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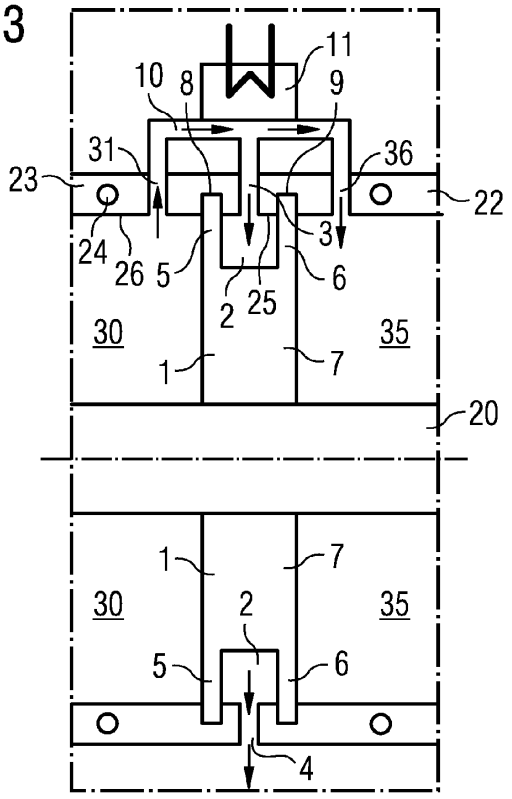
## (54) Steam turbine with a blindwall between adjacent pressure sections

(57) The present invention relates to a steam turbine (40) with a rotor (20), with a blading (21), with a casing (22) comprising two parts, whereby the two casing parts are fixed together at their splitplane (23) with several splitplane bolts (24), the steam turbine (40) having a first pressure section (30) and a second pressure section (35), the pressure sections (30, 35) separated from each other by an annular blindwall (1), wherein the blindwall (1) and an annular part (25) of the inner surface (26) of the casing (22) are building an annular chamber (2), whereby the casing (22) comprises a third steam inlet (3) and a third steam outlet (3) connected to the annular chamber (2) for guiding steam into and out of the annular chamber (2).

FIG 3

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## Description

**[0001]** The present invention relates to a steam turbine comprising a rotor, a blading and a casing comprising two parts, whereby the two casing parts are fixed together at their splitplane with several splitplane bolts. The steam turbine comprises a first pressure section and a second pressure section, whereby the pressure sections are separated from each other by an annular blindwall. Each pressure section comprises a steam inlet and a steam outlet, whereby the steam outlet of the first pressure section and the steam inlet of the second pressure section are arranged next to the blindwall. Between the steam outlet of the first pressure section and the steam inlet of the second pressure section a bypass for guiding steam from the first pressure section to the second pressure section is arranged outside the casing, whereby a reheater is arranged at the bypass for reheating the steam in the bypass.

**[0002]** The first pressure side of such a steam turbine is impinged with a high pressure. The second pressure side of the steam turbine is impinged with a low pressure or an intermediate pressure. Steam turbines are mechanical devices which extract thermal energy from pressurized steam and convert it into a rotary motion. In reheated steam turbines the steam flow exits the high pressure section of the steam turbine, is reheated by an external reheater and is returned to the second pressure section of the steam turbine and continues its expansion. The different pressure sections are divided by a blindwall which is arranged between the rotor of the steam turbine and the casing of the steam turbine. The casing of the steam turbine is divided into two casing parts. The two parts are connected at their splitplane by several splitplane bolts.

**[0003]** The temperature at the inlet of the first pressure section, which is the high pressure side of the steam turbine, and the temperature at the steam outlet of the first pressure section can be very different. That means the temperature gradient between the temperature at the steam inlet and the steam outlet of the first pressure section can be more than 100 degrees Celsius, often mot than 200 or more degrees Celsius. The reheated steam coming from the first pressure section which is introduced at the steam inlet at the second pressure section has normally the same or nearly the same temperature like the temperature at the steam inlet at the first pressure section. Therefore at the area of the blindwall a temperature difference of hundred or more degrees Celsius, often more than 200 degrees Celsius is normal. Because of this high temperature gradient over the splitplane in the steam turbine at the area of the blindwall very strong splitplane bolts are necessary to fix the two parts of the casing together. If small splitplane bolts are used for the fixation of the two casing parts of the steam turbine only a small temperature gradient is allowed over the splitplane to cause no damage at the casing and/or at the splitplane of the two casing parts because of high thermal stresses.

