



(51) International Patent Classification:

B02C 1/08 (2006.01) *B02C 4/02* (2006.01)
B02C 21/00 (2006.01)

(21) International Application Number:

PCT/IB2023/060343

(22) International Filing Date:

13 October 2023 (13.10.2023)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

10 2022 126 862.4

14 October 2022 (14.10.2022) DE

LU502900 14 October 2022 (14.10.2022) LU

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(54) Title: TWO-STAGE PROCESSING PLANT

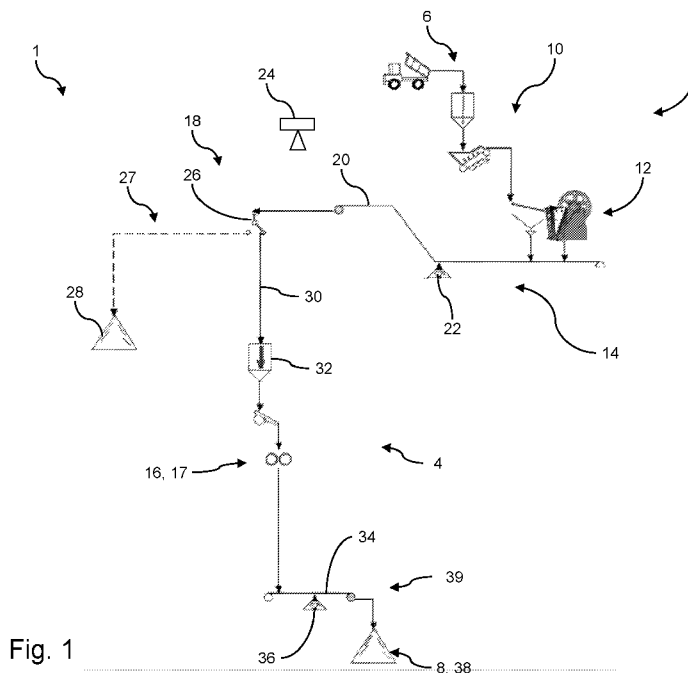


Fig. 1

(57) Abstract: The invention relates to a processing plant (1) for comminution of ROM material (6) to a particle size of <1mm, comprising a primary loading unit (10) for loading ROM material (6); a crusher (12) as a primary stage (2) for comminuting the ROM material (6) to a mill particle size (14) suitable for being fed to a mill (16); a mill (16) as a secondary stage (4) for comminuting the material (14) with mill particle size to a ground particle size of <1mm; and a conveyor device (18) which connects the crusher (12) on the output side to the mill (16) on the input side for feeding the material (14) crushed to the mill particle size to the mill (16), and a withdrawal unit (39) used to withdraw ground material (8) from the mill (16). The invention also relates to a method for comminution of ROM material (6).

(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *of inventorship (Rule 4.17(iv))*

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*
- *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

Two-stage processing plant

The invention relates to a processing plant for comminution of run-of-mine (ROM) material to a particle size of <1 mm. The invention also relates to a method for comminution of ROM material to a particle size of <1 mm.

In the extraction of rock with small particle sizes of 1 mm or smaller, the use of a multi-stage comminution process has become established for surface and underground mines. This is due to the fact that the material primarily obtained, in particular by demolition or blasting, so-called ROM material (run of mine material), has edge lengths of up to 2 m, so that direct comminution of the ROM material to a particle size of 1 mm or smaller is technically not possible. The currently established process is a three-stage process consisting of a primary crusher for comminuting the ROM material from 0 - 2000 mm to 0 - 200 down to approximately 0 - 350 mm, a secondary crusher stage for comminuting the material from the primary stage to a particle size of 0 - 40 mm down to approximately 0 - 80 mm and then a tertiary crusher stage for 0 - 5 mm down to 0 - 20 mm. A mill is usually used for further comminution down to 1mm. One reason for this lies in particular in the limitations of the individual stages, which can carry out small, higher comminution ratios without risking an overloading. For example, crusher gap widths in the primary stage are typically limited to 100 – 200 mm CSS (120 – 270 mm OSS). Also, commercially available mills, such as HPGR (High Pressure Grinding Roll) in particular, can optimally only process material with a particle size of <70 mm. With particle sizes of >100 mm, the sleeves are regularly damaged and the grinding rolls run out of alignment.

The object of the present invention is to remedy this and to provide an improved processing plant and a corresponding method by which ROM material can be processed more efficiently to a particle size of <1 mm.

The invention solves the problem by a processing plant with the features of claim 1 and a method with the features of claim 22. In particular, the invention proposes a processing plant that comprises a crusher as the primary stage for comminuting the ROM material to a mill particle size suitable for being fed to a mill, in particular an HPGR, and a mill, in particular an HPGR as a secondary stage for comminuting the material with mill particle size to a ground particle size of <1 mm. The primary stage and the secondary stage are connected via a conveyor device which feeds the crushed material with mill particle size to the mill. Preferably, the crusher as the primary stage is designed to produce mill particle sizes of 0 - 150 mm, and the mill as the secondary stage is designed to grind material with mill particle sizes of 0 - 150 mm. The processing plant also comprises an extraction unit, which can also be optional. The extraction unit is arranged on the outlet side of the mill and serves to extract ground material, for example to a heap or a silo. For this purpose, the extraction unit can have one or more conveyor belts with optional belt scales.

The invention is based on the finding that a two-stage comminution process can be realized by skillfully combining a crusher as the primary stage and a mill as the secondary stage, which has enormous advantages in terms of plant costs, both the acquisition costs and the operating costs, compared to conventional processes. The invention thus refutes the previously existing prejudice that at least one three-stage comminution process is necessary in order not to risk overloading the individual plant units. However, the present invention takes a different approach and implements the two-stage process in that a grindable product is produced directly with the crusher as the primary stage, i.e. a material with a particle size that can be processed by a mill, and the mill is fed directly with this material as a secondary stage.

The conveyor device preferably has a discharge device for discharging oversize particles between the primary and secondary stage in order to prevent oversize particles from being fed to the secondary stage. In this way it can be avoided that material with too large a particle size is fed to the mill, in particular HPGR, as a secondary stage. The discharge device is preferably designed to remove particle sizes of >170 mm, preferably >150 mm and/or foreign bodies from the process. For example, the discharge device includes a screen which screens out oversize material. The screened-out material can then be removed from the process, preferably by an automatic actuator, and fed to a heap.

As an alternative or in addition, the discharge device includes optical monitoring of the particle size of the crushed material. The optical monitoring can be accommodated, for example, immediately at the outlet of the crusher as the primary stage, immediately before the entrance to the mill as a secondary stage, or at another location on the conveyor device. The optical monitoring preferably uses image recognition to transmit particle sizes with an edge length of >170 mm, preferably >150 mm, so that these can then be discharged from the process in a pendulum flap, for example. Again, the particles discharged in this way can be fed to a heap.

However, it can also be provided that the discharged material is fed to the crusher as the primary stage via a return device. This is particularly preferred for material with a correspondingly large particle size, for example a particle size of >50 mm, preferably >60 mm edge length. To ensure this, another screen or another optical monitor can be used. As a result, the overall efficiency of the process can be further increased.

Another means of increasing the efficiency and reducing wear of the crusher as a primary stage can be realized by a bypass device between the primary feed unit and the crusher for guiding material of mill particle size past the crusher. Such a bypass device can in particular comprise a screening device which is arranged between the primary loading unit, for example a loading chute, and a crushing chamber of the crusher as the primary stage. Such a screening device preferably comprises a finger screen with a plurality of finger elements, wherein the finger elements each have a main axis of extension and are able to be supported on a roll of the crusher. In particular, the screening device

can be designed in accordance with WO 2019/134864 A1 and/or WO 2014/067867 A1, the disclosure content of which is fully incorporated herein by reference. The screening device described herein can have one, a plurality or all features of the screening device described in the documents mentioned. The screening device is not limited to use with an eccentric roll crusher, but can also be used with any other type of crusher. The screening device is preferably arranged in such a way that material falling through the screen lands directly on a conveyor belt which transports material away from the outlet of the crusher as the primary stage. A particularly simple arrangement is realized in this way.

As an alternative or in addition, the bypass device can have optical monitoring for the material being guided past. On the one hand, it is conceivable and preferred that the optical monitoring of the bypass device first identifies sufficiently finely granulated material and then this material is guided past the crusher as the primary stage by means of a pendulum flap, for example; on the other hand, it can also be provided that the optical monitoring of the bypass device checks the screened material, which is guided past the crusher by means of the screening device, to determine whether the particle size is sufficiently small. If this is not the case for whatever reason, the material guided past the crusher by means of the screening device can preferably be discharged from the process with the discharge device or returned to prevent an overloading of the mill as a secondary stage.

