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(54) **Method for assembling granular mixtures of predetermined specifications, starting from granular starting material**

(57) The invention relates to a method and a device for assembling granular mixtures of predetermined specifications from granular starting material without interim storage. The device comprises two or more classifying devices (1) which, with the aid of water, divide the starting material into a plurality of grain fractions.

The grain fractions are taken out of the classifying devices (1) in batches. The volume and weight of each batch is determined, thus allowing the weight of dry matter in the batch to be calculated. The Tromp curve associated with the process conditions prevailing in a classifying device (1) provides information on the relative composition of the grain fraction divided off by the classifying device in question. This information makes it possible to formulate a number of equations which allow the composition of the starting material and the composition of each grain fraction to be calculated. The grain fractions can then be mixed directly in the correct ratio in order to obtain the end product.

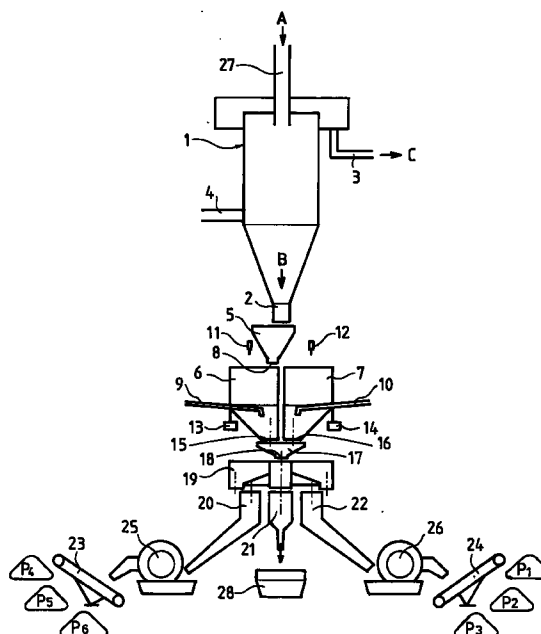


FIG. 1

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Description

The invention relates to a method for assembling granular mixtures of predetermined specifications from granular starting material, use being made of a separating device for dividing the granular starting material into grain fractions, comprising at least two classifying devices which each use liquid to divide the granular material fed to them into a first grain fraction and a second grain fraction, which are respectively discharged in the underflow and the overflow of the classifying device in question, which method comprises the following steps:

- feeding the granular starting material to the separating device,
- dividing the granular starting material into different grain fractions by means of the separating device,
- determining the composition of each of the grain fractions coming out of the separating device and, on the basis of this determination, determining a mixing ratio for grain fractions for the purpose of assembling a granular mixture of a predetermined specification,
- conveying the grain fractions to a collection point for assembling the granular mixture.

A method of this kind is used, for example, in the sand-dredging industry. The granular starting material consists of untreated sand which is divided by the separating device into a plurality of grain fractions, which are stored. After analysing the grain fractions in order to determine the composition of each grain fraction, a mixing ratio is calculated in order to be able to produce a sand mixture which satisfies the specifications given by a customer. The grain fractions are transported from the various storage locations to a collection point for producing the sand mixture.

The drawback of the known method is that each grain fraction is stored separately before mixing the grain fractions to form a granular mixture. Storage and transportation of the grain fractions to and from the storage locations is extremely expensive.

The object of the invention is to provide a method in which the grain fractions of the granular starting material coming out of the separating device can be mixed immediately in the correct ratio to form various granular mixtures of predetermined specifications without the need for temporary storage.

This object is achieved by means of a method as described in the preamble, which according to the invention is characterized by the following steps:

- determining a Tromp curve for each classifying device,
- removing the grain fractions in batches from each classifying device,
- determining, for each grain fraction coming out of each classifying device, the weight and the volume of a batch of a mixture of liquid and the relevant grain fraction, and, from this, determining the dry weight of the grains present in the batch,
- using the Tromp curve of each classifying device and the dry weights of the grains present in the batches to calculate the composition of the granular starting material, and
- calculating the composition of each of the grain fractions.

