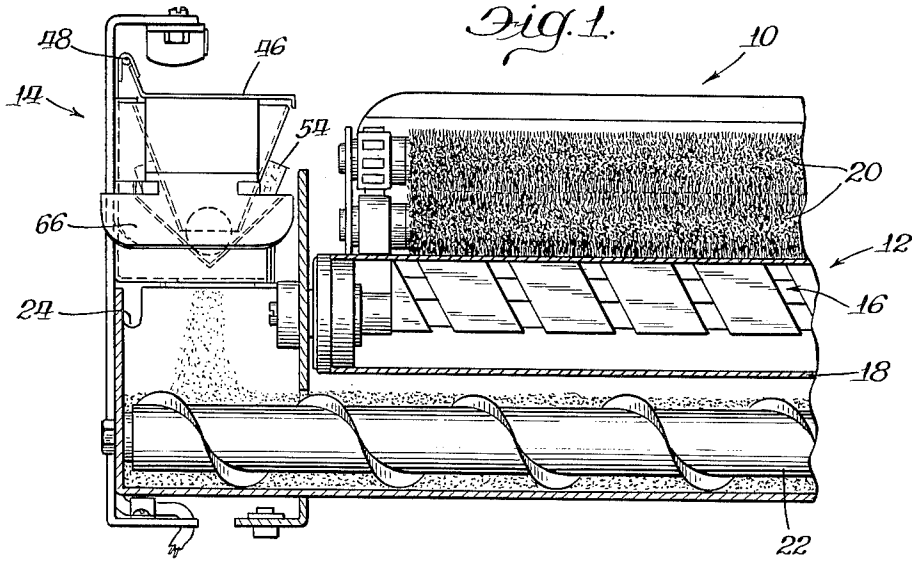
Dec. 21, 1965 R. L. GUNTO 3,224,649

MATERIAL DISPENSING APPARATUS

Filed March 20, 1964 2 Sheets-Sheet 1

Fig. 1.



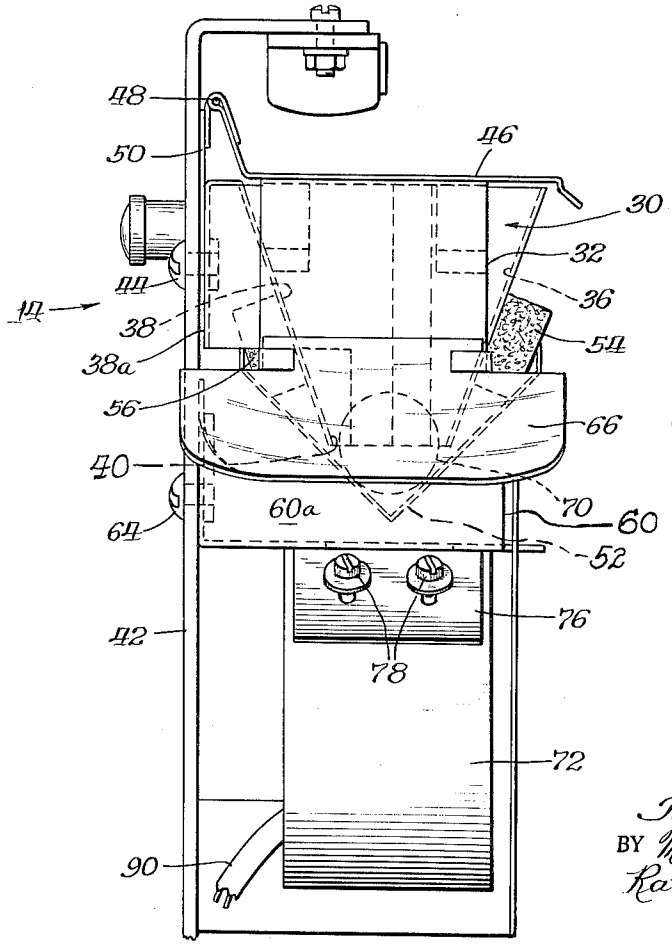


Fig. 2.

