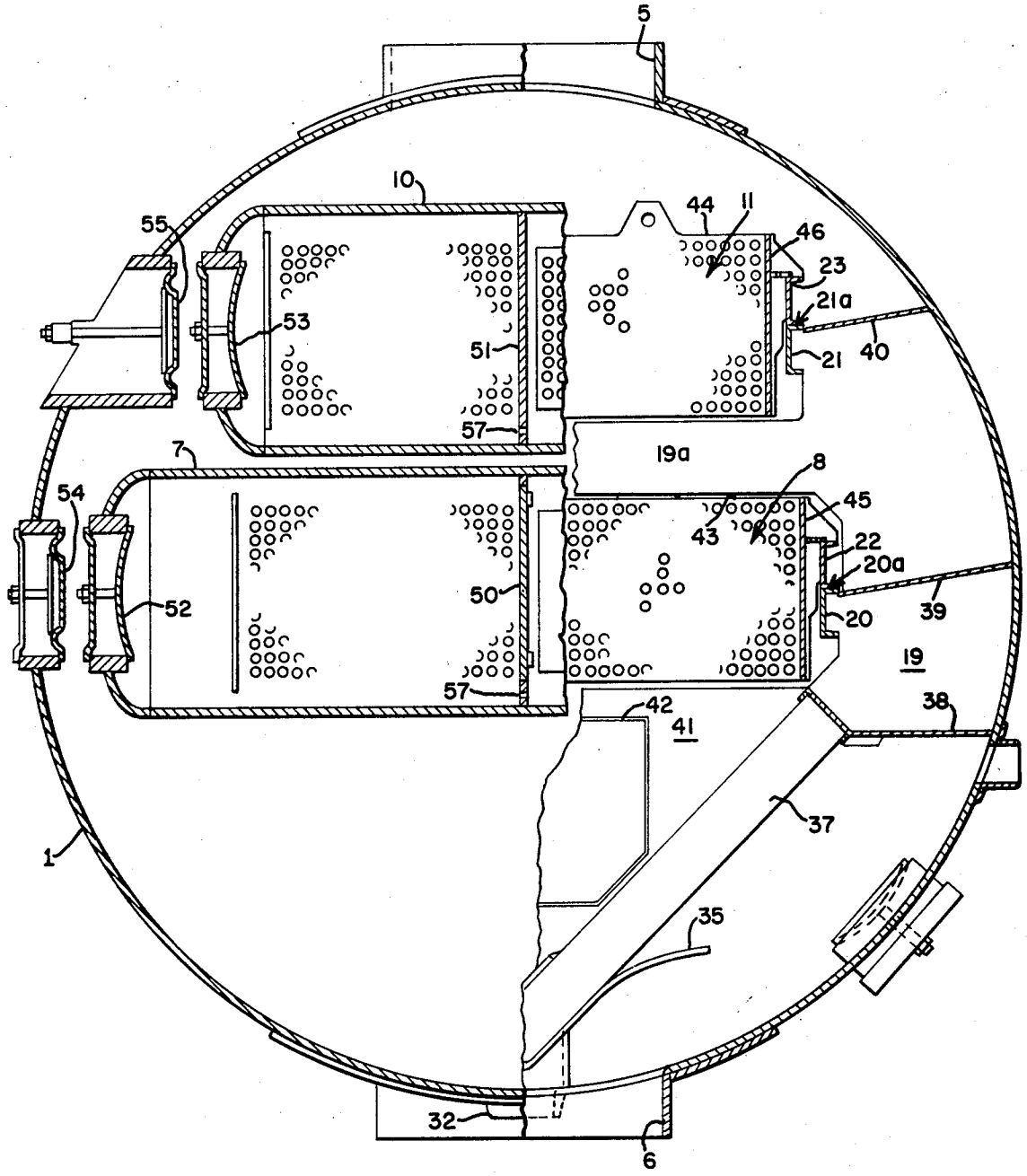
