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Smearsoll et al.

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[54] **FILLING CONTAINERS WITH FRIABLE PARTICLES**

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[52] **U.S. Cl.**..... **141/8**, 53/59 W, 141/12, 141/83, 141/196, 241/25, 241/37, 241/100

[51] **Int. Cl.**..... **B65b 1/20**, B65b 1/32, B65b 3/28, B65b 31/02, B65b 37/18, B65b 59/02, B02c 19/12, B02c 25/00

[58] **Field of Search**..... 141/8, 11, 12, 71, 83, 196; 241/25, 30, 37, 100; 53/59 W

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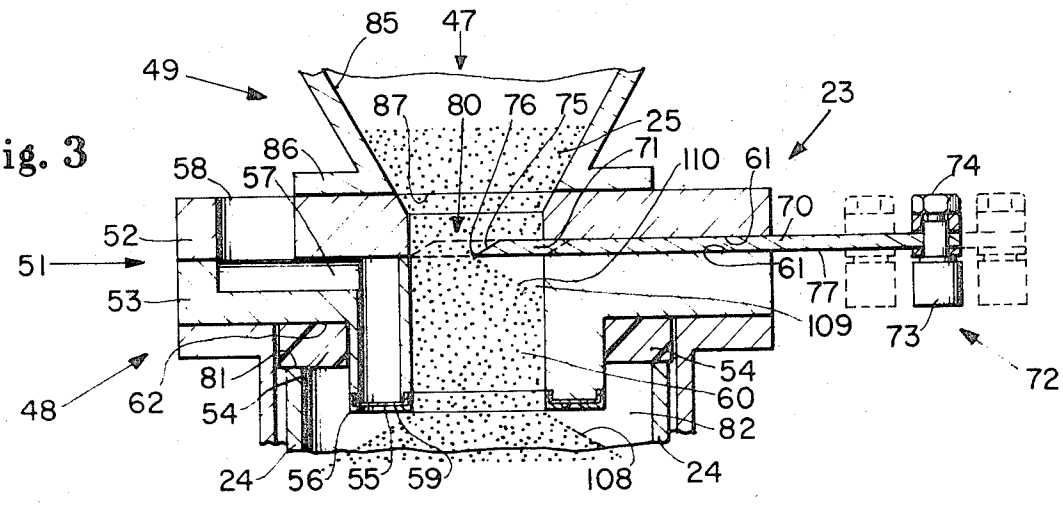
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[57] **ABSTRACT**

A method of filling a succession of containers with friable particles so that the average weight of volumetrically filled containers is substantially uniform, the method comprising controlling the cross-sectional area of an aperture through which the particles flow from a hopper into the container, the area of the aperture being adjusted in response to the deviation from normal of the average filled weight of a preceding plurality of containers.

11 Claims, 5 Drawing Figures

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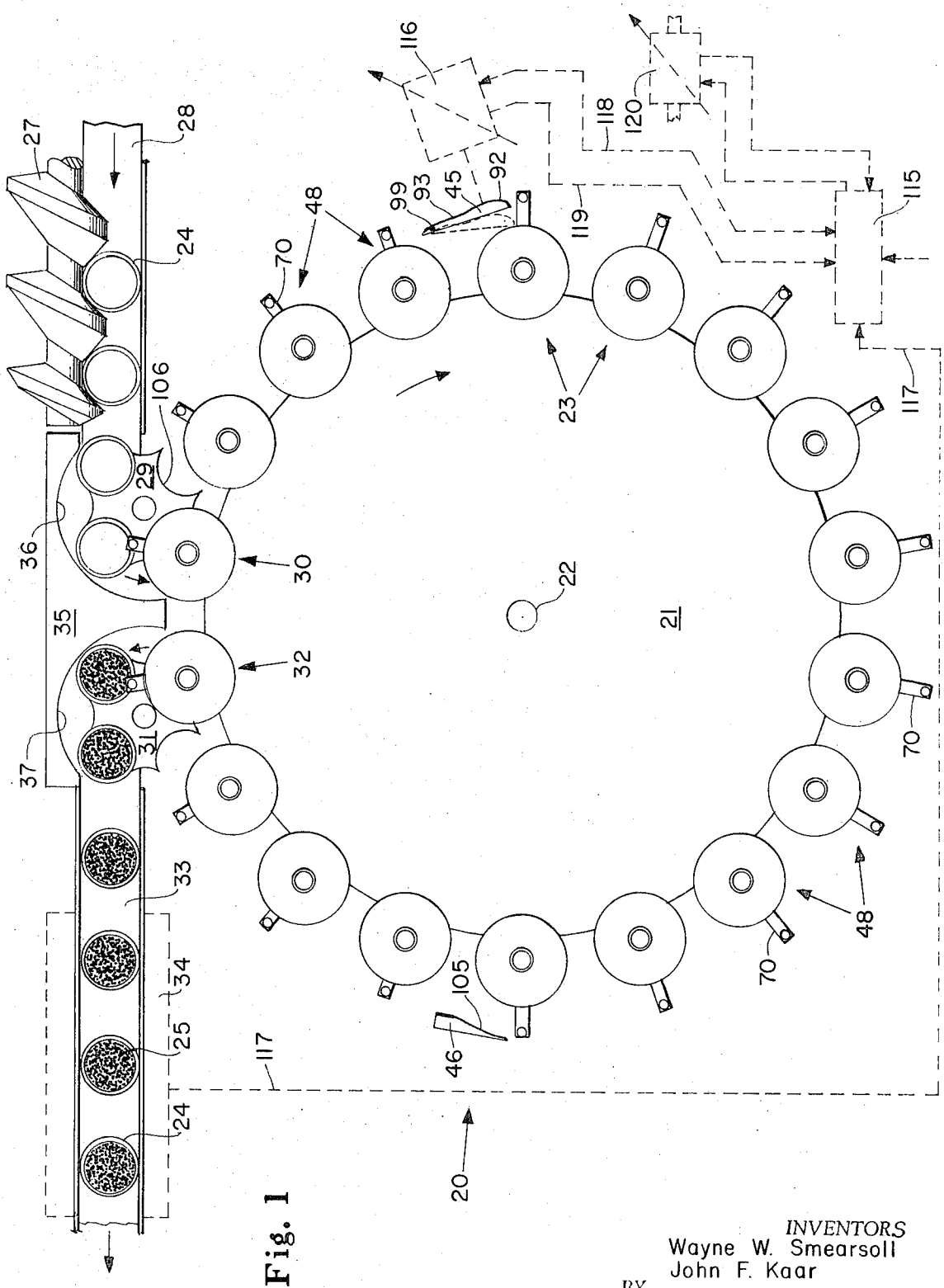


