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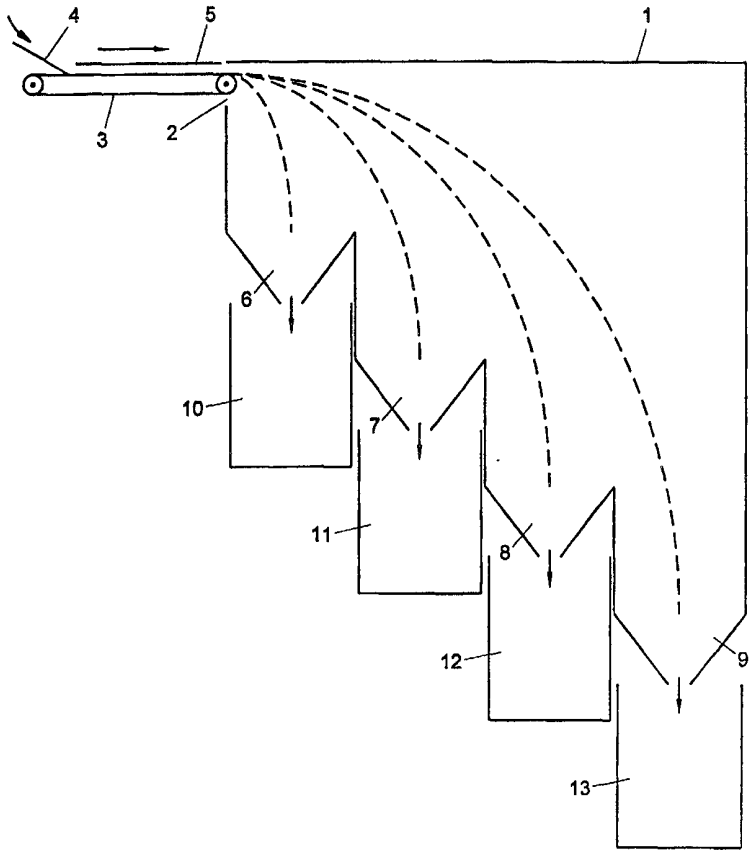
(54) Title: DEVICE FOR AERODYNAMICALLY SEPARATING PARTICLES

(57) Abstract

A device for aerodynamically separating particles according to size, shape, density, drag, etc., comprises a conveyor belt on which the particles to be separated are placed to drop them from the conveyor belt at the end thereof at substantially the same speed of at least 3.5 to 4 m/s. The conveyor belt comprises means for bringing the particles falling thereon substantially into the condition of rest and maintaining them in this condition, until they fall from the belt and then describe specific flights. The movement of the particles from the conveyor belt takes place in a closed space, the minimum drop height of the particles moving through the greatest distance in the horizontal direction being about 4 m, in particular about 5 m, and preferably about 6 m. Furthermore, collecting means arranged behind each other are provided in the plane of the flights to enable collection of the particles separated into categories.



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Title: Device for aerodynamically separating particles

The present invention relates to a device for aerodynamically separating particles according to their physical properties, such as size, shape, density, drag, etc., in particular for separating particles of the order of 0.5 to 20 mm, a density of about 800 to 8000 kg/m^3, and a drag coefficient of about 0.5 to 1.25. Before products, such as cereal grains, seeds, nuts, beans, sugar, etc., are processed, a purification and/or grading must often take place first, in which small stones, hulls, membranes, and other contaminating particles are removed or a grading according to particle size is carried out. Such a device may also be used for, e.g., purifying and selecting cereal grains and seeds, separating hulls from broken cocoa and soya beans. Besides, such a device may also be used for separating waste fractions and mixtures of metals and plastics, grading compost components, gravel, minerals, and the like.

The invention actually relates to a device for aerodynamically separating particles according to their physical properties, such as size, shape, density, drag, etc., which comprises a conveyor belt on which the particles to be separated are placed to drop them from the conveyor belt at the end thereof at substantially the same speed of at least 3.5 to 4 m/s, which particles, depending on their physical properties, describe specific flights, and which comprises collecting means arranged behind each other in the plane of the flights to enable collection of the particles

separated into categories. The conveyor belt may be arranged horizontally as well as at a specific angle. The above minimum speed relates to the speed in the conveying direction of the conveyor belt.