The crusher is particularly preferably designed as an eccentric roll crusher. It has been shown that eccentric roll crushers are particularly well suited to act as primary stages in the two-stage crushing process. The eccentric roll crusher is preferably operated with a crushing gap width of 55 - 150 mm (OSS) in order to produce crushed material with particle sizes of 0 - 150 mm. Preferably, an eccentric roll crusher with an increased crushing ratio is used. The comminution ratio (ratio of loading particle size to product particle size) is preferably <1:8, preferably <1:9, 1:10, 1:11. In this way it is possible, with the eccentric roll crusher as the primary stage, to produce a material directly which can advantageously be ground by a mill.

In order to avoid overloading the eccentric roll crusher, the eccentric roll crusher preferably has an overload safety device on a rocker and/or on a roll of the eccentric roll crusher. An overload safety device on a rocker of the eccentric roll crusher can be implemented, for example, as described in WO 2014/067882 A2, namely in particular by a predetermined breaking point in the case of a mechanical drive or a pressure relief valve in the case of a pneumatic drive of an adjustment device for the rocker of the eccentric roll crusher. Other options for an overload protection on the rocker of the eccentric roller crusher are known from DE 1257004 A, DE 1875346 U, DE 2747257 A1 and each comprise a spring, a hydraulic piston or an electromagnet to release the rocker of the eccentric roll crusher in the event of an imminent overload of the eccentric roll crusher and thus to open the crushing gap so that material that is too large or too hard can be discharged from the crushing chamber of the eccentric roll crusher. An overload safety device on the rocker and/or the roll can also be realized by carrying out a load measurement on one or a plurality of supporting components, for

example a housing, preferably with load sensors, strain sensors or the like, and in the event that a load exceeds a predetermined threshold value, the crushing gap is widened, preferably by displacing the rocker and/or roll, for example by opening a valve in a hydraulic and/or pneumatic cylinder. The particle causing the overload can then be discharged via the discharge device. A corresponding
5 signal can be provided as a function of the ascertained overload and/or as a function of the widening of the crushing gap, which then preferably causes the discharge device to discharge the particle.

In addition to an overload safety device on the rocker, an overload safety device on the roll of the eccentric roll crusher can additionally or alternatively be used. For this purpose, the roll of the eccentric roll crusher is preferably mounted loosely, for example by accommodating shaft ends of
10 the roll in bearing housings which are supported and guided via a guide on the machine frame of the eccentric roll crusher. A displacement of the roll can then be realized against the force of a spring, a hydraulic or pneumatic force and a pressure relief valve, a mechanical predetermined breaking point or the like. In this way, the roll can also be moved away from the rocker of the eccentric roll crusher in the event of an impending overload, so that the crushing gap can be widened particularly well in
15 order to discharge material that is too large or too hard or other foreign bodies from the crushing chamber. An eccentric roll crusher usually has a drive for driving the roll of the eccentric roll crusher. This drive advantageously has a control or is connected to a control that is set up to regulate the speed of the roll. For example, the speed can be regulated as a function of the particle size of the loading material, the target particle size, a power consumption of the drive, and/or a determined
20 vibration and/or noise development. By using an adjustable speed, the size of the crushed material can be limited to <150 mm, which in turn largely prevents an overloading of the mill.

Particularly preferably, the mill is designed as a roll mill, in particular a high-compression roll mill, and is equipped with a first grinding roll and a second grinding roll, which are arranged opposite one another and can be driven in opposite directions, wherein a grinding gap is formed between the
25 grinding rolls. A high-compression roll mill, also called HPGR, has proven to be particularly suitable for grinding the material broken by the crusher as the primary stage in the two-stage processing process. It is preferred that the roll mill has a zero grinding gap of 60 mm or more. Preferably or alternatively, the roll mill has a working grinding gap of 80 mm or more in order to be able to grind the material that has only been crushed in a primary stage.

It is preferred here that at least one of the grinding rolls has an edge element at an end region of the grinding roll, which is designed such that it extends over the grinding gap and at least partially covers the opposite grinding roll on the front side. Preferably, each of the grinding rolls has an edge element at an end region of a roll end, which is designed such that it extends over the grinding gap and at least partially covers the opposite grinding roll on the front side. If such an edge element is only
30 provided on one grinding roll, an edge element is preferably provided on both opposite end regions of this grinding roll. The edge element is preferably designed as a flange, but can be designed in one piece with the roll. The edge element preferably comprises a circumferential circular ring, which can
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also consist of segments, for example. For example, the edge element is attached to the front side or one/the outer circumference of the grinding roll, in particular the respective roll base body. For example, a circumferential groove is arranged on the outer circumference of the respective grinding roll, in each of which an edge element is arranged. The edge elements are preferably made of a wear-resistant material, such as steel or tungsten carbide, and have a wear-resistant coating, in particular on the inside facing the grinding gap. The edge element, for example, has a thickness of 10 mm to 100 mm and covers the opposite grinding roll by approximately 2 - 20%, preferably 4 - 10%, more preferably 3 - 6% of the roll diameter. The edge element(s) can in particular be designed as described in DE 10 2017 208 014 A1, the disclosure content of which is fully incorporated herein by reference. The edge element described herein or the edge elements described herein may have one, a plurality or all features of the edge elements described in DE 10 2017 208 014 A1.

Further preferably, the roll mill comprises a scraper element for at least partial removal of material at the end region of the grinding roll which is provided with an edge element. The scraper element is also preferably designed according to DE 10 2017 208 014 A1 and can have one, a plurality or all features of the scraper element disclosed in DE 10 2017 208 014 A1. The scraper element serves in particular to at least partially remove material deposited on the end region of the grinding roll. The material is scraped off by the scraper element during operation of the roll mill. The scraper element is preferably arranged above the grinding gap. But it can also be arranged below the grinding gap. The scraper element is preferably arranged at the end region of the grinding roll in such a way that it does not touch the grinding roll. The end region of the grinding roll comprises, for example, the front side of the grinding roll, the adjacent grinding roll surface and a region surrounding the grinding roll surface in which material is deposited. For example, such a region has a height of more than or equal to 1.5 - 3 mm, preferably more than or equal to 2 - 5 mm, more preferably about 4 mm. A scraper element is preferably provided on each edge element. It preferably comprises a scraper plate and preferably an angle between the scraper plate and the surface of the grinding roll is in a range of 45° - 135°.

In a preferred development, the grinding rolls are equipped with a plurality of pin-shaped profile bodies to protect against wear. The number of pin-shaped profile bodies is preferably at least 850 pieces/m², preferably at least 1000 pieces/m² of roll surface. The roll surface here refers to the roll surface without pin-shaped profile bodies. The pin-shaped profile bodies, also called studs, preferably have rounded edges and/or a spherical head shape. Such pin-shaped profile bodies make it possible to form an autogenous wear protection layer that protects the roll body from wear. The pin-shaped profile bodies can be designed, for example, as described in DE 10 2013 110 981 A1, the disclosure content of which is fully incorporated herein by reference. The pin-shaped profile bodies can have one, a plurality of or all features of the profile bodies described in DE 10 2013 110 981 A1.

The processing plant preferably comprises at least one monitoring device for the first grinding roll, and preferably second grinding roll, for determining a state of wear of the grinding roll, preferably the pin-shaped profile body. Such a monitoring device preferably comprises a first and a second monitoring unit, wherein each monitoring unit is provided for one of the grinding rolls. The first and second monitoring units are preferably designed so that they can monitor the rotating surface of the grinding rolls during the grinding operation. In this way, increasing wear can be detected in good time, so that the operation of the roll mill can be adapted to the determined state of wear. For example, the speed of the grinding rolls can be adjusted as well as the fineness and the grinding gap in order to achieve an operating mode that is adapted to wear. The material fed can also be fed in a different way at a different speed and/or the operation of the crusher in the primary stage can be adjusted to provide material with the mill particle size in a different way and in a way adapted to the wear of the grinding rolls. The monitoring device can be designed as described in DE 10 2013 110 981 and the operation of the roll mill can also be adjusted as described in this document as a function of the wear.