Fig. 1

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Fig. 2

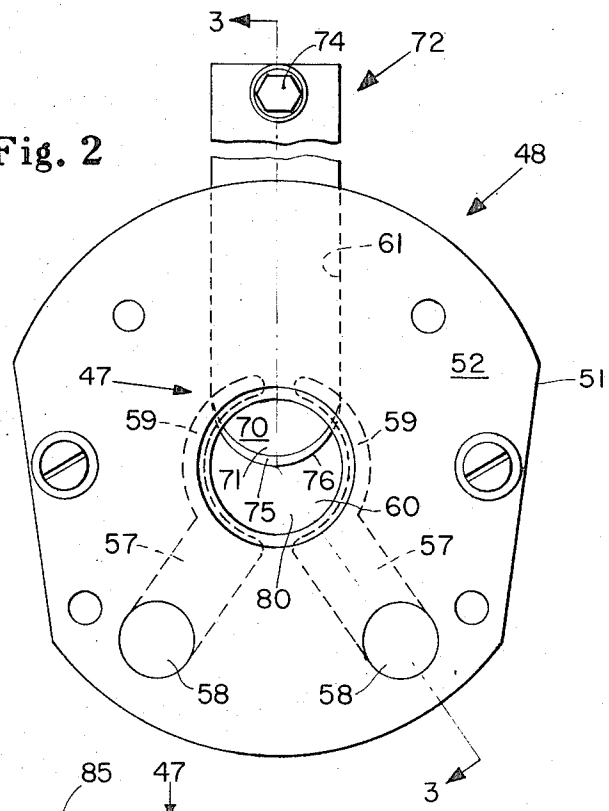


Fig. 3

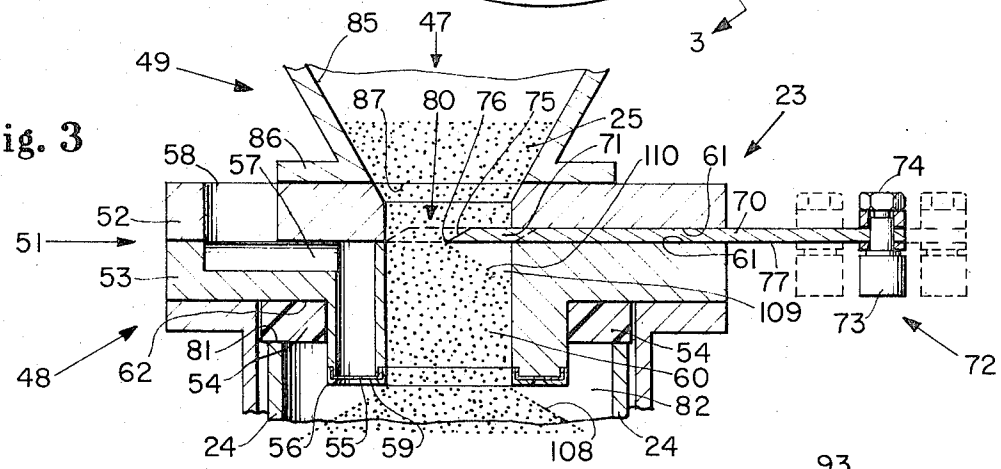


Fig. 4

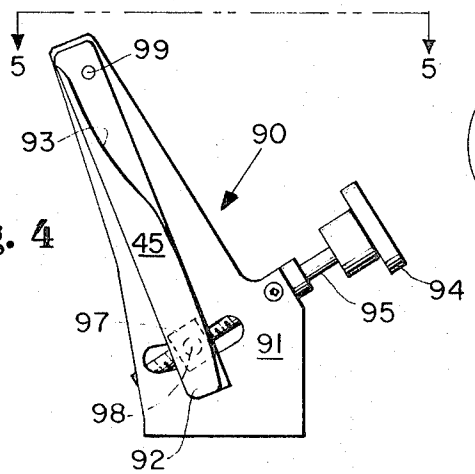
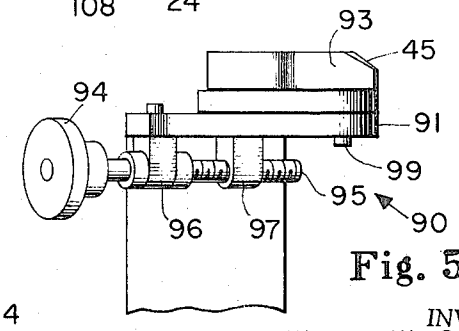


Fig. 5



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FILLING CONTAINERS WITH FRIABLE PARTICLES

FIELD OF INVENTION

Uniformly filling substantially identical containers with flowable solid particles such as instant coffee crystals or the like.

