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

(11) **EP 4 389 287 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.06.2024 Bulletin 2024/26

(21) Application number: **23216193.5**

(22) Date of filing: **13.12.2023**

(51) International Patent Classification (IPC):
B02C 17/18 *(2006.01)* ***B02C 17/10*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B02C 17/1805; B02C 17/1875; B02C 17/10

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

(30) Priority: **20.12.2022 IT 202200026127**

(71) Applicant: **Certech S.p.a**
41049 Sassuolo (Modena) (IT)

(72) Inventor: **PELLINI, Claudio**
41042 FIORANO MODENESE (IT)

(74) Representative: **Casadei, Giovanni**
Bugnion S.p.A.
Via Vellani Marchi, 20
41124 Modena (IT)

(54) INJECTING AIR INTO CONTINOUS MILL

(57) Continuous mill with compressed-air injection device for grinding ceramic powder in a water solution (slip), comprising: a hollow body (1), rotating about a rotation axis (X) through the action of a motor (3), a predefined mass of grinding bodies (6) contained inside the hollow body (1), an inlet conduit (4) and an outlet opening (7) for the slip, characterised in that it comprises a compressed-air injection device (11) to stabilise the volume of air and slip inside the mill, situated upstream of the hollow body (1); a continuous mill comprising a control system (15,16) for detecting the power input of the motor (3), which determines different actions depending on the detected power input value.

