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[US/US]; 8008 Pineville Circle, Castro Valley, CA 94552 (US).

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(74) Agents: HADLOCK, Timothy, J. et al.; ChevronTexaco Corporation, Law Department, P.O. Box 6006, San Ramon, CA 94583-0806 (US).

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(71) Applicant (for all designated States except US):
CHEVRON U.S.A. INC. [US/US]; 6001 Bollinger Canyon Road, 3rd Floor, San Ramon, CA 94583 (US).

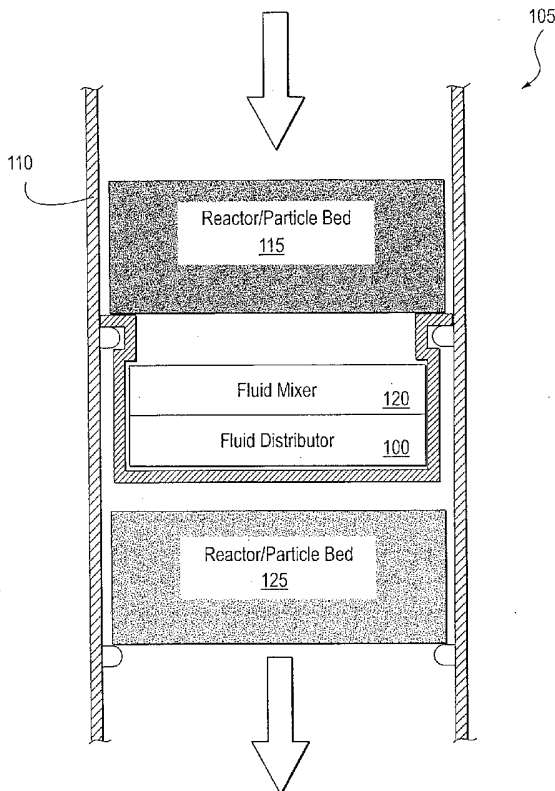
(72) Inventors; and

(75) Inventors/Applicants (for US only): KEMOUN, Abdenour [US/US]; 455 Viking Drive, Pleasant Hill, CA 94523 (US). PARIMI, Krishniah [US/US]; 4460 Shellflower Court, Concord, CA 94547 (US). NGUYEN, Duyen, T.

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(54) Title: FLUID DISTRIBUTION APPARATUS FOR DOWNFLOW MULTIBED POLY-PHASE CATALYTIC REACTOR



(57) Abstract: The invention in one embodiment is a nozzle device for coupling with a fluid distribution conduit for improving the distribution of an upward or downwardly flowing poly-phase mixture including at least one gas phase and at least one liquid phase, above at least one packed bed of granular solid or fluidized bed. The fluid distribution conduit for receiving liquid and gas phases has one or more lateral openings for flow over an upper portion of its height through which a gas phase can enter and has fluid distribution conduit having one or more lateral openings for flow over at least a lower portion of its height through which a liquid phase can enter the fluid distribution conduit. It also has at least one lower cross section for flow through which a mixture of gas and liquid communicate with a packed bed of granular solid or a fluidized bed. The nozzle device includes a venturi nozzle having an outer diameter not greater than an inner diameter of the lower cross section of the fluid distribution conduit, wherein the nozzle device may be fixedly coupled to and co-axially aligned with the lower cross section of the fluid distribution conduit. It is for accelerating and dispersing the liquid and gas phases passing out of the conduit.

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1 **FLUID DISTRIBUTION APPARATUS FOR DOWNFLOW**
2 **MULTIBED POLY-PHASE CATALYTIC REACTOR**

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12 II. FIELD OF THE INVENTION

13 This invention relates to a fluid distributor assembly for multi-bed, down-flow
14 or up-flow catalytic reactors, that is, reactors which include vertically
15 superimposed packed or fluidized beds of particulate catalytic material and
16 where a liquid or liquid and gas mixture is processed as it flows up or down
17 through the packed or fluidized beds. This type of reactor is used in the
18 petroleum and chemical processing industries for carrying out various
19 catalytic reactions, such as hydrotreating, hydrofinishing, hydrocracking, and
20 dewaxing

21 III. BACKGROUND OF THE INVENTION

22 Many catalytic processes are carried out in reactors that contain a series of
23 separate catalytic beds. Reactors used in the chemical, petroleum refining
24 and other industries for passing liquids or mixed-phase liquid/vapor mixtures
25 over packed beds of particular solids are employed for a variety of different
26 processes. Typical of such processes in the petroleum refining industry are
27 catalytic dewaxing, hydrotreating, hydrodesulfurisation, hydrofinishing and

1 hydrocracking. In these processes a liquid phase is typically mixed with a gas
2 or vapor phase and the mixture passed over a particulate catalyst maintained
3 in a packed bed in a downflow reactor.

4 Uniform distribution of liquid/vapor flow to a catalyst bed is an important
5 consideration in assuring efficient utilization of a catalyst. Efficient catalyst use
6 will result in improved yields and product qualities, increased run lengths, and,
7 if desired, increased throughput through the unit. Uniform flow distribution is
8 also a necessary condition to avoid temperature mal-distribution and hot spots
9 in a reactor.

10 Typically, mixing devices, e.g., as disclosed in U.S. Patent No. 6,183,702, are
11 located above an associated fluid distribution system; for example, a
12 horizontally disposed distribution plate or tray. Many different types of fluid
13 distribution systems are known. Some are simple and comprise little more
14 than a pierced or slotted plate. The distribution plate collects the fluid (vapor
15 and liquid), uniformly distributes it across the plate and discharges the fluid on
16 to the catalyst bed. Other types of fluid distribution systems contain a number
17 of downcomers, e.g., "bubble cap" or "chimney" assemblies, which may be
18 disposed over one or more openings in the distribution plate. The bubble cap
19 or chimney provides intimate mixing of the vapor and liquid before the mixed
20 phase fluid is distributed across the catalyst bed below. Deficiencies in
21 existing fluid distribution systems require a large number of slots, bubble
22 caps, or chimneys, which increases cost and complexity and creates more
23 possibility of clogging or other types of failure.

24 A good flow distribution device should meet the following four basic
25 requirements: provide even distribution of feed to a catalyst bed over a range
26 of gas and liquid rates; be tolerant to certain out-of-levelness of the
27 distribution tray; provide good gas-liquid mixing and heat exchange, and
28 require minimum catalyst bed height to reach equilibrated flow distribution.
29 Other considerations are that they require minimum height to conserve
30 reactor space and are easy to maintain.

1 One of the key considerations in flow distributor design is the discharge
2 pattern of liquid and gas from the device. A standard chimney distributor
3 provides only some point contacts of liquid with the catalyst bed. It takes a
4 finite bed height to adequately wet the catalyst surface and the reactions to
5 occur.

6 Bubble cap distributors usually give a mix of some liquid draining along the
7 riser wall, some liquid coming out as a spray and a few droplets occasionally
8 dropping from the center of the riser. In general, we have been satisfied with
9 this pattern of gas and liquid coming out of the riser in a bubble cap
10 distributor. Such a pattern can uniformly wet the catalyst surface directly
11 underneath the distributor. The catalyst bed depth needed for a complete
12 equilibrated flow distribution and catalyst wetting may still be several inches,
13 depending on how consistent and how divergent a spray that is achieved
14 through the flow distributor.

15 A more uniform and consistent spray pattern and more uniform catalyst
16 wetting in a short length of catalyst bed are desired, and the proposed new
17 design achieves this objective. The new design also satisfies the other
18 requirements as stated earlier.

19 IV. BRIEF DESCRIPTION OF THE DRAWINGS

20 FIG. 1 is a schematic, perspective side cut-away view of showing the
21 distributor assembly in the context of a reactor vessel according to the present
22 invention.

23 FIG. 2 is a schematic, perspective side cut-away view of another preferred
24 embodiment of the distributor assembly according to the present invention
25 having slotted passageways for both liquid and gas, a cylindrical passageway
26 for gas connected to the slotted passageway for gas, and having the outlet of
27 the cylindrical passageway for the gas extending below the slotted
28 passageways for the liquid and forming an annual passageway for the liquid.

1 FIG. 3 is a schematic, perspective side cut-away view of another preferred
2 embodiment of the distributor assembly according to the present invention
3 having slotted passageways for gas connected to a cylindrical passageway
4 for gas and having only an annular passageway for liquid.

5 FIG. 4 is similar to FIG. 2 but includes an integral cap above the slotted
6 passageways for gas, wherein in use the gas must enter the cap before
7 entering the cylindrical passageway for gas.

8 FIG. 5 is similar to FIGS. 2 and 4 but does not include an integral cap and
9 does not have an annular passageway for liquid connected to the slotted
10 passageways for liquid.

