Nov. 5, 1968 E. J. KELLY 3,409,273

METHOD AND APPARATUS FOR BLENDING PULVERULENT MATERIALS

Filed Nov. 17, 1967

FIG. 1.

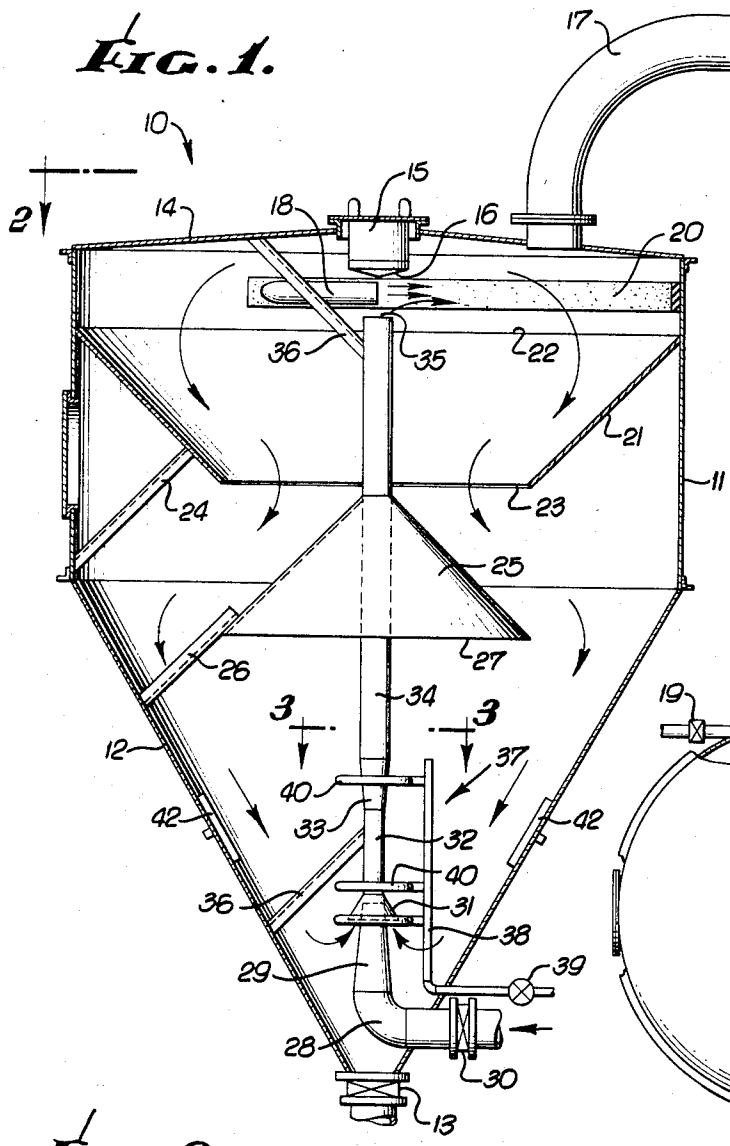


FIG. 4.

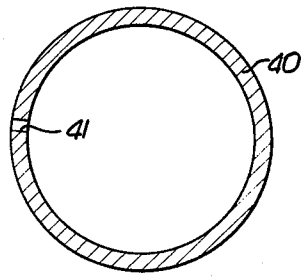


FIG. 2.

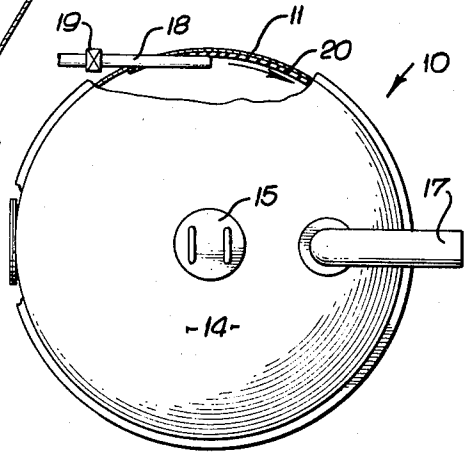
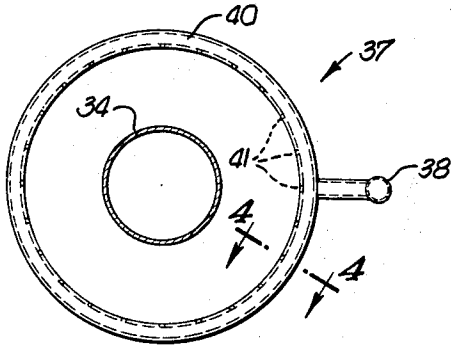