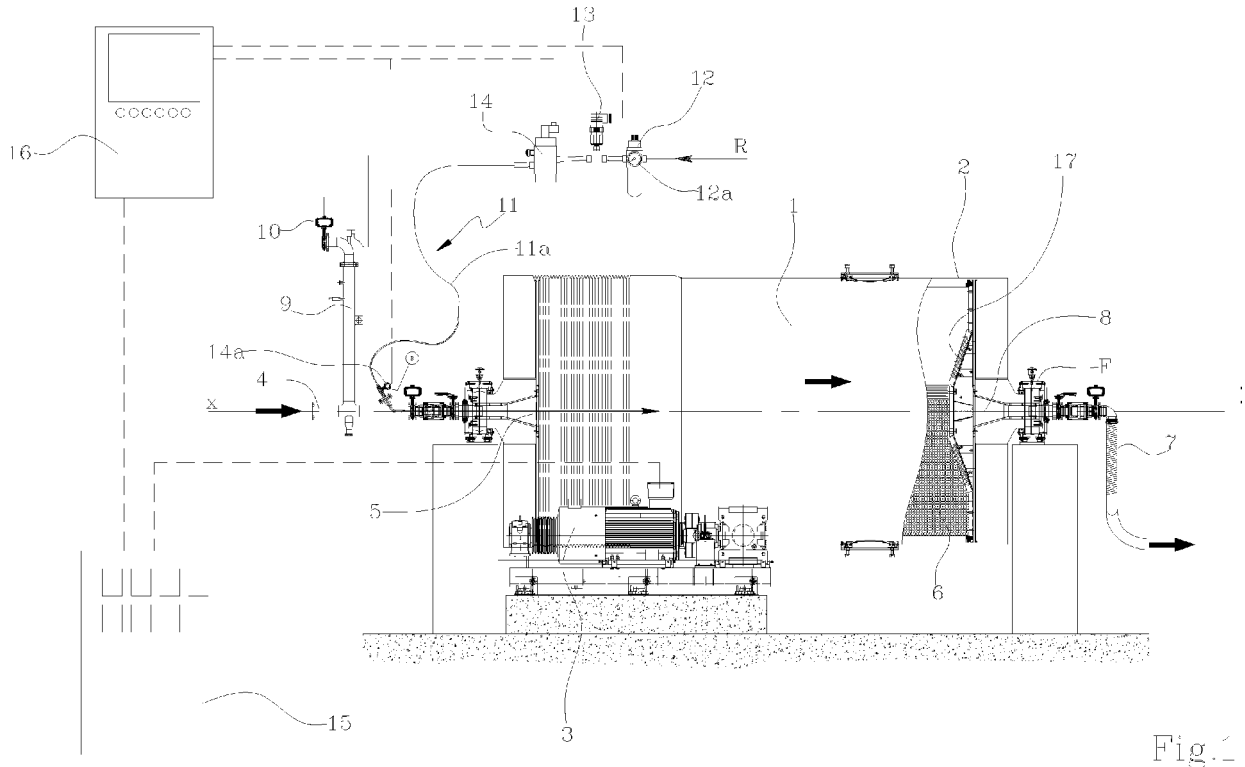

Fig. 1

EP 4 389 287 A1

Description

[0001] The invention in question is a continuous mill for grinding materials in a water suspension, preferably ceramic materials, provided with a compressed-air injection device. In the ceramic industry, grinding mills are widely used to prepare powders to be used in the various production steps. In Italian patent 201800003874, the main components and advantages of a continuous mill are shown.

[0002] A grinding mill usually comprises a casing containing a hollow rotating body in which the grinding bodies are situated, i.e. bodies with a different dimension according to the type of processing and the final result that it is desired to obtain that are responsible for grinding the compound introduced into the mill. The hollow body rotates around its own main axis, causing continuous remixing of the grinding bodies inside the casing. The mill is fed by introducing substances to be ground in a suspension form, typically a water suspension; the ceramic powders and liquid, preferably water, compound is called "slip": the grinding bodies, because of the movement thereof, cause a progressive reduction of the granulometry of the substances in a water suspension, until the desired measurement. In particular, the grinding bodies are cyclically dragged upwards by the rotation of the hollow body and fall down once the maximum height position is reached, The fall of the grinding bodies acts on the slip, causing a reduction of the diameter of the particles that is greater the more prolonged the dwell time of the suspension inside the rotating casing. The exit of the slip, once the desired granulometry is reached, occurs at the end of the process, through discharge.

[0003] The mills that are currently most widespread are continuous mills, i.e. the mills that perform a grinding action according to a continuous cycle: for this type, feeding and discharging occur without interrupting the rotation of the casing and without having to interrupt the grinding process; this is possible owing to the feeding and discharging being located in a position that is concentric relative to the rotation axis of the mill.

[0004] One important aspect to consider during the operation of a continuous mill is the reduction of energy consumption, which is obtained by maintaining the level of the slip and of the grinding bodies above the rotation axis, such that the overall centre of gravity of the mass contained in the mill approaches the rotation axis: in fact, if the filling level is maintained below the rotation axis, the imbalance of the overall mass of the mill with respect to the rotation axis causes an increase in energy consumption that is necessary to maintain the mill in rotation.

[0005] In other words, adopting a filling level inside the mill above the rotation axis enables the operation of the mill to be optimised in relation to power input, which is reduced with the increase in the level of liquid.

[0006] One problem that occurs at the moment in which the filling level is maintained above the rotation axis of the mill is that an inlet-outlet circuit without air intakes is generated: the absence of natural air intakes causes cyclically a rise and lowering of the level of slip. These fluctuations are not insignificant and ultimately affect the characteristics of the product exiting the mill, as these characteristics are guaranteed to be more uniform the more constant the processing parameters like the filling level are maintained.

[0007] In fact, if on the one hand the rise of the filling level favours the process from an energy point of view, on the other hand excessive filling causes a reduction in the grinding effect: it thus becomes fundamental to stabilize the filling level as close as possible to optimal processing, which permits moderate energy consumption and suitable characteristics to be reached for the exiting slip.

[0008] One of the methods for stabilising the filling level, belonging to the prior art, involves adding an inlet conduit for introducing air. The device is so designed: the mill has a rotating body with an inlet conduit into which the slip is introduced under pressure, owing to the operation of a pump. The inlet conduit for the air has an opening/closing valve upstream and downstream enters the inlet conduit for the slip. The device operates, during normal operation, by maintaining the valve for the entry of air into the conduit closed; a control system verifies the variation of volumes inside the rotating body, processing the power input data of the motor sent by the inverter: if the fluctuations of the power values exceed a preset tolerance range, the slip infeed pump is stopped and the valve for the entry of air is opened, restoring the optimal filling level.

