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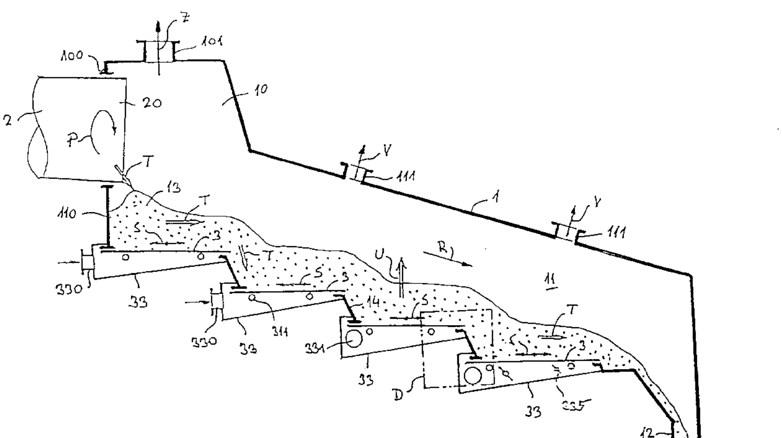
(54) **Title:** A GRATE COOLER FOR GRANULAR MATERIAL



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(57) **Abstract:** The invention deals with construction modifications of a grate cooler for granular material, which is composed from a system of mutually stepwise connected cooling grates. According to the invention at least one of grates (3) is composed from one surface, which can be according to the invention further divided to more independent longitudinal parts (301, 302). The grate (3), eventually its independent longitudinal parts (301, 302) are connected with adriving mechanism (31), with aid of which they are moving with reversible movement in the direction of cooled material movement through the cooler. Over the cooling grate (3) at least one tranversal rod it is preferably located and the forward and backward velocity of reversible motion of independent longitudinal parts (301, 302) can by further according to the invention different. In the air chambers for input of cooling air under the grates (3) of the cooler there are according to the invention independent distribution channels (332) created, which are ended into a common input area (337), where on the inputs into the distribution channels (332), eventually also inside of them, there are eventually regulating elements (335, 336).

A grate cooler for granular material

The area of science

The invention deals with a grate cooler of granular material, namely for cement clinker cooler after the burning of the clinker, consisting at least from one couple, mutually connected independent cooler grates, where at such grate cooler - in the direction of the cooled material movement - each consecutive cooling grate situated lower as the previous one and where between the end part of the first and the beginning part of consecutive cooling grate an intermediate wall is inserted, where the cooling grates are provided with independent bottom input of cooling gas.

The recent state of the science

At the up to now known coolers for cooling of granular material are designed mostly as grate coolers, the cooling surface of which is composed in the direction of the cooled material movement from rows of solid and moving grate bars. The solid and moving rows of grate bars are located alternately one after the other, where the moving rows provide linear to and back movement in the direction of the cooled material movement.

The heat exchange function of such grate cooler is based mostly on the principle of cross heat exchange between the cooled material and the cooling gas. That means, that the layer of cooled material is moving on the grate surface parallel with its surface and the cooling gas cross the layer of this material principally vertically to the direction of its movement. The grate coolers of mentioned type are recently assumed as equipment suitable especially for cooling of cement clinker, which is characterized both with high dust particle content and also with greater pieces of material, which at entering to the cooling area have such a high temperature, that this temperature achieves up to the border of undesirable sticking of their particles.

Also constructions are known, which have more independent grates, which are ordered consecutively in independent in different height ordered stages. Each grate is here composed from more rows of solid, that means not moving grate bars with openings for passing of the cooling medium, and from moving grate bars, which are deposited on a moving frame and so they provide as an unit the requested reversible linear movement in the direction of cooled material movement. With this movement, they carry out the movement of cooled material in the desired direction. The cooling medium is a stream of cooling gas, usually air, which enters to the layer of cooled material from belcw over openings in the grate bars, and this either from a common cooling chamber under the grate or it is fed into the individual rows of grate bars with help of independently controlled feeding tubes.

But the mentioned kind of grate coolers show imperfections, which are determined with the mentioned principle of cross heat exchange already. It must be mentioned first the relatively low efficiency of the heat exchange, with which a greater consumption of cooling air is connected. These imperfections are then consecutively manifested in higher capital and operation costs per unit of end product.

