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## (54) METHOD FOR FEEDING STEAM INTO A STEAM TURBINE AND A STEAM TURBINE WITH A STEAM CONDUIT FOR FEEDING STEAM

(57) The invention relates to a method for feeding steam into a guide wheel (1) of a regulatory stage of a steam turbine, in which steam is fed into mutually separated segments (11, 12, 13, 14, 15, 16) of the guide wheel (1) and the steam supply into each of these segments (11, 12, 13, 14, 15, 16) is regulated by a control valve (41, 41', 42, 42', 43), wherein steam is fed simultaneously into at least two mutually separated segments (11, 12, 13, 14, 15, 16) of the guide wheel (1) of the regulatory stage of the steam turbine, which together constitute a part of the circumference of the guide wheel (1), steam supply into these segments (11, 12, 13, 14, 15, 16) being regulated by one common control valve.

The invention also relates to a steam turbine which comprises a regulatory stage with a guide wheel (1), which is divided into mutually separated segments (11, 12, 13, 14, 15, 16), whereby each of these segments (11, 12, 13, 14, 15, 16) is connected to a steam supply, in which is arranged a shut off valve (3, 3'), behind which is arranged in the direction of the motion of the steam a control valve (41, 41', 42, 42', 43) for each segment (11, 12, 13, 14, 15) of the guide wheel (1), whereby at least two segments (11, 12, 13, 14, 15), which together constitute a part of the circumference of the guide wheel (1) of the regulatory stage, are connected by means of a steam conduit (410, 410', 420, 420', 430) to one common control valve (41, 41', 42, 42', 43).

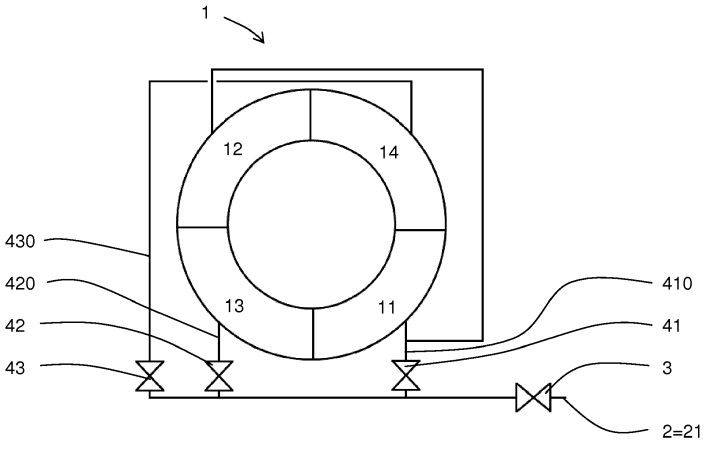



Fig. 2

EP 3 249 167 A1

## Description

### Technical field

**[0001]** The invention relates to a method for feeding steam into a guide wheel of a regulatory stage of a steam turbine in which steam is fed into mutually separated segments of the guide wheel.

**[0002]** The invention also relates to a steam turbine which comprises a regulatory stage with a guide wheel which is divided into mutually separated segments.

### Background art

**[0003]** The most widely used type of control of steam flow through a steam turbine (and the output of a steam turbine) is the so-called group control. During it a stator row of blades of the first stage of the steam turbine is divided into several, usually 4 to 6 identical, mutually separated segments into which steam having a constant pressure and temperature is supplied, whereby the amount of the steam supplied into each of these segments is controlled by an independent control valve. The disadvantage of this method of control, or of this method of steam supply, is the fact that it requires using an independent control valve for each segment of the guide wheel of the regulatory stage. In practice, bifurcated steam flow arrangement is used very often, which requires an additional use of at least one shut off valve for each of its feed lines (the shut off valve completely closes the steam supply in the corresponding line and acts as one of the safety features of the steam turbine) - see, for example, Fig. 1. However, these elements and corresponding devices (such as drives, etc.) not only increase material consumption and the total weight of the finished turbine, but also significantly increase space requirements for installing such a turbine, and, last but not least, they add to its manufacturing and operating costs.

**[0004]** The aim of the invention is to eliminate the disadvantages of the background art and propose a method for feeding steam into a guide wheel of a regulatory stage of a steam turbine which would enable to reduce the number of the components used, but at the same time would not limit the possibility of fully controlling steam supply into the individual segments of the guide wheel of the regulatory stage of the steam turbine, but at the same time would not cause uneven increase in the flow rate of steam through the turbine and/or an increase in the flow rate of steam through the turbine that would be too rapid.

**[0005]** In addition, the goal of the invention is also a steam turbine with a steam conduit for feeding steam into segments of a guide wheel of a regulatory stage of the steam turbine using this method.

### Principle of the invention

**[0006]** The aim of the invention has been achieved by a method for feeding steam to a guide wheel of a regulatory stage of a steam turbine, in which steam is fed into mutually separated segments of this guide wheel and steam supply into each of these segments is regulated by a control valve, whose principle consists in that steam is fed simultaneously into at least two mutually separated segments of the guide wheel of the regulatory stage of the steam turbine, which together constitute a part of the circumference of this guide wheel, the steam supply into these segments being regulated by one common control valve. This embodiment not only enables to reduce the number of control valves, but also allows feeding steam to the guide wheel of the regulatory stage of the steam turbine by means of a simpler conduit system, which may even comprise only one feed line, which results in a reduction of the built-up area or space requirements for the installation, operation and maintenance of the steam turbine. Moreover, this method of feeding steam also decreases the overall energy loss in the steam conduit, as well as in the valves.

**[0007]** The segments of the guide wheel of the regulatory stage of the steam turbine, into which steam is fed simultaneously, steam supply into them being regulated by one common valve, together constitute preferably a maximum of 75 % of the circumference of this guide wheel.

**[0008]** In a preferable variant of the embodiment, steam is fed simultaneously into two segments of the guide wheel of the regulatory stage of the steam turbine, which are arranged on opposite sides of this guide wheel, since in that case both the guide wheel and the action wheel of the regulatory stage of the steam turbine are loaded evenly.

**[0009]** In the case of large turbines with a guide wheel divided into more than three mutually separated segments, steam is fed simultaneously into three segments of the guide wheel of the regulatory stage of the steam turbine, which together constitute a part of the circumference of this guide wheel.

**[0010]** During the startup of the turbine it is advantageous if steam is first fed into at least two mutually separated segments of the guide wheel of the regulatory stage of the steam turbine, which together constitute a part of the circumference of this guide wheel and in which steam supply is regulated by one common control valve, and only after that it is fed into another segment/other segments of the guide wheel of the regulatory stage of the steam turbine. Moreover, some of other segments of the guide wheel can act as overload segment, i.e. to obtain a temporary increase in the

turbine output by increasing the amount of the steam being fed, into which steam is usually not fed during normal operation of the turbine.

**[0011]** In addition, the goal of the invention is achieved by a steam turbine which comprises a regulatory stage with a guide wheel which is divided into mutually separated segments, whereby each of these segments is connected to a source of steam by means of a conduit, in which is arranged a shut off valve, in the direction of the movement of the steam behind which is arranged a control valve for each segment of the guide wheel, whose principle consists in that at least two segments which together constitute a part of the circumference of the guide wheel of the regulatory stage of the steam turbine are connected to one common control valve by means of steam conduit. This embodiment of the turbine allows supplying steam by the above-described method according to the invention.

**[0012]** Preferably, the segments which are connected to one common control valve constitute together a maximum of 75 % of the circumference of the guide wheel of the regulatory stage of the steam turbine.

**[0013]** In a preferable variant of the embodiment, two segments of the guide wheel of the regulatory stage of the steam turbine arranged on opposite sides of this guide wheel are connected to one common control valve, since in such an embodiment both the guide wheel and the action wheel of the regulatory stage of the steam turbine are evenly loaded along their circumferences.

**[0014]** In the case of large turbines having a guide wheel of the regulatory stage divided into more than three segments, three segments of this guide wheel which together constitute a part of its circumference can be connected to one common control valve.

**[0015]** From the point of view of the loading of both the guide wheel and the action wheel of the regulatory stage, it is advantageous if steam, e.g. during the startup of the steam turbine, is first fed into the segments of the guide wheel of the regulatory stage which are connected by means of the steam conduit to a common control valve. Therefore it is advantageous if this common control valve is arranged in the steam conduit as the first one in the direction of the movement of steam behind the shut off valve.

