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(54) **SYSTEM FOR GENERATING STEAM IN A PLANT FOR THE PRODUCTION OF A WEB-LIKE PAPER MATERIAL**

(57) Herein described is a plant for the production of a web-like paper material which comprises a system for generating steam at three or more pressure levels using the discharge coming from a Yankee hood. This system allows an energy recovery, given that the steam produced is generated through two heat exchangers, supplied by the Yankee hood discharge which would otherwise be disposed into the atmosphere. The first heat exchanger conveys the exit of the mixed phase in a first pressurised tank, where the steam is separated from water. From here the steam is introduced into the line for use in the paper drying process, while the water at balance temperature with the steam is transferred in a second pressurised tank, with lower pressure with respect to that of the first tank. Lastly, the residual water is introduced into a third pressurised tank, with lower pressure with respect to that of the second tank, which collects the condensate from the Yankee cylinder together with the blow-through steam, so that this blow-through steam is recompressed to the operating pressure of the plant and it is re-introduced in the plant.

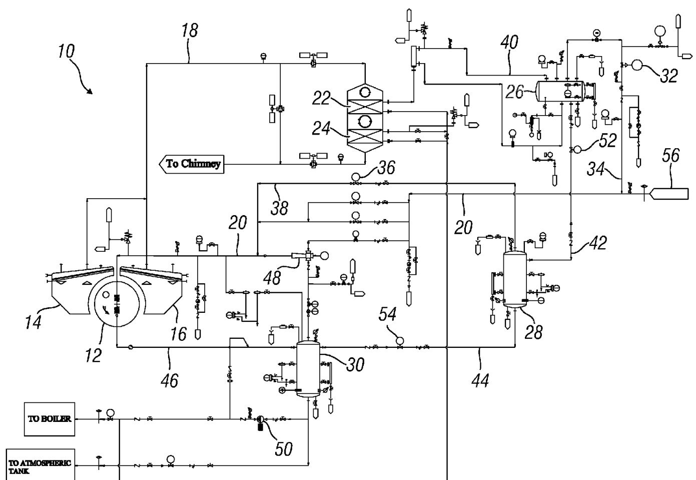

Fig. 1

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Description

[0001] The present invention generally relates to a plant for the production of a web-like paper material and, in particular, a system for generating steam in a plant for the production of a web-like paper material comprising at least one high-efficiency extractor hood.

[0002] As known, in the paper production process in general, and in the tissue paper production process in particular, a step for drying by evaporation the product being processed must be carried out in order to extract the surplus water content thereof. The product to be desiccated, usually consisting of a fibrous slurry based on cellulose and diluted with water, is initially prepared in an appropriate forming equipment and it is therefore delivered to a subsequent drying and desiccating equipment after an intermediate under vacuum extraction step. At the inlet of the drying and desiccating equipment, the slurry which forms the paper sheet being processed contains a low dry part content, which can be equal to about 24%-28%. In other words, after the under vacuum extraction step the slurry may still contain up to 75% and more of water. Therefore, the under vacuum extraction step is not capable of eliminating all the water from the fibres of the slurry, which must therefore be removed by evaporation.

[0003] The finished product, typically but not exclusively consisting of tissue paper, requires a dry part content well higher than the values reported above, that is typically equal to about 94%-98%. Therefore, there clearly arises the need to extract from the fibrous slurry, in the drying step by evaporation, most of the residual water content thereof, in order to obtain a sufficiently dry continuous paper sheet. After the drying and desiccation step by evaporation, the paper sheet is stored in reels in order to be subsequently processed (so-called "converting" step) and, lastly, packaged for shipment and final retail sale.

[0004] The most common drying and desiccating equipment of the paper production plants, in particular toilet paper, comprise two separate drying devices, which however act simultaneously on the web-like paper material being processed, which is still in the state of fibrous slurry to be dried. A first drying device consists of one or more high-efficiency *"Yankee"* hoods, which blow hot air, at a temperature typically comprised between 350°C and 650°C, onto the fibrous slurry being processed. Simultaneously with the blowing, the fibrous slurry being processed is placed in contact with the lateral surface of at least one steam-heated cylinder, having a diameter usually ranging between about 1.5 m and about 6 m. This cylinder, which is usually identified as *"Yankee"*, typically consists of a pressurised container which contains - therein - process steam at a pressure usually ranging between about 4 bar G to about 10 bar G.