Such a device for aerodynamically separating particles is known from, e.g., EP-A-0 329 865. In this known device, the containers are arranged behind each other at equal height, which results in a relatively rough grading according to size and density of the particles. Because the particles are supposed here to leave the conveyor belt at the same speed, in particular of the order of 10 m/s, the flights traveled by the particles are, to be sure, determined by their size, density, and drag, but these flights are prematurely broken off by the arrangement and the shape of the containers.

It is an object of the invention to provide an aerodynamic separating device in which particles can be separated in a very accurate manner according to their physical properties, such as size, density, and drag coefficient.

According to the invention, the device as actually described in the preamble is characterized in that the conveyor belt comprises means for bringing the particles falling thereon substantially into the condition of rest and maintaining them in this condition, and that the movement of the particles from the conveyor belt takes place in a closed space, the minimum drop height of the particles moving

through the greatest distance in the horizontal direction being about 4 m, in particular about 5 m, and preferably about 6 m.

By providing the above means for bringing the particles on the conveyer belt into the condition of rest and maintaining them in this condition, it is guaranteed in a very high degree that the speed at which the particles leave the conveyor belt is the same for all the particles. By allowing the particles to describe their flights within a closed space, the effects of undesired air currents are undone. Because of the above great drop height the horizontal speed component becomes practically zero as a result of the friction to which the particles are subjected by the air, so that, to separate the particles, optimum use is made of the differences in size, density, and drag of the particles, and a very accurate separation of particles can be obtained.

It should further be noted that EP-A-0 427 305 discloses a device for aerodynamically separating particles in which a chute is provided to place the particles at a specific speed on the conveyor belt where they are subjected to such a friction that the particles subjected to the least friction leave the belt at a relatively high speed and the particles subjected to a greater friction leave the belt at a lower speed. The particles are therefore separated on the basis of their surface structure. Consequently, a separation according to, e.g., size is not possible very well.

A further device for aerodynamically separating particles is known from US-A-3,014,584. In this device, the particles are passed angularly upwardly between two co-moving conveyor belts and projected and thereby describe flights in which, in spite of the fact that the containers are all located at practically the same height as the point where the particles are projected from the relevant conveyor belt, the particles are nonetheless more distinguishable from each other. But here, too, the separation of the particles remains insufficiently accurate, which further appears from the fact that in this device two conveyor belts are placed above each other, with the point where the particles leave the relevant conveyor belts being different. Here, too, the containers are completely open, and the particles can be exposed to undesired air currents.

A closed space, of which the separate containers arranged behind each other form the bottom side, is known per se from the aerodynamic separating device as described in French patent 944,137. In this patent, too, the particles are supposed to have the same speed, namely such that they can be brought from the conveyor belt through an opening into this space in which they describe their specific flights and are collected in the relevant containers. Here, too, the flights, because of the small height at which the containers are located, are too short to effect a separation of particles with the desired accuracy. It should further be noted that in

this French patent a screen is arranged above the conveyor belt.

To place the particles on the conveyor belt at a specific speed and to ensure that they relatively rapidly assume a condition of rest thereon, the conveyor belt is provided according to the invention with a chute and with unevennesses in which the particles placed via the chute on the conveyor belt come into the condition of rest. To achieve this, the unevennesses specifically comprise depressions the size of which is adjusted to that of the largest particles.

To inhibit effects on the particles from the outside, in particular those of air currents and air turbulences, and to prevent jumping up of particles as much as possible, the conveyor belt is provided at the top side with a screen.

The particles projected by the conveyor belt are brought via a slot of preferably not more than 5 cm into the closed space. This slot is kept as narrow as possible to stop the air current drawn along with the conveyor belt and the particles located thereon; the air current sucked along into the closed space causes air turbulences in the closed space, which particularly affects the flights of lighter particles.

