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(54) Title: METHOD AND APPARATUS FOR CARRYING OUT CHEMICAL AND/OR PHYSICAL PROCESSES IN A FLUIDIZED BED

(57) Abstract

A method and an apparatus for carrying out, in at least two fluidized beds (4, 5), different chemical and/or physical processes between a heavier medium and two or more mutually different, lighter fluidizing media (F1, F2), for example combustion and gasification of solid fuel by means of air and water vapour, respectively. The beds are disposed spaced from each other but with an open communication between them at their lower ends and the one fluidizing medium (F1) is utilized for circulation of the heavier material (H) between the beds. This one fluidizing media (F1) is blown in at the open communication such that it does not mix with the other fluidizing media of the beds and the fluidizing media are led off from the beds in separate paths (16, 19).

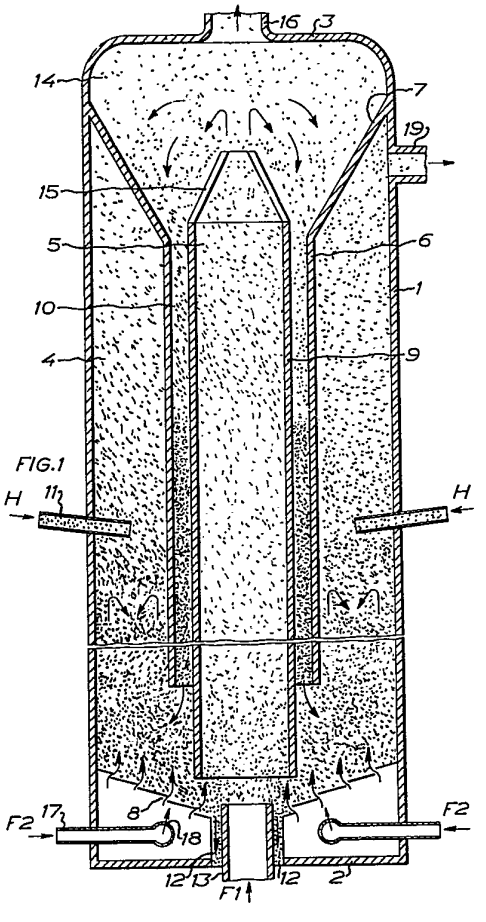

FIG.1

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METHOD AND APPARATUS FOR CARRYING OUT CHEMICAL AND/OR PHYSICAL PROCESSES IN A FLUIDIZED BED

Fluidized beds have long been known and used, primarily within the chemical process industry. Their superiority vis-à-vis conventional solid beds is explained, int. al., by simplicity in the inlet and outlet of large material flows, homogeneous temperature distribution and very good heat transfer properties which lead to the avoidance of inconveniences such as local overheating, so-called "hot spots", in exothermal reactions.

Fluidizing is obtained in that a lighter medium, for example, gas or a fluid, is allowed to flow up through a bed of a heavier (solid or fluid) medium.In low flow velocities of the lighter medium, the bed lies motionless, but in progressively raised flow velocities, the pressure drop increases over the bed and, finally, a stage is reached at which the pressure drop exceeds the force of gravity and the heavier medium begins to move. The bed is then described as fluidizing, and, in particular, this type of fluidized bed is, at these flow velocities, designated "bubbling", since the lighter medium is conveyed through the heavier medium to a certain extent in the form of bubbles.

A further raised flow velocity results in the heaver medium's being lifted by the lighter and finally swept out of the bed and its container.

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For continuous operation of chemical and/or physical processes in a fluidized bed, developments have, in recent times, produced the so-called circulating bed, in which the heavy medium, which is lifted by the lighter medium from the fluidized bed, is recycled after separation from the lighter medium to the bed. For the separation process, use is often made of some internal or external cyclone system. The circulating bed provides the advantage, vis-à-vis the bubbling bed, that contact between the heavier medium and the lighter fluidizing medium is improved, since, in the bubbling bed, a large portion of the lighter medium moves through the bed in the form of bubbles without coming into contact with the heavier medium.

It should be clear to the skilled reader that the technology of fluidized beds offers a large spectrum of possibilities for carrying out chemical and physical processes, in which contact between the different phases is pursued.

One example of processes which advantageously may be carried out in a fluidized bed is the gasification and combustion of solid fuels such as coal, shale, wood, straw etc. When a product gas with low nitrogen content is desired, the material must be gasified with oxygen gas and water vapour in order that the requisite heat be released in the reactor.