This makes interim storage of grain fractions superfluous, resulting in considerable savings on transport costs. In particular, the power consumption for the transportation falls substantially. Moreover, the installation for producing the desired grain mixtures can be of less expensive design, since only end products need be stored.

Preferred embodiments of the method according to the invention are defined in the dependent claims.

The invention also relates to a device for carrying out the method according to the invention.

The invention will be explained in more detail below with reference to the drawing, in which:

Fig. 1 is a diagrammatic illustration of the device for dividing sand into two grain fractions,

Fig. 2 is a diagrammatic illustration of a separating device with a plurality of classifying devices which are placed in series for dividing untreated sand into different grain fractions,

Fig. 3 is a Tromp curve for the classifying device K_2 from Fig. 2 for a separation point of 0.5 mm,

Fig. 4 is a Tromp curve for the classifying device K_3 from Fig. 2 for a separation point of 0.25 mm,

Fig. 5 is a Tromp curve for the classifying device K_4 from Fig. 2 for a separation point of 0.1 mm.

The following description of the figures is intended purely as an example serving to clarify the method.

The device shown in Fig. 1 for dividing sand into grain fractions comprises a classifying device 1 with an outlet opening 2 for the underflow and an outlet opening 3 for the overflow. The outlet opening 2 may be provided with a controllable shut-off valve (not shown). Furthermore, the classifying device 1 is provided with a water-feed line 4, which water is used for the classification of sand fed to the classifying device. The sand is fed to the classifying device 1 via sand-feed line 27.

A sliding hopper 5 with an outlet opening 8, which can be displaced in the horizontal direction between a first position and a second position, is situated beneath the outlet opening 2. Beneath the sliding hopper 5 there are two measuring bins 6, 7, which are positioned in such a manner that the outlet opening 8 of the sliding hopper 5 in the first position is situated above the measuring bin 6 and in the second position is situated above the measuring bin 7. The measuring bins 6, 7 are each provided with a water-feed line 9, 10. Sensors 11, 12 for measuring a level in the measuring bins are arranged above the measuring bins. The measuring bins 6, 7 are each connected to a weighing device 13, 14.

Closable outlet openings 15, 16 in the measuring bins 6, 7 are situated above an funnel 17. An outlet opening 18 in the funnel 17 opens into a sliding chute 19. Collection chutes 20, 21, 22 are arranged beneath the sliding chute 19. The collection chutes 20, 22 each open out into a dewatering/mixing machine 25, 26. The collection chute 21 opens out into a collection tank 28 for residual products, which are discharged from the collection tank 28. Furthermore, rotatable conveyor belts 23, 24 are provided for transporting various products P_1 - P_6 to storage locations.

Like any classifying device, the classifying device 1 has a specific separation level curve, or Tromp curve, which is determined in a laboratory, for specific process parameters. The Tromp curve indicates the probability that grains of a specific size will pass into the underflow or the overflow. This probability is independent of the quantity of grains of that size in the sand supplied. A probability of 100% means that all the grains of that size present in the sand supplied will pass into the underflow. A probability of 10% means that 10% of the grains of that size present in the sand supplied will pass into the underflow and the remaining 90% will pass into the overflow. If only a small quantity of grains of a specific size is present in the sand supplied and the probability of these grains passing into the underflow is 10%, the quantity of these grains in the underflow will be very low. As the quantity of grains of that size in the sand supplied increases, the quantity of these grains in the underflow will increase proportionally. Thus the composition of the sand supplied affects the composition of the classified fractions. The course of the Tromp curve remains the same if the process parameters of the classifying device 1 remain identical. The process parameters are kept constant with the aid of accurate measurement sensors and control equipment. The accuracy of the operation is determined by the process control system.

The device illustrated in Fig. 1 functions as follows.

Sand A is fed to the classifying device 1 through the sand-feed line 27. Water is fed to the classifying device 1 via the water-feed line 4. The water flows through the classifying device from the bottom upwards. Large grains of sand fall downwards, counter to the force exerted by the stream of water on the grains, and pass into the underflow B. Small grains pass into the overflow C. The grain fractions which are situated in the underflow B and the overflow C have a composition which depends on the composition of the sand A supplied and on the Tromp curve of the classifying device 1 under the process parameters prevailing.

