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(71) Applicant: **ATTRITOR MILL Limited**
Sliema (MT)

(72) Inventors:
- **REALE, Luigi**
  95126 Catania (CT) (IT)
- **REALE, Marcello**
  62024 Matelica (MC) (IT)

(74) Representative: **Bonatto, Marco et al**
Barzanò & Zanardo Milano S.p.A.
Via Borgonuovo, 10
20121 Milano (IT)

(54) GRINDING DEVICE AND PROCESS FOR USING IT

(57) The grinding device (**1, 1'**) according to the invention comprises a grinding container (**5**) which forms inside it a grinding chamber (**7**), and a rotor (**9**) which forms a plurality of processing arms (**11**). The rotor (**9**) and the arms (**11**) rotating on themselves, grind, chop, shred or micronise the material to be processed contained in the grinding chamber (**7**). The device (**1**, **1'**) also comprises A) a feeding system (**13**) that feeds the material to be processed into the grinding chamber (**7**); B) a control system configured for controlling the feeder (**13**) based on B**1**) the resistant torque opposing the rotation of the rotor (**9**) in the grinding chamber (**7**); and/or B**2**) based on the speed of rotation of the rotor (**9**); and/or B**3**) based on the power required to drive the rotor (**9**).

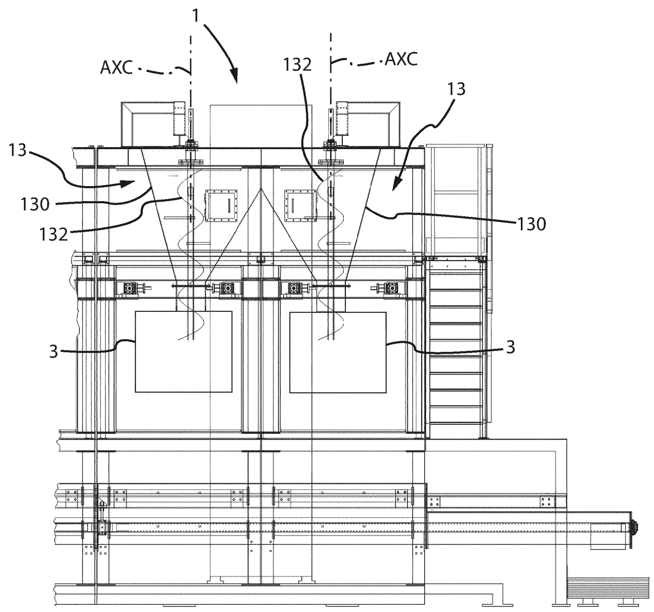

Fig. 1

Processed by Luminess, 75001 PARIS (FR)

Description

Field of the invention

[0001] The present invention relates to a grinding device and a process for grinding a material to be processed - such as for example automotive fluff, agricultural waste, biomass, municipal waste, fibreglass, other plastic waste - and recycle them.

Prior art

[0002] It is currently known to use shredders or chippers with rotating blades to grind and recycle waste; some examples of these known machinery are described in publications CN107350033**,** DE4440769A1**,** DE2432495A1**,** DE19600482A1.

[0003] The authors of the present invention believe that current grinding and shredding plants are not particularly efficient for processing relatively low-density waste, such as for example automotive fluff - i.e., non-metallic waste materials coming from automobile and other motor vehicle dismantling, such as for example plastic parts, seat padding, other foamed plastic components, textiles -, agricultural waste, unsorted municipal waste, where the efficiency of the recycling process can be measured for example as the ratio between the amount of material recycled and the energy consumed to recycle it.

[0004] An object of the present invention is to overcome the above-mentioned drawbacks and in particular to provide a more efficient device and process for recycling or otherwise processing waste materials, including in particular automotive fluff, agricultural waste, unsorted municipal waste, textiles, plastics, sweeping earth, fibreglass, biomass and agricultural waste.

Summary of the invention

[0005] This object is achieved, according to the present invention, by a grinding device having the characteristics according to claim **1**.

[0006] In a second aspect of the present invention, such object is achieved by a process having the characteristics according to claim **11**.

[0007] Further features of the invention are the subject-matter of the dependent claims.

[0008] The advantages attainable with the present invention shall become more readily apparent, to the person skilled in the art, by the following detailed description of some particular, non-limiting embodiments, illustrated with reference to the following schematic figures.

List of Figures

[0009]

Figure **1** shows a partially sectioned side view of a grinding device according to a first particular embodiment of the present invention;

Figure **2** shows a partially sectioned side view of part of the grinding cell of the grinding device of Figure **1**;

Figure **3** shows a first view of the rotor of the grinding device of Figure **1**, according to an observation direction parallel to the axis of rotation of the rotor;

Figure **4** shows a second view of the rotor of the grinding device of Figure **1**, according to an observation direction parallel to the axis of rotation of the rotor;

Figure **5** shows a third view of the rotor of the grinding device of Figure **1**, according to an observation direction perpendicular to the axis of rotation of the rotor;

Figure **6** shows a view, according to an observation direction parallel to the axis of rotation of the rotor, of an axial protrusion present in the grinding chamber of the grinding device of Figure **1**;

Figure **7** shows a partially sectioned side view of a grinding device according to a second particular embodiment of the present invention.

Detailed description

[0010] Figures **1-6** relate to a device and process for grinding materials to be processed according to a first particular embodiment of the present invention, globally referred to as reference **1.**

[0011] These materials to be processed are preferably automotive fluff -i.e. non-metallic waste materials coming from the dismantling of cars, trucks, buses, railway carriages, and other motor vehicles, such as for example plastic parts, seat padding, other foamed plastic components, textiles,- municipal waste, such as organic or inorganic, unsorted, plastics, mowing, waste from pruning or hedge cutting, textiles, non-wovens fabrics, fibrous materials, felts, wadding, plastic or metal foams, fibreglass, sweeping earth, furniture and its stuffing, paper, cardboard, wood, agricultural waste, biomass, sweeping earth, plasmix.

[0012] The plant **1** and the relative operation and/or use process are particularly suitable for processing waste, scrap and other materials to be processed at a relatively low density such as for example automotive fluff or the so-called Plasmix, i.e. a mixture of plastic packaging to be recovered, or even fibreglass.

[0013] The plant **1** and the relative operation and/or use process are particularly suitable for grinding, shredding, chopping, cutting, pulverising or micronising the material to be processed.

[0014] The plant **1** comprises a grinding cell **3** in turn comprising a grinding container **5** which forms a grinding chamber **7** therein.

[0015] The grinding cell **3** further comprises a rotor **9** at least partially contained in the grinding chamber **7.**

[0016] The portion of the rotor **9** contained in the grinding chamber **7** forms a plurality of processing arms **11** which may extend into the grinding chamber **7** to form, for example, a star.

[0017] The rotor **9** and its processing arms **11** are configured for rotating with respect to the rest of the grinding chamber **7** around a predetermined axis of rotation **AXR** in order to grind, cut, chop, shred or micronise the material to be processed contained in the grinding chamber **7.**

[0018] The rotor **9** may comprise, for example, a main shaft **17** to which the processing arms **11** are attached and from which they extend.

[0019] The main shaft **17** may for example be coaxial or otherwise parallel to the axis of rotation **AXR.**

[0020] The arms **11** preferably extend substantially perpendicular or otherwise transverse to the main shaft **17**, and extend, for example, in a star or radial pattern from it (Figure **3**, **4**).