[0005] Generally, in the paper production plants of the type described above, only part of the high temperature moist air, usually referred to as "*mist*", which is then extracted by the fibrous slurry being processed through the Yankee hood, is at least partially recycled. In other words, a part of the mist, consisting of the desiccation air and of the evaporated water, is suctioned by one or more fans and then reintroduced, after appropriate heating, into the drying and desiccating equipment. The remainder of the mist extracted by the Yankee hood is instead typically disposed into the atmosphere, with ensuing dissipation of an amount of potentially useful energy.

[0006] The prior art document IT MI20090364 A1 discloses a plant for the production of a web-like paper material according to the preamble of claim 1. However, the plant for the production of a web-like paper material according to the prior art document IT MI20090364 A1 does not provide for any thermal exchange device acting as a variable flow-rate economizer, that is designed to process an amount of moist air which varies as a function of the amount of steam to be produced at a predetermined pressure value.

[0007] The prior art document DE 102010041231 A1 discloses a plant for the production of a web-like paper material wherein the thermal exchange device which collects thermal energy from the mist is of the air-water type and not of the air/water-steam type. Therefore, there is not provided for any system for generating steam simultaneously having two or more pressure levels.

[0008] Lastly, the prior art document EP 2775030 A1 discloses a plant for the production of a web-like paper material wherein the thermal energy of the mist is collected with a fume-pipe boiler. Also in this case there is not provided for any system for generating steam simultaneously having two or more pressure levels.

[0009] Therefore, an object of the present invention is to provide a system for generating steam in a plant for the production of a web-like paper material which is capable of overcoming the aforementioned drawback of the prior art in an extremely simple, cost-effective and particularly functional manner.

[0010] In detail, an object of the present invention is to provide a system for generating steam in a plant for the production of a web-like paper material which is capable of recovering all or at least most of the energy contained in the mist, so as to directly reuse it in the respective drying and desiccating equipment.

[0011] Another object of the present invention is to provide a system for generating steam in a plant for the production of a web-like paper material which allows to increase thermal recovery from the mist up to above 50% with respect to the plants for the production of a web-like paper material according to the prior art.

[0012] These objects according to the present invention are achieved by providing a system for generating steam in a plant for the production of a web-like paper material as described in claim 1. Further features of the invention are outlined by the dependent claims, which are an integral part of the present description.

[0013] The features and advantages of a system for generating steam in a plant for the production of a web-like paper material according to the present invention will be more apparent from following exemplifying and non-limiting description, referred to in the attached drawings, wherein the only figure is a schematic view which shows both a part of the drying and desiccating equipment, and a preferred embodiment of a system according to the present invention for generating steam in a plant for the production of a web-like paper material.

[0014] With reference to figure 1, as a matter of fact, shown is a preferred embodiment of a system according to the present invention for generating steam in a plant for the production of a web-like paper material. The plant is indicated as a whole with reference numeral 10 and it comprises, in a per se known manner, a drying and desiccating equipment which is designed to desiccate a paper material slurry, so as to convert it into a web-like paper material. The paper material slurry is made using any forming equipment of the known type, which - therefore - will not be described hereinafter.

[0015] In detail, the drying and desiccating equipment of the plant 10 comprises a first drying device, in turn comprising at least one rotary drying cylinder 12 supplied with pressurised steam. The paper material slurry adheres dynamically on the lateral surface of the drying cylinder 12. Therefore, the drying cylinder 12 is of the so-called *"Yankee"* type and it is supplied with live steam at a predefined operating pressure, preferably comprised between about 4 bar G and about 10 bar G. By condensing on the inner lateral surface of the Yankee cylinder 12, the steam transfers heat to the outer lateral surface of the Yankee cylinder 12, that is the surface on which the paper material slurry being dried adheres.

[0016] The drying and desiccating equipment of the plant 10 further comprises a second drying device, in turn comprising at least one Yankee hood 14, 16 which at least partially surrounds the Yankee cylinder 12. In the embodiment shown in figure 1, the Yankee hood consists, purely by way of example, of a first half-hood 14 and of a second half-hood 16 which are both capable of blowing dry air at high temperature onto the paper material slurry wound on the lateral surface of the Yankee cylinder 12, and of sucking hot and moist air released by the paper material slurry. Preferably, the Yankee hood 14, 16 can be designed to blow dry air at a temperature comprised between about 350°C and about 650°C and at a speed comprised between about 100 m/s and about 150 m/s.