BACKGROUND OF THE INVENTION

Prior art apparatus for successively filling flowable solid particles into a procession of conveyed containers is commonly addressed to placing uniform quantities of particles by weight or volume into substantially uniform containers. Although this general procedure is referred to as filling, filling the entire volume of the containers is not normally practiced because spillage would then be very likely. Further, and more importantly, if the containers were all filled brim full, the weight of particles per container would fluctuate as the apparent density of the particles varied, apparent density being defined as weight of particles per unit of volume. Therefore, it is common practice to leave an unfilled space in each filled container, the unfilled space being hereinafter designated outage, which may be varied in order to accommodate variations of apparent density and for other purposes. That is, as apparent density increases, outage must increase and vice versa in order to maintain the weight of particles per filled container substantially constant.

Apparent density of flowable solid particles delivered to filling apparatus commonly varies due to cyclic and/or random process changes upstream of the filling apparatus. Parametric changes such as temperature, pressure, flow rate, and velocity are manifested in particle size, shape and porosity variations and the like which directly affect apparent density. For instance, small non-porous comminuted particles pack more densely than large porous particles such as friable particles of lyophilized or agglomerated coffee. It will be appreciated by those skilled in the art that great expense and care would be required to produce, by lyophilization or agglomeration processes, friable particles having a narrow apparent density range which would be amenable to volumetric filling without providing an outage adjustment means.

Successively filling containers with uniform weights of flowable solid particles is further complicated by the productivity oriented goal of minimizing the duration of the filling operation and by the product quality oriented goals, in some instances, of vacuum packing or blanketing the product with inert gas such as nitrogen.

Rotary powder filling apparatus, hereinafter referred to as turret type powder fillers, and indexing type fillers have been developed to enhance filler production rates measured in containers filled per unit of time. Turret type powder fillers commonly have, more or less, a revolving turret member having a number of filling stations spaced about and secured to its perimeter. Means such as starwheels are provided for transferring an empty container from a container feed means such as a conveyor into each filling station as the filling station passes a fixed position (pick-up position) relative to the turret, means for sealingly securing the container to the filling head of the filling station which includes apparatus for elevating the container to telescope over and/or inside of depending portions of the filling head, means for partially evacuating the container and/or purging it with inert gas before filling, means for flowing solid particles into the container, means for lowering the filled container from the filling head, means such as a starwheel to remove it from the rotating turret at a second fixed position (pick-off position) relative to the turret, and means for depositing the filled container on a take-away conveyor or other means for forwarding filled containers from the filling apparatus.

An illustrative example of a turret type powder filler is disclosed in U.S. Pat. No. 3,295,566 issued to George S. Maniatty, Jan. 3, 1967. In this turret type powder filler, powder flows downwardly into the container through only a segment of a cylindrical outage regulatory tube over which the container is partially telescoped while displaced air flows upwardly through the remaining cross sectional area of the outage regulatory tube whereby flow retarding entrapment of air is substantially precluded. This filler also includes controllable (frequency and/or amplitude) vibratory means for effecting some compaction of particles within the container to selectively affect the apparent density of the particles by tamping so that uniform weight of particles per container over a limited range of apparent particle density can be achieved in a basically volumetric type of powder filler. Further, this apparatus includes means for adjusting the volume of particles delivered to a container by changing the height of a member striking off particles disposed above the top end of the outage regulatory tube as the turret revolves. Raising or lowering the strike-off height increases or decreases, respectively, the volume of particles that will flow into the container as it is lowered from the filling head.

Another method of controlling average filled weights in a turret type powder filler is disclosed in U.S. Pat. No. 3,073,400, issued to U. Bauder et al, Jan. 15, 1963, the method entailing varying the volumes of premeasuring flasks in response to an average filled weight error signal output from a check weigher.

Referring back to filling apparatus addressed to product quality oriented goals, U.S. Pat. No. 2,170,469 issued to C. F. Carter, Aug. 22, 1939, discloses a method and apparatus for filling partially evacuated containers with powder or other comminuted material in order to reduce the amount of freshness-compromising oxygen in contact with such products as instant coffee. The method entails drawing a partial vacuum within the container to establish a pressure differential across the powdered material within a hopper thereabove, communication therebetween being provided by generally vertically extending holes through a perforate retainer in the filling head. The holes in the perforate retainer being sized to cause powdered material to bridge them whereby flow therethrough is prevented except when a vacuum induced pressure differential exists across the powdered material. This filling technique of flowing powder through valveless passageways or holes under the influence of pressure differential is applied to a volumetric turret type powder filler in U.S. Pat. No. 2,613,864 issued to C. F. Carter, Oct. 14, 1952.

Powder filling equipment using pressure differential induced flow through valveless filler heads is subject to dribbling or sifting of some particles through the

holes in the perforate retainer due to vibration of the filler. This is particularly true in turret type powder fillers having rather ponderous revolving and reciprocating members. Such dribbling and/or sifting is somewhat wasteful of product passing through the filler head when a container is not below it, as for instance when a containerless filling station is moving from the pick-off position where a filled container has just been removed to the pick-up position where an empty container is received.

