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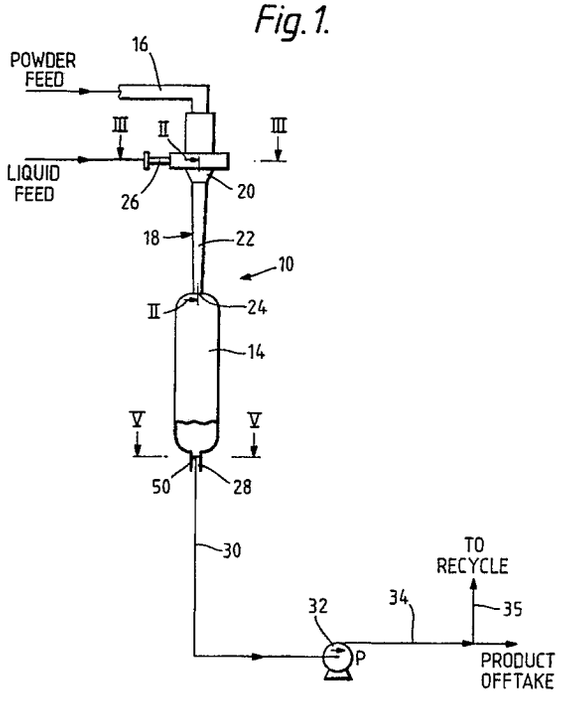
(54) A method of mixing a liquid and solids and apparatus therefor.

(57) In a method of mixing a liquid and solids, the solids are fed into the liquid whilst the liquid is swirling about the surface of a converging chamber (18). The chamber (18) is defined by at least two frusto-conical portions (20, 22) disposed one above the other. The upper portion 20 has a substantially larger included angle than that of the lower portion (22). Inlet nozzles (44) are supplied from an annular plenum 42 and are arranged tangentially with respect to the upper end of the chamber (18) so as to induce swirling of the liquid injected into the chamber (18). Mixed liquid and solids from the chamber (18) are arranged to discharge into a vessel (14) having a vortex breaker at its outlet.

Fig. 1.



EP 0 460 804 A1

This invention relates to a method and apparatus for mixing a liquid and solids and more particularly but not exclusively to the continuous mixing of a liquid and solids in powder form.

According to one aspect of the present invention, there is provided a method of mixing a liquid and solids, the method comprising feeding the solids into the liquid whilst the liquid is swirling about the surface of a chamber which is converging downwardly towards an outlet, the chamber comprising at least two frusto-conical portions thereof disposed one above the other, the upper said portion having a substantially larger included angle than that of the lower said portion.

According to a second aspect of the invention, there is provided apparatus for the mixing of a liquid and solids by the method of the first aspect of the invention, the apparatus comprising a chamber having a plurality of inlets for the liquid aligned so as to induce swirling of the liquid at an upper end of the chamber and an outlet at the lower end of the chamber, and means for feeding the solids into the upper end of the chamber, the chamber comprising at least two frusto-conical portions thereof disposed one above the other, the upper said portion having a substantially larger included angle than that of the lower said portion.

Preferably, the liquid flows in turbulent flow about the portions. Desirably, the included angles of the portions are such as to maintain the tangential component of flow of the liquid thereon above a predetermined velocity.

In one form of the invention, the solids may comprise powder having an average particle size between 5 and 500μm, for example micronised powder having an average particle size of between 5 and 10μm.

The invention will now be further described by way of example only and with reference to the accompanying drawings in which:

Figure 1 shows a schematic representation of a liquid/solids mixing apparatus;

Figure 2 shows to an enlarged scale a fragmentary portion of Figure 1;

Figure 3 shows to an enlarged scale a sectional view on the line III-III of Figure 1;

Figure 4 shows a sectional view on the line IV-IV of Figure 3, and

Figure 5 shows to an enlarged scale a fragmentary view on the line V-V of Figure 1.

