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(54) Title: EDDY CURRENT SEPARATOR UNIT HAVING A MAGNETIC ROTOR POSITIONED ECCENTRICALLY INSIDE AN OUTER DRUM AND COAXIALLY INSIDE AN INNER DRUM.

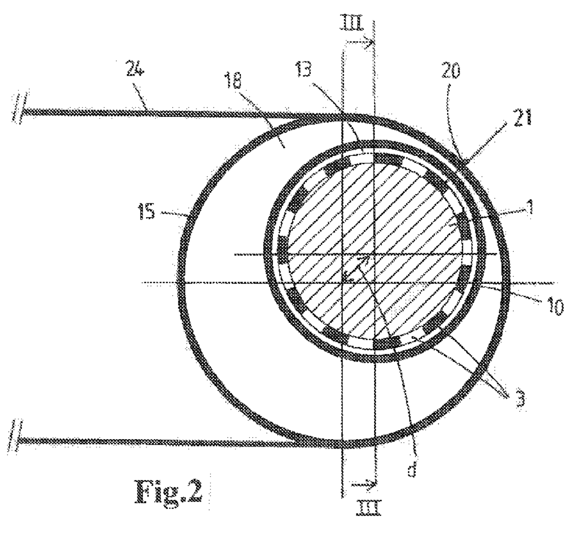

Fig.2

(57) **Abstract**: An eddy current separator unit comprises a drivable conveyor belt 24 for supply of a stream of fractions which contain non-ferrous metals, a rotatable outer drum 15 over which the conveyor belt 24 is guided, and a rotatable magnetic rotor 1 positioned inside the outer drum 15 for the generation of eddy currents. The magnetic rotor 1 is positioned eccentrically inside the outer drum 15. An inner drum 10 is provided coaxially around the magnetic rotor 1 and eccentrically within the outer drum 15, such that an outer gap 18 with a varying thickness is present in between the eccentrically positioned inner and outer drums 10, 15. An inner gap 13 with a substantially constant thickness is provided in between the magnetic rotor 1 and the inner drum 10.

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Title: Eddy current separator unit having a magnetic rotor positioned eccentrically inside an outer drum and coaxially inside an inner drum.

The invention relates to the field of high-intensity eddy current separator units of the type comprising a magnetic rotor which is positioned inside a drum. A conveyor belt is guided over the drum. A stream of fractions which contain non-ferrous metals is conveyed via the belt along the assembly of drum and magnetic rotor. A fast rotating of the magnetic rotor causes eddy current fields to occur inside the non-ferrous metals which lead to throwing the non-ferrous metals from the belt.

Such eddy current separator units are already known in a wide variety of embodiments. With presently known eddy current separator units the magnetic rotor is mostly driven at a maximum rotational speed of 3000-3800 rpm inside the drum. This drum is made out of glass fibre. The conveyor belt is driven at a relative low speed of around 2,5 m/s. The magnetic rotor can be positioned coaxially inside the outer drum. It is however preferred to position the magnetic rotor eccentrically inside the drum. See fig. 1. An air gap is present in between them, which air gap does not have a constant thickness seen in a radial direction, but instead narrows and widens in a circumferential direction because of the eccentric position of the magnetic rotor inside the drum. In this way an aimed separation point can be obtained, there where the magnetic rotor lies closest to the drum, in other words there where the air gap is the smallest, since there the magnetic fields are the largest. The narrowing air gap thus converges towards the aimed separation point where the magnetic rotor lies closest to the drum. In order to obtain high efficiencies and/or in order to be able to deal with fine fractions, it is desired to enlarge the rotational speed of the magnetic rotor as much as possible. The higher this rotational speed gets, the more the field intensity of the generated eddy currents rise. This has a positive effect for the degree of separation of the non-ferrous metals.