Furthermore, it is preferred that the roll mill has a loading chute with a shut-off device for selectively releasing and blocking the loading chute. It has been shown that a particularly high level of wear on the roll mill occurs when, for example, material to be ground is only placed in the middle of the grinding rolls, so that grinding only occurs in the middle of the grinding rolls. This causes an uneven load on the grinding rolls, which increases wear disproportionately. By means of the shut-off device, material can then be retained in the loading chute until a certain filling level is reached and then the loading chute can be released so that a sufficient amount of material reaches the grinding rolls in order to be able to use them over the entire axial length, so that no uneven loading of the grinding rolls occurs. This can reduce wear on the grinding rolls. In a further preferred embodiment, the roll mill comprises a misalignment limiter for limiting load-related misalignment of the grinding rolls to a predetermined level. Preferably one of the grinding rolls, preferably the first grinding roll, is mounted loosely, while the second grinding roll is fixedly mounted. In this way, the first grinding roll can give way if there is a risk of overload and increase the grinding gap. A certain amount of misalignment should be permitted, but this does not exceed a predetermined level. A synchronization device that allows such a misalignment is disclosed, for example, in WO 2021/023643 and the disclosure content of which is fully incorporated herein by reference. The synchronization device described herein, which limits the misalignment to a predetermined level and thus provides a misalignment limitation, may have one, a plurality of or all of the features of the synchronization device with misalignment limitation disclosed in the cited document.

Another means of increasing efficiency is that the grinding roll has a roll base body and an outer wear ring. The wear ring can be attached to the roll base body, for example, by a shrink fit. The roll base body itself can be formed by at least one, two, three or four coaxially arranged intermediate rings. By arranging a wear ring on the roll base body, it can be replaced if it wears out, so that the entire roll does not have to be replaced. Preferably, the edge element or elements described are formed on

the wear ring, so that the edge elements can be replaced together with the wear ring in the event of wear. This can also reduce the overall CO₂ footprint of the plant.

Typically, the grinding rolls are rotatably mounted on a mill frame and, for this purpose, accommodated in bearings, in particular roller bearings or barrel bearings. The roll mill preferably includes circulating oil lubrication for the bearings, preferably for all bearings. In this way, cooling of the bearings can be improved, which means that higher loads on the grinding rolls can be tolerated. This helps ensure that the two-stage processing process as described herein can be implemented.

In a second aspect, the invention solves the aforementioned problem in a method for comminuting ROM material with the steps: feeding the ROM material to a crusher as a primary stage; crushing the ROM material by means of the crusher to a mill particle size suitable for feeding to a mill; conveying the crushed material from the crusher to a mill as a secondary stage; and grinding the crushed material in the mill to a ground particle size of <1 mm; and preferably removing the ground material, preferably by means of a withdrawal unit. It should be understood that the processing plant according to the first aspect of the invention and the method according to the second aspect of the invention have the same and similar sub-aspects as set out in particular in the dependent claims. In this respect, reference is made in full to the above description of the first aspect of the invention.

Embodiments of the invention will now be described below with reference to the drawings. These are not necessarily intended to represent the embodiments to scale; rather, if this is useful for explanation, the drawings are executed in a schematic and/or slightly distorted form. With regard to additions to the teachings immediately apparent from the drawings, reference is made to the relevant state of the art. It should be noted that various modifications and changes can be made to the form and detail of an embodiment without departing from the general idea of the invention. The features of the invention disclosed in the description, in the drawings and in the claims can be substantial for the development of the invention both individually and in any combination. In addition, all combinations of at least two of the features disclosed in the description, the drawings and/or the claims fall within the scope of the invention. The general idea of the invention is not limited to the exact form or detail of the preferred embodiments shown and described hereinafter or limited to a subject matter that would be limited in comparison to the subject matter claimed in the claims. For specified design ranges, values within the specified limits should also be disclosed as limit values and can be used and claimed as desired. For the sake of simplicity, the same reference numerals are used below for identical or similar parts or parts with identical or similar functions.

Further advantages, features and details of the invention emerge from the following description of the preferred embodiments and from the drawings; these show in:

Fig. 1 a schematic representation of a two-stage processing plant according to the invention;

Fig. 2 a representation of an eccentric roll crusher as a primary stage;

Fig. 3 a schematic representation of a roll mill as a secondary stage;

Fig. 4 another embodiment of the roll mill as a secondary stage; and in

Fig. 5 first and second grinding rolls of the roll mill.

5 Fig. 1 shows a processing plant 1 in a first possible embodiment according to the invention. The processing plant 1 is designed in two stages, i.e. it only includes a primary stage 2 and a secondary stage 4. In addition to primary stage 2 and secondary stage 4, the processing plant does not have any other stages. It therefore only has a single primary stage 2 and a single secondary stage 4, neither intermediate stages nor subsequent stages. Overall, the processing plant 1 is intended to
10 produce ground material 8 with particle sizes of <1 mm from ROM material (run of mine material) 6 with an edge length of up to 2 m.

First, the processing plant 1 includes a primary loading unit 10 into which ROM material 6 is loaded. The primary loading unit 10 may be formed in a conventional manner and is known to the person skilled in the art. A crusher 12, for example a jaw crusher or eccentric roll crusher, is provided
15 downstream of the primary loading unit 10 as the primary stage 2 in the embodiment shown here. The crusher is used as a primary stage and crushes the ROM material 6 to a mill particle size 14, i.e. a material with a particle size that can be ground by a mill 16. The crusher conveys the crushed material 14 with mill particle size to a conveyor device 18, which in turn conveys the material 14 to the mill 16.

20 The conveyor device 18 here comprises a first conveyor belt 20 with an optional first belt scale 22. A first optical monitoring unit 24 for monitoring the particle size of the crushed material 14 is also optionally arranged on the first conveyor belt 20. With the first optical monitoring unit 24, fragments with side edges that are too large, in particular larger than 200 mm, preferably larger than 400 mm, can be detected. A first foreign metal monitor is also optionally arranged on the first conveyor belt 20
25 in order to detect foreign metal. A discharge device 26 is arranged downstream of the first conveyor belt 20, by means of which the fragments with side edges that are too large, the so-called oversize particle 27, or the detected foreign metal can then be discharged. The discharge device 26 can be designed, for example, as a double-flap lock or screen or a combination thereof, which discharges the identified oversize particle as a function of signals from the first optical monitoring unit 24. In the
30 example shown in Fig. 1, the discharged oversize particle 27 is fed to an oversize particle heap 28, but can also be returned to the primary loading unit 10 via a return device (not shown here). This return device can be designed with an optional magnetic separator to discharge foreign material. The material with the mill particle size 14, which was not discharged through the discharge device 26, is then fed via, for example, a second conveyor belt 30, or directly to a secondary loading unit 32, in

order to then be fed via this to the mill 16 as a secondary stage 4. The mill 16 is designed here as a roll mill 17, in particular a high-compression roll mill 17. The ground material 8 is fed to a third conveyor belt 34 on the output side of the mill 16, with an optional second belt scale 36, in order to then be fed to a product heap 38 or another storage facility. Together, the third conveyor belt 34 and optionally the belt scale 36 and optionally the product heap 38 can also be referred to as a withdrawal unit 39 or can be part of one. In this way, a two-stage processing process is achieved in which material ground directly from ROM material can be produced.

Figs. 2 to 5 now show details of the processing plant 1. Fig. 2 first shows an eccentric roll crusher 13, which can be used as a crusher 12 as part of the primary stage 2 according to Fig. 1

An eccentric roll crusher 13, also called ERC, comprises a machine frame 102, a rotatable roll 104, a rocker 108 mounted on a rocker axle 106 on the machine frame 102, a crushing chamber 109 between the roll 104 and the rocker 108, and a screening chamber 107, below a screening device 140. At the lower end of the crushing chamber 109, a crushing gap BS is formed between the rocker 108 and the roll 104, which defines the smallest distance between the roll 104 and the rocker 108. During operation, the roll 104 rotates about an axis of rotation 105, wherein the roll 104 is designed here with an eccentricity, so that the roll body 104 rotates eccentrically about the axis of rotation 105. When the roll 104 rotates eccentrically, the distance between the roll 104 and the rocker 108 changes, so that crushed material that is placed in the crushing chamber 109 can be comminuted.

The rocker 108 is here provided with a rocker adjustment device 110, which can be designed as known from WO 2014/067882 A2. Specifically, the rocker adjustment device 110 comprises a rocker wedge 112, which is arranged in a gap between a contact surface 113 formed on the rear side of the rocker and a counter surface 115 assigned to a rocker abutment 114. The rocker wedge 112 can be positioned within the gap with a rocker wedge drive 116 of the rocker adjusting device 110 in order to change the distance between the rocker 108 and the roll 104 and thus the effective crushing gap BS. When the rocker wedge 112 is moved downwards towards its second position with reference to Fig. 2, the distance between roll 104 and rocker 108 increases. If, on the other hand, the rocker wedge 112 is moved upwards towards its first position P1, the crushing gap BS between roll 104 and rocker 108 decreases.