Flow prevention bridging of holes by particles of powder in valveless fillers is somewhat dependent on hole diameters. Holes large enough to allow large particles to flow freely under the influence of pressure differential can be bridged by relatively small particles but will not prevent dribbling of relatively large particles therethrough. Dribbling and/or sifting is aggravated as the range of particle size distribution increases and as hole sizes are increased. Conversely, flow rate under pressure differential is adversely affected as hole sizes are decreased. Thus, a large particle size distribution adversely affects the performance of such valveless fillers.

Friable particles such as coffee crystals produced by lyophilization or agglomeration processes have a large range of particle size distribution making such particles difficult to handle in a valveless filler as hereinbefore described. The instant invention is addressed to better flow control of such friable particles having a large range of particle size distribution during filling of containers therewith. The instant invention utilizes the friable nature of the particles during volumetric filling by causing sufficient fractures thereof as necessary in order to control the average weight of product per filled container at or near the nominal desired value. Fracturing particles reduces the average particle size, which is then manifested as an increase in the apparent density of the particles. To effect this, the instant invention causes the particulate to flow through an aperture, the cross-sectional area of which is adjusted as a function of the average deviation from nominal weight of filled containers. It is believed that inter-particle collisions and collisions of particles with the container cause fractures of friable particles. Further, it is believed that the frequency of such collisions is inversely related to aperture area because it has been empirically determined that increasing the cross-sectional area of the aperture causes the apparent density of friable particulate passing therethrough to decrease and vice versa.

OBJECTS OF THE INVENTION

It is an object of this invention to provide a method of maintaining substantially uniform filled weights of containers filled with uniform volumes of particles of friable material by controlling the amount of breakup of the friable particles during filling.

It is a further object of this invention to provide a method of controlling substantially uniform filled weights of containers filled with uniform volumes of particles of friable material having a relatively large range of particle size distribution by controlling the amount of breakup of the particles during filling.

It is yet a further object of this invention to provide a powder filling apparatus wherein the average size of friable particles can be affected in order to cause containers filled with uniform volumes thereof to each have substantially uniform weight of particles therein.

It is another object of this invention to provide an improved turret type powder filling apparatus wherein the average size of friable particles can be affected in order to cause containers filled with uniform volumes thereof to have substantially uniform outage and weight of particles therein.

It is yet another object of this invention to provide an inproved turret type powder filling apparatus wherein the average size of friable particles is automatically adjusted in order to cause containers filled with uniform volumes thereof to have substantially uniform weight of particles therein.

SUMMARY

Briefly stated, the instant invention is a method of achieving substantially uniform average weight of successive containers filled with substantially uniform volumes of flowable solid friable particles from a hopper containing such particles through a variable area filling aperture by affecting the apparent density of said particles during filling through induced particle fractures. The method comprises determining the average weight deviation from nominal average filled weight of a preceding plurality of filled containers with means suitable therefore, and adjusting an aperture opening means to vary the aperture-open area in response to the average weight deviation, the effect of changing the area of said aperture being empirically related to the apparent density correction required to reduce the weight deviation to zero. After the aperture opening means is adjusted and before the aperture is opened, an unfilled container is positioned below the aperture so that the container will be filled with said particles after the aperture is opened and so that the flow of particles will cease due to their natural angle of repose when the container becomes filled. Then the apperture is opened for a predetermined period of time sufficient to cause the container to be filled. Then, the aperture is closed to substantially preclude additional flow of said particles therethrough until the aperture is intentionally opened again. The filled container is then fowarded to said means for determining the average weight deviation so that a new average weight deviation can be completed.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the present invention, it is believed that the invention will be better understood from the following description of a preferred embodiment taken in connection with the accompanying drawings in which:

FIG. 1 is a fragmentary top plan view illustrating a turret type powder filling apparatus having an adjustable gate valve in each filling head.

FIG. 2 is an enlarged fragmentary top plan view of a preferred embodiment of a filling head having a gate valve therein opened to an intermediate position.

FIG. 3 is a fragmentary vertical sectional view of a filling head taken along line 3—3 of FIG. 2, the view further including other portions of a filling station disposed adjacent to the filling head.

FIG. 4 is a fragmentary top plan view of an adjustable valve opening camming mechanism for controlling the

amount the gate valve in each filler head is opened each revolution of the turret.

FIG. 5 is a fragmentary vertical elevational view of the adjustable valve opening cam mechanism taken along line 5—5 of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings and in particular FIG. 1, filler 20, a preferred turret type, volumetric powder filling apparatus for practicing the instant invention, is shown in a top plan view to include: a revolving turntable 21 mounted for rotating it about a vertical axis by means of the shaft 22; eighteen filling stations 23 spaced about and secured to the perimeter of turntable 21; spacing worm 27; input conveyor 28 and feed starwheel 29 for inserting an empty container 24 into each filling station 23 as the filling stations 23 successively pass container pick-up position 30; exit starwheel 31 for removing filled containers as the filling stations successively pass container pick-off position 32; takeaway conveyor 33 for forwarding filled containers from turntable 21; and weight deviation determining means 34 for ascertaining the average deviation from nominal weight of filled containers 24. Also, adjacent to the perimeter of the turret is adjustable valve opening cam 45 and valve closing cam 46 which are secured to stationary apparatus structure (not shown in the figures). The cams open and close powder flow controlling gate valve 47, FIG. 2, located in filling head 48 of each filling station 23 each revolution of turntable 21. The spacing between opening cam 45 and closing cam 46 in conjunction with the rate of rotation of turntable 21 establishes a predetermined period of time for the valve to be open which period of time is sufficient for container filling to occur.

