(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 808 445 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
03.12.2014 Bulletin 2014/49

(51) Int Cl.:
D21G 1/02 *(2006.01)* ***D21G 1/00*** *(2006.01)*

(21) Application number: **13169860.7**

(22) Date of filing: **30.05.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(54) Method for controlling vibrations of a fiber web machine and a deflection compensated roll of a fiber web machine

(57) The invention relates to a method for controlling vibrations of a fiber web machine, in particular of a calender, which fiber web machine comprises at least one roll (10), which comprises a shaft (12A) and shaft ends (12), a shell (10A) and at least one loading element (20) for loading the shell (10A) located in pressure pockets of the shaft (12A), which roll (10) forms a nip (N) with another roll (11). The method comprises designing at least one roll (10) of the fiber web machine by vibration modeling simultaneously combining limitations of static loading and providing optimal amplitude of movement in the at least one loading element or roll support element of at least one roll (10) in the / in those natural frequency / frequencies that cause nip pressure or nip load variation in the nip (N) such that maximum damping is generated in nip vibration. The invention also relates to a deflection compensated roll which comprises damping means (24, 26) for at least one loading element (20) of the deflection compensated roll (10) for damping vibration of the shell (10A) of the roll, which damping means comprise a spring element (26) and a damping element (24).

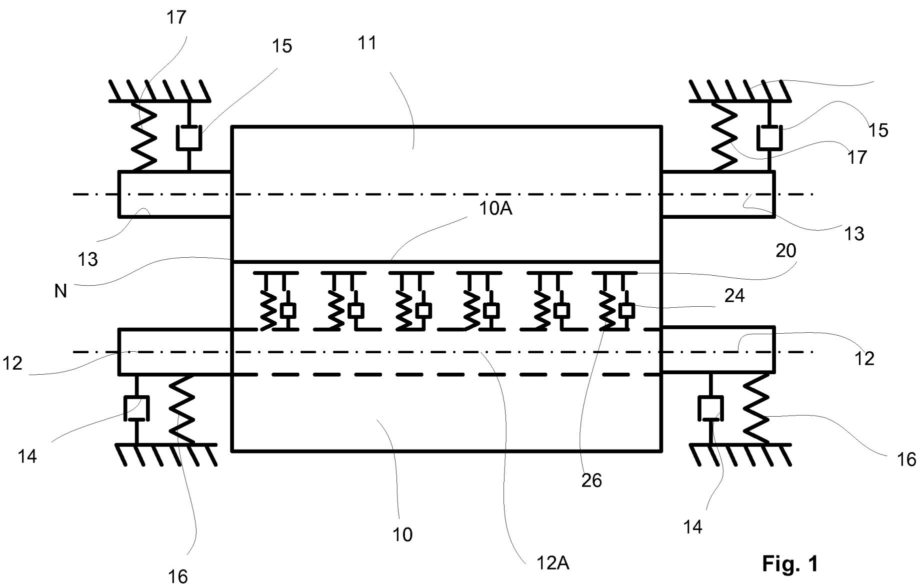

Fig. 1

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Description

[0001] The invention relates to a method for controlling vibrations of a fiber web machine. The invention also relates a deflection compensated roll. Particularly the invention relates to a method according to the preamble of claim 1 and to a deflection compensated roll according to the preamble of claim 6 or of claim 15. Especially the deflection compensated roll is a nip roll for a calender of the fiber web machine.

[0002] In fiber web machines the fiber web is produced and treated in an assembly formed by a number of apparatuses arranged consecutively in a process line. A typical production and treatment line comprises a head box, a wire section and a press section as well as a subsequent drying section and a reel-up. The production and treatment line can further comprise other devices and sections for finishing the fiber web, for example, a sizer, a calender, a coating section. The production and treatment line also comprises at least one winder for forming customer rolls as well as a roll packaging apparatus. In this description and the following claims by fiber webs are meant for example a paper, board, tissue webs. In each section and device vibrations may occur in several different components. For example vibrations may occur in a nip, which is formed in between two elements, typically between two rolls but also the nip can be formed with a roll, a belt, a shoe or corresponding element and a counter-element of corresponding or different kind, often at least one of the nip forming elements is a roll. The roll can be a deflection compensated roll, which are used in nips of the press section and of the calenders of the fiber web machine. In the press nips water is removed from the fiber web and in the calender nips the fiber web is treated for example to achieve certain surface properties such as gloss. The fiber web is passed through the nip freely or supported by a belt, a felt, a wire or a corresponding fabric. In the nip the fiber web is pressed in order to remove water from the web or to effect to the properties of the web and by the deflection compensated roll the nip pressure is controlled in cross-direction or the fiber web i.e. in the longitudinal direction of the roll.

[0003] In calender design of prior art the only dynamical aspects taken into account are unbalance and off-roundness of rolls and first critical speed of rolls. The design of rolls, frames and loading means is done by examining minimum and maximum values of static loading and by ensuring that the criteria of tension or deflection is not exceeded and the first natural frequency of the structure is above maximum roll rotation frequency.

[0004] In calenders one vibration form is barring which is caused by resonance of a roll pair, in which the calender vibrates such that nip load varies. The variations in nip load gradually form the soft cover of the calender such that the cross section of the roll will be angular. The resonance of roll pairs of calenders is unavoidable and only size of rolls and frames have influence on the frequencies on which the resonance occurs. In resonance situations the amplitude of vibration is limited only by damping in the mechanical system i.e. the heat energy created by the vibration of elements of the system. Damping is observed for example as internal hysteresis of materials (very little effect), in connections with friction, as friction losses on glide-surfaces. In calender the largest damping occurs in connection with movements of pistons of loading elements of the deflection compensated roll. It should be noted that the movement must be long enough in order not to remain only as elastic deformation of seals of the loading elements.

[0005] A deflection compensated roll comprises a shell around the loading shaft with loading zones in which loading shoes with a piston are arranged. The loading zones are connected to the shell of the roll rigidly, since thicknesses of lubricating oil between the loading shoes and the shell are thin. The loading shoes are supported on the loading shaft by means of a pressure medium volume, typically an oil volume and also this medium volume is significantly rigid, since as the piston moves the moving medium area is large and flow channels are very narrow.

[0006] In EP patent publication 1411254 B1 is disclosed a middle roll of a calender with a damper assembly having an inertial mass. The roll has a roll shell that surrounds an internal space, in which there is arranged a damper assembly having at least one passive oscillation damper that has a damper frequency which lies below a natural frequency of the roll, or a roll system containing the rolls, that is critical for the formation of barring. According to one example of the middle roll at least in a region between the oscillation damper and the roll shell, the internal space is filled with liquid, the viscosity of which exceeds a predetermined minimum amount. In this roll the damper will be set to a certain frequency for damping. The roll disclosed is a tube roll not a deflection compensated roll.

