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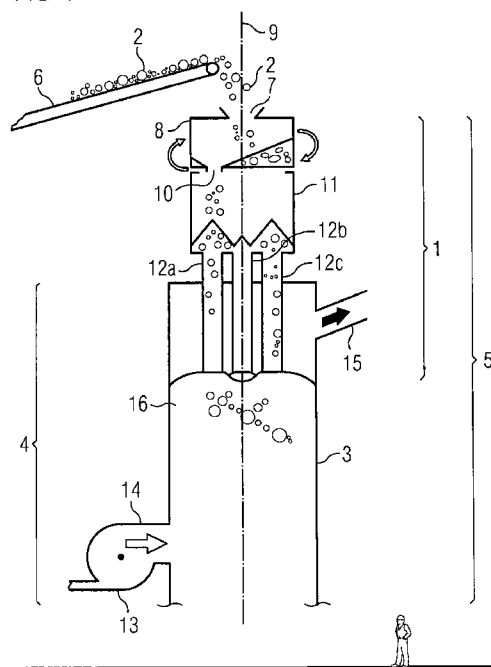
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(54) Title: COOLING OF BULK MATERIAL

FIG 1



(57) Abstract: Input device (1) for the introduction of bulk material (2) into a container, which comprises a rotary bunker (8) rotatable about a central axis of rotation (9), having an inlet opening (7) for the bulk material (2) through which the central axis of rotation (9) passes, and having a discharge opening (10) for the bulk material (2), the discharge opening (10) being arranged eccentrically; a supply bunker (11), in which the discharge opening (10) of the rotary bunker (8) opens; at least three drainpipes (12a, 12b, 12c) emanating from the supply bunker (11); wherein the supply bunker (11) and the drainpipes (12a, 12b, 12c) are stationary.

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## **Cooling of bulk material**

### **Technical Field**

The present invention relates to an input device for the introduction of bulk material consisting of particles with different particle sizes into a container, preferably a shaft cooler.

### **Background Art**

Hot bulk material, such as sintered iron ore from a sintering plant, usually needs to be cooled before it can be stored in a silo and / or further processed.

For cooling of hot bulk material it is known to use cooling devices with a cooling shaft, which in operation is traversed by a cooling gas in countercurrent to the bulk material – so called shaft coolers. In such shaft coolers heat exchange between the hot bulk material and the cooling gas takes place in the cooling shaft. The hot bulk material is usually introduced in the cooling shaft at an upper end and by gravity traverses the cooling shaft downwardly; at the lower end of the cooling shaft, the bulk material is removed in a cooled state. The cooling gas is usually introduced at the lower end of the cooling shaft and discharged above in a heated state as so-called exhaust gas. When the cooling gas is air, it is called cooling air and exhaust air. When cooling the bulk material, efforts are made to avoid uneven respectively spatially inhomogeneous cooling of the bulk material. If, after passing through the cooling shaft, the bulk material has areas which have been cooled only slightly and consequently have a high temperature, such hot material can, for example, damage a conveyor and / or a silo for storing bulk material downstream of the cooling device. In addition, in such a case further transport and / or further processing of the bulk material may be delayed, since it is first necessary to wait until said regions of the bulk material have cooled sufficiently.

In order to achieve the best possible and efficient cooling in the cooling shaft, the bulk material should be distributed as homogeneously as possible in the cooling shaft with respect to particle sizes - that is, as free of segregation as possible in the case of a bulk material with different particle sizes. Inhomogeneous distribution of particle sizes in the cooling shaft leads to different extents of flow resistance of the cooling gas and thus to

areas which compared to other areas are less perfused and less cooled. Furthermore, large particles cool down more slowly than small particles, because their surface-to-volume ratio is less favorable. If the bulk material contained in the cooling shaft has areas in which a concentration of large particles is above average, in these areas the bulk material cools down more slowly than in areas with average or below-average concentration of large particles. So it is thus advantageous if the bulk material grains are spatially homogeneously distributed in terms of their size in the cooling shaft, in order to achieve even cooling of the bulk material in the cooling shaft.

In shaft coolers such as shown in CN204630395U, CN204630396U, CN103234361B or CN204495075, the input of hot sinter as bulk material is done batch-wise or centrally. This segregates the hot sinter, which usually has a very large grain band with particle sizes up to 200 mm, and the cooling becomes inefficient.

In GB2071139A a input device for bulk material is shown, but it is unclear whether its segregation performance would be applicable for hot sinter cooling in a shaft cooler.

With the aid of continuous input by means of moving input devices, attempts are made to achieve as homogeneous a distribution of the particle sizes in the shaft as possible when introducing into the cooling shaft, even if already segregated bulk material is delivered for input. The problem is that moving system parts are exposed to the high temperature of the bulk material and the heated cooling gas. This can result in significant wear and maintenance expenditure.

A temperature of hot sinter from an sintering ore is approximately 400~750°C and of cold ore supplies a blast furnace; a ring cooling machine and a belt cooling machine can only recover 30% of exhaust gas heat approximately owing to their structural features; a vertical cooling shaft – i.e. a shaft cooler, respectively cooling shaft of a shaft cooler - can improve the heat recovery rate, so lots of scientific research institutes and enterprises use vertical cooling shafts to recover waste heat of sintering ores currently. For example, Sintering Furnace Type Cooling Device with a patent application number of 201310127744.5, Vertical Agglomerate Cooling Machine with a patent number of 93117175.X, Vertical Cooling and Waste Heat Recovery Furnace for Agglomerate with a patent number of 201310672967.X, etc., one set of vertical cooling shaft equipment has already been put into operation in Tianjin Tianfeng Steel Co., Ltd., which improves the waste heat recovery rate greatly.

The airtightness of a vertical cooling shaft decides the waste gas recovery rate and its air leakage points are mainly feeding and discharge systems. Currently, feeding modes for vertical cooling shafts comprise: skew bridge + umbrella-shaped material distribution (a patent number of 201511002240.6, Multi-angle Multi-surface Multi-layer 360-degree Air-supplying Sinter Ore Cooling Tower); chain scraper conveyor + rotary material distribution (a patent number of 201320185479.1, Heat Exchange Device for Sintering Ore Furnace Type Cooling); a patent number of 201520756682.9, Sensible Heat Recovery Device for Agglomerate; direct connection with a discharge end of a sintering machine + clock-type/umbrella-shaped material distribution (a patent number of 201310127744.5, Sintering Furnace Type Cooling Device); a patent number of 93117175.X, Vertical Agglomerate Cooling Machine; a patent number of 201310672967.X, Vertical Cooling and Waste Heat Recovery Furnace for Agglomerate; skew bridge feeding is intermittent operation and single bucket tipping, but the airtightness of the shaft top is not as good as chain scraper continuous operation and head rolling discharge. The feeding mode of direct connection with a discharge end of a sintering machine has great limitation to height arrangement of the sintering machine and the vertical shaft in the previous procedure.

Currently, common discharge modes of vertical cooling shafts comprise: star discharging machine (a patent number of 201220491407.5, High-efficient Heat Recovery Type Sinter Mine Cooling System); a patent number of 201610150596.2, System Used for Sinter Ore Cooling and Sensible Heat Efficient Recycling; a patent number of 200910074513.6, Vertical Sinter Cooler Capable of Efficiently Recovering Sensible Heat of Agglomerate; electric vibrating feeder (a patent number of 93117175.X, Vertical Agglomerate Cooling Machine); electric vibrating quantified discharging machine + rotary discharge valve (a patent number of 201320185290.2, Discharging Device of Sinter Cooling Furnace), (a patent number of 201520756682.9, Sensible Heat Recovery Device for Agglomerate). The sintering ore entering the vertical cooling shaft has requirements on the particle size which is not too small; star/rotary discharging equipment has good airtightness, but material extrusion may cause granular materials to be clipped into equipment clearances, which influences normal operation; the electric vibrating feeder doesn't have material crushing conditions, but a suitable height of the sealing material column shall be considered.