[0009] Although this system is efficient, it can be improved further: the main limit is the need to periodically interrupt the slip infeed pump for the time necessary to reset the parameters within the tolerance range.

[0010] The object of this invention is a continuous mill for grinding ceramic materials in a suspension, preferably but not exclusively a water suspension, characterised in that it is provided with a compressed-air injection device, which works at the same time to introduce the slip; the thus designed device further comprises an accessory air intake, according to the prior art, which is used as a safety system, and for a further verification of the parameters.

[0011] Introducing compressed air enables the ratio between the volume of air and the volume of slip to be established advantageously without introducing slip into the rotating body.

[0012] Further, an object of this invention is a control system and management software integrated therewith, which enables preset times and injection frequencies of the compressed air to be set.

[0013] The object of the invention is to provide a system for slip grinding and stabilisation of the filling level that is more efficient than the prior art.

[0014] Further advantages and characteristics will become more apparent from the detailed description of an embodiment of the invention in question, illustrated by way of non-limiting example in the following paragraphs.

[0015] Fig. 1 shows the diagram relating to an embodiment of the invention.

[0016] The continuous mill, according to the invention in question, comprises a hollow body (1) having a substantially cylindrical shape, rotating about a rotation axis (X). The hollow body (1) comprises a casing (2). Rotation actuating means, known to those skilled in the art, is adapted to rotate the hollow body (1). For example, the actuating means comprises a motor (3) and a transmission belt.

[0017] The hollow body (1) is provided with supports (F), which are not illustrated in detail, which are concentric with the rotation axis (X). Each support (F) is coupled with a respective rotatable hub, adapted to support the hollow body (1).

[0018] The hollow body (1) comprises an inlet opening (5) concentric with the rotation axis (X). An inlet conduit (4) is connected to the inlet opening (5) to enable the slip to be introduced into the hollow body. The slip is introduced under pressure into the hollow body owing to a pump, connected to the inlet conduit (4).

[0019] Inside the hollow body (1), a mass of rotating bodies (6) is arranged that are adapted to cause physically grinding of the slip.

[0020] The hollow body (1) further comprises an outlet opening (8) concentric with the rotation axis (X). An outlet opening (7) is connected to the outlet opening (8), to enable the ground slip to be discharged from the rotating bodies (6). The mill is further provided with an air intake (9), situated upstream of the hollow body (1) considering the direction of the air flow. The air intake (9) has a control valve (10) and, at the outlet end, is connected to the inlet conduit (4) for the infeed of the slip. The valve operates between an open configuration, in which it permits the passage of the air, and a closed configuration, in which it does not permit the passage of air towards the inlet conduit.

[0021] Advantageously, the mill according to the present invention comprises a compressed-air injection device (11), adapted to introduce air into the hollow body (1) in a controlled manner. The mill further comprises a control system (15,16) adapted to regulate the injection of compressed air so as to maintain a pre-established level of liquid inside the hollow body (1).

[0022] The injection device (11) enables compressed air to be sent inside the hollow body (1). The compressed air forms a volume, in an upper zone of the hollow body (1), which counteracts the rise in the level of liquid. By increasing or decreasing the pressure of the compressed air, it is possible to increase or decrease the thrust that this volume exerts on the free surface of the liquid, counteracting or permitting the increase in the level of the liquid. This thus enables the level of the liquid inside the hollow body (1) to be controlled.

[0023] Preferably, the injection device (11) comprises an entry conduit (11a) for the compressed air. This entry conduit (11a) is connected to the inlet conduit (4). Preferably, the injection conduit (11a) is provided with an actuated valve (14a) which is adapted to take on an open position in which it allows the entry of compressed air into the inlet conduit (4), and a closed position, in which it prevents the entry of compressed air into the inlet conduit (4). The actuated valve (14a) is connected to the control system (15,16) and is driven by the latter between the open and closed positions.

[0024] In the preferred embodiment, the control system (15,16), is adapted to acquire one or more process parameters by means of one or more sensors of known type, and to determine actions as a function of the acquired process parameters. In particular, the control system (15,16) is adapted to detect the power input of the motor (3), and to regulate the injection of compressed air as a function of the power input of the motor (3).

