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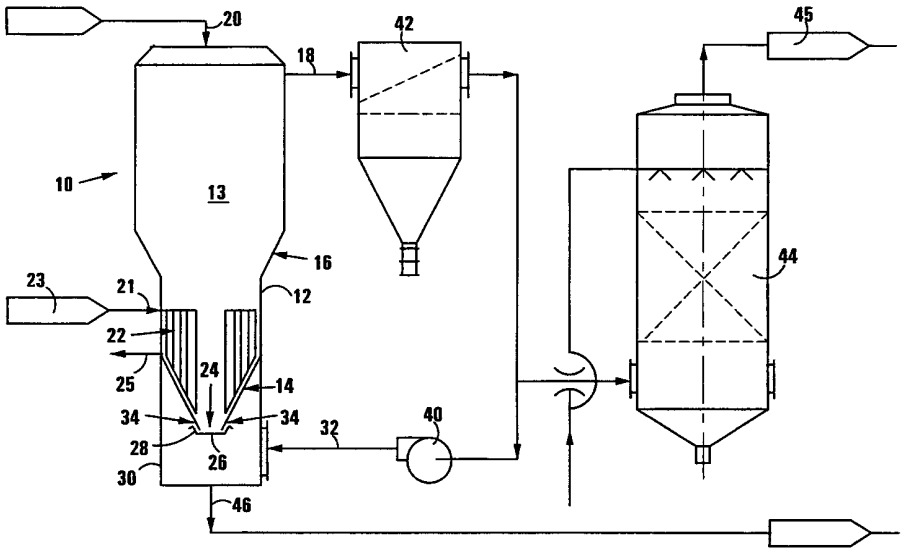
(54) Title: A FLUIDIZED BED APPARATUS




(57) Abstract: The invention relates to a spouting fluidized bed apparatus (10) that comprises a hollow body (12) defining an internal space (13) including a downwardly tapering lower section (14) and an upper section (16) that extends operatively upwardly from the lower section (14). The hollow body (12) defines a gas inlet opening (24) at its operative lower end, that communicates with a gas feed duct (32), and a gas outlet (18) that leads from the hollow body near its operative upper end. A heat exchanger arrangement (22) comprising an elongate fluid conduit (21) is located within the tapering lower section (14) of the hollow body (12). The conduit (21) defines an extended flow path for a heated medium within the lower section (14) and thereby provides for heat transfer from the conduit to particulate product and gases in the said lower section, during use of the apparatus and with the particulate product defining a fluidized bed of particles in the said lower section.

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# A FLUIDIZED BED APPARATUS

THIS INVENTION relates to a fluidized bed apparatus. More particularly, the invention relates to a spouting fluidized bed apparatus.

Known fluidized bed apparatus have many different applications including the drying of particulate products, the gasification of particulate products, the combustion of particulate products, and the like. The present invention provides particularly for a spouting fluidized bed apparatus for drying particulate products.

Each known spouting fluidized bed apparatus known to the Applicant generally comprises a hollow body that defines an internal space including a downwardly tapering lower section, the hollow body defining a gas inlet opening at its operative lower end which communicates, directly or indirectly, with a gas feed duct. The internal space defined by the hollow body includes also an upper section that extends operatively upwardly from the lower section, leading gas to a gas outlet duct that leads from the hollow body and that provides for the passage of gases from the hollow body. The apparatus provides also for the feed of particulate products into the internal space defined by the hollow body and for the discharge of particulate products from the hollow body, which can take place in various different modes.