In operation the position of valve opening cam 45 is adjusted to provide an aperture-open area within a span of practical areas in response to the deviation from normal of the average weight of a plurality of filled containers forwarded from the powder filling apparatus, the amount of adjustment being empirically related to the weight deviation. The span of practical areas extends from the full open position of the valve to a minimum area through which filling will be completed during the predetermined period of time the valve is open. Adjustment of the opening cam to cause valve 47 in each filling head 48 to open less acts to reduce the cross sectional area of the stream of particles passing through valve 47 from hopper 49, FIG. 3, while filling container 24. As hereinbefore discussed, it has been determined empirically that decreasing the aperture-open area results in an increase in the breakup of friable particles 25 during filling which is manifested as an increase in the apparent density of the friable particles. Therefore, decreasing the aperture-open area is used to correct for under average weight of filled containers. In the same manner, adjusting the opening cam to open the gate valves to increase their aperture-open areas acts to decrease the apparent density of particles flowing therethrough so is a means of correcting for heavier than nominal average filled weight.

Turntable 21 of the preferred filler apparatus has a plurality of filling stations 23 secured to its perimeter so that all of the filling stations follow the same circular path as the turntable is turned on shaft 22 by turning means not shown in the figures but many types of which are well known to those skilled in the art. For instance, FIG. 1 shows an apparatus having 18 filling stations.

Each filling station 23, FIG. 3, includes a filling head 48, hopper 49, and means such as guides (not shown in the figures) for assisting insertion of empty containers 24 therein and means for extracting or otherwise removing filled containers 24 therefrom. Also, the apparatus includes means (not shown in the figures) for telescoping an empty container 24 over the depending portions of each filling head 48 in order to establish a sealing relationship between container 24 and filling head 48 through gasket 54. Such means for raising or telescoping containers with filling heads is thoroughly disclosed in the hereinbefore references prior art patents: particularly U.S. Pat. No. 3,295,566, Maniatty and U.S. Pat. No. 2,613,864, Carter so are not further described herein.

Filling head 48, FIG. 3, includes two-piece body 51 comprising top element 52 and bottom element 53 for the convenience of fabrication, gasket 54, screen 55, screen retainer 56, and gate valve 47.

Filling head body 51 has two vacuum-venting conduits 57 therethrough which terminate in upwardly facing ports 58, FIG. 2, and downwardly facing kidney shaped openings 59 indicated by dotted lines in FIG. 2. The body 51 also has a substantially right circular cylindrical passageway 60 extending vertically therethrough that is centrally disposed therein. Body 51 is adapted to have hopper 49 juxtaposed superjacent thereto and to having the other elements of the filling head 48 relate thereto as hereinafter described.

Sealing means such as gasket 54 made of an annular piece of resilient material such as neoprene, is sealingly secured to downwardly facing surface 62 of bottom element 53, FIG. 3, and is adapted to provide a sealing relationship with a container 24 having its lip 81 juxtaposed subjacent thereto.

Screen 55, FIG. 3, fabricated from stainless steel mesh or other foraminous material compatible with the product being package, is secured by retainer 56 in such a manner that communication of gases between the space below filling head 48 and conduits 57 is through screen 55. By thus restricting communication with conduits 57, ingestion of flowable solid particles 25 into vacuum lines, pumps and other vacuum related elements that are connected to ports 58 from time to time during apparatus operation is substantially precluded.

Sliding type gate valve 47, FIG. 3, comprises gate 70 having closure end 71 and positioning end 72, cylindrically shaped roller 73, and means 74 for securing roller 73 to positioning end 72 of gate 70 so that the roller 73 is free to rotate on its axis.

Gate 70, which in the preferred embodiment is fabricated of high density polyethylene, is accommodated in a radially extending slot 61 in body 51. The accommodation slot 61 permits movement of the gate radially relative to body 51 but does not necessarily effect a vacuum tight fit between gate 70 and body 51, a high vacuum not being indispensible to the instant invention.

Closure end 71 of gate 70 is adapted to substantially close passageway 60 to the passage of particles 25 of flowable solid therethrough when in its most leftward position, FIG. 3, but is not necessarily adapted to seal

the passageway against passage of gas therethrough, a high vacuum not being indispensable to the instant invention as hereinbefore stated. Closure end **71** of the preferred embodiment has an upwardly facing beveled portion **75** adapted to form knife edge **76** in the plane of lower surface **77** of gate **70** so that closing of valve **47** while passageway **60** is filled or partially filled with particles **25** of flowable solid does not act downwardly on such particles in the passageway. Particles displaced by the gate **70** upon closing are displaced upwardly which may cause some fracturing of displaced particles. However, because such displaced particles would have the farthest free fall during the next filling operation, it is believed that they would be most likely fractured during filling. Therefore, fractures induced by the gate have a minimal effect on overall apparent density of particles.

Positioning end **72** of gate **70**, FIG **3**, is fitted with roller **73** which is adapted to coact with cams **45, 46** attached to the structure of the filler so that valve **47** is opened by sliding gate **70** to form aperture **80** in passageway **60** and to subsequently close valve **47** each revolution as turntable **21** rotates, such opening being to permit filling containers **24** with flowable solid particles **25** and such closing being to substantially preclude undesirable flow of solid particles. As best seen in FIG. **1**, the gates **70** are disposed so that their longest dimension extends essentially radially relative to the axis of turntable shaft **22** with their positioning ends **72** radially outwardly from their closure ends **71.**

When container **24**, FIG. **3**, is telescoped over the depending portion of filling head **48** so that its rim **81** is sealingly abutted against gasket **54** as hereinbefore described and gate valve **47** is closed, the space within the container can be subjected to vacuum induced through conduits **57** or induced through either conduit **57** with the other conduit **57** closed. Vacuum pump, valving, piping and so forth are not shown in the figures to promote clarity of other features and because particular embodiments of vacuum related hardware are not considered critical to the instant invention. Except for the gate valve **47** embodied in filling head **48**, the combination of filling head **48** and hopper **49** are substantially functionally identical to the configuration shown in FIG. **5** of U.S. Pat. No. 2,613,864, Carter, which is hereby incorporated by reference along with the textual portions of that patent relating to the function of the two vacuum conduits **57** through which vacuum induced flow is periodically reversed to maintain screen **55** substantially free of particles.