[0007] An object of the invention is to create a method for controlling vibrations of a fiber web machine and a deflection compensated roll and in which the disadvantages and problems of prior art are eliminated or at least minimized.

[0008] In particular an object of the invention is to provide a method for controlling vibrations of a deflection compensated roll for a calender of a fiber web machine and a deflection compensated roll for a calender of a fiber web machine.

[0009] In order to achieve the above mentioned objects the method according to the invention is mainly characterized by the features of the characterizing clause of claim 1. The deflection compensated roll according to the invention in turn is mainly characterized by the features of the characterizing clause of claim 6 or of claim 15.

[0010] By the invention a new way of controlling vibrations in a deflection compensated, for example a zone controlled roll for a calender is created, in which the vibrations are controlled with the help of loading means of the deflection compensated roll and/ or with the help of support means of the deflection compensated roll. The support means may be the bearing support to the frame of the calender for the shaft ends of the roll or the loading cylinder support of the calender.

[0011] In the method for controlling vibrations of the fiber web machine, in particular of a deflection compensated, for example of a zone controlled roll, in accordance with the invention optimum design of at least one roll is provided by vibration modeling simultaneously combining limitations of static loading and providing optimal amplitude of movement in the loading elements of the at least one roll in the / in those natural frequency / frequencies that cause nip pressure or nip load variation in the nip formed by the deflection compensated roll with another roll.

[0012] According to an advantageous feature resonance is calculated and critical resonances in view of the vibration are determined and relative damping of critical resonance is maximized into certain frequency limits between 50 - 1000 Hz. Based these vibration modelling factors the deflection compensated roll is designed and damping means are designed for the at least one loading element and advantageously for the support of the roll. It should be noted that prior art design methods of calender rolls do not take into account any parameters relating to vibration or its damping and when vibration occurs in use of the calender rolls solutions are sought to dampen the vibration i.e. action is taken only after the problems occur.

[0013] According to an advantageous aspect of the invention the hydraulic piston of a loading element of the deflection compensated roll is separated from the loading element by resilient connection, for example by a spring, advantageously by a disc spring, and the loading element is located in the pressure pocket of the shaft such that there is a significant tolerance between the loading element and the pressure pocket. The tolerance is 0,1 - 2,5 mm, advantageously 1,0 - 2,0 mm. Furthermore this tolerance is advantageously not sealed and the loading element floats in the medium, advantageously in oil. By separation of the piston from the loading element the flow of the medium into the unsealed space is prevented and thus large flows are avoided. For providing guide of positioning the loading element in the pressure pocket the cross section of the element deviates from circular form, for example it may have grooves for providing cross-sectional flow area.

[0014] When the loading element is under vibration it moves the medium in the volume between the piston and the loading element, which medium is pressurized and forced to flow in the tolerance of the pressure pocket of the loading element. In the tolerance the medium flow creates pressure loss that is in direct relationship with movement velocity of the loading element and thus functions as a viscous damper.

[0015] According to an advantageous aspect of the invention the deflection compensated roll comprises a resilient element, for example a spring or gas volume, which is located between the piston of the at least one loading element of the roll and support of the at least one loading element is provided freely movable in the loading direction of the at least one loading element.

[0016] Advantageously the hydraulic piston of the loading element may also be loaded by a high pressure gas volume, which will be significantly more compressible than oil. A separate oil feed line is arranged for the lubrication of the loading element.

[0017] Leakage free air loaded zones of the roll also make it possible to use simple and compact solenoid valves for pressure control of the loading zones. Complicated servo/proportional valves are not needed, but instead pressure is controlled by adjusting the opening and closing times of the solenoid valves. Such control is known as digital pressure control.

[0018] When the shell of the deflection compensated roll vibrates, at least one loading element moves with the shell as only thin foil of medium is between the shell and the loading element. In case the loading element moves towards the shaft of the roll, it causes a medium flow into the tolerance with high flow speed due to the narrowness of the tolerance and a flow loss is caused. The flow loss is dependent on viscosity of the medium, dimensions of the tolerance and thus at a certain movement speed a pressure loss is created which is dependent on the cross-sectional flow area of the tolerance and by this the damping force is created.

[0019] When designing the deflection compensated roll by means of vibration modelling the optimum damping design can be calculated such that the vibration damping by loading elements will provide its maximum under different vibrations. The vibration damping can further be influenced during operating the calender, as damping is dependent from the viscosity of the medium and adjustment of viscosity of the medium is provided by adjusting the temperature of the medium and thus also adaptive vibration damping can be achieved.

[0020] Advantageously the stiffness of the loading elements is in the range of 1×10^5 N/m - 1×10^7 N/m and damping is the range of 1×10^5 Ns/m - 1×10^6 Ns/m. The roll support stiffness is advantageously 1×10^7 N/m - 5×10^8 N/m. The roll support damping is advantageously 5×10^5 Ns/m - 5×10^7 Ns/m.

[0021] According to an advantageous feature of the invention by the dimensions of the tolerance the desired damping properties are designed to the roll.

[0022] In accordance with an advantageous aspect of the invention the deflection compensated roll is designed for a roll nip of a calender such that total damping is maximized by taking into account all resonances in the roll causing pressure variations in the nip area.

[0023] According to a further advantageous aspect the deflection compensated roll is supported by its shaft ends to the frame of the by resilient support and by a bearing. Thus a vibration damping support of the roll is provided by liquid film damping, i.e. squeeze film damping. According to this advantageous aspect when the shaft of the roll moves oil in a tolerance of a bearing housing, the oil film in the tolerance is squeezed between hard surfaces and forced to flow in the narrow gap volume. Pressure loss in the flow creates an opposite force and damping is achieved. Damping force is dependent on viscosity of the liquid, height of the tolerance and width of the shaft and the liquid film sector dimensions.

[0024] According to an advantageous aspect support of the deflection compensated roll is provided by construction the bearings of the roll on support of a separate bushing which is supported in the loading direction to the respective bearing house by pressure pockets. The pressure pockets are filled for supporting the load pressurized gas, for example air, which has high compressibility. The area and volume of the pressure pocket is designed to provide desired compliance of the support. According to an advantageous feature perpendicular to the loading direction are additionally provided liquid pockets that are filled with oil or other liquid. The tolerance between the liquid pockets and the bushing and the sector covered by the liquid pockets and the area of the liquid pockets give the different factors to design the liquid volume such that desired viscous damping is provided. The support arrangement can also be fitted in the fixing points of calender loading cylinders.

[0025] The damping is provided such that when the bushing moves in loading direction at the other end of the liquid volume the tolerance decreases and at the other end the tolerance increases. As the liquid flows in the narrow tolerance according to the replacement volume pressure loss is created in the flow and thus an opposing force to the movement is provided. By the advantageous aspect of the invention the stiffness and damping properties of the support of the deflection compensated roll are designed.