[0017] The drying and desiccating equipment of the plant 10 further comprises at least one hydraulic discharge circuit 18, which is designed to discharge the moist air exiting from the Yankee hood 14, 16 and at least one hydraulic supply circuit 20, which is designed to supply steam entering into the Yankee cylinder 12. The moist air exits from the Yankee hood 14, 16 at a first predefined temperature value, which is preferably comprised between about 250°C and about 400°C.

[0018] According to the present invention, the plant 10 comprises a system for generating steam in turn comprising at least one first heat exchanger 22 of the air/water-steam type, which is positioned along the hydraulic circuit 18 for discharging the moist air exiting from the Yankee hood 14, 16. This first heat exchanger 22 is designed to receive, as primary fluid, the moist air extracted by the Yankee hood 14, 16 at the aforementioned first predefined temperature value. After the heat exchange with a secondary fluid, the first heat exchanger 22 discharges the moist air at a second predefined temperature value, which is lower than the first predefined temperature value. This second predefined temperature value is preferably equal to about 220°C. Still preferably, the secondary fluid of the first heat exchanger 22 may consist of a secondary condensate fluid, which enters into the first heat exchanger 22 at a temperature equal to about 200°C and at a pressure equal to about 16 bar G and which exits from the first heat exchanger 22, in water/steam mixed phase, at a temperature equal to about 200°C.

[0019] The system for generating steam of the plant 10 then comprises at least one second heat exchanger 24 of the air-water type, acting as a variable flow-rate economizer which is arranged in series with respect to the first heat exchanger 22. This second heat exchanger 24 is designed to receive, as primary fluid, a variable amount of moist air at the second predefined temperature value. After the heat exchange with a secondary fluid, the second heat exchanger 24 discharges the moist air at a third predefined temperature value, which is lower than the second predefined temperature value. This third predefined temperature value is preferably equal to about 180°C. Still preferably, the secondary fluid of the second heat exchanger 24 may consist of a secondary condensate fluid, which enters into the second heat exchanger 24 at a temperature equal to about 150°C and which exits from the second heat exchanger 24 at a temperature equal to about 200°C.

[0020] A plurality of separator tanks 26, 28, 30 is connected to the first heat exchanger 22 and/or to the second heat exchanger 24. These separator tanks 26, 28, 30 are designed to separate the steam of the water supplied thereto, in water/steam mixed phase, and coming from at least one of the first heat exchanger 22 and the second heat exchanger 24. The steam coming from at least one of the separator tanks 26, 28, 30 is therefore supplied to the hydraulic supply circuit 20 of the Yankee cylinder 12 through appropriate steam supply means 32, 34, 36, 38, 50.

[0021] According to the invention, as shown in figure 1, the plurality of separator tanks 26, 28, 30 of the system for generating steam comprises:

- at least one first pressurised tank 26, which is hydraulically connected to the first heat exchanger 22 through a first hydraulic connection circuit 40 and which is capable of delivering steam at a first predefined pressure value;
- at least one second pressurised tank 28, which is

hydraulically connected to the first pressurised tank 26 through a second hydraulic connection 42 and which is capable of delivering steam at a second predefined pressure value, which is smaller than said first predefined pressure value; and

- at least one third pressurised tank 30, which is hydraulically connected to the second pressurised tank 28 through a third hydraulic connection circuit 44 and which is capable of delivering steam at a third predefined pressure value, which is smaller than the second predefined pressure value.

[0022] The first pressurised tank 26 is designed to separate the steam from the water supplied thereto, in water/steam mixed phase, and coming from the first heat exchanger 22. The second pressurised tank 28 is designed to separate the flash steam of the condensate coming from the first pressurised tank 26. Lastly, the third pressurised tank 30 is designed to separate the remaining flash steam of the condensate coming from the second pressurised tank 28. Both the first pressurised tank 26 and the second pressurised tank 28 may be provided with respective valves 52, 54 for the automatic adjustment of the filling level.