[0021] The plant 1 further comprises:

- a feeding system **13** configured for feeding the material to be processed into the grinding chamber **7**; and
- a control system configured for controlling the feeding system **13** based on the resistant torque opposing the rotation of the rotor **9** in the grinding chamber and/or based on the rotation speed of the rotor **9** and/or based on the power required to drive the rotor **9.**

[0022] The control system may comprise, for example, a logic unit, in turn comprising a microprocessor or a PLC (Programmable Logic Controller).

[0023] The feeding system **13** may comprise, for example, a hopper **130**, **130'** and an Archimedes screw or auger **132** at least partially contained in the hopper **130** (Figure **1**, 7) .

[0024] The hopper **130**, **130'** or, more generally, the feeding system **13** may be configured for feeding the material to be processed into the grinding chamber **7** for example through one or more inlets **133** (Figure **2**, **7**) which open, for example, at the top or otherwise at the upper part of the chamber **7** itself.

[0025] Advantageously, each inlet port **133** is arranged substantially vertically, or at least above, the cutting edge trajectory of one or more blades **11** so as to anticipate the cutting and mincing by the blades of the material to be ground falling from the ports **133.**

[0026] During normal operation the auger **132** may be arranged substantially vertically and be configured for rotating on itself e.g. around a vertical axis **AXC** (Figure **1**); as for example in embodiments not shown the auger **132** may be configured for rotating around a non-vertical axis **AXC**, for example around a substantially horizontal axis **AXC** or inclined about **45°** with respect to the horizontal.

[0027] Still, as for example in embodiments not shown, the auger **132** may rotate within a feeding chamber, even different from a hopper and for example comprising a tube, channel or other conduit arranged for example substantially horizontally or inclined but not vertical.

[0028] The auger **132** and its axis of rotation **AXC** may more generally extend from the top to the bottom.

[0029] Each auger **132** is preferably driven by a respective motor (not shown), such as preferably an electric, hydraulic or pneumatic motor.

[0030] The rotor **9** is preferably driven by a respective motor **15**, which may for example be an electric, hydraulic or pneumatic motor.

[0031] Advantageously, the control system is configured for increasing the introduction of new material to be processed into the grinding chamber **7** via the feeder when:

- the resistant torque opposing the rotation of the rotor **9** falls to or below a predetermined torque activation threshold; and/or
- the rotation speed of the rotor **9** increases to or above a predetermined speed activation threshold; and/or
- the electrical power absorbed by the motor **15** falls to or below a predetermined activation threshold.

[0032] These thresholds can be adapted to the size of the plant and the type of waste or more generally of material to be processed.

[0033] For example, the aforesaid power activation threshold may be between **0.5-1.5** times the nominal, i.e. nameplate, power of the motor **15,** or between **0.8-1.3** times, between **1-1.2** times, between **1.1-1.18** times the nominal power of the motor **15.**

[0034] In order to process for example unsorted municipal waste, vegetable biomass or plastic waste, this speed activation threshold can be between **1300-2000** rpm (revolutions per minute), or between **1500-1900** rpm, between **1600-1800** rpm, between **1300-1500** rpm or between **1200-1400** rpm.

[0035] "Increasing the introduction of new material to be processed" means to start introducing material to be processed if, at a previous instant or period of time, no material to be processed was being introduced into the grinding chamber -for example by activating the auger **132** if it was switched off- or to introduce material to be processed faster, or in greater quantity per unit of time if, at a previous instant or period of time, the material was already being introduced into the grinding chamber **7,** for example by increasing the rotation speed of the auger **132** if it was already running.

[0036] Preferably, for this purpose, the control system is configured for detecting the resistant torque and/or the rotation speed of the motor **15** or more generally of the rotor **9**, or to detect the power -for example electric power- absorbed by the electric motor **15.**

[0037] If the motor **15** is electric, the control system can be configured for detecting the resistant torque opposing the rotation of the rotor **9** by detecting -that is, by measuring directly or deriving more or less indirectly- the current travelling through the stator and/or rotor windings of the motor **15**, depending on which type of motor it is, or to detect the rotation speed of the rotor **9** or the power -for example, electric power-absorbed by the motor **15.**

[0038] If the motor **15** is hydraulic or pneumatic, the control system may be configured for detecting the resistant torque opposing the rotation of the rotor **9** by detecting, for example, the pressure of the hydraulic oil or compressed air at the inlet port of the motor, immediately upstream thereof or in any case at a point in the high pressure zone of its inner hydraulic and/or pneumatic circuits, and/or the difference in pressure between two points immediately upstream of the inlet port of the engine and immediately downstream of its outlet port, the difference in pressure between two points at the feed and outlet ports of the engine, or the difference between two points of the high and low pressure zones of its inner hydraulic and/or pneumatic circuits, or may be configured for detecting the power absorbed by the engine **15** itself.

[0039] As an alternative to or in combination with the above, the control system may comprise one or more sensors configured for detecting forces, pressures and/or driving torques applied to the rotor **9** and/or internal thereto, for example torque transducers or load cells attached to the main shaft **17** and configured for detecting drive or resistant torques applied to it, or torsional stresses or forces internal thereto.

[0040] As an alternative or in combination with the above, the control system may be configured for detecting the rotation speed of the rotor **9** and/or the output shaft of the motor **15** driving the rotor **9.**

[0041] For this purpose, the plant or other device **1** may be provided with encoders, resolvers, tachometers, accelerometers, rev counters or other speed or position sensors -for example speed or angular position-configured for detecting the rotation speed or angular position of the rotor **9** and/or the output shaft of the motor **15** driving the rotor **9**.

[0042] These readings of torques, rotation speeds and/or powers are preferably carried out continuously and in real time; they may be analogue or sampled readings.

[0043] As an alternative to or in combination with the foregoing, the control system may comprise one or more communication interfaces configured for providing acoustic or visual indications of the above-mentioned torques, rotation speeds of the rotor **9** and/or powers absorbed by the rotor **9** to a user or operator of the device **1.**

[0044] These communication interfaces may comprise, for example, visual displays, warning lights or acoustic indicators, loudspeakers, buzzers, dials with pointers or sliders, printers, plotters, mechanical nibs displaying numerical and/or graphical indications of torque, speed and/or power detected values.

[0045] These visual displays may be for example LED (Light Emitting Diodes), liquid crystal (LCT) or cathode ray tube displays.

[0046] These visual displays, printers, plotters or mechanical nibs may be configured for displaying graphs or other trends over time of the measured torques, speeds and/or powers, making it possible for an operator to intervene appropriately on the device **1** for example by activating or deactivating the motor **15** or increasing or decreasing its rotation speed, torque output and/or power absorbed.

[0047] As an alternative or in combination with the foregoing, these communication interfaces can be programmed or otherwise configured for signalling when the detected torques, speeds and/or powers are approaching, reaching or exceeding their respective activation threshold values or higher, signalling to the operator that intervention is required.

[0048] The control system may possibly comprise one or more of said communication interfaces and be without a PLC or other logical unit configured for automatically varying the speed, torque output and/or mechanical power absorbed by the motor **15** or more generally by the rotor **9.**

[0049] Preferably, the control system is configured for reducing the introduction of new material to be processed into the grinding chamber **7** via the feeder when:

- the resistant torque opposing the rotation of the rotor **9** increases to or above a predetermined torque activation threshold; and/or
- the rotation speed of the rotor **9** decreases to or below a predetermined speed activation threshold.