**[0004]** An object of the present invention is to provide a steam turbine which can take a high temperature gradient over the blindwall and/or which allows to use small splitplane bolts for the fixation of the two parts of the casing of the steam turbine to reduce costs of the steam turbine.

**[0005]** This object of the invention is solved by a steam turbine according to claim 1 of the present invention. Advantages and embodiments of the steam turbine are disclosed in the dependent claims of the present invention.

**[0006]** More particularly the object of the invention is solved by a steam turbine with a rotor, with a blading, with a casing comprising two parts, whereby the two casing parts are fixed together at their splitplane with several splitplane bolts, the steam turbine having a first pressure section and a second pressure section, the pressure sections separated from each other by an annular blindwall, each pressure section comprising a steam inlet and a steam outlet, whereby the steam outlet of the first pressure section and the steam inlet of the second pressure section are arranged next to the blindwall, whereby between the steam outlet of the first pressure section and the steam inlet of the second pressure section a bypass for guiding steam from the first pressure section to the second pressure section is arranged outside the casing, whereby a reheater is arranged at the bypass for reheating the steam in the bypass, and whereby the blindwall and an annular part of the inner surface of the casing are building an annular chamber, whereby the casing comprises a third steam inlet and a third steam outlet which are connected to the annular chamber for guiding steam into and out of the annular chamber.

**[0007]** Such a steam turbine enables to introduce steam with an intermediate temperature into the annular chamber. The advantage of introducing steam with an intermediate temperature into the annular chamber is that the temperature gradient over the splitplane can be reduced, so that higher temperature gradients can be taken over the blindwall and/or smaller splitplane bolts can be used for the fixation of the two parts of the casing of the steam turbine. That means the temperature difference between the first pressure section and the second pressure section can be more than 200 degrees Celsius without causing damages at the splitplane of the casing parts, in particular in the area of the splitplane where the blindwall is arranged. Introducing steam with an intermediate temperature in the middle of the blindwall enables that the temperature gradient over the splitplane part which is arranged between the steam outlet of the first pressure section and the steam inlet of the second pressure section is very uniform. Therefore the thermal stresses in that splitplane part can be reduced in contrast to a steam turbine using a blindwall without such an annular chamber and without introducing steam with an intermediate temperature into the annular chamber.

**[0008]** In the above described steam turbine the blindwall can comprise a first annular wall, a second annular

wall and an annular main body, whereby the main body is arranged at the rotor of the steam turbine, wherein the annular chamber is build by the first wall, the second wall, the main body and the annular part of the inner surface of the casing. The annular main body of the blindwall is arranged at the rotor. Advantageously the connection between the main body of the blindwall and the rotor is sealed by a sealing element. The first annular wall and the second annular wall can be of the same size and shape. It is also possible that the first annular wall and the second annular wall have different sizes and shapes. Preferably both annular walls run parallel to each other. The size of the annular chamber can be different, as well. According to a first preferred embodiment of the blindwall the main body can be of a small size, so that the annular chamber extends approximately over the whole radial extension between the casing and the rotor. In a second preferred embodiment of the blindwall the main body of the blindwall can extend approximately over the whole radial extension between the casing and the rotor, so that the annular chamber is arranged near to the casing of the steam turbine. The crucial factor is that the inner surface of the casing and of the splitplane of both casing parts can be heated up by the introduced steam, so that the temperature gradient over the inner surface of the casing and the splitplane is uniform and the thermal stresses in that part of the steam turbine are reduced. The first and the second annular wall are spaced apart from each other, so that the main body is building the bottom part between both walls to contact the rotor of the steam turbine.

