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(54) **Pressure casing of a turbomachine**

(57) The invention relates to a pressure casing (10), which comprises a plurality of casing shells (10a, 10b) which are connected in a pressure-tight manner in a parting plane (11) by means of a flange (12), wherein the casing shells (10a, 10b) are pressed together with sealing effect in the parting plane (11) in the region of the flange (12) by means of at least one threaded bolt (14) which extends in a through hole (13) through the flange

(12) perpendicularly to the parting plane (11).

Reduced temperature differences between the flange (12) and the connecting bolts (14) of the flanged joint are achieved by the at least one threaded bolt (14) being charged with a heat transfer medium over a part of its length, wherein said heat transfer medium is supplied via holes (22, 23, 24) extending through the flange (12).

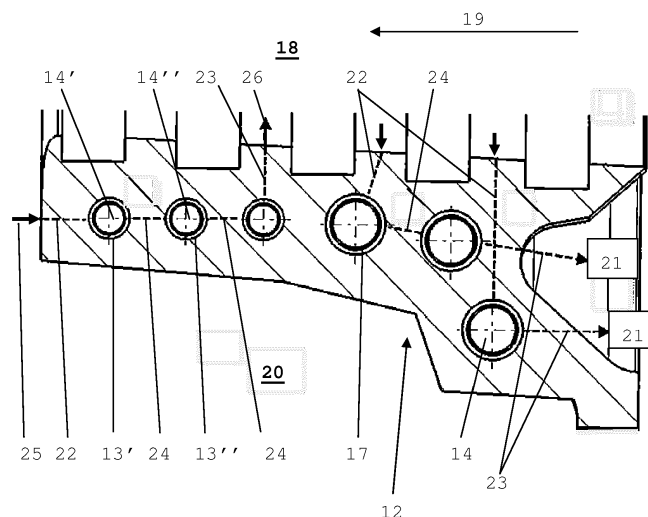


Fig. 2

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to the field of thermal turbomachines, such as stationary turbines for power generation. It refers to a pressure casing, divided in at least two casing shells which are removably connected in a pressure-tight manner in a parting plane by means of a flange.

BACKGROUND ART

[0002] Conventional bolted flange joints for pressure casings of thermal turbomachines, as are reproduced in an example in Fig. 1, or of other installations with similar requirements, have a plurality of disadvantages which are to be eliminated by the present invention. In the known pressure casing 10 from Fig. 1, two casing shells 10a and 10b are bolted together in a pressure-tight manner in a parting plane 11 via a flange 12. This is carried out by means of threaded bolts 14 which, by means of a through-hole 13 in the upper casing shell 10a, are screwed into a threaded hole 16 in the lower casing shell 10b and in this case supported by a nut 15 on a shoulder at the flange of the upper shell 10a. The casing shells 10a, 10b surround a flow channel 18 for a working medium, such as air, steam or hot combustion gases.

[0003] The following disadvantages result from this arrangement:

During the warm-up phase of the pressure casing 10, during a cold start, the casing material which surrounds the threaded bolts 14 heats up more quickly than the shaft of the threaded bolts 14 within the through-hole 13, which, on account of the different thermal expansion of the bolts and the casing 10, can lead to an overload and plastic elongation of the threaded bolts 14. The elongated bolts 14 can relax and the bolting forces diminish with subsequent local leakages during operation of the machine.

[0004] To avoid the above said disadvantage the state of the practice tends to oversize the connecting bolts. But larger bolts effect other negative consequences.

[0005] At heavily loaded places, it can happen that the inner-lying sealing is opened as a result of stresses in the casing wall, whereas the outer-lying support lip is more heavily loaded because the torque created by the wall and the bolt forces has to be compensated by means of a higher counter-force on the outer support lip. Consequently, the necessary pressure upon the sealing cannot be maintained any longer, in fact not even with larger bolts because with bolt diameters becoming larger the axis in which the bolt force acts is further away from the inner sealing lip than in the case of smaller bolts so that the leak-tightness of the sealing lip in actual fact is not

improved.

[0006] The published patent application DE 10225260 A1 discloses a casing for an axial turbomachine with an upper half shell and a lower half shell connected in a horizontal parting plane by means of a flange. The connecting bolts extend through a through hole in the upper half shell and are being placed in a thread hole of the lower half shell, whereby an annular space is formed between the outer surface of the bolt and the inner surface of the through hole. In an upper part of this annular space a thermally insulated sleeve is located. It is the aim of this solution to minimize the heat transfer between the connecting bolts and the ambient fluid. This solution cannot solve the above-mentioned problems during the warm-up phase.