The heat recovery rate of vertical cooling shafts is related to solid-gas heat exchange conditions, and material distribution and ventilation modes are critical. Currently, material distribution modes for vertical cooling shafts comprise: rotary material

distribution (a patent number of 201520756682.9, Sensible Heat Recovery Device for Agglomerate; a patent number of 201310127797.7, Rotary Feeding Device of Sinter Cooling Furnace); vertical screw-type feeding machine and clock-type material distribution (a patent number of 201320185480.4, Suspension Type Distributing Device for Sintering Ore Cooling Furnace; a patent number of 93117175.X, Vertical Agglomerate Cooling Machine; a patent number of 201511002240.6, Multi-angle Multi-surface Multi-layer 360-degree Air-supplying Sinter Ore Cooling Tower; a patent number of 201320814396.4, Feeding Device for Vertical Cooling and Waste Heat Recovering Furnace for Sintering Ore), etc. Ventilation modes comprise: arrangement of multiple wind chambers for surrounding blowing-in (a patent number of 201310128026.X, Sintered Ore Cooling Furnace); central blowing-in (a patent number of 201320814379.0, Cold Air Supplying Device for Vertical Cooling and Waste Heat Recovering Furnace for Sintering Ore), combination of central (multilayer umbrella-type) and surrounding (air ring) blowing-in (a patent number of 201520756682.9, Sensible Heat Recovery Device for Agglomerate); louver ventilation grating (a patent number of 201511002240.6, Multi-angle Multi-surface Multi-layer 360-degree Air-supplying Sinter Ore Cooling Tower); circumferential arrangement of multiple draught fans (a patent number of 200910074513.6, Vertical Sinter Cooler Capable of Efficiently Recovering Sensible Heat of Agglomerate), (a patent number of 93117175.X, Vertical Agglomerate Cooling Machine), etc. The existing material distribution equipment distributes large particles on the edge; by changing the material stocking angle to improve the distribution conditions, uniform distribution of materials on the cross section of the shaft can't be achieved. The ventilation mode uses the combination of surrounding and central blowing-in, which is suitable for vertical shafts with large-size sections and can guarantee uniform and sufficient contact between cold air and the materials. To sum up, existing vertical cooling shafts generally have problems such as poor airtightness and uneven distribution of materials, etc., which causes poor site environment, high discharging temperature and low temperature of recovered exhaust gas, and directly influences the operation of discharge conveying equipment as well as the heat recovery rate and the heat value; consequently, the created economic benefits are not good and the equipment maintenance fees are high.

## **Summary**

### **Technical problem**

It is the object of the present invention to provide an input device, a device for cooling

bulk material, and a method for introducing bulk material in a container, with which a uniform cooling of bulk material consisting of particles of different particle sizes with continuous input under reduced wear can be achieved and improved.

### **Solution to problem**

This object is solved by an input device for the introduction of bulk material consisting of particles with different particle sizes into a container, characterized in that

this input device comprises:

- a rotary bunker rotatable about a central axis of rotation, having an inlet opening for the bulk material through which the central axis of rotation passes, and having a discharge opening for the bulk material, the discharge opening being arranged eccentrically;
  - a supply bunker, in which the discharge opening of the rotary bunker opens;
  - at least three drainpipes emanating from the supply bunker;
- wherein the supply bunker and the drainpipes are stationary.

The container is preferably a cooling shaft of a shaft cooler. The shaft cooler has at least one cooling shaft. The shaft cooler respectively its cooling shaft usually have a vertical longitudinal axis.

The bulk material is preferably hot, that is, has a temperature of at least 300 ° C, preferably at least 400 ° C, preferably it is hot sinter. As already stated in the introduction, the temperature of the bulk material is lowered in the shaft cooler by heat exchange in countercurrent with a cooling gas, the bulk material being hot when introduced into the shaft cooler. For example, sinter may have a temperature in the range of 400 - 700 ° C, or even up to 750°C, when introduced.

The bulk material consists of particles of different particle sizes; it can, for example in sintering, be a very large grain size spectrum with particle sizes up to 200 mm.

A bunker is to be understood a large container for receiving bulk goods, in the case of the present application for receiving bulk material.

The rotary bunker is rotatable about a central axis of rotation, which usually in case of installation of the input device at a container - such as a cooling shaft of a shaft cooler - is perpendicular. During operation of the input device the rotary bunker is rotated about this axis of rotation. The axis of rotation passes through the inlet opening of the rotary bunker for the bulk material. For example, the inlet opening of the rotary bunker for the bulk material is located centrally, i.e. in the middle, - in this case the central axis of rotation passes through this centrally located inlet opening. Through the inlet opening bulk material transported to the input device by means of a transport device - for example, in case of sinter as bulk material, with a chevron conveyor - is introduced into the rotary bunker. Due to the fact that the central axis of rotation passes through the inlet opening - for example in the case of a central arrangement of the inlet opening - does not change the position of the inlet opening relative to the transport device during operation when the rotary bunker rotates about its central axis of rotation. This facilitates the entry from the transport device into the rotary bunker.

The rotary bunker has an eccentrically arranged discharge opening.

The eccentric discharge opening of the rotary bunker opens into a stationary supply bunker, which is positioned adjacent to the rotary bunker. To use gravity to move the bulk material, it is preferable to align the input device with the rotary bunker being arranged above the supply bunker.

When installing the input device at a container, for example, at the cooling shaft of a shaft cooler, the rotary bunker is positioned above the supply bunker, so that the bulk material progresses from the rotary bunker into the supply bunker following gravity. The central axis of rotation of the rotary bunker does not pass through the eccentrically arranged discharge opening.

The eccentric discharge opening of the rotary bunker can be, for example, an eccentrically arranged hole in the bottom of the rotary bunker. During operation, following gravity, the bulk material passes through the discharge opening from the rotary bunker into the supply bunker, which is positioned below the rotary bunker.

The supply bunker has its name because it supplies the bulk material for subsequent entry into the container, such as a cooling shaft of a shaft cooler, through the drainpipes. The supply bunker is stationary, unlike the rotary bunker it is not moving during operation of the input device.

From the supply bunker so-called drainpipes originate, at least three. In case the input

device being installed at a container, for example a cooling shaft of a shaft cooler, they extend from the supply bunker downwards, i.e. they are located below the supply bunker. The drainpipes are tubes through which the bulk material leaves the supply bunker following gravity, it runs out of it. The end of the drainpipes connected to the supply bunker may be called the supply end, the other end of the drainpipes may be called the shaft end.

Preferably, the cross section of the drainpipe becomes larger with increasing distance from the supply bunker, so they expand with increasing distance from the supply bunker. This reduces the risk of clogging.

For example, conical tubes are connected as drainpipes with the narrower end, the supply end, with the supply bunker.

Through an opening in the bottom of the supply bunker, the bulk material, following gravity, runs into the drainpipe provided at the corresponding point on the bottom of the supply bunker. Preferably, the drainpipes are arranged at the bottom of the supply bunker such that in the case of clogging of a drainpipe, the bulk material in the supply bunker above that clogged drainpipe can at least largely run through another drainpipe.

For example, if the input device is operated in conjunction with a shaft cooler, the drainpipes extend into the cooling shaft of the shaft cooler with their lower, potentially wider, end, and during operation, material leaves this, potentially wider, end of the drainpipe - for example potentially conical tubes - into the cooling shaft of the shaft cooler. During operation, the bulk material will run out of the supply bunker through the drainpipes into the cooling shaft following gravity. The such formed material bed of bulk material is perfused by cooling gas - preferably cooling air - in countercurrent.