At equipment with rows of alternately solid and moving grate bars the mechanical complexity is a disadvantage, where for perfect mutual relative movement the bars request beside an accurate production of individual parts also an accurate assembly, where the minimal gap between the corresponding rows has to be observed. A further disadvantage is, that over these - from the technological point of view necessary gaps - even at presence of the from below conducted cooling air stream - the finer share of cooled material is falling down under the whole grate surface, what requests the installation of high dimensioned hoppers in the cooler lower part. Besides this, the hoppers have to be sealed against outflow of cooling air, which is forced under the cooling grate. Besides this a part of cooled material is milled at mutual movement of rows of grate bars in their contact gaps, what on one side increases the energy consumption of the movement of the grate surface and on the other side increases the wear of grate bars self and thus their life time is shortened.

Though that the effectiveness of thermal exchange at newer versions is increased, as for instance at construction according to invention application PV 1998-4032 with use of additional system of transversal grate bars with independent input of cooling gas, remains the unavoidable mutual movement of solid and moving rows of transversal grate bars, with all undesirable accompanying effects described in the previous text.

The fundamentals of the invention

The principal part of mentioned disadvantages is removed by the object of this invention, which is a grate cooler of granular material, especially cement clinker cooler after its burning, consisting from at least one couple, mutually connected independent cooler grates, where at such grate cooler - in the direction of the cooled material movement - each consecutive cooling grate situated lower as the previous one and where between the end part of the first and the beginning part of consecutive cooling grate an intermediate wall is inserted, where the cooling grates are provided with independent bottom input of cooling gas.

The essence of the invention is that at least one cooling grate is in the direction of cooled material movement composed from at least one integral surface, which is connected with a driving mechanism for its to and back movement in the direction of cooled material movement, where the driving mechanism is composed from a retractor hydraulic mechanism, which is for this purpose connected to the cooling grate head.

An other essence of the invention is, that the plane of at least one cooling grate makes with the horizontal plane a sharp angle up to $\pm 8^{O}$.

The essence of the invention is also, that the velocities of the to and back movement at least two, in the direction of the cooled material movement one to the other connected grates are different, and eventually, when the cooling grate is composed from at least two parts, the longitudinal axis of which are parallel with the cooled material movement and each from which is provided with independent mean for the reversible movement.

An other essence of the invention is, that the velocities of reversible movement at least two parts of cooling grate are different, eventually that the velocity of the reversible movement of at least one cooling grate or its part is in the direction of cooled material direction different from the velocity of the reversible movement in the opposite direction.

An other essence of the invention is, that under at least under one cooling grate a system of mutually parallel distribution channels of cooling gas is formed, the longitudinal axis of which is parallel to the cooled material movement, and that the width of distribution channel corresponds preferably to the width to it adjacent longitudinal part of cooling grate, eventually that the system of distribution channels is ended to a common input chamber.

At last the essence of the invention is, that on the beginning of at least one distribution channel a regulating element is situated, eventually that at least one additional regulating element is located in the cavity of at least one distribution channel, and that at least in the lower part of the front wall of the cooling area and/or intermediate wall between the individual grate coolers a system of openings is realized for the input of additional cooling air, eventually, that over the surface of at least one grate surface at least one solid transversal rod is located.

With the embodiment of a construction of a grate cooler according to the invention, in comparison to the up to now used constructions the quantity of its independent moving parts will be simplified, and its operation parameters will be improved, what will be favorably manifested both in the volume of necessary investment and also in decreasing of requirements to the maintenance.

Overview of pictures on the drawing

The examples of embodiment of a construction of the grate cooler according to the invention are schematically demonstrated on the attached drawings, where on the Picture no.1 a cross section of a grate cooler is demonstrated and on the Picture no. 2 a simplified ground plan view to a longitudinally divided cooling grate is demonstrated, on the Picture No. 3 the cross section A-A from the Picture No. 2 is demonstrated, on the Picture No. 4 a cross section B-B from the Picture No. 3 is shown, on the Picture No. 5 a construction version of the detail "D" from the part of the grate cooler according to the Picture No. 1 is shown and on the Picture No. 6 the versions of angle location of cooling grate are shown.

Examples of embodiment of invention:

The grate cooler in the construction version according to Picture no. 1 is composed from a longitudinal case **1** with input area **10** , which is provided with a output socket **101**of hot air and in front wall **110** of which the ending **100** is formed for the output area **20** of rotary kiln **2** , from which the cooled material **13** is transported to the input area **10** . The grate cooler **1** is further composed from the cooling area **11**, which is provided with at least output sockets **111** of preheated air and in the ending part of which the output **12**, ended to the conveyor **5**, is formed.

