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(54) **FLUID BED GRANULATION PROCESS AND APPARATUS**

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(57) **ABSTRACT**

A process for obtaining finished granules of a predetermined substance in a granulation fluid bed (F1) of the so-called vertical growth type, the bed being formed and maintained by a respective flow of fluidification air, comprises a transfer phase by falling of the finished granules in a pressurized space below the granulation bed and a recovery phase of the finished granules from the pressurized space.

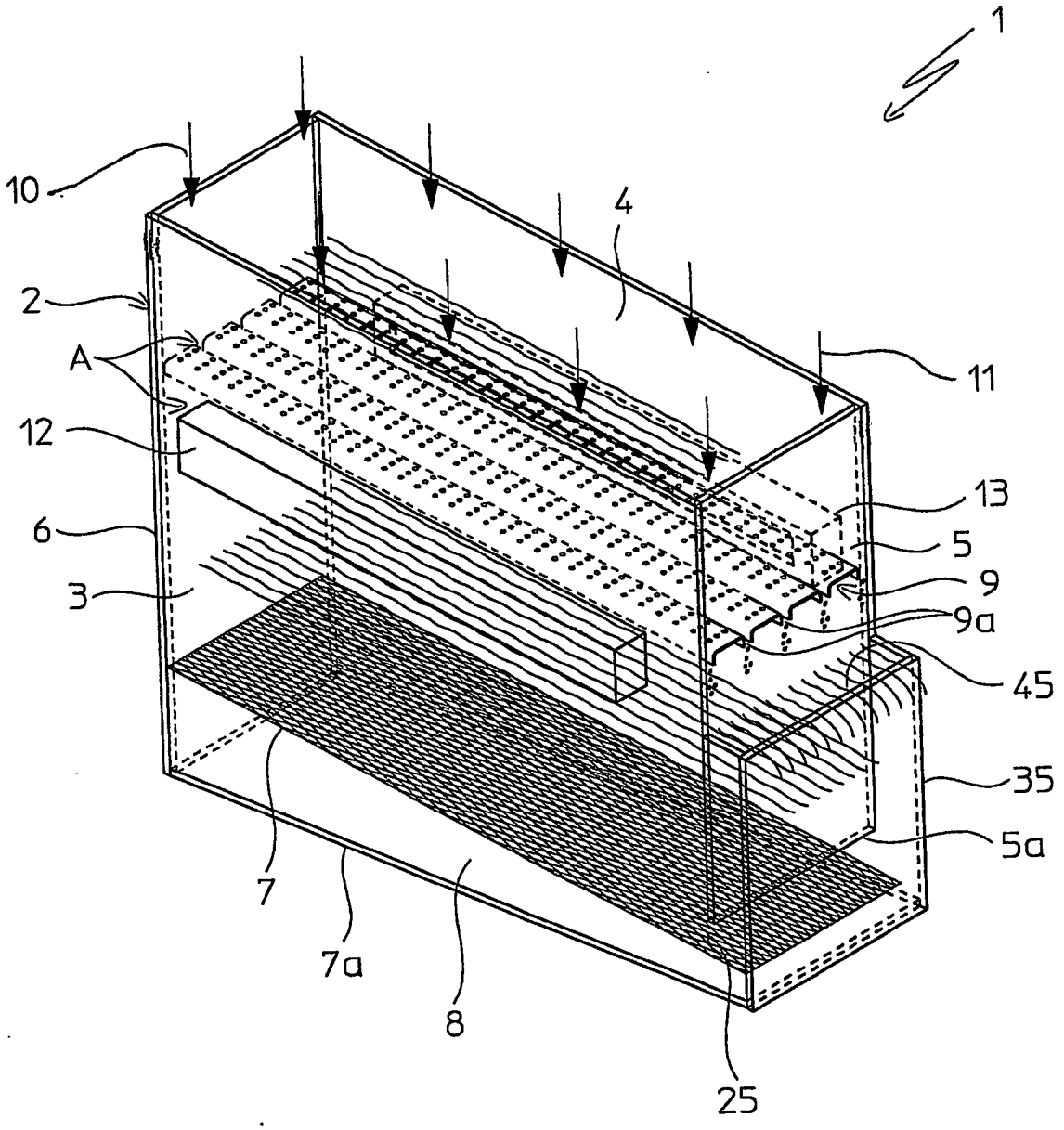


Fig. 1

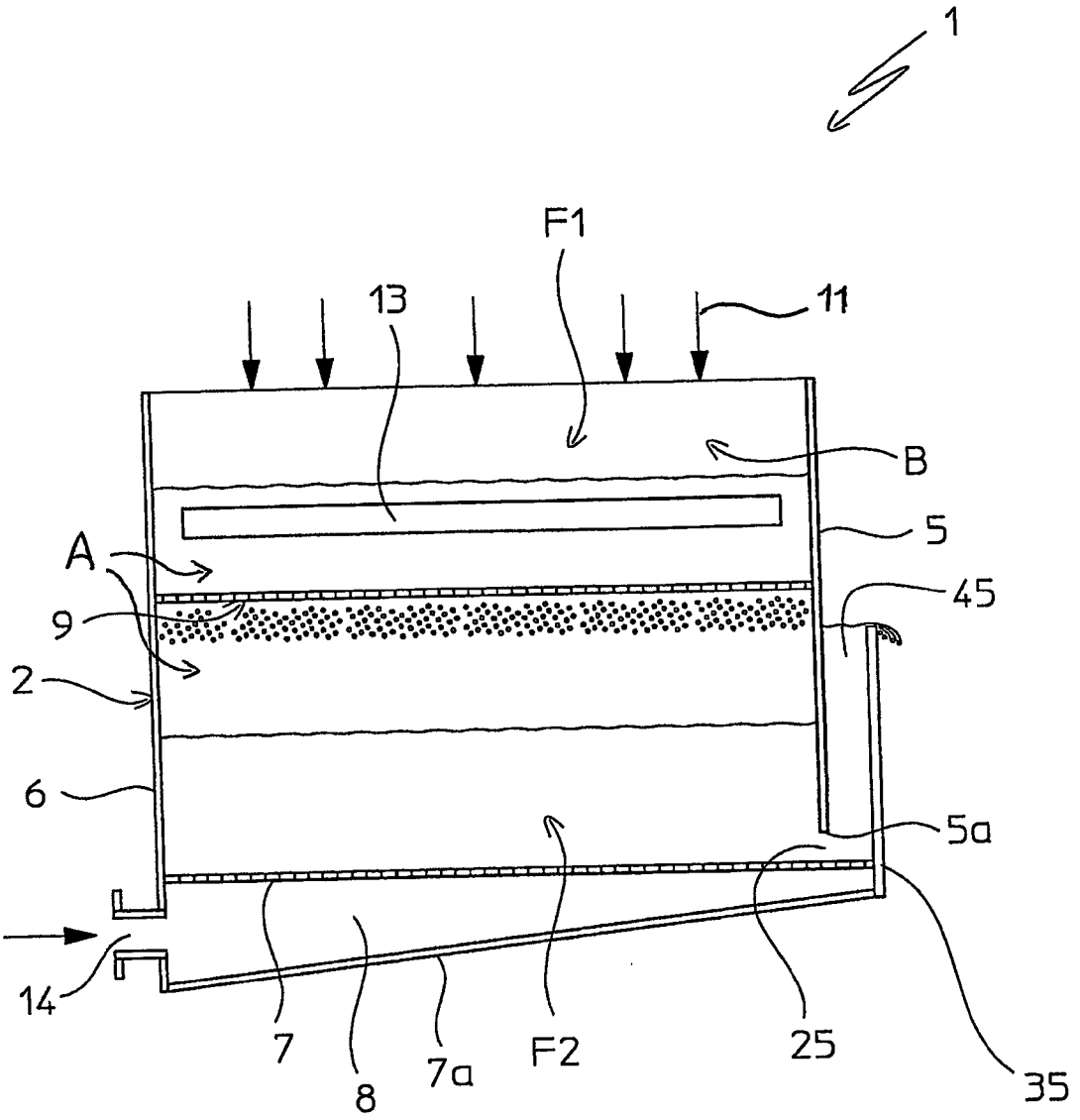


Fig. 2

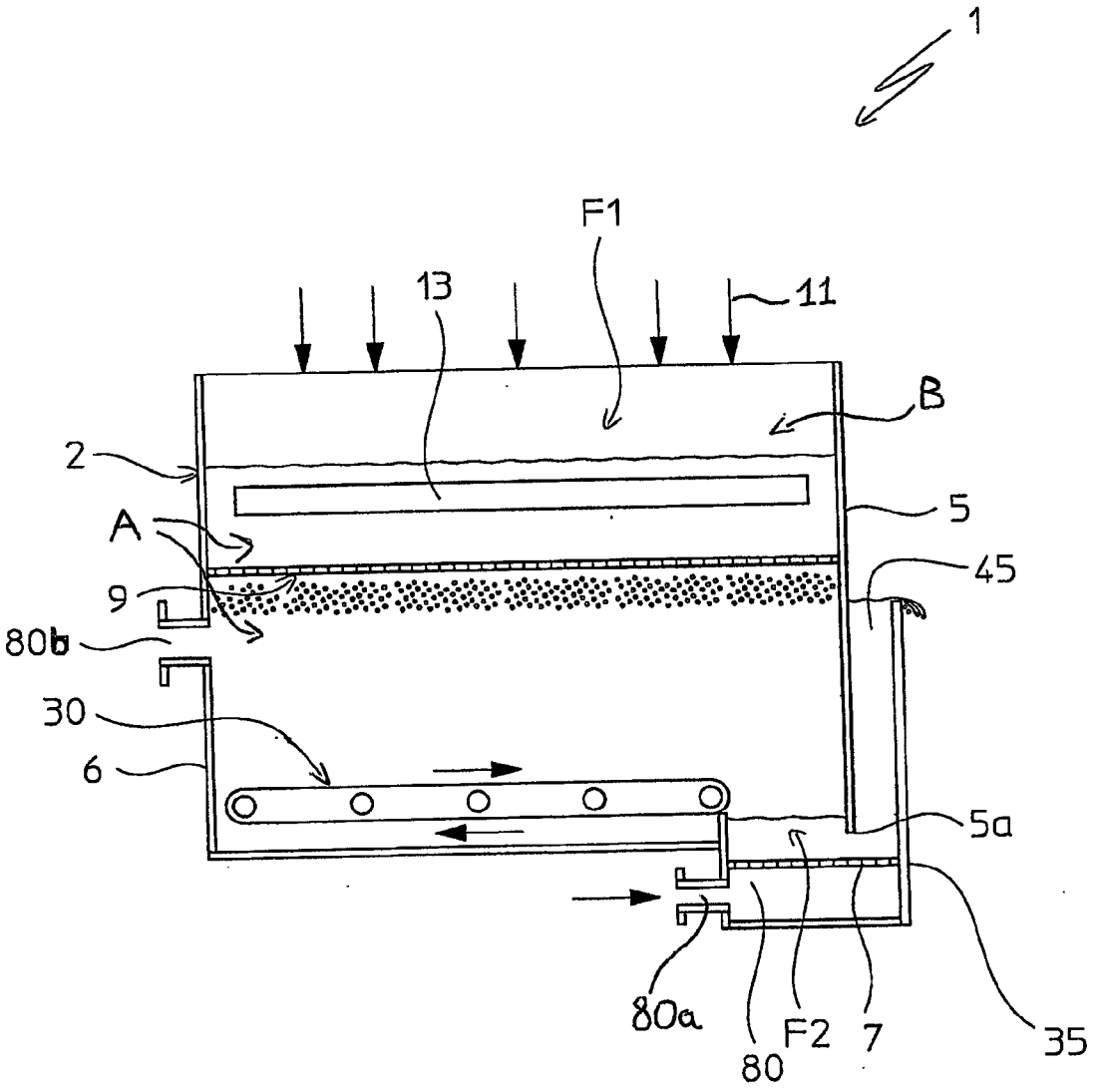


Fig. 3

# FLUID BED GRANULATION PROCESS AND APPARATUS

## FIELD OF APPLICATION

[0001] In its most general aspect, the present invention refers to a fluid bed granulation process for obtaining finished granules of a predetermined substance, comprising a recovery phase of said finished granules from the granulation fluid bed.

[0002] In the rest of the description and in the subsequent claims, with the terms: "finished granules" we mean granules of the predetermined substance of a predetermined size or, in other words, having predetermined grain size.

[0003] The process of the present invention is particularly, but not exclusively recommended for the fluid bed granulation of substances like, for example, urea, ammonium nitrate, ammonium chloride and similar substances susceptible to being granulated.