### **Advantageous Effects of the Invention**

Since during operation of the input device the rotary bunker is rotated about the central axis of rotation, while through the, preferably centrally located, inlet opening bulk material is introduced into it, segregation phenomena of the bulk material occurring during the transition from the transport device into the rotary bunker are mitigated. By way of example, particles thrown off a conveyor belt will fly to different extents depending on the size, i.e. they will segregate - by rotating the rotary bunker, afterwards the particle size distribution in the rotary bunker will be equalized.

Since the rotary bunker is rotated during operation of the input device, while the supply bunker is stationary, and the discharge opening is arranged eccentrically, bulk material following gravity runs from the rotary bunker rotationally symmetric into the supply bunker installed below the rotary bunker. Accordingly, the drainpipes are filled from the supply bunker with bulk material of approximately the same particle size distribution when the bulk material from the supply bunker runs into the drainpipes - which ultimately minimizes inhomogeneous particle size distribution in the container, such as a cooling shaft of a shaft cooler, especially in the circumferential direction. The drainage of the bulk material is favored by potentially increasing cross-sectional area of the drainpipes. In the interior of the container, for example a cooling shaft of a shaft cooler, bulk material cones are formed at the lower end of the discharge tubes; compared to the use of a single drainpipe - for example, a central input of bulk material in the container, for example, cooling shaft - the cones are less high in the presence of multiple drainpipes. As a result, segregation in the radial direction around the respective bulk material cones decreases in comparison to higher bulk material cones. At least three drainpipes should be present for a usable effect compared to a single drainpipe. Overall, in combination the inventive features of the input device in operation synergistically lead to the following effect: even in case of supply of segregated bulk material to the inlet opening of the input device - for example, on a sinter-supplying chevron conveyor segregation effects take place already - in the container - for example, a cooling shaft of an input device associated shaft cooler - both radially as well as circumferentially substantially homogeneous, and with respect to the longitudinal axis of the container - for example, cooling shaft of a shaft cooler - rotationally symmetric, particle size distribution of the bulk material is present.

Segregation effects are equalized over the entire cross section of the bed of bulk material formed in the container, for example cooling shaft.

When used in a device for cooling of bulk material as effects arise:

improved cooling efficiency, uniform and effective cooling of the bulk material, and a good heat yield for subsequent use of the heated cooling gas.

The input device of GB2071139A differs from the claimed input device in that while there is a rotary device with reference number 3 at the very top of it, this rotary device having an eccentrically arranged discharge opening for the bulk material, its inlet opening for the bulk material is not passed through by the central axis of rotation. Material introduction is not done centrally. Hence, segregation mechanism and as a

consequence also cooling capacity and homogeneity is different from the input device as claimed.

Another object of the present application is a device for cooling bulk material consisting of particles of different particle sizes, comprising  
a shaft cooler with cooling shaft,  
and  
an input device according to the invention for the input of bulk material in a shaft cooler, wherein the input device is arranged at the upper end of the cooling shaft of the shaft cooler, wherein the drainpipes open with their lower ends into the cooling shaft, and the rotary bunker and the supply bunker are arranged outside the cooling shaft.

In the cooling shaft, hot bulk material is cooled by cooling gas passed through in countercurrent to the bulk material.

In such a device for cooling bulk material, the rotary bunker and the supply bunker are outside of the cooling shaft and are therefore not exposed to the heated cooling gas present - especially at the upper end - in the cooling shaft. Heat is supplied to the rotary bunker and the supply bunker by the hot bulk material, but they are also cooled by ambient air. By the arrangement outside of the cooling shaft the risk of heat-related damage is reduced, which risk would be particularly large for moving parts – i.e., for example, the rotary bunker. The stationary components drainpipes open with their lower end - the shaft end - into the cooling shaft; from these shaft ends the bulk material pours into the cooling shaft.

The inventive device for cooling bulk material or the input device according to the invention are preferably operated continuously, that is, bulk material is continuously introduced.

The cooling shaft is preferably designed at least partially axially symmetrical. It preferably comprises a hollow cylindrical shaft section. Whereby expediently the cylinder axis of the hollow cylindrical shaft section is vertically aligned.

Preferably, the cooling shaft is an air-cooled heat exchanger. Expediently, the device for cooling bulk material comprises at least one fan, in particular a blower, for injecting cooling gas, for example cooling air, into the cooling shaft. Furthermore, the device for

cooling bulk material may have at least one fan for sucking cooling air out of the cooling shaft at its upper end.

The cold gas respectively cold air blown into the cooling shaft respectively into the bulk material bed within the cooling shaft has to be distributed as evenly as possible. To this end the cooling air exits from a central air outlet of an air duct – also called supplying line - and an annular air outlet of an air duct – also called supplying line - provided at the bottom of the cooling shaft, to guarantee distribution uniformity of cold air within the vertical cooling shaft. Cooling gas supply lines are provided circumferentially and centrally in the cooling shaft with annular and central air outlets. Compared to only annular or only central air outlets the cooling air is distributed more evenly.

Cooled bulk material is discharged to a belt conveyor by multiple discharging chutes uniformly distributed at the bottom of the shaft, according to one variant with an electric vibrating feeder, Preferably the outlet of the discharging chutes on the vibrating feeder is provided with a dust cover.

In a preferred variant a driving motor device for the rotary bunker is provided and a gear ring at the top edge of the rotary bunker respectively the rotary bunker body. Said driving motor device may comprise one, two or more motors symmetrically arranged on the top edge of the rotary bunker respectively the rotary bunker body. Driven by the motor or motors, the gear ring rotates and drives the rotary bunker to rotation. The motor or motors are arranged outside the shaft, in an area which is not subject to intense heat. Due to this arrangement, risk of heat related failure is low.

In a preferred variant driving devices of said rotary distributing device, air blower, electric vibrating feeders use variable frequency control, to guarantee the stability of the charge level within the vertical cooling shaft of the shaft cooler as well as cooling sufficiency and uniformity of the hot sintering ore

In a preferred variant the inner wall of the cooling shaft of the shaft cooler is provided with a lining above the annular air outlet. That lining comprises an inner working layer and an outer insulating layer; the inner working layer is built by refractory bricks and the outer insulating layer is formed by refractory spraying materials; the lining is supported by a refractory support frame.

Another object of the present invention is a method for, preferably continuous, introduction of bulk material consisting of particles of different particle sizes into a container, preferably into a cooling shaft of a shaft cooler, wherein the bulk material is first centrally fed into a rotary bunker rotating about a central axis of rotation, then eccentrically pouring out of the rotary bunker into a stationary supply bunker, and then pouring from the stationary supply bunker through stationary drainpipes into the container, preferably the cooling shaft of the shaft cooler.

With respect to being fed centrally this is to be understood such that it is fed through an opening through which the central axis of rotation passes. The central axis of rotation is preferably vertical.

In such a process management, preferably with the input device according to the invention or the device for cooling bulk material according to the invention, the advantageous effects already discussed in the discussion of the input device and the device for cooling bulk material can be achieved.