11 FIG. 6 is a cut-away view of the embodiment of FIG. 5.

12 FIG. 7 is a schematic, perspective side cut-away view of another embodiment
13 of the distributor assembly according to the present invention having slotted
14 and cylindrical passageways for gas and liquid.

15 FIG. 8 is a schematic, perspective side cut-away view of a lower portion of the
16 embodiment of FIG. 7 showing the gas/liquid outlet.

17 FIG. 9 is a schematic, isometric, perspective view depicting one embodiment
18 of a plurality of the distributor assemblies arrayed on a plate and configured
19 for placement in a reactor vessel.

20 FIGS. 10 and 11 are photographs taken during tests carried out on an
21 experimental model in accordance with one embodiment of the invention
22 showing the improved performance of the invention in performing liquid
23 distributions from the distributor assembly.

24 V. SUMMARY OF THE INVENTION

25 The invention includes a distributor device for distributing a downwardly
26 flowing poly-phase mixture, including at least one gas phase and at least one
27 liquid phase, above at least one bed of granular solid, the device including: at

1 least one tray located above a bed of granular solid; a plurality of fluid
2 distribution conduits for receiving liquid and gas phases, each of the conduits
3 including at least one upper cross section for flow through which a gas phase
4 can enter the mixer conduit, and at least one lower cross section for flow
5 through which a mixture of gas and liquid communicate with a bed of granular
6 solid, the fluid distribution conduits having one or more lateral openings for
7 flow over at least a portion of their height through which a liquid phase can
8 enter the fluid distribution conduit; the upper cross section for flow allowing
9 the majority of the gas phase of the mixture to pass and the lateral openings
10 for flow allowing the passage of the liquid phase into the fluid distribution
11 conduits and at least a portion of the gas phase; and a venturi nozzle having
12 an inlet and an outlet fixedly coupled to and co-axially aligned with the lower
13 cross section of the conduit for accelerating and dispersing the liquid and gas
14 phases passing out of the conduit.

15 In an alternate embodiment, the invention includes a distributor device for
16 distributing a downwardly flowing poly-phase mixture, including at least one
17 gas phase and at least one liquid phase, above at least one bed of granular
18 solid, the device including: a fluid distribution conduit for receiving liquid and
19 gas phases, the fluid distribution conduit having one or more lateral openings
20 for flow over an upper portion of its height through which a gas phase can
21 enter the fluid distribution conduit; the fluid distribution conduit having one or
22 more lateral openings for flow over at least a lower portion of its height
23 through which a liquid phase can enter the fluid distribution conduit; and at
24 least one lower cross section for flow through which a mixture of gas and
25 liquid communicate with a bed of granular solid, the lateral openings over an
26 upper portion of its height for allowing the majority of the gas phase of the
27 mixture to pass and the lateral openings over a lower portion of its height for
28 allowing the passage of the liquid phase into the fluid distribution conduits;
29 and a venturi nozzle having an inlet and an outlet fixedly coupled and
30 co-axially aligned to the lower cross section of the conduit for accelerating and
31 dispersing the liquid and gas phases passing out of the conduit.

1 In another alternate embodiment, the invention includes a distributor device
2 for distributing a downwardly flowing poly-phase mixture, including at least
3 one gas phase and at least one liquid phase, above at least one bed of
4 granular solid, the device including: a fluid distribution conduit for receiving
5 liquid and gas phases, the conduit including at least one upper cross section
6 for flow through which a gas phase can enter the mixer conduit, and at least
7 one lower cross section for flow through which a mixture of gas and liquid
8 communicate with a bed of granular solid, the fluid distribution conduit having
9 one or more lateral openings for flow over at least a portion of its height
10 through which a liquid phase can enter the fluid distribution conduit; the upper
11 cross section for flow allowing the majority of the gas phase of the mixture to
12 pass and the lateral openings for flow allowing the passage of the liquid phase
13 into the fluid distribution conduit and at least a portion of the gas phase; and a
14 venturi nozzle having an inlet and an outlet fixedly coupled to and co-axially
15 aligned with the lower cross section of the conduit for accelerating and
16 dispersing the liquid and gas phases passing out of the conduit.

17 In an alternate embodiment, the invention includes a nozzle device for
18 coupling with a fluid distribution conduit for improving the distribution of a
19 downwardly flowing poly-phase mixture, optionally including at least one gas
20 phase and at least one liquid phase, above at least one bed of granular solid.
21 The fluid distribution conduit for receiving liquid and gas phases has one or
22 more lateral openings for flow over an upper portion of its height through
23 which a gas phase can enter and has fluid distribution conduit having one or
24 more lateral openings for flow over at least a lower portion of its height
25 through which a liquid phase can enter the fluid distribution conduit. It also
26 has at least one lower cross section for flow through which a mixture of gas
27 and liquid communicate with a bed of granular solid. The nozzle device
28 includes a venturi nozzle having an inlet and an outlet, the nozzle having an
29 outer diameter not greater than an inner diameter of the lower cross section of
30 the fluid distribution conduit, wherein the nozzle device may be fixedly
31 coupled to and co-axially aligned with the lower cross section of the fluid

1 distribution conduit. It is for accelerating and dispersing the liquid and gas
2 phases passing out of the conduit.

3 In an alternate embodiment, the invention includes a nozzle device for
4 coupling with a fluid distribution conduit for improving the distribution of a
5 upwardly flowing poly-phase mixture, including at least one gas phase and at
6 least one liquid phase, where the fluid distribution conduit for receiving liquid
7 and gas phases has one or more openings for flow of the poly-phase mixture;
8 said nozzle device comprising a venturi nozzle having an inlet and an outlet,
9 the nozzle having an outer diameter not greater than an inner diameter of the
10 upper cross section of the fluid distribution conduit, wherein the nozzle device
11 may be fixedly coupled to and co-axially aligned with the upper cross section
12 of the fluid distribution conduit for accelerating and dispersing the liquid and
13 gas phases passing out of the conduit.

14 These and other features and advantages of the present invention will be
15 made more apparent through a consideration of the following detailed
16 description of preferred embodiments of the invention. In the course of this
17 description, frequent reference will be made to the attached drawings.

18 VI. DETAILED DESCRIPTION OF THE DRAWINGS
19 AND PREFERRED EMBODIMENTS

20 FIG. 1 is a schematic, perspective side cut-away view showing the fluid
21 distributor assembly according to the present invention in the context of a
22 reactor vessel. The reactor vessel 105 has a cylindrical reactor wall 110.
23 Reactor vessel 105 is configured for supporting fluid mixer 120 and catalyst
24 beds 115-125 containing packed particulate catalytic material (not shown) in
25 vertically superimposed relation to each other to permit liquid and gas to flow
26 from a higher catalyst bed 115 to a lower catalyst bed 125.

27 Fluid distributor assembly 100 is optionally supported in a "basket" hanging
28 from and below a suitable mounting means. Lower catalyst bed 125 is below
29 the distributor assembly 100. The fluid distributor assembly 100 of the present

1 invention is mounted to the reactor wall 110 to receive liquid and gas flowing
2 down from fluid mixer 120 and to distribute the liquid and gas to catalyst bed
3 125.

4 FIGS. 2 and 3 show two different preferred embodiments of the invention.
5 FIG. 2 is a schematic, perspective side cut-away view of another preferred
6 embodiment of the distributor assembly 200 according to the present
7 invention having slotted passageways 210 and 215 for both liquid and gas, a
8 cylindrical passageway 220 for gas connected to the slotted passageway for
9 gas 210, and having the outlet of the cylindrical passageway for the gas
10 extending below the slotted passageways 215 for the liquid and forming an
11 annular passageway for the liquid. In this design, gas and liquid enter the
12 distributor separately and are made to intimately mix as they exit the device.

13 The gas enters the inner pipe through small holes 210 located near the top
14 225. The holes will be sized to result in a high gas velocity through the inner
15 pipe. The liquid phase enters the annular area between the two concentric
16 pipes, 205 and 220, through holes 215 located near the middle of the riser
17 below the expected liquid level. The liquid flows by the pressure differential
18 exerted on the liquid phase. The hydrostatic head plays a lesser role in
19 determining the liquid flow from an individual device. The liquid port 215
20 converges somewhat at the outlet to allow the liquid flow directly into the high
21 velocity gas exiting the inner pipe 220 below the distributor tray. The liquid
22 and gas pass through a converging/diverging, i.e., Venturi, nozzle 230. It
23 produces a greater dispersion of liquid and a greater degree of gas-liquid
24 mixing and heat exchange. As used in this specification and accompanying
25 claims "venturi" or "venturi nozzle" means a system for speeding the flow of a
26 fluid by constricting its flow in a cone-shaped conduit. The scientific principle
27 underlying the system is a fluid passing through smoothly varying
28 constrictions experience changes in velocity and pressure, as described by
29 Bernoulli's principle. Preferably, the venturi nozzle is made of two truncated
30 cone-shaped conduits, where the truncation is at the "top", i.e., narrow end, of
31 the cone-shaped conduits, and the two truncated cone-shaped conduits are

1 fixedly connected co-axially at the truncated tops. Such a system may also be
2 manufactured in various conventional ways, e.g., cut/machined from a single
3 piece of metal or forged from molten metal or other material.