[0007] Patent application WO 2003078799 A1 discloses an arrangement for cooling or heating of the flange bolts in a turbine casing. A bolt comprises one or more bore holes extending axially through the bolt. Said bore holes are optionally charged either with a heating or with a cooling medium. The cooling or heating medium flows through the at least one bore hole thereby cooling or heating the bolt. The stabilized temperature regime of the bolt effects a damping of bolt relaxation and ensures that the bolting forces remain stable during steady-state operation and during transient operations. Another disclosed embodiment teaches to equip the bolts with additional radial bore holes extending from the axial bore hole to the annular space between the bolt and the flange boring. This embodiment effects an increase of heat transfer and forces the cooling or heating gradient. It is an advantage of this solution that the plurality of bore holes weakens the mechanical integrity of the bolts. This weakening of integrity has to be compensated by an undesirably larger dimensioning of the bolts.

[0008] Quite another arrangement is disclosed in the document EP 1096111 B1, directed to a cooling structure for the flange of a steam turbine casing. The aim to prevent steam leakage caused by a drop of the fastening force of the flange bolts is achieved by cooling the flange. The upper and lower half shell of the casing are covered with a heat insulating material and a number of cooling pipes contacts the peripheral end surfaces of the flanges. By convective heat transfer the flange is cooled. The bolts are cooled indirectly via the flange.

[0009] This cooling arrangement effects primarily a cooling of the peripheral end surface of the flange. The cooling effect to the bolts is low, because the working steam inside the steam turbine warms the flange. A significant cooling of the bolts would require an extensive heat removal from the flange.

[0010] This cooling arrangement is only applicable to the outer casing of a turbine, but it is not suitable for inner casings. The above-referred problems during a cold start are not solved by this solution.

SUMMARY OF THE INVENTION

[0011] It is therefore an object of the invention to disclose a pressure casing for a turbomachine which avoids significant thermal gradients within the flanged joint, i.e. between the flange and the connecting bolts, to improve the stabilization of the bolting forces throughout all operating conditions.

[0012] The object is achieved by means of the sum total of the features of claim 1. The invention is based on a pressure casing which comprises at least two casing shells which can be connected in a pressure-tight manner in a parting plane by means of a flange, wherein the casing shells are pressed together with sealing effect in the parting plane in the region of the flange by means of at least one threaded bolt which extends through the flange perpendicularly to the parting plane. The invention is distinguished by the fact that the at least one threaded bolt is charged by a heat transfer medium, i.e. based on operational requirement either a heating or a cooling medium, and this heat transfer medium is supplied or discharged via holes that are passed through the flange.

[0013] This measure supports an equalization of the temperatures of the flange and the connecting bolts, thereby avoiding overload of the bolts during start up phases and diminishment of bolting forces during shut-down.

[0014] According to a preferred embodiment the heat transfer medium charges the bolt in the annular space between the shaft of the bolt and the inner lateral surface of the through hole.

[0015] According to a further embodiment the annular space between the shaft of the bolt and the inner lateral surface of the through hole is sealed in a gas tight manner on its both longitudinal ends, wherein at the one end a feed hole for the heat transfer medium leads into the annular space and at the opposite end an outlet hole for the heat transfer medium branches off.

[0016] One development of the invention is characterized in that the heat transfer medium is air.

In particular, the heat transfer medium is compressor air.

[0017] According to an alternative embodiment the heat transfer medium is steam, particularly branched off steam from a steam turbine.

BRIEF EXPLANATION OF THE FIGURES

[0018] The invention shall subsequently be explained in more detail based on exemplary embodiments in conjunction with the drawing. In the drawing

Fig. 1 shows in a sectional view a flanged joint of a pressure casing according to the state of the art;

Fig. 2 shows in a sectional top view a flanged joint of a pressure casing according to the invention;

Fig. 3 shows in an exemplary embodiment the use of

the invention in a compressor.

WAYS OF IMPLEMENTING THE INVENTION

[0019] The above-described disadvantages of the conventional pressure casing with a flanged joint are eliminated by a construction as is schematically reproduced in Fig. 2 in an exemplary embodiment of the invention. The pressure casing 10 comprises, as shown in Fig. 1, an upper casing shell 10a and a lower casing shell 10b which abut on a flange 12 in a parting plane 11 and are bolted to each other there in a pressure-tight manner by threaded bolts 14. For each of the threaded bolts 14 provision is made in the upper casing shell 10a in the region of the flange 12 for a through-hole 13 with an inner diameter larger than the outer diameter of the bolt 14 to provide an annular space 17, and provision is made in the lateral surface of this through hole 13 for a supply and discharge of either a heating or a cooling medium. On both sides the annular space 17 is sealed in a gas tight manner.