**[0016]** Further reduction in the built-up area can be also achieved by integrating at least some control valves, and, optionally, also the shut off valve, into one valve block, in which a valve chamber is created, being common to them. Apart from further space saving, such an arrangement also reduces the overall steam energy loss in the valves, caused by friction between the boundary layer of the flowing steam and the wall of the valve chamber and of the diffusers of the individual valves.

## Description of drawings

**[0017]** In the enclosed drawings Fig. 1 shows a diagram of feeding steam to a guide wheel of a regulatory stage of a steam turbine with four mutually separated segments according to the background art, Fig. 2 represents a diagram of the first variant of supplying steam to the guide wheel of the regulatory stage of the steam turbine with four mutually separated segments according to the invention, Fig. 3 is a diagram of the second variant of feeding steam to the guide wheel of the regulatory stage of the steam turbine with four mutually separated segments according to the invention, Fig. 4 is a diagram of a variant of supplying steam to the guide wheel of the regulatory stage of the steam turbine with three mutually separated segments according to the invention, Fig. 5 shows a diagram of feeding steam to the guide wheel of the regulatory stage of the steam turbine with five mutually separated segments according to the invention, Fig. 6 shows a diagram of the first variant of feeding steam to the guide wheel of the regulatory stage of the steam turbine with six mutually separated segments according to the invention, Fig. 7 shows a diagram of the second variant of feeding steam to the guide wheel of the regulatory stage of the steam turbine with six mutually separated segments according to the invention, and Fig. 8 is a cross section through an exemplary embodiment of a variant of a valve block.

## Examples of embodiment

**[0018]** When feeding steam to a guide wheel **1** of a regulatory stage of a steam turbine, the steam is fed into mutually separated segments **11**, **12**, **13**, **14**, **15**, **16** of this guide wheel **1**, whereby the steam supply into each of these segments **11**, **12**, **13**, **14**, **15**, **16** is regulated by a corresponding control valve **41**, **42**, **41'**, **42'**, **43.** However, unlike the solution known from the background art - see Fig. 1, in the method according to the invention steam is supplied through one control valve **41, 42, 41'**, **42'**, **43** simultaneously into at least two mutually separated segments **11**, **12** and/or **13**, **14** and/or **15**, **16**, which together constitute a part of the circumference the guide wheel **1** of the regulatory stage, whereby the amount of the steam being fed into these segments **11**, **12** or **13**, **14** or **15**, **16** is regulated by this common control valve **41**, **42**, **41'**, **42'**, **43** - see Figs. 2 to 7. Preferably, these segments **11**, **12**, **13, 14**, **15, 16** together constitute a maximum of 75 % of the circumference of the guide wheel **1**.

**[0019]** In a preferable embodiment - see, for example, Fig. 2, 5, 6, 7, the steam is fed simultaneously into two segments **11, 12** or **13, 14** or **15, 16** of the guide wheel **1** of the regulatory stage, which are arranged on the opposite sides of the guide wheel **1**, which means that the load of both the guide wheel **1** and the unillustrated action wheel of the regulatory

stage of the steam turbine is distributed evenly along their circumferences.

**[0020]** In the case of large steam turbines the steam can be fed through one control valve **41, 42, 41', 42', 43** into three segments **11**, **12**, **13**, **14**, **15**, **16** of the guide wheel **1** of the regulatory stage of the steam turbine, which together constitute a part of the circumference of the guide wheel **1** - see, for example, Fig. 3.

**[0021]** During the startup of the turbine, it is advantageous if the control valve **41**, **42**, **41', 42'**, **43**, which is connected to at least two segments **11**, **12, 13, 14, 15, 16** of the guide wheel **1** of the regulatory stage, opens first. At the same time, or not until it opens to a certain extent, other control valves **41**, **42**, **41'**, **42'**, **43** (but not all of them) open in order to achieve an even and not very rapid increase in the steam flow rate through the guide wheel **1**, or, in other words, to achieve the smoothest possible startup curve. During the normal operation of the turbine the individual control valves **41**, **42**, **41'**, **42'**, **43** regulate the amount of the steam supplied into the individual segments **11**, **12**, **13**, **14**, **15**, **16** of the guide wheel **1** of the regulatory stage (and from there to other stages of the turbine). In addition, one of the segments **11**, **12**, **13**, **14, 15, 16**, or a pair of segments **11**, **12**, **13**, **14, 15**, **16**, of the guide wheel **1** may act as an overload segment, when the corresponding control valve **41, 42, 41'**, **42'**, **43** is closed during the normal operation of the turbine, and does not open until the need arises to increase temporarily the turbine output. When stopping the turbine, the individual control valves **41, 42**, **41'**, **42'**, **43** usually close in reverse order, i.e. the control valve **41**, **42**, **41'**, **42**, **43,** which opened last, closes first.

**[0022]** Thus, the steam turbine according to the invention in all the variants comprises a regulatory stage with a guide wheel **1**, which is divided into mutually separated segments **11**, **12, 13**, **14**, **15**, **16**, whereby each of these segments **11**, **12**, **13**, **14**, **15**, **16** is connected to a conduit **2** of steam, in which is arranged a shut off valve **3**, behind which in the direction of the movement of the steam is arranged a control valve **41**, **42**, **41'**, **42'**, **43** for each segment **11**, **12**, **13**, **14**, **15**, **16** of the guide wheel **1.** Moreover, at least two segments **11**, **12**, **13**, **14**, **15**, **16** which together constitute a part of the circumference of the guide wheel **1** of the regulatory stage are connected by means of the conduit **410, 410'** of steam to one common control valve **41**, **42**, **41'**, **42'**, **43,** which regulates steam supply into these segments **11**, **12**, **13**, **14**, **15**, **16**. Such a control valve **41**, **42**, **41'**, **42', 43** is preferably the first control valve **41**, **42, 41'**, **42', 43** arranged in the direction of the movement of the steam in the conduit **2** of steam behind the shut off valve **3,** although in cases when at least some control valves **41**, **42**, **41'**, **42'**, **43** are provided with a bypass, any other of the control valves **41**, **42**, **41'**, **42', 43** may be used for that purpose. Also, all or at least some control valves **41**, **42**, **41'**, **42'**, **43**, optionally including the shut off valve **3, 3',** can be integrated into one valve block, in which a common valve chamber is created for them. Such an arrangement not only reduces space requirements and the built-up area of the engine room of the turbine, but also the overall steam energy loss, which is caused by friction between the boundary layer of the flowing steam and the walls of the valve chambers and diffusers of the individual valves. Fig. 8 is a schematic cross-section of an exemplary embodiment of a valve block **5**, which was created by integrating the shut off valve **3** and three control valves **41**, **42**, **43** into one valve block. This block **5** then accommodates a common valve chamber **51** with one steam inlet **31** (arrow **A**) and three steam outlets **411, 421**, **431** (arrows **B1, B2**, **B3**). Into the common valve chamber **51** extend rods on which are arranged the cones of the shut off valve **3,** as well as those of all the three control valves **41**, **42**, **43**. At the same time, the control valves **41**, **42**, **43** are preferably arranged so that the first one in the direction of the movement of the steam, i.e. the first one behind the inlet **31** of steam into the valve chamber **51** (if the shut off valve **3** is not integrated in the valve block **5),** or the first one behind the shut off valve **3,** is the common control valve **41,** whose outlet **411** is by means of unillustrated conduit of steam connected to at least two segments **11**, **12**, **13**, **14**, **15, 16** of the guide wheel **1** (which is indicated in Fig. 8 by bifurcated arrow **B1**)**.**

**[0023]** In different variants of embodiment, at least two control valves **41**, **41'**, **42**, **42'**, **43** are integrated into one valve block **5**, but preferably this valve block includes all the control valves **41**, **41'**, **42, 42'**, **43,** or the shut off valve **3**, **3'** and at least the common control valve **41, 41'**, **42**, **42'**, **43,** but preferably all the control valves **41, 41'**, **42**, **42'**, **43.**