4 The design will make the flow distribution less sensitive to out-of-levelness of
5 the distributor tray and to variations in flow rates. The design also facilitates
6 gas-liquid mixing and heat exchange. Other advantages are its simplicity,
7 compactness and easy adaptation to achieve smaller spacing between
8 distributors. With no caps, the tray will be easier to maintain. Another potential
9 advantage is that the perforated tray can be simplified further and designed
10 for a much lower pressure drop, or even be completely eliminated.

11 FIG. 3 depicts is a schematic, perspective side cut-away view of another
12 preferred embodiment 300 of the distributor assembly according to the
13 present invention having slotted passageways 210 for gas connected to a
14 cylindrical passageway for gas and having only an annular passageway for
15 liquid 315. The high velocity gas has an aspirating effect on the liquid flow.
16 The liquid port is an annular passage formed by the interior of wall 310 and
17 the exterior of wall 305. The embodiment has a diverging nozzle 230 at the
18 bottom. In both of these embodiments in FIGS. 2 and 3, a small baffle plate
19 (not shown) at the bottom of the riser can be added for further dispersion of
20 the spray.

21 FIG. 4 is similar to FIG. 2 but includes an integral cap 405 above the slotted
22 passageways 210 for gas, wherein in use the gas must enter the cap 405
23 before entering the cylindrical passageway 210 for gas.

24 FIG. 5 is similar to FIGS. 2 and 4 but does not include an integral cap 405 and
25 does not have an annular passageway for liquid connected to the slotted
26 passageways 215 for liquid.

27 FIG. 6 is a cut-away view of the embodiment of FIG. 5.

1 FIG. 7 is a schematic, perspective side cut-away view of another embodiment
2 900 of the distributor assembly according to the present invention having a
3 conventional riser with a slotted passageways 915 gas and liquid and a
4 cylindrical passageway 920 for gas with a retrofitted venturi nozzle/outlet 230
5 and sleeve 235.

6 FIG. 8 is a schematic, perspective side cut-away view of a lower portion of the
7 embodiment 900 of FIG. 7 showing the gas/liquid venturi-shaped outlet 230
8 and sleeve portion 235 forming an integral assembly 1000. This assembly
9 1000 is preferably adapted and configured for retrofitting conventional risers
10 by sliding the sleeve into the conventional riser outlet and attaching by any
11 conventional means. Integral assembly 1000, and other embodiments
12 thereof, can be installed in any conventional riser, whether a chimney-type
13 riser as shown in FIG. 7 or a bubble cap distributor (not shown) and any other
14 existing flow distributor for, e.g., hydro-processing reactors. Integral assembly
15 1000 can also be used in up flow reactor to provide uniform two and
16 multiphase flow distribution.

17 Thus, integral assembly 1000 may be fixedly coupled to and co-axially aligned
18 with the upper cross section of a fluid distribution conduit for accelerating and
19 dispersing the liquid and gas phases passing out of the conduit. The fluid
20 distribution conduits are preferably adapted and configured to produce a fluid
21 spray pattern wherein the ratio of the diameter of the fluid spray pattern to the
22 diameter of the widest point of the venturi nozzle is from about 1:1 to about
23 10:1 and more preferably from about 3:1 to about 7:1.

24 FIG. 9 is a schematic, isometric, perspective view depicting one embodiment
25 100 (see FIG. 1) of a plurality of the distributor assemblies 900 arrayed on a
26 plate 1105 and configured for placement in a reactor vessel (shown in FIG. 1).
27 The fluid distribution conduits are spaced from about 5 inches to about 7
28 inches apart.

29 FIGS. 10 and 11 are photographs taken during tests carried out on an
30 experimental model in accordance with one embodiment of the invention

1 showing the good performance of the invention in performing liquid
2 distributions from the distributor assembly. In contrast, known risers or
3 downcomers, such as shown, e.g., in FIG. 7, but without the venturi nozzle
4 and sleeve assembly of the invention shown in one embodiment in FIG. 8,
5 have poor distribution patterns. In some case such known risers/chimneys
6 only distribute two liquid streamlines coming out the chimney.

7 Each venturi nozzle has a diameter at its widest point of from about $\frac{1}{2}$ inch to
8 about 4 inches, preferably from about 1 inch to about 2 inches. Each venturi
9 nozzle has a diameter at its narrowest point of from about $\frac{1}{4}$ inch to about
10 2 inches, preferably of from about $\frac{1}{2}$ inch to about 1 inch.

11 The distributor device optionally includes a plate attached below the outlet of
12 the venturi nozzle. It's positioned about 2 inches to about 10 inches,
13 preferably from about 3 inches to about 5 inches, above the bed of granular
14 solid. It is for enhancing dispersion of the fluid stream by providing a strike
15 point for a portion of the fluid which will result in splattering into droplets. The
16 optional plate is positioned from about 2 inches to about 10 inches below the
17 outlet of the venturi nozzle and preferably from about 2 inches to about
18 4 inches. The plate is optionally fixedly or removably attached to a bottom
19 portion of the distribution plate or a bottom portion of the fluid distribution
20 column or the venturi nozzle.

21 Other embodiments of the present invention and its individual components will
22 become readily apparent to those skilled in the art from the foregoing detailed
23 description. As will be realized, the invention is capable of other and different
24 embodiments, and its several details are capable of modifications in various
25 obvious respects, all without departing from the spirit and the scope of the
26 present invention. Accordingly, the drawings and detailed description are to
27 be regarded as illustrative in nature and not as restrictive. It is therefore not
28 intended that the invention be limited except as indicated by the appended
29 claims.

1 WHAT IS CLAIMED IS:

- 2 1. A distributor device for distributing a downwardly flowing poly-phase
3 mixture, comprising at least one gas phase and at least one liquid
4 phase, above at least one bed of granular solid, said device
5 comprising:
- 6 a. at least one tray located above a bed of granular solid;
- 7 b. a plurality of fluid distribution conduits for receiving liquid and
8 gas phases, each of said conduits comprising at least one upper
9 cross section for flow through which a gas phase can enter said
10 mixer conduit, and at least one lower cross section for flow
11 through which a mixture of gas and liquid communicate with a
12 bed of granular solid, said fluid distribution conduits having one
13 or more lateral openings for flow over at least a portion of their
14 height through which a liquid phase can enter said fluid
15 distribution conduit;
- 16 c. said upper cross section for flow allowing the majority of the gas
17 phase of said mixture to pass and said lateral openings for flow
18 allowing the passage of the liquid phase into said fluid
19 distribution conduits and at least a portion of the gas phase; and
- 20 d. a venturi nozzle having an inlet and an outlet fixedly coupled to
21 and co-axially aligned with the lower cross section of the conduit
22 for accelerating and dispersing the liquid and gas phases
23 passing out of the conduit.
- 24 2. The distributor device of claim 1, wherein the fluid distribution conduits
25 are spaced from about 2 inches to about 10 inches apart.
- 26 3. The distributor device of claim 1, wherein the fluid distribution conduits
27 are spaced from about 5 inches to about 7 inches apart.

