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Vertical roller mill and method for operating a vertical roller mill

5 The invention relates to a vertical roller mill and a method for operating a vertical roller mill of which the grinding assemblies, which are composed of a grinding plate and at least one grinding roller, interact in such a manner that material to be ground is comminuted between the grinding plate and the at least one grinding roller, wherein at least one grinding assembly is driven and at least one grinding assembly is trailed.

10 Vertical roller mills which, in relation to other grinding systems, such as, for example, tube mills, make possible a significant saving in energy, are increasingly employed for producing powder-type materials for the binding-agent industry.

15 DE 10 2007 033 256 A1 discloses a vertical roller mill having a driven grinding plate, wherein the grinding plate drives the grinding rollers via the grinding bed. However, this leads to high variations in performance and thus to high loads on the drive train, requiring correspondingly high safety factors in the drive train. On the other hand, input power and also comminution are
20 also subject to high variation and can be only conditionally controlled via the material bed.

DE 35 20 937 A1 furthermore discloses a roller mill having a table which is rotatably mounted about a vertical axle and which, on its upper side, is provided with an annular groove and which interacts with spherically configured
25 grinding rollers, wherein a gap in which material to be ground is crushed and ground is configured between the spherical circumferential part of the grinding rollers and the annular groove.

30 It has, therefore, already been proposed in DE 197 02 854 A1 that the grinding rollers be driven. It has also been pointed out there that the individual grinding rollers are coupled to one another in the manner of a rotary drive via the grinding plate and the material to be ground located thereon, or the bed of material to be ground, respectively, on the one hand, and, on the other
35 hand, may have greatly differing input powers which may be caused for example by differing rolling diameters on the grinding plate (rolling point/diameter), differing effective diameters of the individual grinding rollers (e.g. on account of wear) and by differing behavior during draw-in of the ma-

material to be ground when interacting on the grinding plate and the grinding roller.

5 Even slight changes in revolutions between individual grinding rollers have the effect of comparatively high performance variations in the individual drives. This may lead to the grinding rollers in part being accelerated and decelerated, such that the individually driven grinding rollers work against one another, leading to a significantly higher force and/or energy requirement during the comminuting operation.

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It has, therefore, been proposed in DE 197 02 854 A1 that the variations during operation between the individual rotational drives of all driven grinding rollers are balanced by way of a common performance-balancing regulator.

15 The fines content of the material to be ground which can be achieved with vertical mills, however, is lower than in other grinding systems, such as, for example, tube mills, which, in the production of binding agents, may have a negative effect on the binding-agent properties.

20 The present invention is thus based on the object of improving the vertical roller mill and the method for operating the vertical roller mill such that the fines content per contact of the grinding tool (comminution progress during exposure in the grinding bed between grinding roller and grinding plate) is increased.

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This object is achieved according to the invention by the features of Claims 1 and 10.

30 In the method for operating a vertical roller mill, according to the invention, the grinding assemblies thereof, which are composed of a grinding plate and at least one grinding roller, interact in such a manner that material to be ground is comminuted in the grinding bed between the grinding plate and the at least one grinding roller, wherein at least one grinding assembly is driven and at least one grinding assembly is trailed and, for increasing the flow of
35 energy through the grinding bed between the grinding plate and the at least one grinding roller, the trailed grinding assembly is braked.

The vertical roller mill according to the invention displays at least one driven and at least one trailed grinding assembly, wherein the grinding assemblies are formed by a grinding plate and at least one grinding roller which interact in such a manner that material to be ground is comminuted in the grinding bed between the grinding plate and the at least one grinding roller. The trailed grinding assembly, for increasing the flow of energy through the grinding bed between the grinding plate and the at least one grinding roller, moreover interacts with a brake unit for braking the trailed grinding assembly.

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The trailed grinding assembly is not driven by way of a drive but is set in rotation merely via the material to be ground.

15

Increasing the flow of energy through the grinding bed results in an increase of slippage between the grinding plate and the at least one grinding roller, which is explained in more detail in the following by means of figures 1 to 3. There, a grinding plate 1, a grinding roller 2, and the grinding bed 3 are illustrated in a schematic manner. The contact point of force of the grinding roller 2 on the grinding bed 3 is identified with the reference sign 4. Slippage is defined by the speed differential Δv_s between the circumferential speed of the grinding roller 2 in the contact point of force 4 and the circumferential speed of the grinding plate 1 in the contact point of force (radius R_k) which is projected perpendicularly downward onto the grinding plate 1.