**[0009]** Advantageously the annular chamber is a circumferential groove in the blindwall with the opening in the direction to the casing of the steam turbine. Steam with an intermediate temperature can be introduced through the third steam inlet into the annular chamber where the steam can heat up the inner surface of the casing and the splitplane in this area. The introduced steam is guided through the annular chamber and exits the annular chamber through the third steam outlet. It is possible that more than one third steam inlet and more than one third steam outlet are provided in the casing of the steam turbine for guiding steam with an intermediate temperature into and out of the annular chamber. The distance between the first annular wall and the second annular wall can be different. That means if the temperature difference between the temperature in the first pressure section and the temperature in the second pressure section is very high the distance between the first annular wall and the second annular wall of the blindwall can made relatively large. If the temperature difference between both pressure sections not very high a blindwall can be used with an annular chamber of a small size. In this case the distance between the first annular wall and the second annular wall of the blindwall can be of a smaller size. According to a preferred development of the invention the casing of the steam turbine can comprise a first annular groove for receiving the first annular wall of the blindwall and a second annular groove for receiving the second annular wall of the blindwall. Preferably the first annular groove is arranged parallel to the second annular groove in the casing of the steam turbine. The distance between both grooves in the casing that means in that part of the casing which is directed to the rotor, is the same like the distance between the first annular wall and the second annular wall of the annular or circumferential grooves. The annular or circumferential grooves are shaped in a way that they can receive the ends of the annular walls form-locking. Advantageously in each groove is at least one sealing element arranged for sealing the annular walls with the casing. The arrangement of sealing elements between the first and the second wall and the casing of the steam turbine and the main body of the blindwall and the rotor of the steam turbine enables a secure sealing between the first pressure section and the second pressure section of the steam turbine.

**[0010]** In a first preferred embodiment of the steam turbine the third steam inlet for introducing steam with an intermediate temperature can be connected to an external steam source. That means the steam flow from the first pressure section via the bypass to the second pressure section is separated from the steam flow to the annular chamber of the blindwall. This enables a very unique supply of steam with a certain intermediate temperature into the annular chamber. The supply of steam from an external source enables that no fluctuations of the intermediate temperature of the steam can occur. The external steam source comprises a reheater or is connected to a reheater to heat up the steam temperature which is introduced into the annular chamber to the desired temperature.

**[0011]** Alternatively to the external steam source the third steam inlet of the casing can be connected to the bypass between the steam outlet of the first pressure section and the steam inlet of the second pressure section. In this case steam with an intermediate temperature can be drawn of the bypass and can be introduced into the annular chamber. The connection from the third steam inlet of the casing to the bypass between the steam outlet of the first pressure section and the steam inlet of the second pressure section can be realized by a pipe. The connection is preferably arranged in such a way that the reheater which is arranged at the bypass for reheating the steam can heat up the steam which is guided to the annular chamber to the desired intermediate temperature, whereby the rest of the steam which is guided through the bypass into the second pressure section can be further heated up to a higher temperature. That means the connection of the pipe can be in a middle part of the reheater, so that the steam coming from the steam outlet of the first pressure section is heated up to an intermediate temperature when reaching the connection to the third steam inlet of the casing. The steam which flows through the whole reheater is heated more than the part of the steam which is guided through the pipe into the annular chamber of the blindwall. Alternatively to such a

steam turbine a different steam turbine can comprise two reheaters which are arranged in series, whereby the connection and the pipe, respectively, for guiding steam into the annular chamber is arranged between both reheaters. This enables that the steam coming from the steam outlet of the first pressure section can be reheated in the first reheater up to an intermediate temperature and can be reheated in the second reheater to a higher temperature.

**[0012]** In particular the steam turbine is built for introducing steam into the annular chamber, whereby the steam is having a temperature between the temperature of the steam at the steam outlet of the first pressure section and the temperature of the steam at the steam inlet of the second pressure section. For example, hot steam which enters the first pressure section, which is the high pressure side of the steam turbine, with a temperature of 400 degrees Celsius exits the steam outlet of the first pressure section with a temperature of 200 degrees Celsius. The steam is guided through the bypass from the steam outlet of the first pressure section to the steam inlet of the second pressure section, whereby a reheater heats up again the steam to a temperature of 400 degrees Celsius. In an external steam source a different steam can be heated up to an intermediate temperature of for example 300 degrees Celsius. This second steam with the intermediate temperature of 300 degrees Celsius is introduced into the annular chamber for heating up the inner surface of the casing and the splitplane of the casing parts in the area of the blindwall. By this the temperature gradient over the splitplane in the area of the blindwall can be reduced, so that higher temperature gradients can be taken over the blindwall and/or the size of the splitplane bolts which are necessary for the fixation of the two parts of the casing can be reduced. The reduction of the temperature gradient over the splitplane in the area of the blindwall enables a reduction of the thermal stresses in this area of the casing parts. By reducing the splitplane bolts size the costs of the steam turbine can be reduced.

