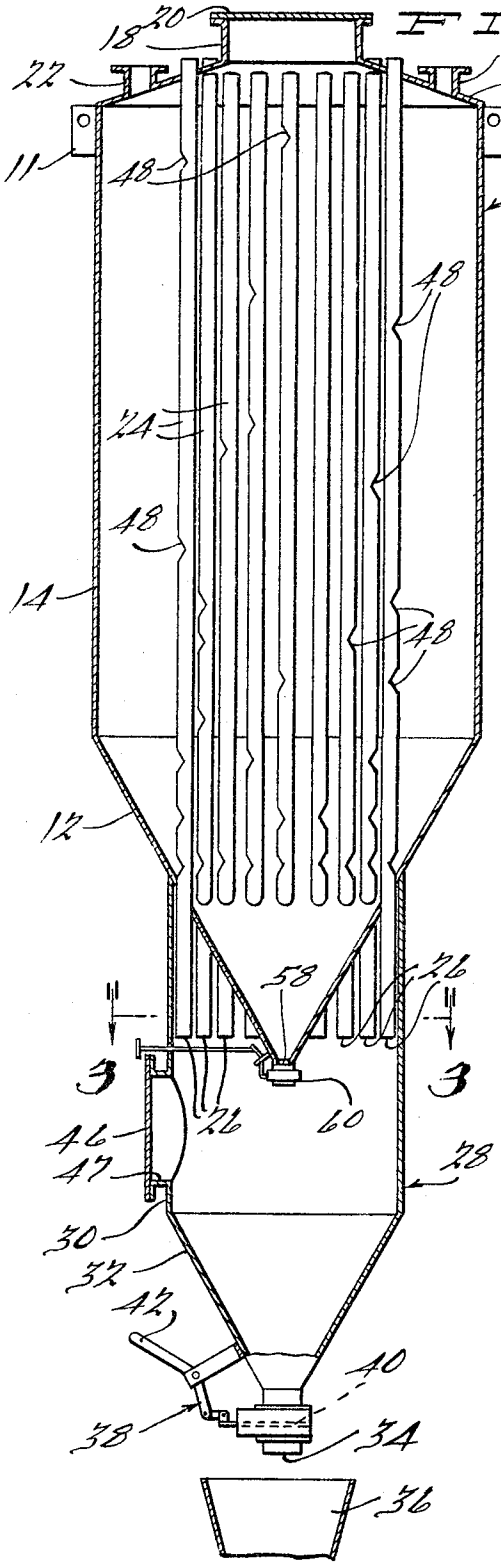
Aug. 23, 1966 T. A. BURTON 3,268,215

BLENDING APPARATUS

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FIG. 1.



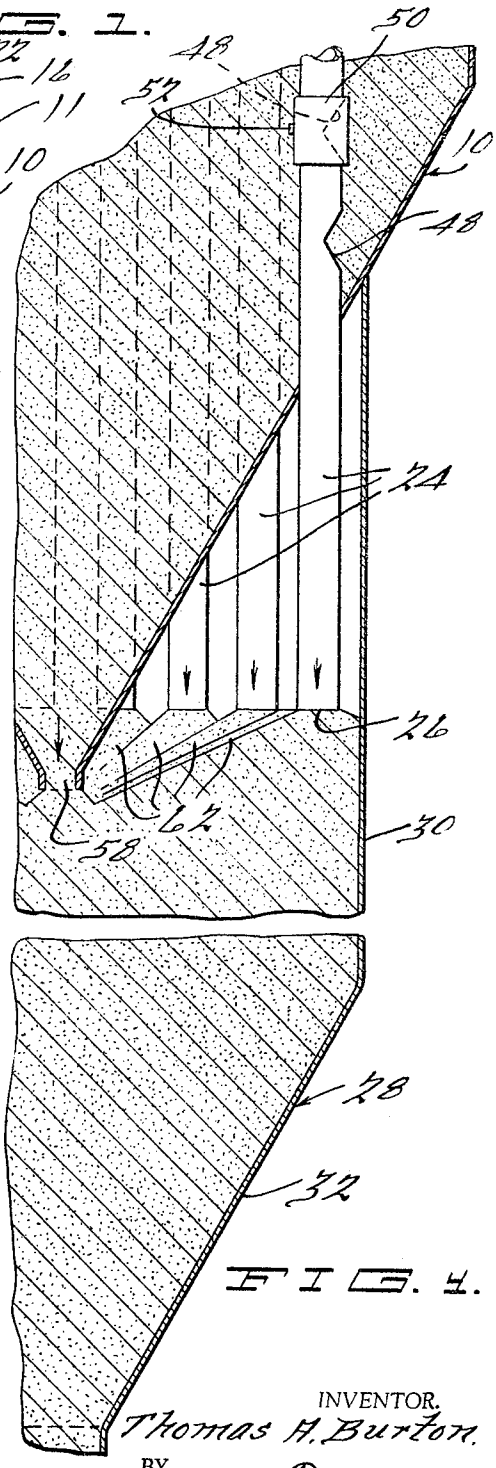


FIG. 4.