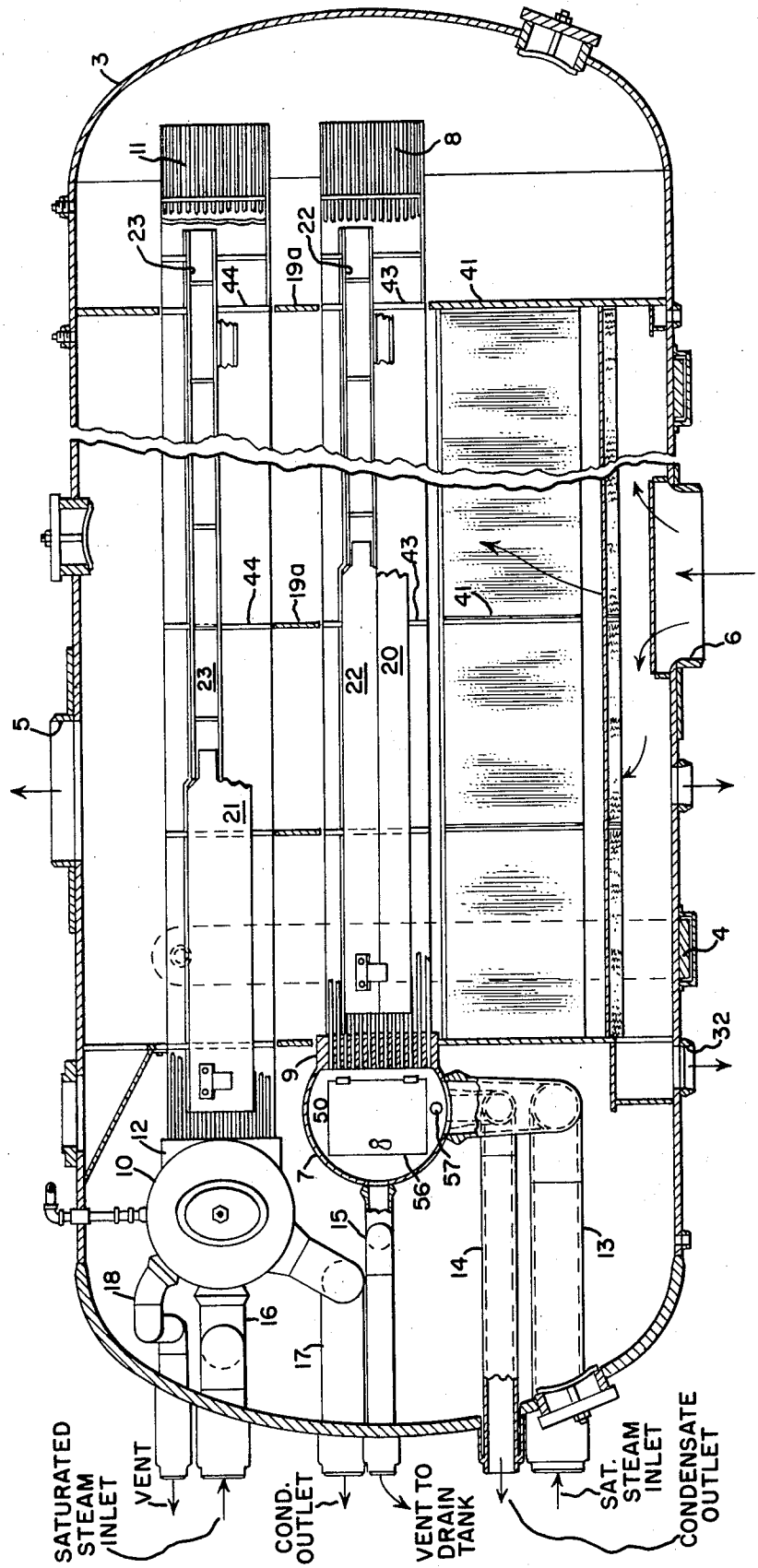