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Fig. 2 shows an example having a driven grinding roller 2 and a trailed grinding plate 1, in the region of the contact point of force 4. It is clearly evident here that the upper layer of the grinding bed 3 which comes into contact with the grinding roller 2 displays a higher speed than the lower layer which is in contact with the trailed grinding plate 1. The difference between the maximum and minimum speed is identified as slippage Δv_{s1} .

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In fig. 3, the trailed grinding plate 1 is additionally braked. While the speed in the uppermost layer of the grinding bed 3 remains substantially unchanged, the speed of the lower layer which is in contact with the grinding plate 1 is reduced. Accordingly, slippage Δv_{s2} in fig. 3 is greater than slippage Δv_{s1} in the situation as per fig. 2. However, if the grinding-plate speed is influenced by a regulator (constant speed, for example), the speed of the layer in contact with the grinding roller 2 is increased.

Slippage Δv_{s1} of fig. 2 that arises substantially depends on the normal force which acts on the grinding bed via the grinding roller, the grinding bed 3, the geometry of the grinding rollers and the grinding plates, and on the transmitted torque. On account of targeted braking of a grinding assembly (increasing the flow of energy through the grinding bed), in this case braking the grinding plate 1 in fig. 3, slippage Δv_{s2} is increased with the same normal force, leading to an increased shear load in the grinding bed 3. In turn, this has the direct effect of a higher fines content per passage.

Further embodiments of the invention are the subject matter of the dependent claims.

Increasing the flow of energy through the grinding bed may be implemented in a variety of manners. Accordingly, a grinding roller may be driven and the grinding plate may be braked, for example, or at least the grinding plate may be driven and at least one grinding roller may be braked. According to a preferred embodiment of the invention, during braking of one grinding assembly, energy which is used for driving the other grinding assembly is generated. On account of feeding back the braking energy, the energy consumption of the entire system is only slightly increased while, in contrast, the grinding efficiency in the case of a desired target fineness is significantly increased.

It may furthermore be provided that, for regulating the flow of energy through the grinding bed, slippage between the grinding plate and the at least one grinding roller is regulated in a prespecified range. To this end, in particular the rotational speed of the braked grinding assembly may be determined and used for regulating. It is furthermore conceivable that slippage between the grinding plate and at least one grinding roller is regulated depending on the fines content of the comminuted material to be ground.

It has been demonstrated in the experiments on which the invention is based that the braked grinding assembly is expediently braked in such a manner in relation to the driven grinding assembly that slippage between the grinding plate and the at least one grinding roller is regulated in a range of 3 – 10%. The braked assembly may furthermore be braked in such a manner in relation to the driven grinding assembly that slippage between the grinding plate

and the at least one grinding roller, in relation to an unbraked and merely trailed grinding assembly, is increased by 15 – 100%.

5 In the physical embodiment of the vertical roller mill the at least one driven grinding assembly may be formed by at least one grinding roller which interacts with a grinding-roller drive and the at least one trailed grinding assembly may be formed by the grinding plate which interacts with a brake unit. It would, however, also be conceivable for the at least one driven grinding assembly to be formed by the grinding plate which interacts with a grinding-plate drive and for the at least one trailed grinding assembly to be formed by at least one grinding roller which interacts with the brake unit. The braking effect may be formed, in particular, by a generator.

15 Further advantages and embodiments of the invention will be explained in more detail in the following by means of the following description and of the drawing. In the drawing:

Fig. 1 shows a schematic detail view of the vertical roller mill, for explaining the contact point of force,

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Fig. 2 shows a schematic illustration of slippage in the case of a driven grinding roller and a trailed grinding plate,

25 Fig. 3 shows a schematic illustration of slippage in the case of a driven grinding roller and a braked grinding plate,

Fig. 3 shows a schematic illustration of a vertical roller mill having driven grinding rollers and a braked grinding plate,

30 Fig. 5 shows a schematic illustration of a vertical roller mill having a driven grinding plate and one driven and one braked grinding roller,

Fig. 6 shows a schematic illustration of slippage in the case of a driven grinding plate and a trailed grinding roller,

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Fig. 7 shows a schematic illustration of slippage in the case of a driven grinding plate and a braked grinding roller,

Fig. 8 shows a schematic illustration of a vertical roller mill having a driven grinding plate and one braked and one trailed grinding roller, and

5 Fig. 9 shows a schematic illustration of a vertical roller mill having a braked grinding plate and one braked and one driven grinding roller.