**[0013]** The present the invention will now be described by way of example with references to the accompanying drawings:

Fig. 1 shows schematically a sectional view of a steam turbine which is constructed according to the invention,

Fig. 2 shows in a sectional view the first pressure section and the second pressure section, which are separated by a blindwall which is build according to the invention,

Fig. 3 shows an increased sectional view of the arrangement of the blindwall between the rotor and the casing of the steam turbine and the steam flow from the first pressure section into the annular chamber and to the second pressure section.

**[0014]** Fig. 1 shows schematically a sectional view of a steam turbine 40 comprising a rotor 20, several bladings 21 and a casing 22, whereby only one part of the casing 22 is shown, so that the splitplane 23 of this part of the casing 22 can be seen. Further several splitplane bolts 24 are shown, which enables the fixation of the two casing parts together at their splitplane 23. The steam turbine 40 comprises a first pressure section 30 and a second pressure section 35. The pressure sections 30, 35 are separated from each other by an annular blindwall 1. The annular blindwall 1 is arranged between the rotor 20 and the inner surface 26 of the casing 22. Both pressure sections 30, 35 comprise a steam inlet and a steam outlet, whereby the steam outlet of the first pressure section 30 and the steam inlet of the second pressure section 35 are arranged next to the blindwall 1. The first pressure section 30 is the high pressure side of the steam turbine 40 and the second pressure section 35 can be the intermediate or low pressure side of the steam turbine 40. In this preferred embodiment of the invention the blindwall 1 and an annular part 25 of the inner surface 26 of the casing 22 are building an annular chamber 2. In the annular chamber 2 steam with an intermediate temperature can be introduced for heating up the annular part 25 of the inner surface 26. This results in a reduction of the temperature gradient over the splitplane 23 in the area of the blindwall 1. As a result of that the temperature differences between the temperature in the first pressure section 30 and the temperature in the second pressure section 35 can be high, in particular more than 200 degrees Celsius. On the other side the reduction of the temperature gradient over the splitplane 23 in the area of the blindwall 1 allows to use splitplane bolts 24 of a small size. Therefore the costs of the steam turbine 40 can be reduced.

**[0015]** Fig. 2 shows schematically a sectional view of both pressure sections 30, 35 which are separated by the blindwall 1, which is constructed according to the invention. Both pressure sections 30, 35 are connected with each other by a bypass 10. That means, a steam outlet of the first pressure section 30 is connected by the bypass 10 with the steam inlet of the second pressure section 35. This enables to heat up the steam by a reheater 11 which is arranged at the bypass 10 and enables to introduce the reheated steam into the second pressure section 35. The additional connection between the annular chamber 2 and the bypass 10 allows introducing parts of the steam flow into the annular chamber 2 of the blindwall 1. The specific arrangement of the reheater 11 at the bypass 10 enables that the steam which is introduced into the annular chamber 2 can be heated up to an intermediate temperature, which lies between the temperature of the steam at the steam outlet of the first pressure section 30 and temperature of the reheated steam at the steam inlet at the second pressure side 35.