The present application text shows a process method and a system using a vertical cooling shaft to recover waste heat of a sintering ore, wherein the use of a novel vertical cooling shaft – i.e. a shaft cooler, respectively cooling shaft of a shaft cooler - to cool the sintering ore can improve the waste heat recovery rate of the sintering ore and improve the production environment to the utmost extent;

The following technical scheme is used:

A process method using a vertical cooling shaft - i.e. a shaft cooler, respectively cooling shaft of a shaft cooler - to recover waste heat of a sintering ore – also shortly called sinter - comprising the following steps:

- 1) A hot sintering ore with a temperature of above 400°C produced by a sintering machine is dropped into a chute after being crushed by a single-roll crusher, delivered to a chain bucket conveyor or a chevron conveyor by an electric vibrating feeder 1 and then hoisted as bulk material to a vertical cooling shaft, i.e. cooling shaft of a shaft cooler; the upper part of the vertical cooling shaft is provided with a rotary distributing device – which according to the wording used previously in this application is the rotary bunker; for which you can define a rotary bunker body which will subsequently be called distributing device body sometimes, and for which you can define a rotary bunker space

which will subsequently be called rotary distributing trough sometimes - and a distributor – which according to the wording used previously in this application comprises the supply bunker and the drainpipes; the supply bunker will subsequently be called barrel sometimes, and the drainpipes will subsequently be called blanking chutes sometimes -, and the distributor comprises multiple blanking chutes, distributed, preferably uniformly, along the circumference of the vertical cooling shaft; the sintering ore is discharged from the head of the chain bucket conveyor or chevron conveyor and enters the rotary distributing device via a receiving chute; the rotary distributing device distributes the materials along the circumference of the distributor; the blanking chutes are used for emptying the supply bunker and uniformly distributing the hot sintering ore on the cross section of the vertical cooling shaft; cold air which is used as cooling gas within the vertical cooling shaft is provided by an air blower and exits from a central air duct outlet and an annular air duct outlet provided at the bottom of the vertical cooling shaft – also called supply lines -, to guarantee distribution uniformity of cold air within the vertical cooling shaft.

2) In the vertical cooling shaft, the sintering ore bulk material performs counterflow heat exchange with cold air; after cooling, the sintering ore with a temperature of less than 135°C is discharged to a belt conveyor by multiple discharging chutes uniformly distributed at the bottom of the shaft and an electric vibrating feeder 2 for outward transport; the exhaust gas with a temperature of above 586°C within the cooling shaft is discharged to a gravity dust collector from the cooling shaft top for primary dedusting.

Driving devices of said rotary distributing device, air blower, electric vibrating feeder 1 and electric vibrating feeder 2 use variable frequency control, to guarantee the stability of the charge level within the vertical cooling shaft -as well as cooling sufficiency and uniformity of the hot sintering ore.

This application describes a process system using a vertical cooling shaft – i.e. a shaft cooler, respectively cooling shaft of a shaft cooler - to recover waste heat of a sintering ore, comprising a vertical cooling shaft and a gravity dust collector which are successively connected according to the process route, wherein a receiving chute is provided above a hot sintering ore inlet on the top of said vertical cooling shaft; a single-roll crusher behind a sintering machine is connected with the receiving chute via a chute, an electric vibrating feeder 1 and a chain bucket conveyor or a chevron conveyor; a distributor is connected at the bottom of the receiving chute via a rotary distributing device; the rotary distributing device comprises a distributing device body, a rotary distributing trough and a driving motor device; the rotary distributing trough may be

obliquely provided within the distributing device body; the top of the rotary distributing trough is located on the top edge of the distributing device body and is connected with the driving motor device for driving; the bottom of the rotary distributing trough is located in the middle above the distributor; driven by the driving motor device, the rotary distributing trough rotates around the central axis of the vertical cooling shaft; the distributor comprises a barrel at the upper part and multiple blanking chutes uniformly distributed along the circumference at the lower part; the blanking chute is a conical structure expanding downwards and its discharge end is provided at the upper space of the vertical cooling shaft; a central air duct outlet and an annular air duct outlet are provided at the bottom of the vertical cooling shaft; multiple annular air duct outlets are provided along the outside edge of the vertical cooling shaft; a central air duct and an annular air duct are connected with an air blower via an air hose, respectively; multiple discharging chutes uniformly distributed along the circumference are provided at the bottom of the vertical cooling shaft; the bottom of the discharging chute is connected with a belt conveyor; an exhaust gas outlet on the top of the vertical cooling shaft is connected with the gravity dust collector. Dust outlets of said gravity dust collector, bag-type dust collector and waste heat boiler are connected with the chain scraper conveyor, respectively.

Bodies of said chute, receiving chute, rotary distributing trough, distributor and discharging chute are made of boiler steel plates or heat-resistance stainless steel; linings are provided or not provided as needed and are made of high abrasion manganese alloy steel plates or refractory materials.

The inner wall of said vertical cooling shaft above the annular air duct outlet is provided with a lining, wherein the lining comprises an inner working layer and an outer insulating layer; the inner working layer is built by refractory bricks and the outer insulating layer is formed by refractory spraying materials; the lining is supported by a refractory support frame.

Said chain bucket conveyor or chevron conveyor is provided with a sealed heat preservation cover.

Said driving motor device comprises one, two or more motors symmetrically arranged on the top edge of the distributing device body; a gear ring is provided on the top edge of the distributing device body; driven by the motor or motors, the gear ring rotates and

is meshed with a gear wheel arranged on the top of the rotary distributing trough, to drive the rotary distributing trough to move along the top edge of the distributing device body and realize the rotation of the rotary distributing trough around the central axis of the vertical cooling shaft. The number of said blanking chutes and discharging chutes for example is six, respectively.

Compared with the prior art the following beneficial effects arise:

1) A novel vertical cooling shaft is used to cool a sintering ore, which can realize uniform distribution of material particles within the shaft; good stability of the charge level within the shaft as well as sufficient and uniform cooling of the hot ore improve the waste heat recovery rate of the sintering ore to the utmost extent; good overall airtightness can improve the production environment.

### **Brief Description of the Drawings**

FIG. 1 schematically shows, by way of example, a longitudinal section of a device for cooling bulk material with an input device for the introduction of bulk material into a container according to the invention.

FIG. 2 shows schematically by way of example a perspective view of a section through the input device according to the invention from FIG. 1.

FIG. 3 is a flow chart of the process method using a vertical cooling shaft to recover waste heat of a sintering ore in the present invention.

FIG. 4 is a facade structure diagram of the vertical cooling shaft in the present invention.

FIG. 5 is a partial enlarged drawing of FIG. 4.

FIG. 6 is a top view of the distributor.

### **Description of embodiments**

#### **Examples**

Figure 1 shows a longitudinal section of an input device 1 according to the invention for introduction of bulk material 2 into a cooling shaft 3 of a shaft cooler 4. The input device 1 is part of a device for cooling 5 of bulk material. The input device 1 is arranged at the upper end of the cooling shaft 3. Bulk material 2, in this case hot sinter with different particle sizes, is supplied via a transport device - in this case a chevron conveyor 6, but it could also be any other type of transport device suitable for transporting hot sinter -

and fed into the rotary bunker 8 through an inlet opening 7 located centrally in the middle.

The rotary bunker 8 is rotatable about a vertical, dashed central axis of rotation 9 - indicated by two curved arrows. In the example shown the central axis of rotation coincides with the longitudinal axis of the cooling shaft 3 respectively the shaft cooler 4, and passes through the inlet opening 7. From an eccentrically arranged discharge opening 10 in the rotary bunker 8, the bulk material 2 pours into the stationary storage bunker 11. In the rotary bunker 8 a contour of the material cushion of bulk material existing in use is indicated; sloping towards the discharge opening 10. From the supply bunker 11 three stationary drainpipes 12a, 12b, 12c originate. These are conical tubes whose wider end - the shaft end - opens into the cooling shaft 3. At their narrower end - the supply end - they are connected to the supply bunker 11.

The shaft cooler 4 comprises, in addition to the cooling shaft 3, a blower 13 for blowing in cooling air, supply lines 14 for cooling air, discharge lines 15 for heated cooling air. The cooling air - represented by a transparent block arrow - is introduced below into the cooling shaft 3, flows through the material bed 16 of bulk material in the cooling shaft in countercurrent, and is discharged at the upper end of the cooling shaft 3 as heated cooling air - represented by a filled block arrow.

Rotary bunker 8 and supply bunker 11 are arranged outside the cooling shaft 3.