Hopper **49** of each filling station **23**, FIG. **3**, of the preferred embodiment has a frusto conical wall **85** integrated with flange **86** which adapts hopper **49** for attachment (by means not shown in FIG. **3**) to filling head **48** so that outlet **87** at the bottom of the hopper is coincident with the upper end of passageway **60.** Located above hoppers **49** (but not shown in the figures) is a solid particle containing means such as a tub which is adapted to maintain sufficient amounts of solid particles in each hopper **49** to fill a container **24** therefrom during each revolution of turntable **21.**

Adjustable gate valve opening cam assembly **90**, including cam **45**, FIGS. **4** and **5**, is located adjacent the perimeter of the turret turntable **21**, only cam **45** of the assembly being shown in FIG. **1.** Cam **45**, FIG. **4**, has one end pivotally secured by pivot **99** to structure mounted baseplate **91** and its free end **92** is connected to means for moving free end **92** towards or away from the axis of shaft **22** of turntable **21.** Cam **45** is oriented with camming surface **93** disposed vertically and generally facing radially outwardly from axis of shaft **22** of turntable **21.** The position of cam **45**, FIG. **5**, is adjusted by turning handle **94** which is rigidly secured to jackscrew **95.** Jackscrew **95** is free to rotate relative to block **96**, FIG. **5**, but not free to translate relative thereto. Block **96** is pivotally secured to base plate **91.** The threaded portion of jackscrew **95** is threadingly engaged with block **97** which is secured to cam **45** by pivot **98**, FIG. **4**, spaced from pivot **99.** Thus, the linkage comprising jackscrew **95** and cam **45** is jointed to articulate as necessary upon turning handle **94** to cause block **97** to translate relative to jackscrew **95.** Translation of block **97** rotates cam **45** about pivot **99** to move its free end **92** closer or further from the axis of shaft **22** depending on the direction handle **94** is turned. The opening cam assembly **90** is disposed relative to the path of gyration of rollers **73** which are secured to positioning ends **72** of gates **70** so that rollers **73** roll on camming surface **93** as they pass thereby during the rotation of turntable **21.** Camming surface **93** is contoured to cam gates **70** from their closed position to an open position as the rollers **73** pass thereby. The open position, designated aperture-open position, is adjustable as described in order to control the area of aperture **80**, FIG. **2.**

Gate valve closing cam **46**, FIG. **1**, has a vertically disposed camming surface **105** which faces generally radially inwardly relative to the axis of shaft **22** of turntable **21.** It is rigidly secured to structure (not shown in the figures) at a position spaced from opening cam **45** around the perimeter of turntable **21.** Camming surface **105** is contoured to act on rollers **73** as they pass thereby to cam each gate **70** to its closed position.

Means for determining the average deviation of the weight of a plurality of filled containers is hereby designated deviation means **34**, FIG. **1.** Deviation means **34** is not considered essential to the instant invention. Weighing, averaging and computing the average weight deviation could be performed by the operator using a weighing scale and longhand math or the equivalent thereof.

Operation of the preferred embodiment powder filler **20**, FIG. **1**, entails synchronizing and indexing input conveyor **28**, spacing worm **27**, feed starwheel **29**, exit starwheel **31**, and takeaway conveyor **33** with rotating turret turntable **21** so that an empty container **24** is inserted into each cusp **106** of feed starwheel **29** which forwards the container around a circular path until it is transferred into a filling station **23** of the passing turntable; removing containers **24** from the turret as filling stations **23** subsequently pass exit starwheel **31**; forwarding containers **24** from the filler on takeaway conveyor **33** to weighing means for determining the average deviation from nominal filled weight of a plurality of containers **24**; and forwarding weighed filled containers **24** to suitable casing and/or storage facilities.

As container **24** moves along a clockwise circular path from pick-up position **30** towards pick-off position **32**, means (not shown in the figures) are provided for causing it to be telescoped over the depending portions of filling head **48** until its rim **81** sealingly abuts gasket **54**, FIG. **3.** Means (not shown in the figures)

then applies vacuum through a conduit 57 in filling head 48 to establish an adjustable level of vacuum within container 24 before gate valve 47 is opened. As the container laden filling station 23 passes valve opening cam 45, gate valve 47 is opened whereupon solid particles flow into the container 24 under the influence of gravity and vacuum induced pressure differential. Flow continues until the solid particles fill the container 24, and the passageway 60 is so full of solid particles that their natural repose blocks further flow. At that time, an annular void space 82 will be present in the container above the conically reposed pile of solid particles, indicated by line 108 in FIG. 3. Also, at the time flow of solid particles ceases, a void space 109 will exist in passageway 60 under gate 70 as indicated by line 110 if the gate valve was not opened far enough to completely withdraw gate 70 from passageway 60.