In a preferred embodiment, the collecting means are formed by hoppers with containers placed below them. Although the hoppers and the containers can be arranged side by side at a sufficient distance below the conveyor belt, so that the closed space can obtain a rectangular shape, the drop height of the particles down to the hoppers is preferably reduced

according as the hoppers are situated closer to the point where the particles are projected the conveyor belt. In fact, for the first hoppers behind this point of projection it holds that the horizontal speed component of the particles falling into the hoppers has very rapidly assumed the value of zero.

The invention will now be explained in more detail with reference to the accompanying drawing. In this drawing:

Fig. 1 schematically shows a practical example of the device according to the invention;

Fig. 2 shows a fragment of the conveyor belt of the device shown in Fig. 1; and

Figs. 3-6 show some diagrams on the basis of which the operation of the device will be further explained.

The device according to the invention, schematically shown in Fig. 1, comprises a closed space 1 with a slit 2, in which a horizontally arranged, driven, endless conveyor belt 3 ends. The conveyor belt is provided with a chute 4 and a screen 5. The bottom side of the closed space is provided with a plurality of hoppers 6-9 with, if desired, a screw conveyor, which hoppers, according as they are situated farther from the conveyor belt 3 in the horizontal direction, are arranged increasingly lower. Fig. 1 shows only four hoppers. However, it will be clear that, in principle, this number may be selected arbitrarily. Placed below the hopper openings are containers 10-13.

Fig. 2 shows a fragment of the conveyor belt 3. In this figure, the conveyor belt 3 has an uneven surface which has depressions 14 the size of which is adjusted to that of the largest particles. For different uses the conveyor belt can be adapted to the size of the particles processed in the relevant use.

The particles placed via the chute 4 on the conveyor belt 3 will come thereon relatively rapidly into a condition of rest, because of the uneven surface of the conveyor belt 3 and the screen 5, so that these particles will all leave the conveyor belt at practically the same speed. The projection speed, which is the speed in the horizontal direction at which the particles leave the conveyor belt, and which speed is therefore almost equal to the conveying speed of the conveyor belt, is adjustable and is at least 3.5-4 m/s.

The particles leaving the conveyor belt describe flights which are defined by the horizontal projection speed, the size, density, and drag coefficient of the particles. These flights are shown in the diagrams of Figs. 3-6. In these diagrams, the displacement of the particles in the horizontal direction is shown against the displacement in the vertical direction, that is to say in meters. It is assumed herein that the dimensions of the particles are approximately equal in all directions. Fig. 3 shows the flights of particles of which the projection speed is 6 m/s, the size 4 mm, and the drag coefficient 1.00. The curves 15-18 show the flights at densities of respectively 1000, 2000, 4000,

and 8000 kg/m^3. Fig. 4 shows the flights of particles of which the projection speed is 6 m/s, the drag coefficient 1.00, and the density 2000 kg/m^3. The curves 19-23 show the flights at a particle size of respectively 1, 2, 4, 8, and 16 mm. Fig. 5 shows the flights of particles of which the projection speed is 6 m/s, the size 4 mm, and the density 2000 kg/m^3. The curves 24-27 show the flights at drag coefficients of respectively 0.5, 0.75, 1.00, and 1.25. Fig. 6 shows the flights of particles of which the drag coefficient is 1.00, the size 4 mm, and the density 2000 kg/m^3. The curves 28-32 show the flights at a projection speed of respectively 2, 4, 6, 8, and 10 m/s. From these curves it appears, as could be expected, that the projection speed affects the horizontal displacement most, while the drag coefficient only plays a minor role. To obtain an efficient separation of particles, the differences in horizontal displacement at a specific drop height will have to be relatively great. Hence the minimum projection speed is adjusted to 3.5-4 m/s and the minimum drop height to about 6 m. Preferably, a drop height of the order of about 10 m is selected. However, because for the smallest particles and/or those having the lowest density it holds that the horizontal speed component has relatively rapidly decreased to practically zero, a smaller drop height can be used for these particles. Hence an arrangement as shown in Fig. 1 is preferred. In this arrangement, the drop height of the heaviest particles and/or those having the highest density is

about 10 m, and in the embodiment shown, this drop height decreases for lighter particles and/or particles having a lower density to respectively about 8, 6, and 4 mm. A further reason therefor is that, when for the above light particles and/or particles having a low density, the horizontal speed component has become practically zero, a further distinction between these particles is no longer possible after all, while exactly such particles, when falling further down, will tend to whirl, in particular through the air turbulences still occurring in the closed space 1.