As it is further evident from the Picture No. 1, the lower part of case **1** is formed from a system of cooling grates **3**, which are arranged in stages such a way, that in the direction of cooled material **13** movement **R** always the in height shifted end of the previous cooling grate **3** is connected to the begin of the following one. The passages between them are realized with aid of in principle vertical intermediate walls **14**. The cooling grate **3** of each stage is here composed from a horizontal surface, which is provided with not demonstrated vents for passage of cooling air in direction of arrow **U** , and where the cooling grate **3** of is in the case 1 fit as sliding in horizontal direction, for instance with aid of rolling bearing 311, eventually with aid of not demonstrated swinging hangings etc.

The reverse motion of cooling grate 3 in the direction of arrow S is realized with one from the known methods of driving mechanism, the example embodiment of which is demonstrated on the Pictures No. 2 and 5. The driving mechanism 31 is composed for instance_with a crank gear, which is driven with rotary motor, with linear hydraulic motor etc. and which is connected with the corresponding cooling grate 3, eventually with its part 301, 302 with a coupler, the construction version of which is depending on the kind of used driving mechanism 31.

Under each cooling grate 3 an air chamber 33 of the cooling air input is formed, where the air, according to the used construction version, is transported either with the front socket 330 or with the side socket 331 . Both of these versions are demonstrated on the Picture No. 1.

As it is evident from the Picture No. 2, the cooling grate 3 according the invention can be divided along the longitudinal axis 300 , which in principle corresponds to the direction R of the cooled material 13 movement according to Picture No. 1, e.g. divided to more longitudinal parts, in this example embodiment to three parts, the middle part 301 and two side parts 302 with different width 303. On the Picture No. 2 the construction version with three parts is demonstrated, from which parts the both side parts are narrower as the middle one. Generally the cooling grate can be divided in different number of parts, the widths of which can be equal or different depending on the construction version and namely on the following function of the cooler. Each longitudinal part 301, 302 according to Picture No. 2 is provided with independent driving mechanism 31. To prevent the undesirable falling down of fine particles of cooled material 13 under the grate there are over the necessary technological gaps between the cooling grate 3 and to it adjacent wall of cooling area 11, eventually between the partial parts 301, 302 of cooling grate 3 catching elements 304 are located.

Also the air chamber 33 for distribution of cooling air under the cooling grate 3 , or its parts 301, 302 , can be according to the Picture No. 3 longitudinally divided to more to its axis 333 parallel distribution channels 332 , which are ended to one common input area 387 with front socket 330 of the cooling air input. This division can be used both at not divided, and at divided cooling grate 3 , as it is demonstrated on the Picture No. 4. In the mentioned example embodiment then the widths 334 of distribution channels 332 in principle correspond to individual, to them adjacent parts 301, 302 of cooling grate 3 . In the input area 337 of the air chamber 33 can be further at the inputs to the individual distribution channels 332 preferably located the independently controlled regulating elements 335 , for instance jalousies or clack valves, whereas the individual independent distribution channels 332 can be completed with additional regulating elements 336 , for instance with clack valves.

As it is demonstrated on the Picture No. 5, the intermediate wall 14 between the individual cooling grates 3 , eventually the front wall 110 of cooler can be provided in the lower part with a jalousie 400, to which from the outer side the input chamber 4 with the input socket 40 of the additional cooling air are connected. The jalousie 400 can be, namely at the lower intermediate walls 14 replaced with a system of openings, which are provided in the corresponding lower parts of intermediate walls 14 and which are not demonstrated on the Pictures.

As it is evident from the Picture No. 6, the plane of cooling grates 3 can be, in relation to the horizontal plane 305 declined by the angle α , and this such a way, that the end of corresponding cooling grate 3 , related to the direction **R** of cooled material 13 movement, in relation to the horizontal plane 305 located higher as the begin of cooling grate 3 or vice versa. With this declination the conditions for the shifting of cooled material 13 in the area of declined cooling grate 3 are modified such a way, that the velocity of shifting in the corresponding part of cooling area 11 is either decreased - and this when the ending part of cooling grate 3 is lifted up - or increased - when the declination is in the opposite direction. It is advantageous to provide the declination in the range of angle α up to the angle ± 8 angle degrees, the real declinations are on the Picture No. 6 for better lucidity increased.