[0050] "Reducing the introduction of new material to be processed" means to stop introducing material to be processed if, at an earlier time or period, it was already being introduced into the grinding chamber -for example by stopping or deactivating the auger **132** if it was already running- or to introduce material to be processed more slowly, or in a lower amount per unit of time if, at an earlier time or period, the material was already being introduced into the grinding chamber **7**, for example by reducing the speed of rotation of the auger if it was already running.

[0051] The control system can control the feeder based on the resistant torque opposing the rotation of the rotor in the grinding chamber and/or based on the rotation speed of the rotor with one or more of the following control methods: all-or-nothing control or bang-bang or **0-1** control, feedback control for example of the proportional, integrative, derivative, proportional-integrative-derivative type, adaptive control, control via *look-up table,* control via neural network.

[0052] Preferably at least part of the processing arms **11** comprises a blade configured for chopping, shredding or otherwise cutting the material to be processed.

[0053] Each blade **11** has at least one cutting edge **110,** i.e. one substantially sharpened cutting flank, and more preferably two cutting edges **110**, i.e. two sharpened flanks located on opposite sides of the blade **11.**

[0054] More preferably, all of the processing arms **11** comprise a substantially sharp blade; however, in embodiments not shown at least part of the arms **11** may form hammers or mallets that are substantially non-cutting and configured for grinding the material to be processed predominantly by impacting and crushing it rather than by cutting it; in this second case, each hammer or mallet may be substantially in the form of a beam, peg or stick whose sides are at least predominantly free of sharp surfaces, for example because their minimum radius of curvature over most of the length of the hammers or mallets is equal to or greater than **5** millimetres, and more preferably equal to or greater than **10**, **20**, **30**, **40**, **50**, **60** or **70** millimetres.

[0055] Preferably, the grinding chamber has an inner diameter **DCM** between **1-2** metres or between **1.2-1.6** metres or between **1.2-1.4** metres and/or an inner height **HCM** between **0.5-1.5** metres or between **0.7-1.2** metres or between **0.8-0.9** metres.

[0056] Each blade **11** can have an overall and substantially oblong shape (Figure **3**, **4**).

[0057] Each blade **11**, or at least its cutting section, can have a length **LLM** for example between **0.2-0.5** metres, or between **0.25-0.35** metres or between **0.27-0.345** metres (Figure **4**) and/or a width **WLM** for example between **4-15** centimetres, or between **6-12** centimetres, between **7-9** centimetres, between **7.7-8.5** centimetres and for example of approximately **8** centimetres.

[0058] The length **LLM** may be, for example, between **0.2-1** metres, or between **0.3-0.5** metres or between **0.3-0.4** metres or between **0.3-0.38** metres.

[0059] The minimum distance of the ends of the blades **11** from the inner walls of the grinding chamber **7** is preferably equal to or lower than **0.1** times the inner diameter of the chamber **7** at the blade concerned; more preferably this minimum distance is equal to or lower than **0.05** times, **0.03** times, **0.02** times or **0.017** times the inner diameter of the chamber **7.**

[0060] This minimum distance may be, for example, **0.01-0.02** times the inner diameter of the chamber **7.**

[0061] These minimum distances help to increase the grinding efficiency and make it easier to release the rotor if it gets stuck in the chamber **7**, for example during maintenance operations.

[0062] Each blade **11** may have substantially parallel cutting flanks or tapered flanks (Figures **3**, **4**), for example, so that the blade narrows ideally approaching its tip or free end.

[0063] Advantageously, the rotor **9** comprises a plurality of blades **11** arranged on several levels, for example on four different levels (Figure **2**), or on two, three, five, seven, eight, nine or ten or more levels.

[0064] Four blades (Figure **3**, **4**), or two to seven blades, three to six blades, five or eight blades can, for example, be arranged on each level.

[0065] For this purpose, the blades **11** are fixed along a section of the main shaft **17** or in any case of the rotor **9** extending over a length **HAL**, parallel to the axis of rotation **AXR**, preferably between **0.2-0.9** times the average inner diameter of the grinding chamber **7**, and more preferably between **0.3-0.7** times, between **0.4-0.5** times or between **0.6-0.8** times the average inner diameter of the grinding chamber **7.**

[0066] The length HAL is preferably between **20-100** centimetres or between **30-60** centimetres or between **30-38** centimetres.

[0067] The motor **15** preferably has a nominal power preferably equal to or higher than **75** kW (kilowatts), more preferably of **80** kW, **85** kW or **90** kW, and for example between **75-150** kW, **80-120** kW, **80-90** kW or **85-95** kW

[0068] The motor **15** is configured for rotating the rotor **9** at a speed preferably between **1600-1800** rpm (revolutions per minute).

[0069] Advantageously, the rotor **9** is provided with a bottom wall **19** having the overall shape of a substantially flat disc or plate, which is integral with the rest of the rotor **9** and which, lying overall in a plane perpendicular or in any case transverse to the axis of rotation **AXR** and/or the shaft **17,** closes the grinding chamber **7** at the bottom (Figures **4**, **5**).

[0070] The bottom wall **19** helps to support and keep the fluff or other ground material suspended in the air by centrifugal force

[0071] Still to support and keep the ground particles in flight or being ground, the inner walls of the grinding chamber **7** form one or more radial protrusions **70** (Figure **6**).

[0072] Preferably, the grinding chamber **7** is provided with two radial projections, arranged diametrically opposite to the axis of rotation **AXR.**

[0073] Each radial projection **70** has an angular extension preferably between **15-45** degrees, and more preferably between **20-30** degrees or between **25-28** degrees, where this extension refers to the angle subtended by the radial projection **70** and having its vertex in the axis **AXR.**

[0074] Each projection **70** protrudes radially from the rest of the inner wall of the chamber **7** towards the inside of the chamber **7** by a radial extension preferably between **10-80** millimetres or between **20-50** millimetres.

[0075] The radial protrusions **70** mainly direct the bounces of ground particles upwards.

[0076] By rotating together with the rest of the rotor 9 the bottom wall **19** facilitates the discharge of the ground material from the grinding chamber **7,** for example through one or more extraction openings formed in the lower part of the grinding chamber **7,** for example at the bottom wall **19.**

[0077] This extraction opening may advantageously be a single slot interposed between the lower edges of the side walls of the grinding chamber **7** and the bottom wall **19,** running along the entire perimeter of certain cross-sections of the grinding chamber **7.**

[0078] Preferably during normal operation and use, the axis of rotation of the rotor **AXR** is kept substantially vertical, or preferably extends along an up-down direction.

[0079] An example of a possible use and operation of the plant **1** is now described.

[0080] The hopper **130** is loaded with the automotive fluff or other material to be processed, which has already been coarsely crushed in advance - for example automotive fluff and plasmix are preferably introduced into the grinding chamber **7** at an average size between **40-80** millimetres- just enough to be moved and advanced into a hopper, for example, by means of the auger **132.**

[0081] By rotating on itself and around its own axis **AXC** the auger **132** advances the fluff or other material to be processed towards the bottom or otherwise the outlet port of the auger **130** causing it to fall -or in any case introducing it- into the grinding chamber **7.**

[0082] By rotating on itself and around its axis **AXR,** the rotor **9** grinds the material to be processed, for example by cutting and chopping it with the blades **11.** Preferably the blades **11** and more generally the rotor **9** grind by means of shock and shear.