In the exemplary embodiment according to fig. 4 two grinding rollers 2, 5 are driven via associated grinding-roller drives 6, 7. The grinding plate 1 is trailed via the grinding bed 3 and is operatively connected to a brake unit 8
10 for regulating slippage between the grinding plate 1 and the grinding rollers 2, 5. Furthermore, a regulator unit 9 which is connected to the grinding-roller drives 6, 7 and the brake unit 8 is provided. Actually existing slippage may be determined via sensors, in particular sensors for detecting the rotational speeds of the grinding plate 1 and, if applicable, the grinding rollers 2, 5, for
15 example.

The brake unit 8 here is configured as a generator in order to generate energy when the grinding plate 1 is braked that may be used for the grinding-roller drives 6 and/or 7, via a common intermediate energy storage device
20 14.

If the grinding plate 1, according to fig. 4, is not additionally braked, slippage Δv_{s1} according to fig. 2 would arise. If the grinding plate 1 is additionally braked via the brake unit 8, according to fig. 3, slippage increases to Δv_{s2} .
25 On account thereof, an increased shear load within the grinding bed 3 is generated since the speed differential within the grinding bed is increased. The additional shear load has the effect of a higher fines content per passage. One may, therefore, also imagine slippage being regulated depending on the fines content of the comminuted material to be ground. To this end, the fines
30 content in the comminuted material to be ground would be determined and used for regulating.

In the exemplary embodiment according to fig. 5 the grinding plate 1 is driven via a grinding-plate drive 11. Furthermore, the grinding roller 2 is driven
35 via the grinding-roller drive 6. On the other hand, one grinding roller 12 is braked via a brake unit 10. Here too, the braking energy created herein may be used for driving the grinding roller 2 and/or the grinding plate 1. Again, slippage between the grinding roller 12 and the grinding plate 1 may be

regulated in a prespecified range via the regulator unit 9. The variant according to fig. 5 has the advantage of greater flexibility of the mill, wherein, in particular a high proportion of fine material at increased throughput may be implemented.

5

In figs. 6 and 7 the situation of slippage between a merely trailed or braked grinding roller, respectively, and a driven grinding plate is illustrated, wherein the grinding roller 13 in fig. 6 is merely trailed and the grinding roller 12 in fig. 7 is additionally braked. Here too, it is evident that on account of additionally braking the grinding roller 12, slippage between the grinding roller 12 and the grinding plate 1, or the shear load within the grinding bed 3, respectively, is again increased ($\Delta v_{s3} < \Delta v_{s4}$).

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In fig. 8 a grinding plate 1 which is driven via a grinding-plate drive 11 is combined with a grinding roller 12 which is braked via a brake unit 10 and a merely trailed grinding roller 13. The setting of slippage between the braked grinding roller 12 and the grinding plate 1 again takes place via the regulator unit 9. The energy recuperated in the braking procedure may also be used for driving the grinding plate 1. Slippage which results in this manner in the region of the grinding rollers 12 and 13 is likewise evident from figs. 6 and 7.

15

20

Finally, in fig. 9 an exemplary embodiment is illustrated in which a braked grinding plate 1 is combined with a driven grinding roller 2 and a braked grinding roller 12.

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The grinding-plate drive 11 and the brake unit 10 of the grinding plate are expediently implemented by way of an assembly which may selectively be capable of driving or braking. The grinding-roller drives 6 and/or 7 and the brake unit 12 may also be formed by an assembly which can implement both objectives.

30

Of course, in all illustrated variants more than two grinding rollers may also be provided, wherein each of the additional grinding rollers may be either driven, braked or merely trailed.