The function of cooling grate according to the invention is as follows. The cooled material gets off from the output part 20 of the rotary kiln 2 into the input area 10 of case 1 and it is unloaded in the direction of arrow T to the begin of first cooling grate 3 . The last is fit on a roller bearing 311 and with aid of driving mechanism 31 , demonstrated for instance on the Picture No. 5, is moving reversibly in direction of arrow S . At movement of cooling grate 3 in direction of the output 12 from the cooler , also and in the same direction the to it tilt cooled material 13 is moving. At reverse motion of cooling grate 3 an important part of this material does not moves back with it, and this for the reason, that to the begin of it from the output part 20 a new material has been poured in the meantime, which is resting on the front wall 110 and is preventing to the reverse motion of the previous portion of cooled material. The original material is so stepwise shifted in direction of arrows T to the end of first cooling grate 3 and over the intermediate wall 14 is fallen down to the next cooling grate 3 and this is repeated so long as the sufficiently cooled material is fallen out from the output 12 on the conveyor 5 , with which is then transported to the next technological process. The velocity of shifting of the cooled material 13 and also the height of its layer on the individual cooling grate 3 can be controlled with use of different velocities of its reversible shifting in direction to the output and vice versa. It is evident, that the faster movement contributes to greater velocity of the cooled material 13 movement on the surface of cooling grate 3 and this way, at preservation of its output quantity from the rotary kiln 2 to decrease of the layer height on it and vice versa. The mentioned situation can be strengthened by use of transversal rods 32 , for instance transversal rods of circular cross section over the surface of cooling grate 3, where the rods are demonstrated on the Picture No. 5 and with dashed line on the Picture No.2.

The cooling air is led through the front sockets 330 , eventually through the side sockets 331 to the air chambers 33, from which then led in direction of the arrow U over the cooling grates 3 and further through the layer of cooled material 13 into the upper part of cooling area 11, from which the preheated air is led out through output sockets **111** in direction of arrows **V** for next use, for instance for drying of raw material. Similarly the hot air from the input chamber **10** led out through the output socket **101** and it is used for instance as combustion air for the burners of a calcinating equipment. For cooling any suitable, from the technology available gas can be used. For simplicity in the description only an application with use of cooling air is used.

As it is demonstrated on the Picture no. 3, as result of the rotary motion of output **20** of rotary kiln **2** the grain size in the layer of cooled material **13** in the cross section in transversal direction to its shifting is different and further the layer height of cooled material **13** is not homogenous. That means, that the resistance against the passage of cooling air in the transversal cross section through the cooling grate **3** is in different places different and the material in the whole cross section is not uniformly cooled.

At realization of construction version according to Picture No. 2 is further possible to move with the different individual parts **301**, **302** of cooling grate **3** with different velocities. When the greater velocity is chosen for the part, on which a higher layer of cooled material **13** is deposited, than this height will be in a considerable extent reduced already after passage though one, or more stages of cooling grates and this way the conditions for cooling will from technological and so also from operation economic point of view more convenient.

At application of longitudinally divided distribution channels according to Picture No. 3 the quantity of cooling air can be additionally controlled, where the cooling air passes through the individual longitudinal zones of cooling grate **3** - and this both in the case, when the grate is compact, or in case when preferably the cooling grate **3** is divided to individual longitudinal parts **301**, **302** and the widths **333** of distribution channels **332** correspond to their widths **303**. At embodiment according to the Picture No. 4 the distribution of cooling air - depending on the conditions on the corresponding parts of the cooling grate - can be when needed regulated with setting the locations of positions of regulating elements **335** on input of the air into the individual distribution channels **332** and in them additionally with use of eventually applied additional regulating elements **336**.

With input of additional cooling air into the front area of the layer of cooled material **13** according to the Picture No. 5 the effectiveness of the cooling in the input areas of individual cooling grates is increased, and this will be applied both at application in the intermediate walls **14** and also at application in the front wall **110** of the cooler.

It is evident, that the construction details according to the invention can be successfully applied in different mutual combinations, eventually to apply equivalent technical details without infringement of the essence of the invention, which is defined in the attached claims.

The areas of application in the industry

The cooling grate according to the invention can be used as equipment, which is namely connected to the output of thermally processed materials from rotary kilns.