**[0024]** The conduit **2** of steam for feeding the steam into the steam turbine by this method comprises at least one feed line **21**, **21'**, in which is arranged a shut off valve **3**, **3'**, which completely closes the feeding of the steam, acting as one of the safety elements of the steam turbine and behind it, in the direction of the movement of the steam, is arranged a control valve **41**, **42**, **41'**, **42'**, **43** for each segment **11**, **12**, **13**, **14, 15, 16** of the guide wheel **1** of the regulatory stage. At least two segments **11**, **12**, **13**, **14**, **15**, **16** of the guide wheel **1**, which together constitute a part of the circumference of the guide wheel **1**, are by means of forked steam conduit **410**, **410'** connected to one common control valve **41**, **42**, **41'**, **42', 43**. As it is advantageous if during the startup of the turbine steam is first supplied into two or more segments **11**, **12**, **13**, **14, 15**, **16** of the guide wheel **1** of the regulatory stage connected to one common control valve **41**, **42**, **41'**, **42'**, **43,** these segments **11, 12, 13, 14, 15, 16** are preferably connected to the control valve **41**, **42, 41'**, **42'**, **43**, which is arranged in the direction of the movement of the steam as the first one behind the shut off valve **3**, **3'**. However, if a bypass/bypases is/are used, also one of the control valves **41, 42**, **41'**, **42', 43** is suitable for this purpose.

**[0025]** In order to save space in the engine room of the turbine, it is further preferred if at least the control valves **41**, **42**, **41'**, **42'**, **43** of one feed line **21**, **21'**, optionally including the shut off valve **3**, **3',** are arranged in one valve block (usually a casting) - see above and Fig. 8.

**[0026]** For the sake of clarity, the enclosed drawings schematically represent various variants of feeding steam to the

guide wheel 1 of the regulatory stage of the steam turbine, both according to the background art (Fig. 1), and according to the invention (Figs. 2 to 7). It is obvious that these are only some of the preferable variants and in the sense of the invention the individual segments **11**, **12**, **13**, **14**, **15**, **16** of the guide wheel **1** (preferably 3 to 6, but the number may be even higher) and the control valves **41**, **42**, **41**', **42**', **43** may be interconnected by various other methods. In that case there is only one condition, namely that at least one of the control valves **41**, **42, 41**', **42', 43** (preferably the one which starts to feed steam to the guide wheel **1** of the regulatory stage of the steam turbine as the first one) must be connected to at least two segments **11**, **12**, **13**, **14**, **15**, **16**, which together constitute a part of the circumference the guide wheel **1**.

**[0027]** Fig. 1 shows a diagram of feeding steam to the guide wheel **1** of the regulatory stage of the steam turbine according to the background art. The guide wheel **1** is divided into four mutually separated segments **11**, **12**, **13**, **14** comprising unillustrated stator blades, which constitute nozzles for accelerating and aiming the steam at the steam supply to (the first) regulatory stage of the steam turbine. All these segments **11, 12, 13, 14** comprise the same number of nozzles, or the number of their nozzles differs at the most by one. To each of these segments **11**, **12**, **13**, **14** is assigned an unillustrated inlet chamber arranged on the circumference of the guide wheel **1**, whereby each inlet chamber is separated from the other inlet chambers and is connected only to a corresponding segment **11**, **12**, **13**, **14** of the guide wheel **1**. These inlet chambers and through them also the corresponding segments **11**, **12**, **13, 14** of the guide wheel **1**, are connected to the steam conduit **2**. In an embodiment according to the background art, the conduit **2** of steam has two identical feed lines **21**, **21**', whereby each of them comprises a shut off valve **3**, **3',** and behind it, in the direction of the movement of the steam, are arranged two control valves **41**, **42**, **41**', **42**', whereby each control valve **41**, **42**, **41**', **42**' is connected to one inlet chamber, or to one segment **11**, **12**, **13**, **14** of the guide wheel **1** by means of the conduit **410, 420**, **410', 420'** of steam. In the direction of the movement of the steam, the first control valves **41**, **41'**, are in a preferable variant, shown in Fig. 1, connected to the segments **12**, or **14** on the opposite sides of the guide wheel **1**.

**[0028]** During the startup of the turbine, three control valves **41**, **42**, **41'** open simultaneously, supplying steam to three segments **12**, **13**, **14** of the guide wheel **1**, whereby after a certain flow rate of steam through the guide wheel **1** is achieved or at the moment when further opening of these control valves **41**, **42**, **41'** does not result in a considerable change in the flow rate, also the fourth control valve **42** opens, feeding admission steam to the last segment **13** of the guide wheel **1** (which is preferably the segment **13**, located in the left lower quadrant during the rotation of the rotor of the turbine anticlockwise). During the subsequent operation of the turbine, the corresponding control valve **41**, **42**, **41'**, **42**' regulates the amount of the steam being fed into each of the segments **11**, **12**, **13**, **14** of the guide wheel **1** according to current needs, whereby it is possible to close completely one or several of the control valves **41**, **42**, **41'**, **42'**.

**[0029]** Analogical connection and system of supplying steam is also used when the guide wheel **1** of the regulatory stage is divided into a different number of the segments **11**, **12**, **13**, **14.**

**[0030]** Fig. 2 shows a diagram of the first variant of feeding steam to the guide wheel **1** of the regulatory stage of the steam turbine with four mutually separated segments **11**, **12**, **13**, **14** according to the invention. In this embodiment, the conduit **2** of steam has only one feed line **21**, in which is arranged a shut off valve **3** and behind it, in the direction of the movement of the steam, are arranged three control valves **41**, **42**, **43**, whereby the first control valve **41** is by means of a bifurcated conduit **410** simultaneously connected to two segments **11**, 12 on the opposite sides of the guide wheel **1**, and each of the following two control valves **42**, **43** is by means of a conduit **430, 440** connected to one of the remaining segments **13**, or **14** of the guide wheel **1**. In comparison with the variant shown in Fig. 1, the conduit **2** of steam has been simplified and at the same time one shut off valve **3'** and one control valve are saved.

**[0031]** In an unillustrated variant of embodiment, the first control valve **41** may be at the same time connected to two other segments **11**, **12**, **13**, **14** or it can be connected to the segments **11**, **12**, **13**, **14** which are arranged in a different manner, e.g. next to each other, or on the same side of the guide wheel **1**.

**[0032]** During the startup of the turbine, the first control valve **41** opens in the first phase, supplying steam simultaneously to two segments **11**, **12**, **13**, **14** of the guide wheel **1**, in a preferable variant of embodiment shown in Fig. 1 to two segments **11**, **12** arranged on the opposite sides of the guide wheel **1**, whereby after achieving a certain rate flow of steam through the guide wheel **1**, or at the moment when further opening of this control valve does not result in a considerable change in the flow rate, also the second or, in case of need, the third control valve **43**, **44** starts to open. If necessary, one of the segments **11**, **12**, **13**, **14** (preferably the segment **13**, located in the left low quadrant during the rotation of the rotor of the turbine anticlockwise) may act as an overload segment, when the control valve **43** assigned to it (preferably arranged as the last one behind the shut off valve **3**) only opens if need arises to increase temporarily the turbine output. During the subsequent operation of the turbine the control valves **41**, **42**, **43** regulate the amount of the steam supplied to each segment **11**, **12**, **13**, **14** of the guide wheel **1**, and from there to other parts of the turbine, and thereby also the turbine output. If necessary, it is even possible to close completely one of the control valves **11**, **12**, **13**, **14**.

**[0033]** When using another method of the startup, in the first phase the first two control valves **41** and **42** may open simultaneously, thus feeding steam simultaneously to three segments **11**, **12** and **13** of the guide wheel **1**.

**[0034]** Fig. 3 shows a diagram of the second variant of feeding steam to the guide wheel **1** of the regulatory stage of the steam turbine with four mutually separated segments **11**, **12**, **13**, **14** according to the invention. In this embodiment

the conduit **2** of steam has only one feed line **21**, in which is arranged a shut off valve **3** and two control valves **41**, **42**, whereby in the direction of the movement of the steam the first control valve **41** is by means of a bifurcated conduit **410** connected simultaneously to three segments **11**, **12**, **13** of the guide wheel **1**, and the second control valve **42** is connected to the last segment **14** of the guide wheel **1** by means of the conduit **420**. In comparison with the variant shown in Fig. 1 there has been simplification of the conduit **2** of steam and one shut off valve **3'** and two control valves **41'**, **42'** saved.