- 1 4. The distributor device of claim 1, further comprising a plate attached
2 below the outlet of the venturi nozzle and from about 2 inches to about
3 10 inches above the bed of granular solid for enhancing dispersion of
4 the fluid stream.
- 5 5. The distributor device of claim 1, further comprising a plate attached
6 below the outlet of the venturi nozzle and from about 3 inches to about
7 5 inches above the bed of granular solid for enhancing dispersion of
8 the fluid stream.
- 9 6. The distributor device of claim 4, wherein the plate is from about
10 2 inches to about 10 inches below the outlet of the venturi nozzle.
- 11 7. The distributor device of claim 4, wherein the plate is from about
12 2 inches to about 4 inches below the outlet of the venturi nozzle.
- 13 8. The distributor device of claim 1, wherein each venturi nozzle has a
14 diameter at its widest point of from about $\frac{1}{2}$ inch to about 4 inches.
- 15 9. The distributor device of claim 1, wherein each venturi nozzle has a
16 diameter at its widest point of from about 1 inch to about 2 inches.
- 17 10. The distributor device of claim 1, wherein the venturi nozzles have a
18 diameter at its narrowest point of from about $\frac{1}{4}$ inch to about 2 inches.
- 19 11. The distributor device of claim 1, wherein the venturi nozzles have a
20 diameter at its narrowest point of from about $\frac{1}{2}$ inch to about 1 inch.
- 21 12. The distributor device of claim 1, wherein the fluid distribution conduits
22 are adapted and configured to produce a fluid spray pattern wherein
23 the ratio of the diameter of the fluid spray pattern to the diameter of the
24 widest point of the venturi nozzle is from about 1:1 to about 10:1.
- 25 13. The distributor device of claim 1, wherein the fluid distribution conduits
26 are adapted and configured to produce a fluid spray pattern wherein

- 1 the ratio of the diameter of the fluid spray pattern to the diameter of the
2 widest point of the venturi nozzle is from about 3:1 to about 7:1.
- 3 14. A distributor device for distributing a downwardly flowing poly-phase
4 mixture, comprising at least one gas phase and at least one liquid
5 phase, above at least one bed of granular solid, said device
6 comprising:
- 7 a. a fluid distribution conduit for receiving liquid and gas phases,
8 said fluid distribution conduit having one or more lateral
9 openings for flow over an upper portion of its height through
10 which a gas phase can enter said fluid distribution conduit; said
11 fluid distribution conduit having one or more lateral openings for
12 flow over at least a lower portion of its height through which a
13 liquid phase can enter said fluid distribution conduit; and at least
14 one lower cross section for flow through which a mixture of gas
15 and liquid communicate with a bed of granular solid,
- 16 b. said lateral openings over an upper portion of its height for
17 allowing the majority of the gas phase of said mixture to pass
18 and said lateral openings over a lower portion of its height for
19 allowing the passage of the liquid phase into said fluid
20 distribution conduits; and
- 21 c. a venturi nozzle having an inlet and an outlet fixedly coupled
22 and co-axially aligned to the lower cross section of the conduit
23 for accelerating and dispersing the liquid and gas phases
24 passing out of the conduit.
- 25 15. The distributor device of claim 14, further comprising a plate attached
26 below the outlet of the venturi nozzle and from about 3 inches to about
27 5 inches above the bed of granular solid for enhancing dispersion of
28 the fluid stream.

- 1 16. The distributor device of claim 15, wherein the plate is from about
2 2 inches to about 4 inches below the outlet of the venturi nozzle.
- 3 17. The distributor device of claim 14, wherein the venturi nozzle has a
4 diameter at its widest point of from about 1 inch to about 2 inches.
- 5 18. The distributor device of claim 14, wherein the venturi nozzles have a
6 diameter at its narrowest point of from about ½ inch to about 1 inch.
- 7 19. The distributor device of claim 14, wherein the fluid distribution
8 conduits are adapted and configured to produce a fluid spray pattern
9 wherein the ratio of the diameter of the fluid spray pattern to the
10 diameter of the widest point of the venturi nozzle is from about 3:1 to
11 about 7:1.
- 12 20. A distributor device for distributing a downwardly flowing poly-phase
13 mixture, comprising at least one gas phase and at least one liquid
14 phase, above at least one bed of granular solid, said device
15 comprising:
- 16 a. a fluid distribution conduit for receiving liquid and gas phases,
17 said conduit comprising at least one upper cross section for flow
18 through which a gas phase can enter said mixer conduit, and at
19 least one lower cross section for flow through which a mixture of
20 gas and liquid communicate with a bed of granular solid, said
21 fluid distribution conduit having one or more lateral openings for
22 flow over at least a portion of its height through which a liquid
23 phase can enter said fluid distribution conduit;
- 24 b. said upper cross section for flow allowing the majority of the gas
25 phase of said mixture to pass and said lateral openings for flow
26 allowing the passage of the liquid phase into said fluid
27 distribution conduit and at least a portion of the gas phase; and

- 1 c. a venturi nozzle having an inlet and an outlet fixedly coupled to
2 and co-axially aligned with the lower cross section of the conduit
3 for accelerating and dispersing the liquid and gas phases
4 passing out of the conduit.
- 5 21. The distributor device of claim 20, further comprising a plate attached
6 below the outlet of the venturi nozzle and from about 3 inches to about
7 5 inches above the bed of granular solid for enhancing dispersion of
8 the fluid stream.
- 9 22. The distributor device of claim 21, wherein the plate is from about
10 2 inches to about 4 inches below the outlet of the venturi nozzle.
- 11 23. The distributor device of claim 20, wherein the venturi nozzle has a
12 diameter at its widest point of from about 1 inch to about 2 inches.
- 13 24. The distributor device of claim 20, wherein the venturi nozzles have a
14 diameter at its narrowest point of from about ½ inch to about 1 inch.
- 15 25. The distributor device of claim 20, wherein the fluid distribution
16 conduits are adapted and configured to produce a fluid spray pattern
17 wherein the ratio of the diameter of the fluid spray pattern to the
18 diameter of the widest point of the venturi nozzle is from about 3:1 to
19 about 7:1.
- 20 26. A nozzle device for coupling with a fluid distribution conduit for
21 improving the distribution of a downwardly flowing poly-phase mixture,
22 comprising at least one gas phase and at least one liquid phase, above
23 at least one bed of granular solid, where the fluid distribution conduit
24 for receiving liquid and gas phases has one or more lateral openings
25 for flow over an upper portion of its height through which a gas phase
26 can enter and has fluid distribution conduit having one or more lateral
27 openings for flow over at least a lower portion of its height through
28 which a liquid phase can enter said fluid distribution conduit; and at

1 least one lower cross section for flow through which a mixture of gas
2 and liquid communicate with a bed of granular solid; said nozzle device
3 comprising a venturi nozzle having an outer diameter not greater than
4 an inner diameter of the lower cross section of the fluid distribution
5 conduit, wherein the nozzle device may be fixedly coupled to and co-
6 axially aligned with the lower cross section of the fluid distribution
7 conduit for accelerating and dispersing the liquid and gas phases
8 passing out of the conduit.

9 27. The nozzle device of claim 26, wherein the venturi nozzle has a
10 diameter at its widest point of from about 1 inch to about 2 inches.

11 28. The nozzle device of claim 26, wherein the venturi nozzles have a
12 diameter at its narrowest point of from about ½ inch to about 1 inch.

13 29. The nozzle device of claim 26, wherein the venture nozzle is adapted
14 and configured to produce a fluid spray pattern wherein the ratio of the
15 diameter of the fluid spray pattern to the diameter of the widest point of
16 the venturi nozzle is from about 3:1 to about 7:1.

17 30. A nozzle device for coupling with a fluid distribution conduit for
18 improving the distribution of a upwardly flowing poly-phase mixture,
19 comprising at least one gas phase and at least one liquid phase, where
20 the fluid distribution conduit for receiving liquid and gas phases has
21 one or more openings for flow of the poly-phase mixture; said nozzle
22 device comprising a venturi nozzle having an outer diameter not
23 greater than an inner diameter of the upper cross section of the fluid
24 distribution conduit, wherein the nozzle device may be fixedly coupled
25 to and co-axially aligned with the upper cross section of the fluid
26 distribution conduit for accelerating and dispersing the liquid and gas
27 phases passing out of the conduit.

28 31. The nozzle device of claim 30, wherein each venturi nozzle has a
29 diameter at its widest point of from about 1 inch to about 2 inches.

- 1 32. The nozzle device of claim 30, wherein the venturi nozzles have a
2 diameter at its narrowest point of from about ½ inch to about 1 inch.