[0025] The power input of the motor (3) is in fact linked to the level of slip inside the mill, by means of a reversed relation: considering an optimal filling level (Lo) to correspond to an optimal power input value (Vo), with an increasing level of slip, the power input value of the motor (3) of the mill decreases; on the other hand with a decreasing level of slip, the power input value of the motor (3) increases. The control system (15,16) activates or deactivates the injection device in function of the power value detected.

[0026] In a preferred embodiment, the control system (15,16) operates in function of the following parameters:

- an optimal power input value (Vo) of the motor (3), corresponding to an optimal slip level inside the hollow body (1);
- a first threshold (St) of the power input, below the optimal value (Vo), which corresponds to a level of slip above the optimal level;
- a second threshold (Se) of the power input, below the first threshold (St), which corresponds to a level of slip above the level corresponding to said first threshold (St) and above a pre-established maximum level.

[0027] The optimal value (Vo) is detected at an optimal filling level (Lo) of the grinding mill. If the power input of the motor (3) is substantially the same as the optimal value (Vo), the level of slip inside the hollow body (1) substantially corresponds to the optimal filling level (Lo). In this case, the compressed air is injected by an injection device (11) at pre-established intervals of time. Such intervals of time are defined, for example, in a calibration step of the control system (15,16), in order to maintain the level of slip constant.

[0028] Further, the control system (15,16) operates in the following modes:

- if the detected power value is comprised between the optimal value (Vo) and the first threshold (St), the control system (15,16) maintains the compressed air injection device (11) active in order to introduce compressed air at pre-established inter-

vals for a settable time, without interrupting the infeed of slip;

- if the detected power value is comprised between the first threshold and the second threshold, the control system (15,16) activates the injection system (11) to bring about an increase in the flow of compressed air without interrupting the infeed of slip;
- if the detected power value is lower than the second threshold (Se), the control system (15,16) brings about an interruption in the infeed of slip into the inlet conduit (4) to allow the intake of air into the hollow body (1) through the inlet conduit (4). In particular, the air is sucked in through an air intake (9), connected to the inlet conduit (4), which is provided with an enabling valve (10) connected to the control module (15,16).

[0029] Owing to the configuration of the control module (15,16), which operates on the basis of the data summarised above, the mill is able to operate substantially automatically, ensuring a substantially constant slip level inside the hollow body (1).

[0030] In the illustrated preferred but non exclusive embodiment, the injection system (11) withdraws the compressed air from a source (R), connected to the injection conduit (11a).

[0031] A pressure reducer (12), a pressure gauge (12a), a pressure switch (13), and a solenoid valve (14) are interposed between the source (R) and the injection conduit (11a).

[0032] The pressure reducer (12) is adapted to adapt the pressure made available by the source (R) to the value provided for use inside the mill. The pressure gauge (12a), arranged on the pressure reducer (12), enables the pressure values of the compressed air to be detected instantaneously. The pressure switch (13) is connected to the control system (15,16) of the mill and is configured to monitor the actual availability of the compressed air, generating an alarm signal in the event of lack of availability of the compressed air. The solenoid valve (14) is adapted to enable or disable the feeding of the compressed air to the injection conduit (11a). Driving the solenoid valve (14) is controlled by the control system (15,16), to which the solenoid valve (14) itself is connected.

[0033] Preferably, the control system (15,16) comprises the following elements: an electric power panel (15), connected to the inverter of the motor (3), and an electric control panel (16), connected to the electric power panel. The electric control panel (16) is moreover connected to the actuated valve (14a). In the illustrated embodiment, the electric control panel (16) is further connected to the pressure switch (13) and to the solenoid valve (14).

[0034] The variations in the power input of the motor (3) are transmitted by the inverter to the electric power panel (15), which records the values and in turn transmits the values to the electric control panel (16). On the basis of the input power data, the electric control panel (16) causes the opening or closure of the solenoid valve (14) and of the actuated valve (14a), so as to increase or decrease the quantity of compressed air injected into the mill and which is necessary for maintaining the filling level of the mill around its operating optimum.