**[0035]** During the startup of the turbine, the first control valve opens in the first phase **41,** supplying steam simultaneously to three segments **11**, **12**, **13** of the guide wheel **1**, whereby after a certain flow rate of the steam through the guide wheel **1** is achieved, or at the moment when further opening of this control valve **41** does not cause a substantial change in the flow rate, the second control valve **42** starts to open. However, if necessary, the last segment **14** of the guide wheel **1** (preferably the segment which is located in the left lower quadrant during the rotation of the rotor of the turbine anticlockwise) may serve as an overload segment, whereby the control valve **42** assigned to it (preferably arranged as the last one behind the shut off valve **3**) opens only when a temporary increase in the turbine output is needed. During the subsequent operation of the turbine the control valve/valves **41**, **42** regulates/regulate the amount of the steam supplied to the individual segments **11**, **12, 13**, **14** of the guide wheel **1** and from there to other parts of the turbine.

**[0036]** In another variant, where the last segment **14** of the guide wheel **1** does not act as an overload segment, it is possible for both the control valves **41**, **42** to open simultaneously and thereby supply the steam to the guide wheel **1** along its entire circumference.

**[0037]** Fig. 4 shows a diagram of other variant of feeding steam to the guide wheel **1** of the regulatory stage of the steam turbine according to the invention. In this embodiment, the guide wheel **1** of the regulatory stage is divided into three mutually separated segments **11**, **12**, **13**. The conduit **2** of steam has only one feed line **21**, in which one shut off valve **3** and two control valves **41**, **42** are arranged, whereby in the direction of the movement of the steam the first control valve **41** is connected simultaneously to two segments **11**, **12** of the valve by means of bifurcated conduit **410**, whereas the second control valve **42** is by means of the conduit **420** connected to the last, third segment **13** of the guide wheel **1**.

**[0038]** Thus, during the startup of the turbine, the first control valve **41** opens first, supplying steam simultaneously into two segments **11**, **12** of the guide wheel **1**, whereby after achieving a certain rate flow of steam through the guide wheel **1**, or at the moment when further opening of this control valve **41** does not result in a considerable change in the flow rate, also the second control valve **42** opens. The last segment **13** of the guide wheel **1** may also act as an overload segment, when the control valve **42** assigned to it (preferably arranged as the last one behind the shut off valve **3**) opens only if a temporary increase in the turbine output is needed. During the subsequent operation of the turbine, the control valve/valves **41**, **42** regulates/regulate the amount of the steam supplied to the individual segments **11**, **12, 13** of the guide wheel **1**.

**[0039]** In another variant, when the last segment **13** of the guide wheel **1** does not act as an overload segment, it is possible for both the control valves **41**, **42** to open simultaneously during the startup of the turbine, thus supplying steam to the guide wheel **1** along its entire circumference.

**[0040]** Fig. 5 shows a diagram of other variant of feeding steam to the guide wheel **1** of the regulatory stage of the steam turbine according to the invention. In this embodiment, the guide wheel **1** of the regulatory stage is divided into five mutually separated segments **11**, **12**, **13**, **14**, **15**. The conduit **2** of steam has only one feed line **21**, in which a shut off valve **3** and three control valves **41**, **42**, **43** are arranged. In the direction of the movement of the steam the first and second control valve **41, 42** are each by means of bifurcated conduit **410,** or **420** connected simultaneously to two segments **11**, **12,** or **13**, **14** arranged on the opposite sides of the guide wheel **1**, whereby the third control valve **43** is by means of the line **430** connected to the last, fifth segment **15** of the guide wheel **1**. At the same time, this segment **15** may act as an overload segment.

**[0041]** During the startup of the turbine, the first control valve **41** opens first, supplying steam simultaneously to two segments **11**, **12** of the guide wheel **1**, whereby after achieving a certain flow rate of steam through the guide wheel **1**, or at the moment when further opening of this control valve **41** does not result in a considerable change in the flow rate, the second control valve **42** starts to open, feeding steam to other two segments **13**, **14** of the guide wheel **1**. The third control valve **43,** if the corresponding segment **15** of the guide wheel **1** does not act as an overload segment, starts to open only after the required steam flow rate is achieved, or at the moment when further opening of the first two control valves **41**, **42** does not cause a substantial change in the flow rate. If the last segment **15** the guide wheel **1** serves as an overload segment, the control valve **43** opens only after respective requirement for a temporary increase in the turbine output. During the subsequent operation of the turbine, the control valves **41**, **42,** or **43** regulate the amount of the steam fed into the individual segments **11**, **12**, **13**, **14**, **15** of the guide wheel **1**, whereby, if necessary, it is even possible to close completely one of the control valves **41**, **42**, **43**.

**[0042]** In another variant, the first two control valves **41**, **42** can open simultaneously and supply the steam to the guide wheel **1** along 4/5 of its circumference.

**[0043]** In other unillustrated variants of embodiment, the segments **11**, **12**, **13**, **14**, **15** of the guide wheel **1** and the control valves **41**, **42**, **43** can be interconnected in a different manner, whereby always one of the control valves **41**, **42**,

**43**, preferably the first one in the direction of the movement of the steam, is connected to two or three segments **11**, **12**, **13**, **14**, **15** of the guide wheel **1**, and the following control valves **41, 42**, **43** are connected to one or two segments **11**, **12**, **13**, **14**, **15** of the guide wheel **1**.

**[0044]** Fig. 6 shows a diagram of one of variants of feeding steam to the guide wheel **1** of the regulatory stage of the steam turbine with six mutually separated segments **11**, **12**, **13**, **14**, **15**, **16** according to the invention. The conduit **2** of steam has only one feed line **21,** in which is arranged a shut off valve **3** and three control valves **41**, **42**, **43**. Each of the control valves **41**, **42**, **43** is by means of a bifurcated conduit **410, 420,** or **430** at the same time connected to two segments **11**, **12,** or **13**, **14**, or **15**, **16** of the guide wheel **1** arranged on its opposite sides.

**[0045]** During the startup of the turbine, all the three control valves **41**, **42**, **43** open successively, supplying steam successively to all the segments **11**, **12**, **13**, **14**, **15, 16** of the guide wheel **1**, or the first two control valves **41**, **42** can open simultaneously, while the third one does not open until the required steam flow rate is achieved, or at the moment when further opening of the first two control valves **41**, **42** does not result in a considerable change in the steam flow rate. During the subsequent operation of the turbine, the control valves **41**, **42**, **43** regulate the amount of the steam fed to the individual segments **11**, **12**, **13, 14, 15**, **16** of the guide wheel **1**, whereby in case of need it is possible to close completely one of the control valves **41**, **42**, **43.** If necessary, one pair of the segments **11**, **12** or **13**, **14** or **15, 16** may act as overload segments, whereby the corresponding control valve **41** or **42** or **43** opens only when a temporary increase in the turbine output is required.

**[0046]** In other variants of embodiments (not shown), the segments **11**, **12**, **13**, **14**, **15**, **16** of the guide wheel **1** and the control valves **41**, **42**, **43** can be interconnected in a different manner, whereby always one of the control valves **41**, **42**, **43**, preferably the first one in the direction of the movement of the steam, is connected to two or three segments **11**, **12, 13, 14, 15, 16** of the guide wheel **1**, whereas the other control valves **41**, **42**, **43** are connected to one, two or, as the case may be, three other segments 11, **12, 13, 14, 15, 16** of the guide wheel **1**.