The ash can then be finally combusted with air in another reactor. Another method of effecting the heat supply without oxygen gas is to circulate ash between gasification and combustion beds. This involves problems with material transport and, since the systems are often under pressure, sealing problems are great.

Many industrial processes include absorption or adsorption steps. This may refer to final products which, in this manner, are taken care of; or it may be a matter of restricting the size of possible discharges which make

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an absorption step a necessary part in the total process. The processes which are currently in operation for solid phase gas absorption are batch processes. In continuous processes, in which an expensive or otherwise valuable absorbent is utilized, and in which the utilization includes a regeneration step for the absorbent, today's industry has recourse to parallel-connected units which are sequentially coupled-in according to the working schedule: absorption, regeneration, absorption, regeneration and so on, this arrangement being a disadvantageous solution from the point of view of process techniques and economy.

The object of the present invention is to produce a method and apparatus which obviate the above-described inconveniences and which, in one and the same container, permit continuous and simultaneous operation of at least two separate physical and/or chemical processes in fluidized beds between a heavier medium, for example a solid material, and different light media, for example, gaseous media, for the different chemical and/or physical processes.

To this end, the beds are disposed substantially laterally separated but with an open communication between them in an area at their lower regions. Moreover, the heavier medium is circulated between the beds via the open communication with the assistance of substantially but the one of the fluidizing media which is supplied at the open communication and is led from the associated bed substantially separate from the other fluidizing medium or media.

According to a further aspect of the present invention, the apparatus for carrying out the different chemical and/or physical processes includes a substantially elongate vertical vessel with an inner first wall which extends in the longitudinal direction of the vessel for dividing the interior of the vessel into two compart-

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ments, the wall being so arranged as to permit open communication between the compartments over the upper and lower ends of the wall. Separate inlets are provided for the lighter media to the compartments, substantially at the lower ends of the compartments, and separate outlets for the lighter media from the compartments. Finally, inlets to and outlets from the vessel for the heavy medium are also provided.

The nature of the present invention and its aspects will be more readily understood from the following brief description of the accompanying drawings, and discussion relating thereto.

In the accompanying drawings:-

Fig. 1 is a diametric longitudinal section through a cylindrical apparatus according to the invention; and

Fig. 2 shows a modified apparatus.

A vertical, elongate vessel with a casing wall 1, bottom wall 2 and top wall 3, has outer and inner concentric compartments 4 and 5 for carrying out different chemical and/or physical processes in fluidized beds between a relatively heavier medium and different relatively lighter media in the two compartments 4 and 5. The outer compartment 4 is substantially defined by the casing wall 1 of the vessel and an elongate inner wall 6 concentric therewith, the inner wall being, at its top, connected to the casing wall by means of an upwardly inclined wall 7 and terminates, at its bottom, a distance above a perforated bottom 8 sloping from the casing wall towards the centre of the vessel. The perforated bottom is disposed a distance above the bottom wall 2 of the vessel. The inner compartment 5 is substantially defined by a cylindrical wall 9 which is concentric with and spaced apart from the wall 6, the wall 9 extending, at the bottom, past the wall 6 and terminating a distance above the perforated bottom 8 and also delimiting the bottom end portion of the outer compartment 4 from the level at which the

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wall 6 has its lower end. Thus, there is open communication between the compartments 4 and 5 at their lower ends. The cylindrical wall 9 is mounted, in a manner which is not shown, in the vessel, for example over radial walls welded to the wall 6. The annular-cylindrical gap which separates the walls 6 and 9 is designated 10.

A number of inlets 11 for the heavier medium H are disposed about the casing wall 1 and discharge in this wall a distance above the lower end of the wall 6, and an outlet passage 12 from the vessel for the heavier medium extends in alignment with the compartment 5 from the perforated bottom 8 through the bottom wall 2. A tube 13 of smaller diameter than the compartment 5 is vertically inserted through this passage from beneath and discharges into the vessel somewhat above the perforated bottom 8 and a distance below the bottom end of the wall 9, this tube serving for blowing in lighter medium F1 into the compartment 5.

At the upper end of the compartment 5, in the space 14 defined by the top wall 3 of the vessel and the wall 7, there is preferably disposed a separator 15 for separating heavier medium from lighter medium. The separator may be of any given conventional cyclone arrangement, preferably an inner cyclone arrangement or a guide-vane arrangement according to Swedish patent application No. 7705352-8; but this arrangement may be dispensed with in certain cases, for which reason it is illustrated but schematically. An outlet 16 for substantially separated lighter medium is disposed in the top wall 3.