[0004] The invention also refers to a granulation apparatus, used to carry out the aforementioned process.

## PRIOR ART

[0005] As is known, in a fluid bed granulation process, the obtainment of granules of a predetermined substance takes place through continuous growth (in volume and in mass), of granule seeds of such a substance, continuously fed into a granulation space, in which a respective fluid bed is realized, at the same time as a flow of an appropriate growth substance.

[0006] Generally, the growth substance is of the same nature as the substance to be granulated and is in liquid form, suitable for wetting, adhering and solidifying on the seeds and on the growing granules which, together, constitute said fluid bed.

[0007] The growth of the granules continues until a predetermined grain size is obtained, after which the finished granules, thus obtained and possibly cooled, are recovered and sent for storage and/or packaging.

[0008] It is also known that the aforementioned granulation fluid bed (formed from seeds and growing granules) is realized and maintained through a considerable and controlled continuous flow of rising air, or another gaseous fluid, also known as fluidification air.

[0009] To obtain a good granulation result it is necessary that only the finished granules are recovered from the granulation fluid bed and extracted or at least discharged from the respective granulation space.

[0010] It is also known the requirement, dictated by commercial needs, of realizing and providing a fluid bed granulation process which ensures the obtainment of monodispersed finished granules, that is to say finished granules having a diameter within a tight predetermined range of dimensions.

[0011] For such a purpose, international patent application Wo 02/074427, of the same applicant, teaches a so-called vertical growth fluid bed granulation process. In a process of this type the growing granules cyclically follow, many times, trajectories similar to each other, planar and substantially circular, until they leave the granulation fluid bed through the base plate on which the fluid bed is realized, which in this case is equipped with a plurality of suitably sized slits, with their size being correlated (larger) with the diameter of the granules intended to be produced.

[0012] In particular, in such a process, as the granulation progresses the granules increase in size and weight, until the flow of fluidification air which crosses the aforementioned slits is no longer able to support them any further.

[0013] At this point the finished granules leave the granulation bed, "falling by gravity" in countercurrent to the fluidification flow, through said slits.

[0014] It should be noted that the fluidification air of the fluid bed, just like the slits crossed by said air, due to their function of "classifying" the granules, i.e. selecting the finished granules from all of the seeds and growing granules present in the fluid bed, are also called classification air and slits, respectively.

[0015] The finished and classified granules which leave the granulation fluid bed, in a process of the aforementioned type, pass into a collection space or zone, below the granulation bed, which is necessarily at a greater pressure than atmospheric pressure since it is engaged, i.e. crossed, by the substantial flow of fluidification air.

[0016] To be able to carry out the storage and packaging of the finished granules obtained and classified in the aforementioned way, they must be recovered from said collection space or zone, i.e. discharged and extracted from said pressurized space.

[0017] For such a purpose the prior art provides mechanical extractor systems, like for example a bucket elevator or noria, and other similar mechanical extractors, which, if used in cases like the one considered here, would provide a sealing engagement in a suitable granule-discharge opening formed, for example, in a wall that defines the collection space.

[0018] But the use of such extracting systems would predictably involve some drawbacks that aren't totally acceptable in the cost-effectiveness of the granulation process intended to be actuated.

[0019] Indeed, a continuous mechanical extraction, from a pressurized space, like the one considered above, to be able to ensure limited or at least controlled losses of air in the granule-collection space and therefore to ensure a satisfactory seal between extractor and respective granule-discharge opening, is constructively very complex to realize and requires burdensome and difficult maintenance operations.

[0020] A further drawback, linked to the mechanical manipulation of the finished and classified granules, consists of the danger of said granules undergoing a sort of grinding or crushing, with the formation of powders and with an even substantial reduction in yield of the entire productive cycle.

## SUMMARY OF THE INVENTION

[0021] The technical problem underlying the present invention is that of devising and providing a granulation process for obtaining finished granules of a predetermined substance in a granulation fluid bed of the so-called vertical growth type, wherein said bed is formed and maintained by a respective flow of fluidification air, comprising a transfer

phase by falling of said finished granules in a pressurized space below said granulation bed and a recovery phase of said granules from said pressurized space, wherein the recovery of the finished granules takes place in a way that is simple to carry out, reliable and which does not require a burdensome and difficult maintenance, and at the same time with functional characteristics such as to safeguard the grain size of said finished granules, and the integrity of the monodispersed finished granules thus produced.