A disadvantage of the eccentric type of eddy current separator units is that the assembly of magnetic rotor and drum may get overheated if the rotational speed of the magnetic rotor gets above a certain level. If the rotational speed of the magnetic rotor is increased, then with those eccentric type of eddy current separator units, disturbing air vortexes may start to occur between the quickly rotating magnetic rotor and the slowly rotating drum. This is caused by the fact that air is dragged along by the quickly rotating magnetic rotor, which air is forced to flow into the narrowing air gap between the drum and the magnetic rotor. Even if an inner circumferential wall of the drum and an outer circumferential wall of the rotor are made as smooth as possible, then the relative rotation between the two shall still cause a flow of air to be forced into the narrowing air gap. At the location of the narrowing, a compression of the air occurs causing this air to heat up. This process is repeated over and over again. In the end the temperature may even rise up to a level that permanent damage may occur to various components of the unit, like magnets, bearings and the fibre drum. The magnetic rotor can also get in unbalance because of the vortexes and start to vibrate, particularly if the glass fibre drum starts to lose some of its rigidity because of the rising temperatures. To prevent all this, present eddy current separator units are mostly known to have their rotational speed maximised at approximately 3800 rpm.

An example of a magnetic eddy current separator with a magnet system that is arranged eccentrically inside a belt drum is shown in US 5,092,986. Here the same disadvantages as mentioned above go.

The present invention aims to at least partly overcome the abovementioned disadvantages or to provide a usable alternative. In particular the present invention aims to provide an eddy current separation unit with an increased efficiency because its magnetic rotor can be driven at higher rotational speeds without this causing all kinds of negative side effects due to a possible temperature build-up.

This aim is achieved by a separation unit according to claim 1. The unit comprises a drivable conveyor belt for supplying a stream of fractions, for example a stream of slags, in particular waste incineration slags, which contain non-ferrous metals. The conveyor belt is guided over a rotatable outer drum. The outer drum is rotatable around a first central axis. If the conveyor belt is driven to move in a conveying direction then the outer drum shall start to co-rotate along with it. It is also possible to drive the outer drum in rotation such that it is able to drive the conveyor belt. A rotatable magnetic rotor is positioned inside the outer drum for the generation of eddy currents. The magnetic rotor is positioned eccentrically inside the outer drum. The magnetic rotor is rotatable around a second central axis. The first and second central axes lie parallel at a distance of each other.

According to the inventive thought, an inner drum is now provided coaxially around the magnetic rotor and thus also eccentrically within the outer drum. The inner drum has a third central axis. The second central axis and third central axis lie coaxial. The inner drum comprises inner and outer circumferential walls with which it lies interspaced from inner and outer circumferential walls of both the inner and outer drums such that inner and outer gaps are obtained in between them. The outer gap is present in between the eccentrically positioned inner and outer drums and has a varying thickness, that is to say that it converges towards a narrowing and from there widens again seen in a circumferential direction. The inner gap is present in between the coaxially positioned magnetic rotor and inner drum and has a substantially constant thickness. Because of the eccentric position of the magnetic rotor and inner drum relative to the outer drum, an aimed separation point can be obtained there where the assembly of magnetic rotor and inner drum lies closest relative to the outer drum. In other words there where the total distance between the magnetic rotor and the conveyor belt at the location of the aimed separation point (the sum of the inner gap, wall thickness of the inner drum, outer gap, wall thickness of the outer drum, and thickness of the conveyor belt) is the smallest, the magnetic fields may be the largest.

Owing to the presence of the inner drum, a substantially uniform and constant layer of cooling medium, for example a layer of air, can be present inside the inner gap in between the magnetic rotor and the inner drum. This layer of medium present inside the inner gap is able to smoothly and evenly rotate along with the magnetic rotor. A repeated compression of this medium no longer has to take place. The medium inside the inner gap does not have to pass through a narrowing each time. The medium which is present inside the inner gap gets much less heated up.

Despite the presence of the inner drum, a varying medium layer, for example a layer of air, can still be present inside the outer gap in between the inner and outer drum. This layer of medium present inside the outer gap may still get dragged along somewhat because of the outer drum co-rotating with the belt. This medium still may get compressed inside the narrowing. This however does not have to lead to substantial temperature rises, as long as the speed of the conveyor belt and outer drum is kept low relative to the inner drum, which normally is the case.