A number of radial conduits 17 evenly distributed throughout the circumference of the casing extend through the casing wall into the space which is defined by the perforated bottom 8, the bottom wall of the vessel 2, the casing wall 1 and the defining wall of the passage 12. The conduits 17 have one or more slots 18 for discharge of a second lighter medium F2 substantially into the compartment 4 via the perforations in the perforated bottom 8.

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An outlet 19 for essentially lighter medium F2 is disposed in the upper region of the casing wall 1 beneath the inclined wall 7.

The above-described apparatus functions as follows. It will be assumed below that the heavier, for example, solid particulate medium H is to be treated with two different lighter, for example gaseous, media F1 and F2 in the reactor compartments 4 and 5, it being understood that, instead, two different lighter media may be treated with one and the same heavier medium, or that heavier medium may be treated with one lighter medium and another lighter medium may be treated with the heavier medium. Relatively heavier medium H is introduced, if desired, continuously, into the outer compartment 4 through the inlets 11 and is exposed in this compartment to a first treatment by means of the lighter medium F2 under fluidization in a bed by means of the same lighter medium F2 which is blown in through the slots 18 of the conduits 17. Heaver medium at the lower end of the compartment 4 is caught and introduced into the compartment 5 through its lower end by means of a second lighter medium F1 which is blown into the vessel through the tube 13. This transfer from compartment 4 to compartment 5 of heavier medium can, as is illustrated, be guided by a partial current of lighter medium F2 by deflecting such a partial current through the perforated bottom 8 in a direction towards the lower end of the compartment 5,

In the compartment 5, heavier medium transferred from the compartment 4 is exposed to a second treatment under fluidization by means of lighter medium F1. The velocity of the lighter medium F1 may be adjusted from just above the minimum fluidization limit, above bubbling and turbulent, so-called rapid fluidization (as shown on the drawing) and pneumatic transport which here is included in the concept fluidization. The important factor is that heavier medium be conveyed upwardly in the compart-

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ment 5 by lighter medium such that the heavier medium, after separation from the lighter medium in the space 14, may fall down in the gap 10. In so-called slow fluidization, the heavier medium in the space 14 may be separated from the lighter medium in a known manner by overflow over the upper end of the compartment 5 via, for example, an overflow outlet, and/or by utilizing the velocity reduction in the broadened space 14, whereas, at higher velocities, a special, previously-mentioned separator 15 may be desirable for the above-mentioned separation. A separator may, however, always reduce the discharge of heavier medium through the outlet 16 together with lighter medium, substantially F1, for which reason a separator is most often to be preferred in the space 14. In the gap 10, heavier medium treated in the compartment 5 falls down into the fluidized bed in the compartment 4, is fluidized therein by means of lighter medium F2 and is transferred, in the previously described manner, to the compartment 5. Thus, a circulation of the heavier medium takes place between the compartments 4 and 5 via the gap 10, the heavier medium being continuously treated in the compartments 4 and 5 by means of the lighter media F1 and F2. Heavier medium treated in both of the compartments is removed through the outlet 12 and fluidizing medium F2 is removed through the outlet 19.

By controlling the flow of lighter medium F2 which is removed through the outlet 19, it is possible to build up a column of heavier medium in the gap 10 of the desired height, this column substantially insulating the compartments 4 and 5 from each other and reducing the possibility of an intermixture of the lighter media F1 and F2 in the vessel while permitting separate regulation of the pressure levels of the lighter media F1 and F2. The column in the gap may have a volume weight which varies within the limits determined by the necessity of avoiding intermixture of the lighter media in the compartment 4 and in the space 14. It should be observed in

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particular that specially the lighter medium F1 may be prevented from gaining access to the reactor compartment 4 and there mixing with the lighter medium F2 thanks to the above-mentioned partial flow of lighter medium F2 to the compartment 5, this partial flow forming a barrier between the compartments 4 and 5. The medium F2 removed through the outlet 19 is hereby as good as free of the medium F1.

In other fields of application, the requirement of non-mixture of the lighter media may be stricter than in the utilization of the above-described first embodiment. For satisfying this requirement, the embodiment of the apparatus according to Fig. 1 but illustrated in Fig. 2 may be used, the same reference numerals being used in Fig. 2 for corresponding or similar details from Fig. 1.