In operation, for example for drying a particulate product, the particulate product to be dried is fed into the internal space defined by the hollow body of the apparatus via the gas outlet duct, the particles forming the product effectively dropping under gravity into the tapering lower section of the said internal space. Heated gas is fed into the internal space defined by the hollow body via a gas feed duct leading to the gas inlet opening defined at the operative lower end of the hollow body, the heated gas thus passing through the bed of particles formed in the said tapering lower section of the internal space defined by the hollow body. As the gas flow rate increases through the bed of particles formed in the tapering lower section of the internal space defined by the hollow body, a point is reached where the gas pressure drop marginally exceeds the mass of the particles forming the particulate product bed, the particles thereby becoming partially suspended in the air stream. As gas flow increases even further, an expansion of the bed of particles takes place, a vigorous boiling action being created similar to a boiling liquid. Thereby, the bed of particles is said to be fluidized. The fact that the gas is heated, clearly provides for drying of the particles.

The flow pattern of gas through the bed of particles results in a spouting action of the particles in the upper region of the fluidized bed, this region being referred to as the free-board space from which particles will drop back into the bed of particles.

In its fluidized state, the particles behave like a fluid insofar as a specific particle level can be detected, this level being controllable and facilitating also the removal of particles from the hollow body of the apparatus via overflow weirs, or the like, in order to be conveyed to a following process stage.

The exact operation and functioning of a spouting fluidized bed apparatus is well known and as this does not constitute a part of the present invention, this is not described in further detail herein.

It is an object of this invention to provide an improved spouting fluidized bed apparatus, particularly for drying particulate products.

According to the invention there is provided a spouting fluidized bed apparatus for drying particulate products, which includes

a hollow body that defines an internal space including a downwardly tapering lower section, which terminates in a gas inlet opening defined by the hollow body at its operative lower end, and an upper section that extends operatively upwardly from the upper end of the lower section, the hollow body defining a gas outlet leading from a location near the upper end of the upper section of the internal space and a particulate product inlet through which particulate products can be fed into the lower section of the internal space defined by the hollow body;

a plenum chamber body that defines a chamber that surrounds at least partially the operative lower part of the hollow body, including the gas inlet opening defined by the hollow body, and that defines a gas inlet opening connectable to a gas supply to permit a gas to enter the chamber and pass from the chamber into the hollow body via the gas inlet opening defined at the operative lower end of the hollow body;

a particulate product discharge means for discharging particulate product from the hollow body; and

a heat exchanger arrangement comprising at least one fluid conduit defining an elongate fluid flow path in the tapering lower section of the internal space defined by the hollow body, through which a heated medium can pass to transfer heat from the conduit to particulate product in the said lower section, in use of the apparatus, for enhancing drying of the particulate product.

In use, the spouting fluidized bed apparatus as defined above will operate essentially conventionally insofar as a heated gas can pass through the internal space defined by the hollow body to create a fluidized bed of particles to be dried therein, the additional heating of the particles due to their contact with the fluid conduit while a heated medium passes through the conduit, enhancing the effective drying of the particulate product. Clearly, the heated gas passing through the internal space defined by the hollow body also will be heated by the exposure thereof to the fluid conduit, which will also enhance the effective drying of the particulate product.

The lower section of the internal space defined by the hollow body may define an inverted frusto-conical configuration with the gas inlet opening being a circular opening defined at the lower end of the hollow body.

Alternatively, the lower section of the internal space defined by the hollow body may define a longitudinal axis and a truncated V-shaped profile in cross-section along the length thereof and, as such, the gas inlet opening defined at the lower end of the hollow body defines an elongate slot-like configuration.

The chamber defined by the plenum chamber body particularly defines a gas flow path therethrough leading from its gas inlet opening to the gas inlet opening defined at the lower end of the hollow body, along which gases can flow and then enter the hollow body with an intensity that will permit a fluidized bed of particles to be generated within the lower section of the internal space defined by the hollow body. For the remainder, the configuration of the hollow body and of the plenum chamber body may be essentially conventional, although individual features can be specially designed to accommodate particular applications of the apparatus.

The particulate product discharge means of the apparatus may be a discharge weir disposed at an elevated level above the operative lower end of the hollow body, over which weir, in use of the apparatus, particulate product in a fluidized state can be

discharged. Instead, the particulate product discharge means may comprise discharge pipes leading from the hollow body at a location where, in use of the apparatus, particulate product in a fluidized state can be discharged from the hollow body.