**[0047]** Fig. 7 shows a diagram of other variant of feeding steam to the guide wheel **1** of the regulatory stage of the steam turbine according to the invention. In this embodiment, the guide wheel **1** of the regulatory stage is divided into six mutually separated segments **11**, **12**, **13**, **14**, **15**, **16**. The conduit **2** of steam has two feed lines **21**, **21',** whereby in each of them is arranged a shut off valve **3**, or **3'** and two control valves **41**, **42**, or **41'**, **42'**. The first control valve **41**, **41** of each feed line **21, 21'** is by means of bifurcated conduit **410,** or **410'** connected to two segments **11**, **12,** or **13**, **14** arranged on the opposite sides of the guide wheel **1**. The second control valve **42**, **42**' of each feed line **21**, **21**' is connected to one of the remaining segments **15**, or **16** by means of the conduit **420,** or **420'.**

**[0048]** During the startup of the turbine, the first control valves **41**, **41'** in each feed line **21**, **21'** open successively, supplying steam successively to four segments **11**, **12**, **13**, **14** of the guide wheel **1**. At the same time, also one of the second control valves **42** or **42'** can open, whereby the last control valve **42** or **42'** opens only after the required steam flow rate is achieved or at the moment when further opening of already opened control valves **41**, **42**, **41'**, **42'** does not introduce a substantial change in the flow rate, or it acts as an overload segment. During the subsequent operation of the turbine, the control valves **41**, **42, 41'**, **42'** regulate the amount of the steam fed into the individual segments **11**, **12**, **13**, **14**, **15, 16** of the guide wheel **1**, whereby in case of need it is possible to close completely one of the control valves **41, 42, 41', 42'**.

**[0049]** In other unillustrated variants of embodiment, it is possible to interconnect the segments **11**, **12**, **13**, **14**, **15**, **16** of the guide wheel **1** and the control valves **41**, **42**, **41'**, **42'** in a different manner, whereby always at least one of the control valves 41, **42**, **41'**, **42'**, preferably the first one in the direction of the movement of the steam, is connected to two or three segments **11**, **12**, **13**, **14**, **15**, **16** of the guide wheel **1**, and the following control valve/valves **41**, **42**, **41'**, **42'** is/are connected to one, two, or three other segments **11**, **12**, **13**, **14**, **15**, **16** of the guide wheel **1**. Furthermore, the conduit **2** of steam may also comprise only one feed line **21**, **21'**, in which are arranged all the control valves **41**, **42**, **41'**, **42'**.

## List of references

**[0050]**

| | |
|---|---|
| 1 | guide wheel of the regulatory stage of the steam turbine |
| 11, 12, 13, 14, 15, 16 | segment of the guide wheel of the regulatory stage of the steam turbine |
| 2 | conduit of steam |
| 21, 21' | feed line |
| 3, 3' | shut off valve |
| 31 | steam inlet of the shut off valve |
| 41, 41', 42, 42', 43 | control valve |
| 410, 410', 420, 420', 430 | steam conduit |
| 411, 421, 431 | steam outlet of the control valve |
| 5 | valve block |

| | |
|---|---|
| 51 | valve chamber of the valve block |
| A | direction of the steam supply |
| B1, B2, B3 | direction of the steam escape |

## Claims

1. A method for feeding steam into a guide wheel (1) of a regulatory stage of a steam turbine, in which steam is fed into mutually separated segments (11, 12, 13, 14, 15, 16) of this guide wheel (1) and the steam supply into each of these segments (11, 12, 13, 14, 15, 16) is regulated by a control valve (41, 41', 42, 42', 43), **characterized in that** steam is supplied simultaneously into at least two mutually separated segments (11, 12, 13, 14, 15, 16) of the guide wheel (1) of the regulatory stage of the steam turbine, which together constitute a part of the circumference of the guide wheel (1), whereby the steam supply into these segments (11, 12, 13, 14, 15, 16) is regulated by one common control valve.

2. The method according to Claim 1, **characterized in that** the segments (11, 12, 13, 14, 15, 16), into which steam is fed simultaneously and the steam supply is regulated by one common valve, together constitute a maximum of 75 % of the circumference of the guide wheel (1) of the regulatory stage of the steam turbine.

3. The method according to Claim 1 or 2, **characterized in that** steam is fed simultaneously into two segments (11, 12, 13, 14, 15, 16) of the guide wheel (1) of the regulatory stage of the steam turbine, which are arranged on the opposite sides of the guide wheel (1).

4. The method according to Claim 1 or 2, **characterized in that** steam is fed simultaneously into three segments (11, 12, 13, 14, 15, 16) of the guide wheel (1) of the regulatory stage of the steam turbine, which together constitute a part of the circumference of the guide wheel (1).

5. The method according to any of the preceding claims, **characterized in that** at first steam starts to be fed into at least two mutually separated segments (11, 12, 13, 14, 15, 16) of the guide wheel (1) of the regulatory stage of the steam turbine, which together constitute a part of the circumference of the guide wheel (1) and in which the steam supply is regulated by one common control valve (41, 41', 42, 42', 43), and only after that the steam starts to be fed into another segment/segments (11, 12, 13, 14, 15, 16) the guide wheel (1) of the regulatory stage of the steam turbine.

6. A steam turbine which comprises a regulatory stage with a guide wheel (1), which is divided into mutually separated segments (11, 12, 13, 14, 15, 16), whereby each of these segments (11, 12, 13, 14, 15, 16) is connected to a steam supply, in which is arranged a shut off valve (3, 3'), behind which is arranged in the direction of the motion of the steam a control valve (41, 41', 42, 42', 43) for each segment (11, 12, 13, 14, 15) of the guide wheel (1), **characterized in that** at least two segments (11, 12, 13, 14, 15), which together constitute a part of the circumference of the guide wheel (1) of the regulatory stage are connected to one common control valve (41, 41', 42, 42', 43) by means of a steam conduit (410, 410', 420, 420', 430).

7. The steam turbine according to Claim 6, **characterized in that** the segments (11, 12, 13, 14, 15), which are connected to one common control valve (41, 41', 42, 42', 43), together constitute a maximum of 75 % of the circumference of the guide wheel (1) of the regulatory stage of the steam turbine.

8. The steam turbine according to Claim 6 or 7, **characterized in that** two segments (11, 12, 13, 14, 15, 16) of the guide wheel (1) of the regulatory stage of the steam turbine are connected to one common control valve (41, 41', 42, 42', 43), the two segments (11, 12, 13, 14, 15, 16) being arranged on the opposite sides of this guide wheel (1).

9. The steam turbine according to Claim 6 or 7, **characterized in that** three segments (11, 12, 13, 14, 15, 16) of the guide wheel (1) of the regulatory stage of the steam turbine, which together constitute a part of the circumference of this guide wheel (1), are connected to one common control valve (41, 41', 42, 42', 43).

10. The steam turbine according to Claim 6 or 7, **characterized in that** one common control valve (41, 41', 42, 42', 43) is arranged in the direction of the movement of the steam in the conduit (2) of the steam as the first one behind the shut off valve (3, 3').

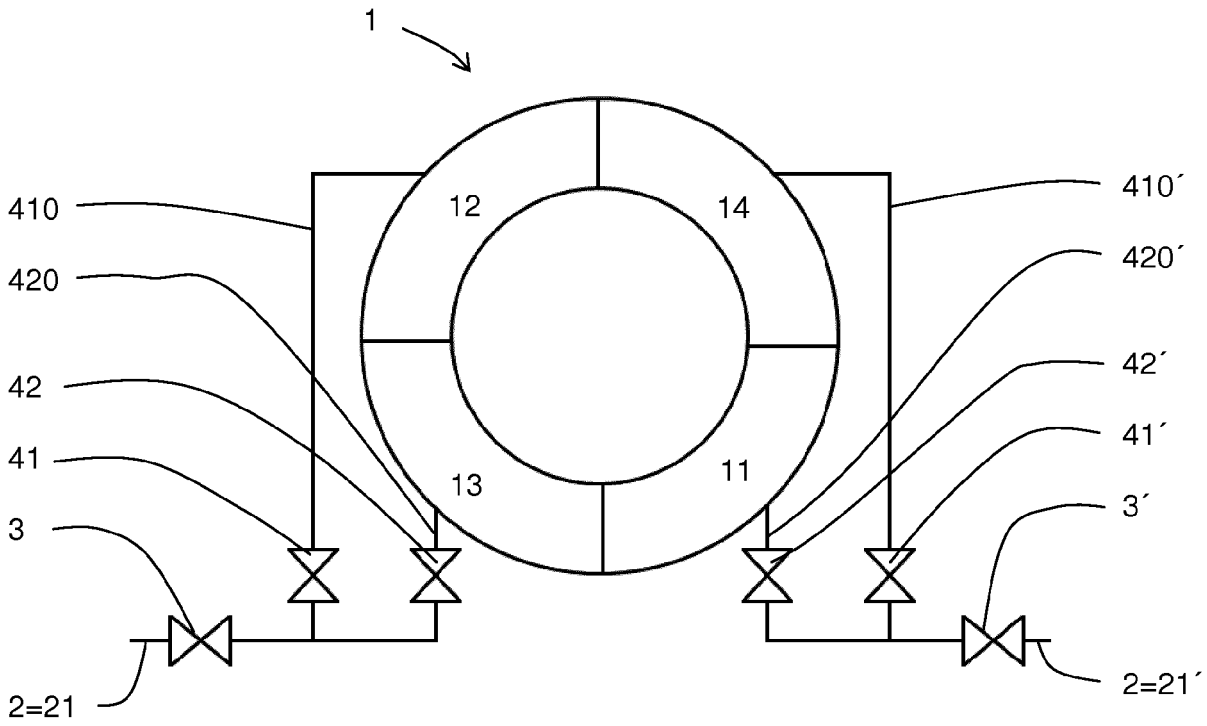
11. The steam turbine according to any of claims 6 to 10, **characterized in that** at least two control valves (41, 41', 42,