In this embodiment, the injection tube 13 for the lighter medium F1 is advanced a distance into the lower end region of the reactor compartment 5 and annular channels 20 with slots 21 are disposed concentrically with and spaced apart from each other slightly above the lower end of the wall 6 in the compartment 4. These channels 20, whose supply lead from outside the reactor vessel is not shown, serves for the blowing in of lighter treatment and fluidizing medium F2 into the reactor compartment 4, whereas the conduits 17 serve, in this case, for the blowing in of lighter guide medium F3. The task of the guide medium F3 is, on the one hand, to guide heavier medium from the compartment 4 to the lower end of the compartment 5, and, on the other hand, to fluidize the heavier medium in the compartment 4 towards the channels 20, through which the blown-in lighter treatment medium F2 creates a fluidized bed above these channels 20 for treatment of the heavier medium, by means of the medium F2, the heavier material emanating from the compartment 5 via the gap 10 and, if continuous supply of heavier medium is effected to the vessel, from the inlets

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11. Through the spaces between the channels 20, exchange takes place of heavier material between the bed created by the medium F3 and the bed created by the medium F2. Since the medium F3 creates a barrier between the compartments 4 and 5, mixture of the lighter treatment media F1 and F2 in the vessel is prevented, in combination with the presence of the column in the gap 10 and the tube 13 advanced into the compartment 5. The guide medium F3 may be selected so as to be inert with respect both to the heavier medium and the lighter treatment media so that it will have no effect on any of these media.

Alternatively to, or as well as the channels 20, a blowing box 22 may be provided beneath the perforated bottom close to the casing wall 1 for blowing in lighter treatment medium F2 into the compartment 4.

Examples of processes which may be carried out and which have been carried out in the method according to the invention and with the apparatus of, for example, Fig. 1, are the previously-mentioned combined combustion and gasification of fluidizable fuel, such as coal, shale and biomasses. The organic content in the fuel, which is continually introduced through the inlets 11, may be completely or partially combusted and gasified in the reactor compartment 5 with a mixture of air and water vapour. The gas departing from the compartment 5 may, in this case, be a low-value fuel gas or a flue gas whose energy content may be used in a boiler outside the apparatus. The combustion heat developed in the compartment 5 can by the above-described transport and circulation via the gap 10, of fuel material with the material as heat carrier, heat the compartment 4 where gasification with, for example, only water vapour, may take place. The gas emanating from the compartment 4 by the intermediary of the outlet 19 may be prevented from entraining nitrogen from the air which is introduced into the compartment 5, by the provision of the previously-mentioned partial flow from the

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water vapour flow for guiding the fuel material from the compartment 4 to the compartment 5, this partial flow forming a barrier preventing the leakage of air to the compartment 4. Nitrogen-free gas from the outlet 19 may advantageously be used in syntheses, for pipe-line transport etc.

A further example of the use of the invention is the previously-mentioned absorption or adsorption processes. In such a context, the heavier medium may constitute the absorbent or adsorbent which is to be continuously regenerated.

The flow, for example of process gas, containing the substance which is to be absorbed or adsorbed, is introduced through the channels 20 in the compartment 4 for absorption or adsorption of this substance by heavier absorption or adsorption media, and the purified gas can be removed through the outlet 19. Regeneration of the heavier medium is effected in the compartment 5, in which this medium is exposed to a lighter regeneration medium which is blown in through the tube 13.

Both in this case and in the example with the combined combustion and gasification, the beds formed by the lighter media F1 and F2 may, naturally, change place in the compartments 4 and 5.

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CLAIMS

1. A method of carrying out, in at least two fluidized beds, different chemical and/or physical processes between a heavier medium and two or more mutually different, lighter fluidizing media for the different processes, characterized in that the beds are disposed substantially laterally separate but with an open communication between them in an area at their lower regions, and that the heavier medium is circulated between the beds via the open communication with the assistance of substantially but the one of the fluidizing media which is introduced at the open communication and is led from the associated bed substantially separate from the other fluidizing medium or media.

2. Method according to claim 1, characterized in that the one bed is exposed to such powerful blowing-in of associated fluidizing medium that the heavier medium continuously leaves the bed, which heavier medium, under the utilization of gravitational forces, is transferred to at least the second bed whence it is transferred, under the action of at least said one fluidizing medium, to said one bed.