The fluid conduit forming the heat exchanger arrangement has opposite ends thereof disposed externally of the hollow body, permitting connection to a heated medium flow line for feeding a heated medium through the fluid conduit, with the conduit section of the fluid conduit disposed within the lower section of the internal space defined by the hollow body providing, in use of the apparatus, for heat transfer to particulate products in a fluidized state within the said lower section of the internal space defined by the hollow body. The said conduit section of the fluid conduit located within the hollow body may define an extended flow path within the said lower section of the internal space defined by the hollow body, while the formation of a fluidized bed of particles in the lower section is still permitted, in use of the apparatus.

The particulate product inlet for feeding particulate products to be dried into the hollow body may be defined near the operative upper end of the hollow body. The apparatus also may include product feed means for feeding particulate products at a controlled feed rate into the hollow body via the particulate product inlet.

The apparatus of the invention also may include a gas displacement means for displacing a heated gas to the chamber defined by the plenum chamber and through the internal space defined by the hollow body. The gas displacement means typically comprises a fan-type gas displacement means.

The apparatus particularly includes a continuous gas flow line that incorporates the hollow body, the plenum chamber body and the gas displacement means and that provides for a continuous gas circulation through the flow line. The continuous gas flow line may include, in line therewith, a dust separator for separating impurities within

heated gas circulating through the flow line, in use of the apparatus. The dust separator typically is a cyclone-type separator.

The apparatus further may include a scrubber apparatus, in line with a branch from the said gas flow line, the scrubber apparatus serving to clean gases guided from the flow line to provide a required gas quality which will permit emission thereof to the atmosphere.

Gases released from the scrubber apparatus may be exposed to thermal oxidation, or the like, to enhance still further the quality of gases emitted to the atmosphere.

It will be appreciated that the overall configuration of the apparatus is greatly variable and that various different arrangements are envisaged for accommodating different requirements associated with the drying of particulate products. The invention extends also to such alternative configuration apparatus.

The invention is now described, by way of an example, with reference to the accompanying diagrammatic drawing which illustrates schematically the configuration of a spouting fluidized bed apparatus, in accordance with the invention.

Referring to the drawing, a spouting fluidized bed apparatus for drying particulate products, in accordance with the invention, is designated generally by the reference numeral 10. The apparatus 10 includes a hollow body 12 that defines an internal space 13. The space 13 defines a longitudinal axis and has a lower section 14 which defines a truncated V-shaped profile in cross section along the length thereof. The internal space 13 defined by the hollow body 12 further has an upper section 16 that extends operatively upwardly from the upper end of the lower section 14 and that leads to a gas outlet 18 defined by the hollow body 12 at a location near the upper end of the upper section 12 of the space 13. An inlet 20 for feeding a particulate product into the internal space 13 defined by the hollow body 12 is provided at the operative top end

of the hollow body 12, permitting particulate product to drop into the lower section 14 of the space 13 defined by the hollow body 12.

The lower section 14 of the space 13 defined by the hollow body 12 further has a heat exchanger arrangement 22 located therein, the heat exchanger arrangement 22 comprising an elongate fluid conduit 21 defining an elongate fluid flow path within the said lower section 14 of the space 13. The fluid conduit 21 defines an extended outer surface area whereby heat can be transferred to particulate product contacting the conduit, during use of the apparatus, for drying the product. The opposite ends of the conduit 21 forming the heat exchanger arrangement 22 are disposed externally of the hollow body 12 (as shown), the conduit particularly being connectable in line with a heated medium supply that can feed a heated medium through the conduit, to create a heated outer surface of the conduit section of the conduit disposed within the hollow body 12. For example, a boiler 23 may feed steam to the conduit 21 and condensate may be released from the outlet end 25 of the conduit. The condensate clearly can be recycled to the boiler 23.