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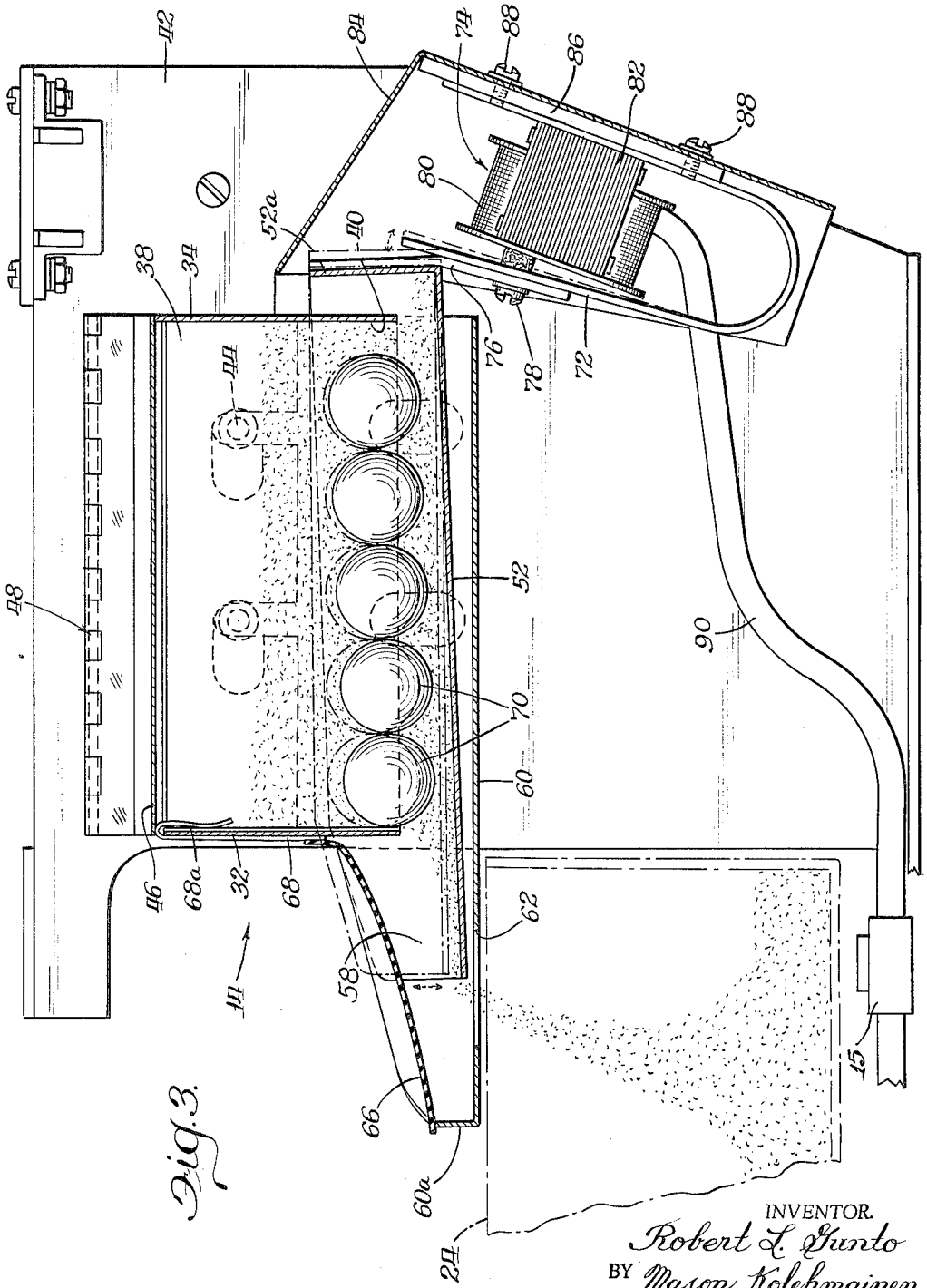

Fig. 3.

