ABSTRACT: Apparatus for feeding powdered material from a hopper in which a cup-shaped flexible diaphragm is mounted on the lower end of a hopper so as to receive downwardly flowing powdered material in the hopper. The diaphragm has a central outlet opening adjacent its lower end, and pusher members are provided for flexing the diaphragm so as to provide for a rolling back and forth movement of powdered material in the diaphragm and across the outlet opening, thereby preventing compacting and bridging of the powdered material prior to flow through the outlet opening.
DISPENSING HOPPER WITH FLEXIBLE-WALLED DISCHARGE COMPARTMENT

BACKGROUND OF THE INVENTION

The feeding of powdered material, such as ceramic powder and materials of a similar fine particle nature, is difficult because the material tends to compact and bridge. Prior attempts to prevent this bridging have considered the use of flexible hoppers and flexible discharge portions. For example, Hughes U.S. Pat. No. 2,520,545, shows a feeder in which portions of the hopper are formed of flexible material and rocking plates are provided for flexing these hopper portions; Lemmon U.S. Pat. No. 3,346,917, shows a hopper provided with a flexible lining; Davis U.S. Pat. No. 2,732,099, shows a hopper provided with distensible membranes; and Vogt U.S. Pat. No. 3,045,717, shows a flexible hopper lining which is flexed by pushing elements. However, none of these solutions to the bridging and arching problems involved in feeding this type of material have utilized a cup-shaped flexible diaphragm which is flexed so as to promote a rolling back and forth motion of the powdered material across the outlet.

It is an object of this invention, therefore, to provide an improved feeder for material of the above-described type.

SUMMARY OF THE INVENTION

The apparatus of this invention includes a hopper for the powdered material, one or more flexible container-shaped diaphragms mounted on the lower end of the hopper so as to receive powdered material therefrom, and pusher members for flexing the diaphragms so as to obtain the desired rolling back and forth movement of the powdered material in the diaphragms. This material then flows freely out of the diaphragms through outlets formed in the lower ends thereof.

The pusher members are actuated by a cam and a cam follower assembly which provides for movement of the pusher members through nonsymmetrical patterns of movement. In other words, when the pusher members are being moved toward each other, at a given instant one of the pusher members is moved more than the other thereby imparting the desired components of horizontal force to the powdered material in the diaphragms. This causes the material in each diaphragm to move, during each cycle of pusher movement back and forth in a rolling path so as to prevent bridging and compacting of the material.

In addition, the diaphragm is flexed so as to compress its internal volume thereby increasing the pressure inside the hopper, which is air tight, so as to assist onward flow of material from the diaphragms. At the completion of each cycle of flexing movement of the diaphragm an air inlet to the hopper is opened to compensate for the lower pressure in the hopper caused by return of each diaphragm to its unflexed position and the reduced volume of material in the hopper due to feeding. As a result, in the feeding apparatus of this invention the flexible diaphragms, the pusher members, and the hopper air inlet cooperate to provide for a moving pumping action on the powdered material causing it to flow at a uniform rate out of the feeding apparatus.

Further objects, features and advantages of this invention will become apparent from a consideration of the following description, the appended claims, and the accompanying drawing in which:

FIG. 1 is a fragmentary perspective view of the feeding apparatus of this invention;
FIG. 2 is a side elevational view of a portion of the feeding apparatus of this invention;
FIG. 3 is an enlarged transverse sectional view of a portion of the apparatus of this invention illustrating the unflexed position of a diaphragm in the apparatus;
FIG. 4 is a side elevational view of a portion of the apparatus of this invention showing the cam and cam follower assembly in one position; and
FIGS. 5, 6 and 7 are side elevational views illustrated similarly to FIG. 4, showing the cam and cam follower in progressively moved positions.

With reference to the drawing, the feeding apparatus of this invention, indicated generally at 10, is illustrated in FIG. 1 as including a main supporting frame 12, a hopper 14 mounted on the frame 12 and provided with a sloping wall 16 causing material therein to flow under the action of gravity toward the lower end 18 of the hopper 14. The lower end 18 of the hopper 14 is provided, in the illustrated embodiment of the invention, with a pair of circular discharge openings 19 (FIG. 3), only one of which is shown bounded by downwardly extending flanges 21. It is to be understood that the hopper 14 can be of any desired shape, so long as it provides for gravity movement of powdered material therein toward the lower or discharge openings 19 in the hopper. The hopper 14 also has a cover 20 which is mounted in a fluid tight relation thereon to provide an airtight hopper 14.