42', 43) are integrated into one valve block (5), in which a valve chamber (51) is created, being common to them.

**12.** The steam turbine according to Claim 11, **characterized in that** all the control valves (41, 41', 42, 42', 43) are integrated into one valve block (5).

**13.** The steam turbine according to any of claims 6 to 10, **characterized in that** the shut off valve (3, 3') and at least the common control valve (41, 41', 42, 42', 43) are integrated into one valve block (5), in which is created a valve chamber (51), which is common to them.

**14.** The steam turbine according to Claim 13, **characterized in that** the shut off valve (3, 3') and all the control valves (41, 41', 42, 42', 43) are integrated into one valve block (5).


1
410
420
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41
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14
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11
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3´
2=21´

Fig. 1

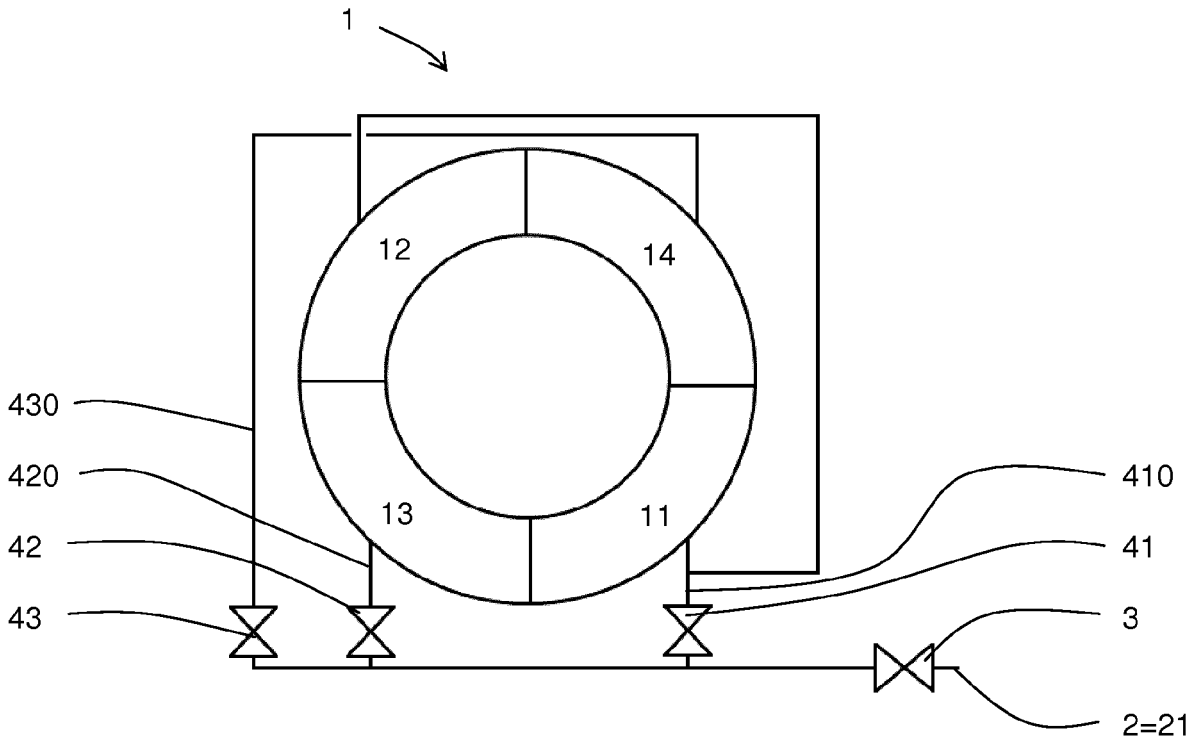
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Fig. 2