[0026] According to a further advantageous aspect the deflection compensated roll is loaded in the calender by loading cylinders provided with resilient support. Thus vibrations damping support is provided by liquid film damping, i.e. squeeze film damping, in which in loading direction the force is carried by a high pressurized gas pocket and the shaft of the loading cylinder is "floating" on a small tolerance defined by discharge amount and throttling of the inlet side.

[0027] In the following the invention is explained in detail with reference to the accompanying drawing to which the invention is not to be narrowly limited.

[0028] In figure 1 is shown schematically an example of the invention.

[0029] In figure 2A is shown schematically an example of an advantageous loading element according to the invention.

[0030] In figure 2B is shown schematically another example of an advantageous loading element according to the invention.

[0031] In figure 3 is shown schematically an example of an advantageous bearing arrangement according to an advantageous feature of invention.

[0032] In figure 4 is shown schematically in further detail the liquid flow in liquid pockets of the example of figure 3.

[0033] In figure 5 is shown schematically another example of an advantageous bearing arrangement according to an advantageous feature of invention.

[0034] In figures 6 and 7 are schematically shown an example of schematic example a swimming roll.

[0035] In figures 8A - 8B is shown schematically an example the loading cylinder support of the calender.

[0036] During the course of the following description like numbers and signs will be used to identify like elements according to the different views which illustrate the invention and its advantageous examples.

[0037] In the example of figure 1 a nip N, for example a calender nip, is formed between a deflection compensated roll 10 and its counter roll 11. The counter roll 11 is supported by its shaft ends 13 by a vibration damping element 15 and by a spring element 17 to the frame structure of the device, for example the calender. Correspondingly the deflection compensated roll 10 is supported by its shaft ends 12 by a vibration damping element 14 and by a spring element 16 to the frame structure of the device for example the calender. On the shaft 12A of the deflection compensated roll 10 are supported loading elements 20 of which only one is marked by reference numeral for clarity reasons. The loading elements 20 load the shell 10A of the roll in the nip direction, as shown in the figure, i.e. towards the counter roll 11 of the deflection compensated roll 10. Each loading element 20 is also provided with a damping element 24 and a spring element 26.

[0038] When designing the deflection compensated roll by means of vibration modelling the optimum damping design can be calculated such that in vibration modes the vibration damping by loading elements is maximized. The vibration damping can further be influenced during operating the calender, as damping is dependent from the viscosity of the medium and adjustment of viscosity of the medium is provided by adjusting the temperature of the medium and thus also adaptive vibration damping can be achieved.

[0039] In figure 2A is the example of the loading element 20 loads the shell 10A and it is located in a pressure pocket of the shaft 12A of the deflection compensated roll10. The loading element 20 comprises a loading shoe 23, which has oil pockets 25 for lubricating medium, for example oil. The lubricating medium is passed to the oil pockets 25 via channels 27. The hydraulic piston 21 is separated from the loading element 20 by the resilient spring element 26, advantageously by a disc spring and seals 35 seal the loading pressure pocket 33 of the piston 21. The loading element 20 is located in the pressure pocket 33 of the shaft 12A such that there is a significant tolerance 31 between the loading element 20 and the pressure pocket. The tolerance is 0,5 - 2,5 mm, advantageously 1,0 - 2,0 mm. Furthermore the loading element 20 floats in the medium, advantageously in oil. For providing guide of positioning the loading element 20 in the pressure pocket 33 the cross section of the element deviates from circular form, for example it may have grooves for providing cross-sectional flow area (not shown). Below the spring element 26 is the piston 21 that provides the loading force for the loading element 20, as shown by arrows. The piston 21 is sealed in the pressure pocket 33 by seals 35.

[0040] The hydraulic piston 21 of the loading element 20 may also be loaded by a high pressure gas volume in loading pocket 33 sealed by seals 35 as shown in figure 2B. The loading element 20 comprises a loading shoe 23, which has oil pockets 25 for lubricating medium, for example oil. A separate oil feed line 38 is arranged for the lubrication of the loading element 20. The piston 21 of the loading element 20 of is separated from the loading element 20 by the gas space 39 sealed by seals 35, 36. The loading element 20 is located in the pressure pocket 33 of the shaft 12A such that there is a significant tolerance 31 between the loading element 20 and the pressure pocket. The tolerance is 0,5 - 2,5 mm, advantageously 1,0 - 2,0 mm. With reference to figures 1 and 2A - 2B a deflection compensated roll 10 comprises a shell 10A around the loading shaft 12A with loading zones provides by the loading elements 20 pistons 21. The loading zones are connected to the shell 10A of the roll 10 rigidly, since thicknesses of lubricating oil between the loading elements 20 and the shell 10A are thin. The loading elements 20 are supported on the loading shaft 12A by means of a pressure medium volume. The loading and vibration damping is provided such that when the shell 10A of the deflection compensated roll 10 vibrates the at least one loading element 10 moves with the shell 10A as only thin foil of medium is between the shell 10A and the loading shoe 23 of the loading element 20. In case the loading element 20 moves towards the shaft 12A of the roll 10 and it causes a medium flow into the tolerance 21 with high flow speed due to the narrowness of the tolerance 31 and a flow loss is caused. The flow loss is dependent on viscosity of the medium, dimensions of the tolerance and thus at a certain movement speed a pressure loss is created which is dependent on the cross-sectional flow area of the tolerance and by this the damping force is created.

[0041] In figure 3 is shown a schematic example of the shaft end 12 bearing house 41, in which around bearing 43 an oil film is provided in tolerance i.e. liquid pocket 45 between the bearing 43 and the bearing house 41. The loading direction is marked by arrow LD. Pressure pockets 47 are provided in the loading direction LD. Seals 49 are located between the pressure pockets 47 and liquid pockets 45.

[0042] As shown in figure 4 when movement L occurs in loading direction LD at the other end of the liquid pocket 45 the width decreases and at the other end the width increases. As the liquid flows in the narrow liquid pocket 45 according to the replacement volume pressure loss is created in the flow FL and thus an opposing force F to the movement is provided as indicated by dashed arrows and which provide the damping.

[0043] As shown schematically in figure 5 the support of the shaft ends 12 of the roll 10 has a separate bushing 50 which is supported in the loading direction LD to the respective bearing house 41 by pressure pockets 47. The pressure pockets 47 are filled with pressurized gas, for example air, which high compressibility. The area and volume of the pressure pocket 47 is designed to provide desired compliance of the support. Perpendicular to the loading direction LD is additionally provided liquid pockets 45 that are filled with oil or other liquid. The tolerance between the liquid pockets 45 and the bushing 50 and sector covered by the liquid pockets 45 and area of the liquid pockets 45 give the different factors to design the liquid volume such that desired viscous damping is provided. The damping is provided such that when the bushing 50 moves in loading direction LD at the other end of the liquid volume the tolerance decreases and at the other end the tolerance increases. As the liquid flows in the narrow tolerance according to the replacement volume pressure loss is created in the flow and thus an opposing force to the movement is provided.