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MATERIAL DISPENSING APPARATUS

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10 Claims. (Cl. 222—199)

This invention relates to a material handling apparatus, and more particularly, to an apparatus for feeding or dispensing pulverulent or powdered material of small particle size.

Photoelectrostatic copying involves the conversion of a light image into an electrostatic latent image or charge pattern on a suitable photoconductive insulating material, such as, for example zinc oxide particles suspended in a resin binder. The latent electrostatic image is rendered visible by a development step in which the charged surface is brought into intimate physical contact with a suitable developer mix. This can be done by means of the well-known magnetic brush-type applicator. In some types of machines, the electroscopic powder is applied by causing the developer mix to cascade over the latent electrostatic image. Suitable developer mix compositions, well-known in the art, generally contain dyed or colored pigmented thermoplastic powders, known either as toner particles, or as electroscopic powders. The toner particles are admixed with larger particles such as, for example, iron powder to produce a satisfactory magnetic brush-type developer mix. This thermoplastic powder image is subsequently fixed or placed in permanent form by any suitable means, such as the application of a solvent or heat.

Developer mixes are formulated so that there is a definite relationship between the amount of magnetically attractable carrier particles and the amount of electroscopic powder present therein. Since a quantity of the electroscopic powder is carried off by each developed image, it is necessary to periodically supply additional toner or electroscopic powder to the carrier or magnetic particles in the developer mix in order to maintain a proper balance for satisfactory printing.

The individual particles of electroscopic powder, being thermoplastic in character and of a particle size falling in the range of between one and fifty microns with an average value of five microns, there is a pronounced tendency for the toner particles to agglomerate or pack in the assemblies previously used to automatically feed or meter the powder to the copying equipment. As an example, in one type of feeding assembly in which rotating knives are used in an attempt to insure even and uninterrupted feeding of the toner, the particles tend to pack or bridge adjacent the area swept by the moving knives with the result that the powder is not fed or is fed in large agglomerations unsuitable for uniform distribution throughout the developer mix. The assemblies for replenishing the developer powder should therefore be capable of supplying an even flow of powder in particulate form, and, preferably should also be of such construction that this can be done with toner fed into the assembly that has caked while in its original shipping container.

Accordingly, one object of the present invention is to provide a new and improved apparatus for feeding particulate material of small size.

Another object is to provide a feeding apparatus capable of supplying an even flow of small particulate material from a large body thereof.

Another object is to provide a particle feeding apparatus including a receptacle having a discharge opening in which is disposed a plurality of discrete material feeding elements resting on a vibrating element.

A further object is to provide an apparatus for feeding material from a receptacle having an elongated lower discharge opening in which a plurality of aligned spherically shaped elements are disposed on a vibrating and downwardly inclined feeding means.

A still further object is to provide an apparatus for intermittently feeding a metered amount of particulate material from a receptacle having an elongated lower discharge opening in which a plurality of aligned spherical elements are disposed on a vibrating element wherein said metered amount may be varied by adjusting the amount of vibration of the element.

In accordance with these and many other objects, an embodiment of the present invention comprises an assembly for feeding electroscopic or other material of small particle size from a large body thereof while avoiding substantial agglomeration or clumping of the particles. In the illustrated embodiment, this assembly comprises means for feeding electroscopic toner particles having an average size of five microns from a supply receptacle to a conveying means that mixes and distributes the electroscopic powder with the magnetic or carrier particles in the developer mix thereby maintaining the proper concentration of powder therein in order to achieve proper development of the electrostatic images. The supply receptacle is provided with spaced downwardly and inwardly inclined lower wall portions defining a horizontally extending discharge opening in which is disposed a plurality of elements having a generally spherical conformation and which rests on the legs of a downwardly inclined and generally V-shaped material feeding trough, the material feeding elements or spheres being disposed in alignment and forming a downwardly extending line corresponding to the degree of inclination of the V-shaped trough. The lower end of the trough is disposed above a material receiving receptacle from which the electroscopic powder is transported by a conveying and distributing means forming a portion of a magnetic brush assembly in an electrophotographic copying unit. The upper end of the V-shaped trough is connected to a vibrator or oscillating mechanism that periodically moves the V-shaped trough and the spheres resting thereon from a downwardly inclined position to one approaching a horizontal position.