As turntable 21 continues to turn, moving container 24 towards pick-off position 32, gate valve 47 is closed by the action of closing cam 46 on roller 73. Then the vacuum source is blocked, container 24 is vented, and container 24 is lowered so that it can be removed from filling station 23 by exit starwheel 31 at pick-off position 32 without interfering with the depending portions of filling head 48. The filled container 24 is then forwarded on takeaway conveyor 33 whereupon it may be weighed manually (by means not shown) so that its weight may be used to compute the average deviation of the weight of a plurality of filled containers. Of course, this yields deviation of average weight per filled container 24 rather than apparent density of the product but for all intents and purposes the two parameters are nearly linearly related thereby validating the use of deviation from nominal weight of the average weight per filled container to determine what apparent density change is necessary to achieve nominal average weight of particles per filled container. Alternatively, weighing filled containers 24 exiting from the filler and determining the average weight deviation of a plurality of filled containers could be automated as indicated by deviation means 34, FIG. 1. The average weight deviation of filled containers is utilized by the operator of the apparatus to adjust valve opening cam 45 as hereinbefore described to reduce the deviation towards zero.

A more sophisticated automated apparatus for practicing the instant invention includes a feedback control system comprising deviation means 34, controller 115, and valve opening cam positioner 116, the elements of which are indicated by dotted lines in FIG. 1. It is considered well within the skill of a person having ordinary skill in feedback control systems to apply commercially available components to form such a system so the details thereof will not be delineated in great detail. Two feedback control systems applied to fillers are disclosed in U.S. Pat. No. 2,851,063 issued to R. K. Leinhart, Sept. 9, 1958, and U.S. Pat. No. 3,073,400, issued to U. Bauder et al, Jan. 15, 1963, referenced for convenience.

In such a sophisticated feedback control system, deviation means 34 provides an analog signal 117 having a fixed relationship to the average weight of a plurality of filled containers exiting from the filling apparatus. Analog signal 117 is used by controller 115 to generate repositioning signal 118 to cause the opening cam to be positioned by valve opening cam positioner 116 to reduce the deviation towards zero. For instance, to correct for below average weight, controller 115 causes opening cam 45 to be adjusted so that its free end 92 is closer to shaft 22 of turntable 21 causing gates 70 to be opened less. This increases the incidence of fracturing friable particles whereby a greater weight of smaller sized particles flow into each container 24 during the filling operation. Conversely, above average weight ultimately results in adjusting the opening cam to a more open position to increase the aperture-open area to reduce particle breakup during filling.

Valve opening cam positioner 116, FIG. 1, may also include a positon feedback means to generate a signal 119 which in effect tells controller 115 where cam 45 is positioned at all times. Or, limit switches or the like may be incorporated on the opening cam adjustor to detect whenever the opening cam is adjusted to its maximum area position or to its minimum area open position and to generate signal 119 to, in effect, tell controller 115 that the gate valve 47 has reached a limit. Thus, controller 115 will know whenever valve 47 has reached a position where it can no longer effect desired density control whereupon contorller 115 may be made to sound an alarm, energize a light, or otherwise indicate that the density is out of limits and cannot be corrected by adjusting aperture-open area of the gate valve 47.

Adjusting the level of vacuum by vacuum controller 120, FIG. 1, also affects breakup of friable particles. It has been determined empirically that increasing the level of vacuum increases apparent density and vice versa.

The range of density change that can be effected by modulating both the area of aperture 80 and the level of vacuum is somewhat cumulative. For instance, if gate 70 has been adjusted to either limit position in an effort to reduce the deviation to zero but has not succeeded in doing so, a stepwise change of vacuum level by vacuum controller 120 may be made to affect particle breakup sufficiently for control of density to be resumed by modulation of aperture 80. This mode of operation is hereby designated valve modulation/-vacuum override.

Alternatively, primary control of apparent particle density can be achieved over a limited range by modulating the level of vacuum between predetermined acceptable high and low limits without modulating the aperture-open area. If vacuum modulation is insufficient to maintain apparent particle density within acceptable limits, stepwise changes in the aperture-open area of the gate valve 47 can be made until control of apparent particle density can be resumed by vacuum level modulation. In such a scheme, hereby designated vacuum modulation/valve override, the high vacuum limit is commonly the limit of the vacuum pump and associated conduits while a low vacuum limit is established by the amount of oxygen that can be tolerated in a packed container. Such a vacuum modulation/-valve override system including high and low vacuum limit switches is not depicted in the figures because such a control system would function substantially identically to the valve modulation/vacuum override system that is depicted in the figures and discussed hereinbefore.

It will be understood that the elements comprising the filling station must be sized to adapt filler 20 to the

style and size of container **24** to be filled by the filler. For instance, gasket **54,** preferably has an outside diameter larger than and an inside diameter smaller than the corresponding dimensions of rim **81** of container **24.**

Many modifications of the above invention may be devised and it is not intended to hereby limit it to the particular embodiments shown or described. The terms used in describing the invention are used in their descriptive sense and not as terms of limitation, it being intended that all equivalents thereof be included within the scope of the appended claims.

What is claimed is:

1. A method of achieving substantially uniform average weight of successive containers filled with flowably solid friable particles from a hopper containing such particles through a closeable, variable open-area filling aperture, said method comprising:

successively positioning each unfilled container beneath said aperture when said aperture is closed, opening said aperture to fill said container with said friable particles, the flow of said friable particles into said container ceasing due to their natural angle of repose when said container becomes filled, closing said aperture after filling each said container, and forwarding each said filled container from beneath said aperture;

monitoring the average filled weight and determining the average weight deviation of said filled containers being forwarded from beneath said aperture by means suitable therefore; and

modulating the open-area of said aperture as a function of said deviation to increase the open-area if the average filled weight is above the nominal average and to decrease the open-area if the average filled weight is below nominal average,

whereby sufficient said friable particles are fractured during said filling to sufficiently reduce the average size of said particles to achieve the desired uniform weight of filled containers.