[0020] During operation, based on operational requirements, either a cooling or a heating medium is supplied from a source 20 to the annular space 17 via at least one feed hole 22. The feed hole 22 opens into the space 17 at one of its longitudinal ends. From there the heat transfer medium flows around the shaft of the bolt 14 towards the opposite end of space 17. Via outlet hole 23 the heat transfer medium leaves the annular space 17 to be discharged in a volume 21 with a lower pressure compared to the pressure of the source 20. This volume 21 may be a suitable cavity inside or outside of the casing 10. Outlet hole 23 again extends through the flange 12 in a way to intensify the heat transfer between the heat transfer medium and the flange 12.

[0021] The heat transfer medium is supplied from a fluid source 20. In principle, any source 20 with a pressure higher than the pressure of volume 21 and a temperature in the required operable range is suitable. Preferred sources 20 for the heat transfer medium are an air plenum of a gas turbine or the flow channel 18 of a compressor or a steam turbine. From this source 20 the feed hole 22 is passed through the flange 12 in a way to allow heat transfer between the flange 12 and the heat transfer medium. The feed hole 22 may have a circular or a non-circular, particularly a rectangular cross section. The feed hole 22 may comprise a section with an enlargement of cross section to combine feed holes 22 from different sources 20 or to branch feed holes 22 to different through holes 13.

[0022] According to an embodiment of the invention the feed holes 22 or the outlet holes 23 are arranged in the parting line 11. By this arrangement curved or even serpentine holes 22, 23 can be manufactured easily, e.g. by milling a groove in the contact surfaces of the flange 12.

[0023] Fig. 2 schematically shows alternative embodiments to realize this invention. According to a first em-

bodiment, illustrated on the left side of Fig. 2, from a plenum 20 a mass flow of air is discharged into feed line 22. Feed line 22 passes an area of the flange 12 and ends in the through hole 13' of a first threaded bolt 14'. From this first through hole 13' the heat transfer medium passes through a connecting hole 24 inside of flange 12 to a second bolt 14'' in a second through hole 13'' etc. Finally, the exhaust heat transfer medium 26 is discharged via outlet hole 23 into the flow channel 18.

[0024] According to a second embodiment, as illustrated on the right side of Fig. 2, the flow channel 18 of the turbomachine serves as source of the heat transfer medium. A partial flow of the working medium is branched off from the flow channel 18 and fed into the feed line 22. From feed line 22 the heat transfer medium is passed through the flange 12 to one or more connecting bolts 14 and is finally discharged via the outlet hole 23 into a cavity 21 inside or outside of the outer casing of the turbomachine.

[0025] The embodiment of Fig. 3 refers to another embodiment of the invention, especially applicable to a compressor casing. The lower and the upper shell of the compressor are equipped with a flange 12. Threaded bolts 14, extending through the through holes 13 in the upper shell 10a, join the two half shells in a gas tight manner by interaction with a thread in the lower half shell. The flow channel 18 of the compressor comprises a number of compressor stages. A feed line 22 branches off from the flow channel 18 at a defined vane row (i) (reference 28). The feed line 22 extends through the flange 12 and ends inside a first through hole 13' at its longitudinal end. At the opposite longitudinal end a connecting hole 24 connects this first through hole 13' with a second through hole 13'', whereby this second hole 13'' is located upstream against the flow direction 19 of the working medium in the flow channel 18. From the second through hole 13'' an outlet hole 23 extends through the flange 12 and ends in the flow channel 18 at a vane row 29 upstream of the above-mentioned vane row (i) (reference 29), i.e. in an upstream compressor section with a lower pressure. During transient operating phases a partial flow 25 of the compressor air stream is branched off from the flow channel 18 into the feed hole 22. Under convective heat transfer the air stream 25 passes the flange 12, enters the annular space 17' between the through hole 13' and the shaft of the first bolt 14' at its e.g. upper longitudinal end. The air flows along the shaft of bolt 14' under convective heat transfer. At the opposite longitudinal end the air flow 27 enters the connecting hole 24, passes again the flange 12 and reaches the through hole 13'' of the second bolt 14'', flows along the shaft of the second bolt 14''. Via the outlet hole 23 the exhausted air 26 is directed back into the flow channel 18 at a vane row 29, located upstream of the vane row 28.