The rocker wedge 112, the contact surface 113 and the counter surface 115 are aligned with one another in such a way that the rocker wedge 112 is pushed downwards, i.e. in the direction of the second position P2, by the forces acting on the rocker 108. The geometry of the contact surface 113, the counter surface 115 and the rocker wedge 112 is selected so that the rocker wedge 112 is not self-locking, i.e. no self-locking occurs. In particular, the rocker wedge 112 can be set up to automatically move downwards towards the second position after decoupling from the rocker wedge drive 116. The counter surface 115 is formed on a counterholder 117, which forms a fixed bearing but is rotatably arranged around the abutment 114, which is designed as an axle journal. In this way, the counter surface 115 can rotate around the abutment 114 when the rocker wedge 112 is adjusted.

This takes into account the fact that the rocker 108 rotates about the rocker axle 106 when the rocker wedge 112 is adjusted.

In the exemplary embodiment shown here (Fig. 2), the rocker wedge drive 116 comprises a hydraulic or pneumatic drive 118, with a hydraulic or pneumatic cylinder 119, which is firmly connected to the rocker 108 here, and a hydraulic or pneumatic piston 120, which is connected in an articulated manner with the rocker wedge. By appropriately applying hydraulic or pneumatic pressure inside the hydraulic or pneumatic cylinder 119, the hydraulic or pneumatic piston 120 can be moved upwards or downwards with reference to Fig. 2 in order to adjust the rocker wedge.

The rocker adjustment device 110 also includes a rocker overload protection 122, which here includes a pressure relief valve 123, such that hydraulic or pneumatic fluid can be released from the pressure relief valve 123 when the rocker 108 is overloaded in order to bring the rocker wedge 112 to a lower position and thus widen the crushing gap BS. Alternatively or additionally, the pressure relief valve 123 can also be actively opened, for example based on a signal that is generated based on a load determination on one or a plurality of the load-bearing parts of the eccentric roll crusher 13.

In addition to the rocker adjustment device 110, the embodiment shown here (Fig. 2) of the eccentric roll crusher 13 includes a roll adjustment device 130. The roll adjustment device 130 is used to adjust the roll 104 perpendicular to its axis of rotation 105 in the direction of the rocker 108 to adjust the crushing gap BS. In order to enable deflection of the roll 104 in the horizontal direction with reference to Fig. 2, it is mounted loosely. In the exemplary embodiment shown in Fig. 2, the roll adjustment device 130 is designed to be purely passive and comprises at least a first spring 132. The compression spring 132 is supported against a support 134 which is connected to the machine frame 102. The first spring 132 can engage directly on a first shaft shoulder 136 of the roll 104, or (as will be described in detail later with reference to Figs. 2 and 3) on a first bearing housing of the first shaft shoulder 136. The spring 132 is preferably dimensioned so that it does not flex during normal operation, but only then deflects if a force in the crushing chamber 109 would exceed a load limit of the eccentric roll crusher 13 and there is therefore a risk of damage to the eccentric roll crusher 13. Additionally or alternatively, a second spring (not shown) can also be provided on the other side of the roll 104, not shown in Fig. 2, on the second shaft shoulder (not shown in Fig. 2). It can also be provided that only a first spring is provided, which then acts on both the first and the second shaft shoulder via a holding mechanism. It can also be provided that the first and second springs are coupled to one another, so that a synchronization of the roll 104 is ensured.

In Fig. 2 it can also be seen that a screening device 140 is provided above the roll 104, which can be supported on the one hand on a stationary abutment 142 on the machine frame 102 and on the other hand on a support surface of the roll 104 or on the machine frame. A movement of the roll 104 causes a shaking movement on the support surface between the screening device 140 and the roll 104. The screening device 140 can also rotate about the abutment 142 so that the screening device 140 can compensate for eccentric rotation of the roll 104. The screening device 140 is designed in

such a way that material to be crushed below a predetermined size falls through the screen and, with reference to Fig. 2, can be guided past the roller 104 on the left, i.e. it does not reach the crushing chamber 109. Only material to be crushed with a size above the predetermined size, i.e. material to be crushed that cannot pass through the screening device 140, is fed to the crushing chamber 109.

5 The screening device 140 is preferably designed in accordance with WO 2014/067867 and can have one or all of the features of the screening device described there. In particular, it can be provided that the screening device 102 comprises a finger screen and/or sliding shoes are provided and/or elastic damping elements and/or rubber buffers.

10 The eccentric roll crusher 13 also has a guide element 144 that is separate from the rocker 108 and is attached to the machine frame or housing 102. The guide element 144 is separate from the rocker 108 and is stationary and does not move together with the rocker 108, neither when adjusting the crushing gap nor during any overload compensation movement of the rocker 108. The guide element 144 is preferably formed in accordance with WO 2014/067858 A1 and has one or all of the features of the guide element according to WO 2014/067858 A1.

15 Both the rocker 108 and the guide element 144 and the roll 104 are fitted with crushing jaws 145, 146, 147. The crushing jaws 145, 146, 147 are wearing parts that can be replaced. The crushing jaws 145, 146 on the rocker 108 and the guide element 144 are profiled, the crushing jaw 145 on the rocker 108 is wavy or has a convex-concave shape, particularly in the lower region of the crushing gap. The crushing jaws 147 of the roll 104 are arranged in a circle around the roll 104.

20 Even if in Fig. 2 both the roll 104 and the rocker 108 are equipped with an overload safety device, it should be understood that only the rocker 108 or only the roll 104 can be equipped with an overload safety device.

Figs. 3 to 5 now show details and configurations of the mill 16, namely in particular the roll mill 17. Fig. 3 shows an example of a roll mill 17 with a first grinding roll 212 and a second grinding roll 214, 25 wherein the grinding rolls 212, 214 are arranged opposite one another and rotatable in opposite directions. A grinding gap 216 is formed between the grinding rolls 212, 214. The grinding rolls 212, 214 each have a substantially cylindrical roll base body 218, 220 and a drive shaft 222, 224 arranged coaxially therewith, the ends of which preferably extend in the axial direction beyond the respective roll base body 218, 220. Each of the grinding rolls 212, 214 is accommodated in a bearing unit, 30 wherein the bearing units are supported, for example, on a machine frame 229, which is not completely shown in Fig. 3. The first grinding roll 212 is accommodated in a floating bearing unit 226, wherein the second grinding roll 214 is accommodated in a fixed bearing unit 228. Alternatively, it can also be provided that both grinding rolls 212, 214 are accommodated in fixed bearing units, or both grinding rolls 212, 214 are accommodated in floating bearing units. The fixed bearing unit 228 35 comprises two bearings 230, 232, which are each arranged at opposite roller ends and accommodate the drive shaft 224. The bearings 230, 232 are firmly attached to the machine frame 229 so that they can absorb forces, particularly in the axial and radial directions of the grinding roll 214. The floating

bearing unit 226 includes two bearings 234, 236, each of which accommodates one end of the first drive shaft 222. The bearings 234, 236 of the floating bearing unit 226 are accommodated on the machine frame 229 in such a way that they can be moved linearly, preferably in a sliding manner. The bearings 234, 236 are preferably firmly attached in the axial direction of the first grinding roll 212.

- 5 Here, for example, the bearings 230, 232, 234, 236 are each provided with circulating oil lubrication 231, 233, 235, 237 in order to be able to absorb higher forces.

In the exemplary embodiment shown in Fig. 3, the bearings 234, 236 of the floating bearing unit 226 are each connected to one, preferably two, hydraulic actuators 238, 240. The hydraulic actuators 238, 240 each serve to apply a grinding force to the first grinding roll 212 in the direction of the second grinding roll 214. The grinding force is preferably directed in a direction orthogonal to the loading of
10 the material 14 into the grinding gap 216. The floating bearing unit 226 can be moved in the direction of the grinding force applied by the hydraulic actuators 238, 240. The hydraulic actuators 238, 240 are each supported with one end on one of the bearings 234, 236 and with their opposite end on the machine frame 229. A movement of the respective bearing 234, 236 of the floating bearing unit 226
15 results in a corresponding movement of the hydraulic actuator 238, 240 attached thereto. Each hydraulic actuator 238, 240 preferably has a cylinder and a piston movably attached thereto, wherein the movement of the hydraulic actuator 238, 240 is understood to mean, for example, a movement of the piston within the cylinder. The roll mill 17 also has a synchronization device 242, which is connected to the hydraulic actuators 238, 240 via hydraulic lines 244, 246. The synchronization
20 device 242 serves to couple, in particular to synchronize, the movement of the hydraulic actuators 238, 240, so that the bearings 234, 236 move in a coupled manner or in the same direction and in particular a misalignment of the grinding rolls 212, 214, in which they are not aligned parallel to one another, is avoided or preferably limited. In particular, the synchronization device 242 is designed such that a movement of one of the hydraulic actuators 238, 240 results in a corresponding
25 movement of the other of the hydraulic actuators 238, 240.