The invention is not limited to the practical example described herein with reference to the drawing, but comprises all kinds of modifications, of course as far as falling within the scope of protection of the annexed claims. In particular, the conveyor belt can be arranged in the conveying direction at a specific angle upwardly. In that case, to obtain an equivalent particle separation, the drop height can be slightly reduced.

Claims

1. A device for aerodynamically separating particles according to their physical properties, such as size, shape, density, drag, etc., which comprises a conveyor belt on which the particles to be separated are placed to drop them from the conveyor belt at the end thereof at substantially the same speed of at least 3.5 to 4 m/s, which particles, depending on their physical properties, describe specific flights, and which comprises collecting means arranged behind each other in the plane of the flights to enable collection of the particles separated into categories, characterized in that the conveyor belt comprises means for bringing the particles falling thereon substantially into the condition of rest and maintaining them in this condition, and that the movement of the particles from the conveyor belt takes place in a closed space, the minimum drop height of the particles covering the greatest distance in the horizontal direction being about 4 m, in particular about 5 m, and preferably about 6 m.

2. A device according to claim 1, characterized in that the conveyor belt is provided with a chute and with unevennesses, the particles placed via the chute on the conveyor belt coming into the condition of rest in the unevennesses.

3. A device according to claim 2, characterized in that the unevennesses comprise depressions the size of which is adjusted to that of the largest particles.

4. A device according to any of the preceding claims, characterized in that the conveyor belt is provided at the top side with a screen.

5. A device according to any of the preceding claims, characterized in that the particles projected by the conveyor belt are brought via a slot of not more than 5 cm into the closed space.

6. A device according to any of the preceding claims, characterized in that the collecting means are formed by hoppers with containers placed below them.

7. A device according to claim 6, characterized in that the drop height of the particles down to the hoppers decreases according as the hoppers are situated closer to the point where the particles are projected from the conveyor belt.