The material bed 16 builds up in the cooling shaft 3, because the bulk material 2 pours from the stationary supply bunker 11 through the drainpipes 12a, 12b, 12c into the cooling shaft 3. The contour of the material bed 16 is indicated in the cooling shaft 3. The bulk material 2 passes through the cooling shaft 3 in the material bed 16 from top to bottom following gravity. At the lower end of the cooling shaft 3, the cooled bulk material is discharged. In Figure 1, presentation of other parts of the device for cooling 5, for example, discharge devices for discharging the cooled bulk material from the cooling shaft was omitted for clarity.

FIG. 2 shows enlarged in perspective sectional view the combination of rotary bunker 8, supply bunker 11 and drainpipes 12a, 12b, 12c in an input device 1 according to the invention from FIG. 1. The rotary bunker 8 is rotatable about the vertical central axis of rotation 9, indicated by a curved arrow. Its inlet opening 7 is centrally located in the middle, its discharge opening 10 is arranged eccentrically. The central axis of rotation 9 passes through the inlet opening 7. Below the rotary bunker 8, the stationary supply

bunker 11 is arranged. From the supply bunker 11, the three stationary drainpipes 12a, 12b, 12c originate.

Specific embodiments of the present application are further described below in combination with the drawings 3 to 6.

As shown in FIG. 3, the process method using a vertical cooling shaft to recover waste heat of a sintering ore in the present invention comprises the following steps:

1) A hot sintering ore with a temperature of above 700°C produced by a sintering machine 17 is dropped into a chute 18 after being crushed by a single-roll crusher 19, delivered to a chain bucket conveyor 20 by an electric vibrating feeder 1 21 and then hoisted to a vertical cooling shaft 22 - i.e. a shaft cooler, respectively cooling shaft of a shaft cooler -; the upper part of the vertical cooling shaft 22 is provided with a rotary distributing device 23 and a distributor 24, and the distributor 24 comprises multiple blanking chutes 25 uniformly distributed along the circumference of the vertical cooling shaft 22; the sintering ore is discharged from the head of the chain bucket conveyor 20 and enters the rotary distributing device 23 via a receiving chute 26; the rotary distributing device 23 distributes the materials along the circumference of the distributor 24; the blanking chute 25 is used for blanking cushion and uniformly distributing the hot sintering ore on the cross section of the vertical cooling shaft 22; cold air within the vertical cooling shaft 22 is provided by an air blower 27 and exits from a central air duct outlet 28 and an annular air duct outlet 29 provided at the bottom of the vertical cooling shaft 22, to guarantee distribution uniformity of cold air within the vertical cooling shaft 22;

In the vertical cooling shaft 22, the sintering ore performs counterflow heat exchange with cold air; after cooling, the sintering ore with a temperature of less than 135°C is discharged to a belt conveyor 30 by multiple discharging chutes 31 uniformly distributed at the bottom of the shaft and an electric vibrating feeder 2 32 for outward transport; the exhaust gas with a temperature of above 586°C within the shaft is discharged to a gravity dust collector 33 from the shaft top for primary dedusting. Dust from dust collector 33 after sedimentation is transported outward by a chain scraper conveyor 34 along with the dust collected in the gravity dust collector 33.

Driving devices of said rotary distributing device 23, air blower, electric vibrating feeder 1 21 and electric vibrating feeder 2 32 use variable frequency control, to guarantee the stability of the charge level within the vertical cooling shaft 22 as well as cooling

sufficiency and uniformity of the hot sintering ore.

As shown in FIG. 3 and FIG. 4, a process system using a vertical cooling shaft to recover waste heat of a sintering ore for realizing said process method, comprising a vertical cooling shaft 22, a gravity dust collector 33, which are successively connected according to the process route, wherein a receiving chute 26 is provided above a hot sintering ore inlet on the top of said vertical cooling shaft 22; a single-roll crusher 19 behind a sintering machine 17 is connected with the receiving chute 26 via a chute 18, an electric vibrating feeder 1 21 and a chain bucket conveyor 20; as shown in FIG. 3, a distributor 24 is connected at the bottom of the receiving chute 26 via a rotary distributing device 23; the rotary distributing device 23 comprises a distributing device body 35, a rotary distributing trough 36 and a driving motor device 37; the rotary distributing trough 36 is obliquely provided within the distributing device body 35; the top of the rotary distributing trough 36 is located on the top edge of the distributing device body 35 and is connected with the driving motor device 37 for driving; the bottom of the rotary distributing trough 36 is located in the middle above the distributor 24; driven by the driving motor device 37, the rotary distributing trough 36 rotates around the central axis of the vertical cooling shaft 22; the distributor 24 comprises a barrel 38 at the upper part and multiple blanking chutes 25 uniformly distributed along the circumference at the lower part; the blanking chute 25 is a conical structure expanded downwards and its discharge end is provided at the upper space of the vertical cooling shaft 22; a central air duct outlet 28 and an annular air duct outlet 29 are provided at the bottom of the vertical cooling shaft 22; multiple annular air duct outlets 29 are provided along the outside edge of the vertical cooling shaft 22; a central air duct and an annular air duct are connected with an air blower via an air hose, respectively; multiple discharging chutes 31 uniformly distributed along the circumference are provided at the bottom of the vertical cooling shaft 22; the bottom of the discharging chute 31 is connected with a belt conveyor 30. The outlet of the multiple discharging chutes 31 on the vibrating feeder 32 is provided with a dust cover 39.

An air blower 27 pumps cooling air into the bulk material bed. An exhaust gas outlet on the top of the vertical cooling shaft 22 is connected with the gravity dust collector 33; a high-temperature exhaust gas pipe behind the gravity dust collector 33 is also present. Dust outlets of said gravity dust collector 33 are connected with the chain scraper conveyor 34.

Bodies of said chute 18, receiving chute 26, rotary distributing trough 36, distributor 24 and discharging chute 31 are made of boiler steel plates or heat-resistance stainless

steel; linings are provided or not provided as needed and are made of high abrasion manganese alloy steel plates or refractory materials.

The inner wall of said vertical cooling shaft 22 above the annular air duct outlet 29 is provided with a lining, wherein the lining comprises an inner working layer and an outer insulating layer; the inner working layer is built by refractory bricks 40 and the outer insulating layer is formed by refractory spraying materials; the lining is supported by a refractory support frame.

Said chain bucket conveyor 20 is provided with a sealed heat preservation cover.

Said driving motor device 37 comprises two motors symmetrically arranged on the top edge of the distributing device body 35; a gear ring is provided on the top edge of the distributing device body 35; driven by the motor, the gear ring rotates and is meshed with a gear wheel arranged on the top of the rotary distributing trough 36, to drive the rotary distributing trough 36 to move along the top edge of the distributing device body 35 and realize the rotation of the rotary distributing trough 36 around the central axis of the vertical cooling shaft 22. The number of said blanking chutes 25 and discharging chutes 31 is six, respectively.

The above-mentioned contents are only preferred embodiments of the present invention, but the protection scope of the present invention is not limited to this; within the technical scope disclosed in the present invention, equivalent replacements or changes made according to the technical scheme and the concept of the present invention by any technician familiar with the technical field shall fall into the protection scope of the present invention.

