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(54) METHOD AND DEVICE FOR THE GAS CONVEYANCE OF FLOWABLE BULK MATERIAL

(71) We, MITTELMANN GmbH. & Co. KG., a German company, of 5928 Laasphe, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a method and a device for the gas conveyance of flowable bulk material, such as particulate material, viscous substances, sludges or the like in a feed pipe which is filled with the product to be conveyed and is supplied with a gas along its length.

Conveyance of this type is usually used when flowable bulk material is to be removed from a storage tank and supplied to further stations.

For this type of conveyance work, so-called pneumatic grooves were used hitherto. These grooves contain two chambers which are disposed one above the other and are separated one from the other by a partition made of a porous material, the lower chamber being filled with a gas and the upper chamber being filled with the product to be conveyed, such that only an incomplete cross-sectional filling is achieved. The space kept free above the product which has been loaded in the chamber serves as an expansion and collecting space and also serves as the discharge conduit for the gas which is pressed through the porous partition and the product located thereon and is supplied therefrom to a gas-supplying device connected to the upper chamber. During the passage of the gas, the product located on the porous partition is converted into a suspended state, i.e. fluidized, and should therefore be able to flow away like a fluid when the feed pipe is suitably lowered.

It can be seen therefrom that the known arrangements cause, on the one hand, the feed pipe to have a relatively large overall height and, in addition, still do not operate without lowering the feed pipe, this leading to an immense space being needed in the vertical direction and consequently leading often to a considerable loss of storage room. Quite irrespective of this, there is in this case the danger that heterogeneous products are separated as a result of the flow of gas through the product, so that coarse-grained components are precipitated on the partition and fine-grained components are carried upwards. Besides there being a separation there may also be a change in consistency. The precipitating layer of coarse-grained components is no longer fluidizable to the desired extent, and this must cause the entire feed pipe to sag sooner or later and necessitate its removal. This disadvantage is even apparent during the processing of relatively coarse-grained material. However, even with pulverulent products of homogeneous consistency, problems may arise if materials are involved which have a relatively heavy bulk density since the gas requirement increases with the bulk density. In any case, the energy costs are not inconsiderable. Moreover, the partition has to be cleaned or replaced from time to time since the dust in the air spoils this partition. However, since quality materials are used in this case and, on the other hand, the partition face is not inconsiderable in the known arrangements, the expense associated therewith is also still very considerable. There are also problems with the known arrangements if it is necessary to alter the direction of the feed pipe.

An object of the invention, therefore, is to provide by simple and economical means, both from the point of view of manufacture and from the point of view of continuous operation, a method and a device whereby, avoiding the disadvantages of known solutions, any fluid bulk material, viscous substances, sludges or the like can be conveyed in a feed pipe so that not only is a compara-

tively high throughput achieved with a low input of power and a small cross-section for the pipe, thus creating extremely high efficiency, but the conveying process itself is also easily made controllable.

The present invention provides a method for the pneumatic conveyance of flowable bulk material in a horizontal or inclined feed pipe, said pipe being in the form of a single chamber and being of undivided cross section, which comprises gravitationally feeding the product to be conveyed into the inlet part of the feed pipe and filling the pipe over the entire cross section of the pipe in said inlet part thereof and continuously supplying percolating gas to said pipe via inlets disposed along the length of the pipe in the lower cross sectional portion thereof at a slow, turbulence-free velocity, the amount of percolating gas supplied to the pipe being such as to load the material being conveyed throughout with percolating gas, so that the volume occupied by the material continues to increase, and the material is distributed over the entire cross-section of the pipe, as it passes from the inlet part thereof through pipe to the the exit therefor from the pipe.

The present invention also provides a device for carrying out the method of the invention, comprising a horizontal or inclined feed pipe constructed as a single chambered pipe of undivided cross section and a source of the product for feeding the product under gravity to an inlet port of the feed pipe so that the inlet port is filled with product over its entire cross section under the action of gravity, said tube having plurality of percolation inlets disposed along its length in the lower cross sectional portion thereof, said inlets being adapted for connection to a supply of gas and being dimensioned so that percolating gas may be supplied continuously via the inlets to the pipe in an amount such that the bulk material being conveyed is loaded throughout with percolating gas so that the volume occupied by the material continues to increase, and the material is distributed over the entire cross-section of the pipe, as it passes from the inlet part thereof through the pipe to the exit therefor from the pipe.