Whenever a given amount of material is to be transferred from the supply receptacle thereof to the material receiving means, the vibrating or oscillating drive means is placed in operation to swing or pivot the trough from its downwardly inclined position to a position approaching the horizontal. During this movement, the spheres resting on the trough are moved upwardly varying distances depending on the position in which the supporting trough is engaged with the lowermost spheres experiencing the greatest vertical displacement as compared to the spheres immediately adjacent the vibrating source. Similarly the particles are moved upwardly and advanced toward the discharge opening of the receptacle in a manner typical of vibrating dispensers. The spheres tend to roll and collide with one another within the discharge opening of the receptacle tending to bias the lowest spheres against the end wall of said receptacle. The result is that these lowermost spheres which experience the greatest upward displacement and are restricted by the end wall of the receptacle are momentarily held in their elevated position when the feeding trough is restored to its normal or more sharply inclined position. This causes the spheres to fall back into engagement with the supporting trough in what approximates a sequence extending from the spheres engaging the higher portion of the trough to the spheres engaging the lower portion of the trough. This sequential falling back of the spheres simu-

lates a peristaltic feeding action which combines with the natural tendency of the particulate matter to move down a vibrating inclined surface to cause the material to be discharged from the lower end of the trough. It should be noted that the spherically-shaped elements are not uniform spheres but have a somewhat irregularly-shaped surface causing the spheres to experience a rotary motion in addition to the vertical displacement at the time they are vibrating in the discharge opening of the receptacle. This movement of the individual spheres relative to each other prevents agglomeration or bridging of the material within the supply receptacle and insures the feeding of the toner material in a particulate form from the supply receptacle to the receiving hopper. The size of the spheres relative to the dimension of the discharge opening also serves to meter a given amount of the particulate matter which can be varied by increasing or decreasing the amount of vibration.

Many other objects and advantages of the present invention will become apparent from considering the following detailed description in conjunction with the drawings in which:

FIG. 1 is a fragmentary elevational view in partial section of a magnetic brush assembly in combination with a material feeding apparatus embodying the present invention;

FIG. 2 is an enlarged end elevational view of the material feeding apparatus shown in FIG. 1; and

FIG. 3 is a side elevational view of the material apparatus with some of the components shown in section.

Referring now more specifically to FIG. 1 of the drawings, therein is illustrated a developer unit **10** for an electrophotographic copying machine. The unit **10** includes a magnetic brush assembly indicated generally as **12** which applies a developer mix including electroscopic developer powder and magnetic particles to the electrostatic image bearing surfaces of copy sheets fed through the machine in proximity to the magnetic brush assembly. Since the developer or electroscopic powder is depleted during the developing process, a powder feeding assembly **14** embodying the present invention is provided for feeding additional electroscopic powder to the developer mix to insure that this mix includes proper proportions of electroscopic powder and magnetic particles. The assembly **14** is capable of providing an even flow of electroscopic powder in particulate form at predetermined feeding intervals during which the assembly **14** is actuated such as, for example a function of the length of the original to be reproduced. The amount of toner metered out is controlled by increasing or decreasing the amount of vibration imparted to the assembly by adjusting a rheostat **15** (FIG. 3) which varies the amount of A.C. voltage applied to the assembly.