[0044] According to the schematic example presented in figure 6 and 7 a swimming roll 60 is provided by a spring (not shown) in the loading element 62, which loading element is similar to figure 2. When the shell 65 of the roll 60 moves due to vibration the spring follows the shell 65 and thus compensates the movement and vibration damping is provided.

[0045] In figures 8A - 8B is shown schematically an example the loading cylinder support 70 of the calender, with resilient support. Thus vibrations damping support is provided by liquid film damping, i.e. squeeze film damping, in which in loading direction the force is carried by a high pressurized gas pocket 71, which corresponds to pressure pocket 47 of figures 3 and 5 and the shaft of the loading cylinder is "floating" on a small tolerance defined by discharge amount and throttling of the inlet side. A cone structure 72 provides the positioning of the shaft of the loading cylinder and functional tolerances re provided by axial tightening means 73. In direction perpendicular to the loading the shaft positions by hydraulic pockets 74, in which oil is fed into middle of the pockets and discharged from edge grooves of the pockets and operation of which corresponds to that of liquid pockets 45 of figures 3 - 5. Hydraulic pockets 74 also provide viscous dampening by squeeze film effect.

Claims

1. Method for controlling vibrations of a fiber web machine, in particular of a calender, which fiber web machine comprises at least one roll (10), which comprises a shaft (12A) and shaft ends (12), a shell (10A) and at least one loading element (20) for loading the shell (10A) located in pressure pockets (33) of the shaft (12A), which roll (10) forms a nip (N) with another roll (11), **characterized in that** the method

comprises designing at least one roll (10) of the fiber web machine by vibration modeling simultaneously combining limitations of static loading and providing optimal amplitude of movement in the at least one loading element or roll support element of at least one roll (10) in the / in those natural frequency / frequencies that cause nip pressure or nip load variation in the nip (N) such that maximum damping is generated in nip vibration.

2. Method according to claim 1, **characterized in that** the method further comprises calculating resonance and determining critical resonances in view of the vibration and maximizing relative damping of critical resonance in frequency limits between 50 - 1000 Hz.

3. Method according to claim 1 or 2, **characterized in that** in the method a deflection compensated roll is designed and that the method comprises further step, in which damping means (24, 26) is utilized for the at least one loading element (20) of the deflection compensated roll (10) is designed for damping vibration of the roll shell (10A).

4. Method according to claim 1 or 2, **characterized in that** that in the method a deflection compensated roll is designed and that the method comprises further step, in which support means with dampening (15, 17) is utilized for supporting the shaft ends (12) of the deflection compensated roll (10) are designed for damping vibration of the roll (10) and/or support means for loading cylinder (70) with dampening (71, 74) are designed for damping the vibration of the roll (10).

5. Method according to claim 1 or 2, **characterized in that** that the method comprises further step, in which support means with dampening (15, 17) is utilized for supporting the shaft ends (13) of the another roll (11), which forms the nip with at least one roll (10), and/or support means for loading cylinder (70) with dampening (71, 74) are designed for damping the vibration of the roll (10).

6. Deflection compensated roll for a fiber web machine, in particular for a calender, which roll (10) comprises a shaft (12A) and shaft ends (12), a shell (10A) and at least one loading element (20) for loading the shell (10A) located in pressure pockets (33) of the shaft (12A), which roll (10) forms a nip (N) with another roll (11), **characterized in that** the deflection compensated roll (10) of the fiber web machine comprises damping means (24, 26) for at least one loading element (20) of the deflection compensated roll (10) for damping vibration of the shell (10A) of the roll, which damping means comprise a spring element (26) and a damping element (24) and that at least one loading element (20) is freely movable in the loading direction.

7. Deflection compensated roll according to claim 6, **characterized in that** the loading element (20) and a piston (21) for moving the loading element (21) are located in the pressure pocket (33) and the spring element is a disc spring (26) located in the pressure pocket (33) between the loading element (20) and the piston (21).

8. Deflection compensated roll according to claim 6, **characterized in that** the pressure pocket (30) comprises medium in which the loading element (20) floats, and that the damping element (24) is provided as a viscous damper by a tolerance (31) between the loading element (20) and the pressure pocket (33), which tolerance (31) comprises the medium and when the loading element (20) is under vibration due to vibration of the roll shell (10A) the medium moves in the pressure pocket (33) towards the tolerance (31) and in the tolerance (31) the medium flow creates pressure loss that is in direct relationship with movement velocity of the loading element (20).

9. Deflection compensated roll according to claim 8, **characterized in that** the tolerance (31) is 0,5 - 2,5 mm, advantageously 1,0 - 2,0 mm

10. Deflection compensated roll according to claim 8, **characterized in that** the tolerance (31) is unsealed.

11. Deflection compensated roll according to claim 6, **characterized in that** the deflection compensated roll (10) of the fiber web machine further comprises a resilient support (17) and a bearing (15) by which its shaft ends (12) are supported to a frame of the fiber web machine and that the vibration damping of the shaft ends (12) of the roll (10) is provided by liquid film damping, i.e. squeeze film damping.

12. Deflection compensated roll according to claim 11, **characterized in that** the bearing (15) comprises a separate bushing (50) which is supported in the loading direction (LD) to the respective bearing house by pressure pockets (47), which are filled with pressurized gas, for example air, with high compressibility.

13. Deflection compensated roll according to claim 11, **characterized in that** the bearing (15) comprises perpendicular to the loading direction liquid pockets that are filled with oil or other liquid.

14. Deflection compensated roll according to claim 6, **characterized in that** the deflection compensated roll (10) of the fiber web machine further forms a nip with another roll (11) that comprises a resilient support (17) and a bearing (15) by which its shaft ends

(13) are supported to a frame of the fiber web machine and that the vibration damping of the shaft ends (13) of the roll (11) is provided by liquid film damping, i.e. squeeze film damping.

15. Deflection compensated roll for a fiber web machine, in particular for a calender, which roll (10) comprises a shaft (12A) and shaft ends (12, a shell (10A) and at least one loading element (20) for loading the shell (10A) located in pressure pockets (33) of the shaft (12A), which roll (10) forms a nip (N) with another roll (11), **characterized in that** the loading element (20) and a piston (21) for moving the loading element (21) are located in the pressure pocket (33) and the spring element is a gas space (39) with high pressurized gas located in the pressure pocket (33) between the loading element (20) and the piston (21).