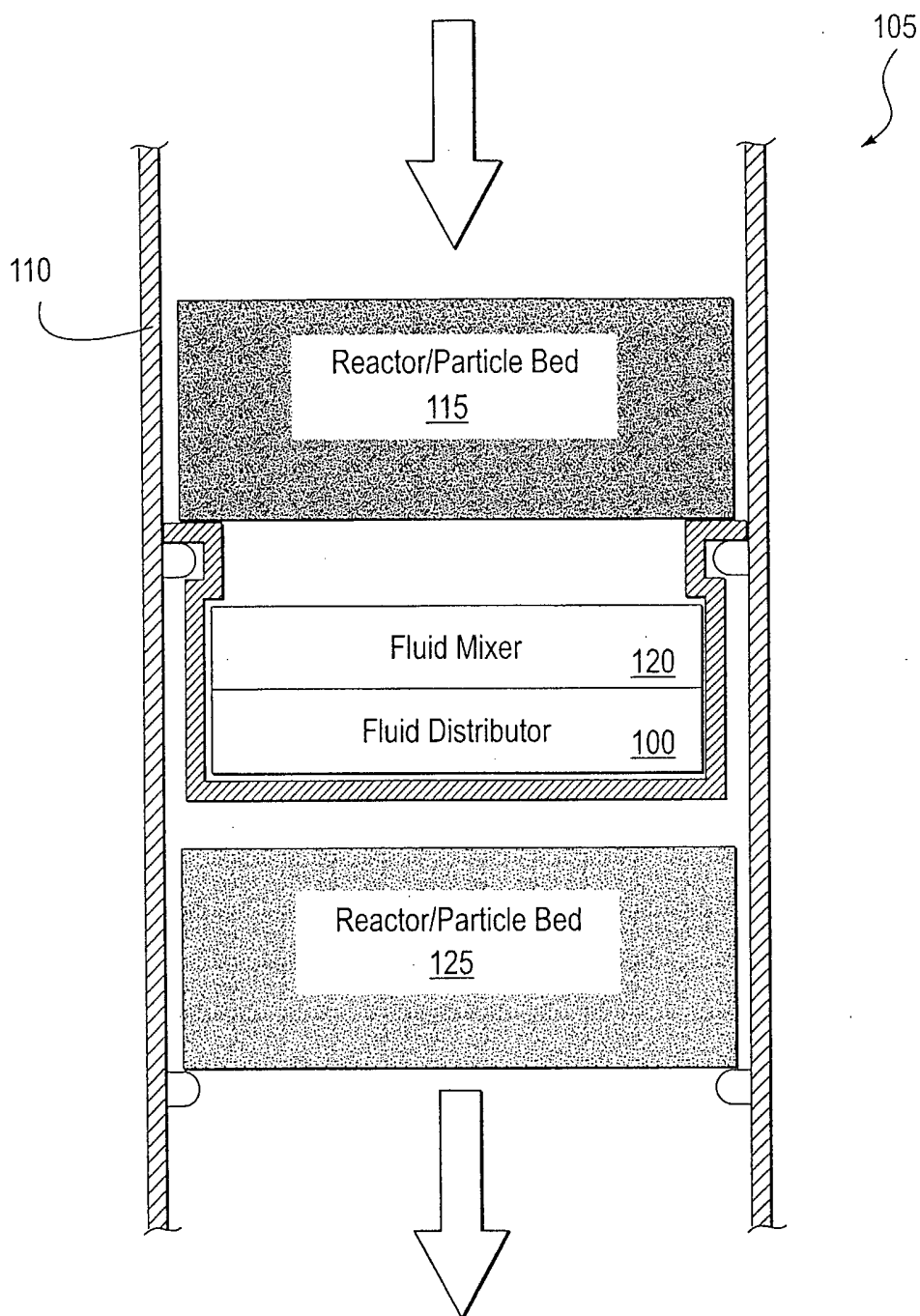


FIG. 1

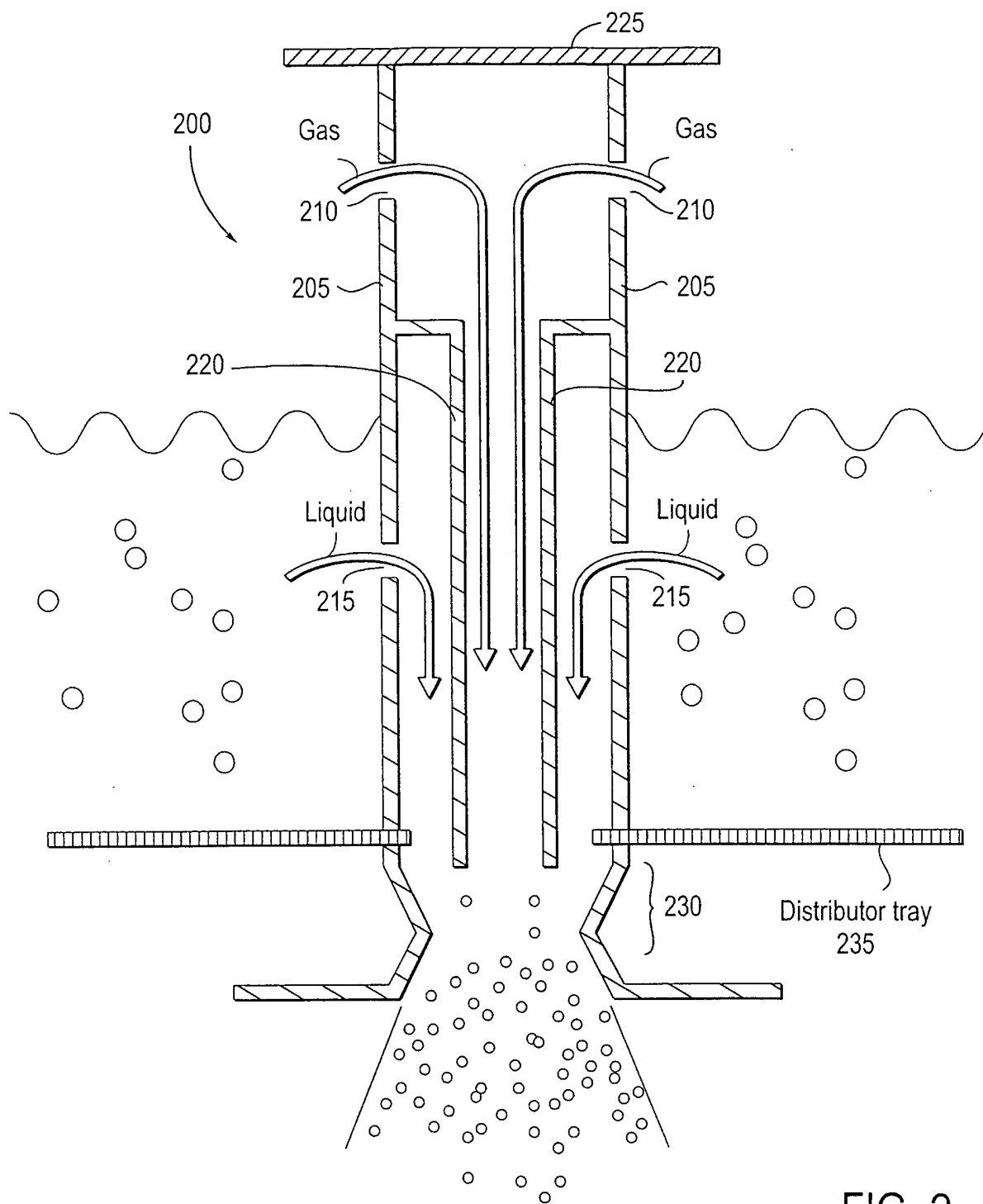


FIG. 2

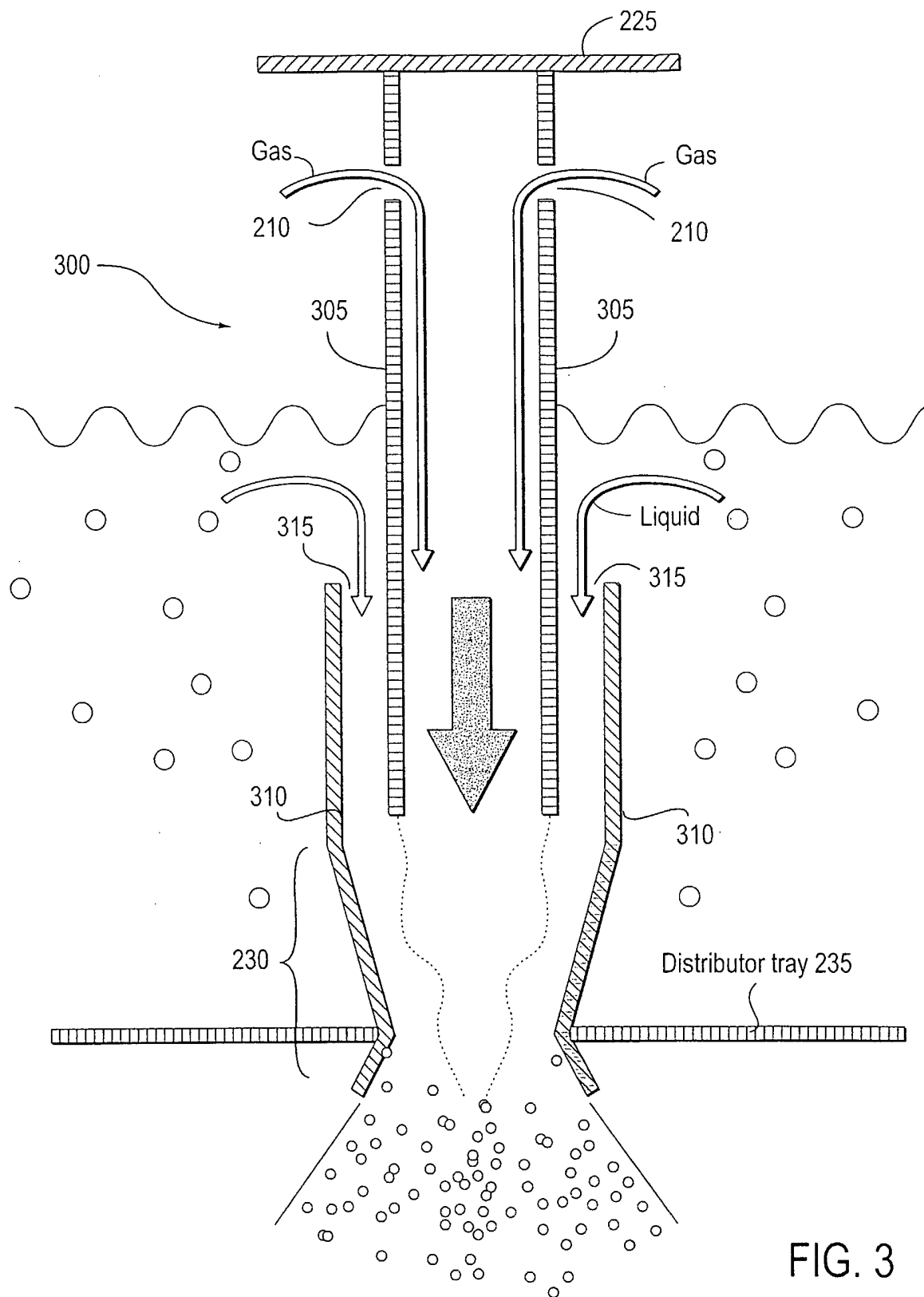