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It has been demonstrated in the experiments on which the invention is based that slippage between a driven and a braked grinding assembly is expediently to be regulated in a range of 3 – 10%, in order to significantly increase the

proportion of fines content, on the one hand, and to keep the additional energy requirement within reasonable limits, on the other hand. This means that the speed of the grinding bed in the contact region of the driven grinding assembly is higher by 3 – 10% than the speed of the grinding bed in the contact region of the braked grinding assembly.

Patentkrav

1. Fremgangsmåde til drift af en vertikalvalsemølle, hvis maleaggregater, som består af en malepande (1) og mindst en malevalse (2, 5, 12, 13), samvirker så-
5 dan, at malegodset findeles i malelejet mellem malepanden (1) og den mindst ene malevalse (2, 5, 12, 13), hvorved mindst et maleaggregat bliver drevet og mindst et maleaggregat bliver slæbt, **kendetegnet ved, at** det slæbte maleaggregat bremses for at øge energistrømmen gennem malelejet mellem malepanden og den mindst ene malevalse.
- 10 2. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at** mindst en malevalse (2, 5) drives og malepanden (1) bremses.
3. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at** i det mindste malepanden (1) drives og mindst en malevalse (12) bremses.
- 15 4. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at** under bremsning af et maleaggregat genereres energi, som anvendes til at drive det andet maleaggregat.
- 20 5. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at** energistrømmen gennem malelejet reguleres i et forudbestemt område ved slip (Δv_{S2} ; Δv_{S4}), som opstår mellem malepanden (1) og den mindst ene malevalse (2, 5, 12).
- 25 6. Fremgangsmåde ifølge krav 5, **kendetegnet ved, at** omdrejningshastigheden af det bremsede maleaggregat bestemmes for regulering af slip (Δv_{S2} ; Δv_{S4}) mellem malepanden (1) og den mindst ene malevalse (2, 5, 12).
- 30 7. Fremgangsmåde ifølge krav 5, **kendetegnet ved, at** det bremsede maleaggregat bremses på sådan måde i forhold til det drevne maleaggregat, at slip (Δv_{S2} ; Δv_{S4}) mellem malepanden (1) og den mindst ene malevalse (2, 5, 12) reguleres i et område på 3 til 10%.
- 35 8. Fremgangsmåde ifølge krav 5, **kendetegnet ved, at** slip (Δv_{S2} ; Δv_{S4}) mellem malepanden (1) og den mindst ene malevalse (2, 5, 12) reguleres i afhængighed af finheden af det findelte malegods.

9. Fremgangsmåde ifølge krav 5, **kendetegnet ved, at** det bremsede maleaggregat bremses på sådan måde i forhold til det drevne maleaggregat, at slip (Δv_{s2} ; Δv_{s4}) mellem malepanden (1) og den mindst ene malevalse (2, 5, 12) øges med 15 til 100% i forhold til et ubremset og blot slæbt maleaggregat.
- 5
10. Vertikalvalsemølle med mindst et drevet og mindst et slæbt maleaggregat dannet af en malepande (1) og mindst en malevalse (2, 5, 12, 13), som samvirker sådan, at malegodset findeles i malelejet mellem malepanden (1) og den mindst ene malevalse (2, 5, 12, 13), **kendetegnet ved, at** det slæbte maleaggregat samvirker med en bremseenhed (8, 10) for at bremse det slæbte maleaggregat for at øge energistrømmen gennem malelejet mellem malepanden (1) og den mindst ene malevalse (2, 5, 12).
- 10
11. Vertikalvalsemølle ifølge krav 10, **kendetegnet ved, at** det mindst ene drevne maleaggregat er dannet af mindst en malevalse (2, 5), som samvirker med et malevalsedrev (6, 7), og det mindst ene slæbte maleaggregat er dannet af malepanden (1), som samvirker med bremseenheden (8).
- 15
12. Vertikalvalsemølle ifølge krav 10, **kendetegnet ved, at** det mindst ene drevne maleaggregat er dannet af malepanden (1), som samvirker med et malepan-dedrev (11), og det mindst ene slæbte maleaggregat er dannet af mindst en malevalse (12), som samvirker med bremseenheden (10).
- 20
13. Vertikalvalsemølle ifølge krav 10, **kendetegnet ved, at** bremseenheden (8, 10) udgøres af en generator.
- 25
14. Vertikalvalsemølle ifølge krav 10, **kendetegnet ved, at** der er tilvejebragt en reguleringsindretning (9) til at regulere slip mellem malepanden og den mindst ene malevalse (2, 5, 12) i et forudbestemt område.