3. Method according to claim 1 or 2, characterized in that heavier medium is guided into the flow path for said one fluidizing medium by means of a lighter guide medium which is introduced in the area of said open communication.

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4. Method according to claim 3, characterized in that a second fluidizing medium is selected as the guide medium.

5. Method according to claim 3, characterized in that the heavier medium is fluidized and, through fluidization, is transferred to the second bed by means of the guide medium.

6. Method according to any one of claims 1 to 5, characterized in that, for controlling the pressure level of the fluidizing media, a column is built up of heavier material between the beds and in communication with the beds.

7. Method according to any one of claims 2 to 6, characterized in that heavier medium intended for subjection to said processes is introduced into the second bed.

8. Method according to any one of claims 1 to 7 for carrying out a combined combustion and gasification of fuel constituting the heavier medium.

9. Method according to any one of claims 1 to 7 for carrying out adsorption or absorption of gas from a gas mixture constituting a lighter medium, by means of a solid adsorption or absorption agent, and for carrying out regeneration of the adsorption or absorption agent by means of a lighter regeneration medium.

10. An apparatus for carrying out, in at least two fluidized beds, different chemical and/or physical processes between a heavier medium and two or more mutually different, lighter fluidizing media for the different processes, characterized by a substantially elongate vertical vessel with an inner first wall (9) extending in the longitudinal direction of the vessel for dividing the interior of the vessel into two compartments (4, 5) the wall being so disposed as to permit open communication between the compartments over the upper and lower ends of the wall; separate inlets (13, 18, 21, 22) for lighter media to the compartments

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(4, 5) substantially at the lower ends of these compartments, and separate outlets (16, 19) for lighter media from the compartments, and by inlets (11) to and outlets (13) from the vessel for heavier medium.

11. Apparatus according to claim 10, characterized in that means are provided for deflecting a portion of the lighter medium blown into the one compartment into the area of the open communication between the compartments at the lower end of the first wall.

12. Apparatus according to claim 10 or 11, characterized in that a second wall (6) which, at the bottom, terminates a distance above the first wall (9), is provided in spaced apart relationship to the first wall, the second wall delimiting, at the top, one of the compartments (4) which has its own outlet (19) for lighter medium.

13. Apparatus according to any one of claims 10 to 12, characterized in that said first and second walls (6, 9) are circular and mutually concentric, and that a perforated bottom (8) is disposed a distance beneath the first and second walls for admittance of lighter medium to the outer compartment (4).

14. Apparatus according to claim 13, characterized in that a tube (13) extends through the perforated bottom (8) for blowing in lighter medium into the inner compartment (5).

15. Apparatus according to claim 13 or 14, characterized in that channels (20) are provided in the outer compartment (4) above the perforated bottom for blowing in further lighter medium into the outer compartment (4).

16. Apparatus according to claim 15, characterized in that the outlet (12) for heavier medium is a passage concentric with the inlet (13) for lighter medium in the inner compartment (5).

17. Apparatus according to any one of claims 10 to 16, characterized in that a separator (15) is disposed in the one compartment (5) at the upper end of the first

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wall (9) for separating heavier medium from lighter medium.

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AMENDED CLAIMS
(received by the International Bureau on 6 November 1978 (06.11.78))

1. A method, in at least two fluidized beds, of carrying out different chemical and/or physical processes between a heavy medium and two or more mutually different, lighter gaseous and/or vaporous fluidizing media for the different processes, characterized in that the beds are disposed substantially separated in the lateral direction but with open communication between them in an area at their lower regions, and that heavy medium is circulated in the vertical direction between the beds via the open communication with the assistance of substantially but the one of the fluidizing media which is supplied at the open communication and which is led from the associated bed substantially separated from the other fluidizing medium or media.

2. Method according to claim 1, characterized in that the one bed is blown through so powerfully by means of the associated fluidizing medium that the heavy medium continuously leaves the bed, which heavy medium is, under the utilization of gravitational forces, transferred to at least the second bed whence it is transferred to said one bed under the action of at least said one fluidizing medium.

3. Method according to claim 1 or 2, characterized in that the heavy medium is guided into the flow path for said one fluidizing medium by means of a lighter guiding medium which is supplied in the area of said open communication.

4. Method according to claim 3, characterized in that a second fluidizing medium is selected as the guiding medium.

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5. Method according to claim 3, characterized in that the heavy medium is fluidized and, by fluidizing, is transferred to the second bed by means of the guide medium.