FIG. 3.



INVENTOR.
EDGAR J. KELLY
By
Miketta, Glenny, Pome & Smith
ATTORNEYS.

United States Patent Office 3,409,273
Patented Nov. 5, 1968

3,409,273

METHOD AND APPARATUS FOR BLENDING PULVERULENT MATERIALS

Edgar J. Kelly, Lake Zurich, Ill., assignor to American Colloid Company, Skokie, Ill., a corporation of Delaware

Filed Nov. 17, 1967, Ser. No. 683,956
7 Claims. (Cl. 259—4)

ABSTRACT OF THE DISCLOSURE

A method and apparatus for mixing pulverulent or finely-divided materials by fluidizing such materials to reduce the friction between the particles so as to facilitate combining, and recirculating such fluidized materials within an enclosed container so as to effect complete blending and mixing thereof, permitting discharge of unsegregated material.

Pulverulent or granular materials, such as clays, cements, crushed minerals, coal, etc. are generally composed of particles which differ in size and when a silo or hopper is being filled, larger or coarse particles tend to separate from finer particles. Such segregation results in the initial discharge of material high in fines and a later discharge high in coarse particles, whereas constancy and homogeneity is desired and often essential. Mixing devices have been proposed in the prior art which attempted to obtain homogeneity of a single material or a plurality of materials, but such devices were expensive, generally capable of handling only small batches and not satisfactory. The use of stirring arms with and without injected air and the use of air alone in specialized constructions have been tried. Generally, the air was supplied at high pressure thereby increasing the cost, and the mode of operation of these prior devices was not capable of producing satisfactory results.

It has been found that the particular interior configuration of blenders or hoppers is critical to obtaining a satisfactory mix of the material. In the prior art, the use of nozzles positioned in the lower portion of a container or hopper so as to discharge air under high pressure has been tried in an attempt to create vortices within the container or hopper so as to effect satisfactory blending. However, there are disadvantages to such prior art devices caused by the turbulence created within the container due to the introduction of high pressure air and difficulty in controlling the flow path of the fluidized material within the container due to such air turbulence.

The present invention provides an inexpensive apparatus of large capacity, which may be used to continuously blend and discharge material at exemplary rates of 400 to 600 tons per hour (or in batches of, for example, 30–40 tons each), the apparatus being capable of being used either as a silo or storage container or a blender or both. Segregation of coarse and fine material components is prevented by a novel mode of operation including tangential feed into the upper portion of an enclosed chamber, and the movement of the material in a series of successive inwardly contracting and outwardly expanding spirals to the lower portion of the chamber, followed by axial and upward return for recirculation and effective mixing. The repeated reversal in the direction of movement of the material (inwardly, outwardly, up and down) is facilitated by the use of an aspirator for the upward movement of the material, the presence of air fluidizing the material and permitting a large tonnage to be mixed within a very short period of time.

Accordingly, it is a general object of the present invention to provide a method and apparatus for blending pulverulent material that avoids all of the foregoing disadvantages of similar types of methods and apparatus for blending pulverulent material used heretofore.

One object of the present invention is to effectively mix or blend materials in a container by controlling the flow path of fluidized pulverulent material particles and recirculating such fluidized material by aspirating means.

Another object of the present invention is to blend pulverulent materials with an apparatus having zones or regions of varying pressure within a substantially cylindrical container and having stationary mechanical means disposed within the container for controlling the flow path of the fluidized material.