The magnetic brush assembly **12** with which the material feeding assembly **14** is associated can be of any of the known construction such as that shown and described in detail in United States Patent No. 3,003,462. The assembly **14** also can be used with entirely different types of equipment utilizing particulate material. In general, the illustrated magnetic brush assembly includes permanent magnetic means **16** secured in a fixed position within a rotating cylinder **18** so as to form a brush of bristle-like fingers of the developer mix. These bristles brush against the adjacent surface of a sheet containing an electrostatic image to be developed and selectively deposit only the electroscopic powder on the adjacent surface in accordance with the charge pattern thereon. The sheet bearing the developed or powder image is discharged from the unit **10** by a pair of feed rollers **20** having an outer periphery formed of nap or pile material which prevents smearing or other distortion of the powder image as the sheet is transported to a subsequent station at which the powder image is fixed or placed in permanent form. To replenish the supply of developer material depleted by normal use of the unit **10**, a material conveying and distributing screw **22** is mounted below the cylinder **18** and extends into a material receiving bin or hopper **24** to which the electroscopic powder is supplied by the assembly **14**. The rotation of the conveying screw **22** transfers the particulate material supplied to the hopper **24** from the assembly **14** to a position disposed adjacent the rotating drum **18** and also serves to mix the developer or electroscopic powder with the magnetic particles to provide a developer mix of uniform consistency.

The assembly **14**, shown in FIG. 2 and FIG. 3, for feeding the toner or electroscopic powder to the hopper or material receiving means **24**, includes a supply receptacle **30** (FIG. 2) having a front wall **32**, a rear wall **34** (FIG. 3), and a pair of downwardly and inwardly inclined side walls **36** and **38** defining an elongated bottom opening **40** through which the powder is discharged from the supply receptacle **30**. An offset portion on the side wall **38** includes a vertically extending wall **38***a* that is secured to a supporting frame element **42** by a plurality of machine screws or bolts **44** so as to mount the receptacle **30** on the frame of the machine in a position generally above and to one side of the hopper **24** (FIG. 3). The open top of the supply receptacle **30** through which electroscopic or toner powder is placed in this receptacle is normally closed by a lid or closure **46** that is pivotally connected by a hinge construction **48** to a mounting plate **50**. The mounting plate **50** is secured on the supporting frame **42** interposed between this frame and the vertical wall section **38***a* of the side wall **38** by the plurality of fasteners **44**.

To provide means for selectively feeding toner or electroscopic material discharged through the bottom opening **40** to the hopper **24**, a generally V-shaped trough member **52** is disposed in a somewhat nested position with the inclined side walls **36** and **38** of the supply receptacle **30** so that the apex of the trough member **52** is disposed below and in alignment with the discharge opening **40**. The opposite side walls of the trough means **52** are connected to the adjacent side walls **36** and **38** of the supply receptacle **30** by two blocks of resilient and flexible material **54** and **56**, such as sponge rubber. In its normal position, the trough **52** is mounted in an inclined position so that a lower end forming a discharge or outlet **58** (FIG. 3) from the trough means **52** is disposed above the material receiving bin or hopper **24**. A somewhat U-shaped member **60** disposed below the trough **52** and having an opening **62** (FIG. 3) therein through which the powder discharged from the outlet **58** of the trough **52** passes to the material receiving means **24** is secured on the frame **42** by a plurality of machine screws **64** (FIG. 2). To prevent loose particles of electroscopic powder from becoming entrained in the air and distributed about the interior of the machine, a flexible cover **66** (FIG. 2) is provided which rests on the side walls and the front wall **60***a* of the member **60** covering the discharge **58** from the trough **52**. The flexible cover **66** is secured at one end to a supporting member **68** having a hook-shaped upper end **68***a* that is detachably mounted on the front wall **32** of the supply receptacle **30** to permit the cover **66** to be removed.

To provide means for controlling the feeding and dispensing of the developer or electroscopic powder in particulate form from the supply receptacle **30** through the trough means **52** to the receiving means **24**, a plurality of discrete material feeding elements or spheres **70** are disposed in the discharge opening **40** resting on the opposite side walls of the trough means **52** (FIG. 2). The spheres **70** substantially fill the discharge opening **40** and are spaced slightly above the apex of the V-shaped trough means **52**. In view of the downwardly inclined position of the trough **52** on which the spheres **70** rest, these spheres tend to roll to the left (FIG. 3) to bear against each other, the lowermost sphere **70** bearing against the end wall **32** of the supply receptacle **30**. In this position, the uppermost sphere **70** or the sphere **70** positioned to

the right in FIG. 3 is disposed more completely within the supply receptacle 30 than the lowermost sphere 70, i.e., the sphere disposed at the extreme left in FIG. 3. The spheres 70 are irregularly shaped quartz balls of the type commonly used in pebble mills, but they can be formed of any suitable material such as steel or ceramic substances which are compatible with the electroscopic powder.