Because the medium layers inside the inner and outer gaps no longer get heated up extensively during the fast rotations of the magnetic rotor, the magnetic rotor can be driven at substantial higher rotational speeds compared to the state of the art. Top speeds of more than 4500 rpm, in particular more than 5000 rpm, and even more than 6000 rpm are deemed possible, in particular for industrial applicable high intensity eddy current separator units having widths of 800-1500 mm or more. This in turn will lead to an increase in efficiency. Higher rotational speeds, will increase the number of field changes per second of the eddy currents. This will highly increase the separation of fine cq small non-ferrous metals, in particular having sizes of less than 10 mm, more in particular having sizes of less than 8 mm.

The magnetic rotor preferably comprises the highest class of Neodymium magnets. Because of the high rotational speeds at which the magnetic rotor can be driven, those Neodymium magnets need to be reliably connected to a body of the rotor. This is crucial since otherwise outbreaks of heavy magnets may lead to serious accidents. For example the magnets may be encapsulated in a resin or carbon while lying inside cavities which are provided in a core body of the rotor. The resin or carbon layer for example can be a layer, which lies tight-fitted around substantially the entire circumference of the magnetic rotor and thus can help to prevent the magnets from breaking out of the magnetic rotor during its high rotational speeds. Preferably this layer then is pre-tensioned around the rotor, such that it is even able to withstand higher outbreak forces.

Preferably the Neodymium magnets are of the highest temperature classification. Those Neodymium magnets preferably comprise dysprosium in order to improve their performance and resistance to demagnetization. For example it may make them heat resistant up to 120°C without losing magnetism.

It is possible to provide the inner drum rotatable, for example freely rotatable, such that it can start to co-rotate to a certain extent with the dragged along layers of medium inside the inner and outer gaps. It is also possible to drive the inner drum in rotation, for example in the same direction as the outer drum and conveyor belt respectively, such that the relative rotational speed between the inner drum and the outer drum can be minimized or even reduced to zero. In a preferred embodiment, however, the inner drum is mounted stationary such that it is unable to rotate around its central axis. This has the advantage that the mounting of the inner drum can be kept simple, and that no bearings or the like have to be provided for the inner drum.

In the stationary variant of the inner drum, it is possible to vary the local wall thickness of the inner drum. In particular the inner drum can be made and positioned such that a section of minimum wall thickness comes to lie in line with the aimed separation point. This has the advantage that the rest of the inner drum can be made relative thick, strong and robust, while at the same time the total distance between the magnetic rotor and the conveyor belt at the location of the aimed separation point can be kept minimized. Thus vibrations of the inner drum during operation of the unit can be more easily prevented. The local varying wall thickness can for example be achieved by locally planing/flattening a substantially cylindrical inner drum.

The inner drum may have a (local) wall thickness, at least in front of the aimed separation point, of less than 2 mm, in particular less than 1 mm. The inner drum advantageously can (locally in front of the aimed separation point) be made this thin-walled since it does not have to take up any direct forces. No conveyor belt or the like runs over it like with the outer drum. Owing to this, the inner drum can (locally in front of the aimed separation point) be constructed as thinly walled as possible. This is particularly advantageous because it may help to minimize the total distance between the magnetic rotor and the conveyor belt at the location of the aimed separation point.

The inner drum mostly is made from glass fibre. Advantageously it may comprise an aramid fibre, in particular Kevlar. This makes it possible to make the inner drum even more thinly walled, because of the increased rigidity and strength of such materials.

The outer drum can also be made out of all kinds of materials like glass fibre. Advantageously it may comprise an aramid fibre, in particular Kevlar. Owing to this the outer drum then may have a wall thickness of less than 5 mm, in particular less than 4 mm. Because of this the total distance between the quickly rotating magnet poles of the magnetic rotor and the non-ferrous metals lying on the conveyor belt at the location of the aimed separation point can be further reduced. The added thin-walled inner drum around the magnetic rotor which helps to keep temperature rises restricted, makes it possible to use the thinner walled outer drum compared to the state of the art, without running the risk of the outer drum getting softened/weakened/deformed during operation. Operating temperatures no longer start to rise extensively because all kinds of disturbing air vortexes no longer occur around the quickly rotating magnetic rotor.