Still another object of the present invention is to blend finely divided, powdered or granular material either continuously or by a batch process selected by controlling the volumetric or weight rate of flow of materials into an enclosed container relative to the volumetric rate of flow of air supplied to aspirating means used for recirculating and fluidizing material.

A further object of the present invention is to mix pulverulent material within a container by introducing material into the upper portion of the container by air transport in a tangential direction and blending such material by controlling the downward flow of the fluidized material and recirculating such material by aspirating means.

Other objects and advantages of this invention will be readily apparent in the following description when considered in connection with the appended drawings.

In the drawings:

FIG. 1 is a side elevation sectional view of an apparatus for blending pulverulent material constructed in accordance with the present invention;

FIG. 2 is a top plan view of the apparatus as shown in FIG. 1, with a portion thereof shown in section;

FIG. 3 is a top plan view of a portion of the apparatus shown in FIG. 1, taken along the line 3—3; and

FIG. 4 is a side elevation sectional view taken along the line 4—4 of FIG. 3.

The exemplary form of apparatus of this invention shown in the appended drawings is illustrated by the blender and container **10** which comprises an upper cylindrical portion indicated at **11** and a lower portion **12** in the form of an inverted truncated cone, this inverted truncated cone being connected to the upper cylindrical portion **11**. The lower or discharge portion of the cone **12** is preferably provided with a valved material outlet indicated at **13**; the top of the container **10** is provided with a top wall **14** having a central aperture in which there is held a removably attachable, inwardly extending deflector **15** having a conical lower surface **16**. Another aperture in the top wall **14** is in communication with a vent pipe **17** which may lead to the atmosphere or to a small dust collector (not shown).

The periphery of the upper cylindrical portion **11**, adjacent the top wall **14**, is provided with a tangential material inlet **18**. It is to be understood that the material supplied to the mixer and blender **10** may be introduced in airborne suspension or the material may be supplied to the blender by gravity or any other means. Pulverate material supplied by air transport is most often employed and therefore inlet line **18** is shown provided with a manually adjustable valve **19**, shown in FIG. 2. It may also be noted that the inner surface of the cylindrical portion **11** immediately adjacent the inlet may be lined with a wear pad **20**, such wear pad extending for 60–120° of the arc of the portion **11**.

To facilitate blending and eliminate segregation of the particulate pulverulent or granular material being blended, means are provided for controlling and reversing the downward movement of the material supplied. As

shown best in FIG. 1, the blender is provided with an inverted truncated, conical baffle **21** the upper edge **22** of the baffle being attached to the inner surface of upper cylindrical portion **11** slightly below the level of the inlet pipe **18**. The lower edge **23** of the baffle **21** opens downwardly. Very good results have been obtained when the diameter of the baffle **21** at its lower or discharge edge **23** is on the order of 0.4 to 0.6 D, where D represents the diameter of the upper cylindrical portion **11** of the blender. The inwardly and downwardly extending directional baffle **21** is maintained in a position by three or more struts, one of which is indicated at **24**, the struts being welded or otherwise suitably attached to the walls of the blender and to the baffle.

It will be understood that the upper or inner surface of the baffle **21** directs the incoming pulverulent material towards the center of the blender. Material so directed in a constricting spiral path is then deflected by a second conical baffle **25** (shown held in position by struts, one of which is shown at **26**), the upper surface of the baffle **25** being virtually normal to the upper surface of baffle **21** but spaced therefrom, thereby causing the material to be reversed in its direction of downward flow in an expanding spiral towards the inner surface of the lower, inverted cone portion **12** of the blender. Again it has been found that very effective operation is obtained when the diameter of the lower marginal edge **27** of baffle **25** is on the order of from about 0.4 to 0.6 D. The conical baffle **25** may be welded or suitably attached at its upper end to the outer wall of aspirator pipe section **34**.