6. Method according to any one of claims 1 to 5, characterized in that, for controlling the pressure level of the fluidizing media a column of heavier material is built up between the beds and in communication with the beds.

7. Method according to any one of claims 2 to 6, characterized in that heavy medium intended for carrying out said processes is introduced in the second bed.

8. Method according to any one of claims 1 to 7 for carrying out a combined combustion and gasification of fuel constituting the heavy medium.

9. Method according to any one of claims 1 to 7 for carrying out adsorption or absorption of gas from a gas mixture which constitutes a lighter medium, by means of solid adsorption or absorption agent, and for carrying out regeneration of the adsorption or absorption agent by means of a lighter regeneration agent.

10. An apparatus, in at least two fluidized beds, for carrying out different chemical and/or physical processes between a heavy medium and two or more mutually different, lighter gaseous and/or vaporous fluidizing media for the different processes, characterized by a substantially elongate, vertical vessel with an inner first wall (9) which extends in the longitudinal direction of the vessel for dividing the interior of the vessel into two compartments (4, 5), said wall being disposed such as to permit open communication between the compartments over the upper and lower ends of the wall, a second wall (6) which, in the vessel, is disposed in spaced apart relationship with the first wall and terminating, at its bottom, a distance above the bottom end of the first wall, and said second wall delimiting, at its top, the compartments (4, 5) from each other,

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separate inlets (13, 18, 21, 22) for lighter media to the compartments (4, 5) substantially at the bottom ends of said compartments, and separate outlets (16, 19) for lighter media from the compartments, and inlet (11) to and outlet (12) from the vessel for the heavier medium.

11. Apparatus according to claim 10, characterized in that means are provided for deflecting off a portion of the lighter medium blown into the one compartment, to the area of the open communication between the compartments at the bottom end of said first wall.

12. Apparatus according to claim 10 or 11, characterized in that said first and second walls (6, 9) are circular and mutually concentric, and that a perforated bottom (8) is disposed in spaced apart relationship beneath the first and second walls for admittance of lighter medium into the outer compartment (4).

13. Apparatus according to claim 12, characterized in that a pipe (13) extends through the perforated bottom (8) for blowing-in of lighter medium into the inner compartment (5).

14. Apparatus according to claim 12 or 13, characterized in that passages (20) are disposed in the outer compartment (5) over the perforated bottom for blowing-in of further lighter medium into the outer compartment (4).

15. Apparatus according to claim 14, characterized in that the outlet (12) for heavier medium is a passage which is concentric with the inlet (13) for lighter medium in the inner compartment (5).

16. Apparatus according to any one of claims 10 to 15, characterized in that a separator (15) is disposed in the one compartment (5) at the upper end of the first wall (9) for separating heavier medium from lighter medium.

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STATEMENT UNDER ARTICLE 19

In accordance with the requirements of Article 19 and Rule 46, new claims are enclosed on replacement pages 9-11.

In amended claim 1, the expression "gaseous and/or vaporous" has been inserted between "lighter" and "fluidizing media" in the preamble; and "in the vertical direction" between "circulated" and "between" in the characterizing clause.

In claim 7, the expression "material" has been amended to "medium".

In amended claim 10, the expression "gaseous and/or vaporous" has been inserted between "lighter" and "fluidizing media" in the preamble; and substantial parts of earlier claim 12 have been included in the characterizing clause. Claim 12 has been cancelled and claims 13 to 17 have been renumbered as 12 to 16, respectively.

The object of these amendments is to eliminate the importance of the novelty references in the international search report.

