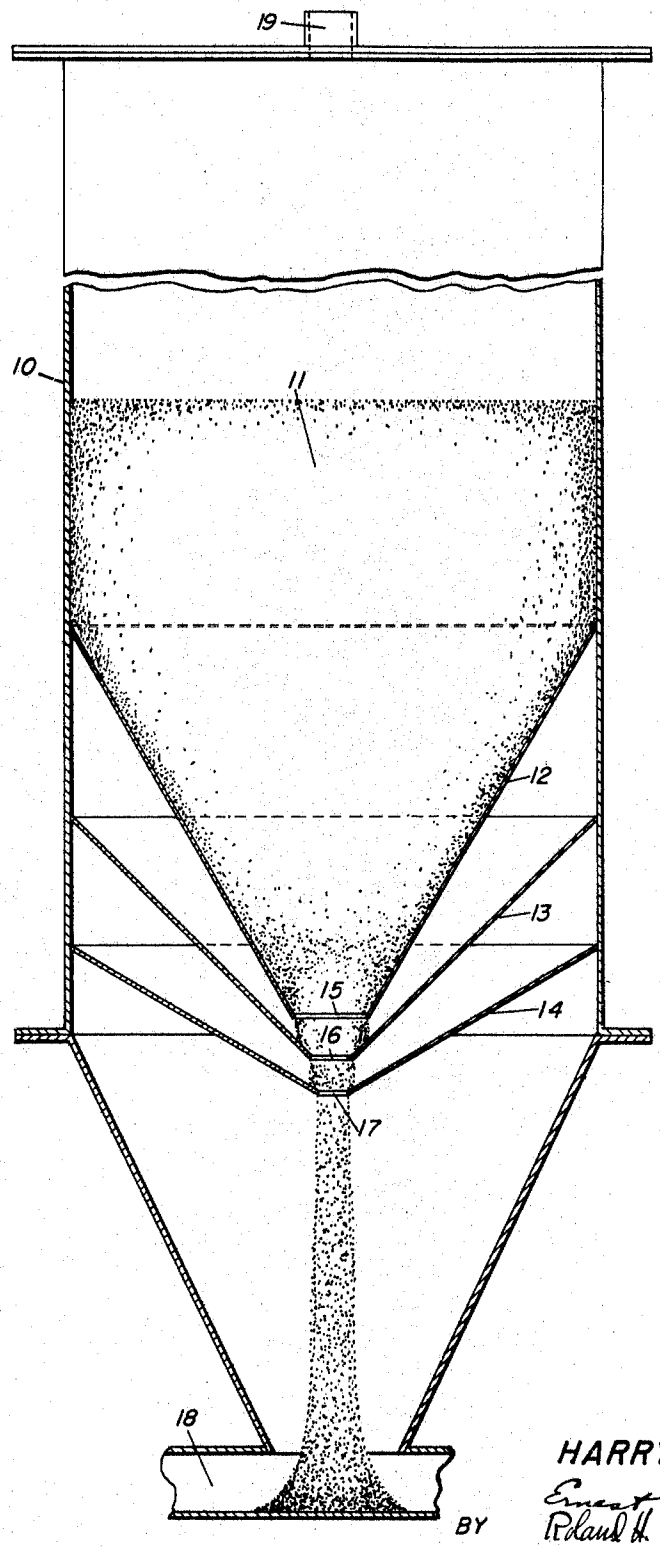
Dec. 23, 1969 H. G. LUCAS 3,485,420

PARTICLE FEEDER WITH WALLS OF PROGRESSIVELY INCREASING RESISTANCE

Filed Aug. 13, 1968



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United States Patent Office 3,485,420
Patented Dec. 23, 1969

3,485,420

PARTICLE FEEDER WITH WALLS OF PROGRESSIVELY INCREASING RESISTANCE

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Filed Aug. 13, 1968, Ser. No. 752,270
Int. Cl. B67d 3/00; B65g 47/19
U.S. Cl. 222—564 9 Claims

ABSTRACT OF THE DISCLOSURE

An orifice-type particle feeder having multiple orifices spaced apart in vertical alignment and decreasing progressively in size from the uppermost to the lowermost orifice.

This invention resulted from work done by the Bureau of Mines of the Department of the Interior, and the domestic title to the invention is in the Government.

Background of the invention

In the testing or processing of particulate solid materials, it is often desirable and sometimes necessary to introduce a stream of particulate material into a reaction or testing chamber at a uniform and constant rate. There are a number of mechanical or mechanical-pneumatic feeders which have been developed for this purpose. Examples of such feeders are various types of rotating valves, screw feeders and the like. All of these feeders produce a pulsing flow of solids. Only orifice controlled feeders provide a non-pulsing flow and in these the discharge rate is not constant.

Flow of solids through an orifice is a very complex phenomenon. Flow rate through an orifice is very roughly proportional to the cube of the orifice diameter but is also dependent upon the slope of the area surrounding the orifice, the solids head above the orifice, the size and shape of the individual particles flowing through the orifice, and the size distribution of the particulate material. Orifice feeders generally are unsatisfactory for use with a particulate material having a wide variation in the size distribution of indivdual particles.

It has now been found that these previously recognized disadvantages of an orifice feeder may be overcome in a very simple manner. By providing multiple, spaced apart, vertically arranged orifices of decreasing size from top to bottom, there is effectively provided a constant solids head on the lowermost, or rate controlling orifice. In this manner, flow variations which would normally be produced by a varying solids head are complete eliminated. In addition, if the slope of the area surrounding each orifice is made progressively less from the uppermost orifice to the lowermost orifice, then flow variations introduced by changes in the size distribution of the particulate material are also eliminated.

Hence, it is an object of this invention to provide a device for the regulated feeding of a particulate material.