Referring to Figure 1 a liquid/solids mixing apparatus 10 is shown and comprises an inlet head assembly 12, and a collecting vessel 14. A powder feed 16 is arranged to drop powder through the inlet head assembly 12 into a converging chamber 18. The chamber 18 as shown more clearly in Figure 2 has an upper frusto-conical portion 20 joined to a lower frusto-conical portion 22 having an outlet 24 to the collecting vessel 14. An inlet 26 for liquid discharges into the inlet head assembly 12. The collecting vessel 14 discharges through an outlet 28 into a pipeline 30 connected to a pump 32. The pump 32 has a product discharge line 34 with a branch line 35 for recycling, when desired, mixed liquid and solids to the chamber 18.

In more detail and referring now to Figures 3 and 4, the inlet head assembly 12 comprises parallel circular flanges 36, 38 respectively having between them a body member 40 defining an annular plenum chamber 42 into which the inlet 26 discharges. A plurality of nozzles 44 (ten are shown) from the plenum chamber 42 are aligned substantially tangentially to a cylindrical inlet chamber 46 to connect the plenum chamber 42 thereto. The upper portion 20 is joined to the flange 38 below the inlet chamber, and a tube 48 from the powder feed 16 (not shown in Figures 2 and 3) extends through the inlet chamber 46 to discharge into the upper portion 20. At the outlet 28 of Figure 1, a vortex breaker 50 as shown in Figure 5 eliminates air flow associated with swirling liquid, the vortex breaker 50 comprising a circular plate 52 having several (three are shown) holes 54 therethrough for liquid flow.

In operation, liquid is injected through the inlet 26 into the plenum chamber 42 and is discharged through the nozzles 44 into the inlet chamber 46 at an angle thereto so as to set up a swirling motion. From the inlet chamber 46 the liquid falls onto the upper portion 20, and because of the relatively large angle defined by the upper portion 20 the downward liquid flow is retarded which ensures that the entire surface of the upper portion 20 is wetted by the liquid. From the upper portion 20 the swirling liquid falls into the lower portion 22, and then whilst still swirling falls through the outlet 24 into the collecting vessel 14. Powder fed from the powder feed 16 and through the tube 48 falls onto the wetted surface of the upper portion 20 and the lower portion 22, where it is entrained in the liquid thereon. The effect of the angular shape of the upper portion 20 and the lower portion 22 is to overcome frictional effects and maintain the tangential component of flow of the liquid as it falls in the chamber 18. Hence the swirling motion of the liquid is maintained as it falls in the chamber 18 into the vessel 14. The mixed liquid/powder is then discharged through the outlet 28 and the pipe 30 to the pump 32.

The rate of flow of the liquid is arranged to ensure that there are no dry areas on the upper portion 20 and the lower portion 22 on which powder could collect. The flow is also arranged to be turbulent in the chamber 18 to enhance entrainment of the powder by the liquid. A typical liquid flow velocity of about 6.5 m/sec at a pressure of 3

x 10^5 Nm^2 has been suitable for some applications, in which the upper portion 20 defines an angle from the vertical of 30° (ie 60° included angle) and the lower portion 22 an angle from the vertical of between 7 to 10° (14°-20° included angle).

The liquid may be organic, for example an organic solvent, or aqueous, for example an acid or alkali solution. The powder may have an average particle size between 5 and 500μm, for example micronised powder having an average particle size of between 5 and 10 μm.

One advantage of the invention is that continuous mixing of the liquid and solids occurs, and the absence of dry areas on the mixing surfaces inhibits the local build-up of solids. If necessary the mixed liquid and solids may be recycled through the apparatus via the branch line 35. A conventional screw feeder device (not shown) may be used to feed powder to the powder feed 16.