A pair of generally cup-shaped diaphragms 22 are mounted in a side-by-side relation on the lower end 18 of the hopper 14 so that material in the hopper 14 will flow downwardly into the diaphragms 22. As shown in FIG. 3, each diaphragm 22 has its upper end 23 extended about a hopper flange 21 and clamped thereto by a clamping ring 25. It is to be understood that the diaphragms 22 may be provided in any desired number, and the apparatus 10 can be used with only a single diaphragm 22 if desired. Each diaphragm 22 is provided at its lower end with an outlet fitting 24 having an open upper end 26 through which it is desired to have the powdered material from the hopper 14 flow at a uniform rate.

As shown in FIG. 3, each diaphragm 22 is positioned between a pair of pusher members 28 each of which is of a generally semispherical shape in the illustrated embodiment of the invention. The pusher members 28 are mounted on pusher bars 30 which extend horizontally and are secured at one of their ends to upwardly extending arms 32 and at their opposite ends to upwardly extending follower arms 34 and 36. The arms 32 (FIG. 2) are mounted intermediate their ends on pivot members 38 carried by the hopper 14, and the arms 34 and 36 are similarly mounted intermediate their ends on pivot members 40 which are substantially coaxial with the pivot members 38. A tension spring 42 is connected to and extends between the upper ends of the arms 32 so as to urge the arms 34 and 36 toward each other.

A rotatable cam member 44, of elongated rod shape having substantially parallel straight sides 46 and rounded ends 48 is mounted on a point midway between its ends on a shaft 50 for rotation in a counterclockwise direction from its side views shown in FIGS. 4—6. The springs 42 maintain the inner sides 52 of the arms 34 and 36 in engagement at all times with the cam 44. As shown in FIG. 4, the arm sides 52, which function as follower surfaces, are substantially straight and are nonparallel at all times being inclined upwardly toward each other in the vertically extending positions of the cam 44 shown in FIG. 4.

In the position of the cam 44 shown in FIG. 4, the arms 34 and 36 are spaced equal distances from a vertical plane 54 extending through the shaft 50 and through a central portion of the diaphragm 22. A motor and speed reducer assembly 56, mounted on a bracket 58 secured to the main frame 12, drives the shaft 50 on which the cam 44 is mounted so as to rotate the cam 44 in a counterclockwise direction as viewed in FIG. 4. By virtue of the relative arrangement of the follower surfaces 52 and the cam 44, this rotation of the cam 44 will cause the arms 34 and 36 to move through nonsymmetrical patterns of movement relative to the diaphragm 22. In other words, rotation of cam 44 will cause the arms 34 and 36 to move so that the pusher members 28 are at any given instant moving at different speeds relative to the diaphragm 22 except at those times when the pusher members 28 are moving at zero velocity. For example, when the cam 44 has moved from its FIG. 4 to its FIG. 5 position, the arm 34 has been moved further toward the plane 54 than has the arm 36, even though the pusher members 28 have been moved toward each other.
so as to compress the diaphragm 22. This movement will cause the powdered material in the diaphragms 22 to be moved to the left as viewed in FIG. 5, will also cause it to be moved upwardly by virtue of the squeezing action exerted on the diaphragms 22 and will also increase the pressure in the hopper 14 because the volume of the diaphragms 22 has been reduced by compression of the diaphragms.

By the time the cam 44 has moved through 90° angle, to the position shown in FIG. 6, the velocity of the pusher members 28 has been reduced to zero and the squeezing action of the diaphragms 22 has been completed, but during movement of the cam 44 from the FIG. 5 to the FIG. 6 position, the arm 36 has been moving inwardly at a faster rate than the arm 34 so that the material in the hopper will have had forces imparted to it causing it to move to the right as viewed in FIG. 6. When the cam 44 is further rotated to the position shown in FIG. 7, the arm 34 has commenced moving away from the arm 36 which is continuing to move inward. Consequently, the material in the diaphragm 22 will have continued to have been moved toward the right as viewed in FIG. 7. This cycle continues until the cam 44 has been moved 180° to again position it in the position shown in FIG. 4. Thus, as the cam 44 rotates, a continual back and forth rolling motion is imparted to the powdered material in the diaphragms 22.