[0023] The third pressurised tank 30 may be provided with a fourth hydraulic circuit 46 for connection with said Yankee cylinder 12, so as to be designed to collect the condensate coming from such Yankee cylinder 12. The third pressurised tank 30 may also be operatively connected to at least one thermocompressor 48, which is designed to suction the blow-through and flash steam from the third pressurised tank 30, so as to increase the pressure thereof and to send it, for use, to the Yankee cylinder 12 through the respective hydraulic supply circuit 20.

[0024] The second heat exchanger 24 is therefore designed to process an amount of moist air which varies as a function of the amount of steam produced by the second pressurised tank 28 at the second predefined pressure value. The water level in the second pressurised tank 28 is then kept constant, automatically reaching close to the water overflow toward the third pressurised tank 30. From this third pressurised tank 30, the blow-through and flash steam is suctioned by the thermocompressor 48, and then delivered to the Yankee cylinder 12 for condensation.

[0025] The second heat exchanger 24 also has a dual purpose. A first function is that of pre-heating the make-up water used by the first heat exchanger 22, which produces high pressure steam for the first pressurised tank 26. However, the second main function of the second heat exchanger 24 is to collect the thermal energy, heating much more water than required (from 2 to 3 times), which is then released as flash steam on the second pressurised tank 28 and on the third pressurised tank 30, connected in a cascade fashion, which therefore produce steam at two respectively lower pressure values. This system for generating steam allows to use, in a more effective manner, the thermal content of the mist coming from the Yankee hood 14, 16, given that this mist may be released into the atmosphere at a significantly much lower temperature for example with respect to the plant shown in the prior art document IT MI20090364 A1.

[0026] Preferably, the steam supply means 32, 34, 36, 38, 50, which are designed to supply the steam coming from the separator tanks 26, 28, 30 to the hydraulic supply circuit 20 of the Yankee cylinder 12, comprise at least one first automatic motor-driven valve 32 for delivering the steam coming from the first pressurised tank 26, as well as one first hydraulic connection 34 for connecting such first automatic motor-driven valve 32 with the hydraulic supply circuit 20 of the Yankee cylinder 12. The steam supply means 32, 34, 36, 38, 50 may also comprise at least one second automatic motor-driven valve 36 for delivering steam coming from the second pressurised tank 28, as well as one second hydraulic connection 38 for connecting such second automatic motor-driven valve 36 with the hydraulic supply circuit 20 of the Yankee cylinder 12.

[0027] The steam supply means 32, 34, 36, 38, 50 may also comprise one or more circulation pumps 50 for supplying the steam coming from at least one of the separator tanks 26, 28, 30 to the hydraulic supply circuit 20 of the Yankee cylinder 12. Each circulation pump 50 is provided with pressure control means.

[0028] In particular, at least one of the circulation pumps 50 is installed at the third pressurised tank 30, which is the tank which collects the condensate produced by the Yankee cylinder 12 through the fourth hydraulic connection circuit 46. This circulation pump 50 preferably operates at high temperature and at high prevalence and it acts as a water circulator for supplying the second heat exchanger 24 of the air-water type, that is the economizer. Then this water returns, in cascade fashion, to the initial tank thereof and in the initial amount, entirely devoid of the produced steam.

[0029] Therefore, the system for generating steam of the plant 10 described up to now uses the discharge mist of the Yankee hood 14, 16 to produce steam at three or more predefined pressure values. The steam, useful to the process for drying the paper material slurry wound around the Yankee cylinder 12, is produced using the two heat exchangers 22, 24 arranged in a countercurrent fashion with respect to the passage of the mist extracted by the Yankee hood 14, 16. Therefore, the system for generating steam of the plant 10 operates as follows.

[0030] The high-pressure steam, produced by the first heat exchanger 22 of the air/water-steam type, is separated from the water in the first pressurised tank 26. Therefore, this steam is introduced into the hydraulic supply circuit 20 of the Yankee cylinder 12, through the first hydraulic connection 34 and the first automatic motor-driven valve 32, so as to be added to the main steam flow coming from a boiler 56.

[0031] The surplus water, in thermal balance with the steam, is transferred from the first pressurised tank 26 to the second pressurised tank 28. In this second pressurised tank 28, the water releases the flash steam, which is also used for the process of drying the slurry before prior to introduction, through the second hydraulic connection 38 and the second automatic motor-driven valve 36, into the hydraulic supply circuit 20 of the Yankee cylinder 12.