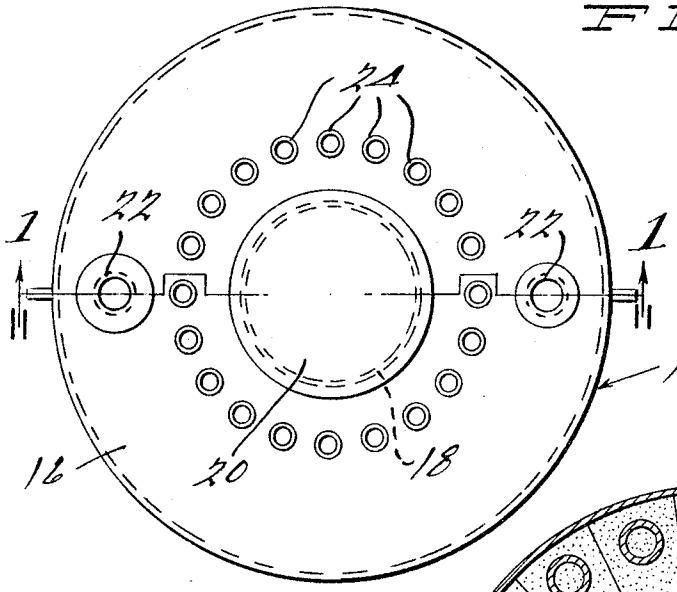
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BLENDING APPARATUS

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FIG. 2.



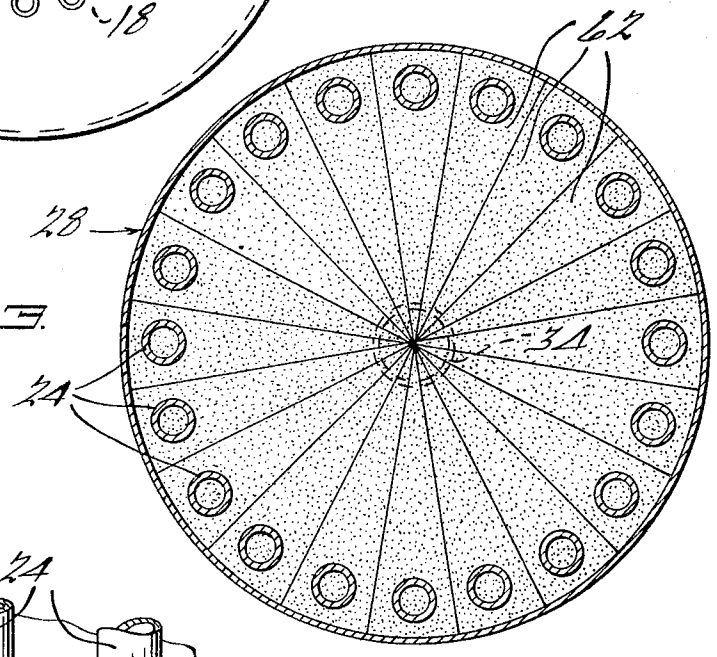
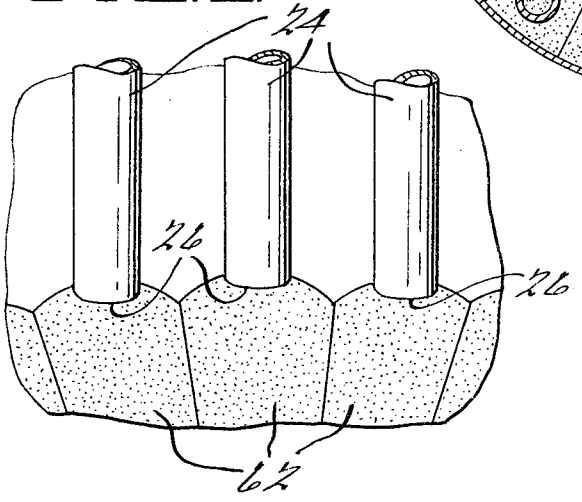


FIG. 3.

FIG. 5.