[0026] This embodiment of a device for flange and bolts temperature adjustment uses the pressure difference between two different compressor stages.

[0027] As a result of this type of construction according

to the invention the following advantages are achieved:

- The heat transfer medium flowing through the annular space 17 between the through hole 13 and the threaded bolt 14 will quicker warm up the bolt 14 during start-up, compared to used conventional solutions;
- The heat transfer medium flowing through the annular space 17 between the through hole 13 and the threaded bolt 14 will quicker cool down the bolt 14 during shut down;
- The temperature difference between the flange 12 and the connecting bolts 14 during transient operating modes are significantly reduced;
- The risk of overload of the connecting bolts 14 during start-up phases is eliminated;
- The pretension of the bolts during shut down is maintained.

LIST OF DESIGNATIONS

[0028]

10	casing
10a	upper casing shell
10b	lower casing shell
11	parting plane
12	flange
13	through hole
14	threaded bolt
15	Nut
16	threaded hole
17	annular space
18	flow channel
19	flow direction of the working medium in channel 18
20	source of the heat transfer medium, space of higher pressure
21	volume for exhausted heat transfer medium, cavity of lower pressure
22	feed hole from source 20 to the bolt 14
23	outlet hole from the bolt 14 to volume 21
24	connecting hole between bolts 14', 14''...
25	fresh heat transfer medium
26	exhausted heat transfer medium
27	partially used heat transfer medium
28	compressor stage
29	compressor stage
30	plug

Claims

1. Pressure casing of a turbomachine, which comprises at least two casing shells (10a, 10b) which are connected in a pressure-tight manner in a parting plane (11) by means of a flange (12), wherein the casing shells (10a, 10b) are pressed together with

sealing effect in the parting plane (11) in the region of the flange (12) by means of at least one threaded bolt (14) which extends through a through hole (13) in the flange (12) perpendicularly to the parting plane (11), and wherein the at least one threaded bolt (14) is charged by a heat transfer medium, **characterized in that** at least one of feed holes (22) or outlet holes (23) for the heat transfer medium are passed through the flange (12).

2. Pressure casing as claimed in claim 1, **characterized in that** one or more feed holes (22) for the heat transfer medium start at a source (20) for the heat transfer medium, extend through the flange (12) and end in a lateral surface of the through hole (13). 5
3. Pressure casing as claimed in claim 1 or 2, **characterized in that** one or more outlet holes (23) for the heat transfer medium start at the through hole (13), extend through the flange (11) and end in a volume (21) of a relatively low pressure compared to the pressure of the source (20). 10
4. Pressure casing as claimed in one of the claims 1 to 3, **characterized in that** an annular space (17) is provided between the inner lateral surface of the through hole (13) and the shaft of the threaded bolt (14), this annular space (17) is sealed in a tight manner on its both longitudinal ends and this annular space (17) is charged by the heat transfer medium. 15
5. Pressure casing as claimed in claim 4, **characterized in that** at least one of the feed holes (22) or the outlet holes (23) are open to the annular space (17). 20
6. Pressure casing as claimed in claim 5, **characterized in that** the at least one feed hole (22) and the at least one outlet hole (23) lead to opposite ends of the annular space (17). 25
7. Pressure casing as claimed in one of the claims 1 to 6, **characterized in that** at least a portion of the passages 22, 23, 24 for the heat transfer medium are arranged in the parting line (11) of the flange (12). 30
8. Pressure casing as claimed in one of the claims 1 to 7, **characterized in that** heat transfer medium is air. 35
9. Pressure casing as claimed in one of the claims 1 to 7, **characterized in that** the heat transfer medium is steam. 40
10. Pressure casing as claimed in one of the claims 1 to 9, **characterized in that** the source (20) for the fresh heat transfer medium is a plenum or the flow channel (18) of the turbomachine. 45
11. Pressure casing as claimed in claim 10, **character-**

ized in that the both the source (20) of the fresh heat transfer medium and the volume (21) for the exhausted heat transfer medium is the flow channel (18) of the turbomachine

12. Pressure casing as claimed in claim 11, **characterized in that** the turbomachine is a compressor.
13. Pressure casing as claimed in one of claims 1 to 10, **characterized in that** the casing is an inner carrier of a gas turbine.