## Reference signs list

1	Input device
2	Bulk material
3	Cooling shaft
4	Shaft cooler
5	Device for cooling bulk material
6	Chevron conveyor
7	Inlet opening
8	Rotary bunker
9	Central axis of rotation
10	Discharge opening
11	Supply bunker
12a,b,c	Drainpipe
13	Blower
14	Supply lines
15	Discharge lines
16	Material bed
17	sintering machine
18	chute
19	single-roll crusher
20	chain bucket conveyor
21	electric vibrating feeder 1
22	vertical cooling shaft
23	rotary distributing device
24	distributor
25	blanking chute
26	receiving chute
27	Air blower
28	central air duct outlet
29	annular air duct outlet
30	belt conveyor
31	discharging chute
32	electric vibrating feeder 2
33	gravity dust collector

- 34 chain scraper conveyor
- 35 distributing device body
- 36 rotary distributing trough
- 37 driving motor device
- 38 barrel
- 39 Dust cover
- 40 refractory brick

**Citation list**

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## Claims

1) Input device (1) for the introduction of bulk material (2) consisting of particles with different particle sizes into a container, characterized in that

this input device (1) comprises:

- a rotary bunker (8) rotatable about a central axis of rotation (9), having an inlet opening (7) for the bulk material (2) through which the central axis of rotation (9) passes, and having a discharge opening (10) for the bulk material (2), the discharge opening (10) being arranged eccentrically;
- a supply bunker (11), in which the discharge opening (10) of the rotary bunker (8) opens;
- at least three drainpipes (12a, 12b, 12c) emanating from the supply bunker (11); wherein the supply bunker (11) and the drainpipes (12a, 12b, 12c) are stationary.

2) Input device (1) according to claim 1, characterized in that the container is a cooling shaft (3) of a shaft cooler (4).

3) Input device (1) according to claim 1, characterized in that the bulk material (2) has a temperature of at least 300 ° C, preferably at least 400 ° C.

4) Input device (1) according to claim 1, characterized in that the bulk material (2) is hot sinter.

5) Input device (1) according to claim 1, characterized in that the cross section of the drainpipe (12a, 12b, 12c) becomes larger with increasing distance from the supply bunker (11).

6) Device for cooling bulk material (2) consisting of particles of different particle sizes, comprising  
a shaft cooler (4) with cooling shaft (3),  
and  
an input device (1) for the input of bulk material (2) in a shaft cooler (4) according to any

of claims 1 to 5,

wherein the input device (1) is arranged at the upper end of the cooling shaft (3) of the shaft cooler (4), wherein the drainpipes (12a,12b,12c) open with their lower ends into the cooling shaft (3), and the rotary bunker (8) and the supply bunker (11) are arranged outside the cooling shaft (3).

7) Device for cooling according to claim 6, characterized in that the bulk material (2) has a temperature of at least 300 ° C, preferably at least 400 ° C.

8) Device for cooling according to claim 6, characterized in that the bulk material (2) is hot sinter.

9) Device for cooling according to claim 6, characterized that cooling gas supply lines are provided circumferentially and centrally in the cooling shaft (3) with annular and central air outlets (29,28).

10) Device for cooling according to claim 6, characterized in that a driving motor device (37) for the rotary bunker (8) is provided and a gear ring is provided at the top edge of the rotary bunker (8) for driving rotation of the rotary bunker (8).

11) Device for cooling according to claim 6 with air blowers (27) and electric vibrating feeders (21,32), characterized in that driving devices of said rotary distributing device (23), air blower (27), electric vibrating feeders (21,32) use variable frequency control.

12) Device for cooling according to claim 9, characterized in that the inner wall of the cooling shaft (3) of the shaft cooler (4) is provided with a lining above the annular air outlet.

13) Method for, preferably continuous, introduction of bulk material (2) consisting of particles of different particle sizes into a container, preferably into a cooling shaft (3) of a shaft cooler (4), wherein the bulk material is first centrally fed into a rotary bunker (8) rotating about a central axis of rotation (9), then eccentrically pouring out of the rotary bunker (8) into a stationary supply bunker (11), and then pouring from the stationary supply bunker (11) through stationary drainpipes (12a,12b,12c) into the container, preferably the cooling shaft (3) of the shaft cooler (4).

14) Method according to claim 13, characterized in that the bulk material (2) has a temperature of at least 300 ° C, preferably at least 400 ° C.

15) Method according to claim 13, characterized in that the bulk material (2) is hot sinter.