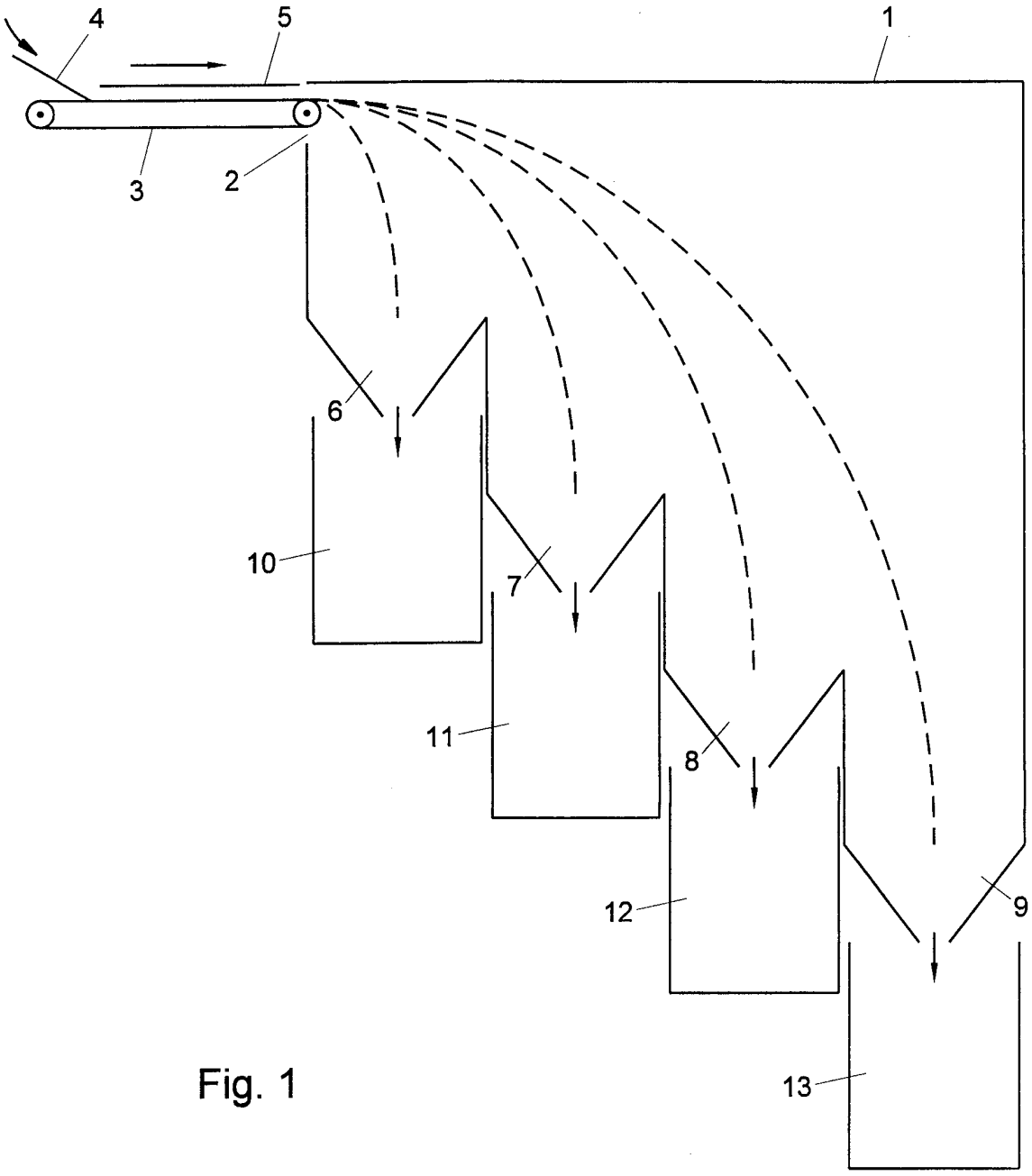


Fig. 1

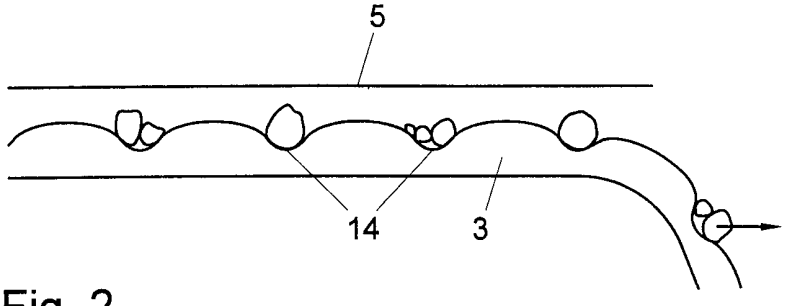


Fig. 2

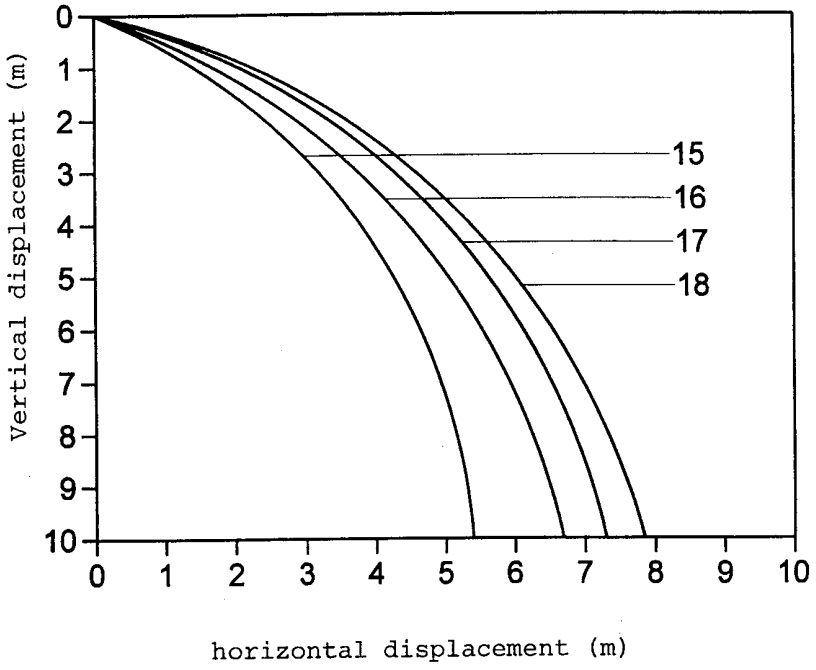
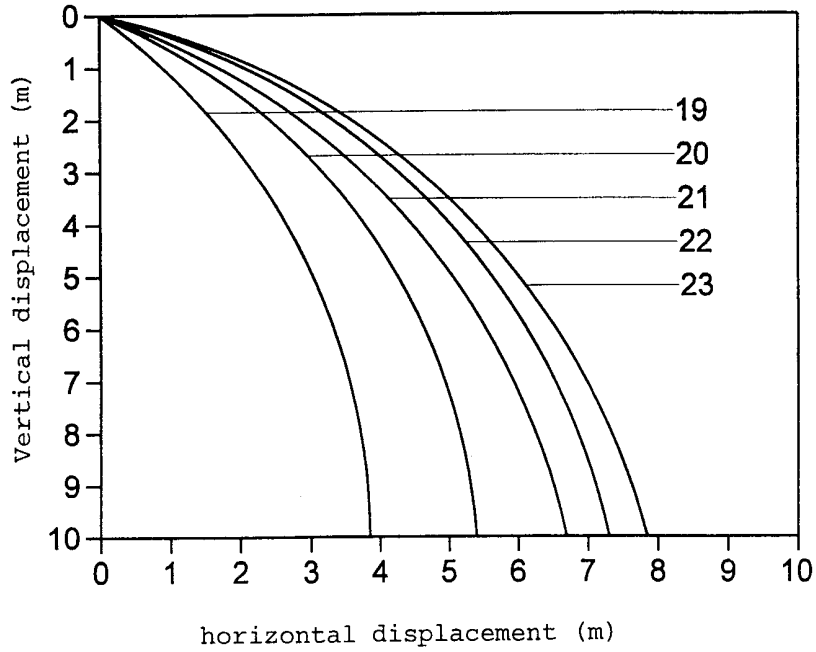

Vertical displacement (m)
0
1
2
3
4
5
6
7
8
9
10
15
16