(Patent claims)

Patent claims

1. A grate cooler for granular material, namely a cooler for cement clinker after its burning, consisting at least from one couple mutually connected independent cooler grates, where at such grate cooler - in the direction of the cooled material movement - each consecutive cooling grate situated lower as the previous one and where between the end part of the first and the beginning part of consecutive cooling grate an intermediate wall is inserted, where the cooling grates are provided with independent bottom input of cooling gas, ***characterized in that*** the at least one cooling grate (3) is in the direction (R) of cooled material (13) movement composed from at least one integral surface, which is connected to a driving mechanism (31) for its reversible movement in the direction (R) of the cooled material (13) movement.

2. A grate cooler according to claim 1, ***characterized in that*** the driving mechanism (31) is composed from reversible hydraulic mechanism, which is connected to the front of cooling grate (3).

3. A grate cooler according to claim 1 or claim 2, ***characterized in that*** the plane of at least one cooling grate (3) makes with the horizontal plane a sharp angle (α) up to ± 8 degrees.

4. A grate cooler according to one of claims 1 to 3, ***characterized in that*** the velocities of reversible movement of at least two, in direction (R) of cooled material (13) movement of to each other connected cooling grates (3) are different.

5. A grate cooler according to one of claims 1 to 4, ***characterized in that*** the cooling grate (3) is composed from at least two parts (301,302), the longitudinal axis (300) of which are parallel with the direction (R) of cooled material (13) movement and that each from them is provided with independent mean (31) for reversible movement.

6. A grate cooler according to claim 5, ***characterized in that*** the velocities of reversible movement of at least two parts (301,302) of cooling grate (3) are different.

7. A grate cooler according to one of claims 1 to 6, ***characterized in that*** the velocity of reversible movement of at least one cooling grate (3), or its part (301,302) is in direction (R) of cooled material (13) movement different from the velocity of reversible movement in the opposite direction.

8. A grate cooler according to one of claims 1 to 7, ***characterized in that*** the under at least one cooling grate (3) a system of mutually parallel distribution channels (332) of cooling gas is created, the longitudinal axis (333) of which is parallel to the direction (R) of the cooled material (13) movement.

9. A grate cooler according to claim 8, ***characterized in that*** the with (334) of distribution channel (332) corresponds to the width (303) of to it adjacent longitudinal part (301, 302) of cooling grate (3).

10. A grate cooler according to claim 8 or 9, ***characterized in that*** the system of parallel distribution channels (332) is ended to a common input chamber (337).

11. A grate cooler according to claim 10, ***characterized in that*** on the begin of at least one distribution channel (332) is a regulating element (335) located.

12. A grate cooler according to one of claims 8 to 11, ***characterized in that*** in the cavity of at least one distribution channel (332) at least one additional regulating element (336) is located.

13. A grate cooler according to one of claims 1 to 12, ***characterized in that*** at least in the lower part of front wall (110) of the cooling area (10) and/or intermediate wall (14) between the individual grate coolers (3) a system of openings for input of additional cooling air is provided.

14. A grate cooler according to one of claims 1 to 13, ***characterized in that*** over at least one grate surface (3) at least one solid transversal rod (32) is located.