FIG 1

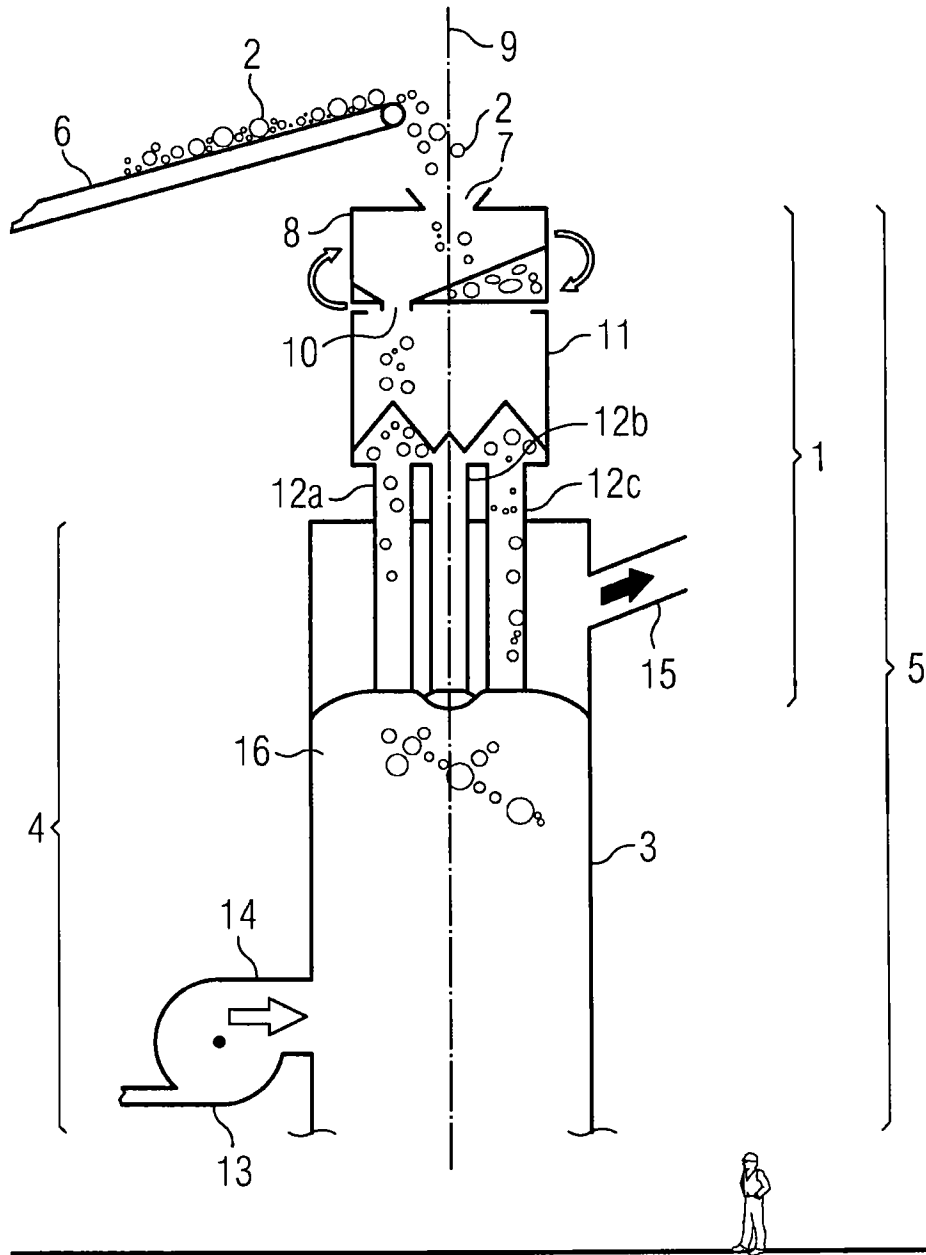


FIG 2

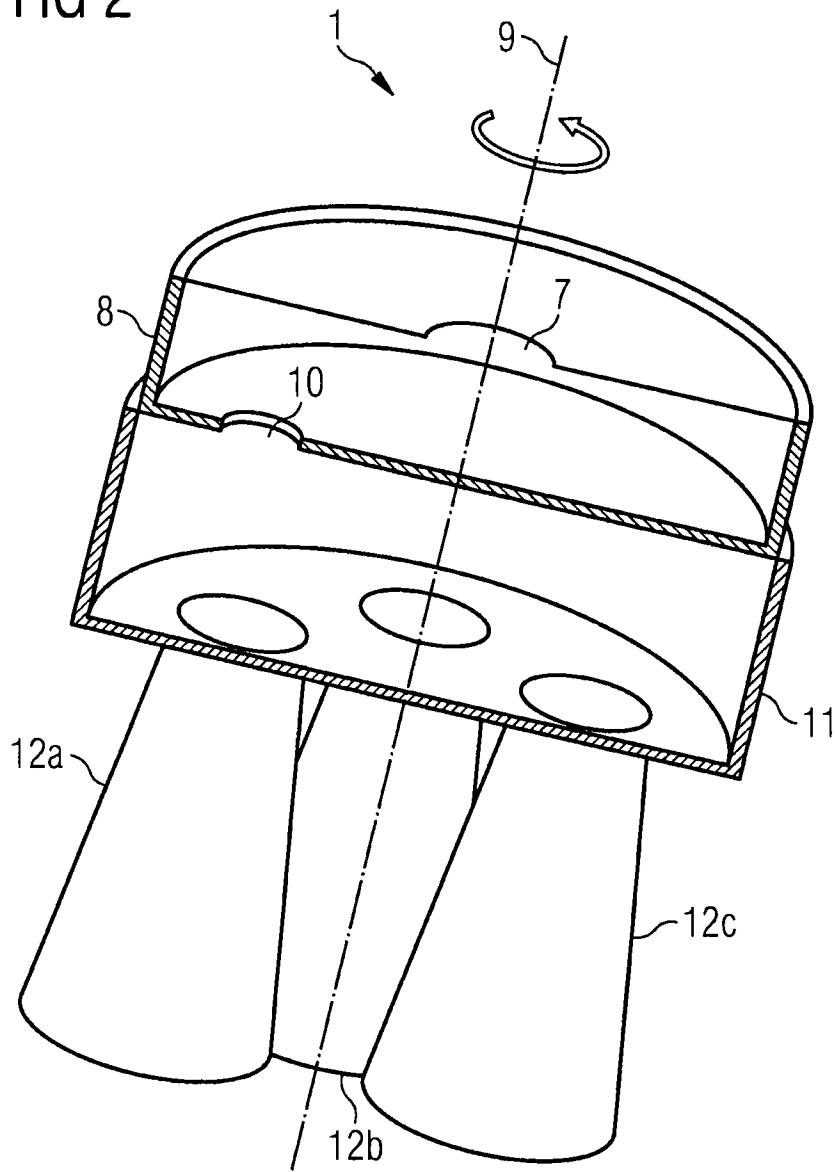
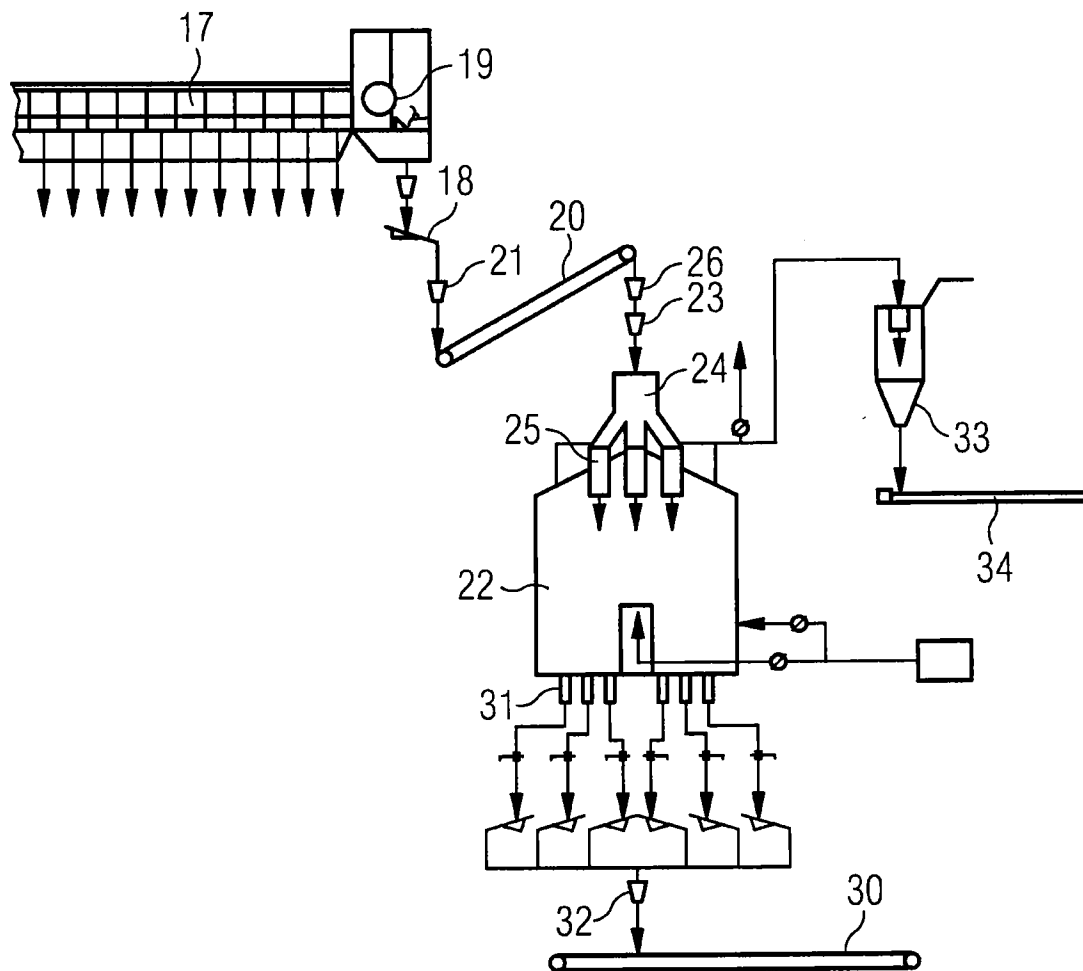