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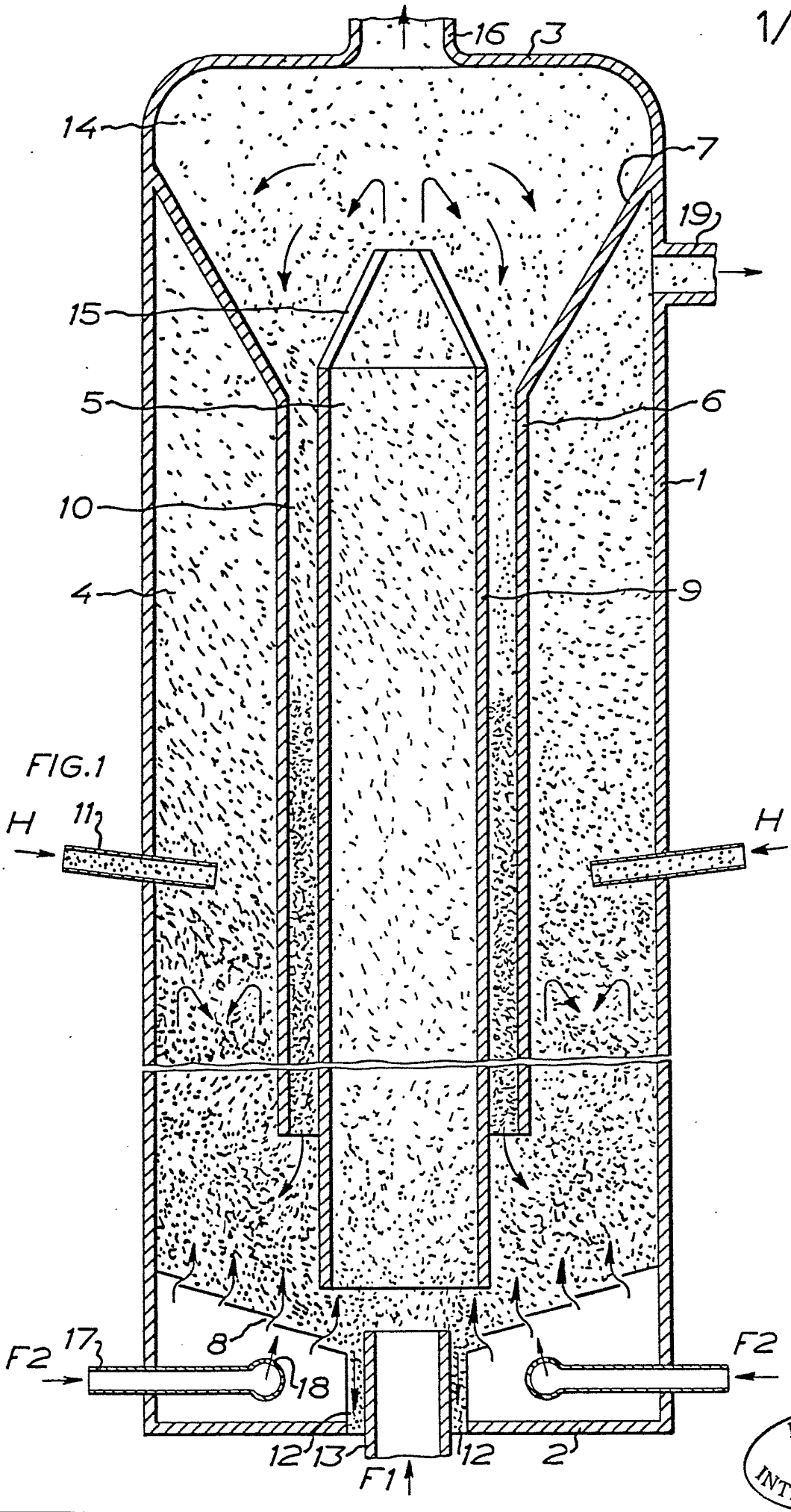