The underflow B flows through the outlet opening 2 into the sliding hopper 5 and then into the measuring bin 6. The underflow B is a mixture of water and sand. The closable outlet opening 15 of the measuring bin 6 is closed. The level in the measuring bin 6 is measured with the aid of the sensor 11. The level can be measured, for example, with the aid of ultrasonic distance measurement. When the level in the measuring bin 6 reaches a predetermined value, the sliding hopper 5 is displaced in such a manner that the outlet opening 8 of the sliding hopper 5 opens out into the measuring bin 7. A batch of water-sand mixture is now present in the measuring bin 6.

The volume of the batch of water-sand mixture present in the measuring bin 6 is then measured with the aid of the sensor 11. The weighing device 13 measures the weight of the batch present in the measuring bin 6. The measurement data are recorded with the aid of a computer (not shown). With the aid of the information about the volume and the weight of the batch, it is possible to determine the weight of dry sand in the batch.

The overflow C is fed via the outlet opening 3 to a subsequent classifying device with a different separation point, where the weight of dry sand in a batch of water-sand mixture coming out of this classifying device is determined in the same way.

The quantities of dry sand in the batches coming out of the classifying devices used, as defined in the manner indicated above, and the probability percentages which are known from the Tromp curves of the classifying devices can be used to calculate the composition of the sand supplied and of the grain fractions in the underflows of the classifying devices.

A computer is used to process the observations from the measurement sensors and to carry out the calculations.

The information about the composition of the sand supplied and the grain fractions is used by the computer to make a choice between a number of given products in such a manner that products of as high a quality as possible are produced. Thus the amount of waste is as low as possible.

As long as there is no outside intervention, the computer determines which collection chute each batch in the measuring bin is to be discharged to directly. Once it has been established to which collection chute the batch is to be discharged, the sliding chute 19 is placed in the correct position. The outlet opening 15 is opened and the batch from the measuring bin 6 is discharged via one of the collection chutes 20, 21, 22 to a dewatering machine 25, 26 or the collecting tank 28. The dewatering machines 25, 26 also serve as a device for mixing batches which come from various

measuring bins. In order to effect a smooth discharge, extra water is fed in via water-feed line 9, thus shortening the discharge time and allowing the sand to be discharged via slightly inclined slides. The position of the sliding chute 19 is controlled by the computer. Moreover, the computer is able to calculate the yield of the complete installation and indicate which product is recommended in order to achieve as high a yield as possible using the sand supplied.

Fig. 2 diagrammatically illustrates a separating device for dividing sand into different grain fractions. The installation comprises a first, second, third and fourth classifying device K_1 , K_2 , K_3 , K_4 . The first classifying device K_1 , which is formed by screens, divides the untreated sand into three grain fractions, a first grain fraction containing grains which are larger than 4 mm, a second grain fraction which contains grains which are between 2 mm and 4 mm, and a third grain fraction which contains grains which are smaller than 2 mm. The quantities of grains in the first and second grain fractions are determined by measuring the weight. The quantity of moisture in the grain fractions coming out of the screen classifying device is generally negligible.

Hydrocyclones 30, 31, 32 are placed upstream of the second, third and fourth classifying devices K_2 , K_3 , K_4 . These hydrocyclones separate off the sand of a grain size of less than 0.1 mm. The sand with grains smaller than 2 mm is fed via the hydrocyclone 30 to the second classifying device K_2 , which divides the sand fed to it at the level of 0.5 mm. i.e. the underflow from the second classifying device K_2 contains grains of a size between 2 mm and 0.5 mm. The underflow also contains a quantity of incorrect grains which are smaller than 0.5 mm. The overflow from the second classifying device K_2 substantially contains grains of smaller than 0.5 mm. The overflow is fed via the hydrocyclone 31 to the third classifying device K_3 , which divides the sand fed to it at the level of 0.25 mm. The overflow from the third classifying device K_3 is fed via the hydrocyclone 32 to the fourth classifying device K_4 , which divides the sand at the level of 0.1 mm. The quantity of grains which are smaller than 0.1 mm in the underflow of the fourth classifying device K_4 is negligible and is not included in the calculations. The quantities of dry sand in the underflows from the second, third and fourth classifying devices K_2 , K_3 , K_4 are determined with the aid of measuring bins in the manner described above.