In the exemplary embodiment shown here, the synchronization device 242 also has a plurality of hydraulic cylinders 250, 252, 254, 256. The detailed view shown at the bottom left in Fig. 3 shows a cross-section of the synchronization device 242 with, for example, four hydraulic cylinders 250, 252, 254, 256, which are arranged in a housing 248, for example. However, a different number of hydraulic
30 cylinders is also conceivable and preferred. Preferably, half of the hydraulic cylinders 250 - 256 are connected exclusively to one of the hydraulic actuators 238, 240. For example, each hydraulic cylinder 250 - 256 of the synchronization device 242 is connected to exactly one hydraulic actuator 238, 240. In each of the hydraulic cylinders 250 - 256 (only two shown in detail in the cross-section in Fig. 3) a piston 258, 260 is arranged to be linearly movable. The pistons 258, 260 are firmly
35 connected to one another via a mechanical coupling 262. Preferably, the pistons 258, 260 each have one end protruding from the respective hydraulic cylinder 250 - 256, wherein the end of the piston 258, 260 protruding from the hydraulic cylinder is attached to the mechanical coupling 262. The

mechanical coupling 262 is, for example, a plate to which the pistons 258, 260 are attached. The pistons 258, 260 are preferably aligned parallel to one another and orthogonal to the mechanical coupling 262, preferably the plate.

The hydraulic cylinders 250 - 256 are connected to the hydraulic actuators 238, 240 via the hydraulic lines 244, 246. The roll mill 17 preferably has two hydraulic lines 244, 246, wherein the hydraulic line 244 is connected to the hydraulic actuators 238 of a bearing 234 of the floating bearing unit 226 and the other hydraulic line 246 is connected to the hydraulic actuators 240 of the other bearing 236 of the floating bearing unit 226. Preferably, each of the hydraulic lines 244, 246 is exclusively connected to one half of the hydraulic cylinders 250 - 256 of the synchronization device 242.

By way of example, the mechanical coupling 262 in the exemplary embodiment of Fig. 3 is designed as a piston 262, wherein the synchronization device 242 has a cylinder 274 with a gas chamber 276, which is preferably filled with a compressible gas, such as nitrogen. The gas chamber 276 is delimited, for example, by two pistons 262, 278, wherein one of the pistons 262, 278 is preferably the mechanical coupling 262 and the other piston 278 separates the gas chamber 276 from a hydraulic chamber 280. The hydraulic chamber 280 is preferably filled with a non-compressible hydraulic oil and is in particular connected to a hydraulic pump, not shown, via a hydraulic line.

In the exemplary embodiment of Fig. 3, a buffer unit 264, 266 is arranged between the synchronization device 242 and each hydraulic actuator 238, 240. The buffer units 264, 266 are each connected to the synchronization device 242 and the hydraulic actuators 238, 240 via one of the hydraulic lines 244, 246. The buffer units 264, 266 are preferably designed to be substantially identical. Each of the buffer units 264, 266 is designed in particular as a single-acting hydraulic cylinder and each has a cylinder with a piston 268 which separates a gas chamber 270 from a hydraulic chamber 272 and is movable within the cylinder. The gas chamber 270 is preferably filled with a compressible gas, such as nitrogen, wherein the hydraulic chamber 272 is filled with a non-compressible hydraulic oil and is connected to the respective hydraulic line 244, 246 so that hydraulic oil can flow from the respective hydraulic line 244, 246 into the hydraulic chamber 272. The buffer unit 264, 266 serves as a buffer between the synchronization device 242 and the hydraulic actuators 238, 240, so that the hydraulic actuators 238, 240 can be decoupled from the synchronization device 242 in order to allow and limit a movement of the hydraulic actuators 238, 240 in a certain travel limit range. The travel limit range is preferably a deviation of the position of the hydraulic actuator 238, 240 relative to a zero position, which corresponds to the desired size of the grinding gap 216.

The grinding gap 216 is preferably designed as a zero gap of 60 mm or more. However, the zero gap is selected so that ground material with particle sizes of <1 mm can be produced.

It should be understood that other types and designs of the synchronization device and the limitation of the synchronization and enabling misalignment are also conceivable and preferred, as disclosed

in particular in WO 2021/023643. It should be understood that all types of synchronization device and misalignment limitation disclosed in this document can also be used within the scope of the present application. In a side view of the roll mill 17 shown in Fig. 4 it can first be seen that a spacer 217 is provided between the grinding rolls 212, 214 in order to set the grinding gap 216 to the zero gap. The machine frame 229 is shown here as having a base frame 229a, a pressure beam 229b and top straps 229c. A hydraulic unit for operating the hydraulic actuators 238, 240 is not shown in Fig. 4 for simplicity.

A plurality of pin-shaped profile bodies 282, 284 are arranged on the peripheral surfaces of the first and second grinding rolls 212, 214, namely in particular with a density of 1000 or more per m² of the surface of the grinding roll 212, 214, measured without profile bodies. The pin-shaped profile bodies are preferably designed with rounded edges and have a spherical head shape. In this way, an autogenous wear protection layer can be formed on the surface of the grinding rolls 212, 214.

In order to detect the state of wear of the grinding rolls 212, 214 and in particular of the pin-shaped profile bodies 282, 284, a monitoring device 286 is provided, which comprises a first monitoring unit 288 for the first grinding roll 212 and a second monitoring unit 289 for the second grinding roll 214. The monitoring units 288, 289 can in particular include optical sensors or other non-contact sensors for determining the state of wear. It can be provided that the operating mode of the roll mill 17 is adjusted if a state of wear indicates increased wear.

Finally, Fig. 5 illustrates the first and second grinding rolls 212, 214 with the first and second roll base bodies 218, 220 in cross-section. It can be seen that the first roll base body 218 is provided with a first outer wear ring 290 and the second roll base body 220 is provided with a second outer wear ring 292. The first and second wear rings 290, 292 can be pressed on or shrunk on and amount to approximately 2 - 10% of a roll base body diameter.

A first edge element 294 on the first wear ring 290 and a second edge element 295 on a second axial end are additionally provided, which are formed here in one piece with the wear ring 290. In the event that no wear rings 290, 292 are provided, the edge elements 294, 295 can also be attached directly to the roll base body 218, 220, preferably detachable from it, in order to be replaceable in the event of wear. It can also be provided that not two edge elements 294, 295 are provided on a roll 212, 214, but only one, or that each of the rolls 212, 214 has one edge element 294, 295. The edge element 294, 295 extends beyond the grinding gap 216 and approximately to the roll base body 220 of the second grinding roll 214. The edge elements 294, 295, for example, have a thickness of 10 mm to 100 mm and cover the opposite grinding roll 212, 214 by approximately 2 - 20%, in particular 4 - 10%, preferably 3 - 6% of the roll diameter. In addition, a scraper element, not shown in detail here, can also be provided, as disclosed in particular in DE 10 2017 208 014 A1.

List of reference numerals (part of the description)

	1	processing plant
	2	primary stage
	4	secondary stage
	6	ROM material
5	8	ground material
	10	primary loading unit
	12	crusher
	13	eccentric roll crusher
	14	mill particle size
10	16	mill
	17	roll mill
	18	conveyor device
	20	first conveyor belt
	22	first belt scale
15	24	first optical monitoring unit
	26	discharge device
	27	oversize particle
	28	oversize particle heap
	30	second conveyor belt
20	32	secondary loading unit
	34	third conveyor belt
	36	second belt scale
	38	product heap
	39	withdrawal unit
25	102	machine frame of the eccentric roll crusher
	104	roll
	106	rocker axle
	107	screening chamber
	108	rocker
30	109	crushing chamber
	110	rocker adjustment device
	112	rocker wedge
	113	contact surface on the rear side of the rocker
	114	abutment
35	115	counter surface
	116	rocker wedge drive
	117	rocker counter element
	118	hydraulic or pneumatic drive
	119	hydraulic or pneumatic cylinder
40	120	hydraulic or pneumatic piston
	122	rocker overload protection

	123	pressure relief valve
	130	roll adjustment device
	132	first spring
	134	support
5	140	screening device
	142	stationary abutment
	144	guide element
	145, 146, 147	crushing jaws
	212	first grinding roll
10	214	second grinding roll
	216	grinding gap
	217	spacer
	218	first roll base body
	220	second roll base body
15	222	first drive shaft
	224	second drive shaft
	226	floating bearing unit
	228	fixed bearing unit
	229	machine frame
20	230, 232, 234, 236	bearing
	231, 233, 235, 237	circulating oil lubrication
	238, 240	hydraulic actuators
	242	synchronization device
	244, 246	hydraulic lines
25	248	housing of the synchronization device
	250, 252, 254, 256	hydraulic cylinder
	258, 260	piston
	262	mechanical coupling
	264, 266	buffer unit
30	268	piston
	270	gas chamber
	272	hydraulic chamber
	274	cylinder
	276	gas chamber
35	278	piston
	280	hydraulic chamber
	282, 284	pin-shaped profile bodies
	286	monitoring device
	288, 289	monitoring units
40	290, 292	wear ring
	294, 295	edge element

Claims

1. Processing plant (1) for comminution of ROM material (6) to a particle size of <1mm, comprising

a primary loading unit (10) for loading ROM material (6);

5 a crusher (12) as a primary stage (2) for comminuting the ROM material (6) to a mill particle size (14) suitable for being fed to a mill (16);

a mill (16) as a secondary stage (4) for comminuting the material (14) with mill particle size to a ground particle size of <1mm;

10 a conveyor device (18) which connects the crusher (12) on the output side to the mill (16) on the input side for feeding the material (14) crushed to the mill particle size to the mill (16); and

a withdrawal unit (39) which is used to withdraw ground material (8) from the mill (16).