[0083] When it detects that the resistant torque on the rotor **9,** the drive torque output by the motor **15** or the power absorbed by the motor **1** reaches or falls below the relevant torque or power activation threshold, or detects that the rotation speed of the rotor **9** and/or motor **15** reaches or exceeds the relative speed activation threshold, an operator or the automatic control system -for example, the aforementioned PLC or other logic unit- can activate each auger **132,** if it was previously inactive, or can increase its rotation speed if it was already active.

[0084] When, on the other hand, it detects that the resistant torque on the rotor **9,** the drive torque output by the motor **15** or the power absorbed by the motor **1** reaches or is above the relative torque or power activation threshold, or detects that the rotation speed of the rotor **9** and/or motor **15** reaches or is below the relative speed activation threshold, the operator or the automatic control system can, for example, keep each auger **132** active if it was already previously active, or keep it inactive if it was already previously inactive.

[0085] This ensures that an appropriate amount of waste or other material to be processed is constantly present in the grinding chamber and that the rotor **9** and more generally the grinding cell **3** operate under optimal conditions or in any case without the grinding chamber being excessively empty, thus increasing the performance and efficiency of the grinding cell **3.**

In particular, it prevents the rotor **9** from rotating at or near idle speed.

[0086] Furthermore, thanks to the control system described above, as the grinding chamber **7** is generally fuller during grinding, the rotor **9** is able to grind, reducing the fluff or other material to the desired particle size or other size, by rotating at lower speeds than grinding plants without such a grinding system; this in turn results in lower energy consumption by the motor **15** and more generally by the grinding cell **3,** shorter grinding times with the same size and quality of the ground material obtained, low maintenance costs thanks to the ease of intervention in the blade and plate replacement steps, ease and precision in adjusting the above-mentioned activation thresholds and parameters regulating speed, torque output and power of the augers **132** and, more generally, the loading according to the characteristics of the waste or others to be processed, for example based on moisture, specific weight, and the size of the outgoing ground material.

[0087] For example, all other things being equal, in order to grind and reduce a given material to be processed to a given size, the grinding plant **1** with the control system deactivated must rotate at **1600-1800** rmp (revolutions per minute) while with the control system activated, the rotor can rotate at **1100** rpm.

[0088] The grinding plant **1** is preferably used to grind without adding into the grinding chamber free grinding bodies such as balls or pebbles made of metal, stone, ceramic or other materials harder than waste or other material to be processed, and in particular without throwing these free grinding bodies into the grinding chamber **7** by hitting them with the arms **11** or other parts of the rotor **9**.

[0089] The embodiments described above are susceptible to numerous modifications and variants, without departing from the scope of the present invention.

[0090] For example, a plant **1**, **1**' according to the present invention may comprise an indefinite number of grinding cells **3** and associated feeding systems **13**, such as one, two (Figure **1**), three, four, five, six, ten or more feeding cells **3** and/or feeding systems **13**.

[0091] The feeding system **13** can be configured for feeding the relevant grinding cell substantially continuously or in batch operation.

[0092] As for example shown in Figure **7**, the hopper **130**' may also comprise two or more augers **132** configured for introducing into the same grinding chamber **7** the waste or other material to be processed by means of a plurality of respective feeding ports **133** (Figure **7**) : this solution makes it possible to distribute the material to be processed more evenly in the grinding chamber, in particular by distributing it more evenly over the blade assembly **11** improving the grinding efficiency and ensuring a continuous or otherwise more regular feeding.

[0093] A grinding plant according to an embodiment not shown may be provided with a plurality of hoppers which feed the same grinding cell in parallel, and each hopper may be provided with a single auger **132.**

[0094] In embodiments not shown, the feeding system **13** may comprise, for example, a feeding chamber and a piston, slide valve or other pusher configured for sliding in and along the feeding chamber, or a hopper and a piston, slide valve or other pusher that pushes the material to be processed towards the bottom or otherwise towards the hopper outlet, or a tilting skip loader or vibrating tray system.

[0095] The control system may be configured for controlling the motor **15** not only by an all-or-nothing or on/off or bang-bang control method such as those described above, in which the motor **15** is simply activated or deactivated based on reaching or exceeding a predetermined activation threshold, but can also be configured for varying the rotation speed of each auger **132** and the motor torque driving it continuously or by making it take on not only two possible values but more than two, for example four, eight, sixteen, **32**, **64**, **128** and more than one hundred or one thousand possible values, thus realising a control strategy that is not only zero/one but also by means of continuous, analogue, or more finely discretised - i.e. quantized - variables.

[0096] Every reference in this description to "an embodiment", "an example of embodiment" means that a particular characteristic or structure described in relation to such embodiment is comprised in at least one embodiment of the invention and in particular in a particular variant of the invention as defined in a main claim.

[0097] The fact that such expressions appear in various passages of the description does not imply that they are necessarily referred solely to the same embodiment.

[0098] In addition, when a feature, element or structure is described in relation to a particular embodiment, it is observed that it is within the competence of the person skilled in the art to apply such feature, element or structure to other embodiments.

[0099] Numerical references which only differ in terms of different superscripts **21', 21", 21**^{III} unless specified otherwise indicate different variants of an element with the same name.

[0100] Furthermore, all of the details can be replaced by technically equivalent elements.

[0101] In practice, the materials used, as well as the dimensions thereof, can be of any type according to the technical requirements.

[0102] It must be understood that an expression of the type "A *comprises* B, C, D" or "A *is formed by* B, C, D" also comprises and describes the particular case in which "A *consists of* B, C, D".

[0103] The expression "*A comprises a B element*" unless otherwise specified is to be understood as "*A comprises one or more elements B".*

[0104] References to a "first, second, third, ... n-th entity" have the sole purpose of distinguishing them from each other but the indication of the n-th entity does not necessarily imply the existence of the first, second ... (n-**1**)th entity.

[0105] The examples and lists of possible variants of the present application are to be construed as non-exhaustive lists.

Claims

1. Grinding device (**1**, **1**') comprising a grinding container (**5**) which forms inside it a grinding chamber (**7**), a rotor (**9**) at least partially contained within the grinding chamber (**7**), and wherein

    - the portion of the rotor (**9**) contained in the grinding chamber (**7**) forms a plurality of processing arms (**11**);
    - the rotor (**9**) and its processing arms (**11**) are configured for rotating with respect to the rest of the grinding chamber (**7**) around a predetermined axis of rotation (**AXR**) in order to grind, cut, chop, shred or micronise the material to be processed contained in the grinding chamber (**7**);
    - a feeding system (**13**) configured for feeding the material to be processed into the grinding chamber (**7**);
    - a control system configured for controlling the feeder (**13**) based on:

        - the resistant torque opposing the rotation of the rotor (**9**) in the grinding chamber (**7**); and/or
        the base of the same rotation speed of the rotor (**9**); and/or
        - the power required to drive the rotor (**9**).

2. Grinding device (**1**) according to claim **1**, wherein the control system is configured for increasing the introduction of new material to be processed into the grinding chamber (**7**) via the feeder when:

    - the resistant torque opposing the rotation of the rotor drops up to or below, or is at or below a predetermined torque activation threshold; and/or
    - the rotation speed of the rotor (**9**) increases up to or above, or is at or above a predetermined speed activation threshold; and/or
    - the power required to drive the rotor (**9**) drops up to or below, or is at or below a predetermined power activation threshold.