There now follows an example of a calculation of the composition of the sand supplied, i.e. of the sand having a grain size of less than 2 mm which is fed to the second classifying device K_2 . In this calculation, it is assumed that the grain size distribution of the sand supplied has a continuous curve. The separate grain size ranges are denoted by letters:

D : 0.5 - 2 mm
E : 0.25 - 0.5 mm
F : 0.1 - 0.25 mm

For each underflow, it is possible to formulate an equation, the percentage of each grain size range passing into the underflow of a specific classifying device following from the Tromp curve for this classifying device.

Fig. 3 shows a Tromp curve for the second classifying device K_2 with a separation point of 0.5 mm.

According to this Tromp curve, particles with a diameter of 0.25 mm have a 10% probability of passing into the underflow of the second classifying device K_2 . Particles which have a diameter of 0.5 mm or greater have a virtually 100% probability of passing into the underflow of the second classifying device K_2 .

In the calculations, it is assumed that the probability of a particle from a specific grain size range passing into the underflow of the classifying device is equal to the probability of the particles of a size which is equal to the lower limit of the grain size range passing into the underflow of the classifying device. In practice, it is possible to use different values which will give a better approximation.

Fig. 4 shows a Tromp curve for the third classifying device K_3 . The separation point for the third classifying device K_3 is 0.25 mm.

The probability according to the Tromp curve that particles having a diameter of 0.25 mm will pass into the underflow of the third classifying device K_3 is virtually 100%.

10% of the grains from the grain size range E present in the sand supplied are located in the underflow of the second classifying device K_2 . The percentage of the grains present in the sand supplied which are from the grain size range F which is located in the underflow of the second classifying device K_2 is negligible.

The remainder of the grains, present in the sand supplied, from the grain size range E and 8% of the grains, present in the sand supplied, from the grain size range F are located in the underflow of the third classifying device K_3 . The amount of grains located in the underflow of the third classifying device K_3 , from the grain size range D present in the sand supplied, is negligible.

In this exemplary calculation, the underflow of the fourth classifying device K_4 contains 92% of the grains, present in the sand supplied, from the grain size range F. The quantities of grains, present in the sand supplied, from the grain size ranges of less than 0.1 mm and greater than 0.25 mm in the underflow of the fourth classifying device K_4 are negligible.

A number of equations can be formulated on the basis of this information.

For a quantity by weight of dry sand G_1 coming out of the second classifying device K_2 , the following equation is

true:

$$G_1 = D + 0.1 \cdot E.$$

5 For a quantity by weight of dry sand G_2 coming out of the third classifying device K_3 , the following equation is true:

$$G_2 = 0.9 \cdot E + 0.08 \cdot F.$$

10 For a quantity by weight of dry sand G_3 coming out of the fourth classifying device K_4 , the following equation is true:

$$G_3 = 0.92 \cdot F.$$

These three equations yield the quantities by weight of the grain size ranges D, E and F in the sand supplied to the second classifying device K_2 .

15 The calculation of the quantity by weight of dry sand in a batch coming out of the classifying device using the combined volume - weight measurement follows from the following derived formula:

$$20 \quad G_z = (G_L - V_L \times 10^3) \frac{2.65}{1.65}$$

in which:

25 V_L = volume of the mixture in m^3
 G_L = weight of the mixture in kg
 G_z = weight of dry sand in kg

In this equation, the relative densities of sand and water are respectively $2.65 \cdot 10^3 \text{ kg/m}^3$ and $1 \cdot 10^3 \text{ kg/m}^3$.

30 If the untreated sand overall differs relatively little from the desired products, a partial classification may be sufficient. The part which in that case is classified has to be divided off from the main stream of material in such a manner that its composition largely corresponds to the remainder of the untreated sand. This is because the composition of the untreated sand can be calculated after the classification, so that it is also possible then to determine which and how much of the classified fractions must be added to the original sand in order to obtain a product of the desired composition. This method provides a considerable saving in investment and energy costs.