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BLENDING APPARATUS

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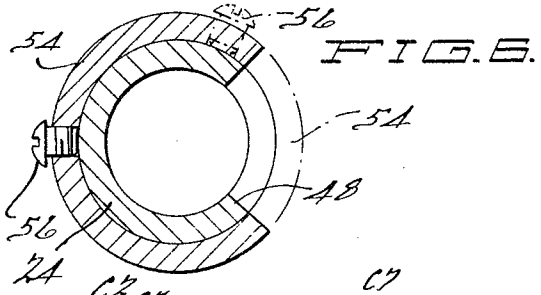


FIG. 6.

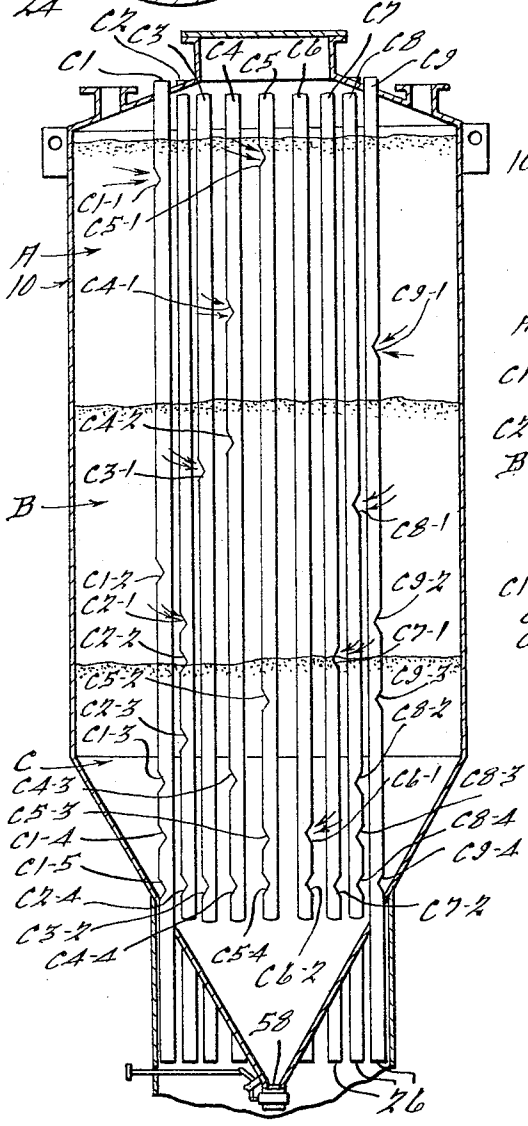


FIG. 7.

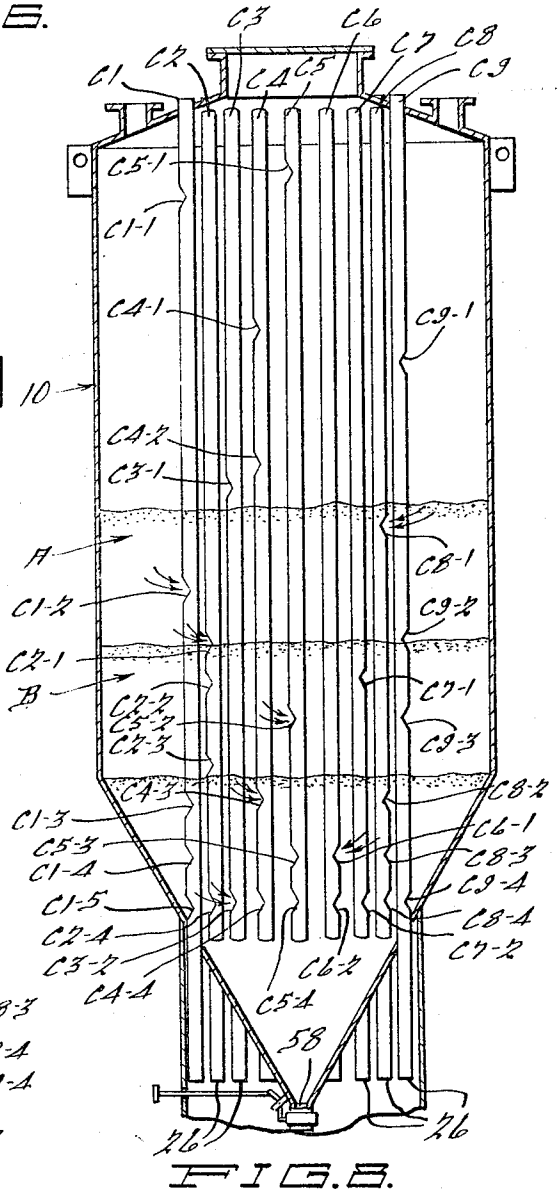


FIG. 8.