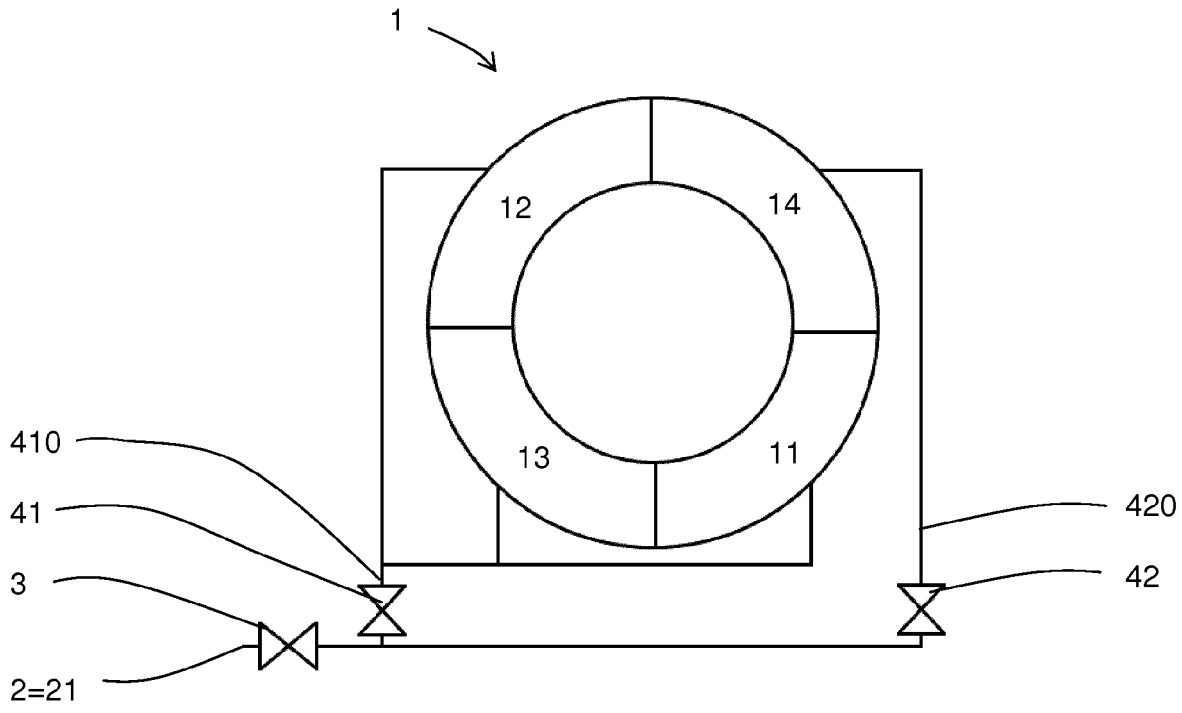



Fig. 3

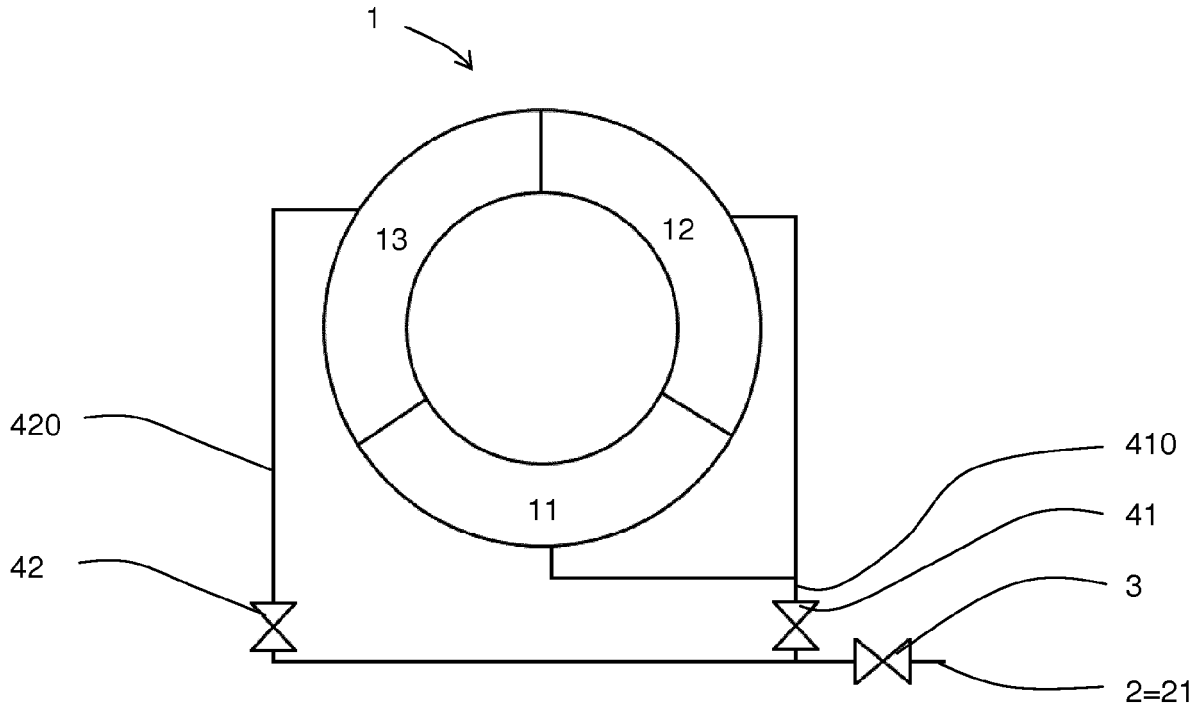
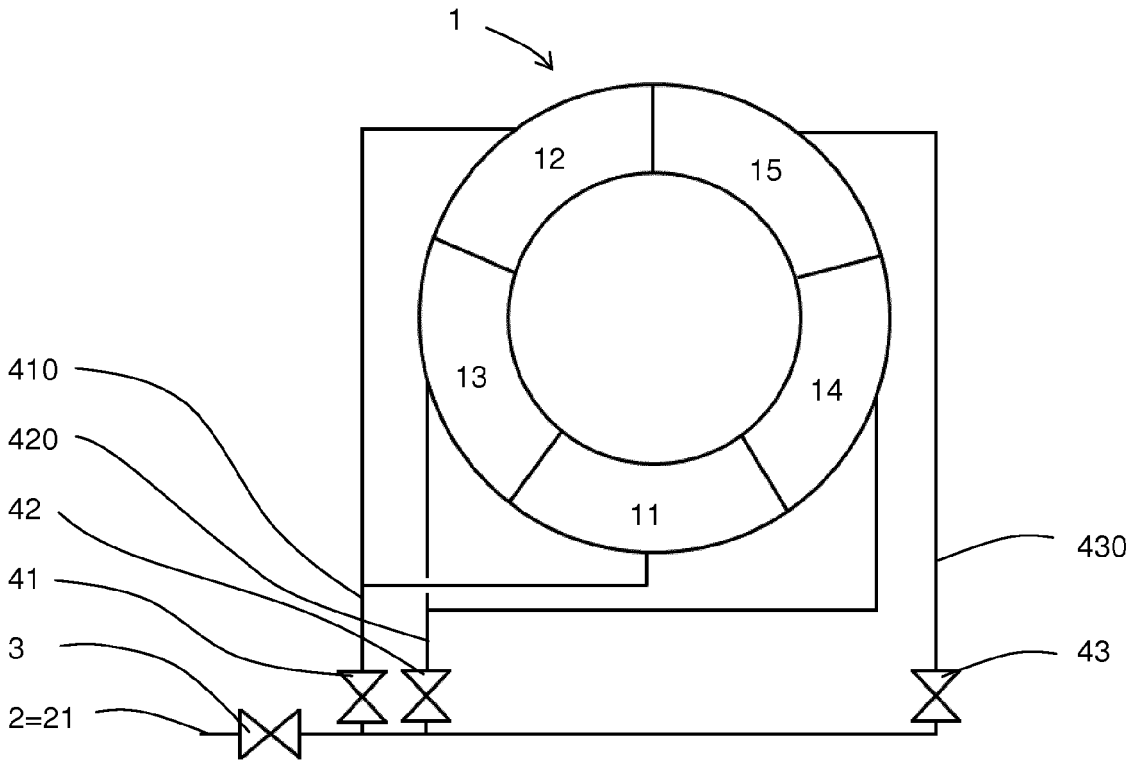