FIG.1

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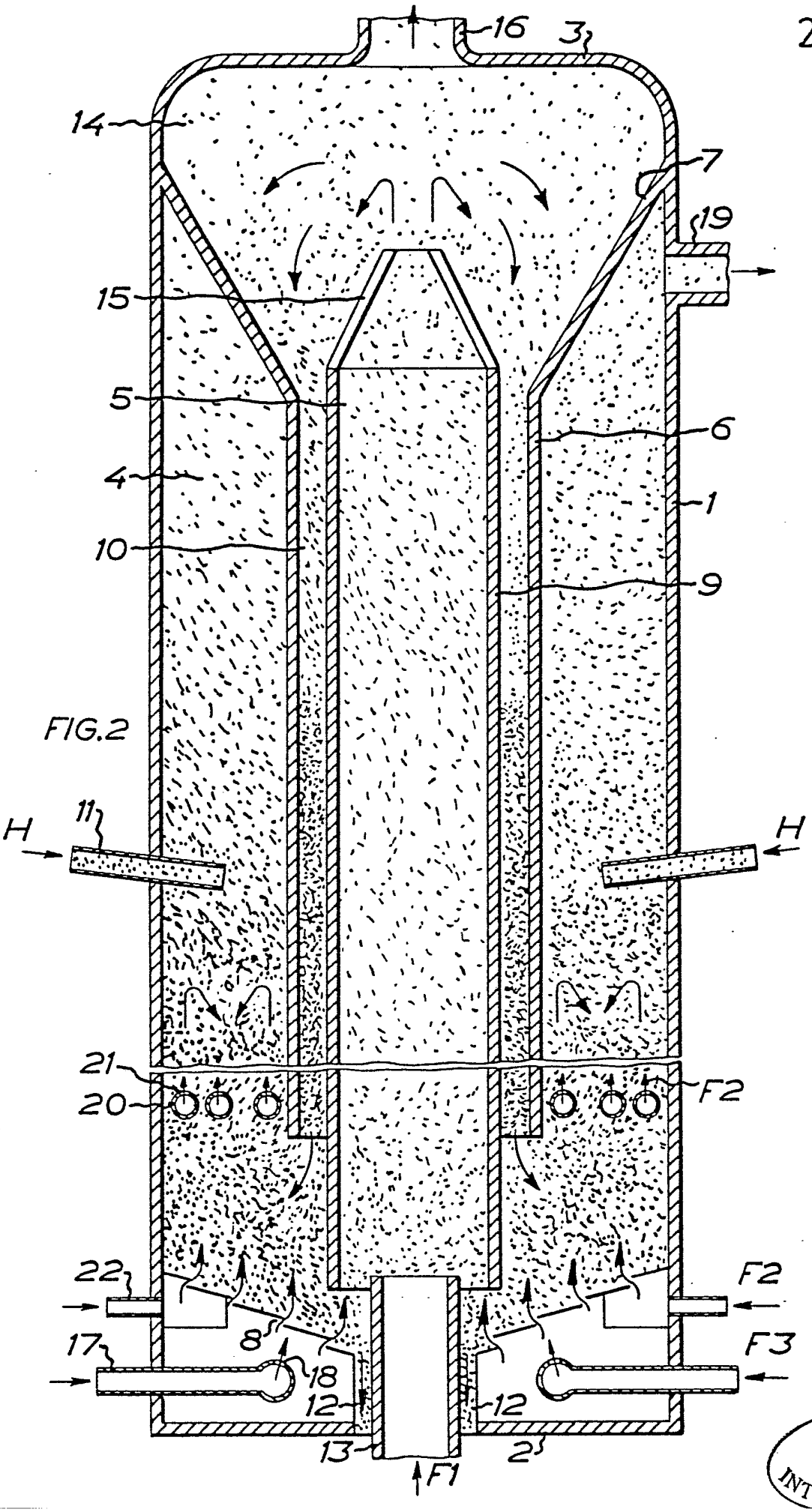

FIG.2

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INTERNATIONAL SEARCH REPORT

International Application No PCT/SE78/00007

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

B01J 8/26, C10J 3/46, B01D 53/12 // F23D 19/00

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 2	B01D 46/38,53/10,53/12, B01J 1/00,8/00,8/18-8/46 C10B 47/22,47/24,49/08,49/10,49/20,49/22,55/08,55/10 C10J 3/00,3/46-3/56,C22B 1/00,1/10,5/14, F23D 19/00 .../...

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

SE, NO, DK, FI, classes as above.

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	GB, A, 1439457, published 1976, 16 June, see Fig 3 Exxon Research and Engineering Company	1, 2, 3
X	FR, A, 1404349, published 1965, Maschinenfabrik Augsburg-Nürnberg AG	1, 2, 9, 10, 11
A	DE, A1, 2611191, published 1976, 7 October, Stora Kopparbergs Bergslags AB	
A	US, A, 3236607, published 1966, 22 February, W.J. Porter Jr Et Al	
A	DE, A1, 2023239, published 1971, 25 November, Exxon Research and Engineering Company	

* Special categories of cited documents: [15]

"A" document defining the general state of the art

"E" earlier document but published on or after the international filing date

"L" document cited for special reason other than those referred to in the other categories

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but on or after the priority date claimed

"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention

"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
1978-09-04	1978-09-05
International Searching Authority [1]	**Signature of Authorized Officer [20]**
Swedish Patent Office	Mats Rauma

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

II. Fields searched

Classification System

IPC 2 F26B 3/08, F27B 15/00-15/20

US 23:284, 55:34,60,77,99,181,317,390,474
75:9, 201:31, 432:15,58

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ....., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.