[0022] This problem is solved, according to the invention, by a fluid bed granulation process of the type considered above, characterized in that said recovery phase comprises:

[0023] a) the formation in said pressurized space of a collection fluid bed of said finished granules, through at least part of said fluidification air; and

[0024] b) extraction in continuous flow of said finished granules from said collection bed and from the respective pressurized space, placing the base plate of said collection bed in fluid communication with a well, outside said pressurized space, fed substantially upstream from the finished granules of said collection bed.

[0025] The advantages and the features of the granulation process according to the present invention will become clearer from the detailed description of an exemplificative embodiment thereof, made herein below with reference to the attached drawings, for indicative and non-limiting purposes.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. **1** schematically shows an axonometric view of an apparatus for carrying out the fluid bed granulation process according to the present invention;

[0027] FIG. **2** schematically shows a section view of the apparatus of FIG. **1**;

[0028] FIG. **3** is a schematic section view of a variant embodiment of the apparatus of FIG. **1**.

## DETAILED DESCRIPTION

[0029] With reference to the aforementioned figures, an apparatus for carrying out the process of the present invention is schematically indicated with **1**.

[0030] Such an apparatus comprises a self-supporting structure **2**, substantially in the shape of a parallelepiped container, which defines a space A inside it, in which two fluid beds F**1** and F**2** are intended to be realized, as can be seen more clearly in the rest of the description.

[0031] Said container structure **2** (which hereafter shall simply be called: container **2**), has long side walls **3**, **4**, short front **5** and rear **6** walls; and, at the bottom, it is equipped with a double base plate, **7**, **7***a*, upper and lower respectively.

[0032] In accordance with a characteristic of the present invention, the front wall **5**, of said container **2**, has the bottom side **5***a*, spaced from the base plate **7**, of said double base plate, with which it thus defines a passage (or port) **25**, which places the space A in communication with the outside of said container **2**.

[0033] Moreover, in accordance with another characteristic of the present invention, the aforementioned base plates **7**, **7***a*, extend from the rear wall **6**, of the container **2**, up to past said front wall **5**, for a predetermined length portion.

[0034] At their free front ends, a vertical panel **35** is fixed to the base plates **7**, **7***a*, preferably parallel to the wall **5**, with which it defines a sort of duct or well **45**, open at the top, extending for the whole width of said wall **5** and in communication with the space A, through the aforementioned passage **25**.

[0035] The base plates **7**, **7***a* of said double base plate, the rear wall **6** of the container **2** and the vertical panel **35**, define a chamber **8** which is in fluid communication with the space A actually through said base plate **7**, provided perforated, grated or in any case permeable to gas flows.

[0036] Said chamber **8**, extending below the space A and the well **45**, is of limited height and is intended to constitute a chamber for uniform distribution of a gaseous flow of fluidification air coming into said space A and into said well **45**, as will better turn out from the following of the description.

[0037] Advantageously and in accordance with a further characteristic of the present invention, said distribution chamber **8** has a tapered profile starting from the rear wall **6**, of the container **2**, towards the vertical panel **35**.

[0038] For such a purpose, the base plate **7***a* is provided tilted on the opposite base plate **7**, and converging on it towards the aforementioned vertical panel **35**.

[0039] Inside the container **2** and at a predetermined distance from its base plate **7** a rectangular shelf **9** is positioned, perimetrically fixed to the long side walls **3**, **4**, and to the short front and rear walls **5**, **6**, of said container **2**.

[0040] Said shelf **9** defines, in said space A, a granulation zone B, and the granulation fluid bed F**1** of a predetermined substance is intended to be realized on it. For such a purpose it is made permeable (for example it is perforated or grated) to the flow of fluidification air necessary for the formation and maintenance of said bed F**1**. Moreover, the aforementioned shelf **9** is equipped with a plurality of slits **9***a*, also known as classification slits since they are intended to allow the passage of the finished granules classified by the respective classification flow, as will better turn out from the following of the description.

[0041] For the aforementioned reason said slits **9***a* are suitably sized with a width correlated (larger) with the diameter of the granules intended to be produced.