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3,268,215

BLENDING APPARATUS

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Filed July 31, 1964, Ser. No. 386,639
2 Claims. (Cl. 259—180)

The present invention broadly relates to a blending apparatus, and more particularly to an improved blending apparatus for mixing bulk quantities of different solid granular or particulated materials by withdrawing bulk quantities of the materials through supply conduits and discharging the materials thus withdrawn into a collector manifold or receiver which automatically regulates the gravitational flow of the material through each of the plurality of conduits.

The blending apparatus comprising the present invention constitutes a further improvement over the blending apparatus described in United States patent application Serial No. 200,858, now Patent No. 3,158,362, filed June 7, 1962, for "Method and Apparatus for Blending Granular Materials" which is assigned to the same assignee as the present invention. Blending apparatuses of the type disclosed in the aforementioned pending United States patent application and, as herein disclosed, are intended to overcome the disadvantages present in mechanical-type blenders such as drum-type mixers, for example, which heretofore have been employed for forming substantially homogeneous blends or mixtures of two or more dissimilar materials such as various types of grains, grits and abrasives, different colored plastic pellets, etc. Mechanical-type blending apparatuses, such as drum-type mixers, are subject to the inherent disadvantages of having relatively small capacities and requiring relatively high horsepower requirements over extended operating periods for effecting a substantially uniform mixture of several dissimilar granulated constituents. During the course of such mechanical blending, the particles being mixed are subjected to abrasion, causing attrition of the materials being mixed, and frequently producing an excessive quantity of unuseable fines which further detracts from the efficiency and economy of the mixing operation.

Various hopper-type blending apparatuses have heretofore been used or proposed for use to overcome the inherent disadvantages of mechanical blending apparatuses. In such hopper-type blending apparatuses, the granular material is either agitated by high-pressure fluid or is withdrawn from selected portions of a combination mixing and storage tank, and the admixed material is thereafter returned to the tank. In blending apparatuses of the hopper-type in which material is withdrawn from diverse locations in the hopper, a continuing problem has heretofore been presented by the difficulty of controlling the gravitational or pressure-induced flow of the granular material through each of the plurality of supply pipes. Conventionally, unequal flow rates frequently result in stratification of the material in the storage hopper, resulting in either a non-uniform mixture or in excessively prolonging the time required for forming a uniform blend of the material. In order to overcome this problem, various intricate valving systems have heretofore been employed which require relatively careful manipulation and control to achieve the proper flow rates to provide a satisfactory mixing action. The cost, complexity, and susceptibility of such valving systems to malfunction, in addition to the relatively stringent regulation and control required of these valving systems during a blending operation, have seriously detracted from a more widespread adoption of such hopper-type blending apparatuses.

In accordance with the invention disclosed in the aforementioned pending patent application, a receiver manifold is provided to which the material from each of the supply conduits is discharged and wherein the outlet ends of the supply conduits are disposed so as to be partially blocked by the material discharged therein, providing therewith automatic flow control and dispensing with the necessity of requiring intricate valving systems of the types heretofore required. While the hopper-type blending apparatus as disclosed in the aforementioned United States patent application constitutes a significant advancement in hopper-type blending apparatuses, difficulty is still encountered in certain blending operations when a relatively uniform mixture of the various granulated materials is desired without any recirculation of the material to the hopper or with only a minimum of recirculation.

It is accordingly a principal object of the present invention to provide an improved hopper-type blending apparatus in which a more uniform sampling of the materials in the hopper is attained, overcoming the necessity of repeatedly recycling the admixed material back into the hopper to achieve a uniform mixture.

Another object of the present invention is to provide an improved hopper-type blending apparatus, the storage hopper or receptacle of which incorporates a plurality of supply conduits each of which is provided with a plurality of apertures therein at preselected vertically spaced increments, providing therewith a substantially uniform sampling of the stratified charge of material in the hopper during the initiation of the blending operation as well as during the progress of the blending operation as the level of material in the hopper progressively decreases.

Still another object of the present invention is to provide an improved hopper-type blending apparatus which, in combination with the novel withdrawal means incorporated in the hopper and the collector manifold disposed therebelow, provides for a completely automatic and self-regulated blending of the granulated materials, achieving an efficiency and economy heretofore unattainable in blending apparatuses of the various types heretofore known.