It is another object of this invention to assure the uniform flow of particulate material through a feeding device.

Detailed description of the invention

The invention will be more clearly understood from the following description of a preferred emobodiment wherein reference is made to the accompanying drawing.

The figure is a sectional view of the orifice feeder.

Referring now to the figure, there is provided a housing or chamber **10** which functions both as a surge storage volume for the particulate solid material **11** and as a structural support for flow restrictors **12, 13 and 14.**

Housing **10** is preferably, but not necessarily, of cylindrical configuration and flow restrictors **12, 13** and **14** are preferably of inverted conical form truncated at their apices to form orifices **15, 16** and **17**, respectively. While there is shown three flow restrictors and orifices, the number of such restrictors and orifices may vary from as few as two to as many as six or seven. It has been found that best results are obtained with most particulate materials using either three or four orifices in series.

Orifices **15, 16** and **17** are aligned vertically and the orifice size decreases progressively from top to bottom of the array. For example, in the feeding of phosphate rock having a size range of approximately 0.075 to 3.2 mm., a series of 4 orifices having a sizes of approximately 19, 13, 9.5 and 7.9 mm. from top to bottom, respectively, delivered a constant rate, nonsurging flow. It is important that the lowermost orifice, which is the smallest and therefore is the rate controlling orifice, be at least about twice the diameter of the largest particle in the material being metered so as to prevent physical plugging or bridging of the orifice.

In the cases where the particulate material has a significant variation in particle size, it is also important that the slope of the flow restrictors be progressively decreased from the uppermost restrictor to the lowermost restrictor. Slope of the uppermost restrictor may be as great as about 70° while the slope of the lowermost restrictor may be as little as about 10°. Generally it is advantageous to vary the slope of the restrictors from about 60° on the uppermost restrictor to about 30° on the lowermost restrictor.

In a most preferred embodiment, the vertical spacing between the planes defined by the orifices in the flow restrictors also progressively decreases from top to bottom. As shown in the drawing, the distance between the planes defined by orifices **15** and **16** is greater than the distance between the planes defined by orifices **16** and **17**. As a general rule, the distance between the planes defined by successive orifies should be less than the diameter of the upper orifice. Referring specifically to the drawing, for example, the distance between the planes defined by orifices **15** and **16** should be less than the diameter of orifice **15**. This distance or spacing may conveniently be in the range of 0.2 to 0.9 upper orifice diameters. Spacing between the flow restrictors, orifice sizes, flow restrictor slopes and number of flow restrictors are set according to the flow rate desired and the properties of the materials being fed.

In the drawing, the orifice feeder is illustrated as discharging into a pneumatic pick-up line **18**. Solids have also been successfully fed into a screw conveyor, into a fluidized bed, and directly into a pressurized reactor. During operation, particulate material in the storage volume above the flow restrictors may be replenished from any convenient source through entry port **19**.

Lowest constant feeding rate so far achieved has been the feeding of 200–325 mesh fly ash to a particle monitor at the rate of 1.4 g./hr. In another use of the device, coal char has been fed into a fluidized bed at constant rates as low as 4 g./hr. and as high as 27.5 kg./hr. Particulate solids varying in size from 0.04 to 3 mm. and varying in density from 0.8 to 2.4 have been successfully fed at a constant rate using this device. Performance of the device has been found to be independent of feeding rate, in other words scale-up to any desired size introduces no problems. Likewise, size consist and density of the particulate material do not appear to affect performance, provided of course that maximum particle size is compatible with orifice size or feeding rate.

When using the orifice feeder to introduce material into a pressurized reactor, it has been found advantageous to maintain a slight positive gas pressure, relative to reactor

pressure, in the storage area of the feeder. In this circumstance, it is also convenient to introduce particulate material into the storage volume of the feeder by means of pressurized lock hoppers communicating with entry port **19** in a manner well known in the art.

What is claimed is:

1. A device for the feeding of particulate solid material at a substantially constant rate comprising a chamber having disposed in the lower portion thereof multiple vertically spaced-apart flow restrictors, each of said flow restrictors sloping downwardly from the walls of said chamber to a single central orifice, the downward slope of said flow restrictors progressively decreasing from the uppermost one of said flow restrictors to the lowermost one of said flow restrictors, the area of said orifices decreasing progressively from the uppermost orifice to the lowermost orifice and all of said orifices being in substantial vertical alignment.

2. The device of claim **1** wherein the planes defined by said orifices are parallel.

3. The device of claim **2** wherein the spacing of planes defined by said orifices becomes progressively less from the uppermost flow restrictor to the lowermost flow restrictor.

4. The device of claim **3** wherein the planes defined by said orifices are substantially horizontal.

5. The device of claim **4** wherein said chamber is of circular cross section and wherein said flow restrictors comprise downwardly pointing cones, the end of each cone being truncated to form a circular orifice.

6. The device of claim **5** wherein the spacing of horizontal planes formed by any two adjacent orifices is less than the diameter of the uppermost of said orifices.

7. The device of claim **6** wherein the downward slope of the uppermost of said flow restrictors is less than about 70° relative to the horizontal and the downward slope of the lowermost of said flow restrictors is greater than about 10° relative to the horizontal.

8. The device of claim **7** wherein said solid particulate material is fed into a zone maintained at a pressure different from atmospheric and wherein the pressure in said chamber is maintained equal to or slightly greater than the pressure within said zone.

9. A method of feeding solid particulate material at a substantially constant rate which comprises passing said material downwardly under the influence of gravity through a series of flow restrictors, each of said restrictors offering progressively greater resistance to the flow of said material and each of said restrictors offering a progressively decreasing angle of repose to the downwardly moving particulate material stream.

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