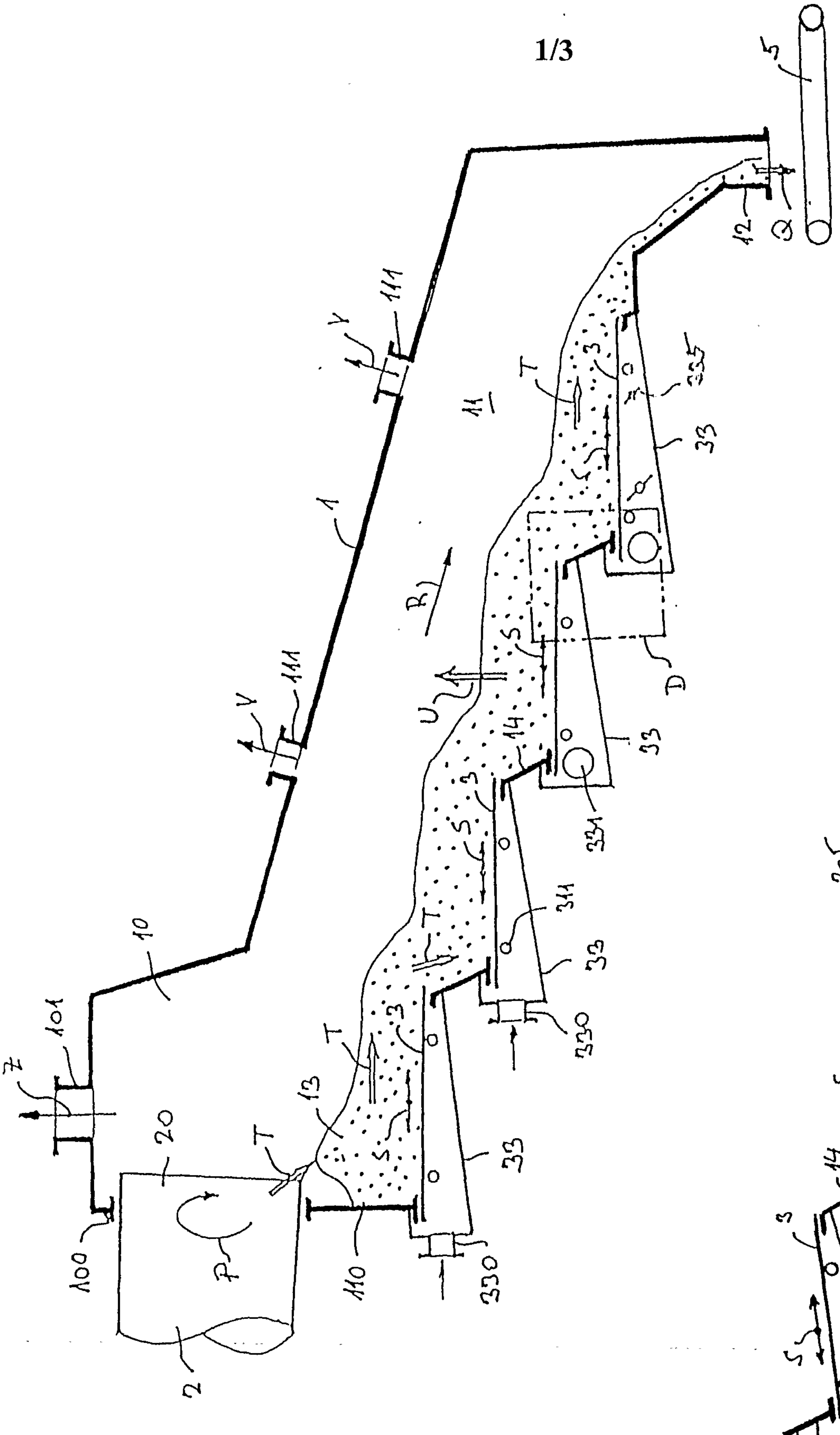
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Fig. 1

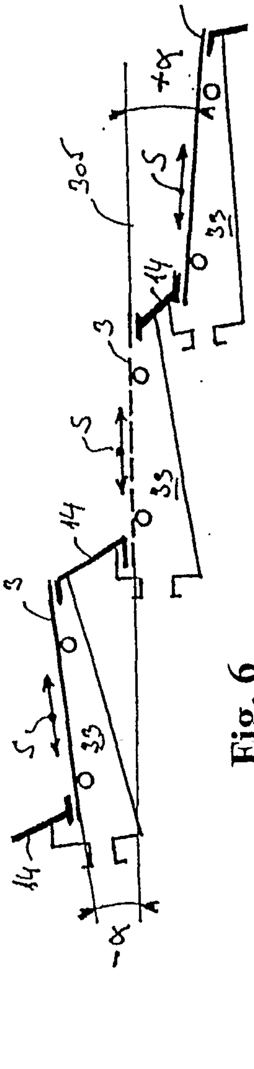
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Fig. 6