17
18
0 1 2 3 4 5 6 7 8 9 10
horizontal displacement (m)

Fig. 3


Vertical displacement (m)
0
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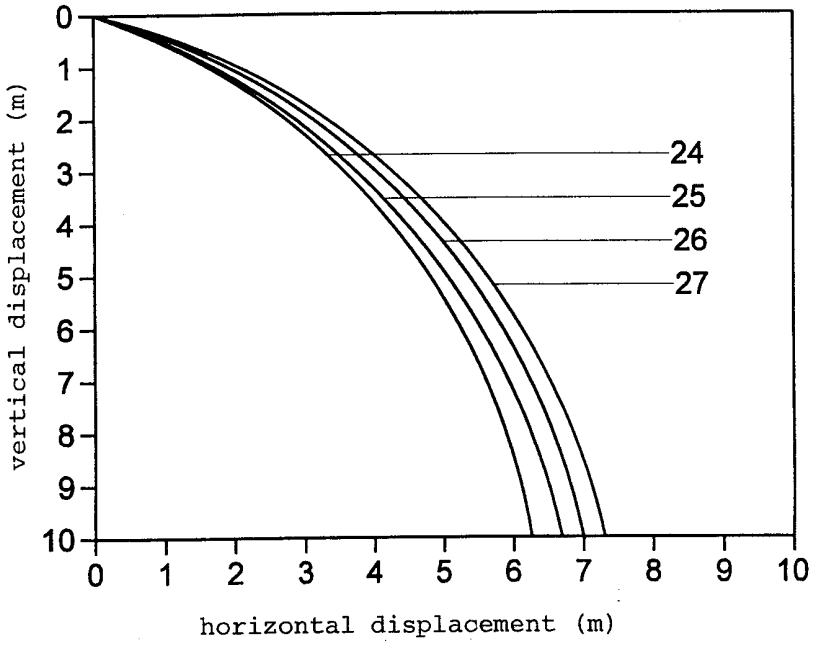
0 1 2 3 4 5 6 7 8 9 10
horizontal displacement (m)