[0042] In FIG. **1**, arrows are represented with **10** and **11** which schematize the feeding (realized with per se known systems and, therefore, not represented) of granule seeds of the substance to be granulated, at the opposite side walls **3**, **4** of the container **2** and for all of their length. While with **12** and **13** distributor-supplier devices of granule growth liquid substance are schematized, also known and therefore not represented in detail, arranged at said side walls **3** and **4** below the free surface of the granulation fluid bed (F**1**), also of the known type and therefore not represented in detail.

[0043] In FIG. **2**, an opening is schematized with **14**, associated with the rear wall **6**, for the entry of air inside the

chamber **8**. Such opening **14** is in fluid communication with per se known and therefore not represented means, for blowing air into said chamber **19**.

[**0044**] With reference to the apparatus of FIGS. **1** and **2**, an embodiment of the granulation process of the present invention will now be described.

[**0045**] In a starting condition, on the shelf **9** a granulation fluid bed F**1** is formed, consisting of granule seeds and growing granules. Said bed is obtained, supported and maintained through a continuous flow of fluidification air, fed into the chamber **8** and from here, through the base plate **7**, into the space A, below said shelf **9**.

[**0046**] When the granules in the granulation fluid bed reach a predetermined size and weight, hereafter called finished granules, the flow of fluidification air is no longer able to support them and they fall by gravity through the classification slits **9***a*.

[**0047**] At this point the finished granules thus obtained are affected by a transfer phase by falling of the finished granules themselves, and only by their falling, in a pressurized space, below the granulation bed F**1**.

[**0048**] In accordance with a characteristic of the present invention, said finished granules, and only these, form, in said pressurized space, a collection fluid bed F**2** of said finished granules, realized and supported through the same flow of fluidification air of the fluid bed F**1**.

[**0049**] In accordance with a further characteristic of the present invention, the extraction of the finished and classified granules from said collection fluid bed F**2**, i.e. from said pressurized collection space, takes place substantially by hydraulic means, in continuous flow, since the collection space, and more precisely the base plate **7** of the bed F**2** realized in said space, is in fluid communication with the well **45**.

[**0050**] The well **45** and said collection space can be considered "communicating vessels", so that in the well **45** the level of the finished granules, i.e. the level of the fluid bed F**2** in said well **45**, stabilizes at a height (piezometric height) corresponding to the internal pressure present in the collection space, such as to counterbalance said internal pressure, so as to allow the continuous discharge of the finished granules, at the same time maintaining the pressure inside the collection space necessary for the operation of the upper granulation fluid bed (F**1**).

[**0051**] A further important advantage of the present invention, due to the use of a fluid bed for the collection and extraction of the finished granules from the granulation apparatus, in particular from the collection space for the finished granules where the pressure is of a greater value than atmospheric pressure, resides in the lowest or even inexistent mechanical stresses to which the finished granules are subjected, with a consequent guarantee of the safeguarding of the grain size and integrality of said finished and classified granules.

[**0052**] Said advantages, accomplished by the present invention, translate in a substantial energy saving and a substantial increase in yield of the entire productive cycle.

[**0053**] In particular, the extraction method of the finished granules from a pressurized space to outside the granulator is particularly simple to carry out, reliable even for long operating cycles and does not require particular maintenance interventions.

[**0054**] Of course, a man skilled in the art, in order to satisfy contingent and specific requirements, can make numerous modifications, all of which are in any case covered by the scope of protection of the invention as defined by the claims shown hereafter.

[**0055**] Thus, for example, the granulation process according to the present invention shall now be described in a variant embodiment, carried out in a granulation apparatus shown in FIG. **3**, where details and cooperating parts having the same structure and operation as the previous embodiment shall be indicated with the same reference numerals and symbols.

[**0056**] In such a variant embodiment a collection fluid bed (F**2**) for the finished and classified granules is realized, having a limited length with respect to what was previously described for the collection fluid bed, and said finished and classified granules, coming from the granulation fluid bed (F**1**), are fed to it through an appropriate transportation device **30**, for example a chute, an endless conveyor belt and similar transportation systems, positioned in the collection space for said granules, under said shelf **9** in the container **2**.

[**0057**] Said collection fluid bed (F**2**), in accordance with the present invention, extends in the well **45** and inside the pressurized space, beyond the front wall **5** of the container **2**, by an appropriate predetermined portion of limited length.