FIG. 3

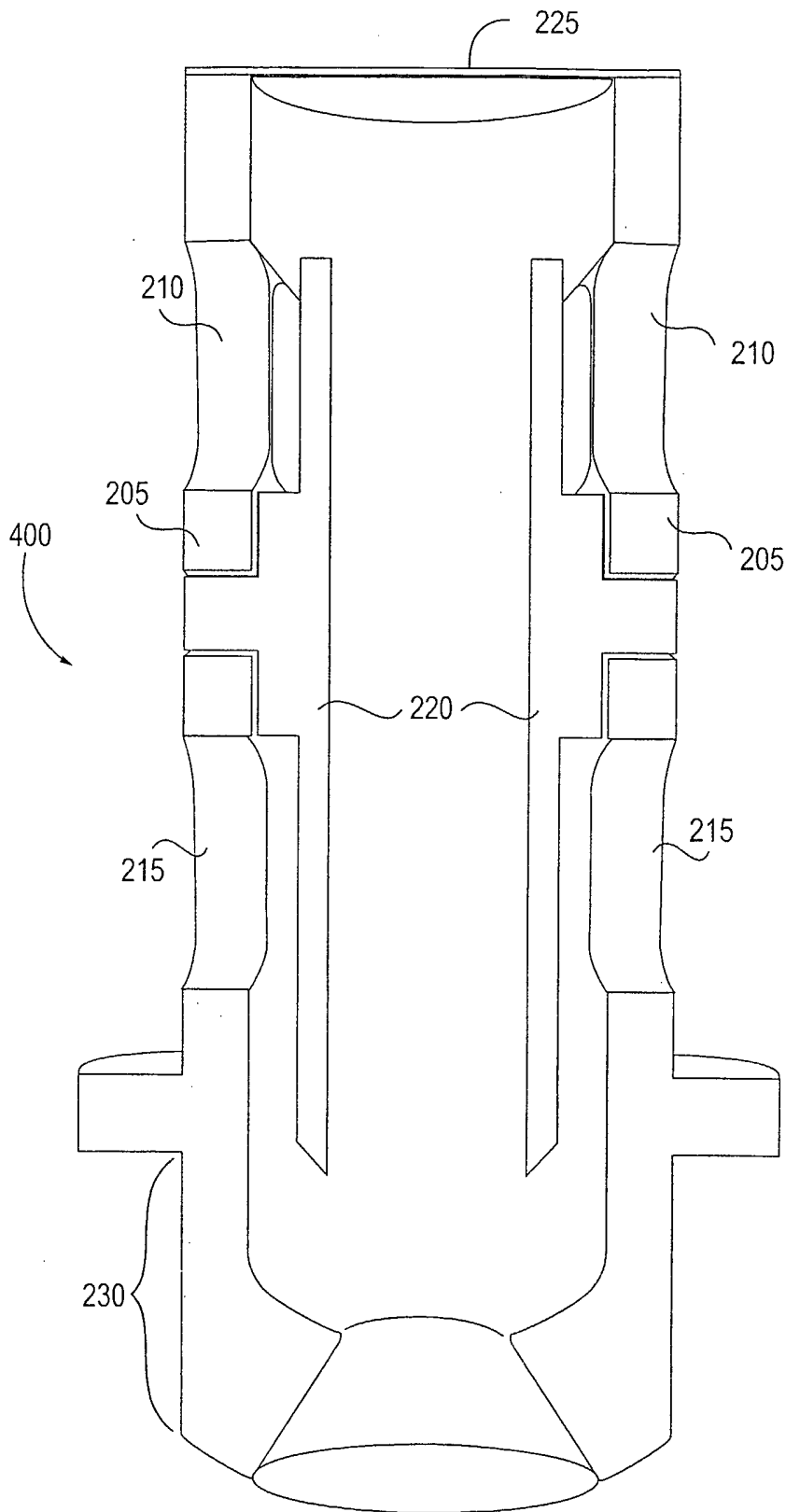


FIG. 4

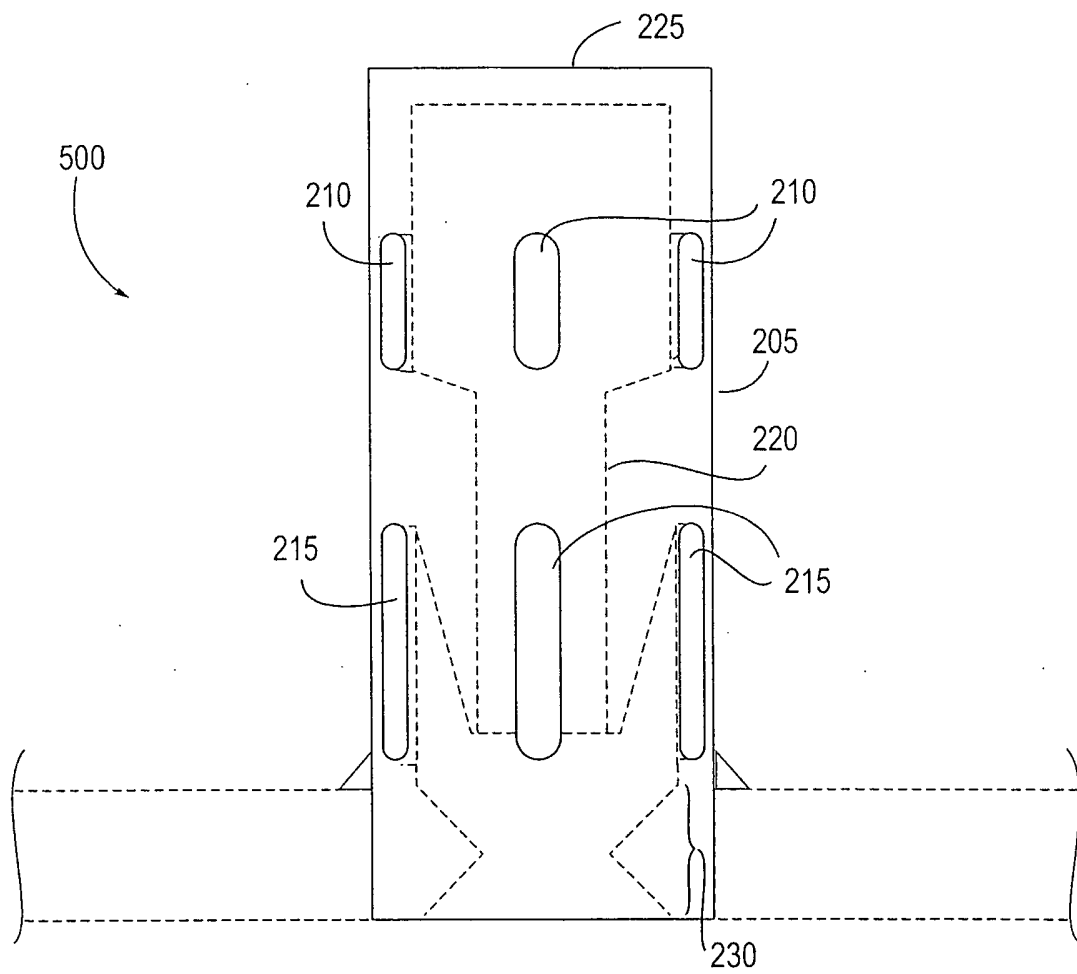


FIG. 5