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10
55
44
11
46
23
21a
53
51
21
40
57
19a
7
8
54
45
43
22
20a
52
50
20
39
19
57
42
38
41
1
37
35
32
6

FIG.4


SATURATED STEAM INLET
VENT
COND. OUTLET
VENT TO DRAIN TANK
SAT. STEAM INLET
CONDENSATE OUTLET

COMBINED MOISTURE SEPARATOR AND REHEATER

BACKGROUND OF THE INVENTION

This invention relates generally to apparatus for separating moisture from wet steam in a steam turbine power plant and then reheating the steam for use in a lower pressure turbine stage. More particularly, it relates to a combined moisture separator and reheater (MSR) designed to accomplish reheating with substantially saturated steam from the power plant cycle with provisions for facilitating examination and maintenance of the reheater.

In large steam turbine power stations, where a series of turbines are employed, it is often desirable to separate moisture from the steam and to reheat it before it passes to a succeeding turbine section. Combined moisture separators and reheaters are known in the art wherein the moisture separator elements are combined with the reheater elements in a single pressure shell. In most cases, the reheaters are comprised of tube bundles, extending longitudinally along the pressure shell with provisions for introducing a heating fluid to the tubes from headers. In most of the cases, the headers are either disposed outside of the pressure shell or extend partially through the pressure shell so that access to the header is obtained from outside the shell in order to examine condition of the tubes. Exemplary of the prior art are U.S. Pat. Nos. 3,508,527 to Durrer, No. 3,472,209 to Roffler, No. 3,518,830 to Viscovich et al, No. 3,574,303 to Rabas and British Pat. No. 931,235 to Byerley. Certain stress problems which are caused by bringing the tubes and headers through the pressure shell are avoided by completely enclosing enclosing the headers and the tube bundles inside the pressure shell as disclosed in a pending application Ser. No. 43,359, now U.S. Pat. No. 3,667,430, filed in the names of Hubble et al on June 4, 1970, and assigned to the assignee of the present application. However, in all of the aforementioned prior art, which is generally intended to utilize substantially saturated steam as the heating fluid flowing in the tube bundles, the disclosed arrangement is to dispose the U-bend of each tube in a substantially vertical plane. This means that access to the ends of the tubes in the header is severely restricted because of the presence of a horizontal partition between the inlet and outlet sides of the header.

Another problem associated with combined moisture separators and reheaters arises from the relative temperature differences between the reheater tubes (which are at substantially constant temperature if they are operating as condensing tubes) and the steam in the pressure shell flowing around the tubes. Some means must be provided to support the tubes along their length and to allow for thermal expansion and contraction relative to the pressure shell during transient conditions.

Accordingly, one object of the present invention is to provide an improved, combined moisture separator and reheater wherein the reheaters have relatively long tube bundles and headers disposed inside the pressure shell.

Another object of the invention is to provide a construction for improved access and maintenance of tube bundles in a combined moisture separator and reheater of the type described.

Still another object of the invention is to provide an improved construction for supporting long tubes in a moisture separator reheater subject to relative temperature differences of the reheater elements with respect to the shell.

DRAWING

The invention, both as to organization and method of practice, together with further objects and advantages thereof, will best be understood by reference to the following specification, taken in connection with the accompanying drawings, in which:

FIG. 1 is a perspective view, partly in section, of the combined moisture separator and reheater (MSR),

FIG. 1*a* is a partial perspective view from the other end of the MSR,

FIG. 2 is a simplified diagram of a steam turbine-generator power plant incorporating the MSR of the present invention,

FIG. 3 is a transverse cross section taken through the MSR headers on the left-hand side and through the tube bundles and separator elements on the right-hand side, and

FIG. 4 is a partial longitudinal cross section through the MSR.

SUMMARY OF THE INVENTION

Briefly stated, the invention comprises the improvement in a combined moisture separator and reheater of the type having separator and reheater elements disposed in a horizontal cylindrical pressure shell of transverse headers disposed within one end of the shell and connected to longitudinally extending tube bundles, with the tubes arranged in a U-shaped configuration disposed in a horizontal plane, together with sliding rail supports for supporting the tubes and allowing them to expand and contract relative to the shell.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 of the drawing, a cylindrical shell 1 is made pressure-tight by fitting with hemispherical end pieces 2, 3 welded about the periphery. The vessel is arranged to be supported by straps 4 and may be on the order of 56 feet long and 12 feet in diameter. The vessel is fitted with three steam outlet openings 5 at the top and two steam inlet openings 6 (see FIGS. 2–4) at the bottom.

The interior arrangement, partially shown in the broken-away portion of FIG. 1, includes a lower transversely extending header 7 communicating with a bundle of first-stage heating tubes 8 via a massive tube sheet 9 forming part of the header wall. Similarly, an upper transversely extending header 10 communicates with a second-stage tube bundle 11 via a similar tube sheet 12. Header 7 is connected to a steam inlet line 13, a condensate outlet line 14 and a vent line 15. Similarly, header 10 is connected to a saturated steam inlet line 16, a condensate outlet line 17 and a vent line 18. All of the steam supply, condensate and vent lines 13–18 extend through the end piece 2 of the pressure shell and are arranged with generous bends inside the vessel to relieve stress due to thermal transients.