Since the pipe cross section is completely filled with the product, no gas expansion chamber or discharge chamber is formed. There is therefore no free gas flow here. Rather, the gas which is caused to percolate into the product to be conveyed produces a loosening and increase in the bulk material gas volume and thus, advantageously, an expansion of volume and a reduction in the bulk density, a conveying process thereby being effected. The suspended state which cannot be eliminated in the prior art does not, however, occur. The gas which has percolated into the product to be conveyed, but which is no longer to be retained thereby automatically seeks the path of least resistance which runs here in the direction of the product output. Since the gas advances along this path rather more quickly than the product itself, the gas throughput per cross-section increases because of the supply which is added from the rear as it comes closer to the product output. Compared with the prior art, however, the gas velocity in this case is extremely low, so that no particles can be dragged along. Because of the increasing gas throughput, the consistency of the product to be conveyed is loosened more and more along the length of the pipe as the product comes closer to the product output, i.e. the air portion increases and thus the inner and outer friction, as well as the bulk density, are reduced. Consequently a quasi-fluidization advantageously results in the conveying direction, the conveying process being assisted thereby.

The measures according to the invention require an extremely small amount of gas which may have an exponential equation of several powers less than in the prior art. Advantages thus arise regarding the energy requirement, the supply unit whose dimensions have to be correspondingly small and the much better use of the filling station which is connected to the feed pipe. In addition, the extremely low gas requirement makes a so-called recycling substantially easier and cheaper, there is also no danger of dust explosions with the small gas quantities and the granular composition and consistency are maintained within the pipe cross-section. The minimum development of dust also leads to a relieving of the peripheral units, such as dust filters.

Gas filling occurs advantageously in an automatically controlled manner, all kinds of susceptibilities being practically eliminated thereby. Gas may only enter in the region of such percolation inlets where expansion and gas absorption are possible. It can be seen therefrom that the conveying process of the invention continues automatically rearwards of the output where expansion can occur at the earliest, for example, during re-starting after a conveyance stop until the entire feed pipe is covered. To control the conveyance, the air supply can be turned on or off without fear of the feed pipe suffering a so-called "sagging" when the air supply is stationary. The measures according to the invention therefore produce a conveyor path, which can be controlled extremely easily, with brief controlled dead times which were hitherto not considered possible, with a high degree of operational reliability, with easy controllability and with excellent efficiency.

A simple round pipe may advantageously be used for the feed pipe and this considerably reduces the manufacturing costs. Ac-

cording to a further proposal of the invention, a slow turbulence-free velocity is imposed upon the percolating gas prior to its introduction into the feed pipe. For this purpose, the percolation inlets are suitably so dimensioned that their cross-section is very large compared with the usual cross-section for a nozzle. On the other hand, however, this cross-section is still relatively small compared with the cross-section of the feed pipe. The percolation inlets may therefore be constructed simply as wall recesses provided with a connecting piece. To effect a tight and secure connection which, nevertheless, can be produced easily and therefore economically, the connecting pieces may be simply welded into the wall of the feed pipe and be provided substantially at the rear with a thread for the connection of a supply pipe.

A substantially uniform distribution is advantageously imposed upon the percolating gas by way of its respective inlet cross-section. One respective percolating gas distributing device which covers the entire inlet cross-section like a filter may be provided for this purpose in the region of the percolation inlets. A further retardation of the percolating gas is hereby achieved.

To prevent the product from penetrating the gas supply, at least one respective gas-permeable product block may be disposed advantageously in the region of each percolation inlet. A particularly simple and therefore economical embodiment may be achieved in this case by designing the percolating gas distributing device, which is in the form of a filter and also produces a certain degree of gas retardation, simultaneously as the product block. For this purpose, substantially a narrow-meshed filter, made substantially of ceramic material, sintered metal and/or a textile fabric, may suitably be used. These filters should be easy to replace. A relief valve is advantageously disposed in front of the filter.

A further advantageous embodiment of the invention lies in providing a plurality of percolation inlets which are distributed substantially uniformly along the length of the feed pipe. In the region where the feed pipe changes direction there is appropriately a slightly greater concentration of percolation inlets than in adjacent straight regions.

A further advantageous measure is to give the percolating gas a long path. For this purpose, the connecting pieces which are inserted into associated wall recesses may advantageously slope relative to the axis of the feed pipe. This also prevents the passing product from falling into the connecting pieces. The connecting pieces therefore slope appropriately in the conveying direction towards the axis of the feed pipe, and this simplifies the removal of any deposits. The connecting pieces may advantageously be directed substantially into the lowest region of the feed pipe, and this in particular enables a particularly sharp reduction in friction to be achieved here. Because successive connecting pieces or respectively the percolation inlets supplied therewith are staggered laterally relative to each other, quick discharge of gas is advantageously opposed and consequently an almost uniform shape for the conveyed mass is sustained.