EXAMPLES

EXAMPLE I

Mixing kieselguhr powder with water as follows:-

a) powder feed @ 90ℓ/hr ≡ 18kg/hr 420ℓ/hr water
b) as (a) but with 48ℓ/hr water
c) powder feed @ 200ℓ/hr ≡ 40kg/hr 420ℓ/hr water
d) as (c) but 195ℓ/hr water

EXAMPLE II

Pharmaceutical powders:

a) base powder at 22-44kg/hr organic solvent mix @ 120→240ℓ/hr
b) base powder @ 22-44kg/hr organic solvent @ 170→340ℓ/hr

EXAMPLE III

Flocculent Dispersal Aid:
granules @ 0.3 to 1.2kg/hr
water @ 195-390ℓ/hr

The liquids and solids of the above EXAMPLES were successfully mixed using the apparatus of Figures 1 to 5.

Claims

1. A method of mixing a liquid and solids, characterised by feeding the solids into the liquid whilst the liquid is swirling about the surface of a chamber (18) which is converging downwardly towards an outlet (24), the chamber (18) comprising at least two frusto-conical portions (20,22) thereof positioned one above the other, the upper said portion (20) having a substantially larger included angle than the included angle of the lower said portion (22).

2. A method as claimed in Claim 1, wherein the liquid flows in turbulent flow about the portions (20,22).

3. A method as claimed in Claim 1 or Claim 2, wherein the included angles of the portions (20,22) are such as to maintain the tangential component of flow of the liquid thereon above a predetermined velocity.

4. A method as claimed in Claim 3, wherein the liquid has a flow velocity of about 6.5m/sec.

5. A method as claimed in Claim 3, wherein the liquid is injected into the upper portion (20) at a pressure of about $3x10^5 Nm^2$.

6. A method as claimed in Claim 3, wherein the solids comprise powder having an average particle size of between 5 and 500μm.

7. A method as claimed in Claim 6, wherein the powder has an average particle size of between 5 and 10μm.

8. A method as claimed in Claim 6, wherein the solids comprise kieselguhr or a flocculent dispersal aid.

9. A method as claimed in Claim 8, wherein the liquid comprises water.

10. A method as claimed in anyone of Claims 1 to 7, wherein the solids comprise a pharmaceutical compound.

11. A method as claimed in Claim 10, wherein the liquid comprises an organic liquid.

12. A method as claimed in Claim 11, wherein the organic liquid has a flow rate between 170 and 340ℓ/hr.

13. A method as claimed in any one of the preceding Claims, wherein mixed liquid and solids from the outlet (24) are recycled through the chamber (18).

14. Apparatus for the mixing of a liquid and solids by the method as claimed in Claim 1, characterised by a chamber (18) having a plurality of inlets (44) for the liquid aligned so as to induce swirling of the liquid at an upper end of the

chamber (18) and an outlet (24) at the lower end of the chamber (18), and means (16,48) for feeding the solids into the upper end (46) of the chamber (18), the chamber (18) comprising at least two frusto-conical portions (20,22) thereof disposed one above the other, the upper said portion (20) having a substantially larger included angle than that of the lower said portion (22).

15. An apparatus as claimed in Claim 14, wherein the inlets (44) are arranged to be supplied from an annular plenum (42) defined about the chamber (18).

16. An apparatus as claimed in Claim 14 or Claim 15, wherein the outlet (24) is connectable to an inlet of a vessel (14) for collecting solids and liquid mixed in the chamber (18).

17. An apparatus as claimed in Claim 16, wherein a vortex breaking means (50) is disposed at an outlet (28) from the vessel (14).

18. An apparatus as claimed in any one of Claims 14 to 17, wherein the solids feeding means (48) extends to below the inlets (44) but terminates above the upper portion (20).

19. An apparatus as claimed in any one of Claims 14 to 18, wherein the upper portion (20) has an included angle of about 60° C.

20. An apparatus as claimed in any one of Claims 14 to 19, wherein the lower portion (22) has an included angle of between 14° and 20°.

21. An apparatus as claimed in any one of Claims 14 to 20, wherein the inlets (44) are aligned so as to be substantially tangential to the upper end (46) of the chamber (18).

22. An apparatus as claimed in any one of Claims 14 to 21, wherein pump means (32) are connectable with the vessel outlet (28) so as to extract mixed liquid and solids from the vessel (14).