The operative lower end of the hollow body 12 defines a gas inlet 24 which is in the form of an elongate slot-like opening, the gas inlet 24 having a tray formation 26 disposed operatively beneath the inlet 24. The tray formation 26 defines side walls 28 that are disposed in a parallel, spaced, overlapping relationship with the walls defining the tapering lower section 14 of the hollow body 12, as illustrated.

The lower section 14 of the hollow body 12 is partially surrounded by a plenum chamber body 30 which is connectable in line with a gas supply line 32. The plenum chamber body 30 provides a flow path for gas entering the chamber defined thereby, to be introduced into the hollow body 12 via the inlet 24, having passed through the slot-like openings 34 defined between the walls of the tapering lower section 14 of the hollow body 12 and the side walls 28 of the tray formation 26. A predetermined flow path for gas through the hollow body 12 thereby is provided for, but insofar as this

does not form a part of the present invention, this is not described in further detail herein. The flow rate of gas entering the lower section 14 of the internal space 13 defined by the hollow body 12, however, is such that a fluidized bed of particles forming a particulate product can be formed in the lower section 14 of the internal space 13 defined by the hollow body 12, essentially in a conventional manner as is associated with spouting fluidized bed apparatus.

It must be appreciated in this regard that the configuration of the conduit forming the heat exchanger arrangement 22 within the lower section 14 of the internal space 13 defined by the hollow body 12 must be such that the formation of a fluidized bed is not unduly inhibited, while at the same time providing for the maximum exposed surface area so that a heated medium passing through the heat exchanger can heat particles forming the fluidized bed due to contact with the conduit, to cause additional heating of the particles and thereby to enhance effective drying of the particles for which the apparatus 10 is provided. Clearly, the heated medium passing through the heat exchanger arrangement 22 also can heat the gas passing through the internal space 13 defined by the hollow body 12 which induces the formation of the fluidized bed of particles and, thereby, the effective drying of the particles is still further enhanced.

It must therefore be understood that the heat exchanger arrangement 22 is particularly suitable for use in a spouting fluidized bed apparatus provided for drying particulate products.

In practice, the apparatus 10 is associated also with an air displacement fan 40 which is disposed in line with a gas flow line leading to the plenum chamber body 30 and leading from the gas outlet 18 defined by the hollow body 12, a cyclone-type particle filter 42 also being provided in line with this gas flow line to provide for the removal of solid particles passing through this flow line. A scrubber arrangement 44 also is provided, through which gases to be released to the atmosphere must pass, effectively to clean the gases to the extent that the gas quality of the gases to be released, is

suitable for emission to the atmosphere. Downstream of the scrubber arrangement 44, an arrangement 45 within which thermal oxidation can occur is also provided, particularly to deal with odours and to enhance still further the quality of gases emitted to the atmosphere.

The apparatus 10 includes also a discharge arrangement (not shown) for discharging dried particulate product from the hollow body 12, the discharge line 46 being provided for guiding discharged particulate product to a required destination for further processing.

The Applicant submits that the heat exchanger arrangement as used in conjunction with the fluidized bed apparatus of the invention will significantly improve the drying efficiency with which particulate product can be dried. It must be appreciated also that the exact configuration of apparatus, in accordance with the invention, is greatly variable and that the invention also extends to such alternative configuration apparatus which includes the main features and principles of the invention as are hereinabove defined and described.

CLAIMS

1. A spouting fluidized bed apparatus for drying particulate products, which includes

a hollow body that defines an internal space including a downwardly tapering lower section, which terminates in a gas inlet opening defined by the hollow body at its operative lower end, and an upper section that extends operatively upwardly from the upper end of the lower section, the hollow body defining a gas outlet leading from a location near the upper end of the upper section of the internal space and a particulate product inlet through which particulate products can be fed into the lower section of the internal space defined by the hollow body;

a plenum chamber body defining a chamber that surrounds at least partially the operative lower section of the hollow body, including the gas inlet opening defined by the hollow body, and that defines a gas inlet opening connectable to a gas supply to permit a gas to enter the chamber and pass from the chamber into the hollow body via the gas inlet opening defined at the operative lower end of the hollow body;

a particulate product discharge means for discharging particulate product from the hollow body; and

a heat exchanger arrangement comprising at least one fluid conduit defining an elongate fluid flow path in the tapering lower section of the internal space defined by the hollow body, through which a heated medium can pass to transfer heat from the conduit to particulate product in the said lower section, in use of the apparatus, for enhancing drying of the particulate product.