[0032] The second predefined pressure value of the flash steam delivered by the second pressurised tanks 28 is smaller than the first predefined pressure value of the steam delivered by the first pressurised tank 26 and, furthermore, it is very close to the operating pressure value of the Yankee cylinder 12, so that this flash steam can be used, through suitable adjustment, directly in the process for drying the web-like paper material. Preferably, as a matter of fact, the second predefined pressure value of the flash steam delivered by the second pressurised tank 28 is smaller by an amount comprised between about 4 bar G and about 8 bar G with respect to the first predefined pressure value of the steam delivered by the first pressurised tank 26. Still preferably, the second predefined pressure value of the flash steam delivered by the second pressurised tank 28 is substantially equal to the operating pressure value of the Yankee cylinder 12.

[0033] Lastly, the residual water is transferred from the second pressurised tank 28 to the third pressurised tank 30, which is the initial one. From this third pressurised tank 30, the flash steam, reduced to a very small amount by now, is suctioned by the thermocompressor 48 which, using the energy of the high-pressure steam circulating in the hydraulic supply circuit 20 of the Yankee cylinder 12, recompresses this flash steam, together with the blow-through steam used to extract the condensate of the Yankee cylinder 12, to raise the pressure thereof up to the operating pressure value of such Yankee cylinder 12. Still preferably, the third predefined pressure value of the flash steam delivered by the third pressurised tank 30 is therefore smaller by about 1 bar G with respect to the predefined pressure value of the flash steam delivered by the second pressurised tank 26.

[0034] Given that the temperature which can be measured in the third pressurised tank 30 is smaller by an amount comprised between about 30°C and about 40°C with respect to the temperature which can be measured in the first pressurised tank 24, the system for generating steam of the plant 10 according to the present invention allows to reduce the temperature of the mist coming from the Yankee hood 14, 16 by a number of degrees centigrade equal to the aforementioned temperature difference between the first pressurised tank 24 and the third pressurised tank 30. This system for generating recovery steam, in a pressure cascade fashion, is managed in adjustment both by controlling the automatic motor-driven valves 32, 36 for delivering steam and by controlling the rotary speed of the circulation pump 50, so that the pressure level of the steam produced can be modulated in a wide range of values.

[0035] Therefore, it has been shown that the system for generating steam in a plant for the production of a web-like paper material according to the present invention attains the objects outlined above. The logic of this system for generating steam, which produces steam with at least three different pressure levels, actually allows to increase the thermal recovery from the mist of the Yankee hood up to 50% more with respect to plants for the production of a web-like paper material according to the prior art.

[0036] The system for generating steam of the present invention thus conceived is in any case susceptible to various modifications and variants, all falling within the same inventive concept; furthermore, all details can be replaced by technically equivalent elements. Basically, the materials used as well as the shapes and dimensions may vary according to the technical needs.

[0037] Therefore, the scope of protection of the invention is defined by the attached claims.

Claims

1. Plant (10) for the production of a web-like paper material starting from a paper material slurry to be desiccated, the plant (10) comprising:

- a first drying device comprising at least one rotary Yankee cylinder (12), supplied with a pressurised steam, wherein said paper material slurry dynamically adheres on the lateral surface of said Yankee cylinder (12);
- a second drying device comprising at least one Yankee hood (14, 16) which at least partially surrounds said Yankee cylinder (12) and which is capable of both blowing dry air at high temperature on said paper material slurry wound on the lateral surface of said Yankee cylinder (12), and of sucking hot and moist air released from said paper material slurry;
- at least one hydraulic discharge circuit (18), which is designed to discharge said moist air exiting from said at least one Yankee hood (14, 16) at a first predefined temperature value;
- at least one hydraulic supply circuit (20), which is designed to supply said steam entering into said at least one Yankee cylinder (12) at a predefined operating pressure; and
- a steam generation system in turn comprising:
    - at least one first heat exchanger (22) of the air/water-steam type, which is positioned along said hydraulic discharge circuit (18) and which is designed to receive, as primary fluid, said moist air at said first predefined temperature value and to discharge said moist air at a second predefined temperature value, which is smaller than said

first predefined temperature value, after heat exchange with a secondary fluid of said first heat exchanger (22);