As will be explained further in greater detail, a number of spaced support ribs **19** are attached at intervals to the row of shell **1** and both serve to partition the vessel into sections for aiding in flow distribution and to support horizontal stationary rails **20** and **21**. The tube bundles **8**, **11** are attached to and supported by sliding side rails **22**, **23**, respectively, arranged to slide on the stationary rails as will be described in detail.

Reference to FIG. 1a which is a perspective partial cross section looking from the other end of the MSR indicates that the individual tubes of bundles **8**, **11** are each arranged to bend in a horizontal plane. The advantages of this arrangement will be set forth in detail.

Referring now to FIG. 2 of the drawing, a simplified schematic is presented of the environment in which the MSR operates. High-temperature steam from inlet line **25** enters a high-pressure turbine **26** and wet steam is exhausted via outlet line **27** to the MSR inlets **6**. Inside the MSR, the steam passes through moisture separators (not shown) and over the first-stage and second-stage reheat tube bundles **8**, **11**, respectively, to the MSR outlets **5** on top of the shell. From there the dried and reheated steam flows through line **28** to the inlets of the low-pressure turbines **29**.

First-stage reheating fluid is obtained from slightly wet steam extracted from the high-pressure turbines via line **30** which enters the MSR at inlet pipe **13**, flows into header **7**, down and back through tubes **8** and the condensed steam leaves through outlet pipe **14** connected to the drain line.

Second-stage reheating fluid is provided by a branch line **31** from the main inlet line **25** which enters the MSR via pipe **16**, flows to header **10**, down and back through tubes **11**, and the condensate leaves by way of outlet pipe **17** to the drain line. Additional liquid from the moisture separator elements is drained from the MSR by way of pipes **32**.

Referring now to FIG. 3 of the drawing, a cross section is shown taken through the headers **7** and **10** on the left-hand side and through the tube bundles **8** and **11** on the right-hand side. The MSR is symmetrical about the vertical centerline with respect to the aforesaid items, so that details not shown on one side can be considered identical to those shown on the opposite side.

Referring first to the right-hand side of the drawing, a curved plate **35** is disposed above the inlet **6** to serve as an impingement baffle to deflect incoming steam. At spaced intervals along the shell **1** on the order of every four feet, transverse support ribs **19** are attached to the side walls of the shell **1**. Extensions **19a** on the support ribs extend between the tube bundles **8**, **11**.

Ribs **19** serve to support the upper edge of an inclined bank of moisture separator elements **37** extending the length of the shell. A similar bank of moisture separators on the other side of the shell causes the elements to be placed in a V-configuration. The details of the moisture separator **37** are immaterial to the present invention, but are preferably of the zigzag or corrugated plate type with the corrugations running longitudinally along the elements, downward and toward the center of the MSR.

The support ribs **19** are also arranged to hold the aforementioned longitudinally extending stationary side rails **20**, **21** which extend the length of the shell and are disposed to present upper sliding surfaces **20*a***, **21*a***, respectively.

Extending between support ribs **19** and serving to block the passage of steam up the sides of the MSR are generally horizontal connecting plates **38**, **39**, **40**.

A number of additional spaced vertical partitions **41** extend transversely across the MSR between separator banks **37** and the first-stage tube bundle **8**. These are aligned with rib extensions **19a**. Partitions **41** have hinged doors **42** for passage of maintenance personnel along the MSR.

The tube bundles **8**, **11** are similarly constructed with respect to the means of support. Tube support sheets **43**, **44** for the respective tube bundles **8**, **11** extend transversely at spaced intervals along the MSR. These are attached to longitudinal side plates **45**, **46** which, in turn are connected by means of suitable gussets to the slidable side rails **22**, **23**. The side rails **22**, **23** slide on the stationary supporting side rails **20**, **21** to accommodate temperature changes between the tube bundles and the pressure shell structure.

It is important to note from the standpoint of uniform flow distribution that the vertical partitions **41**, the tube support sheets **43**, **44** and the support rib extensions **19*a*** are all aligned with respect to one another, as well as being spaced at intervals along the MSR. This serves to cause the flow resistance of the tube bundles **8**, **11** to force a uniform flow distribution through the moisture separator bank **37** and thereby improve the efficiency of the separating elements.

Referring to the left-hand side of FIG. 3 through the headers **7**, **10**, vertical partitions **50**, **51** provided with hinged doors serve to divide the headers into inlet and outlet chambers. The inlet chamber is shown for header **10** and the outlet chamber is shown for header **7**. Elliptical manways **52** are provided in opposite ends of header **7** and similarly manways **53** are provided in opposite ends of header **10**. These are aligned with manways **54**, **55**, respectively, through the cylindrical pressure shell **1** on opposite sides of the vessel.