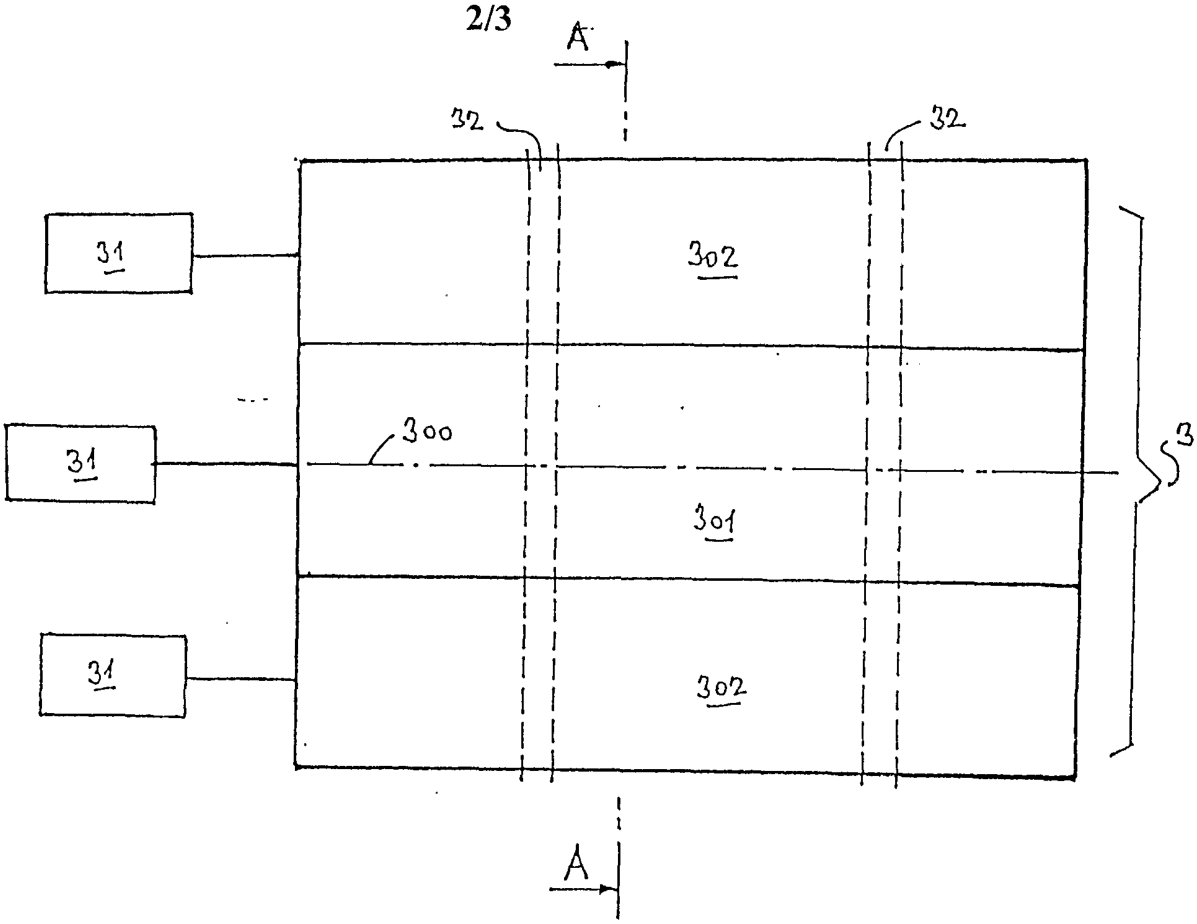
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Fig. 2

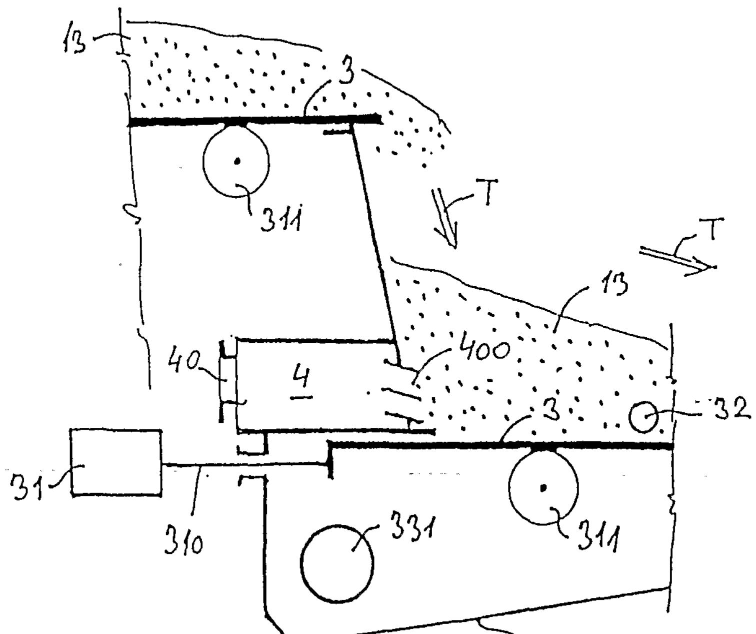
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Fig. 5