Fig. 4


vertical displacement (m)
0
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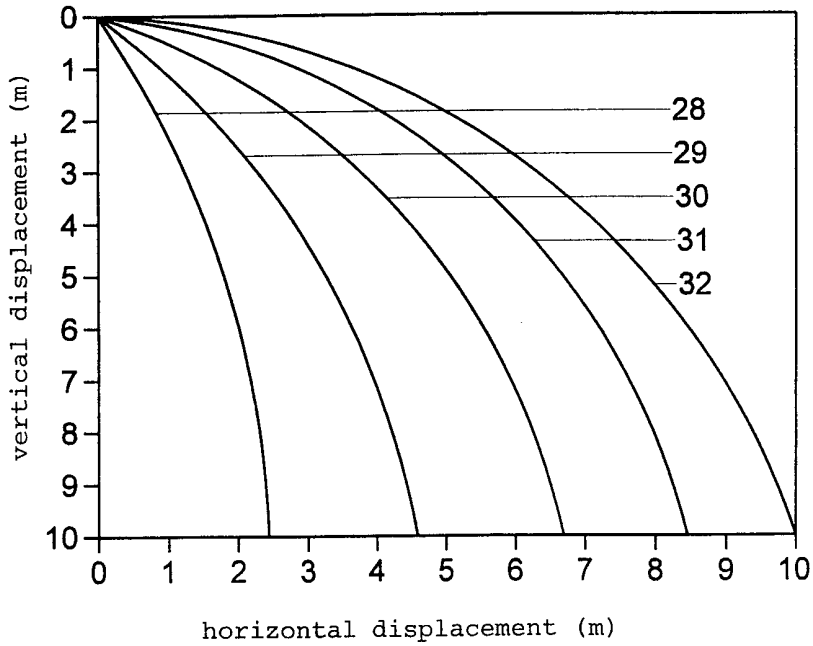
0 1 2 3 4 5 6 7 8 9 10
horizontal displacement (m)
24
25
26
27

Fig. 5


vertical displacement (m)
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2
3
4
5
6
7
8
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0 1 2 3 4 5 6 7 8 9 10
horizontal displacement (m)
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Fig. 6

INTERNATIONAL SEARCH REPORT

Interr nal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B07B13/10 B07B13/16

According to International Patent Classification (IPC) or to both national classification and IPC

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 064 123 A (DANECO-DANIELI ECOLOGIA) 10 November 1982 (1982-11-10) page 4, line 7 - line 23; figure ---	1-3,6
Y	FR 975 556 A (TRAITEMENT INDUSTRIEL) 7 March 1951 (1951-03-07) page 3, left-hand column, paragraph 1 figure 1 ---	1-3,6
A	DE 42 26 635 A (HERBOLD) 17 February 1994 (1994-02-17) figure 3 ---	1,4,6
A	FR 944 137 A (H. SIMON) 28 March 1949 (1949-03-28) cited in the application the whole document --- -/--	1,4-6

[X] Further documents are listed in the continuation of box C.

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30 May 2000	07/06/2000

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Interr ıal Application No
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C.(Continuation) 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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...formation on patent family members

Interr ...nal Application No
PCT/NL 00/00185

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