According to a further preferred feature of the invention, the supplied quantity of percolating gas is advantageously selected so that the volumetric capacity of the product to be conveyed is exceeded. This may be effected crudely by a corresponding number of percolation inlets. Fine adjustment may be achieved in a simple manner by means of an appropriate valve in the gas supply.

During normal operation there is a continuous supply of percolating gas. This is achieved in that the connecting pieces are connected to a common collecting pipe by means of respective flexible connecting pipes. The collecting pipe may be mounted on the feed pipe. Individual percolating inlets may be rendered inactive by interrupting the connecting pipe, whereby it is possible to adapt to the circumstances of each individual case.

To stop the product output, it is sufficient to stop the percolating gas supply to the feed pipe. The percolating gas supply is merely recommenced for the purposes of starting or re-starting.

For the emptying of the feed pipe, the product filling of the pipe is merely stopped. For this purpose, the product inlet in the feed pipe may be provided with a, preferably remote-controllable, slide valve.

For the elimination of dust, the feed pipe in the region of its front edge may be provided with a dust filter installed in a gas inlet. Because of the relatively slight filling of gas here and therefore also because of an extremely reduced development of dust, this dust filter may advantageously have extremely small dimensions.

If air serves as the percolating gas, then this air can be removed from the compressed-air system and be released into the atmosphere. The air requirement is so slight that no substantial loading of the compressed-air system is to be feared here. Because of the low gas requirement, however, the measures according to the invention also simplify a so-called recycling of the percolating gas which, for this purpose, is kept in a closed circuit. In addition, the gas outlet may advantageously be connected to the suction connection of a fan which acts upon the collecting pipe.

An embodiment of the invention will now be described with reference to the accompa-

nying drawings, in which:—

Fig. 1 is a view of a feed pipe according to the invention as seen from below,

Fig. 2 is a section through a preferred embodiment of the invention and

Fig. 3 shows an example for an advantageous form of the product output.

In Fig. 1, 1 indicates a silo for accommodating, for example, granulated plastics material, the content of this silo being able to be supplied to a filling station, for example, a sagging unit, which is not shown more fully here, by way of a feed pipe which is denoted as a whole by 2. As the section in Fig. 2 shows, the feed pipe 2, which is conveniently formed by a commercially conventional pipe 3 with an undivided cross-section, is to be filled with the product to be conveyed over its entire cross-section. A simple curved pipe 4 is used therefore to connect the pipe 3 to the silo outlet connection. The feed pipe 2 is filled by the action of the pressure, cause by the inherent weight, of the product column existing in the silo 1. A valve 5 may be used to block the outlet funnel of the silo 1. The conveying process in the feed pipe 2 is started and continued, in that, a gas, preferably air in this embodiment, is caused to percolate into the product which is to be conveyed, and this leads to a loosening of the consistency and to an increase in the air bulk material volume and thus produces a forward movement because of the counter-pressure existing at the silo end.

In order to supply the feed pipe 2 with the necessary air, an air collecting pipe 6 is used which is connected to the compressed-air system, runs parallel to the feed pipe 2 and is connected by way of branch pipes 7 to associated longitudinally distributed percolation inlets 8 in the feed pipe 2. The air collecting pipe 6 is mounted on the feed pipe 2 by means of pipe clamps 9 (Fig. 2).

The individual percolation inlets 8 are distributed substantially evenly along the length of the feed pipe 2. One exception to this is in the region where the feed pipe 2 changes direction, this being effected by inserting an approriate curved pipe portion 10. The concentration of percolation inlets 8 in the curved portion 10 is rather greater than in the adjacent straight stretches. In the region where the feed pipe 2 changes direction, a particular loosening effect is achieved with a corresponding reduction in the internal friction of the material to be conveyed and its friction with the pipe, thus producing an extremely good curve-negotiating ability. The distance between, and the size of, the percolation inlets 8 are preferably to be selected so that the quantity of air, which can be introduced at each inlet can no longer be fully absorbed and retained by the product to be conveyed, but flows away forwards at least partially along the path of least resistance, thus producing a quasi-fluidization, superimposed on the loosening and expansion features mentioned above, in the flow direction with a simultaneous advancing effect.