- a plurality of separator tanks (26, 28, 30), which are hydraulically connected to said first heat exchanger (22) and which are designed to separate the steam of the water supplied thereto, in water/steam mixed phase, and coming from said first heat exchanger (22); and
- steam supply means (32, 34, 36, 38, 50), which are designed to supply the steam coming from at least one of said separator tanks (26, 28, 30) to said hydraulic supply circuit (20),

the plant (10) being **characterized in that** it comprises at least one second heat exchanger (24) of the air-water type, acting as a variable flow-rate economizer, which is arranged in series with respect to said first heat exchanger (22) and which is designed to receive, as primary fluid, a variable amount of said moist air at said second predefined temperature value and to discharge said moist air at a third predefined temperature value, which is lower than said second predefined temperature value, after heat exchange with a secondary fluid of said second heat exchanger (24), wherein said plurality of separator tanks (26, 28, 30) comprises:

- at least one first pressurised tank (26), which is hydraulically connected to said first heat exchanger (22) through a first hydraulic connection circuit (40) and which is capable of delivering steam at a first predefined pressure value;
- at least one second pressurised tank (28), which is hydraulically connected to said first pressurised tank (26) through a second hydraulic connection circuit (42) and which is capable of delivering steam at a second predefined pressure value, wherein said second predefined pressure value is smaller than said first predefined pressure value; and
- at least one third pressurised tank (30), which is hydraulically connected to said second pressurised tank (28) through a third hydraulic connection circuit (44) and which is capable of delivering steam at a third predefined pressure value, wherein said third predefined pressure value is smaller than said second predefined pressure value.

2. Plant (10) according to claim 1, **characterized in that** said second predefined pressure value is smaller by an amount comprised between about 4 bar G and about 8 bar G with respect to said first predefined pressure value.

3. Plant (10) according to claim 1 or 2, **characterized in that** said second predefined pressure value is substantially equal to the operating pressure value of said Yankee cylinder (12).

4. Plant (10) according to claim 3, **characterized in that** said operating pressure value of the Yankee cylinder (12) is comprised between about 4 bar G and about 10 bar G.

5. Plant (10) according to any one of claims 1 to 4, **characterized in that** said third predefined pressure value is smaller by about 1 bar G with respect to said second predefined pressure value.

6. Plant (10) according to any one of claims 1 to 5, **characterized in that** said third pressurised tank (30) is provided with a fourth hydraulic circuit (46) for connection with said Yankee cylinder (12), so that said third pressurised tank (30) is designed to collect the condensate coming from said Yankee cylinder (12).

7. Plant (10) according to any one of claims 1 to 6, **characterized in that** said third pressurised tank (30) is operatively connected to at least one thermocompressor (48), which is designed to suction the blow-through and flash steam from said third pressurised tank (30), to increase the pressure of said blow-through and flash steam and to deliver said blow-through and flash steam, for use, to said Yankee cylinder (12) through said hydraulic supply circuit (20).