It may be observed that by the construction described, whether the incoming pulverulent material is fed by gravity or in airborne suspension, the incoming material is caused to swirl and cascade downwardly, reversing its direction from the external areas of the blender towards the center and then again to the outside and again towards the center. The normal tendency of coarse particles to find their way to the sides of the hopper or container are thus repeatedly thwarted and an effective mixing of coarse and fine particles is obtained.

The blender **10** is also provided with additional mixing and aspirating means which repetitively circulates the material within the blender and facilitates discharge of a homogeneous mixture of particulate material differing in particle size. Such additional aspirating and mixing means comprise the air inlet pipe **28** extending through the lowermost portion of cone portion **12** and terminating in the vertically and centrally oriented nozzle **29** whose upwardly directed open end is of smaller diameter than the pipe **28**. The pipe **28** is preferably supplied with air at a relatively low pressure, for example, 5 to 10 pounds per square inch gauge, but in sufficient quantity ot fluidize the pulverulent material, the volumetric rate of flow of air being controlled through a valve **30**. The upwardly directed converging nozzle **29** is positioned and spaced in operative relation to a shroud **31** carried by the lower end of an aspirating pipe **32** which, in turn, is connected by an expanding conical pipe section **33** to the upstanding axial pipe section **34** which terminates below the conical deflecting surface **16** of the deflector **15** carried by the top wall **14** of the blender. Preferably, the upper or discharge portion **35** of the aspirator pipe section **34** is below the level of the supply inlet pipe **18** and approximately at or slightly above the upper edge **22** of the baffle **21**, as illustrated.

It will be noted that the upper open end of nozzle **29** is in spaced relation with the inner walls of the shroud **31** whereby the velocity of the incoming air, together with the reduced pressure caused by such velocity, aspirates or sucks in the material contained in the lower portion of cone **12** and causes such material to be conveyed upwardly through the aspirator pipe section **34** and discharged upwardly against the conical lower deflecting surface **16**, thereby spreading the fluidized material radially in the upper end of the cylindrical portion **11** of the blender. The aspirating pipe sections may be supported from the walls of the blender by means of struts, one of such struts being indicated at **36**.

Disposed below baffle **25** is means to maintain the flow path of fluidized material near the inner wall of the lower cone portion **12** of the blender, indicated generally by the reference numeral **37**. Flow path control means **37** comprises a gas pressure inlet manifold pipe **38** connected to a gas pressure source (not shown) located exteriorly of container **10** through an air flow control valve **39**. The flow path control means **37** also includes a plurality of toroidal gas discharge pipes **40**, each of which has a plurality of radially inwardly directed discharge openings **41**, as seen best in FIGS. 3 and 4.

The flow path control means **37** will create a gas pressure zone in the lower cone portion **12** of the blender **10** which exceeds the ambient pressure within the container so that the spiraling cascading pulverulent material passing into the upper end of lower cone portion **12** will be forced to flow in the peripheral area adjacent the inner wall thereof. To prevent the fluidized material, particularly the more coarse particles of such material, from adhering to the inner wall of the lower cone portion **12** of the container, a plurality of fluid injecting pads **42** may be positioned around the periphery of the inner walls of this lower portion of the container. Each of the fluid pads **42** are connected through a coupling to an external gas supply source (not shown).

In operation, pulverulent material is introduced into the blender **10**, preferably by air transport through the material supply inlet pipe **18** by opening valve **19** disposed in such pipe. As mentioned above, the material may also be fed into the blender **10** through gravity feed into the peripheral upper end of the upper cylindrical portion **11** of the blender. Simultaneously with the introduction of the pulverulent material, valve **30** in air inlet pipe **28** is opened so that a relatively high velocity, but low pressure, stream of air is introduced into the blender through the recirculation pipe section **34** into the upper portion of the blender. The air discharged from the upper end **35** of recirculator pipe section **34** will impinge upon reflector **16** and spread radially through the upper end of the cylindrical portion **11**. Since the pulverulent material is introduced in a tangential direction the material will combine with the radially discharged air so as to form a confluent flow of fluidized pulverulent material moving in a downwardly spiraling direction guided by the baffle **21** towards the center of the blender.