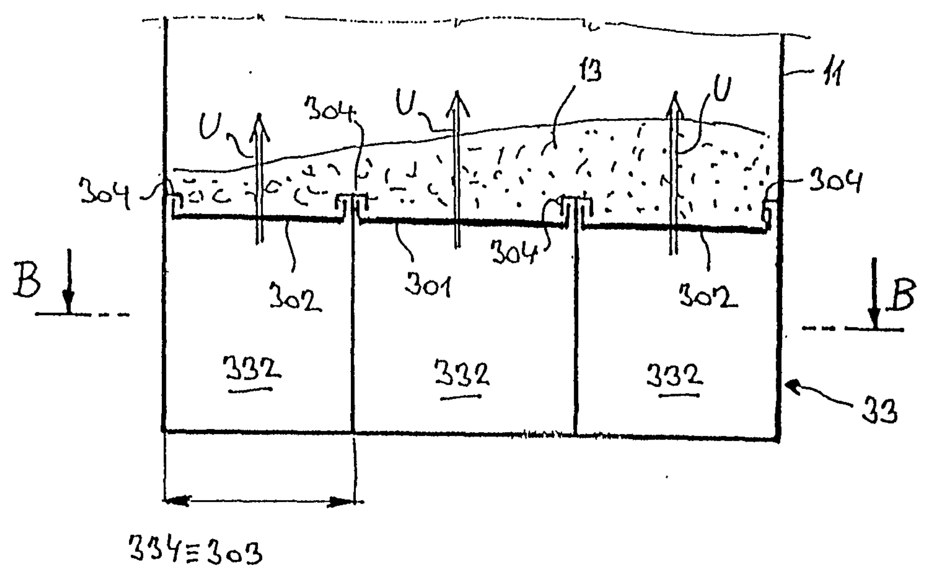
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Fig. 3

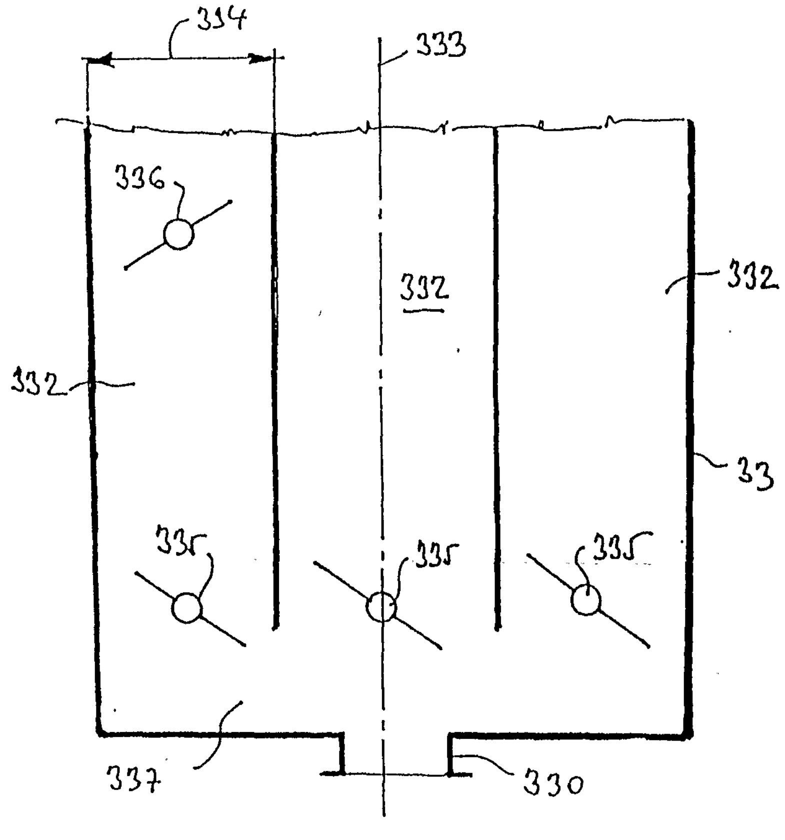
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Fig. 4

INTERNATIONAL SEARCH REPORT

Inte Application No
PCT/CZ 01/00048

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F27D15/02 C04B7/47

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)
IPC 7 F27D F28C C04B F27B

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 practical, search terms used)

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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A	GB 2 009 900 A (READYMIX CEMENT ENGINEERING GMBH) 20 June 1979 (1979-06-20)	
A	US 5 149 266 A (OTTO HEINEMANN) 22 September 1992 (1992-09-22)	

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

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
28 February 2002	07/03/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Coulomb, J

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CZ 01/00048

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