23. Apparatus as claimed in Claim 22, wherein the pump means (32) is arranged to discharge through discharge duct means (34), and branch duct means (35) are connectable to the discharge duct means (34) for recycling mixed liquid and solids to the chamber (18).

Fig. 1.

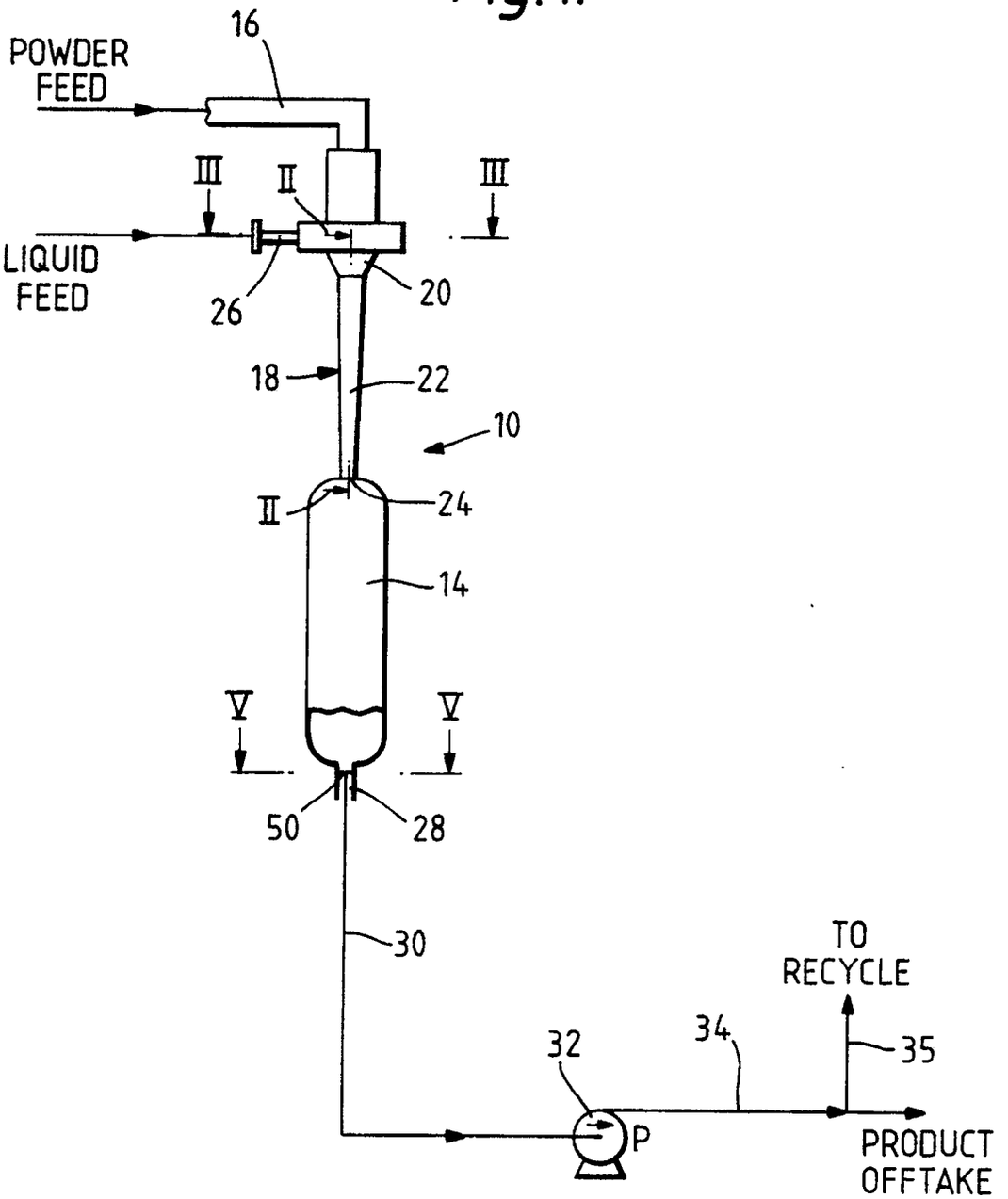

POWDER FEED
16
III
II
III
LIQUID FEED
26
20
18
22
10
II
24
14
V
V
50
28
30
TO RECYCLE
32
34
35
P
PRODUCT OFFTAKE

Fig.2.