2. Processing plant according to claim 1, wherein the conveyor device (18) has a discharge device (26) for discharging oversize particles (27) between the primary and secondary stages (2, 4) to prevent oversize particles (27) from being fed to the secondary stage (4).

15 3. Processing plant according to claim 2, wherein the discharge device (26) comprises an optical monitoring (24) of the particle size of the crushed material (14).

4. Processing plant according to claim 2 or 3, comprising a return device for returning discharged material to the primary stage (2).

20 5. Processing plant according to any one of the preceding claims, comprising a bypass device between the primary loading unit (10) and the crusher (12) for guiding material (14) with a mill particle size past the crusher (12).

6. Processing plant according to claim 5, wherein the bypass device comprises a screening device (140).

25 7. Processing plant according to claim 5 or 6, wherein the bypass device has optical monitoring for the material being guided past.

8. Processing plant according to any one of the preceding claims, wherein the crusher (12) is designed as an eccentric roll crusher (13).

9. Processing plant according to claim 8, wherein the eccentric roll crusher (13) has an increased comminution ratio, preferably with a crushing gap (BS) in a range of 50 mm to 200 mm.

10. Processing plant according to claim 8 or 9, wherein the eccentric roll crusher (13) comprises an overload safety device (122, 132) on a rocker (108) and/or a roll (104) of the eccentric roll crusher (13).

11. Processing plant according to any one of claims 8 to 10, wherein the eccentric roll crusher (13) has a drive for driving a roll (108) of the eccentric roll crusher (13), wherein the drive has a control unit for regulating a speed of the roll.

12. Processing plant according to any one of the preceding claims, wherein the mill (16) is designed as a roll mill (17) with a first grinding roll (212) and a second grinding roll (214), which are arranged opposite one another and can be driven in opposite directions, wherein between the grinding rolls (212, 214) a grinding gap (216) is formed.

13. Processing plant according to claim 12, wherein the roll mill (17) has a zero grinding gap of 60mm or more.

14. Processing plant according to claim 12 or 13, wherein at least one of the grinding rolls (212, 214) has an edge element (294, 295) at an end region of the grinding roll (212, 214), which is designed such that it extends over the grinding gap (216) and at least partially covers the opposite grinding roll (212, 214) on the front side.

15. Processing plant according to claim 14, wherein a scraper element for at least partial removal of material is arranged on the end region of the grinding roll (12, 14), which is provided with an edge element ().

16. Processing plant according to any one of claims 12 to 15, wherein the grinding rolls are equipped with a plurality of pin-shaped profile bodies (282, 284) to protect against wear, wherein the number of pin-shaped profile bodies is 850 pieces/m² of the roll surface.

17. Processing plant according to claim 16, comprising at least one monitoring device (286) for the first grinding roll (212) for determining a state of wear of the grinding roll, preferably the pin-shaped profile body (282, 284).

18. Processing plant according to any one of claims 12 to 17, wherein the roll mill (17) has a loading chute with a shut-off device for selectively releasing and blocking the loading chute.

19. Processing plant according to any one of claims 12 to 18, wherein the roll mill (17) has a misalignment limiter for limiting load-related misalignment of the grinding rolls (212, 214) to a predetermined level.

20. Processing plant according to any one of claims 12 to 19, wherein each grinding roll (212, 214)
5 has a roll base body (218, 220) and an outer wear ring (290, 292).

21. Processing plant according to any one of claims 12 to 20, wherein the grinding rolls (212, 214) are rotatably mounted on a mill frame (229), wherein the bearings (230, 232, 234, 236) have a circulating oil lubrication (231, 233, 235, 237).

22. Method for comminuting ROM material (6), comprising the steps:

- 10 - feeding the ROM material (6) to a crusher (12) as a primary stage (2);
- crushing the ROM material (6) by means of the crusher (12) to a mill particle size suitable for being fed to a mill (16);
- conveying the crushed material (14) from the crusher (12) to a mill (16) as a secondary stage (4);
- grinding the crushed material (14) in the mill (16) to a ground particle size (8) of <1mm; and
- 15 - guiding the ground material (8) away.