2. An apparatus as claimed in Claim 1, in which the lower section of the internal space defined by the hollow body defines an inverted frusto-conical configuration with the gas inlet opening being a circular opening defined at the lower end of the hollow body.

3. An apparatus as claimed in Claim 1, in which the lower section of the internal space defined by the hollow body defines a longitudinal axis and a truncated V-shaped profile in cross section along the length thereof and in which the gas inlet opening defined at the lower end of the hollow body defines an elongate slot-like configuration.

4. An apparatus as claimed in any one of the preceding claims, in which the chamber defined by the plenum chamber body defines a gas flow path therethrough leading from its gas inlet opening to the gas inlet opening defined at the lower end of the hollow body, along which gases can flow and then enter the hollow body with an intensity that will permit a fluidized bed of particles to be generated within the lower section of the internal space defined by the hollow body.

5. An apparatus as claimed in any one of the preceding claims, in which the particulate product discharge means is a discharge weir disposed at an elevated level above the operative lower end of the hollow body, over which weir, in use of the apparatus, particulate product in a fluidized state can be discharged.

6. An apparatus as claimed in any one of Claims 1 to 4, in which the particulate product discharge means comprises discharge pipes leading from the hollow body at a location where, in use of the apparatus, particulate product in a fluidized state can be discharged from the hollow body.

7. An apparatus as claimed in any one of the preceding claims, in which the fluid conduit forming the heat exchanger arrangement has opposite ends thereof disposed externally of the hollow body, permitting connection to a heated medium flow line for feeding a heated medium through the fluid conduit, with the conduit section of the fluid conduit disposed within the lower section of the internal space defined by the hollow body providing, in use of the apparatus, for heat transfer to particulate products in a fluidized state within the said lower section of the internal space defined by the hollow body.

8. An apparatus as claimed in Claim 7, in which the said conduit section of the fluid conduit located within the hollow body defines an extended flow path within the said lower section of the internal space defined by the hollow body, while the formation of a fluidized bed of particles in the lower section is still permitted, in use of the apparatus.

9. An apparatus as claimed in any one of the preceding claims, in which the particulate product inlet for feeding particulate products to be dried into the hollow body is defined near the operative upper end of the hollow body.

10. An apparatus as claimed in Claim 9, which includes product feed means for feeding particulate products at a controlled feed rate into the hollow body via the particulate product inlet.

11. An apparatus as claimed in any one of the preceding claims, which includes a gas displacement means for displacing a heated gas to the chamber defined by the plenum chamber and through the internal space defined by the hollow body.