The foregoing and other objects and advantages of the present invention are achieved by providing a hopper or tank in which a plurality of conduits are positioned, each formed with a series of apertures at vertically spaced intervals therealong for uniformly sampling and withdrawing the material from within the interior of said tank and discharging the material thus withdrawn into a collector manifold in which the material is combined, forming a substantially uniform mixture. In accordance with a preferred embodiment of the present invention, the receiving receptacle is positioned such that the outlets of each of the conduits are disposed at substantially the same level and wherein the material is withdrawn from the receptacle at a rate so as to maintain the outlets of the conduits at least partially blocked with the material in the receiver, providing a self-regulated control of the withdrawal of material through each of the conduits.

Further objects and advantages will become more apparent from a consideration of the following detailed description taken in conjunction with the drawings in which:

FIGURE 1 is a vertical sectional view of a hopper-type blending apparatus constructed in accordance with the preferred embodiments of the present invention and taken along the line 1—1 of FIGURE 2;

FIG. 2 is an enlarged plan view of the blending apparatus shown in FIGURE 1;

FIG. 3 is a transverse sectional view of the lower end portion of the blending apparatus shown in FIGURE 1 and taken along the line 3—3 thereof;

FIG. 4 is a fragmentary enlarged vertical sectional view of the lower portion of the hopper or receptacle and the receiver disposed therebelow, illustrating the dynamic disposition of the granulated material during the course of a blending operation;

FIG. 5 is an enlarged fragmentary side elevation view of the lower ends of the supply conduits and the shape of the material being discharged therefrom into the receiver;

FIG. 6 is a transverse sectional view of a supply conduit formed with an inlet port therein which may be selectively opened or closed by means of a slotted sleeve valve;

FIG. 7 is an elevation view of the hopper of the blending apparatus, schematically illustrating a typical flow pattern of the stratified material charge into the inlet ports of the supply conduits incorporated therein; and

FIG. 8 is a side elevation view similar to that illustrated in FIGURE 7 illustrating a typical flow pattern of the material after approximately one-half thereof has been withdrawn from the hopper.

Referring now in detail to the drawings, and as may be best seen in FIGURES 1 and 2, a blending apparatus constructed in accordance with the preferred embodiments of the present invention consists of a storage tank or hopper **10** which is supported from brackets **11** attached to the upper sides thereof by a suitable frame (not shown) which maintains the tank in a substantially upright position. The exemplary tank as shown in the drawings is of a circular-cross-sectional configuration and includes a conical base portion **12**, a substantially cylindrical intermediate portion **14**, and a convex dome or top **16**. While a tank of a circular cross-sectional configuration is usually preferred, alternative satisfactory configurations such as square, hexagonal, elliptical, rectangular, etc., can also be satisfactorily employed. The dome or top **16** of the hopper **10** is formed with a centrally located flanged port **18** which is provided with a removable closure member or cover **20** for gaining access into the interior of the hopper as well as for loading the granulated or particulated materials to be admixed. In addition, a pair of auxiliary flanged ports indicated at **22** are also provided on the top **16** which may be directly connected to suitable conduits for charging the materials to be mixed directly into the interior of the hopper.

A plurality of delivery pipes or supply conduits **24** are positioned within the interior of the hopper **10** and extend upwardly therethrough and are secured to the dome or top **16** of the hopper. The lower portions of the supply conduits **24** extend through the conical base portion **12** of the hopper and terminate with the discharge ports thereof indicated at **26** disposed in communication with the interior of a collector manifold or receiver **28** connected to and disposed directly below the conical base portion **12**. In the preferred embodiment of the blending apparatus as illustrated in the drawings, each of the discharge ports **26** of the supply conduits **24** are disposed in substantially the same horizontal plane for providing automatic regulated control of the discharge or flow of material out through the discharge ports **26** in a manner subsequently to be described.

The collector manifold or receiver **28**, as best seen in FIGURE 1, consists of a substantially cylindrical upper portion **30** which is integrally connected to a conical base portion **32** which is formed with a discharge outlet **34** in the base thereof through which the material received in the collector manifold is discharged into a suitable container indicated at **36** in which the discharge material can be transported or through which the material can be conveyed to the next processing operation or packaging operation. It is also contemplated within the scope of the present invention that the material in the container **36** can be recirculated back into the interior of the hopper **10** if desired, although such recirculation is ordinarily not necessary to achieve a substantially uniform blend of the materials charged to the hopper. The discharged outlet **34** is provided with a suitable gate valve assembly indicated at **38** including a slidably mounted plate or gate **40** and a pivotally mounted lever **42** connected thereto for adjustably positioning the gate **40** relative to the discharge outlet **34**. The collector manifold **28** is also provided with a flanged access port **47** mounted on the periphery of the cylindrical upper portion **30** thereof, which is provided with a suitable removably mounted closure member or cover **46** for gaining access to the interior of the receiver as may be required from time to time.