Claims

1. Method for assembling granular mixtures of predetermined specifications from granular starting material, use being made of a separating device for dividing the granular starting material into grain fractions, comprising at least two classifying devices which each use liquid to divide the granular material fed to them into a first grain fraction and a second grain fraction, which are respectively discharged in the underflow and the overflow of the classifying device in question, which method comprises the following steps:
- 45 - feeding the granular starting material to the separating device,
 - dividing the granular starting material into different grain fractions by means of the separating device,
 - determining the composition of each of the grain fractions coming out of the separating device and, on the basis of this determination, determining a mixing ratio for grain fractions for the purpose of assembling a granular mixture of a predetermined specification,
- 50 - conveying the grain fractions to a collection point for assembling the granular mixture, characterized by the following steps:
 - determining a Tromp curve for each classifying device,
 - removing the grain fractions in batches from each classifying device,
 - determining, for each grain fraction coming out of each classifying device, the weight and the volume of a batch of a mixture of liquid and the relevant grain fraction, and, from this, determining the dry weight of the grains present in the batch,
- 55 - using the Tromp curve of each classifying device and the dry weights of the grains present in the batches to calculate the composition of the granular starting material, and

- calculating the composition of each of the grain fractions.

2. Method according to claim 1, in which use is made of a separating device with a plurality of classifying devices placed in series, the overflow from each classifying device being fed to the next classifying device.

3. Method according to claim 1 or 2, in which at least part of the granular starting material is transported directly to the collection point for producing the granular mixture.

4. Device for carrying out the method according to claims 1-3, comprising a separating device for dividing granular starting material into grain fractions and comprising at least two classifying devices, which are each able, with the aid of liquid, to divide a granular material fed to them into a first grain fraction and a second grain fraction, characterized in that at least two measuring bins are provided in each classifying device for receiving a batch of liquid/granular mixture coming out of the classifying device in question, and in that means are provided for determining the weight and the volume of the batch.

5. Assembly comprising a classifying device, at least two measuring bins for receiving a batch of liquid/granular mixture coming out of the classifying device and means for determining the weight and the volume of the batch, which assembly is designed for use in a device according to claim 4.