[0035] The control system (15,16), in a further embodiment, can also be set up to acquire data on the compressed air to be injected into the grinding mill: in particular, it can receive signals on the pressure of the compressed air from the network (R) and on its availability or lack owing to the data transmitted by the pressure switch (13).

[0036] According to one embodiment, moreover, at the inlet opening (5) and the outlet opening (8) diaphragms (17) can be present, or filtering grilles of the grinding bodies: in the case of the use of grinding bodies (6) of small dimensions, in the presence of inlet conduits (5) and outlet conduits (8) that are concentric with the rotation axis, it is necessary to provide the continuous mill with diaphragms (17) that prevent the grinding bodies from depositing and accumulating at the outlet opening (8), preventing the slip from exiting. The grinding bodies are retained by the diaphragms (17), whereas the slip can flow towards the outlet opening (7).

[0037] The operating method of the continuous mill provided with compressed-air injection device is described in the following paragraphs.

[0038] The slip flows through the inlet conduit (4) and is introduced under pressure into the rotating hollow body (1), owing to the action of a pump. According to the continuous mill that is the object of this invention, the compressed air is injected simultaneously with the slip, without interrupting the operation of the slip-dispensing pump, at time intervals established previously by calibration tests of the system. The compressed air is injected through the injection conduit (11a) of the compressed air, belonging to the injection device (11). Injecting compressed air at regular intervals and for a pre-established duration, simultaneously with the introduction of the slip, enables the filling level of the grinding mill to be maintained stable, ensuring good performance in terms of energy and of grinding quality.

[0039] The slip passes through the inlet opening (5) and joins the grinding bodies (6): the hollow body (1), containing a predefined mass of grinding bodies (6) and slip, rotates around its rotation axis (X), dragging the grinding bodies that, once maximum height is reached, fall back and are remixed, causing grinding of the slip; the granulometry of the ceramic particles in a water suspension decreases progressively as the dwell time of the slip inside the hollow body (1) increases.

[0040] The suitably ground slip passes through the outlet opening (8) and travels through the outlet opening (7).

[0041] The grinding mill that is the object of this invention can be used in different points of the ceramic products processing line.

[0042] A first possible application is in the modular mills: in the case of several grinding mills in sequence

that are characterised by an increasing level of refinement, the compressed-air injection device can be used in all the mills, or preferably, but not exclusively, in the last grinding steps, where it is important to reach characteristics of the exiting slip that are as uniform and regular as possible.

[0043] Another application is in more complex grinding plants consisting of a multiplicity of modules interspersed with storage modules: according to this application, the compressed-air injection device can be positioned in the final refining module; also in this case, not only is the energy requested by the mill optimised but the capacity to obtain slip of the desired granulometry and with uniform characteristics is exploited.

Claims

1. A continuous mill comprising:

- a hollow body (1) with a substantially cylindrical shape and rotating about a rotation axis (X);
- a motor (3) adapted to set the hollow body (1) in rotation and comprising an inverter;
- an inlet opening (5), concentric with the rotation axis (X);
- an inlet conduit (4), connected to the inlet opening (5);
- an outlet opening (8), concentric with the rotation axis (X);
- an outlet conduit (7), connected to the outlet opening (8);

characterised in that it comprises a compressed air injection device (11), adapted to introduce air into the hollow body (1) in a controlled manner.

2. The mill according to claim 1, wherein the compressed air injection device (11) comprises a control system (15,16) adapted to regulate the injection of compressed air so as to maintain a pre-established level of liquid inside the hollow body (1).

3. The mill according to claim 2, wherein the control system (15,16) is adapted to detect the power input of the motor (3), and to regulate the injection of compressed air as a function of the power input of the motor (3).

4. The mill according to claim 3, wherein: the injection device (11) comprises an entry conduit (11a), connected to the inlet conduit (4) and equipped with an actuated valve (14a) which is adapted to take on an open position, in which it allows the entry of compressed air into the inlet conduit (4), and a closed position, in which it prevents the entry of compressed air into the inlet conduit (11); the control system (15,16) is connected to the actuated valve (14a) and controls the passage between the open and closed positions.