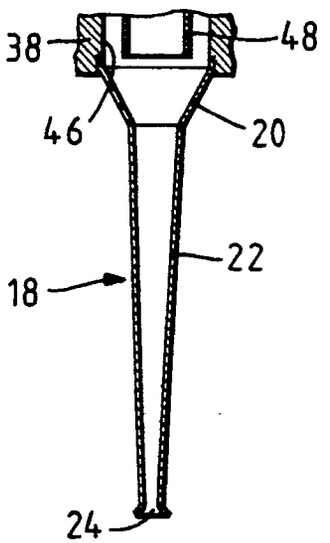


Fig.3.

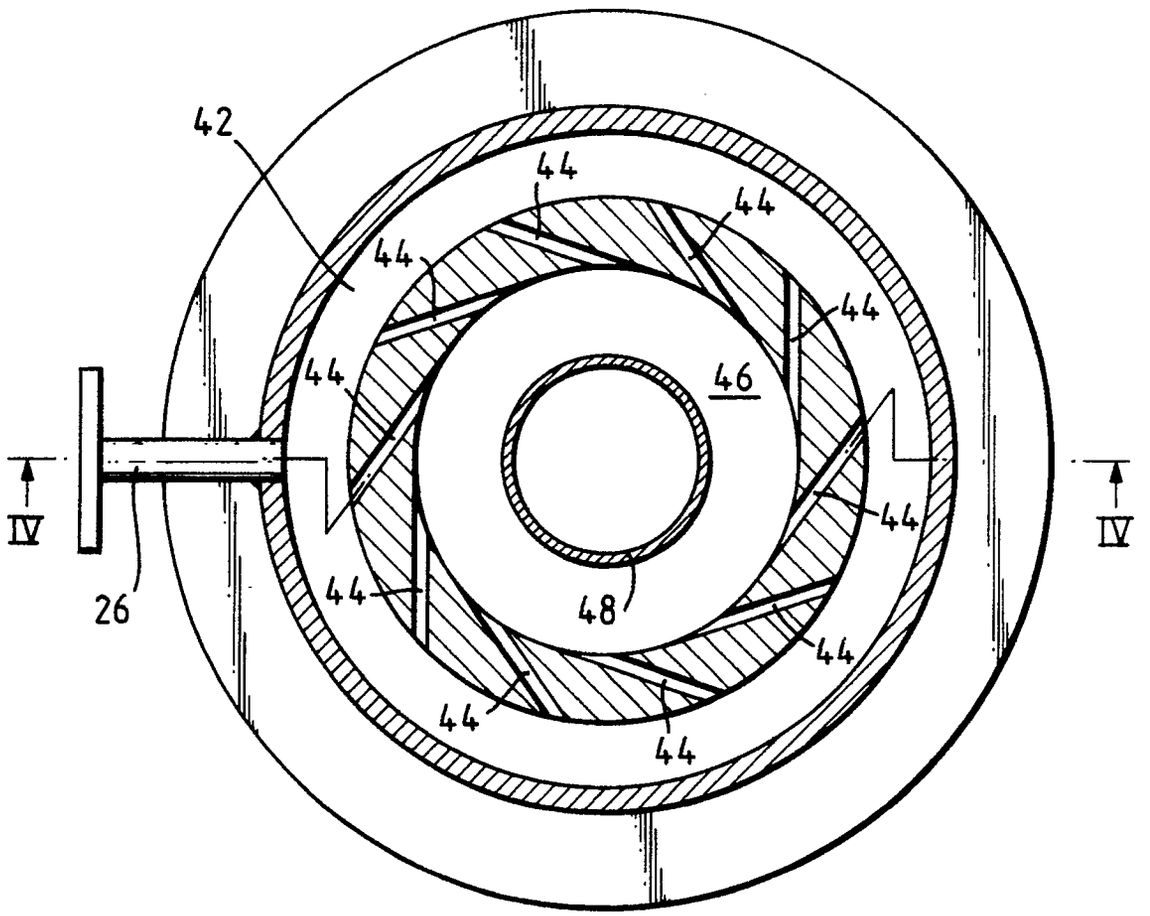


Fig.4.

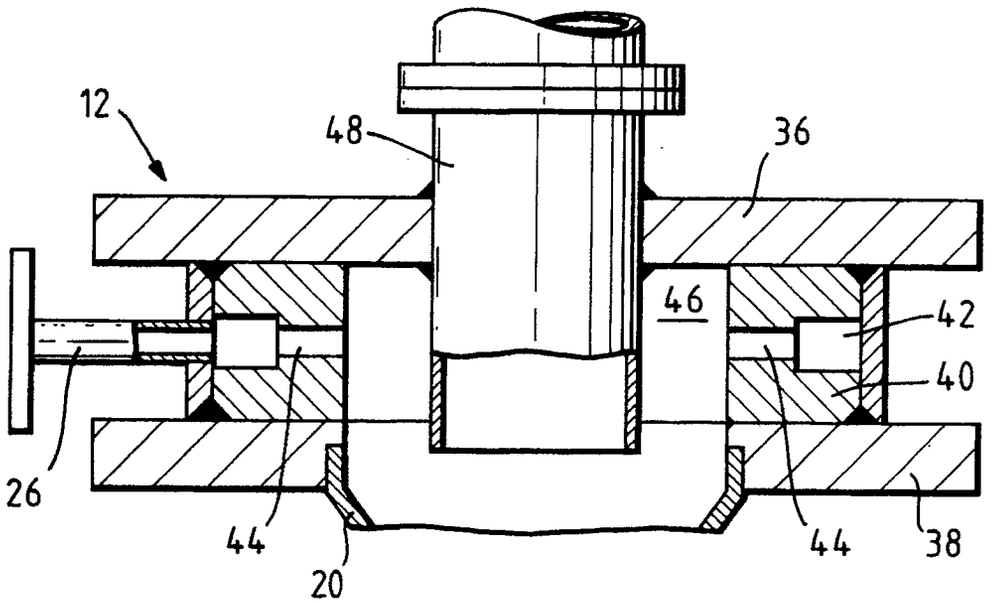
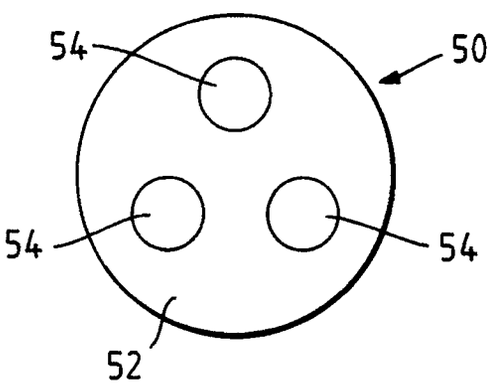


Fig.5.



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EUROPEAN SEARCH REPORT

Application Number

EP 91 30 3940

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.5)
X	EP-A-0 050 312 (HOECHST) * Whole document *	1-15, 17-22	B 01 F 5/00
A	GB-A-2 130 908 (CONOCO) * Abstract; fig. *	23	
A	US-A-3 741 533 (WINN)		
A	FR-A-2 307 570 (ANLIKER)		
A	GB-A-1 290 486 (FOSECO)		
A	US-A-4 053 142 (JOHANNES)		
A	US-A-2 653 801 (FONTEIN)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B 01 F

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	26 August 91	PEETERS S.

CATEGORY OF CITED DOCUMENTS

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