Further advantageous embodiments are stated in the dependent subclaims.

The invention also relates to a method for operating the eddy current separator unit, and to a use of the eddy current separator unit for the extraction of non-ferrous metal containing fractions of slags, in particular residual slags of a waste incinerator plant.

The invention shall now be explained in more detail with reference to the accompanying drawings, in which:

Fig. 1 schematically shows an embodiment of an eddy current separator unit without an inner drum according to the state of the art;

Fig. 2 schematically shows an embodiment of an eddy current separator unit with an inner drum according to the invention; and

Fig. 3 schematically shows a cross sectional view over the line III-III in fig. 2.

In the eddy current separator unit shown in fig. 2 and 3, the magnetic rotor has been given the reference numeral 1. The magnetic rotor 1 comprises a substantially cylindrical rotor body with a number of Neodymium magnet pole bodies 3 connected thereto and divided around its circumference. The rotor 1 has a central axis CA1 and is mounted rotatable inside bearings 5 of a frame 7. A drive motor 8 is provided for driving the rotor 1 in rotation at rotational speeds of 4500 rpm or more.

The unit further comprises a substantially cylindrical inner drum 10. This inner drum 10 has a central axis CA2 and is fixedly and non-rotatably mounted to the frame 7. The rotor 1 and inner drum 10 are positioned substantially coaxially with each other, such that CA1 is substantially equal to CA2. The rotor 1 has a substantially smooth outer circumferential wall with a radius R1. The inner drum has a substantially smooth inner circumferential wall with a radius R2. R1 is smaller than R2. An inner gap 13 is thus present in between the rotor 1 and inner drum 10. This inner gap 13 has a substantially constant radial thickness and is filled with air.

The unit further comprises a substantially cylindrical outer drum 15. This outer drum 15 has a central axis CA3 and is mounted rotatable inside bearings 16 of the frame 7. The rotor 1 cq the inner drum 10 are positioned eccentrically relative to the outer drum 15, such that CA1/CA2 lie at a distance d of CA3. The inner drum 10 has a substantially smooth outer circumferential wall with a radius R3. The outer drum 15 has a substantially smooth inner circumferential wall with a radius R4. R3 is smaller than R4. An outer gap 18 is thus present in between the inner drum 10 and the outer drum 15. This outer gap 18 is also filled with air and has a varying radial thickness and converges towards an aimed separation point 20 which lies on an imaginary line 21 running through the central axes CA1/CA2 and CA3.

An endless conveyor belt 24 (only partly shown) is guided over an outer circumferential wall of the outer drum 15. If desired the outer circumferential wall of the outer drum 15 can be provided with some kind of profile such that the belt 24 gets more grip on it.

During operation of the unit the conveyor belt 24 is driven at a relative low speed of 1-4 m/s, whereas the rotor 1 is driven at a relative high rotational speed. Depending on the circumstances, the magnetic rotor 1 and the conveyor belt 24 can be driven in co-rotation or in counter rotation.

A stream of waste incineration slag fractions, in particular broken and/or sieved into fine fractions having cross-sectional dimensions of between 0-10 mm, in particular of 0-8 mm, which contain non-ferrous metals, is fed to the conveyor belt 24. The conveyor belt 24 feeds the stream of fine fractions along the aimed separation point 20. The fast rotating magnetic rotor 1 causes eddy currents to occur inside the non-ferrous metal parts, which causes strong magnetic fields to occur. The strong magnetic fields cause the non-ferrous metal parts to be launched out of the stream of fractions.

Owing to the provision of the opposing substantially smooth surfaces of the rotor 1 and inner drum 10, and owing to a substantially constant thickness of the air layer in between them, less intense or hardly no vortexes shall start to occur inside the inner gap 13. This has the advantage that the unit gets less heated up during operation, because of which the efficiency can be increased and because of which the inner and/or outer drum 10, 15 can be made more thin-walled.