**[0016]** Fig. 3 shows schematically an increased sec-

tional view of the arrangement of the blindwall 1 between the rotor 20 and the casing 22 of the steam turbine 40. The arrows show the steam flow which exits the first pressure section 30 at the steam outlet 31 and which is partly introduced into the annular chamber 2 of the blindwall 1 and which is partly introduced into the second pressure section 35 through the steam inlet 36. The steam outlet 31 at the first pressure section 30 is connected with the steam inlet 36 at the second pressure section 35 by the bypass 10. The reheater 11 is arranged in such a way to the bypass 10 that the steam which can be introduced into the annular chamber 2 can reach an intermediate temperature, whereby the steam which is introduced through the steam inlet 36 into the second pressure section 35 can be fully heated up. That means the steam which is introduced into the annular chamber 2 reaches an intermediate temperature which lies between, in particular in the middle between, the temperature of the steam in the steam outlet 31 of the first pressure section 30 and the temperature of the steam in the steam inlet 36 at the second pressure section 35. The circumferential part 25 of the inner surface 26 of the casing 22 which is building one border of the annular chamber 2 can be heated up by the introduced steam, so that the temperature gradient over the splitplane 23 of the casing 22 can be reduced. This allows higher temperature differences between both pressure sections 30, 35. Further or alternatively to that the inventive blindwall 1 allows to reduce the size of the splitplane bolts 24, because of the reduced temperature gradient over the splitplane 23 and the reduced thermal stresses in the parts of the casing 22.

**[0017]** The steam turbine 40 is built in such a way that the steam which is introduced into the annular chamber 2 of the blindwall 1 has always an intermediate temperature which lies between the temperature next to the blindwall 1 at the first pressure section 30 and the temperature next to the blindwall 1 at the second pressure section 35.

**[0018]** The annular chamber 2 which is built by the first wall 5, the second wall 6, the main body 7 of the blindwall 1 and the annular part 25 of the inner surface 26 of the casing 22 can be of different sizes. The annular chamber 2 has advantageously the shape of a circumferential groove.

**[0019]** Alternatively to the embodiment of the steam turbine 40 shown in Fig. 2 and 3, the steam turbine 40 can comprise an external steam source. The external steam source is built to generate hot steam, which can be introduced by a separate pipe and the third steam inlet 3 into the annular chamber 2 of the blindwall 1. In this case there is no connection between the annular chamber 2 and the bypass 10, which guides the steam from the first pressure section 30 to the second pressure section 35. In this case a second reheater is arranged at the external steam source to heat up the steam, which can be introduced into the annular chamber 2 of the blindwall 1. The first reheater 11 heats up the steam coming from the first pressure section 30. The first reheater 11 enables to reheat the steam up to a temperature like the temperature of the steam which is introduced into the first pressure section 30.

**[0020]** The steam which is introduced into the annular chamber 2 by the third steam inlet 3 exits the annular chamber 2 by the third steam outlet 4, see fig 4.

## Claims

1. Steam turbine (40) with a rotor (20), with a blading (21), with a casing (22) comprising two parts, whereby the two casing parts are fixed together at their splitplane (23) with several splitplane bolts (24), the steam turbine (40) having a first pressure section (30) and a second pressure section (35), the pressure sections (30, 35) separated from each other by an annular blindwall (1), each pressure section (30, 35) comprising a steam inlet (36) and a steam outlet (31), whereby the steam outlet (31) of the first pressure section (30) and the steam inlet (36) of the second pressure section (35) are arranged next to the blindwall (1), whereby between the steam outlet (31) of the first pressure section (30) and the steam inlet (36) of the second pressure section (35) a bypass (10) for guiding steam from the first pressure section (30) to the second pressure section (35) is arranged outside the casing (22), whereby an reheater (11) is arranged at the bypass (10) for reheating the steam in the bypass (10), **characterised in that** the blindwall (1) and an annular part (25) of the inner surface (26) of the casing (22) are building an annular chamber (2), whereby the casing (22) comprises a third steam inlet (3) and a third steam outlet (4) which are connected to the annular chamber (2) for guiding steam into and out of the annular chamber (2).

2. Steam turbine (40) according to claim 1, **characterised in that** the blindwall (1) comprises a first annular wall (5), a second annular wall (6) and an annular main body (7), whereby the main body (7) is arranged at the rotor (20) of the steam turbine (40), wherein the annular chamber (2) is built by the first wall (5), the second wall (6), the main body (7) and the annular part (25) of the inner surface (26) of the casing (22).

3. Steam turbine (40) according to claim 2, **characterised in that** a first annular groove (8) is arranged in the casing (22) for receiving the first annular wall (5) and a second annular groove (9) is arranged in the casing (22) for receiving the second annular wall (6).

4. Steam turbine (40) according to any one of the claims 2 to 3, **characterised in that** between the first (5) and the second wall (6) and the casing (22) and/or between the main body (7) of the blindwall (1) and the rotor (20) sealing means are arranged.