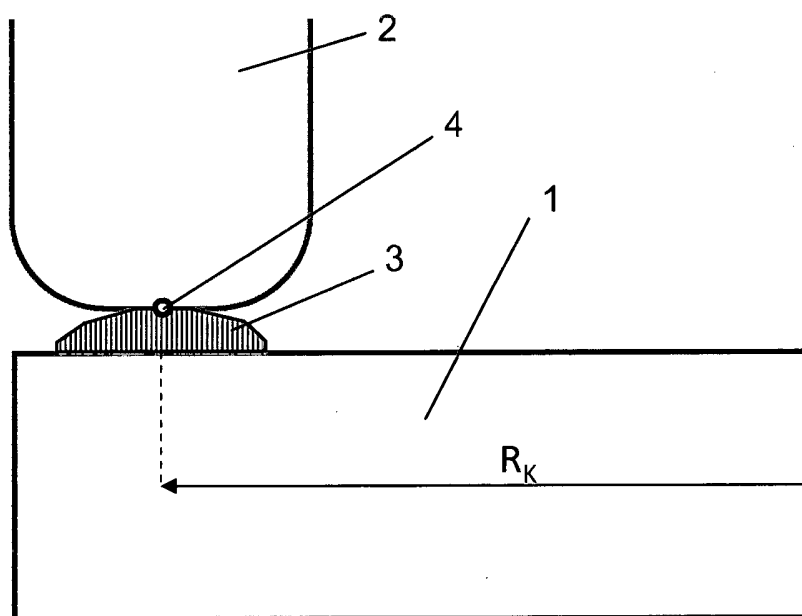


Fig. 1

Fig. 2

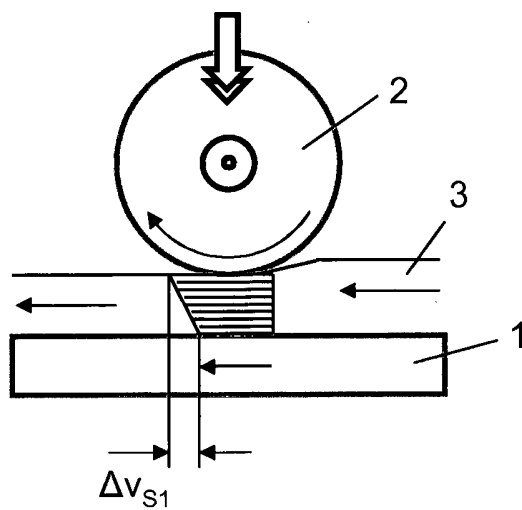
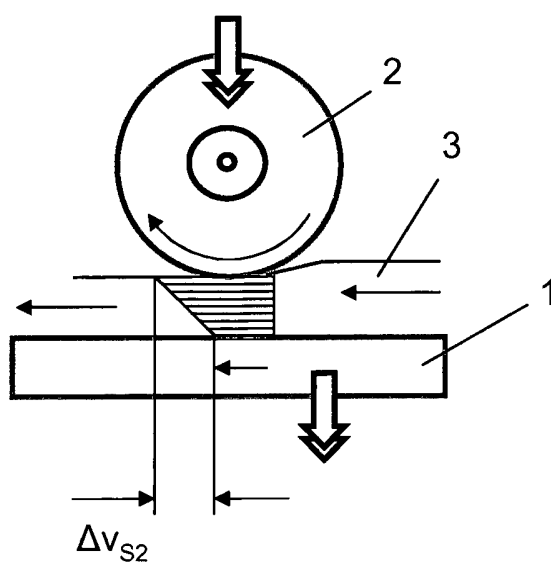