Besides the embodiment shown various variants are possible. For example the dimensions, shapes and materials of the various parts/components can be varied. Instead of air being present inside the inner and outer gaps, it is also possible to use another medium, like for example oil as a cooling medium. The media inside the inner and outer gaps can be kept entirely separated from each other. It is also possible to provide some kind of bridging connections between the inner and outer gaps, like for example one or more through-holes inside the inner drum, such that any pressure differences between the media inside them can automatically get eliminated. This may in particular be advantageous for the thin walled inner drum, which otherwise might start to deform because of such pressure differences.

Thus the invention provides a simple and effective construction for an eddy current separator unit to be operated at substantial higher rotational speeds in order to be able to improve the efficiency thereof without the temperature rising excessively.

CLAIMS

1. Eddy current separator unit comprising:

- a drivable conveyor belt (24) for supply of a stream of fractions which contain non-ferrous metals;

- a rotatable outer drum (15) over which the conveyor belt (24) is guided; and

- a rotatable magnetic rotor (1) positioned inside the outer drum (15) for the generation of eddy currents,

in which the magnetic rotor (1) is positioned eccentrically inside the outer drum (15),

characterized in that,

an inner drum (10) is provided coaxially around the magnetic rotor (1) and eccentrically within the outer drum (15), such that an outer gap (18) with a varying thickness is present in between the eccentrically positioned inner and outer drums (10, 15), and

wherein an inner gap (13) with a substantially constant thickness is provided in between the magnetic rotor (1) and the inner drum (10).

2. Eddy current separator unit according to claim 1, wherein the inner drum (10) is mounted stationary.

3. Eddy current separator unit according to one of the preceding claims, wherein the inner drum (10) comprises an aramid fibre.

4. Eddy current separator unit according to one of the preceding claims, wherein the inner drum (10) has a wall thickness of less than 2 mm, in particular less than 1 mm.

5. Eddy current separator unit according to one of the preceding claims, wherein the outer drum (15) comprises an aramid fibre.

6. Eddy current separator unit according to one of the preceding claims, wherein the outer drum (15) has a wall thickness of less than 5 mm, in particular less than 4 mm.

7. Eddy current separator unit according to one of the preceding claims, wherein the inner drum (10) comprises a substantially cylindrical inner wall and the magnetic rotor comprises a substantially cylindrical outer wall, and wherein the inner diameter of the inner drum (10) is larger than the outer diameter of the magnetic rotor (1).

8. Method for operating an eddy current separator unit according to one of the preceding claims, comprising the steps of:
- feeding a stream of fractions, in particular fine fractions having cross-sectional dimensions of less than 10 mm, which contain non-ferrous metals to the conveyor belt (24);
- driving the conveyor belt (24) for feeding the stream of fractions along the assembly of outer drum (15), inner drum (10) and magnetic rotor (1);
- driving the magnetic rotor (1) at a rotational speed of more than 4500 rpm; and
- separating the non-ferrous metals out of the stream of fractions by means of magnetic fields generated by the rotating magnetic rotor (1).

9. Method according to claim 8, wherein the magnetic rotor (1) is driven at a rotational speed of more than 6000 rpm.

10. Method according to one of the preceding claims 8-9, wherein the magnetic rotor (1) is driven in counter-rotation relative to the conveyor belt (24).

11. Use of an eddy current separator unit according to one of the preceding claims for the extraction of non-ferrous metal containing fractions of slags, in particular residual slags of a waste incinerator plant.