**5.** Steam turbine (40) according to any one of the claims 1 to 4, **characterised in that** the third steam inlet (3) is connected to an external steam source or to the bypass (10).

**6.** Steam turbine (40) according to any one of the claims 1 to 5, **characterised in that** the steam turbine (40) is built for introducing steam into the annular chamber (2), the steam having a temperature between the temperature of the steam at the steam outlet (31) at the first pressure side (30) and the temperature of the steam at the steam inlet (36) at the second pressure side (35.

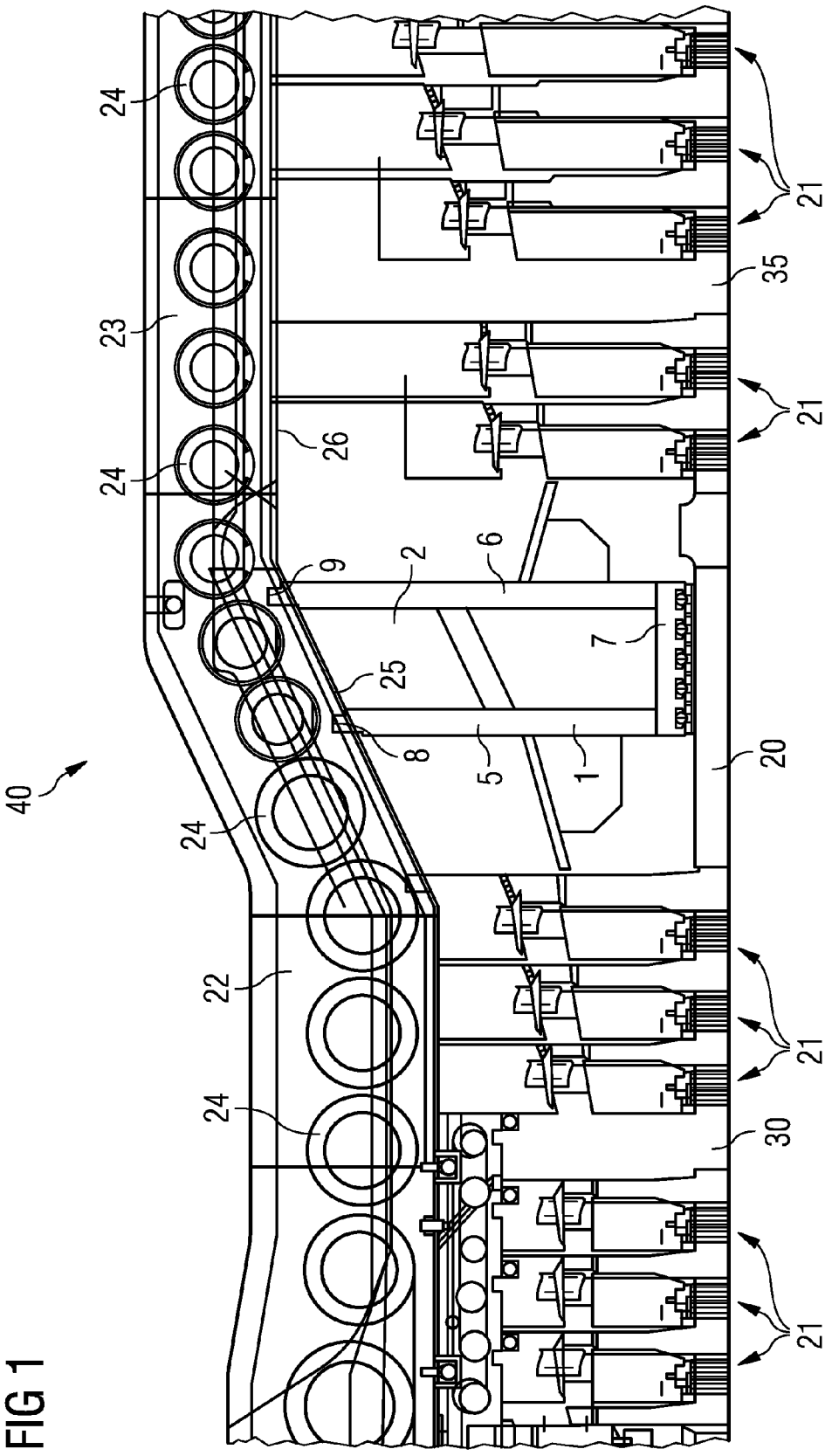