To provide means for vibrating or imparting a combined oscillating and swinging movement to the trough means 52, a vertically extending back wall 52*a* closing the rear end of the trough means 52 is secured to a resilient armature 72 of a vibrator assembly indicated generally as 74 by an offset mounting plate 76 which is secured to the element 72 by a plurality of machine screws or headed fasteners 78. The vibrator assembly 74, which includes an operating winding 80 and a magnetic field structure 82, is secured to a somewhat open housing 84 carried on the frame 42 by a supporting plate 86 and a plurality of machine screws 88. The operating winding 80 is selectively connected to a potential source by a line cord 90. When the winding 80 in the vibrator assembly 74 is not energized, the trough means 52 occupies the position illustrated in solid line in FIG. 3 of the drawings.

When the assembly 14 is placed in operation to feed electroscopic particles from the supply receptacle 30 to the material receiving hopper 24, the operating winding 80 is energized to intermittently attract and release the resilient magnetic armature 72 so that this element moves between positions illustrated in solid and dashed outline in FIG. 3. This produces movement of the trough 52 between the normal position shown in solid outline and the displaced position shown in dashed outline in this figure, which displacement can be varied by increasing or decreasing the power input to the operating winding 80 by adjusting the rheostat control 15 (FIG. 3). More specifically, when the magnetic armature 72 is moved to the right toward the field structure 82, the left-hand end of the trough 52 swings upwardly to the position shown in dashed outline. Since the spheres 70 rest on the walls of the trough means 52, these spheres are also elevated within the discharge opening 40 of the supply receptacle 30, the left-hand spheres 70 moving through a greater distance than the right-hand spheres 70 because of their greater displacement from the point about which the trough 52 is pivoted or oscillated. The spheres 70 move upwardly and tend to loosen the toner material in the adjacent portion of the supply receptacle 30.

When the armature 72 is released and returns to its normal position due to its inherent resilience, the trough 52 similarly is returned to its normal position shown in solid outline in FIG. 3. This moves the supporting walls away from the spheres 70. Since these spheres are biased to the left by the force of gravity, the left-hand spheres are held against the front wall 32 of the receptacle 30 and against each other, and they tend to remain in their elevated position when the trough 52 is restored to its normal position. The right-hand spheres tend to be the first to fall to a position engaging the walls of the trough 52. As the right-hand spheres drop, the biasing force applied to the left-hand spheres is removed so that these spheres tend to drop in sequence proceeding from the right-hand spheres 70 to the left-hand spheres 70. This sequential return of the spheres 70 to positions engaging the walls of the trough tends to move the powdered toner or electroscopic material that has fallen below these spheres to the left in a wave-like motion approximating a peristaltic action. This wave-like movement of the material caused by the sequential return of the spheres 70 coupled with the natural tendency of this material to move down the inclined trough means 52 due to the force of gravity during vibration of the trough means provides an even and uninterrupted flow of powder or pulverulent material to the material receiving receptacle 24. The relatively small clearance between the walls defining the discharge opening 40 and the spheres 70 coupled with the relatively small clearance between these spheres and the walls of the trough 52 cooperates with the reciprocating movement of these spheres to insure that the powder or pulverulent material is not agglomerated or compacted and thus delivers the electroscopic powder to the receptacle 24 in particulate form.

Although the present invention has been described with reference to a single illustrative embodiment thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this invention.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. A pulverulent material dispenser comprising a receptacle for receiving the material and having a bottom opening, a generally V-shaped trough disposed below the bottom opening, a plurality of spheres loosely resting on the trough and extending upwardly into the opening, and means for vibrating the trough and the spheres.