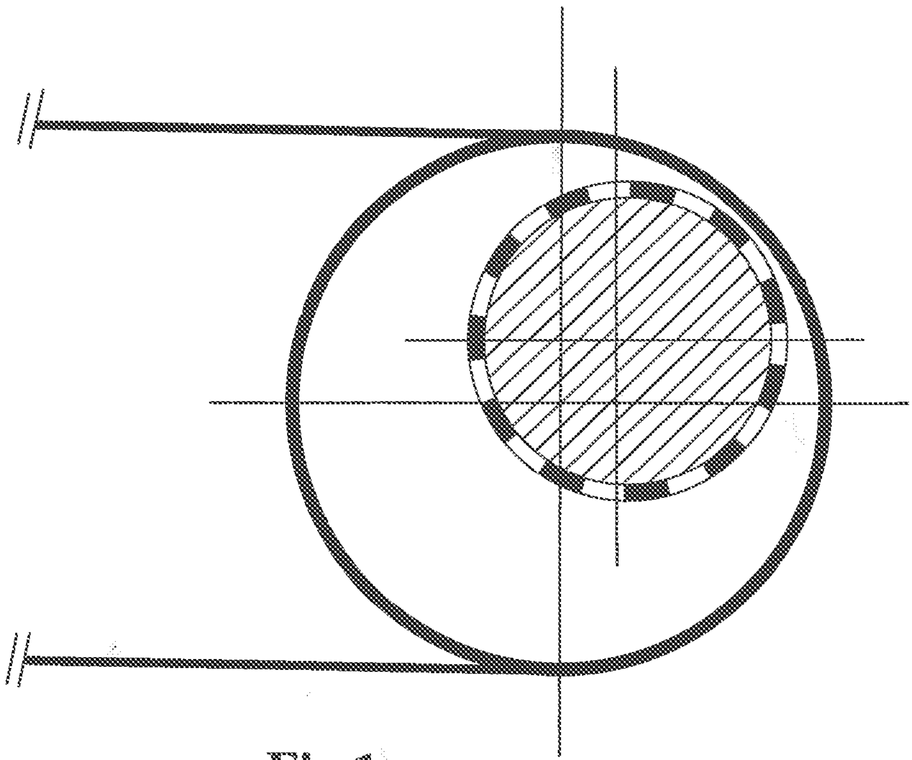

Fig.1

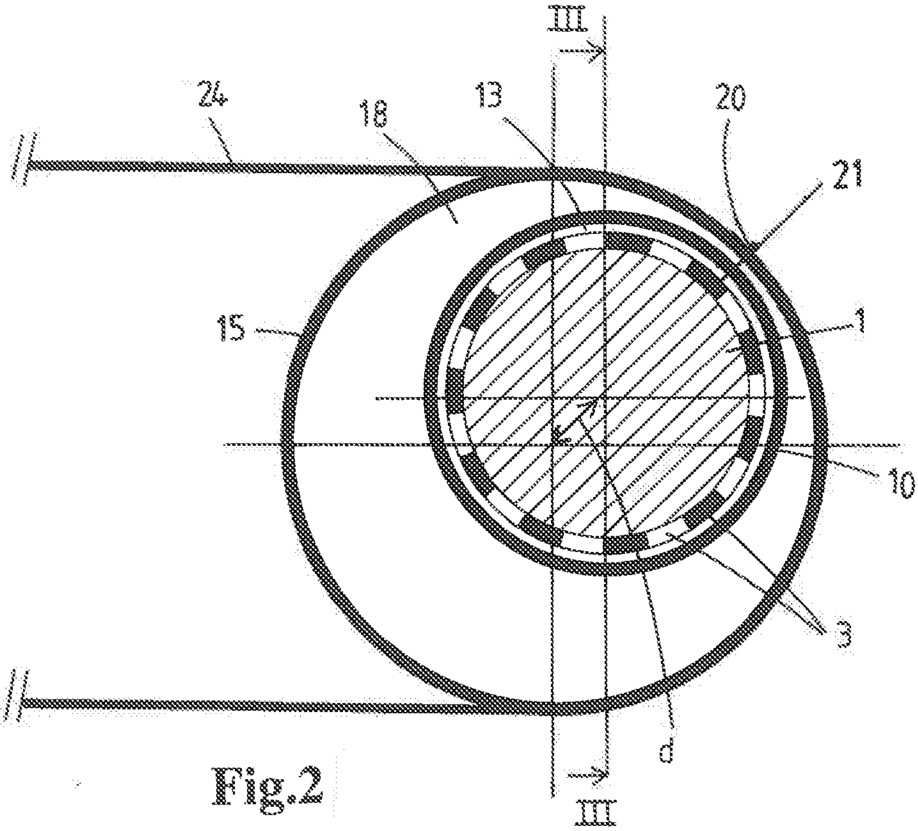

Fig.2

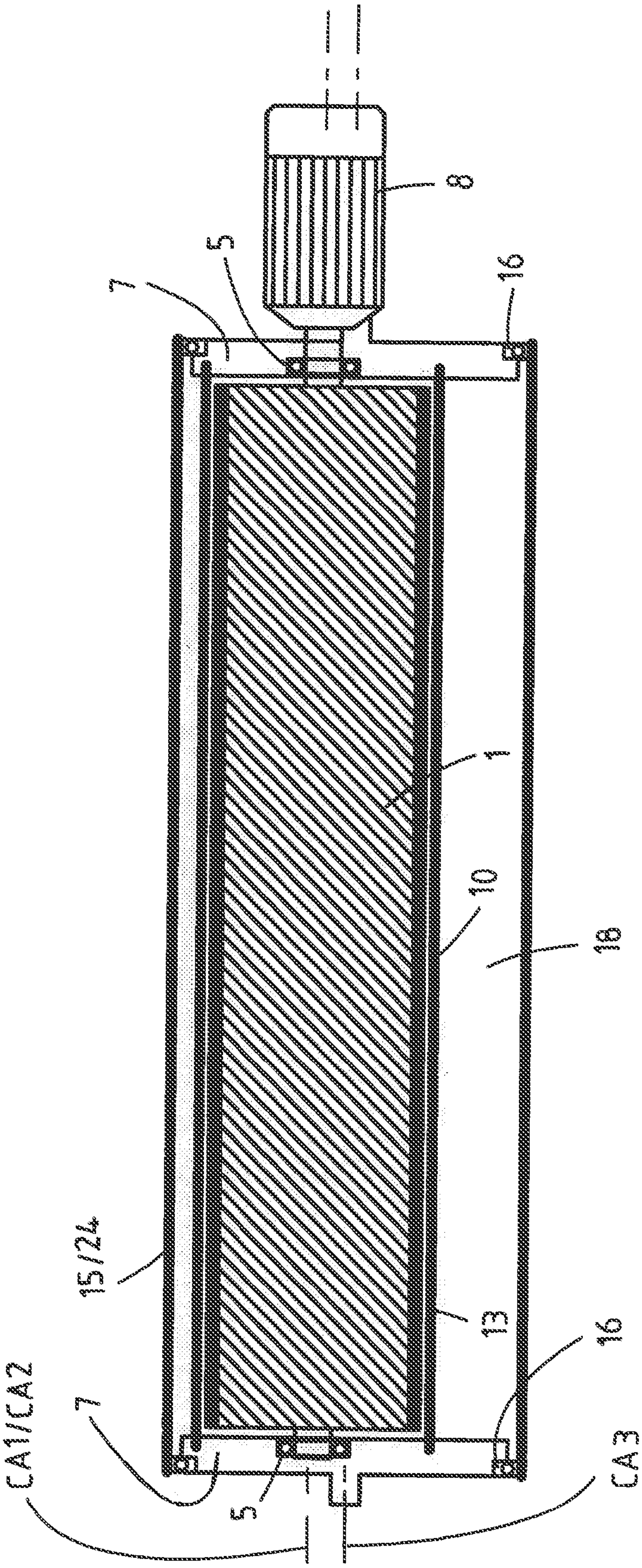

Fig.3

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2014/050665

A. CLASSIFICATION OF SUBJECT MATTER
INV. B03C1/247
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B03C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 092 986 A (FEISTNER KLAUS [DE] ET AL) 3 March 1992 (1992-03-03) figure (not numbered) column 2, line 51 - column 3, line 59 -----	1-11
A	DE 20 2012 004227 U1 (IMRO MASCHB GMBH [DE]) 1 August 2013 (2013-08-01) figure 1 paragraph [0015] - paragraph [0018] -----	1-11
A	EP 0 342 330 A2 (LINDEMANN MASCHFAB GMBH [DE]) 23 November 1989 (1989-11-23) figures 1, 3 column 12, line 7 - line 56 -----	1-11
A	DE 40 31 585 A1 (LINDEMANN MASCHFAB GMBH [DE]) 9 April 1992 (1992-04-09) figures 1, 2 column 4, line 37 - column 6, line 16 -----	1-11

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2014/050665

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