2. A method of achieving substantially uniform average weight of successive containers filled with flowably solid friable particles from a hopper containing such particles through a closeable, variable open-area filling aperture, said method comprising:

successively positioning each unfilled container beneath said aperture when said aperture is closed;

sealingly connecting the interior of each successive unfilled container to a controllable vacuum source; and then

evacuating each successive unfilled container to a pre-determined level of vacuum before opening said filling aperture;

opening said aperture to fill said container with said friable particles, the flow of said friable particles into said container ceasing due to their natural angle of response when said container becomes filled;

closing said aperture after filling each said container; and, after closing said filling aperture venting each filled container; then forwarding each said filled container from beneath said aperture;

monitoring the average filled weight of said filled containers being forwarded from beneath said aperture by means suitable therefore; and,

modulating the open-area of said aperture to increase the open-area if the average filled weight is below nominal average and to decrease the open-area if the average filled weight is below nominal average,

whereby sufficient said friable particles are fractured during said filling to sufficiently reduce the average size of said particles to achieve the desired uniform weight of filled containers.

3. The method of claim **2** further comprising increasing the predetermined level of vacuum in response to monitoring below average filled weight or decreasing the predetermined level of vacuum in response to monitoring above average filled weight.

4. The method of claim **3** where the predetermined level of vacuum is only adjusted if the full range of aperture open-area adjustment is not sufficient to fully achieve said nominal average filled weight.

5. The method of claim **3** where the open-area of the aperture is only adjusted if the full range of vacuum level adjustment is not sufficient to fully achieve said nominal average filled weight.

6. In a filling apparatus for filling successive containers with substantially uniform weights of friable particles of a flowable solid, said apparatus comprising a hopper, a filling head, and means for monitoring the average filled weight of preceding filled containers, said hopper being adapted to hold and dispense said particles, said filling head having a passageway therethrough juxtaposed with said hopper so that said particles are discharged from said hopper into said passageway, said filling head being adapted to receive an empty container juxtaposed subjacent thereto so that said particles flow from said passageway into said container, the improvement comprising a filling-aperture-forming valve disposed in said passageway which valve is operable between an adjustable-area open position and a closed position, and means for adjusting said adjustable-area open position, said valve adapted to substantially preclude flow of said particles through said passageway when closed and to form said filling-aperture when in the open position through which a stream of said particles passes from said hopper into said container, the cross-sectional area of said stream of said particles being a function of said adjustable-area of said valve, the improved apparatus further comprising means for determining the magnitude of the deviation of the average weight of a preceding plurality of filled containers from nominal average filled weight, and control means for adjusting said open position of said valve as a function of said deviation, said means acting to increase the area of the aperture in the open position to compensate for above average filled weight and to decrease the area of the aperture in the open position to compensate for below average filled weight whereby the average weight of successive filled containers can be maintained substantially constant by adjusting said open position in response to deviations from nominal of the average filled weight of a preceding plurality of filled containers.

7. In a filling apparatus for filling successive containers with friable particles of a flowable solid, said apparatus comprising a hopper, a filling head, and means for monitoring the average filled weight of preceding filled containers, said hopper being adapted to hold and dispense said particles, said filling head having a passageway therethrough juxtaposed with said hopper

so that said particles are discharged from said hopper into said passageway, said filling head being adapted to receive an empty container juxtaposed subjacent thereto so that said particles flow from said passageway into said container, the improvement comprising a filling-aperture-forming valve disposed in said passageway which valve is operable between an adjustable-area open position and a closed position, and means for adjusting said adjustable-area open position, said valve adapted to substantially preclude flow of said particles through said passageway when closed and to form said filling-aperture when in the open position through which a stream of said particles passes from said hopper into said container, the cross-sectional area of said stream of said particles being a function of said adjustable-area of said valve, said filling head further comprising means for sealing said container to said filling head, means for establishing a predetermined level of vacuum within said container before said valve is opened, and means for venting said container after said valve is closed, said vacuum acting to expedite the flow of said particles, and said venting assisting the removal of the container from the filling head whereby the average weight of successive filled containers can be maintained substantially constant by adjusting said open position in response to deviations from nominal of the average filled weight of a preceding plurality of filled containers.

8. The apparatus of claim **7** further comprising means for determining the magnitude of the deviation of the average weight of a preceding plurality of filled containers from nominal average filled weight, and control means for adjusting said open position of said valve as a function of said deviation, said control means acting to increase the area of the aperture in the open position to compensate for above average filled weight and to decrease the area of the aperture in the open position to compensate for below average filled weight.

9. The apparatus of claim **8** having adjustable means for establishing the level of vacuum, and control means therefore adapted to increase the level of vacuum to compensate for below average filled weight and to decrease the level of vacuum to compensate for above average filled weight.

10. The apparatus of claim **9** further including means for ascertaining when further adjustment of said open position of said valve is not available to compensate for said deviation, said vacuum level adjusting means being operative only when further adjustment of said open position of said valve is not available to compensate for said deviation.

11. The apparatus of claim **9** further including means for ascertaining when further adjustment of said vacuum level is not available to compensate for said deviation, said control means for adjusting said open position of said valve being operative only when such further adjustment of said vacuum level is not available to compensate for said deviation.

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