In the specific form of the invention as illustrated in the drawings, the supply conduits **24** are arranged in a circular pattern disposed concentric to the wall of the cylindrical intermediate portion **14** of the hopper **10** and are positioned at substantially equal arcuate increments. The lower end portions of the supply conduits **24**, as best seen in FIGURE 3, are similarly positioned in substantially equal circumferential increments adjacent to and concentric with the wall of the cylindrical upper portion **30** of the collector manifold **28**. Each of the supply conduits **24** extending upwardly into the interior of the hopper **10** is formed with one or a plurality of inlet ports indicated at **48** which are disposed at vertically spaced increments therealong for uniformly sampling and withdrawing the granulated material from the interior of the hopper and for discharging the withdrawn material into the collector manifold therebelow. The specific number and the vertical location and spacing of the inlet ports in each supply conduit **24** as well as the specific arrangement of the supply conduits **24** within the hopper will vary in accordance with the configuration, volume, and height of the hopper as well as the nature of the materials being blended. The specific location of the inlet ports **48** along the length of each of the supply conduits is selected so that geometrically similar sections of the material in the hopper are disposed in communication with an inlet port whereby the solid granulated or particular material is withdrawn substantially equally through each of the inlet ports providing for a uniform sampling of the initial stratified or layered charge regardless of the level of the material in the hopper. In accordance with this relationship, samples are withdrawn from the granulated material in the hopper from equal geometrically similar sections thereof and are discharged into the collector manifold in which they are combined, forming an accurate composite of the entire contents of the material in the hopper.

The foregoing relationship is based on the discovery that while a plurality of vertically spaced inlet ports are provided in each supply conduit, only the uppermost of these inlet ports disposed below the level of the material in the hopper is operative to withdraw material while the remaining inlet ports in that conduit spaced vertically below are rendered substantially inoperative and are blocked by the material flowing downwardly through the conduit. The relationship is maintained, provided that the flow rate of material through the supply conduits is less than the unobstructed free-fall rate of the particles.

The term free-fall rate as herein employed refers to the unobstructed gravitational falling rate of the particles downwardly through the supply conduits. The rate of withdrawal of material from the tank through the supply conduits in accordance with the practice of the present invention is less than the free-fall rate whereby each of the conduits are substantially completely filled with material downwardly of the inlet port through which the material is withdrawn.

While the static and dynamic forces governing the controlled withdrawal of material from the tank are not completely understood at the present time, it is believed that the downward movement of the particles in a supply conduit at less than free-fall conditions wherein the conduit is completely filled with the particles exerts an

outward force at the inlet ports disposed below the uppermost inlet port which substantially balances the static inward force of the particles adjacent to such lower inlet ports, preventing any appreciable inward flow of granular material into such lower inlet ports. As a result, a dynamic equilibrium condition is attained adjacent to such lowermost inlet ports positioned below an operative inlet port until such time that the level of the material in the hopper decreases, exposing the uppermost operative inlet port whereupon the next vertically spaced inlet port becomes operative after the material in that supply conduit decreases to a level corresponding to the vertical height of the next inlet port. Accordingly, as the level of the material progressively decreases in the hopper, each of the inlet ports disposed along a given supply conduit become successively operative to withdraw material from the interior of the hopper until such time that the level of the material drops below such inlet port.

It will be appreciated from the foregoing that the number and location of the inlet ports along the lengths of the supply conduits provide for a continuous withdrawal of material from geometrically similar sections of the granular material regardless of the volume or level of the material in the hopper. As the level of the material progressively decreases, the geometrically similar sections or volumes of the material sampled also decrease proportionately. While the specific relationship of the number of supply conduits, their positions in the interior of the hopper, and the number and location of inlet ports along the length thereof can be mathematically computed to provide the requisite uniformity in sampling of the contents of the material charge in the hopper, mathematical estimates combined with a trial-and-error testing have been found to enable the attainment of extremely accurate uniform mixtures of a plurality of dissimilar materials without the necessity of recirculating the admixed material.