16. Deflection compensated roll according to claim 15, **characterized in that** the loading element (20) is controlled by digital pressure control and that a separate oil feed line is arranged for the lubrication of the loading element (20).

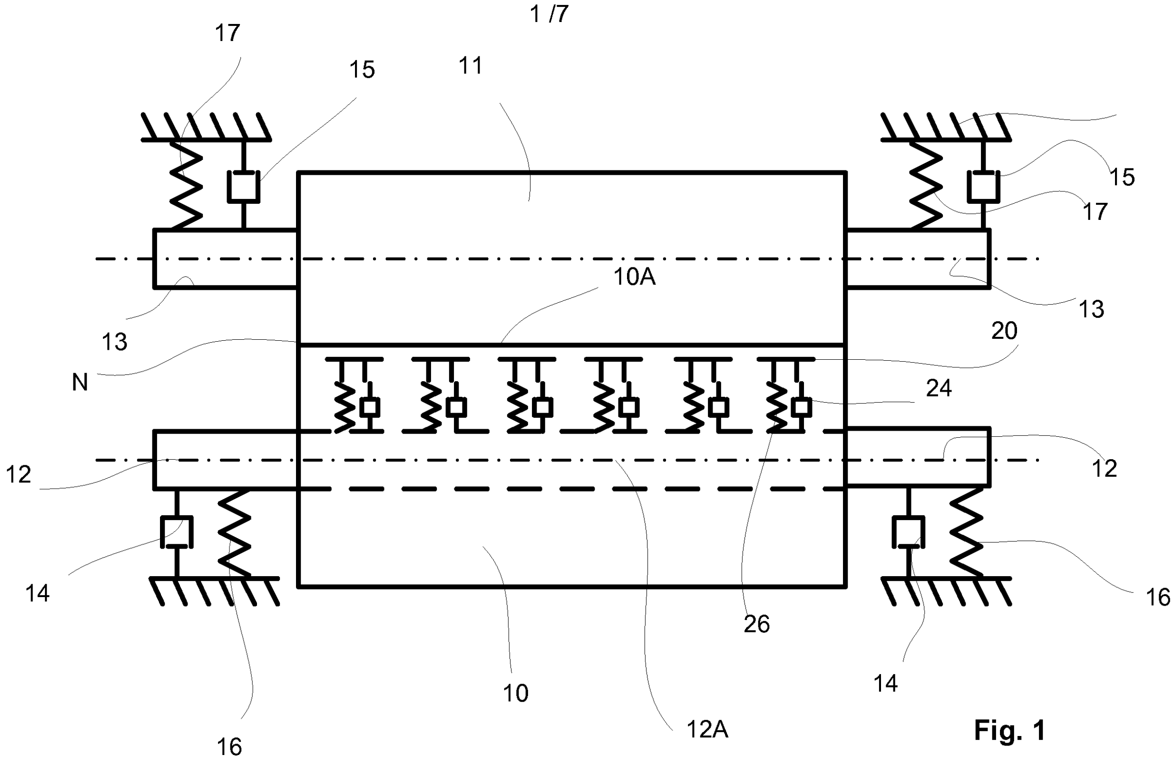

Fig. 1

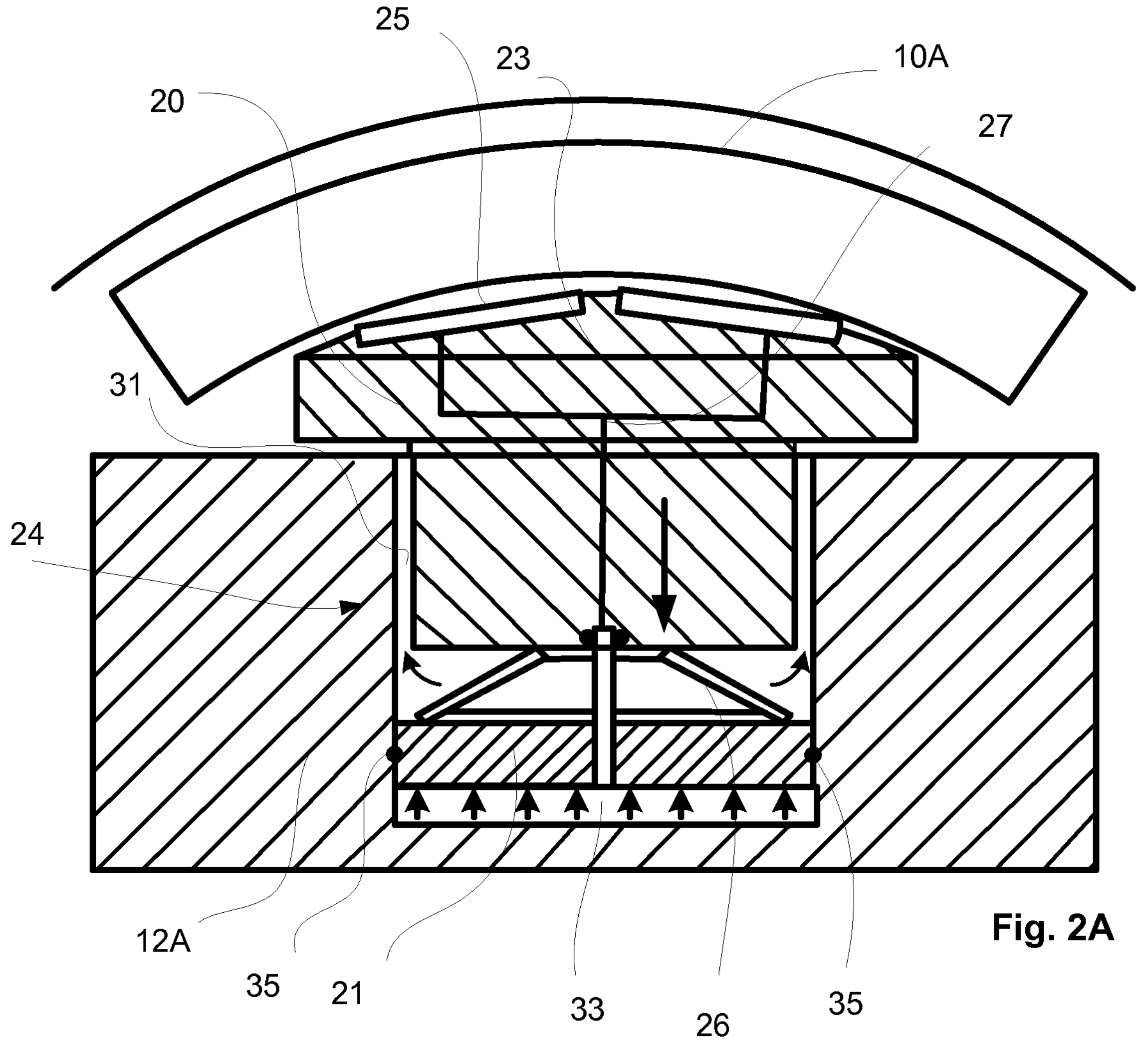

Fig. 2A

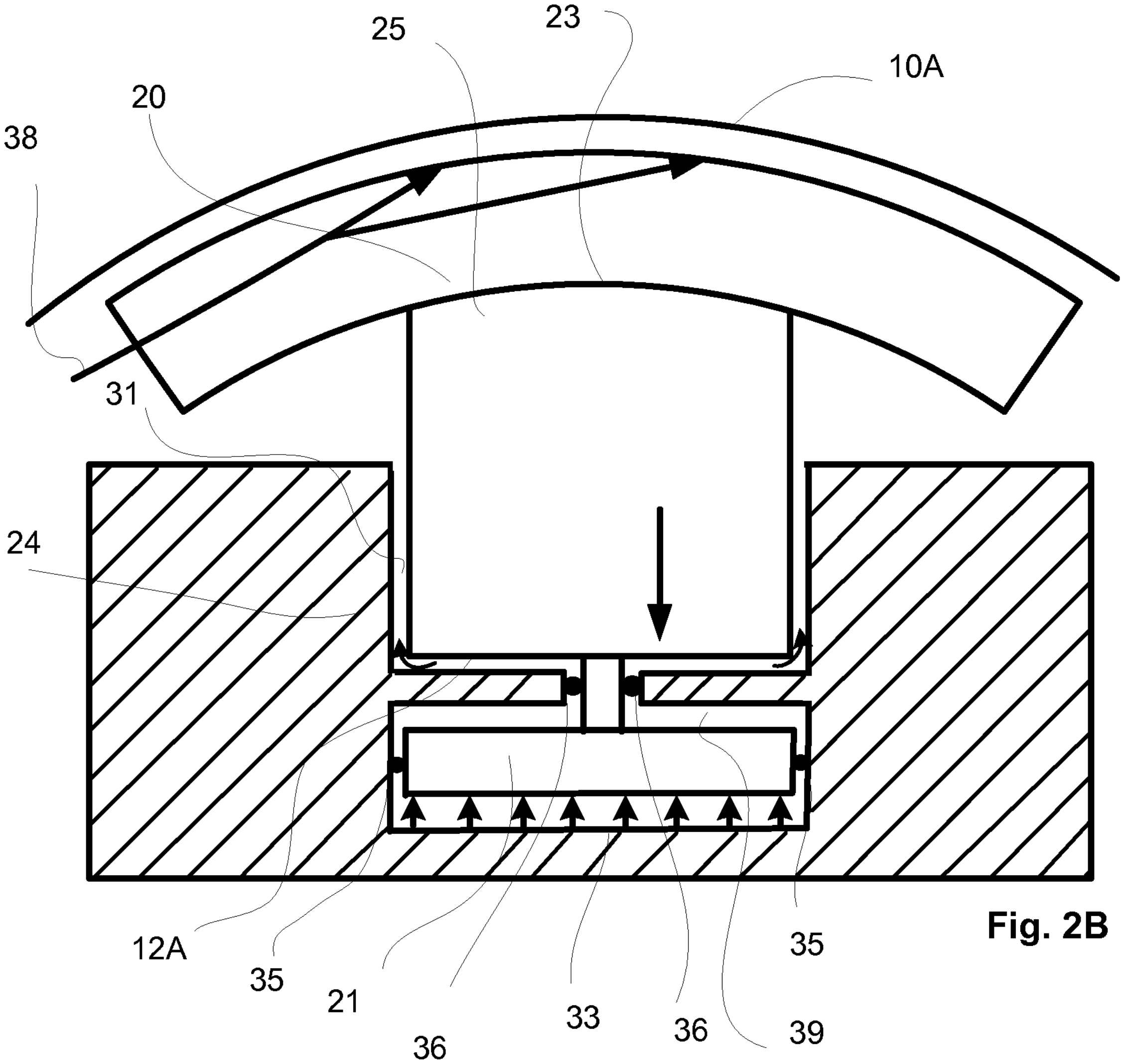

Fig. 2B

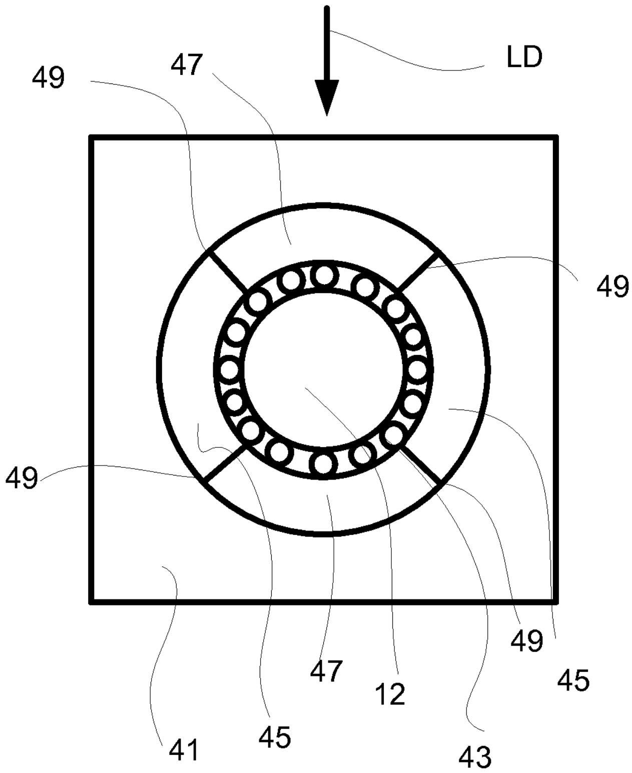

Fig. 3

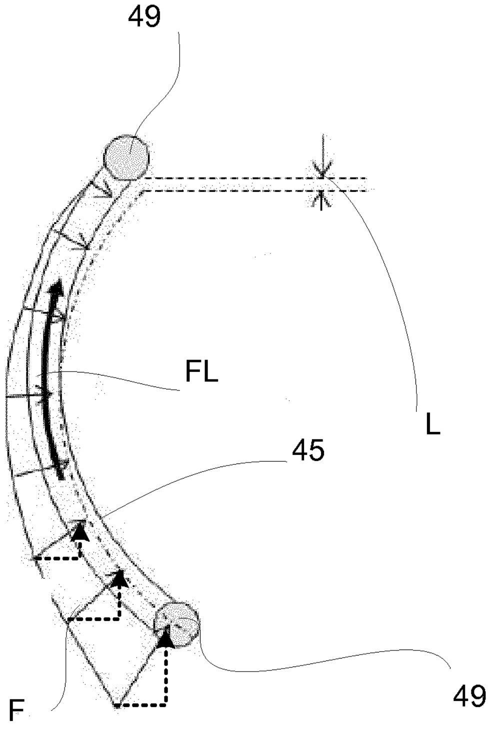