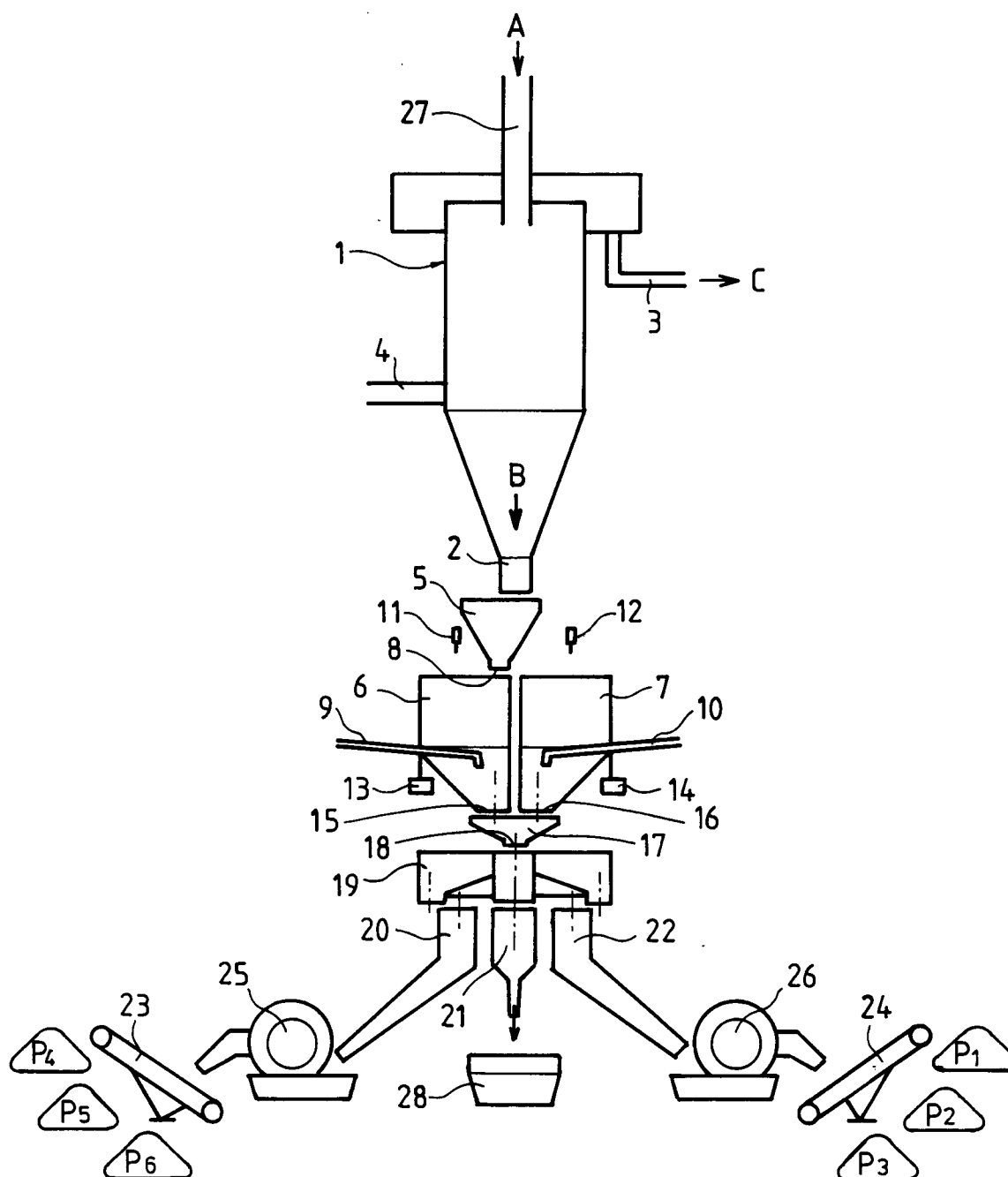


FIG. 1

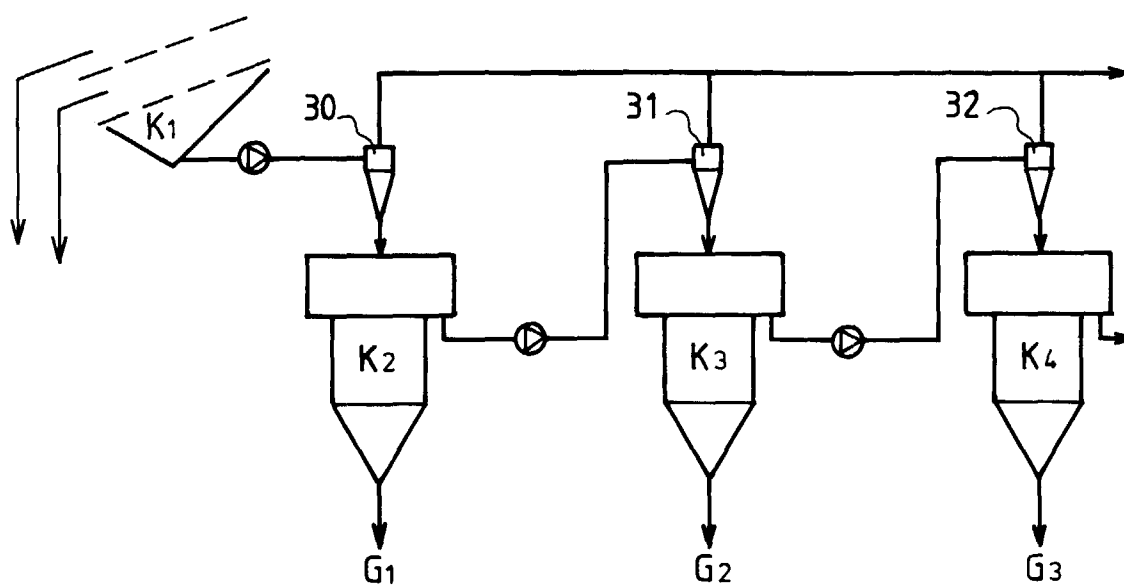


FIG. 2

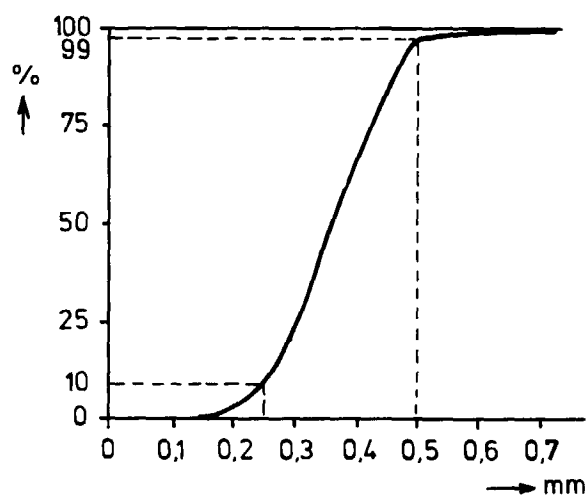


FIG. 3

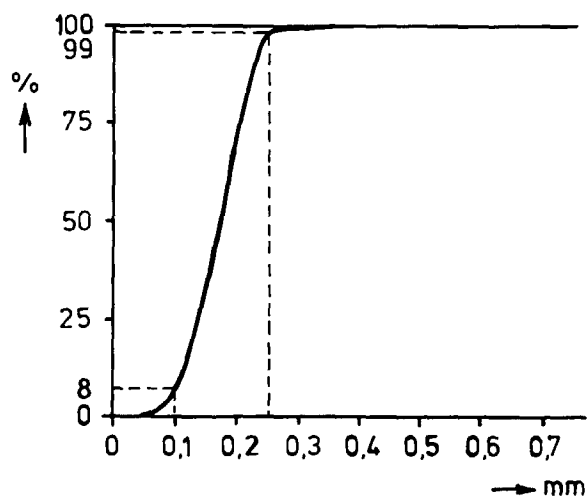


FIG. 4

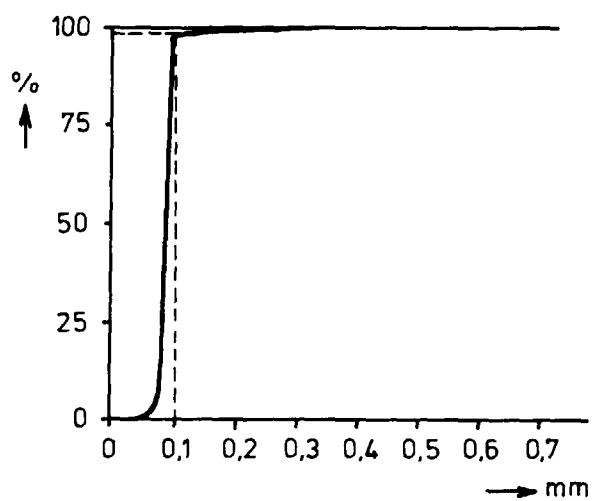


FIG. 5



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EUROPEAN SEARCH REPORT

Application Number
EP 98 20 0591

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	NL 8 105 887 A (LINATEX 'NEDERLAND! BV) 18 July 1983 * the whole document *	1,2,4,5	B03B9/00 B03B13/00
A	DE 35 22 478 A (GESELLSCHAFT FÜR AUFBREITUNGSMASCHINEN MBH & CO KG) 2 January 1987 * abstract * * column 3, line 29 - column 4, line 53; figures *	1,4,5	
A	DÖRNER: "Producing High-Quality Sands with Sophisticated Technology in the New Sand Beneficiation Plant of Pinnow Gravel Works" AUFBEREITUNGS TECHNIK., vol. 38, no. 1, January 1997, WIESBADEN DE, pages 27-32, XP000641902 * Section 4. 'The new process for sand beneficiation' * Section 5. 'Correction of size fractions' * figures *	1,4	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B03B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		19 June 1998	Van der Zee, W
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