Referring now to FIG. 4 of the drawing, the longitudinal cross section indicates the alignment of the vertical flow separating elements comprising tube support sheets **43**, **44**, lower partitions **41** and rib extensions **19*a***. The drawing also indicates clearly the fact that the individual tubes of tube bundles **8**, **11** are bent in a horizontal plane as opposed to prior art, constructions for condensing tube elements.

A cross section through the first-stage header **7** indicates the interior construction with respect to integration of the tube sheet **9** into the wall of the header **7**. Tube sheet **9** (as well as the corresponding tube sheet **12** on the second-stage header) is of massive construction in order to withstand stresses imposed during operation. As seen inside the header, the vertical partition **50** is provided with a hinged door **56** so that once entry is gained to the header from either side of the pressure vessel, inspection of the tube ends in both the inlet and outlet chamber may be carried out by opening the door. It should be particularly noted that the aforementioned horizontal arrangement of the tubes allows the use of a vertical partition and therefore full height is available within the header for a man to examine all of the tube ends.

It remains to note that a small opening **57** is provided through partition **50** below the door. This serves to hold the pressure different between the inlet and outlet chambers at a substantially constant value.

OPERATION OF THE INVENTION

Referring to FIG. **3**, steam entering through inlet **6** is deflected by impingement baffle **35** and flows longitudinally along the lower unpartitioned portion of the MSR and enters moisture separator elements **37**. Uniform flow distribution is forced by the downstream resistance of the tube bundles through the flow passages formed between the vertical aligned partitions and tube support sheets. Moisture drains toward the bottom center of the vessel and is removed to drain via the outlets **32**. The steam is heated as it passes over the first- and second-stage tube bundles in succession to leave the vessel via outlets **5**. As the steam flows over the tube bundles, it causes condensation of the substantially saturated steam inside the tubes. This condensed steam enters the outlet chambers in headers **7**, **10** and flows to drain.

Since the tube bundles are of extremely long length, changes in length due to temperature variations are magnified. These relative temperature differences between the tubes and the shell are accommodated by the sliding side rail supports **20–23**.

To gain entry into the MSR for tube inspection and repair, the horizontal disposition of tubes and use of vertical partitions in the headers provide generous spaces for a man to work and examine the tubes. Entry into the completely enclosed headers may be had from manways from either side of the shell. The use of completely enclosed headers reduces the stress and construction difficulties which were occasioned by the prior art practice of extending the headers and tubes through the pressure shell.

While there is shown what is considered at present to be the preferred embodiment of the invention, it is of course understood that various other modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a combined moisture separator and reheater of the type having a substantially pressure-tight cylindrical shell of substantial length and also having moisture separating elements and reheating sections disposed in series flow relationship within the shell, the improvement in a said reheating section comprising:

a transverse header disposed inside said shell at one end thereof and extending horizontally across the shell, said header having a vertical tube sheet forming a wall portion thereof and also having a vertical partition dividing said header into inlet and outlet chambers,

a tube bundle of substantial length extending from said tube sheet horizontally along the shell, each of the tubes in said bundle having opposite ends communicating with said inlet and outlet chambers in the header via said tube sheet and forming a bend in a horizontal plane at the far end of the vessel,

a plurality of tube support sheets spaced along and supporting said tubes,

a pair of first stationary longitudinal side rails supported within the shell on either side thereof and alongside said tube bundle,

a pair of second side rails connected to the tube support sheets and disposed in sliding relationship on top of said first side rails to accommodate relative thermal movements of the tube bundle.

2. The combination according to claim **1**, wherein said moisture separating elements are disposed in a V-relationship in the lower part of the pressure vessel and wherein two of said reheating sections as claimed are disposed atop one another and above the moisture separating elements.

3. The combination according to claim **1**, wherein said header is provided with a manway at at least one end thereof, and wherein said shell is provided with a second manway aligned with said first manway to provide access to said header.

4. The combination according to claim **1**, wherein said first longitudinal side rails are supported by oppositely extending vertical support ribs aligned with said tube support sheets.

5. The combination according to claim **1**, wherein said header vertical partition is provided with an access door for allowing inspection of both said inlet and outlet chambers from one side of the header.

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