Fig. 3



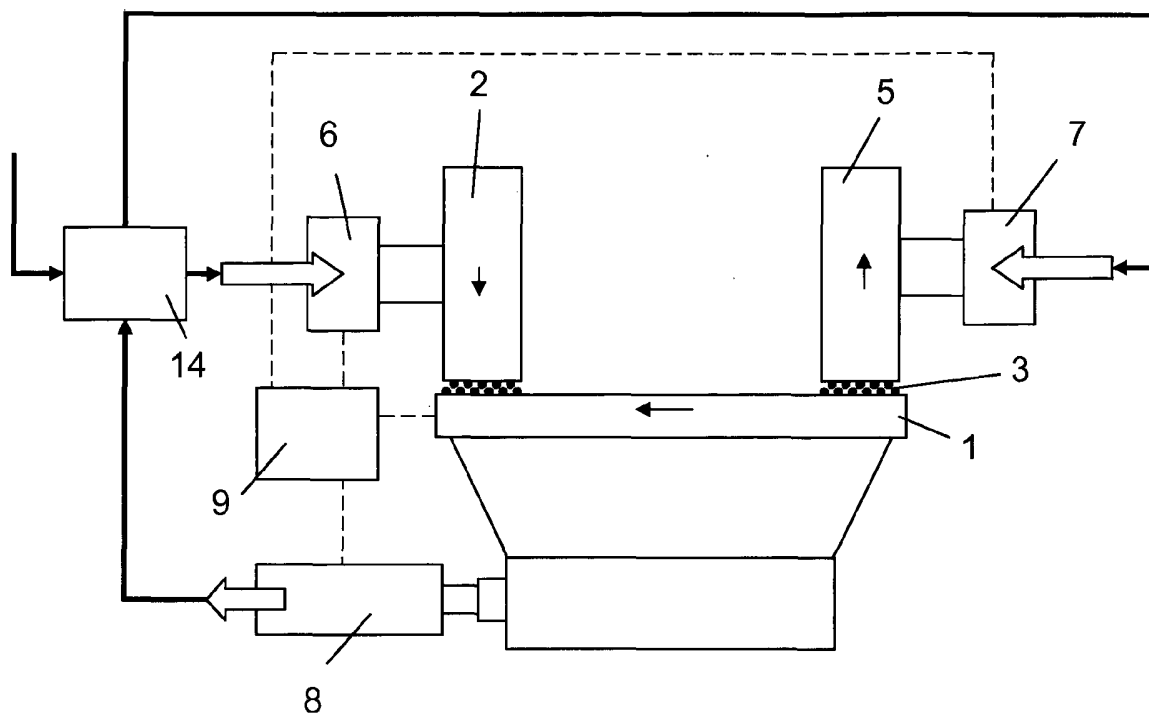


Fig. 4

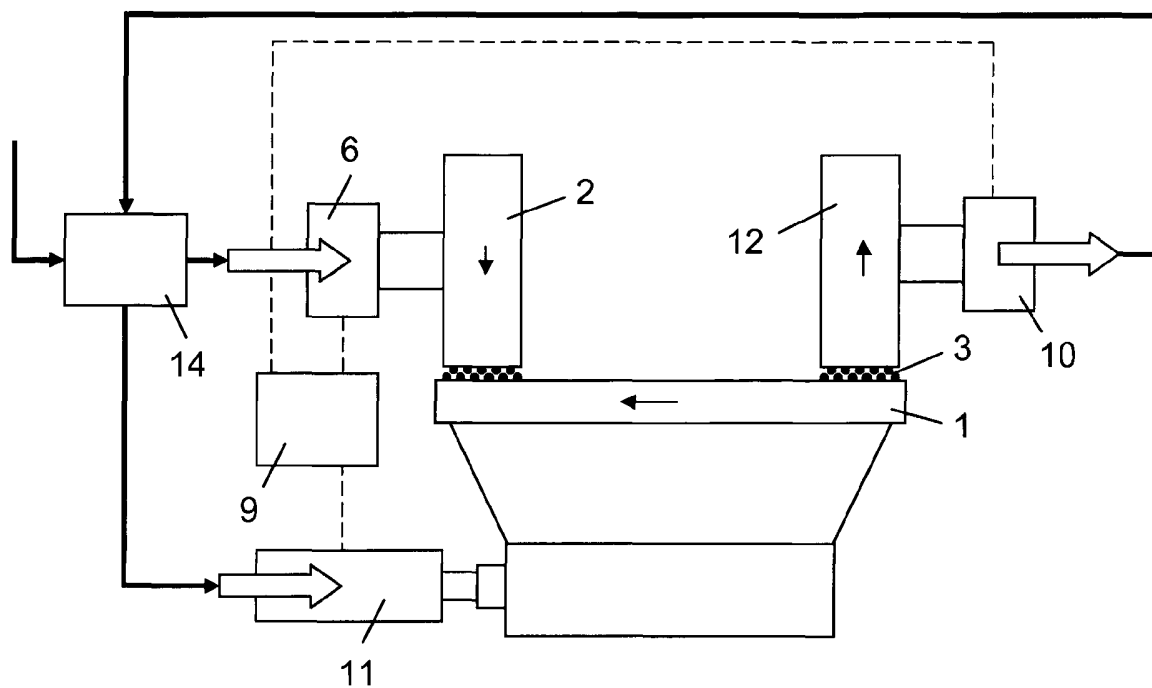