Fig. 4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43

Fig. 5

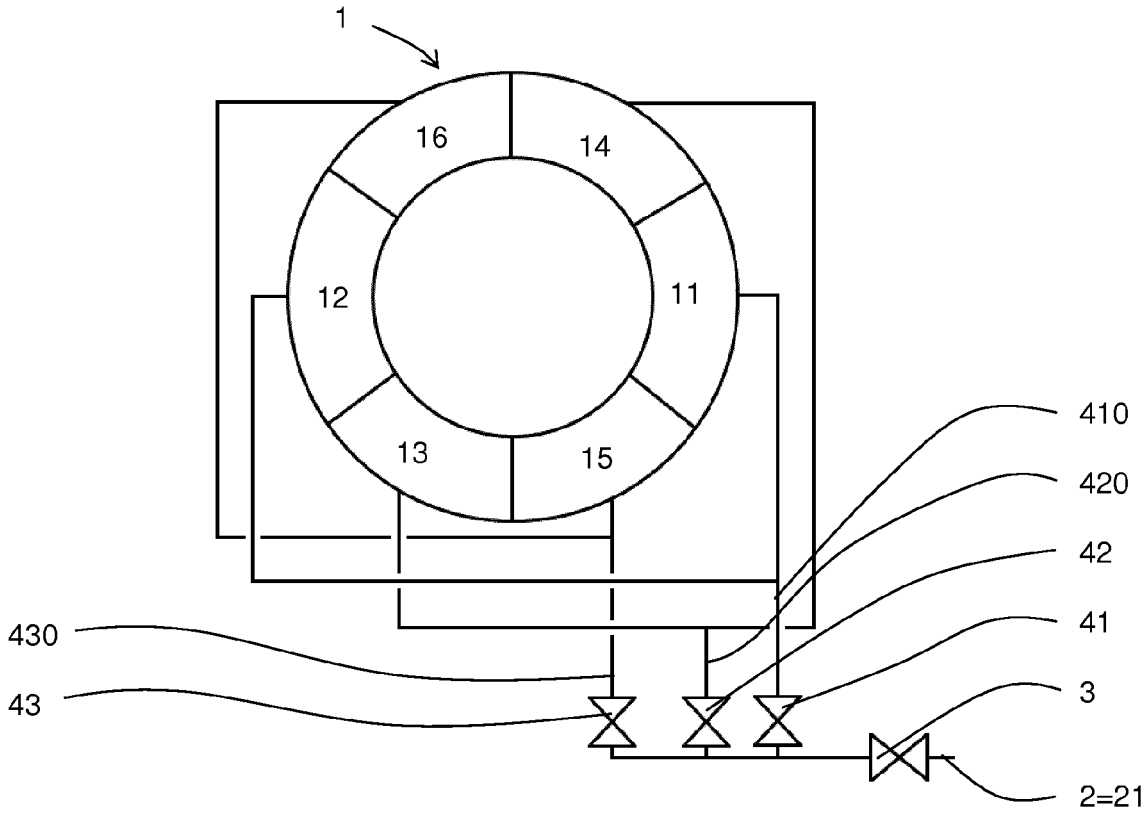
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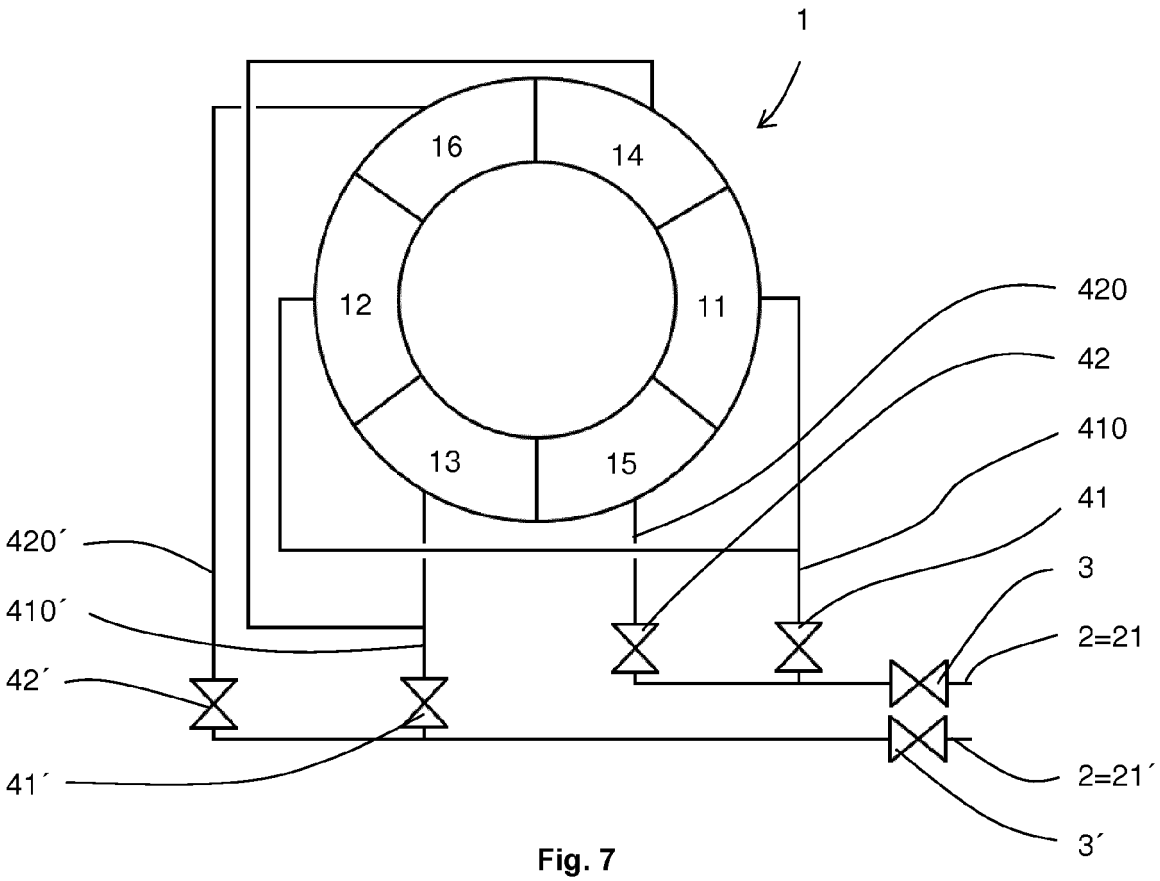
Fig. 6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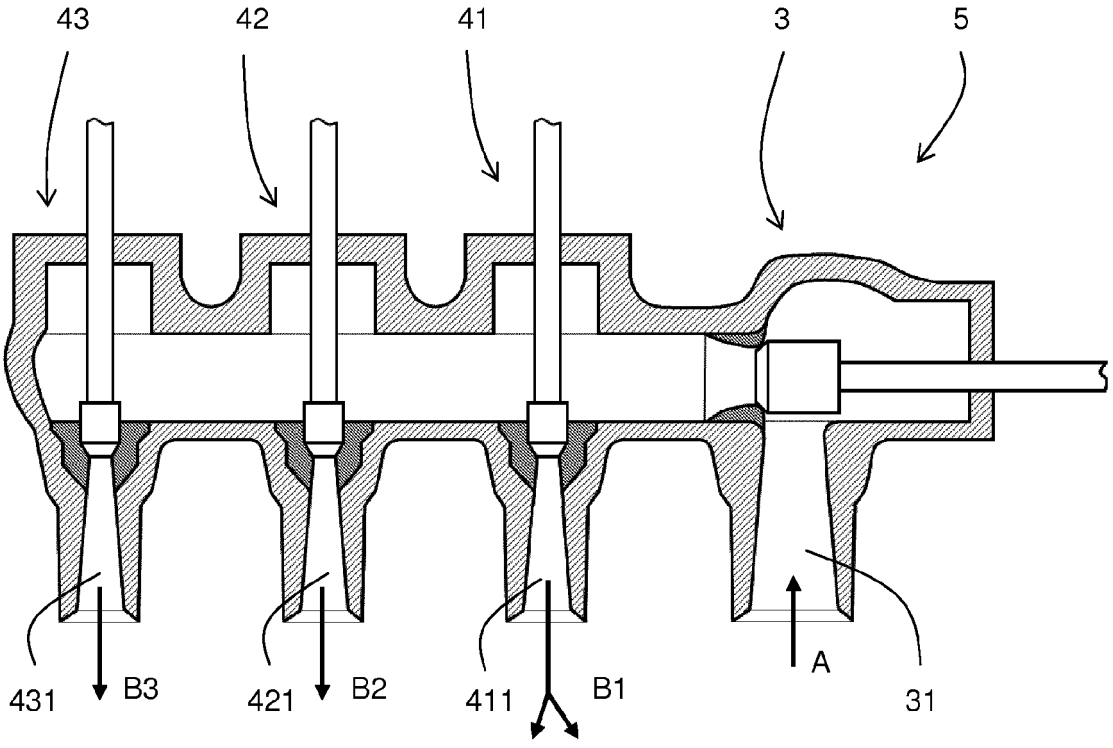
41´

Fig. 7


43
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5
431
B3
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B2
411
B1
A
31

Fig. 8

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# EUROPEAN SEARCH REPORT

Application Number
EP 16 17 0795

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | EP 1 813 779 A1 (SIEMENS AG [DE])<br>1 August 2007 (2007-08-01)<br>* page 1, paragraph 9 - page 2, paragraph 18; figures 4-7 *<br>----- | 1,6,10 | INV.<br>F01D9/06<br>F01D17/14<br>F01D17/18 |
| X | GB 535 559 A (ESCHER WYSS MASCHF AG)<br>11 April 1941 (1941-04-11) | 1-9 | |
| Y | * page 1, line 65 - page 2, line 64; figure 1 *<br>----- | 11-14 | |
| Y | US 3 642 381 A (WICKL RUDOLF)<br>15 February 1972 (1972-02-15)<br>* column 4, line 73 - column 5, line 35; figures 4,5 *<br>----- | 11-14 | |
| X | GB 345 826 A (GEN ELECTRIC)<br>2 April 1931 (1931-04-02)<br>* page 1, line 89 - page 1, line 93 *<br>----- | 1,6 | |
| | | | TECHNICAL FIELDS SEARCHED (IPC)<br>F01D |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 12 December 2016 | Rau, Guido |

CATEGORY OF CITED DOCUMENTS

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 17 0795

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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12-12-2016

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| EP 1813779 A1 | 01-08-2007 | AT 493566 T | 15-01-2011 |
| | | EP 1813779 A1 | 01-08-2007 |
| | | EP 1979580 A1 | 15-10-2008 |
| | | ES 2354838 T3 | 18-03-2011 |
| | | WO 2007088087 A1 | 09-08-2007 |
| GB 535559 A | 11-04-1941 | NONE | |
| US 3642381 A | 15-02-1972 | CH 504613 A | 15-03-1971 |
| | | DE 1915267 A1 | 15-10-1970 |
| | | FR 2039942 A5 | 15-01-1971 |
| | | GB 1272559 A | 03-05-1972 |
| | | US 3642381 A | 15-02-1972 |
| GB 345826 A | 02-04-1931 | NONE | |

EPO FORM P0459

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