In the embodiment, the percolation inlets 8 are designed as nozzle-less wall recesses 12 which are provided with a connecting piece 11. The cross-section of the wall recesses 12 is accordingly kept relatively large compared with a conventional nozzle cross-section. The typical nozzle effect, which naturally would have to lead to a high air speed and consequently, of necessity, to a fractionation of the material to be conveyed, is hereby effectively avoided. On the other hand, the cross-section of the wall recesses 12 may be kept relatively small compared with the pipe cross-section of the pipe 3 which forms the feed pipe 2, since the conveying process can in fact be actuated with relatively small quantities of air. As indicated at 13, the connecting pieces 11 may be welded to the pipe 3. In the rear region, a thread 14 is provided for the connection of the branch pipe 7 which is preferably formed by a flexible pipe piece. A distributing device 15 which covers the entire inlet cross-section like a filter is provided on the connecting pieces 11 for the uniform distribution of the percolating air over the entire cross-section. This leads to an extremely slow tubulence-free air speed in the laminar region during full utilization of the cross-section. To prevent the product penetrating the air supply through the wall recesses 12, product blocks may be provided in the region of each wall recess. In the embodiment, the distributing device 15, which is advantageously formed by a narrow-meshed filter made of sintered metal, etc., may be used simultaneously to form a product block, so that any further outlay therefor can be eliminated. From the point of view of servicing, the filter 15 is to be easily replaceable, and may be held, for example, by means of a retaining nut. In the embodiment, a relief valve 16 is disposed in front of the filter 15 so that the filter is secured to the rear end face of the connecting pieces 11 by means of the valve housing. By means of appropriate coupling pieces 17 and 18, the branch pipe 7 can be attached to the valve housing, on the one hand, and to associated connection pieces 19 of the collecting pipe 6, on the other hand.

As can be seen from Figures 1 and 2, the wall recesses 12, forming the percolation inlets 8, may be disposed in alternating sequence on different respective sides of the pipe 3 forming the feed pipe 2, thus causing a balanced filling of air over the pipe cross-section. A straight line of percolation inlets may also be used for weaker pipes, as indicated in Fig. 1 after the fork in the pipe 20. The wall recesses 12, forming the percola-

tion inlets 8, appropriately extend in the region of of the lower half of the pipe, thus ensuring that even the material in the lower cross-sectional areas, which is usually set more strongly than the material above it, is plentifully supplied with percolating gas. As indicated with reference to the percolation inlets 8 which are provided in the region of the fork in the pipe 20 and are disposed in one line, the wall recesses 12 and the connecting pieces 11 attached thereto may in this case extend substantially vertically downwards. In the case of percolation inlets 8 which are staggered laterally, these inlets may be appropriately disposed, as can be seen in particular in Fig. 2, so that the axis of the wall recess 12 and the connecting piece 11 attached thereto intersects substantially the lowermost surface line (generatrix) of the internal circumference of the pipe 3. Because a simple starting method is simultaneously provided in the conveying direction, it is also possible for product extras, which settle substantially in the region of the recesses 12 or the connecting pieces 11 attached thereto. to be easily reintroduced into the general product flow by means of the air. Because of the above-described arrangement of the percolation inlets 8 in the region of the lower half of the pipe, a relatively long percolation path is simultaneously advantageously achieved.

The above-described arrangement operates as follows:

The feed pipe 2 is filled gravitationally with the product to be conveyed from the silo 1 by way of the entire cross-section of the pipe. If the collecting pipe 6 is filled with air, then the percolating air forms a pneumatically inflated mass which causes the product to move forward. Since air may only be introduced in the region of such percolation inlets 8, where a loosening of consistency and an expansion takes place the conveying process commences automatically. As soon as the air supply is stopped, the conveying process also comes to an immediate standstill. In this case, therefore, the conveying process can be stopped or started easily by opening or switching off the air supply. For this purpose, a slide valve 21 in the collecting pipe 6 may be used. The air supply can be adapted to the circumstances of the individual case by means of this slide valve. Individual slide valves may also be disposed in the connecting pipes 7.

A further component of the conveying process of the invention is the pushing force produced by the air which travels forwards more quickly than the material to be conveyed. The counter-pressure is produced by the inherent pressure arising from the silo 1. Contrary to the prior art, the feed pipe 2 does not therefore need to be even lowered, but can in fact overcome an incline according to the counter-pressure. For the emptying of the feed pipe 2, the product supply from the silo 1 is simply blocked, the product quantity still in the feed pipe 2 then being brought out according to the blow-pipe effect.