3. Grinding device (**1**) according to claim **1** or **2**, wherein the control system is configured for reducing, for example automatically, the introduction of new material to be processed into the grinding chamber (**7**) via the feeder when:

    - the resistant torque opposing the rotation of the rotor increases up to or above, or is at or above a predetermined torque activation threshold; and/or
    - the rotation speed of the rotor (**9**) decreases up to or below, or is at or below a predetermined speed activation threshold; and/or
    - the power required to drive the rotor (**9**) increases up to or above, or is at or above a predetermined power activation threshold.

4. Grinding device (**1**) according to one or more of the preceding claims, wherein the rotor (**9**) is driven and set into rotation by a motor (**15**) and the control system is configured for detect the resistant torque opposing the rotation of the rotor (**9**), the rotation speed

of the rotor (**9**) and/or the power required to drive the rotor (**9**) by detecting one or more of the following physical quantities

- the current flowing through the stator or rotor windings of the motor (**15**);
- the current that powers the motor (**15**) if it is electric.

5. Grinding device (**1**) according to one or more of the preceding claims, wherein the rotor (**9**) is driven and set into rotation by a motor (**15**) and the control system is configured for detecting the resistant torque opposing the rotation of the rotor (**9**) by means of one or more of the following sensors mounted on the rotor (**9**), on the output shaft of the motor (**15**) and/or on a coupling connecting said shaft to the rotor (**9**) : a torque transducer, a torque sensor or transducer, a load cell or other force sensor.

6. Grinding device (**1**) according to one or more of the preceding claims, wherein the feeding system (**13**) comprises an auger (**132**) and a relative motor that drives it by rotating it, and the control system is configured for controlling the rotation speed of the auger (**132**) based on one or more of the following quantities: the resistant torque opposing the rotation of the rotor (**9**) in the grinding chamber (**7**), the same rotation speed of the rotor (**9**), the power required to drive the rotor (**9**).

7. Grinding device (**1**) according to one or more of the preceding claims, wherein at least part of the processing arms (**11**) or possibly all of them comprise blades or other cutting parts configured for grinding, cutting, chopping, shredding or micronising the material to be processed with which they come into contact in the grinding chamber (**7**).

8. Grinding device (**1**) according to one or more of the preceding claims, wherein at least part of the processing arms (**11**) are disposed substantially star-shaped around the predetermined axis of rotation (**AXR**).

9. Grinding device (**1**) at least according to claim **7**, wherein at least part of the processing arms (**11**) are disposed at different levels along the predetermined axis of rotation (**AXR**).

10. Grinding device (**1**) at least according to claim **7**, wherein the processing arms (**11**) are fixed along a section of the axis of rotation (**AXR**) of the rotor (**9)** extending over a length (**HAL**) between **30-38** centimetres and/or between **0.2-0.6** times or between **0.25-0.58** times and for example equal to or greater than **3.5** times the average inner diameter of the grinding chamber (**7)**.

11. Process for grinding a material to be processed, comprising the following operations:

S.**1**) providing a grinding device (**1**) according to one or more of the preceding claims;
S.**2**) grinding in the grinding device (**1**) the material to be processed, which comprises one or more of the following materials: municipal waste e.g. organic, unsorted, of plastics, mowing, waste from pruning or hedge cutting, textiles, non-woven fabrics, fibrous materials, felts, wadding, plastic or metallic films, furniture and its stuffing, paper, cardboard, wood, automotive fluff and other non-metallic waste materials coming from the demolition of cars, trucks, buses, railway carriages and other motor vehicles, aircraft or boats such as for example plastic parts, seat padding, other foamed plastic components, fabrics, plasmix, fibreglass, sweeping earths.

12. Process according to claim **11**, comprising the operation of grinding the material to be processed by rotating the rotor (**9**) at a speed between **1600**-**1800** rpm.