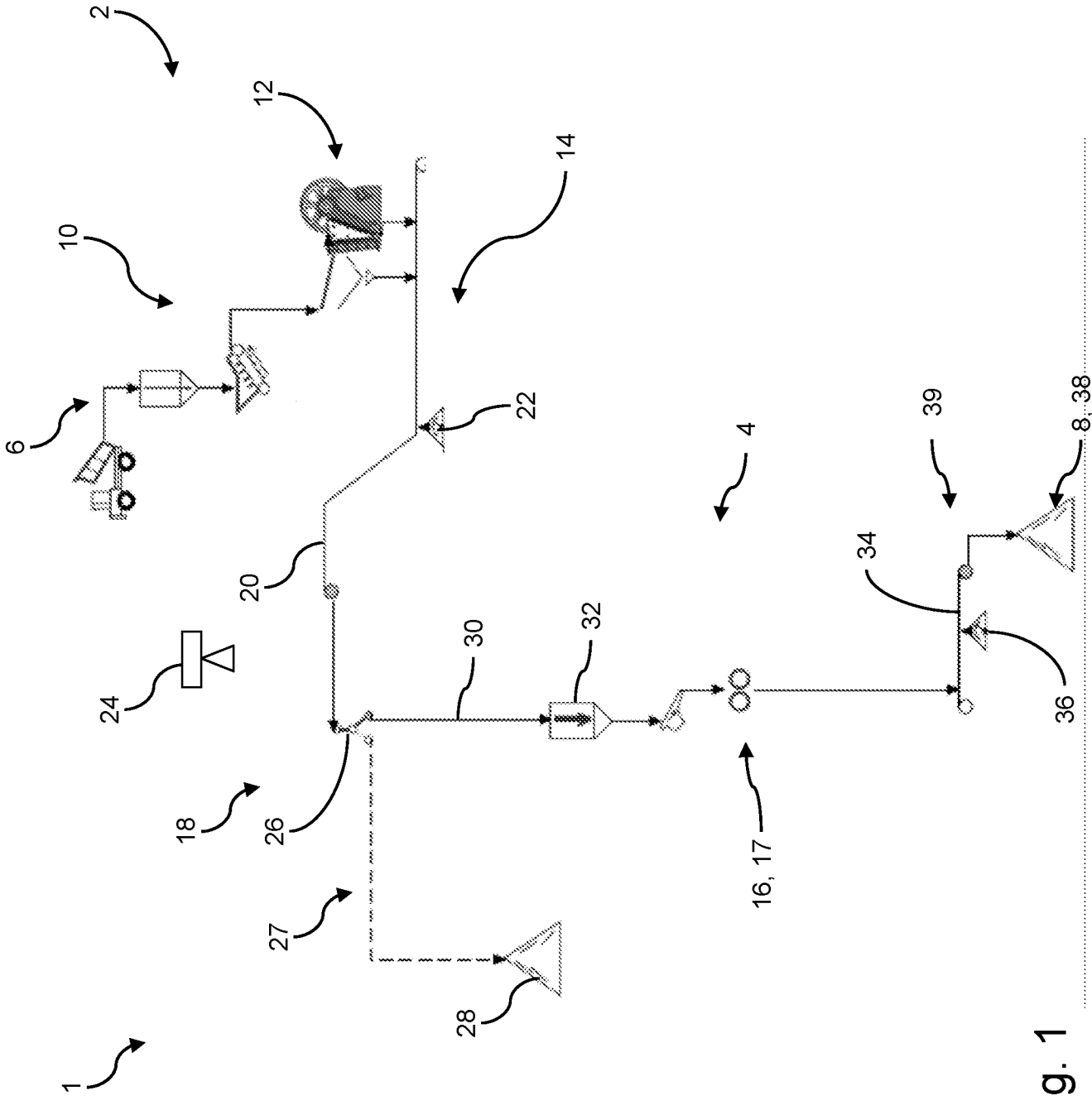


Fig. 1

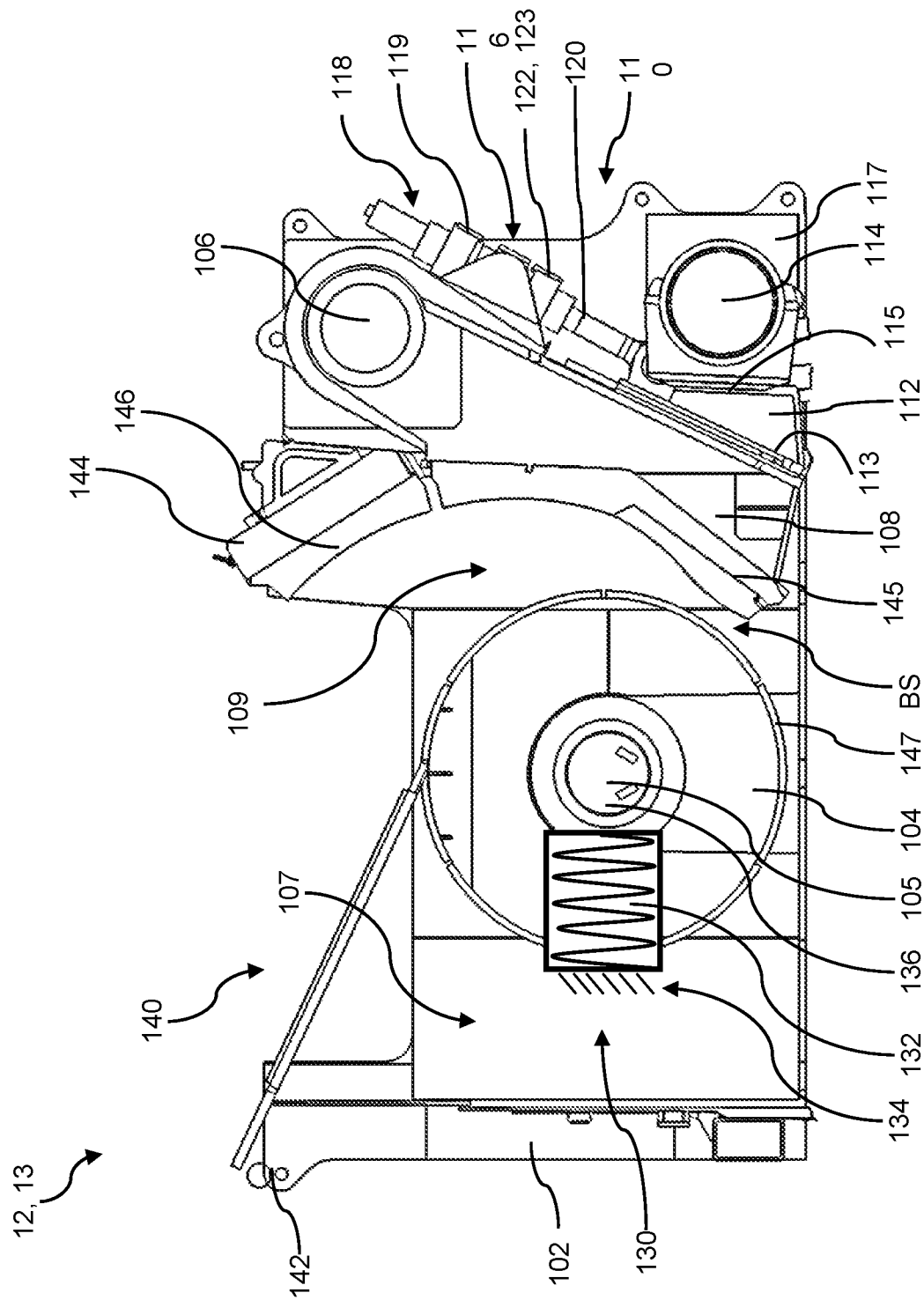


Fig. 2

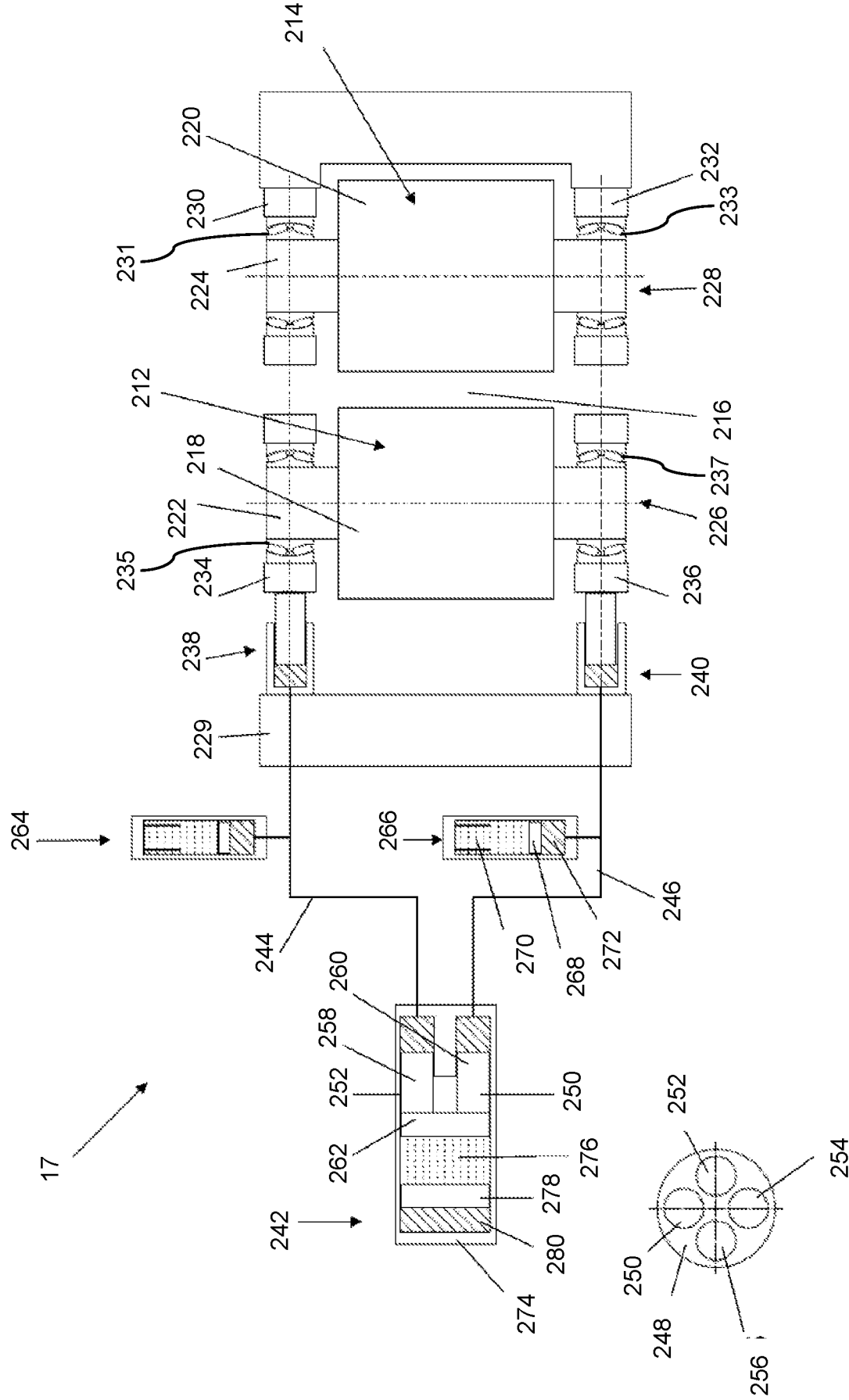


Fig. 3

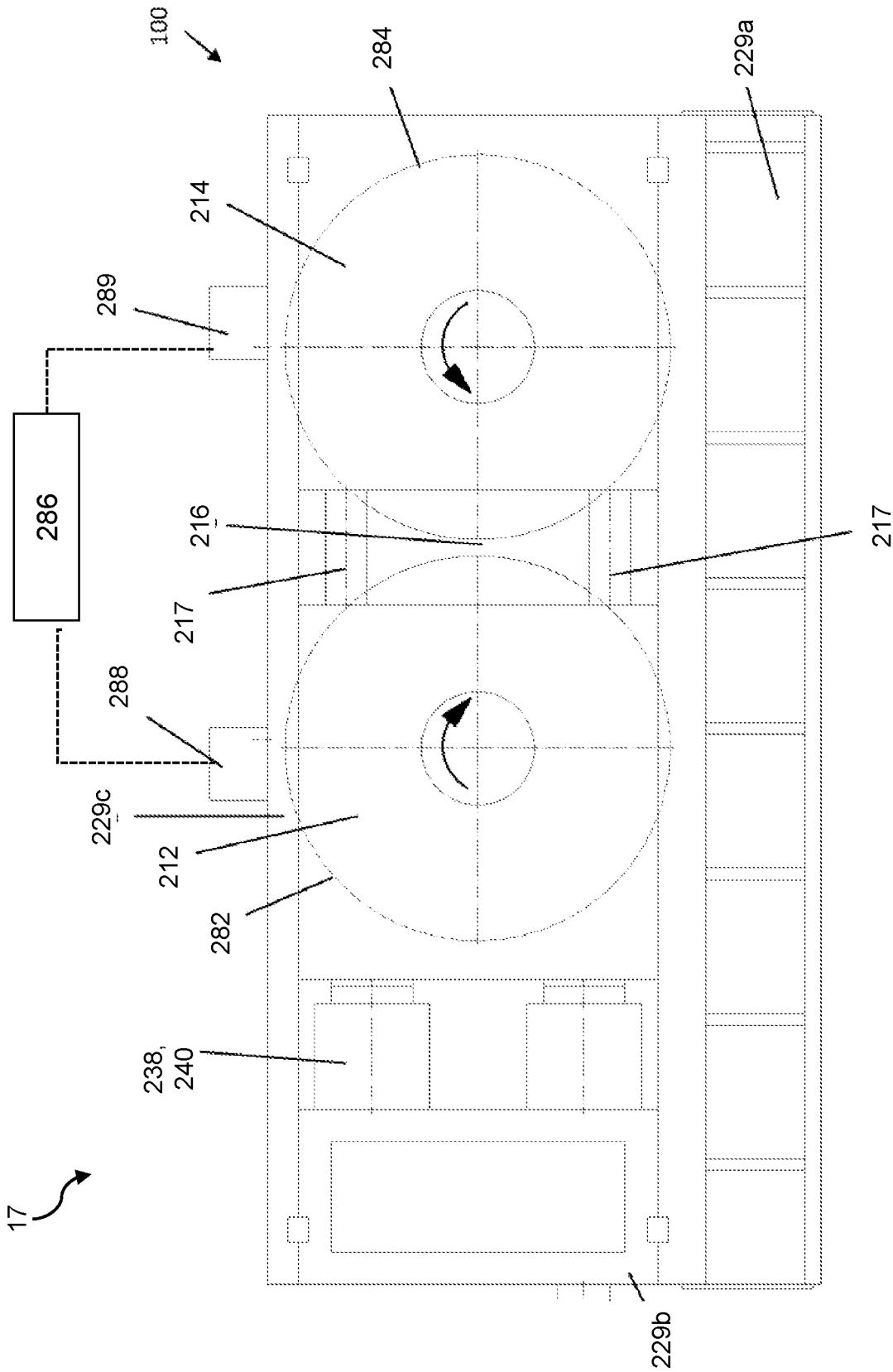


Fig. 4

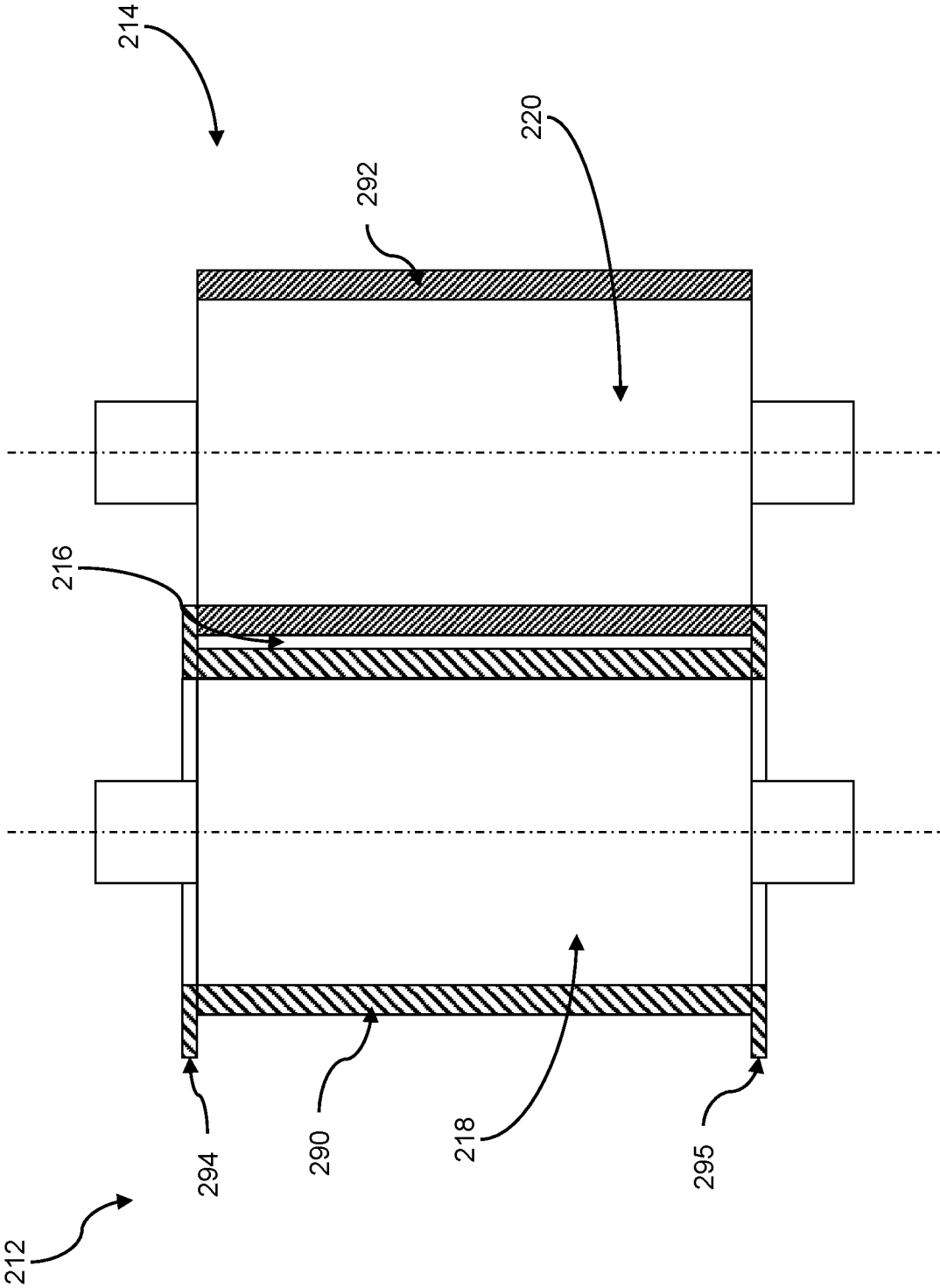


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2023/060343

A. CLASSIFICATION OF SUBJECT MATTER

INV. B02C1/08 B02C21/00 B02C4/02
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)

B02C

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 10 2013 110981 A1 (THYSSENKRUPP IND SOLUTIONS AG [DE]) 2 April 2015 (2015-04-02) figures -----	1-21
X	WO 2016/071197 A1 (THYSSENKRUPP AG [DE]; THYSSENKRUPP IND SOLUTIONS AG [DE]) 12 May 2016 (2016-05-12)	1, 22
Y	page 13; figures -----	1-21



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

7 February 2024

Date of mailing of the international search report

19/02/2024

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2023/060343

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102013110981 A1	02-04-2015	AU 2014331405 A1	14-04-2016
		BR 112016007229 A2	01-08-2017
		CA 2924968 A1	09-04-2015
		CN 105592926 A	18-05-2016
		DE 102013110981 A1	02-04-2015
		DK 3052239 T3	01-07-2019
		EA 201690440 A1	30-09-2016
		EP 3052239 A1	10-08-2016
		MX 368561 B	07-10-2019
		PE 20161087 A1	21-10-2016
		US 2016243556 A1	25-08-2016
		WO 2015049043 A1	09-04-2015
		ZA 201602072 B	26-07-2017

WO 2016071197 A1	12-05-2016	DE 102014115975 A1	19-05-2016
		DK 3215272 T3	31-08-2020
		EP 3215272 A1	13-09-2017
		WO 2016071197 A1	12-05-2016