5. The mill according to claim 4, wherein the entry conduit (11a) is connected, on the inlet side, to a compressed air distribution network (R).

6. The mill according to claims 4, 5, wherein the control system is adapted to detect the compressed air pressure and emit an error signal in the event of unavailability of compressed air.

7. The mill according to any of the preceding claims, wherein the inlet conduit (4) comprises an air intake (9) provided with a control valve (10).

8. The continuous mill according to claim 1, wherein the compressed air is introduced under pressure into the hollow body (1) simultaneously with the slip.

9. The continuous mill according to claim 1, wherein management software is associated with the control system (15,16).

10. The continuous mill according to claim 9, wherein the management software is configured to receive at least the following input data: an optimal power input value (Vo) of the motor (3), corresponding to an optimal level of slip inside the hollow body (1); a tolerance threshold (St) of the power input (Vo), corresponding to a level of slip that is higher than the optimal level; an error threshold (Se) of the optimal power (Vo), corresponding to a level of slip that is higher than the level corresponding to said tolerance threshold (St).

11. The continuous mill according to one or more of the preceding claims, wherein the control system (15, 16) determines different actions as a function of the detected power input value of the motor (3), in particular:

- if the detected power value is comprised between the optimal value (Vo) and the first threshold (St), the control system (15,16) maintains the compressed air injection device (11) active in order to introduce compressed air at pre-established intervals for a settable time, without interrupting the infeed of slip;
- if the detected power value is comprised between the first threshold and the second threshold, the control system (15,16) activates the injection system (11) to bring about an increase in the flow of compressed air without interrupting the infeed of slip;
- if the detected power value is lower than the second threshold (Se), the control system (15,16) brings about an interruption in the infeed

of slip into the inlet conduit (4) to allow the intake of air into hollow body (1) through the inlet conduit (4).

12. The continuous mill according to any one of the preceding claims, comprising the following devices for controlling and managing the compressed air:

- a pressure reducer (12) connected to a compressed air source (R) and to a pressure gauge (12a) for the instant detection of the compressed air pressure values;
- a pressure switch (13), located downstream of the reducer (12) considering the direction of the compressed air flow, said pressure switch being connected to the control system (15,16) and configured to monitor the presence of compressed air from the network and generate an alarm signal in case of the absence thereof;
- a solenoid valve (14) located downstream of the pressure switch (13) considering the direction of the compressed air flow, the solenoid valve being connected to the control system and adapted to take on an open or closed configuration as a function of a command of the control system (15,16) which brings about the passage or interruption of the compressed air flow towards the entry conduit (11a).