2. A powdered material feeding apparatus comprising a receptacle mounted in a fixed position for receiving the material and having a pair of spaced and inwardly directed side walls defining an elongated bottom opening through which the material is discharged, a supporting structure disposed below the opening, a plurality of spheres loosely resting on the supporting structure and generally disposed in a line at least partially within the opening, and means for periodically moving the supporting structure and the spheres resting on the structure between an inclined position and a position closer to horizontal to raise and lower the spheres within the opening in the receptacle so that the material is fed out of the elongated opening around the spheres.

3. A pulverulent material dispenser comprising a receptacle having opposed downwardly and inwardly inclined walls forming a bottom opening, a generally V-shaped trough disposed below and in alignment with the opening in the receptacle, a plurality of discrete elements loosely resting on the trough and extending upwardly into the opening in the receptacle, a plurality of elements forming a line extending substantially the full length of the opening, and means for vibrating the trough and the discrete elements to discharge pulverulent material from the receptacle.

4. A pulverulent material dispenser comprising a receptacle having opposed downwardly and inwardly inclined walls forming a bottom opening, a generally V-shaped trough disposed below and in alignment with the opening in the receptacle, a plurality of spheres disposed in alignment in said opening and resting loosely on the trough, and means for imparting vertically and horizontally directed movement to the trough and the spheres to feed the pulverulent material from the receptacle to the trough.

5. An apparatus for dispensing pulverulent material comprising a receptacle having a bottom opening, a downwardly inclined trough means disposed below and in alignment with the opening, the lower end of the trough means providing a material discharge, a plurality of discrete material feeding elements disposed in the opening and resting on the trough means, and means connected to the upper end of the trough means for imparting an oscillatory swinging movement to the trough to vibrate both the trough means and the plurality of discrete material feeding elements to feed material to and discharge metered amounts of material from the trough means.

6. A powdered material dispensing apparatus comprising a receptacle having a downwardly and inwardly inclined wall structure defining a bottom opening, trough means disposed below the opening and inclined slightly downwardly, the lower end of the trough providing a material discharge, a plurality of discrete elements disposed in the opening, and vibrating means secured to the upper

end of the trough means for imparting an oscillatory swinging movement to the trough means so that it moves the discrete elements to feed material from the receptacle to the trough means, the oscillatory movement also discharging material from the trough means.

7. A powdered material dispensing apparatus comprising a receptacle having a downwardly and inwardly inclined wall structure defining a bottom opening, trough means disposed below the opening and inclined slightly downwardly, the lower end of the trough providing a material discharge, a plurality of spheres disposed in the opening and loosely resting on the trough, the plurality of spheres being disposed in substantial alignment within the opening and having a diameter no greater than the transverse dimension of the opening, and means for imparting oscillatory movement to the trough means and the spheres to feed material from the receptacle to the trough means and to discharge metered amounts of material from the trough means.

8. An apparatus for dispensing pulverulent material comprising a receptacle having an inwardly tapered lower portion defining an opening, a generally V-shaped trough disposed below the opening with the walls of the trough extending upwardly adjacent the tapered lower portion of the receptacle, a plurality of spheres loosely disposed within the trough and the receptacle, and means for imparting oscillatory movement to the trough and the spheres to feed material from the receptacle into the trough and to discharge metered amounts of material from the trough.

9. An apparatus for feeding pulverulent material comprising material receiving means, material conveying means communicating with the receiving means for removing material from the receiving means, a material receptacle disposed above said material receiving means and adapted to receive a supply of the material, said receptacle including a tapered lower wall portion forming an elongated opening, trough means mounted below said receptacle in a nesting relation with at least a part of the tapered lower wall portion, said trough means extending generally transverse to the material conveying means and having a discharge portion disposed above the material receiving means, a plurality of discrete material feeding elements disposed in the nested portion of the receptacle and trough means and generally aligned with the elongated openings, and variable drive means for vibrating the trough means to feed a metered amount of material from the trough means to the material receiving means through the discharge portion.

10. The apparatus set forth in claim 9 in which the trough means is inclined upwardly from the discharge portion and including means for connecting the drive means to the trough means at a position spaced above the discharge portion.

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