Fig. 5

Fig. 6

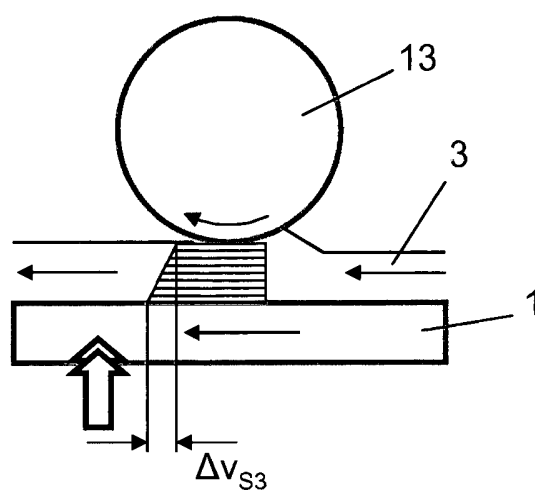
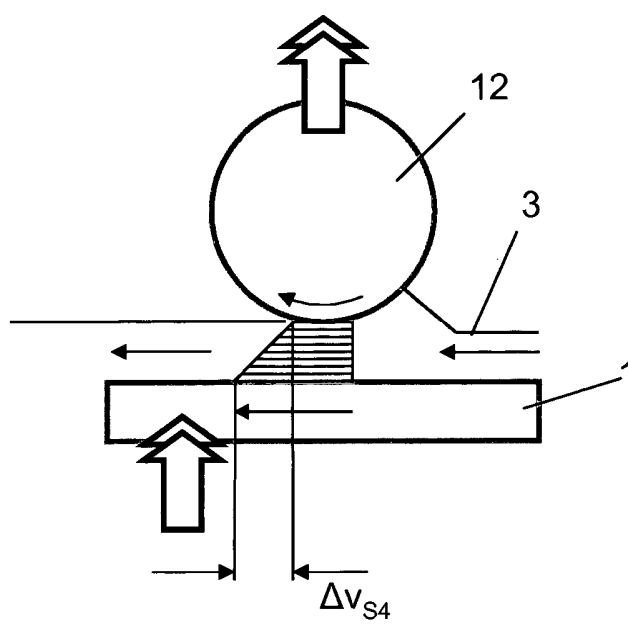