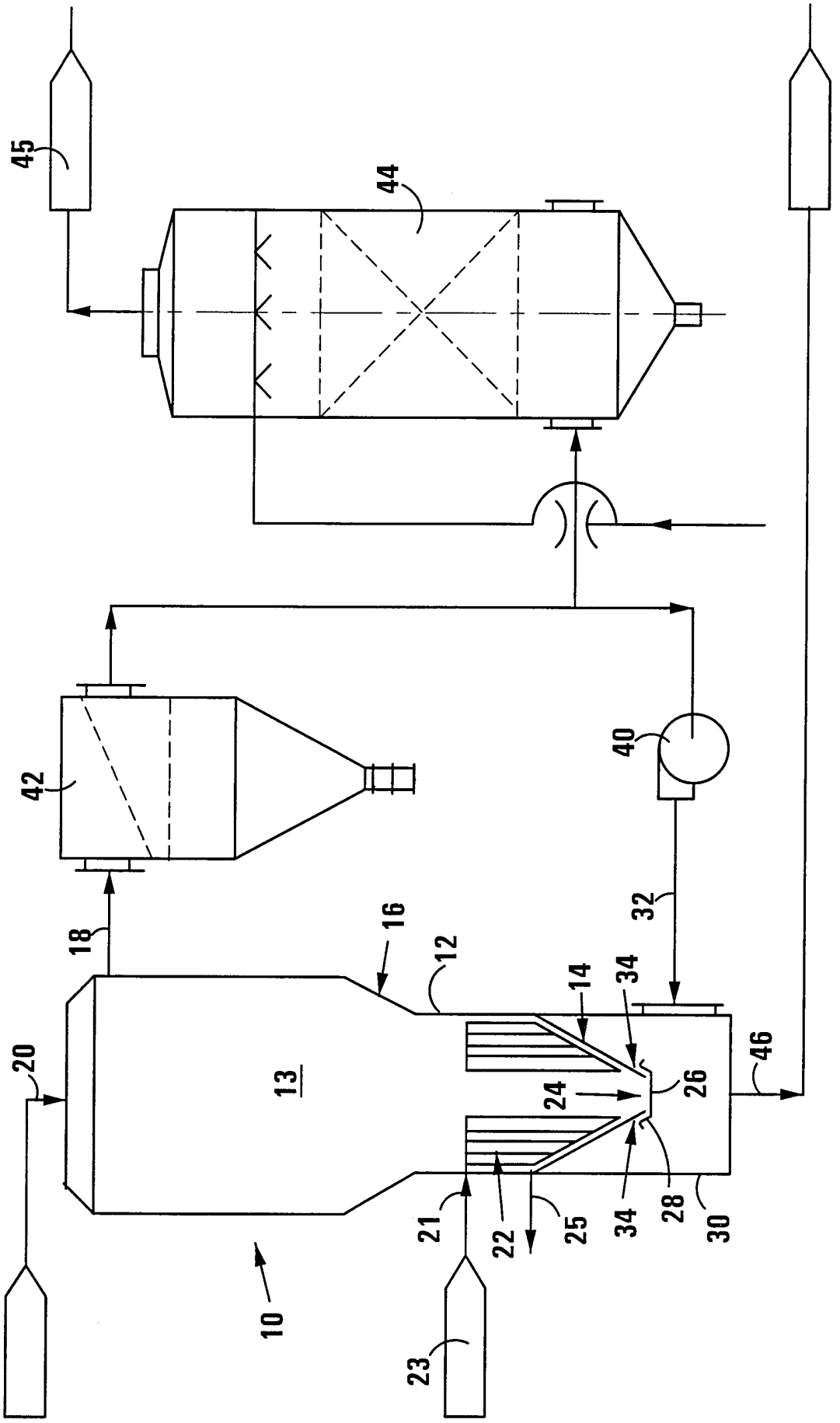
12. An apparatus as claimed in Claim 11, in which the gas displacement means is a fan-type gas displacement means.

13. An apparatus as claimed in Claim 11 or Claim 12, which includes a continuous gas flow line that incorporates the hollow body, the plenum chamber body and the gas displacement means and that provides for continuous gas circulation through the flow line.

14. An apparatus as claimed in Claim 13, in which the continuous gas flow line includes, in line therewith, a dust separator for separating impurities within heated gas circulating through the flow line, in use of the apparatus.

15. An apparatus as claimed Claim 13 or Claim 14, which includes a scrubber apparatus connected in line with a branch from the continuous gas flow line, the scrubber apparatus permitting cleaning of gases guided from the continuous gas flow line, before emission thereof to the atmosphere.

16. A spouting fluidized bed apparatus for drying particulate products substantially as described in the specification with reference to and as illustrated in the accompanying drawings.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# INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/IB 00/01648

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F26B3/084

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F26B

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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

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| Date of the actual completion of the international search | Date of mailing of the international search report |
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| 1 February 2001 | 07/02/2001 |

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

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