[**0058**] In accordance with a further characteristic of the present invention, said fluid bed (F**2**) is fluidified through only part of the fluidification air of the granulation fluid bed (F**1**). In particular said part of fluidification air of the granulation fluid bed (F**1**) is distributed to the collection fluid bed (F**2**) through a base plate **7**, permeable to gaseous flows, through a respective chamber **80**, equipped with an opening **80***a* for feeding said fluidification air, extending below said bed (F**2**) and for the same said limited length.

[**0059**] The container **2**, in order to feed the remaining part of fluidification air to the granulation fluid bed (F**1**), is equipped with an opening **80***b*, associated with the rear wall **6**, below the shelf **9**, for the entry of air inside the space A.

[**0060**] The openings **80***a* and **80***b* are in fluid communication with respective means, per se known and therefore not represented, for blowing air into said chamber **80** and into said space A, respectively.

[**0061**] According to a further variant embodiment of the present invention, the well **45** can be realized with a lower width with respect to the width of the corresponding front wall **5** of said container **2**.

**1**. Process for obtaining finished granules of a predetermined substance in a granulation fluid bed (F**1**) of the so-called vertical growth type, said bed being formed and maintained by a respective flow of fluidification air, comprising a transfer phase by falling of said finished granules in a pressurized space below said granulation bed and a recovery phase of said granules from said pressurized space, characterized in that said recovery phase comprises:

a) the formation in said pressurized space of a collection fluid bed of said finished granules, through at least part of said fluidification air; and

b) extraction in continuous flow of said finished granules from said collection bed (F**2**) and from the respective pressurized space, placing the base plate of said collection bed (F**2**) in fluid communication with a well (**45**), outside said pressurized space, fed substantially upstream from the finished granules of said collection bed (F**2**).

**2**. Process for obtaining finished granules of a predetermined substance according to claim 1, characterized in that all of the fluidification air of the granulation fluid bed (F**1**) is used for the fluidification of the collection fluid bed (F**2**) for the finished granules.

**3**. Apparatus for obtaining finished granules of a predetermined substance in a granulation fluid bed (F**1**) of the so-called vertical growth type comprising a self-supporting structure (**2**) substantially shaped like a container, defining a space (A) inside of it, in which a shelf (**9**) is positioned, equipped with a plurality of classification slits (**9***a*) and intended to support a granulation fluid bed (F**1**), characterized in that it comprises, in said space (A), a base plate (**7**), permeable to gaseous flows, extending below and in a predetermined spaced relationship from said shelf (**9**) until it goes beyond a wall (**5**) of said container (**2**) by a portion of predetermined length, said base plate (**7**) being intended to support a respective collection fluid bed (F**2**) of finished granules, a well (**45**), open at the top, extending outside of said space (A) and in fluid communication with it through a passage (**25**) provided in said wall (**5**) at said base plate (**7**), means for feeding (**14**, **80***a*) a flow of fluidification air, a distribution chamber (**8**, **80**) of said fluidification air in said space (A) and in said well (**45**).

**4**. Apparatus according to claim 3, wherein said wall (**5**) has a lower side (**5***a*), spaced from said base plate (**7**) defining said passage (**25**) which places the aforementioned space (A) in communication with the outside of said container (**2**).

**5**. Apparatus according to claim 3, characterized in that said well (**45**), comprises a vertical panel (**35**), outside of said space (A), in a predetermined spaced relationship to said front wall (**5**) and preferably parallel to it, fixed to said base plate (**7**).

**6**. Apparatus according to claim 3, characterized in that, associated with said base plate (**7**), in a predetermined spaced relationship from it, there is a second base plate (**7***a*) provided tilted on said base plate (**7**) and converging towards said vertical panel (**35**), to define said distribution chamber (**8**) of said fluidification air.

**7**. Apparatus according to claim 3, characterized in that said base plate (**7**), permeable to gas flows, intended to support a respective collection fluid bed (F**2**), extends in said well (**45**) and inside said space (A), going beyond said wall (**5**) by an appropriate predetermined portion of limited length, said apparatus comprising transportation devices (**30**) of the finished granules, to feed said finished granules, transferred from the granulation fluid bed (F**1**), to said collection fluid bed (F**2**), said transportation devices (**30**) being provided in said space (A) below said shelf (**9**) of the container (**2**).

* * * * *