Fig. 7



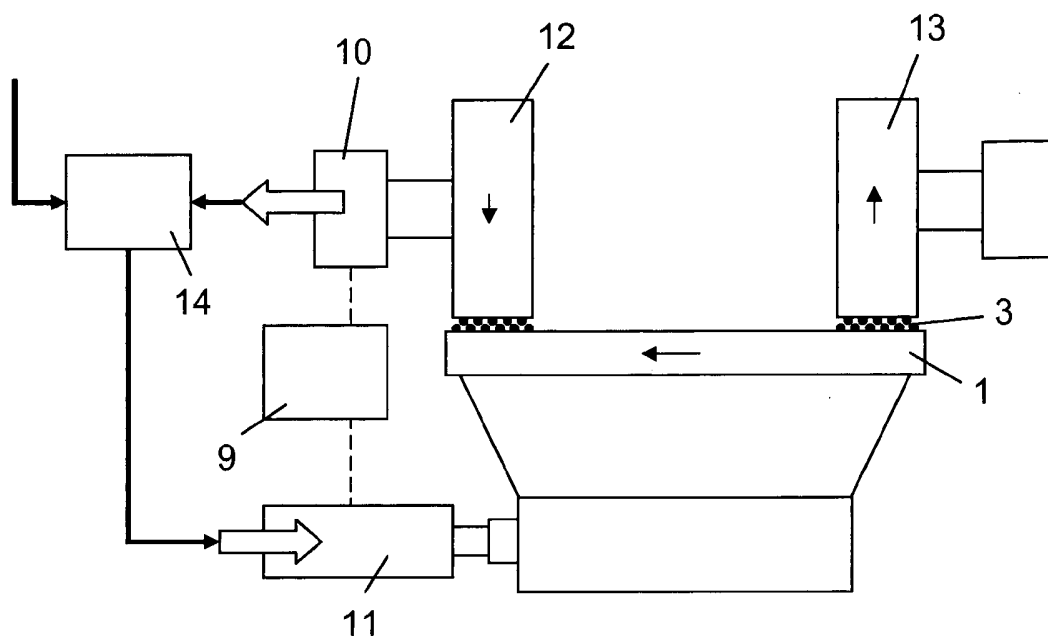


Fig. 8

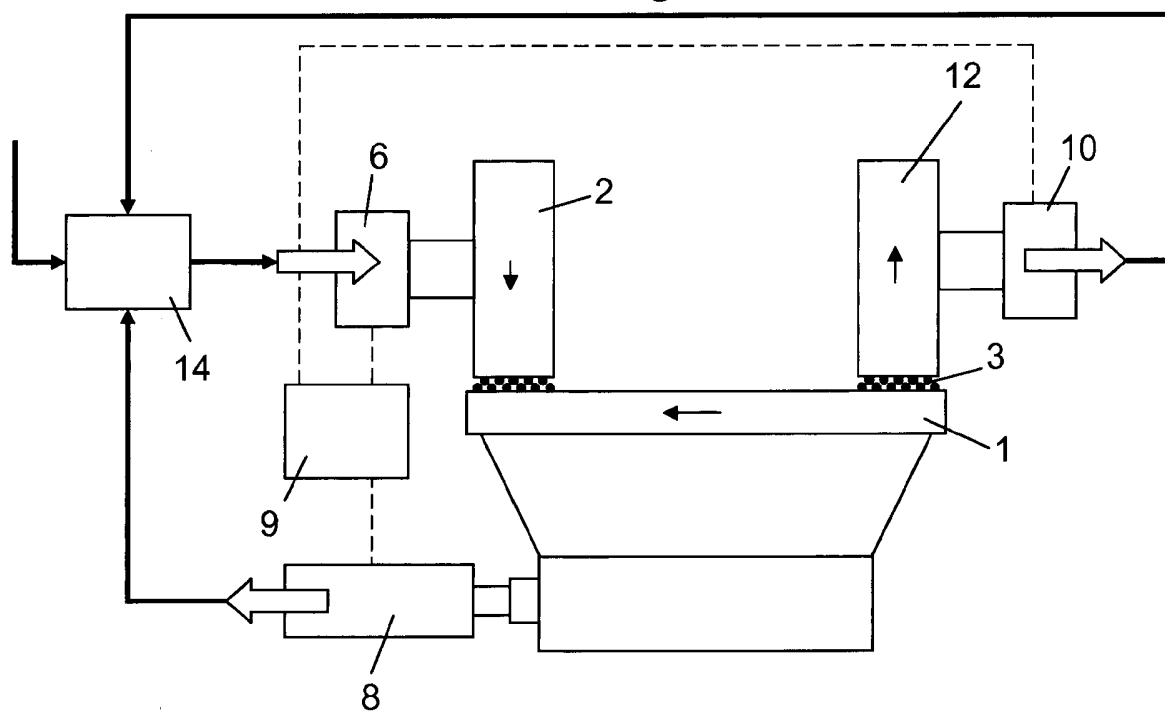


Fig. 9