In order to enhance the flexibility and versatility of the blending apparatus comprising the present invention, it is contemplated that each of the supply conduits can be provided with a plurality of inlet ports **48** at substantially equal vertically spaced intervals therealong and that selected ones of the inlet ports along each supply conduit are rendered inoperative by adjustably positioning a sleeve **50** as best seen in FIGURE 4 over the selected ones of the inlet ports in order to provide the requisite sampling relationship consistent with the number and characteristics of the particular materials to be blended. As shown in FIGURE 4, the sleeve **50** is slidably mounted around the periphery of the supply conduit **24** and is retained in appropriate vertical adjusted relationship thereon by means of a suitable set screw **52**. Alternatively, the sleeve **50** may comprise a tubular segment having a longitudinal portion of the wall thereof removed corresponding substantially to the arcuate width of the inlet port and enabling selected rotation of the sleeve so as either to open communication of the inlet port with the interior of the hopper or to completely close the port as may be desired. This latter arrangement is illustrated in FIGURE 6 wherein a slotted sleeve **54** is slidably disposed around a supply conduit **24** having an inlet port **48** in one wall thereof and which sleeve **54** is adjustably positionable from an open position as shown in solid lines in FIGURE 6 to a closed position as shown in phantom, effecting a complete mechanical blocking of the inlet port. Appropriate adjusted positions of the slotted sleeve **54** can be conveniently maintained by means of a set screw indicated at **56**.

A typical flow pattern of the particulated material into the inlet ports of the supply conduits in accordance with the arrangement and relationships as hereinabove set forth is best illustrated in FIGURES 7 and 8. As shown in FIGURE 7, the tank or hopper **10** is filled with three layers of a stratified charge generally indicated at A, B and C. The supply conduits which correspond to those shown in FIGURE 1 in accordance with the section taken along the line **1—1** of FIGURE 2, numbering nine in all, are designated as C1 through C9, respectively, and the inlet ports therealong commencing with the uppermost in each supply conduit and moving downwardly therealong are numbered respectively such as, for example, C1–1, C1–2, C1–3, etc. In the condition as shown in FIGURE 7, the upper layer of charge material A is withdrawn from the hopper through the inlet ports C1–1, C4–1, C5–1 and C9–1. The material B in the intermediate stratified layer is withdrawn through inlet ports C2–1, C3–1, C7–1 and C8–1. The material C in the lower portion of the hopper **10** is withdrawn from inlet port C6–1 and through a central outlet **58** in the base of the tank **10**.

The material withdrawn from the various inlet ports is discharged out through the discharge ports **26** into the collector manifold therebelow in which it is consolidated and withdrawn therefrom into a suitable receiver **36**, as illustrated in FIGURE 1. The inlet ports, as will be noted in FIGURE 7, which are spaced below an operative inlet port in the same supply conduit such as, for example, the inlet ports C1–2, C1–3, C1–4 and C1–5 of the supply conduit C1, are rendered substantially inoperative by the downward flow of material through the conduit C1 at less than a free-fall rate as it is withdrawn through the operative inlet port C1–1. As the level of the material progressively decreases during the course of the blending operation, the stratified materials A, B and C attain an intermediate level, as diagrammatically indicated in FIGURE 8. During the course of the downward movement of the material, inlet ports C1–1, C3–1, C4–1, C4–2, C5–1 and C9–1 have become exposed and are rendered inoperative, whereby the next inlet port in each of the supply conduits disposed below the exposed inlet port commences to withdraw the material remaining in the hopper. Accordingly, in the condition shown in FIGURE 8, the stratified layer of material A is withdrawn by inlet port C1–2 and C8–1 as well as by inlet ports C2–1 and C9–2 which overlie the stratified charges A and B. The layer of material B is withdrawn through inlet ports C5–2 and C7–1 in addition to inlet ports C2–1 and C9–2 which straddle the interface between the layers A and B. The material C in the base of the tank is withdrawn through inlet ports C3–2, C4–3 and C6–1 in addition to the central outlet **58** in the base of the tank.

In the flow patterns as exemplified in FIGURES 7 and 8, material is being constantly withdrawn from geometrically similar sections of the charge in spite of a progressive decrease in the total quantity of material in the tank whereupon the composite material discharged into the collector manifold is an accurate sampling of the contents of the interior of the hopper. As the material level progressively decreases from the position as shown in FIGURE 8, the inlet ports disposed below those inlet ports currently active are rendered operative and finally the remaining material is withdrawn through the lowermost inlet ports designated C1–5, C2–4, C3–2, C4–4, C5–4, C6–2, C7–2, C8–4 and C9–4. When the level of material drops below the level of the aforementioned lowermost inlet ports, the balance of material is withdrawn from the tank by the central outlet **58** in the base thereof.