Fig. 4

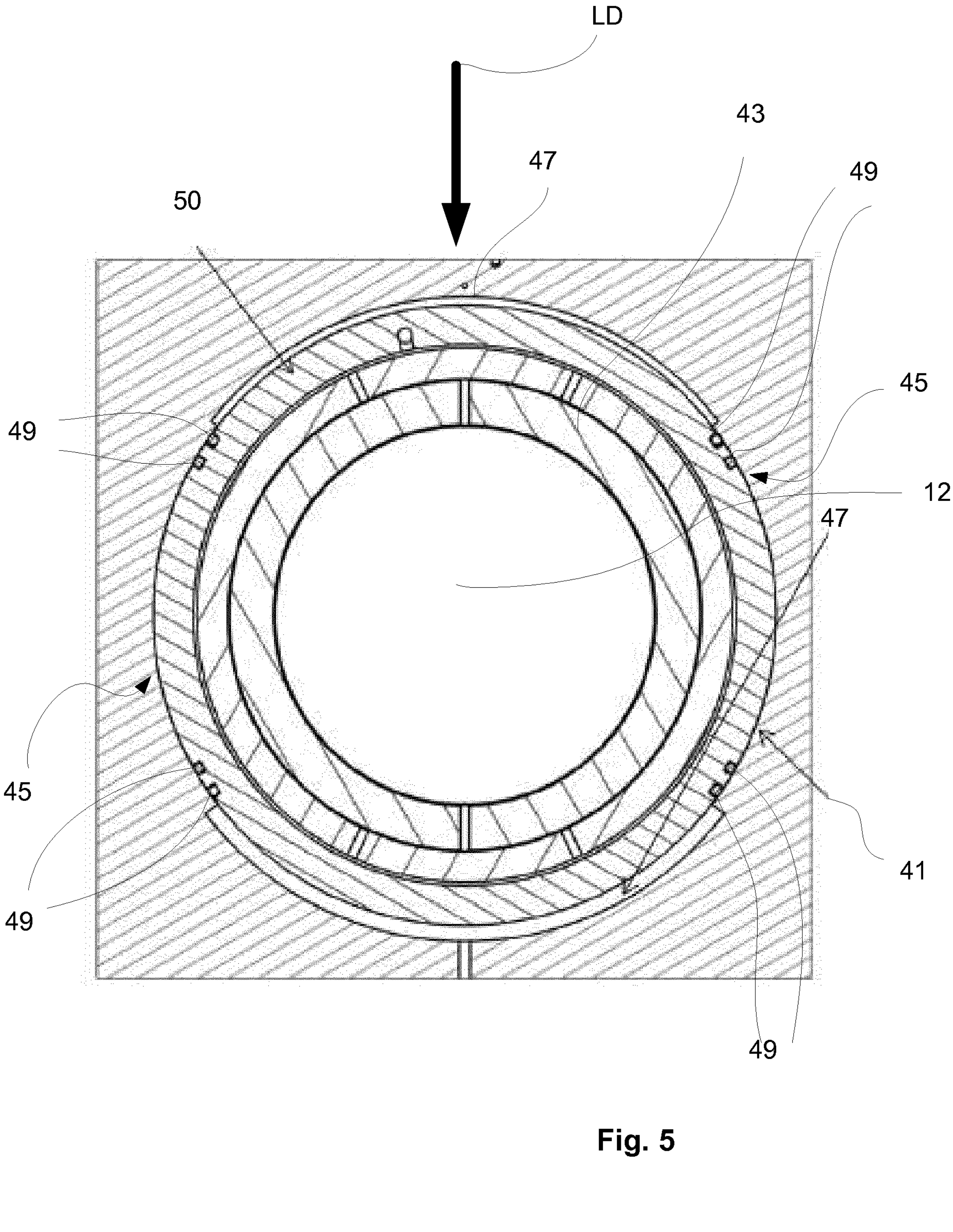

Fig. 5

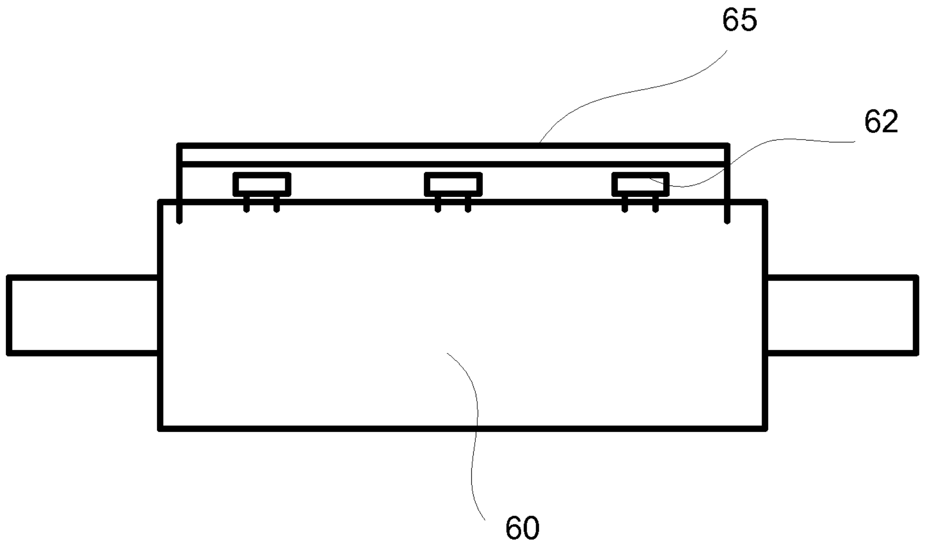

Fig. 6

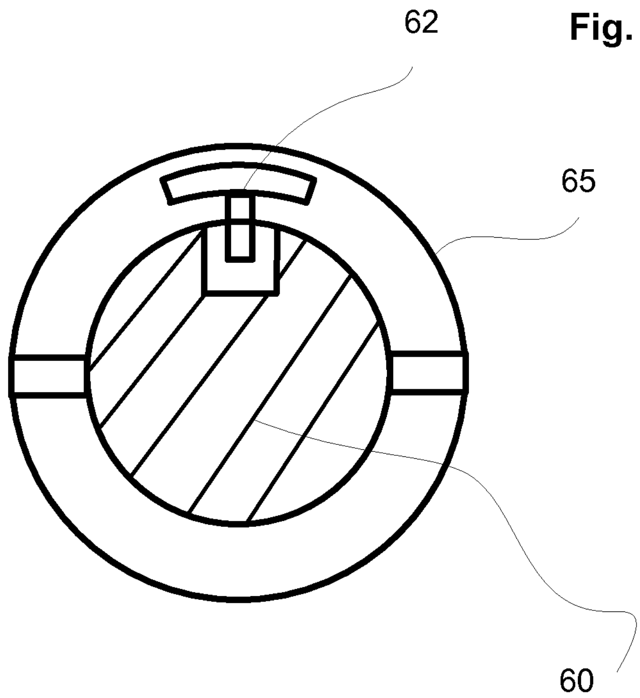

Fig. 7

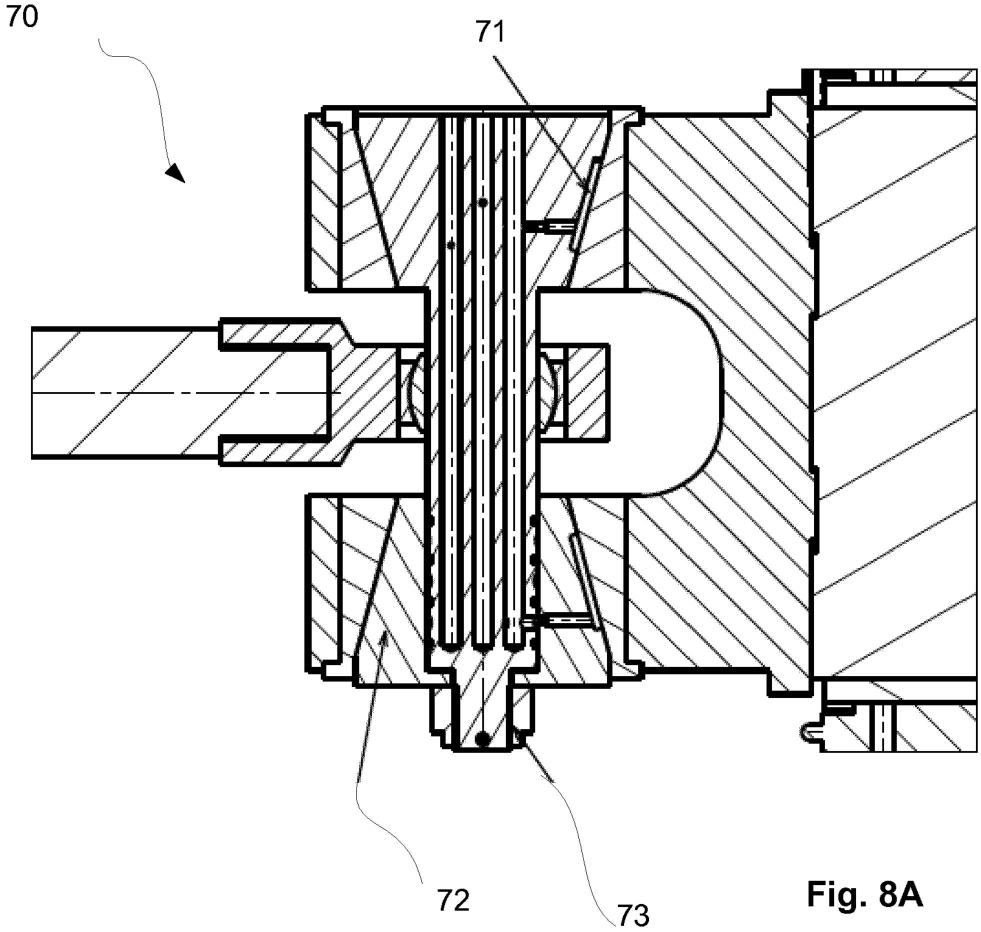

Fig. 8A

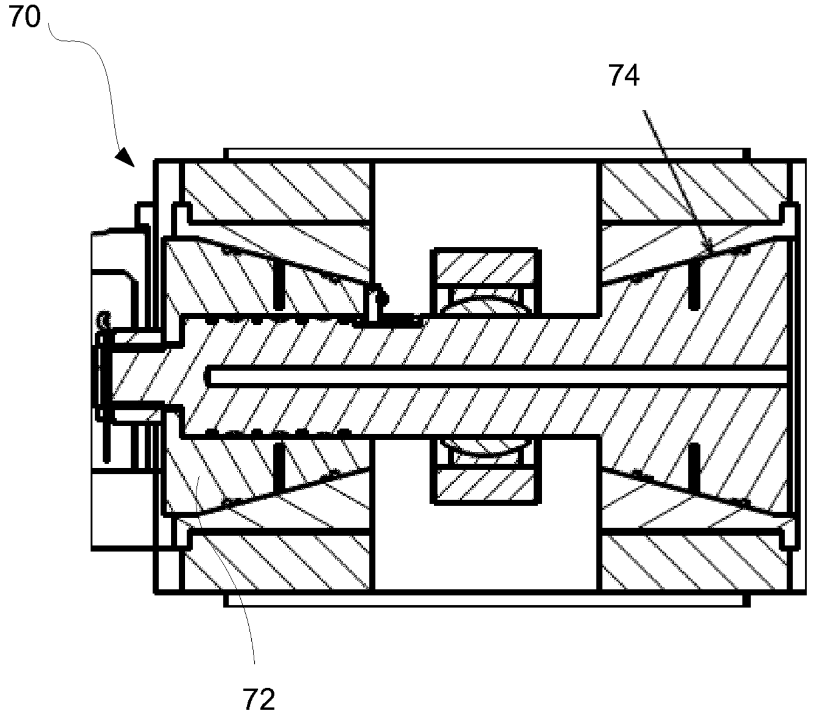

Fig. 8B

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EUROPEAN SEARCH REPORT

Application Number
EP 13 16 9860

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	US 2008/000363 A1 (STREBEL RICHARD M [US]) 3 January 2008 (2008-01-03) * paragraph [0023]; figures 1-5,7,8 * -----	1,2,5	INV. D21G1/02 D21G1/00
X	WO 2007/088240 A1 (METSO PAPER INC [FI]; OLKKONEN MIKA [FI]; KAISANLANTI MIKA [FI]; LEINO) 9 August 2007 (2007-08-09) * the whole document * -----	1,2,5	
X	DE 10 2005 049524 A1 (METSO PAPER INC [FI]) 24 May 2006 (2006-05-24) * paragraph [0029] - paragraph [0033]; figures 4,5 * -----	6,7,15	
X	EP 2 366 911 A1 (VOITH PATENT GMBH [DE]) 21 September 2011 (2011-09-21) * the whole document * -----	1,3,6,8, 10	
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A	DE 10 2010 030846 A1 (METSO PAPER INC [FI]) 13 January 2011 (2011-01-13) * the whole document * -----	1-5	D21G

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	2 August 2013	Beckman, Anja

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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L : document cited for other reasons

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