This downward spiraling stream of fluidized material contracts until it passes through the lower opening **23** of baffle **21** and is then expanded and directed by baffle **25** into the upper end of the lower conical portion **12** of the blender. The cascading flow of pulverulent material will continue proximate the inner wall of the lower portion **12** of the blender towards the central region in which the aspirating means is positioned by virtue of the higher pressure gas zone created by the flow directing means **37**. The fluidized material continues toward the discharge opening in the lowermost end of the cone portion **12**, but as it approaches the region of the aspirating means the material will be drawn or sucked into the aspirating means due to the low pressure region existing at the discharge end of the inlet nozzle **29**. In this manner, the material will be further fluidized and recirculated to the upper end of the blender **10** through the recirculation pipe section **34**.

It will be appreciated that the blender **10** may be operated so as to mix materials either continuously or by a batch method. The weight rate of flow of pulverulent material into the blender through inlet pipe **18** may be selected by means of control valve **19**. The volumetric rate of air flow introduced into the blender will also be controlled by selective operation of air inlet control valve **30**. The amount of pulverulent material which will collect at the discharge opening of the blender will thus be controlled by balancing the amount of material intro-

duced with the amount of air introduced so that all, or a portion thereof, may be aspirated and continuously recirculated within the container. In operation as a batch method, the amount of air introduced will be sufficient so as to continuously recirculate all material introduced into the blender, for a given period of time, and the discharge opening of the blender will be closed. To operate continuously, the amount of material introduced relative to the amount of air introduced into the blender will be controlled so that a portion of the pulverulent material will continuously collect at the discharge opening of the blender, which will be open, so that the blended unsegregated combined material may be exhausted.

An actual example of use of the above-described embodiment of the invention will demonstrate the novel blending effectiveness of the apparatus. Approximately two hundred tons of powdered bentonite clay, having a nominal classification of ninety percent less than 200 mesh and a bulk density of 55 lbs. per cubic foot, was fed into the apparatus for blending. Sieve analysis indicated that the pulverulent bentonite was one hundred percent less than 150 mesh, ninety percent less than 200 mesh, and five percent less than 325 mesh. Furthermore, bentonite has the property of imparting viscosity to a water solution but natural bentonite clay, i.e. as it is mined, has a great variation in viscosity. This particular bentonite material had a natural unblended viscosity range of from 3 cps. to 26 cps. in a 6¼% concentration.

In blending the bentonite by batch process, 650 cubic feet per minute of air was introduced through the mixing and aspirating means at 6 p.s.i.g. Since the entire charge of pulverulent material was fed into the container prior to commencing blending, the material head required 18 p.s.i.g. in the air inlet pipe to overcome the head. However, the pressure required for operation shortly dropped to 6 p.s.i.g. The mixing and aspirating means with this volumetric rate of flow produced a recirculation rate of 600 tons per hour and, for this particular pulverulent material, it was found that ten recirculation cycles yielded a well-blended homogeneous material of differing particle size.

Specifically, sieve analysis of the blended material showed a uniform homogeneous mixture of particle sizes and a viscosity of 13 cps. in a 6¼% concentration.

The above-described material was also used in a test of the apparatus in continuous operation. The container was fed at a rate of fifty tons per hour and the lower portion of the container was allowed to fill to a desirable level by closing the discharge opening. The mixing and aspirating means was operated so as to allow the level of blended material to be maintained after the discharge opening was opened providing a continuous operation. The same uniform homogeneous mixture of blended material was obtained.

In another example of use of this apparatus for both storage and blending, a fifty ton container was filled with silica sand weighing 100 lbs. per cubic foot, and having a No. 90 grain fineness according to American Foundry Society standards. Without blending, it was found that the container when discharged would initially deliver material high in fines and subsequently the coarse part of the material.

However, when the apparatus was operated with 900 cubic feet per minute introduced through the mixing and aspirating means at a starting pressure of 22 p.s.i.g. and an operating pressure of 7 p.s.i.g., a homogeneous mixture was discharged with the grain size graduation consistently plus or minus one-half of one percent.