The product which is conveyed to the output station 22 may be discharged here because of its inherent weight. For this purpose, the feed pipe 2 comprises opening ports 23. A plurality of such opening ports may be disposed one behind the other. The opening ports 23 may advantageously be designed as wall recesses in the lower region of the pipe 3 forming the feed pipe 2. The opening ports 23 may, for example, be sealed by means of flaps. It is advantageous to attach to each wall recess an immersion pipe 24 (Fig. 3) whose lower end discharges into a dosing funnel 25, the opening cross-section of this funnel permitting an accurate dosing of the discharged product quantity.

WHAT WE CLAIM IS:—

1. A method for the pneumatic conveyance of flowable bulk material in a horizontal or inclined feed pipe, said pipe being in the form of a single chamber and being of undivided cross section, which comprises gravitationally feeding the product to be conveyed into the inlet part of the feed pipe and filling the pipe over the entire cross-section of the pipe in said inlet part thereof and continuously supplying percolating gas to said pipe via inlets disposed along the length of the pipe in the lower cross sectional portion thereof at a slow, turbulence-free velocity, the amount of percolating gas supplied to the pipe being such as to load the material being conveyed throughout with percolating gas so that the volume occupied by the material continues to increase, and the material is distributed over the entire cross-section of the pipe, as it passes from the inlet part thereof through the pipe to the exit therefor from the pipe.

2. Method according to claim 1, wherein a greater quantity of percolating gas is supplied in any region where the feed pipe changes direction and in any ascending region, than in straight or horizontal stretches.

3. Method according to claim 1 or 2, wherein the quantity of percolating gas which is supplied exceeds at any place in the feed pipe the volume occupied by the material thereat.

4. Method according to any of the preceding claims, wherein the material is withdrawn from the pipe at one exit or at a succession thereof, by means of gravity.

5. Method according to any of the preceding claims, wherein the supply of percolating gas to the feed pipe is stopped or started to effect stopping and starting respectively of the conveying of the product.

6. Device for carrying out the method according to any one of the preceding claims, comprising a horizontal or inclined feed pipe constructed as a single chambered pipe of undivided cross section, and a source of the product for feeding the product to an inlet part of the feed pipe by gravity so that the inlet part is filled with product over its entire cross section under the action of gravity, said tube having plurality of percolation inlets disposed along its length in the lower cross sectional portion thereof, said inlets being dimensioned so that percolating gas may be supplied continuously via the inlets to the pipe in an amount such that the bulk material being conveyed is loaded throughout with percolating gas so that the volume occupied by the material continues to increase, and the material is distributed over the entire cross-section of the pipe, as it passes from the inlet part thereof through the pipe to the exit therefor from the pipe.

7. Device according to claim 6, wherein said gas inlets are dimensioned to permit the material being conveyed to be loaded with gas so that the quantity of gas which is supplied at any gas inlet in the feed pipe exceeds the volume occupied by the material thereat.

8. Device according to claim 6 or 7, wherein the percolation inlets are constructed as wall recesses each provided with a connecting piece, the cross-section of said recesses being small relative to the feed pipe and being large relative to a nozzle cross-section.

9. Device according to claim 8, wherein the connecting pieces are welded in the feed pipe and are provided at the outer end with a thread for the connection of a supply pipe.

10. Device according to any of the preceding claims 6 to 9, wherein at least one respective gas-permeable product block, which is designed as a percolating gas distributing device, is disposed in each percolation inlet.

11. Device according to claim 9, wherein the distributing device is a narrow-meshed filter which is made of a ceramic material, a fabric or a sintered metal.

12. Device according to any claim 9 or 11, wherein a relief valve is disposed upstream, in respect of gas flow, product block.

13. Device according to any of the preceding claims 6 to 14, wherein at least part of the feed pipe lies horizontally, and the percolation inlets are distributed substantially uniformly therein, and wherein there is a greater concentration of percolation inlets in any region where there is a change in direction or in any ascending region of the feed pipe.

14. Device according to claim 8 or any of the preceding claims 9 to 13 as dependent on claim 8, wherein the wall recesses, which form the percolation inlets, and the connecting pieces slope relative to the axis of the feed pipe.

15. Device according to any of the preceding claims 6 to 14, wherein the percolation inlets extend into the lowest region of a horizontal part of the feed pipe.