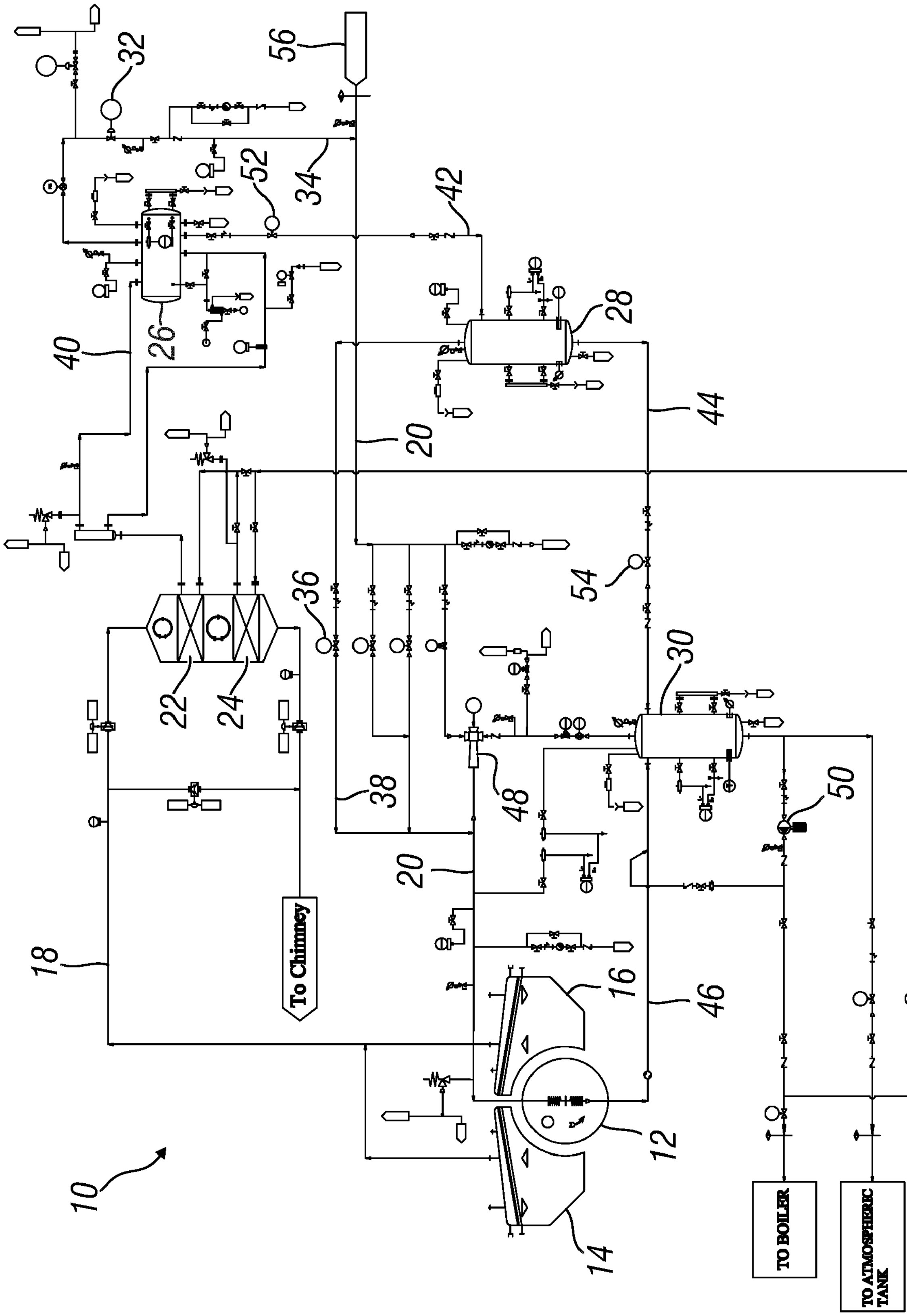
8. Plant (10) according to any one of claims 1 to 7, **characterized in that** said steam supply means (32, 34, 36, 38, 50) comprise at least one first automatic motor-driven valve (32) for delivering the steam coming from said first pressurised tank (26), as well as one first hydraulic connection (34) for connecting said first automatic motor-driven valve (32) with said hydraulic supply circuit (20).

9. Plant (10) according to any one of claims 1 to 8, **characterized in that** said steam supply means (32, 34, 36, 38, 50) further comprise at least one second automatic motor-driven valve (36) for delivering the steam coming from said second pressurised tank (28), as well as one second hydraulic connection (38) for connecting said second automatic motor-driven valve (36) with said hydraulic supply circuit (20).

10. Plant (10) according to any one of claims 1 to 9, **characterized in that** said steam supply means (32, 34, 36, 38, 50) comprise one or more circulation pumps (50) for supplying, to said hydraulic supply circuit (20), the steam coming from at least one of said separator tanks (26, 28, 30), said circulation

pump (50) being provided with pressure control means.

11. Plant (10) according to claim 10, **characterized in that** at least one of said circulation pumps (50) is installed at said third pressurised tank (30) and it is designed to supply water to said second heat exchanger (24).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To Chimney
TO BOILER
TO ATMOSPHERIC TANK

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 22 17 2798

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	IT MI20 090 364 A1 (NOVIMPIANTI S R L) 12 September 2010 (2010-09-12) * paragraphs [0026] - [0032]; figures *	1-11	INV. D21F5/18 D21F5/20
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TECHNICAL FIELDS SEARCHED (IPC)

D21F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	4 October 2022	Pregetter, Mario

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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