The hopper 14 is provided adjacent its upper end with an air inlet opening 60 and a pivoted L-shaped arm 62 is mounted on the hopper 14 so that one end thereof is normally in a position closing the opening 60 and is maintained in this position by a spring 66 which extends between the hopper 14 and the arm 62. The opposite end of the arm 62 carries a projection 68 which is engaged by the cam 44 only in the vertically extending position thereof illustrated in FIG. 4 so as to move the arm 62 in a counterclockwise direction moving the arm end 64 into a clearance relation with the air inlet opening 60, thereby allowing air to flow into or out of the hopper 14.

In the operation of the feeding apparatus 10, the cam 44 is continuously rotated by the shaft 50 so as to move the pusher members 28 in the above-described manner to impart a rolling back and forth movement to powdered material within the diaphragms 22. During each full circle cycle of rotation of the cam 44, each diaphragm 22 is squeezed twice and the air inlet opening 60 is opened twice. When the opening 60 is closed, the pressure in the hopper 14 is increased by the reduction in volume of the diaphragms 22 and this pressure increase helps to force the powered material through the outlet opening 26. The net result is a uniform and continuous flow of material through the outlet opening 26. It will be understood that the feeding apparatus which is herein disclosed and described is presented for purposes of explanation and illustration and is not intended to indicate limits of the invention, the scope of which is defined by the following claims.

1 claim:
1. Apparatus for feeding powdered material comprising an upright hopper having a lower discharge end, a generally cup-shaped member formed of a flexible material and mounted on the lower end of said hopper at a position in communication with said hopper for receiving downwardly flowing powdered material therefrom, outlet means for said flexible member located substantially centrally thereof and adjacent the lower end thereof, rockable pusher members movable substantially laterally of and back and forth toward the vertical plane of said outlet means, and means including a drive for moving said pusher members through nonsymmetrical patterns of cyclical movement in which said pusher members move generally toward each other at unequal velocities during at least a portion of each cycle so as to cause powdered material in said flexible member to move in a direction having a horizontal component extending across said outlet means during said portion of each cycle and to discharge from said outlet means during a further portion of said cycle.

2. Apparatus comprising:
a. an upright hopper having a lower discharge end;
b. a diaphragm of upwardly concave shape formed of a flexible material and secured to said hopper discharge end;
c. means forming an outlet opening for said diaphragm adjacent the lower end thereof;
d. a pair of pusher members engaged with horizontally opposite sides of said diaphragm;
e. coating cam and cam follower means for moving said pusher members through a cycle in which said members are moved toward each other to compress said diaphragm and away from each other to allow said diaphragm to flex to its original uncompressed shape;
f. top cover means on said hopper in a substantially fluid tight relation therewith;
g. means providing an air inlet opening for said hopper adjacent said top cover means, means arranged in a closing relation with said air inlet opening; and
h. means engaged with said cam means and operable in one position thereof for moving said air inlet opening closing means to a position spaced from said air inlet opening, said one position of said cam member being a position thereof in which said pusher members are moved away from each other to allow said diaphragm to return to its uncompressed shape.

3. Apparatus according to claim 1 wherein said means for moving said pusher members includes coating cam and cam follower means operatively associated with said pusher members.

4. Apparatus according to claim 3 wherein said cam and cam follower means includes a pair of rotatably mounted cam followers attached to said pusher members and having follower surfaces which are nonparallel, and a cam member rotatably mounted between and in engagement with said surfaces and operable on rotation to rotate said followers at unequal instantaneous speeds in relatively opposite directions.

5. Apparatus according to claim 4 further including spring means urging said cam follower surfaces toward and into engagement with said cam.

6. Apparatus according to claim 5 wherein said cam member is of a noncircular substantially symmetrical shape.

7. Apparatus according to claim 6 wherein said follower surfaces are substantially straight surfaces.