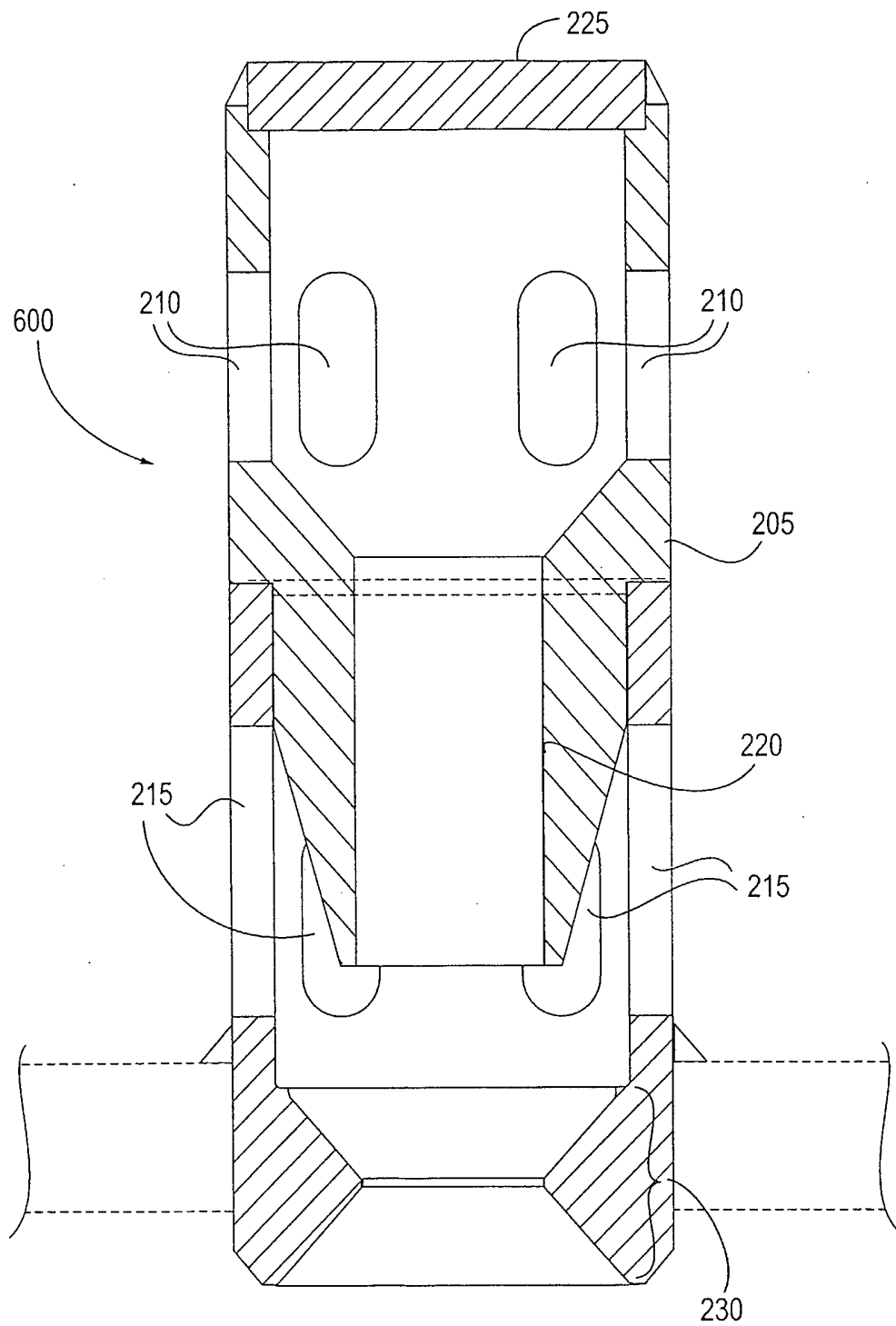


FIG. 6

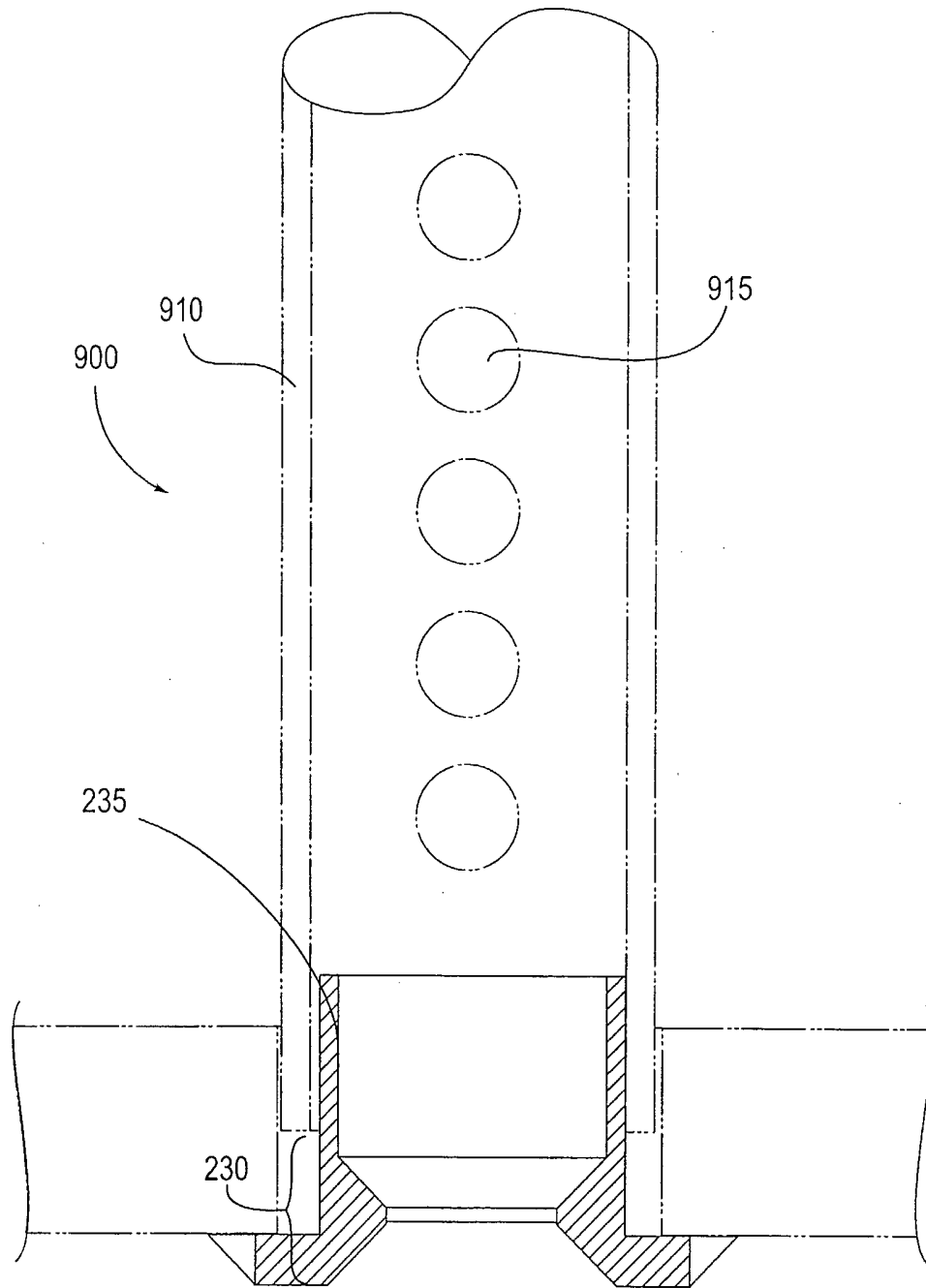


FIG. 7

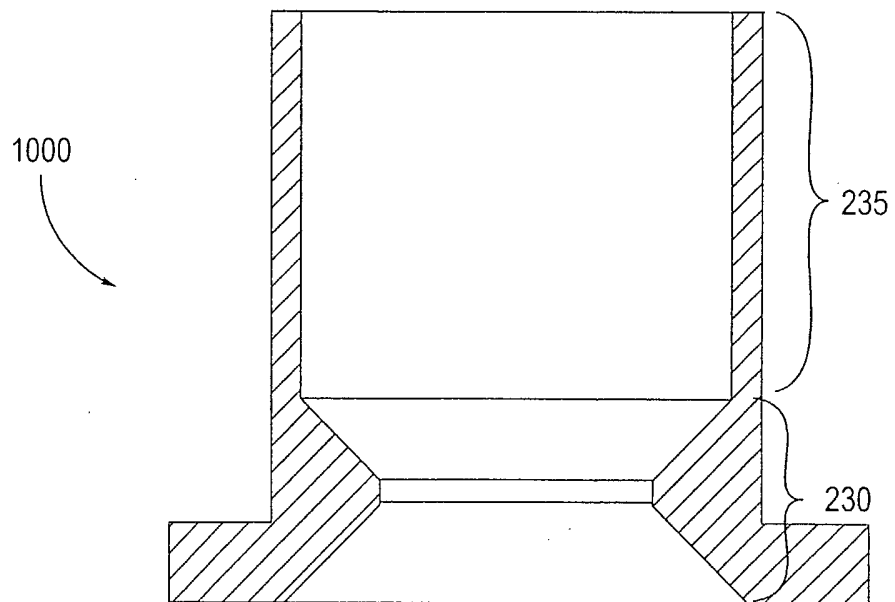