FIG 3



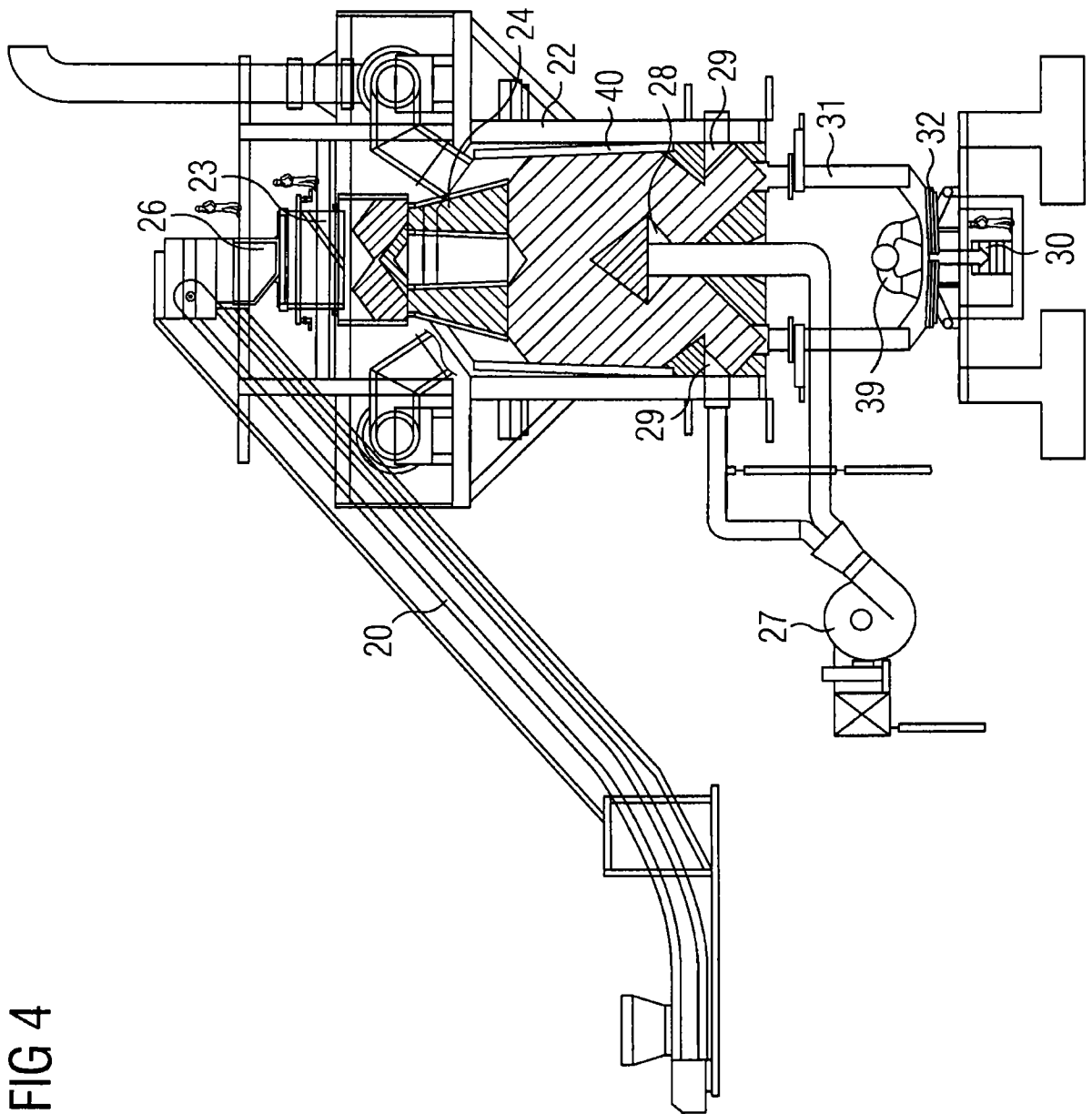


FIG 4

FIG 5

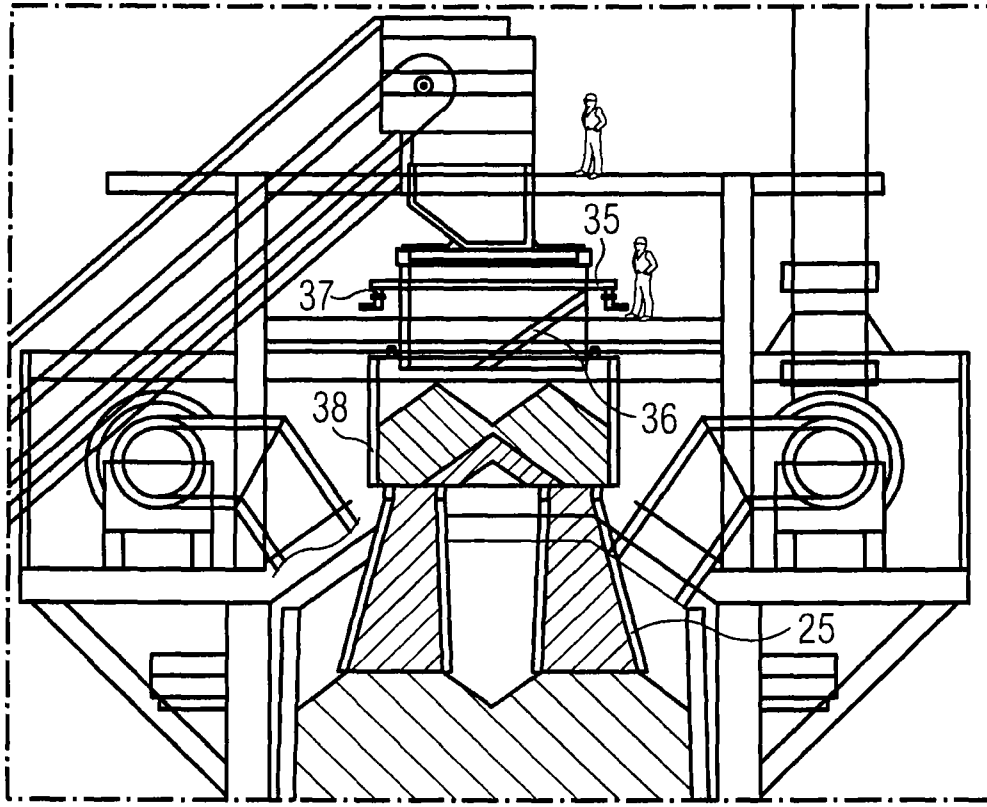
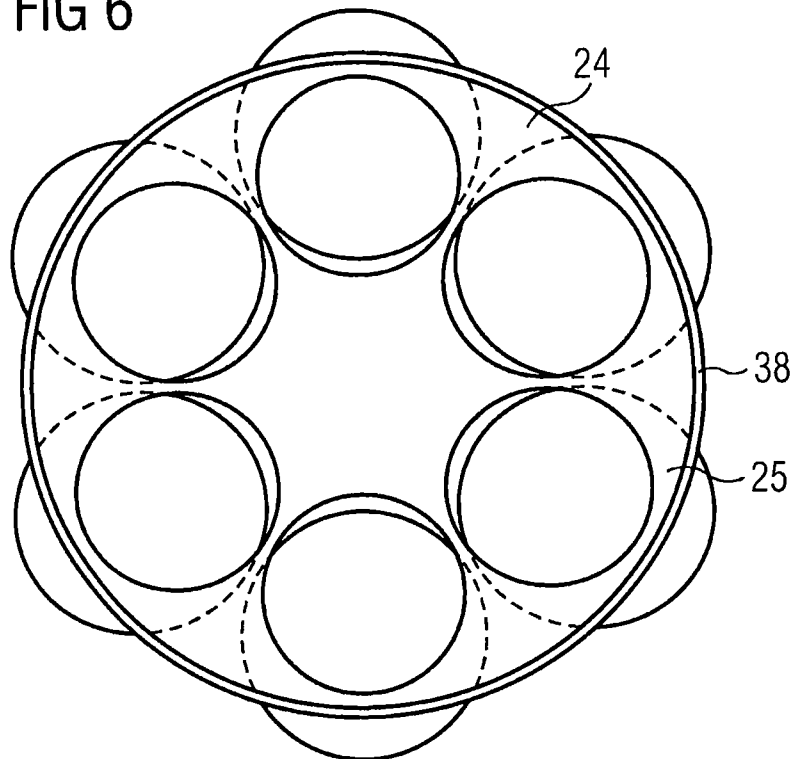


FIG 6



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2017/119855

**A. CLASSIFICATION OF SUBJECT MATTER**

F27D 15/02(2006.01)i

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)

F27D15; B65G2; B65G11

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)

CNKI,CNPAT,WPI,EPODOC:rotat+, bunker?, drainpipe?, discharg+, input, drain+, input device?, bulk material, inlet, chute?, container

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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 Further documents are listed in the continuation of Box C. See patent family annex.

\* Special categories of cited documents:

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“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

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“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

23 March 2018

Date of mailing of the international search report

02 April 2018

Name and mailing address of the ISA/CN

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**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

International application No.

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