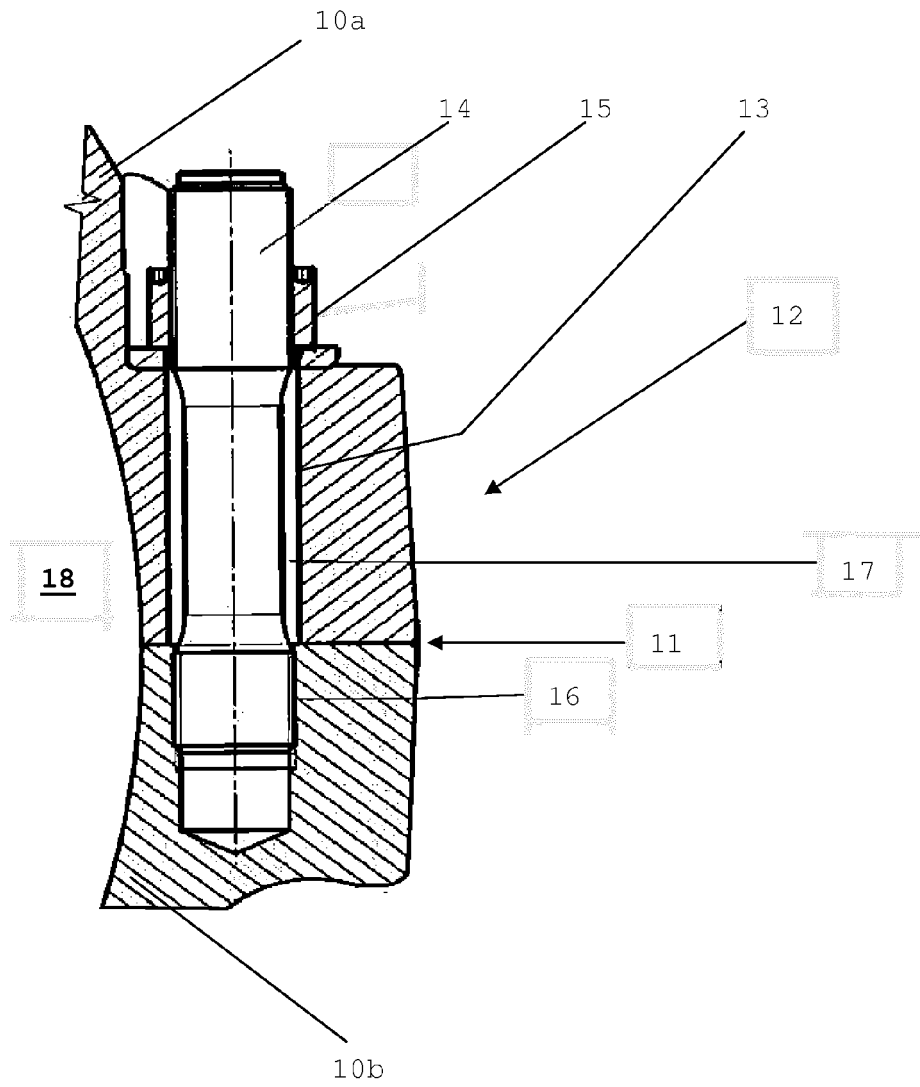


Fig. 1

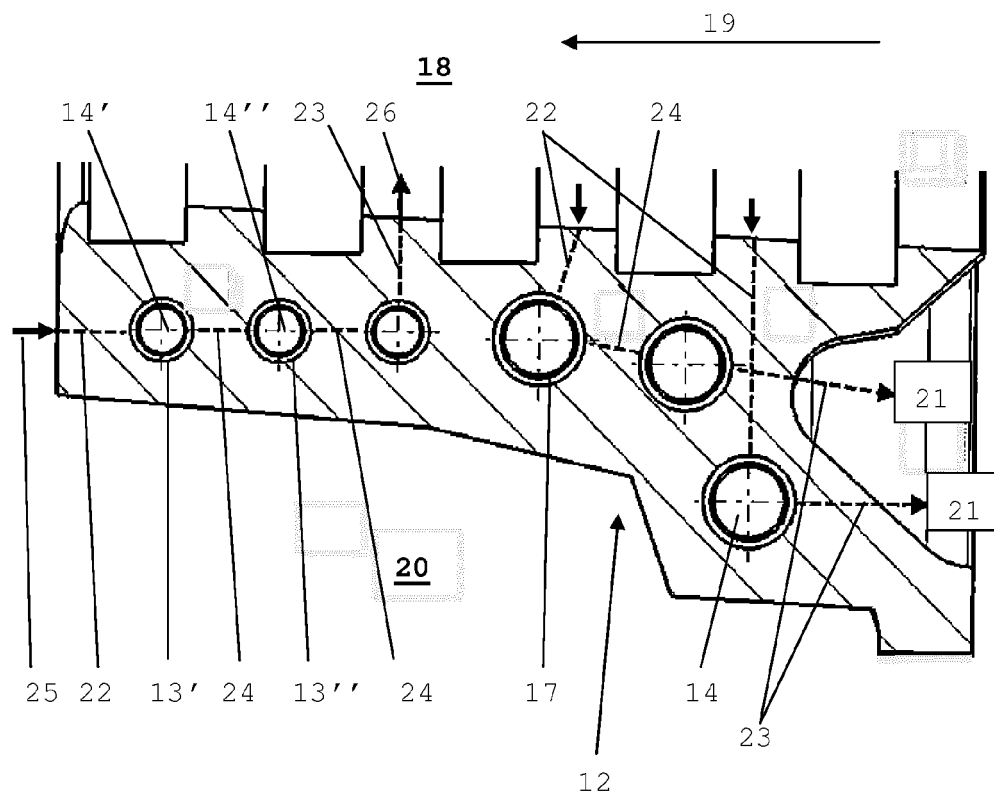


Fig. 2

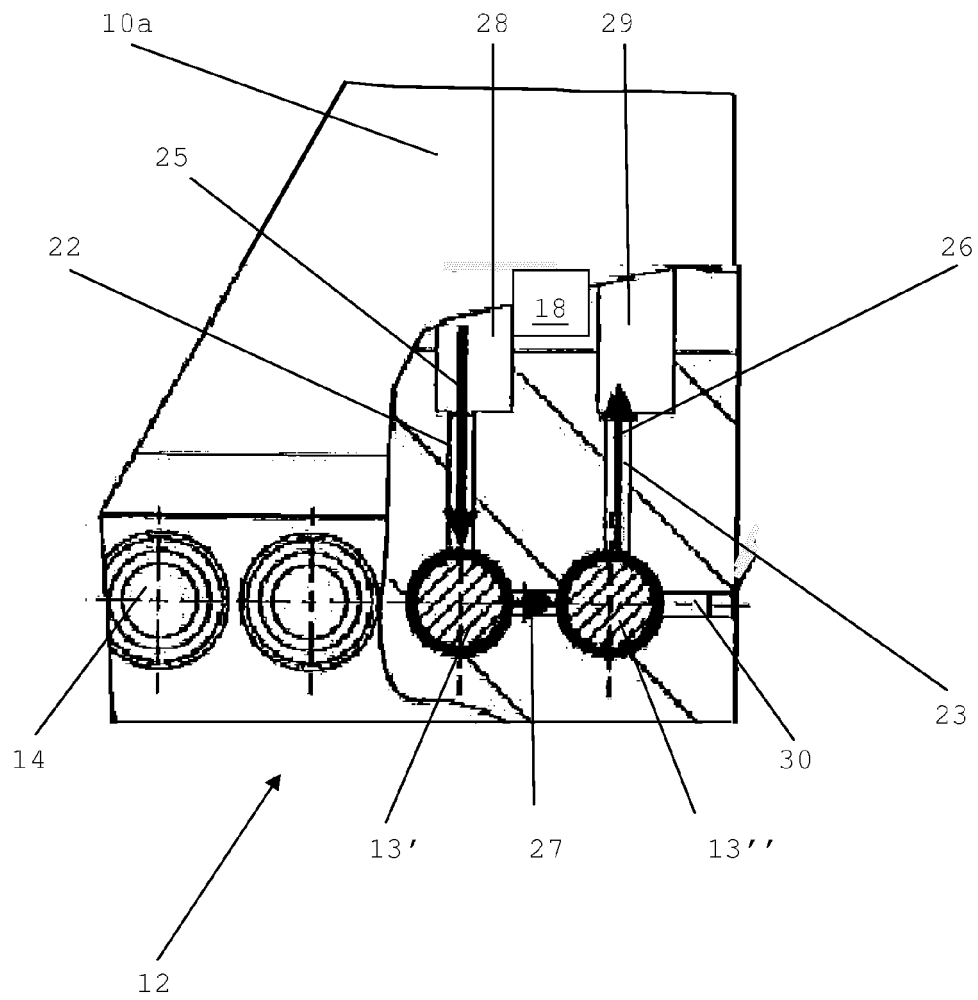


Fig. 3



EUROPEAN SEARCH REPORT

 Application Number
EP 13 17 5613

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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