FIG 1

FIG 2

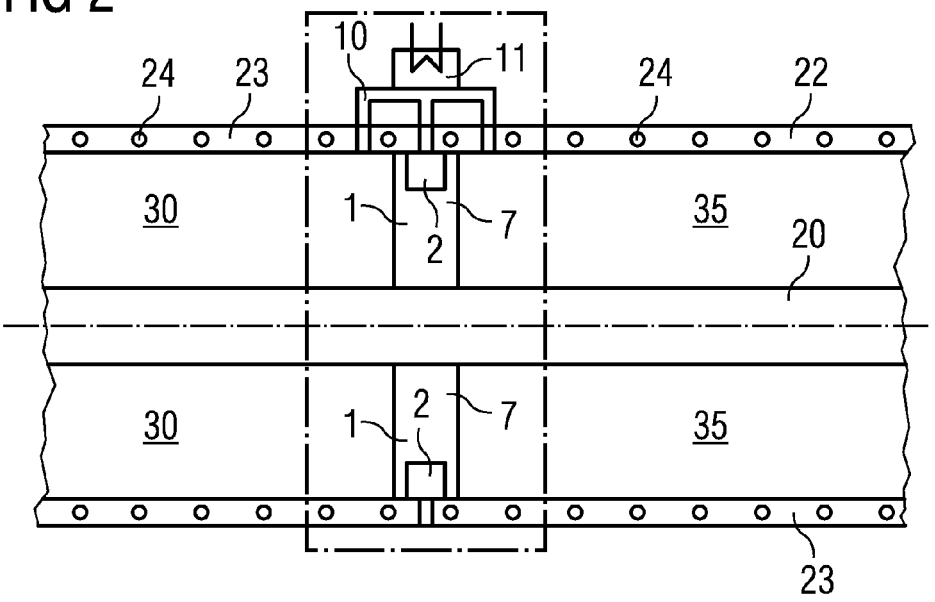
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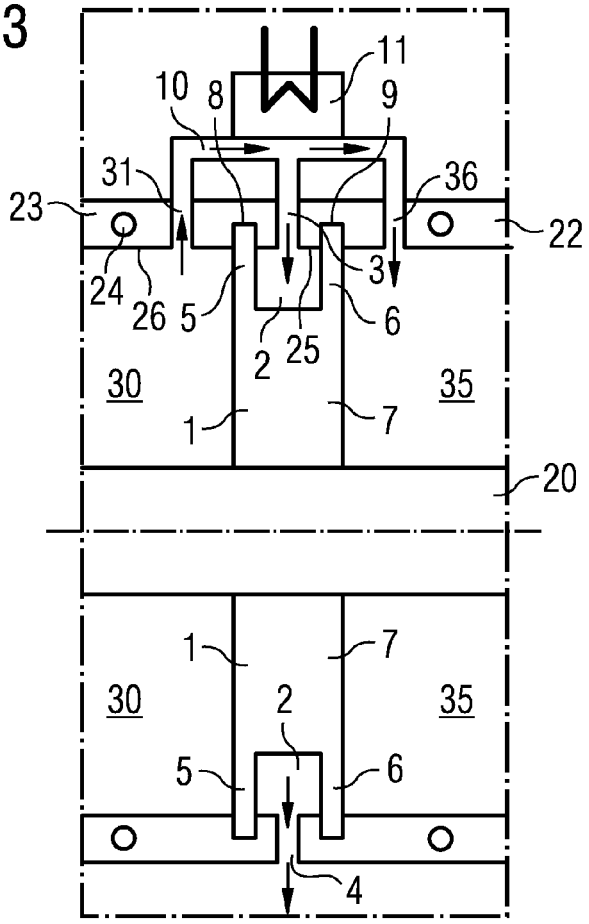
FIG 3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# EUROPEAN SEARCH REPORT

Application Number
EP 10 18 2377

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The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 17 March 2011 | Steinhauser, Udo |

CATEGORY OF CITED DOCUMENTS

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 10 18 2377

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