16. Device according to claim 8 or any of the preceding claims 10 to 16 as dependent on claim 8, wherein the connecting pieces are connected to a common collection pipe by means of respective flexible connecting pipes.

17. Device according to any of the preceding claims 6 to 16, wherein a collecting pipe for gas is mounted on the feed pipe.

18. Device according to claim 17, wherein the supply of gas to the collecting pipe can be stopped and disconnected by a valve.

19. Device according to any of the preceding claims 6 to 18, wherein the access of the product to the feed pipe can be blocked by means of a slide valve.

20. Device according to any of the preceding claims 6 to 19, wherein the feed pipe is provided with discharge ports which are designed as wall recesses and are disposed in the lower surface region of a horizontal part of the feed pipe.

21. Device according to claim 20, wherein several discharge ports are disposed one behind the other.

22. Device according to claim 20 or 21, wherein an immersion pipe, which discharges into a funnel, is connected to the discharge ports.

23. Device according to any of the preceding claims 6 to 22, wherein there is a fork in the pipe so as to subdivide the feed pipe into several branches.

24. Device according to any of preceding claims 6 to 23, wherein the feed pipe comprises a dust filter which is connected to a gas outlet in the region of the outlet end of feed pipe.

25. A method for the gas conveyance of flowable bulk material, substantially as hereinbefore described with reference to the accompanying drawings.

26. A device for the gas conveyance of flowable material, substantially as hereinbefore described with reference to the accompanying drawings.

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1594830 COMPLETE SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

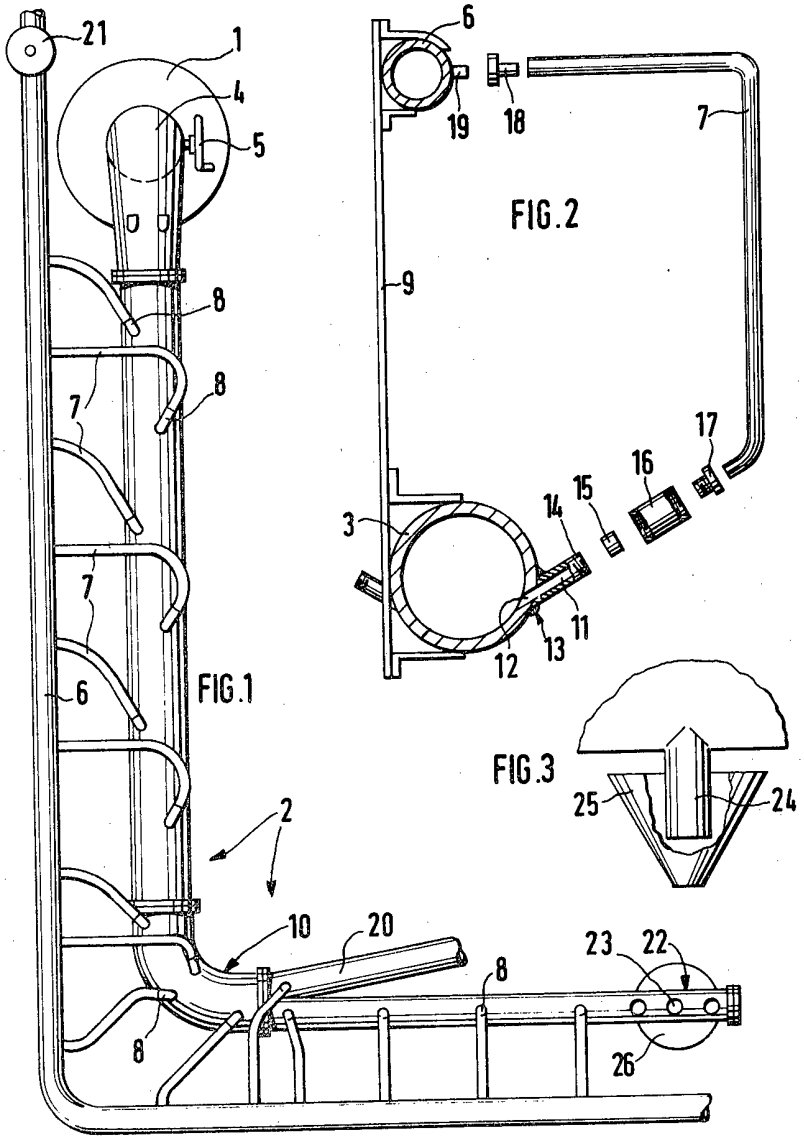

FIG.1

FIG.2

FIG.3