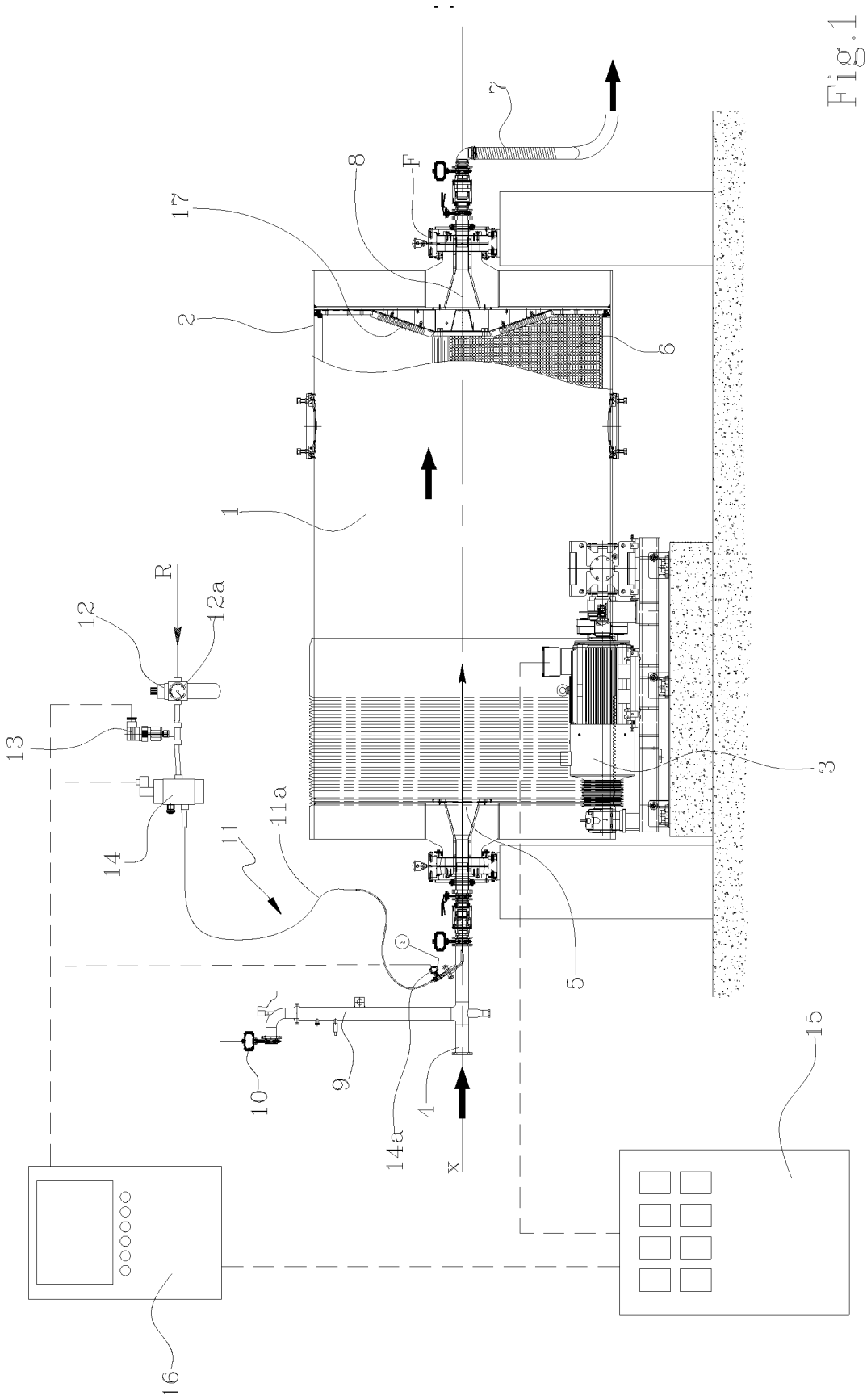

Fig.1

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 21 6193

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 A	CN 110 586 265 A (TAISHAN JINHAO TRADE CO LTD) 20 December 2019 (2019-12-20) * the whole document *	1,9 2-8, 10-12	INV. B02C17/18 B02C17/10
A	WO 2021/044355 A1 (CERTECH S P A A SOCIO UNICO [IT]) 11 March 2021 (2021-03-11) * pages 5-7; figures *	1-12	
A	DE 89 14 652 U1 (SNAMPROGETTI S.P.A., MILANO, IT) 22 March 1990 (1990-03-22) * abstract; figures *	1-12	

TECHNICAL FIELDS SEARCHED (IPC)

B02C
B04C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 May 2024	von Mittelstaedt, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 21 6193

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

06-05-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 110586265 A	20-12-2019	NONE	
WO 2021044355 A1	11-03-2021	BR 112022002835 A2	10-05-2022
		CN 114340796 A	12-04-2022
		EP 4025346 A1	13-07-2022
		US 2022314230 A1	06-10-2022
		WO 2021044355 A1	11-03-2021
DE 8914652 U1	22-03-1990	AU 619369 B2	23-01-1992
		CN 1044419 A	08-08-1990
		DE 3940906 A1	21-06-1990
		DE 8914652 U1	22-03-1990
		GB 2229940 A	10-10-1990
		IT 1228049 B	27-05-1991
		SU 1776199 A3	15-11-1992

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- IT 201800003874 **[0001]**