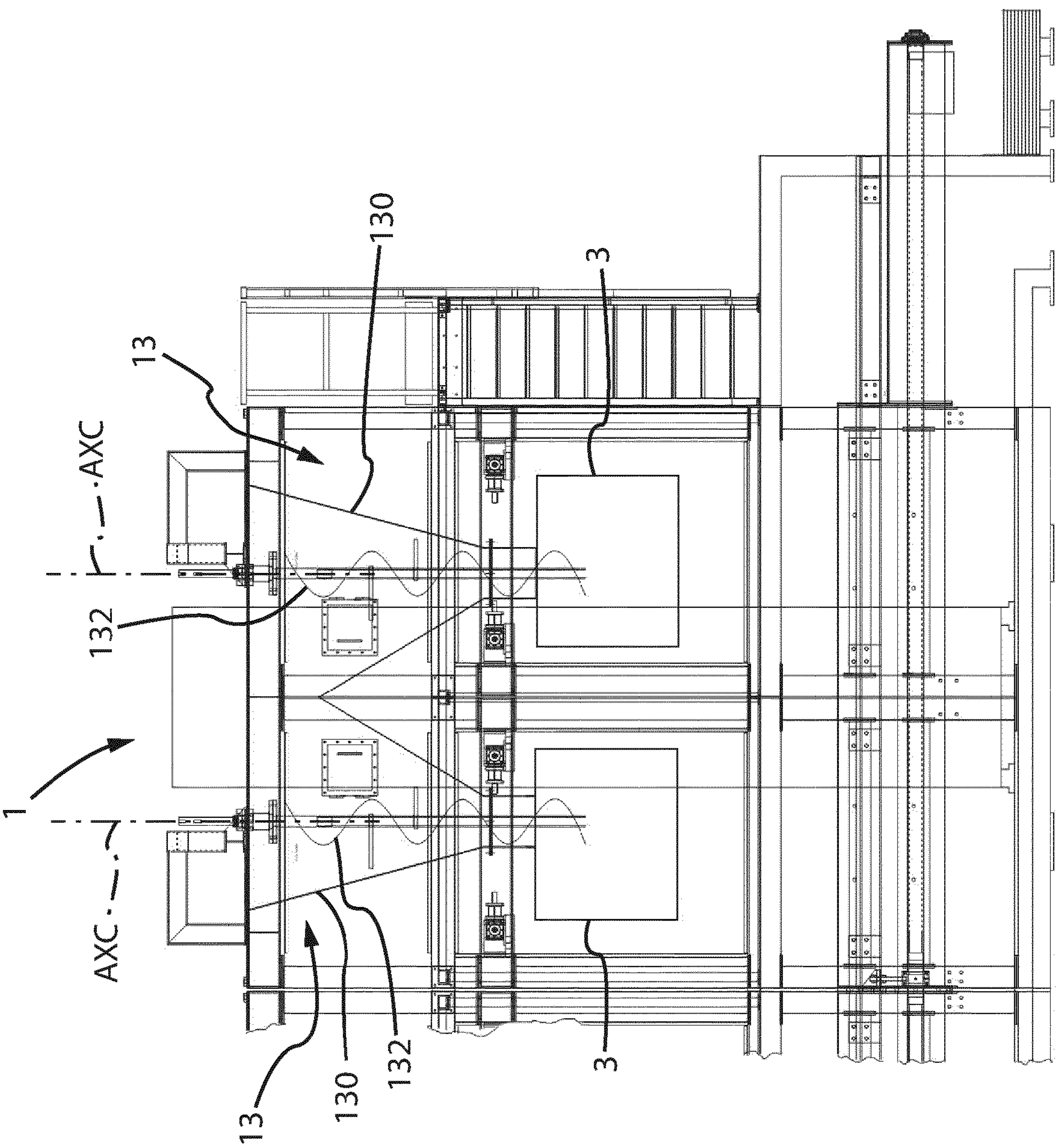

Fig. 1

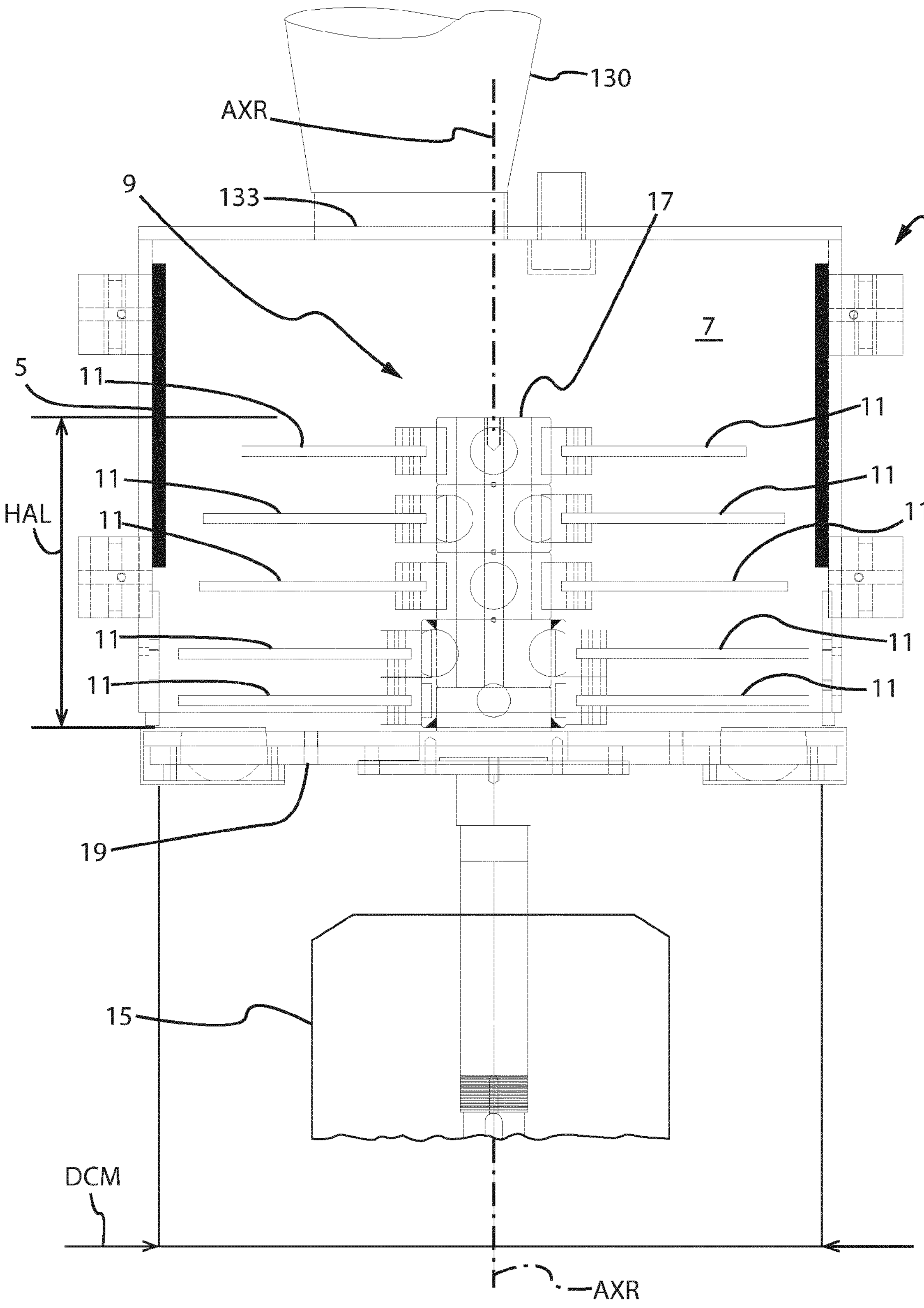

Fig. 2

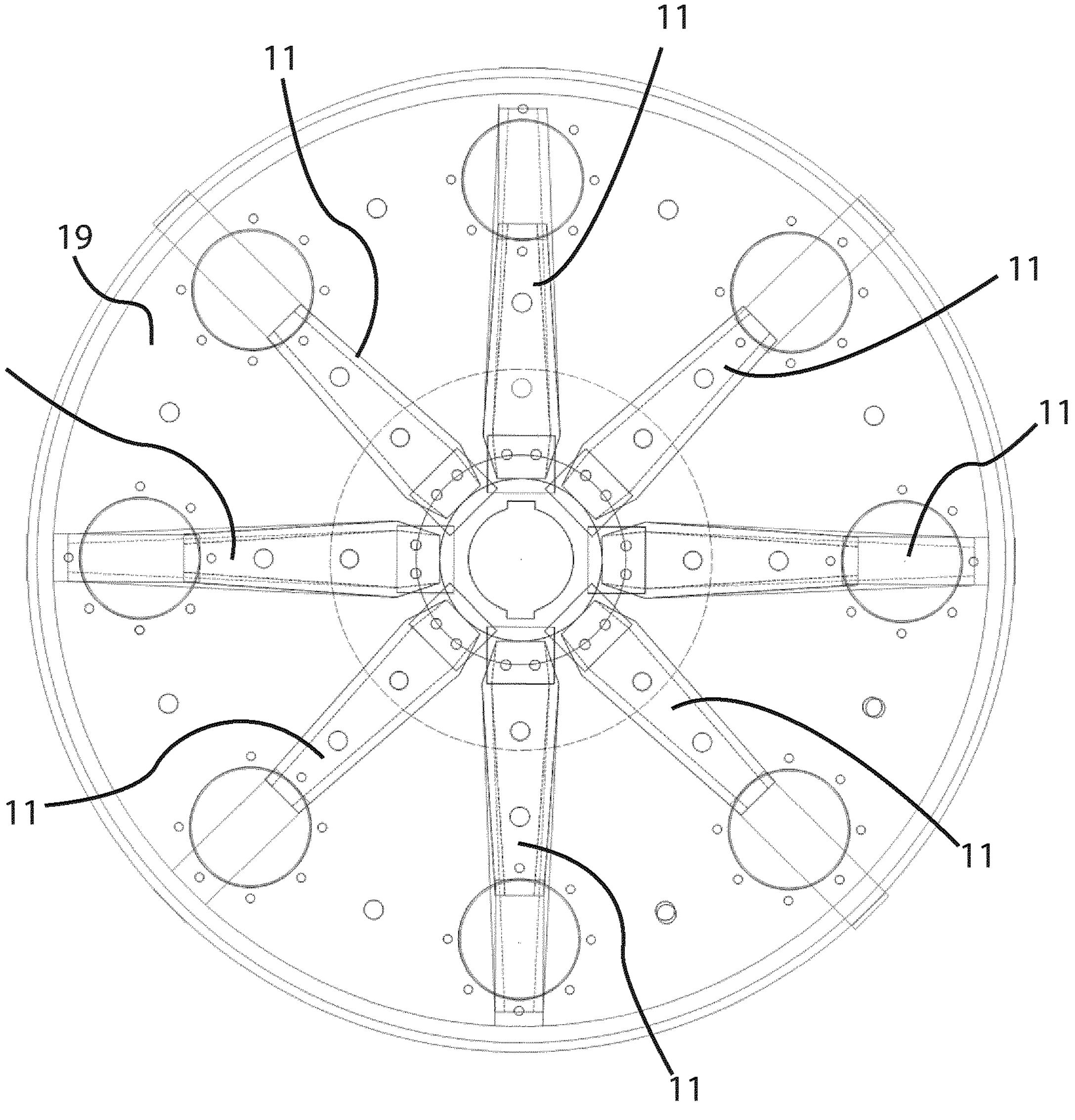

Fig. 3

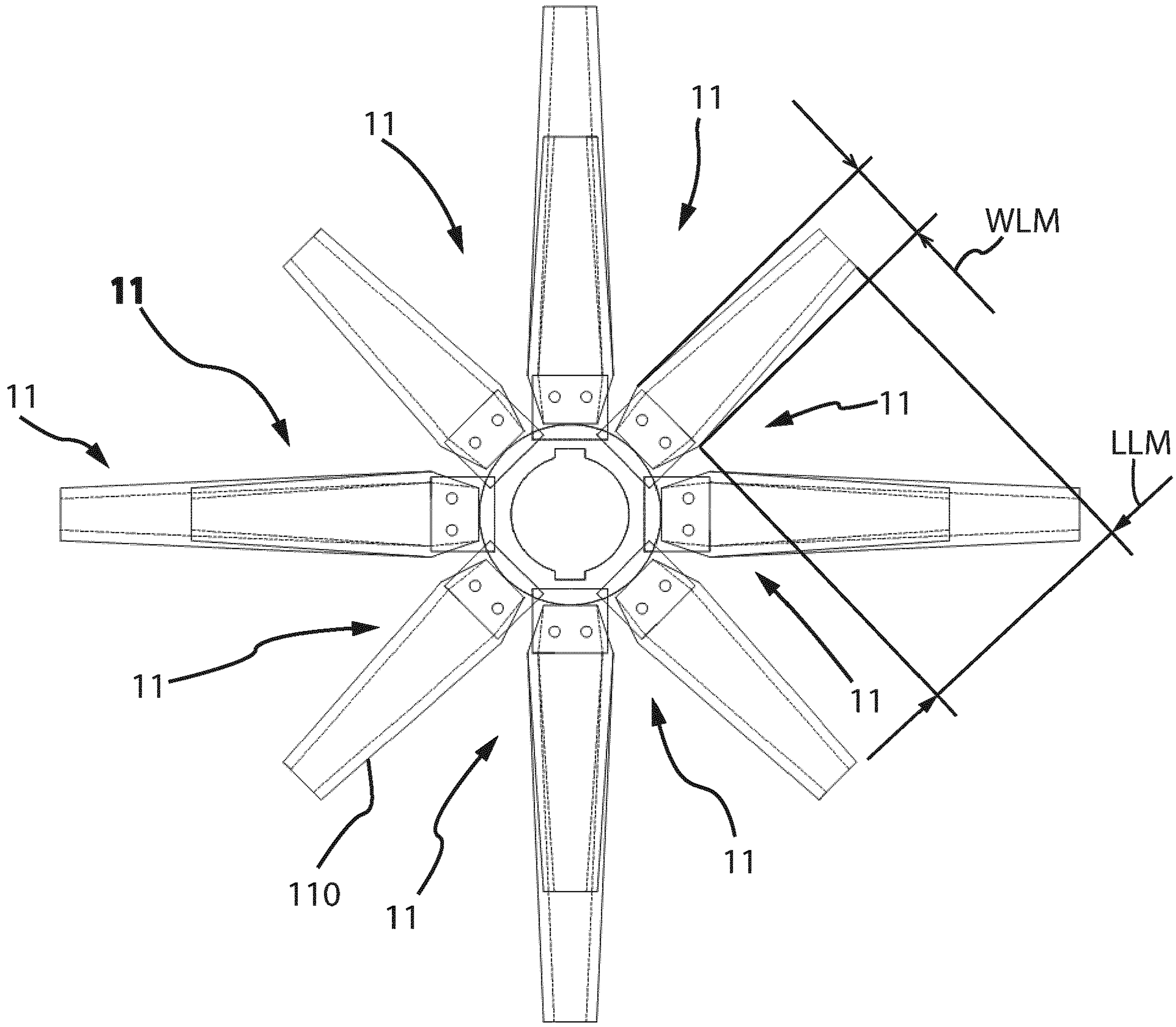

Fig. 4

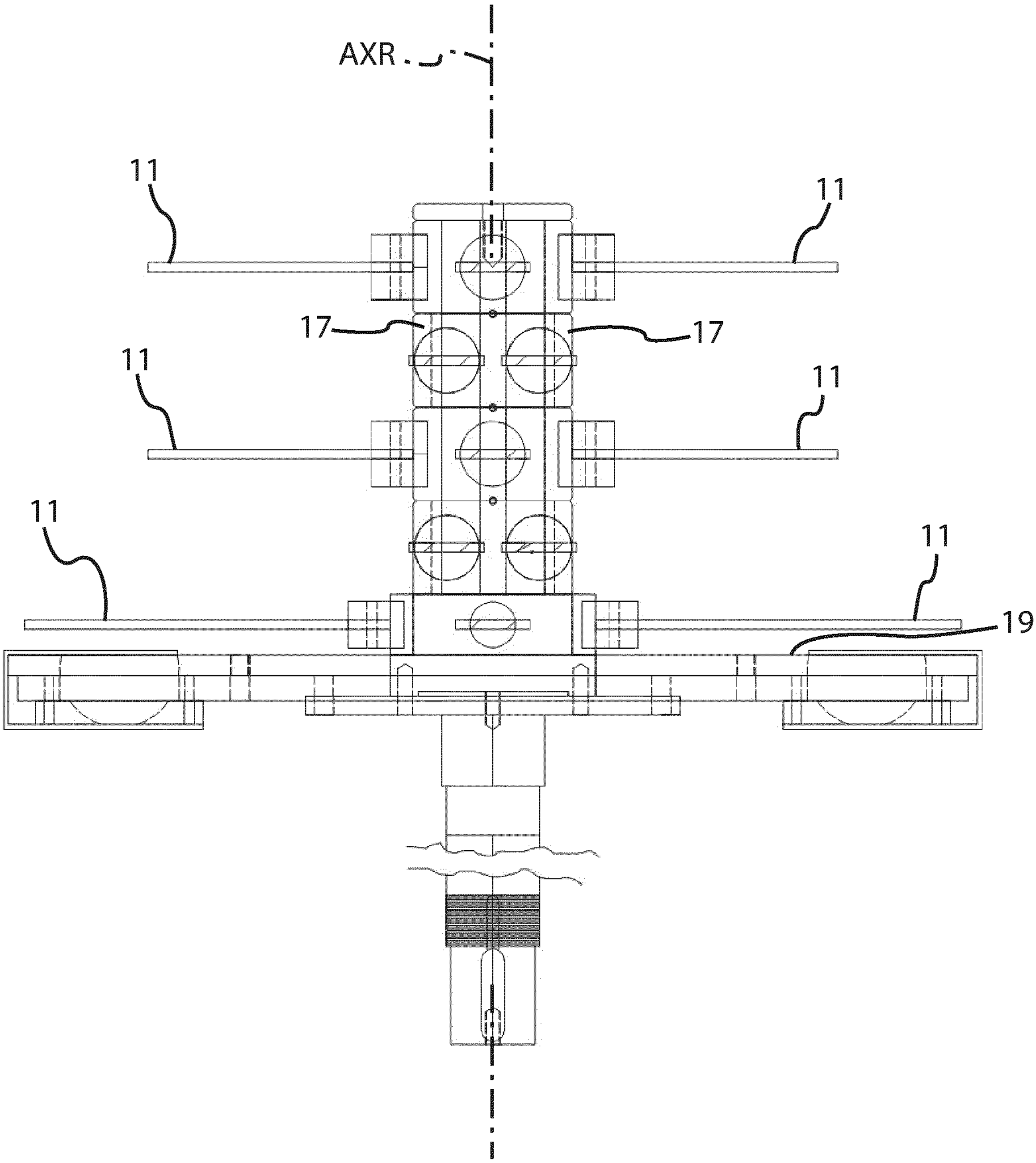

Fig. 5

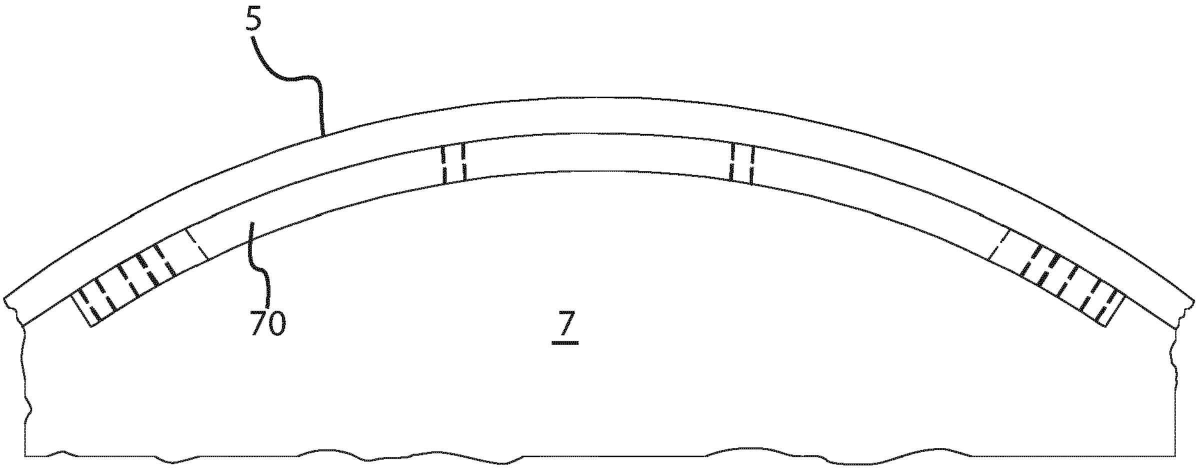

Fig. 6

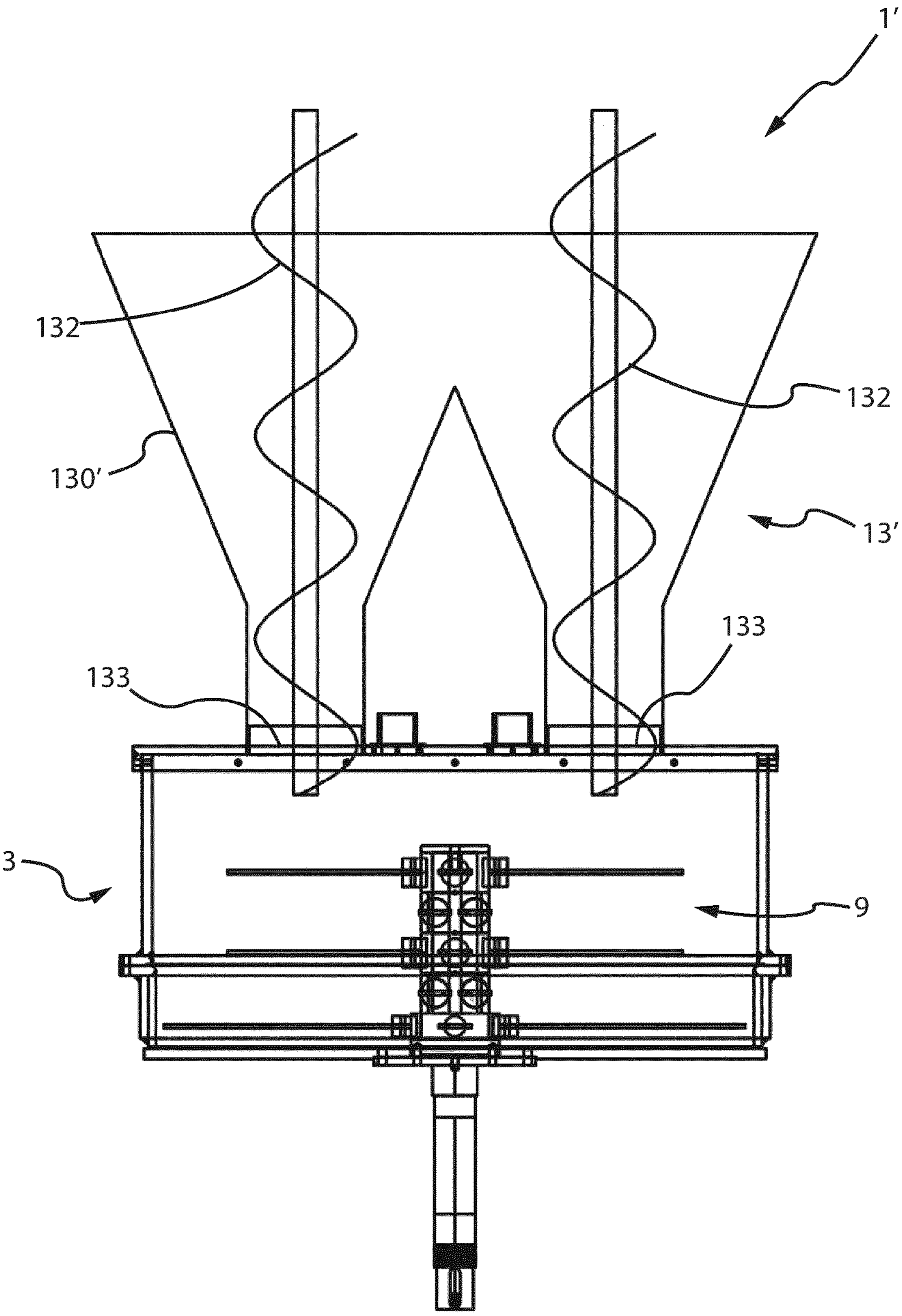

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 24 16 2437

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 10 2011 014219 A1 (HUNING MASCHB GMBH [DE]) 20 September 2012 (2012-09-20) * paragraphs [0001] - [0005], [0023]; figures 1,2,5,7 *	1-4,6-12 5	INV. B02C18/12 B02C18/16 B02C18/18 B02C18/22 B02C18/24 B02C25/00
X Y	EP 2 749 360 A1 (KYORITSU INDUSTRY CO LTD [JP]; KYORITSU CO LTD [JP]) 2 July 2014 (2014-07-02) * paragraphs [0003], [0004], [0006], [0047], [0055], [0067], [0068]; figures 1,4,5,8,9,10,12-18 *	1-5,7,8,11,12 5	
X Y	US 3 964 720 A (MAST AQUILA D) 22 June 1976 (1976-06-22) * column 1, lines 7-11; figures 1,6 * * column 6, line 24 - line 43 *	1-4,6-12 5	
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			B02C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 May 2024	Pössinger, Tobias

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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16-05-2024

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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