FIG. 8

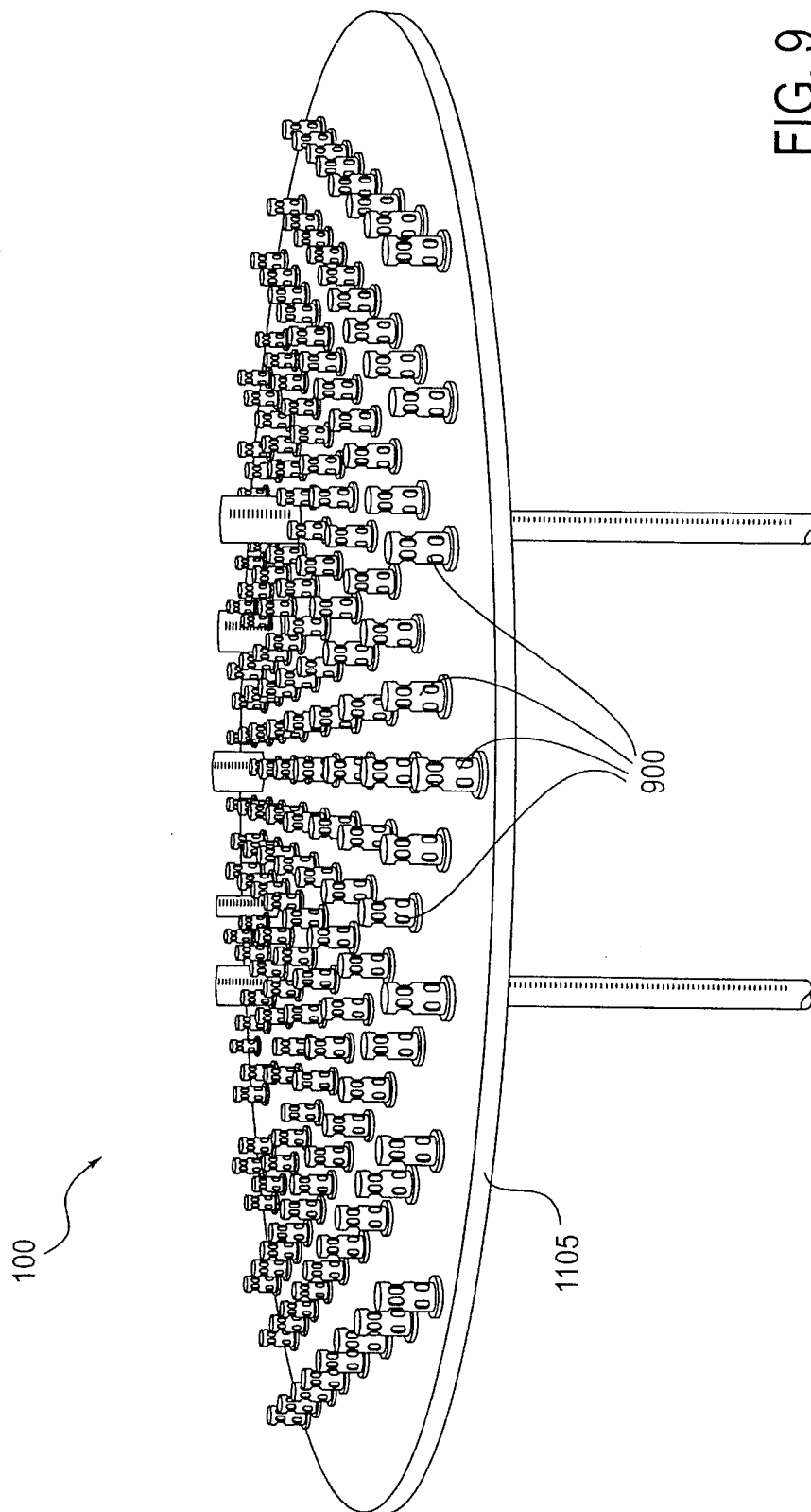


FIG. 9



FIG. 10

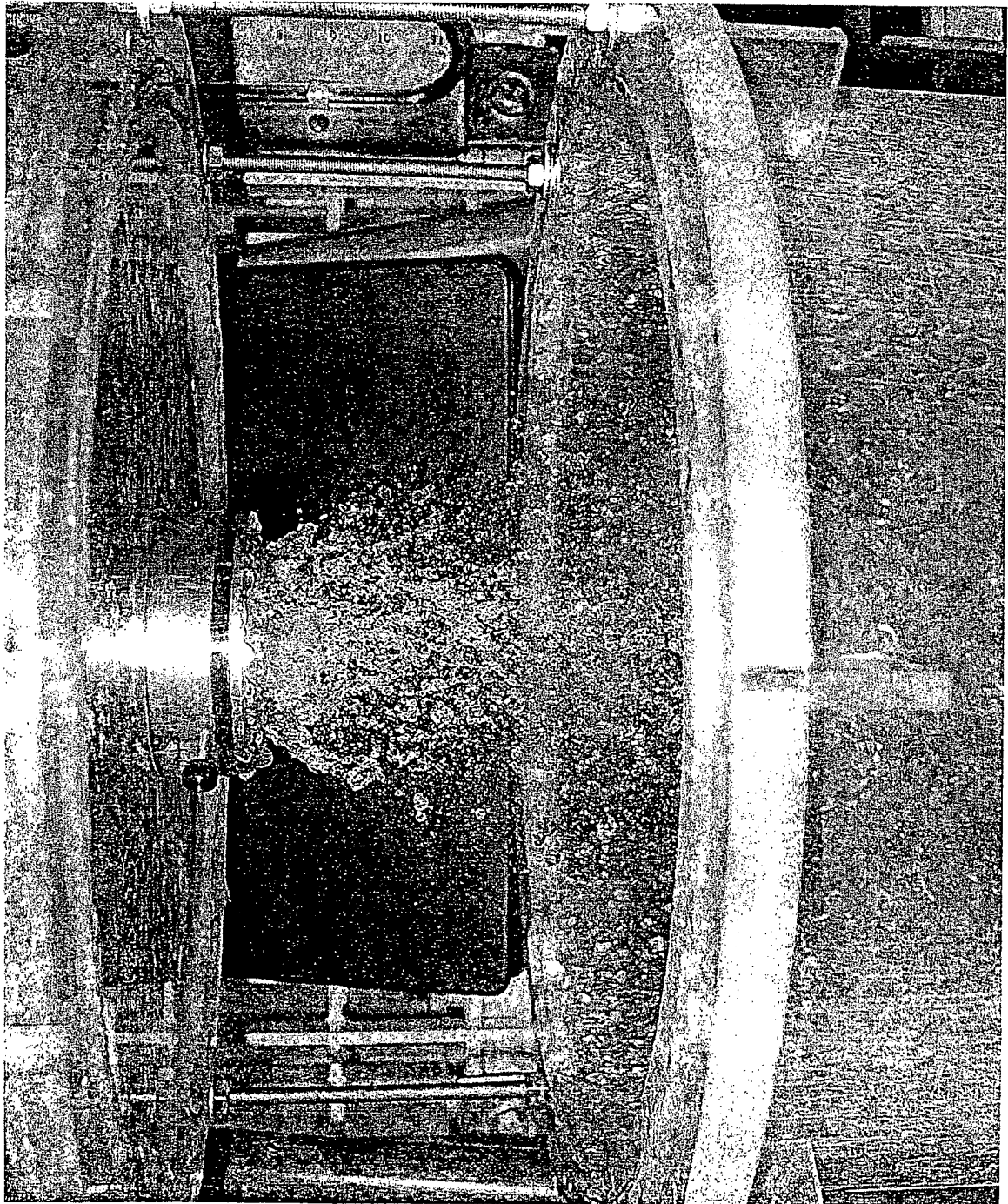


FIG. 11