It will be appreciated from these examples that the present invention provides a blending and storage apparatus of large capacity which by controlled movement of the material will provide an unsegregated, homogeneous, uniform mixture of pulverulent material. It will therefore be seen that many modifications and variations of the present method and apparatus for blending pulverulent materials are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than specifically described.

I claim:

1. A method for producing, storing and discharging homogeneous mixtures of finely divided solid materials comprising the steps of:
- introducing finely divided solid material by air transport into the upper end of a cylindrical portion of a container in a tangential direction to create a circumferential flow path of the material;
- directing low pressure air flow radially in the upper end of the cylindrical portion of the container to create a confluent flow path of fluidized material;
- directing the flow of the fluidized material in a downward spiral path toward the axis of the container cylindrical portion;
- re-directing the downward spiralling flow of fluidized material away from the axis of the container and into the upper end of an inverted cone portion of the container;
- reversing the flow of downward spiralling fluidized material toward the container axis;
- aspirating the fluidized material in the lower region of the inverted cone portion of the container; and
- re-circulating the aspirated fluidized material to the upper end of the cylindrical portion of the container to effect complete homogeneous blending of the finely divided solid materials.

2. An apparatus for producing, storing and discharging homogeneous mixtures of finely divided solid material comprising:
- a container housing having an upper cylindrical portion provided with a top wall and a lower inverted cone portion with a discharge opening at the lower end thereof;
- a tangential material inlet means in the periphery of the upper end of the cylindrical portion adjacent said top wall;
- means within said container housing for reversing the direction of downward movement of the material by a series of successively inwardly contracting and outwardly expanding spirals to the lower portion of said housing, said means comprising an upper inverted truncated conical baffle in said cylindrical portion extending from a zone slightly below said material inlet means and providing a surface for guiding material toward the central axis,
- and a lower conical baffle providing a surface adapted to receive material from the upper truncated conical baffle and guide material away from the central axis toward the lower portion of the container housing;
- axially positioned, upwardly directed aspirating means in the lower portion of the lower section of the housing, a pipe positioned in operative vertical axial alignment with said aspirating means and extending through said housiing lower cone portion to the upper end of the cylindrical portion of the housing;
- and means for supplying low pressure air to said aspirating means to circulate material from the lower portion of the housing to the upper portion thereof.

3. The apparatus of claim 2 wherein said tangential material inlet means includes means providing air transport of such material into the container.

4. The apparatus of claim 3 additionally including means supported in the lower inverted cone portion of the housing for creating a pressure zone exceeding the housing ambient pressure so as to direct the downward movement of the material outwardly toward the wall of the housing lower portion.

5. The apparatus of claim 4 additionally comprising:
valve means in operative relation with the tangential material inlet means for selectively controlling the weight rate of material flow introduced; and
valve means in operative relation with the low pressure air supply means for selectively controlling the volumetric rate of air flow introduced,
whereby a selected portion of the downward flow of material may be aspirated and the remainder collected in the lower end of the lower inverted cone portion of the container.

6. The apparatus of claim 5 wherein the lower opening of the upper inverted truncated conical baffle is between 0.4 and 0.6 of the diameter of the upper cylindrical portion of the container and the lower edge of the lower conical baffle has a diameter no less than the diameter of the lower opening of the upper inverted truncated conical baffle.

7. The apparatus of claim 6 additionally comprising:
means for providing a fluidized bed of gas on the inner wall of the lower inverted cone portion of the container so as to prevent the material from adhering to the wall; and
means for collecting the fines from the material which are suspended proximate the top wall of the container.

References Cited

UNITED STATES PATENTS

1,000,689	8/1911	Paterson	259—4 XR
2,718,471	9/1955	Samler	259—4 XR
3,164,376	1/1965	Clark	259—4

WALTER A. SCHEEL, *Primary Examiner.*

JOHN M. BELL, *Assistant Examiner.*