It is contemplated in accordance with the present invention that the central outlet **58** in the base of the tank can be entirely omitted, resulting in a dead area such that the level of material withdrawn would stop when lowermost inlet ports are exposed. Alternatively, a suitable gate valve indicated at **60** in FIGURE 1, can be incorporated on the central outlet **58** similar to the gate valve assembly **38** at the base of the collector manifold **28**, enabling a closure of the outlet port **58** during the course

of a blending operation and subsequently enabling a drainage of the residuary material therein after the admixed material has been removed from the collector manifold which can thereafter be recirculated to the interior of the hopper for the next blending operation or, alternatively, can be discarded, as desired. It is further contemplated that the lower end portion of the conical base portion **12** of the tank **10**, can be modified in configuration so as to minimize the dead space disposed below the lowermost inlet ports in the several supply conduits.

When a central outlet **58** is employed consistent with the blending cycle as described in connection with FIGURES 7 and 8, the outlet opening thereof is of a cross-sectional area such that the volume of granular material withdrawn therethrough during the course of a blending operation is equal to the volume of material disposed below the lowermost inlet ports in the supply conduits, during which time the material in the storage hopper or blending tank disposed above the lowermost inlet ports is withdrawn through the several inlet ports of the several supply conduits. Accordingly, the material located in the base of the tank is uniformly withdrawn in a direct proportion to the material being withdrawn through the various supply conduits providing therewith an accurate sampling and uniform mixing of the several materials.

In accordance with the preferred practice and construction of the blending apparatus comprising the present invention, the flow of material discharged from the discharge ports **26** of each of the supply conduits **24** is regulated by means of a controlled withdrawal of the composited material from the collector manifold **28**. The withdrawal of material from the collector manifold **28** provides for a partial blocking of the discharge outlets **26** and the central outlet **58**, providing thereby an automatic regulated flow of material and assuring that the material withdrawn passes downwardly through the supply conduits **24** at a velocity less than the free-fall rates of the materials. The discharge outlet **34** in the base of the collector manifold **28** is of a size to assure that when the gate **40** is completely withdrawn the flow of material out of the collector manifold will be less than the free-fall rate of withdrawal or delivery of material from all of the supply conduits **24** and the center outlet **58**. This assures a dynamic partial blocking relationship of the discharge ports **26** in the base of the supply conduits **24** and of the central outlet **58** as is illustrated in FIGURES 3–5. As illustrated in these figures, the angularity of the material moving away from each of the discharge ports **26** of the supply conduits **24** corresponds substantially to the angle of repose of the particular granular material involved under the flow condition wherein the withdrawal of material from the base of the collector manifold **28** is less than the total free-fall delivery rate of material through all of the supply conduits and central outlet **58**. Accordingly, as the material is withdrawn downwardly and substantially centrally from the base of the collector manifold **28** through the discharge outlet **34** in the base thereof, a controlled quantity of material will flow downwardly and out through each of the discharge ports **26** as well as the central outlet **58**, dynamically maintaining the angles of repose of the material as diagrammatically illustrated in FIGURES 4 and 5. The material supplied from each supply conduit can be represented by a pie-shaped segment indicated at **62** in FIGURE 3 which, as illustrated in FIGURE 5, is convex in shape corresponding to the natural angle of repose of the material. Each such pie-shaped segment **62** contributes an equal amount to the admixed material withdrawn from the base of the collector manifold, providing an accurate composite of the entire contents in the tank **10**.

During the initial charging of material into the storage tank **10**, a portion thereof will pass downwardly into the collector manifold until the level therein rises to a point wherein the discharge outlets of the supply conduits are blocked, after which no further withdrawal of material will occur until the gate valve assembly **38** is actuated. The material initially deposited in the collector manifold **28** will not constitute an accurate sampling of the materials unless extremely rapid loading of the tank is achieved. Accordingly, the initial withdrawal of material from the collector manifold may suitably be recirculated to the interior of the tank or discarded, as desired.

While specific embodiments of the present invention have been illustrated and described in detail above, it will be appreciated that this invention is subject to modification, variation and change without departing from the proper scope or spirit of the subjoined claims.

What is claimed is:

1. A blending apparatus for uniformly mixing solid granulated materials comprising a tank, a receiver disposed below said tank, a plurality of conduits extending upwardly of said tank and formed with a series of apertures at vertically spaced intervals therealong disposed in communication with the interior of said tank for uniformly sampling and withdrawing material from said tank, said conduits and apertures being so spaced that substantially geometrically similar sections of the materials in the hopper are disposed in communication with the uppermost covered apertures of each of the conduits regardless of the level of material in the hopper, said conduits having outlet ends for discharging the material into said receiver, and means for maintaining a substantially equal flow rate of material downwardly through said conduits and in an amount such that the materials passing downwardly through said conduits is less than the free-fall rate of the materials and such that only the uppermost of the apertures in each said conduit disposed below the level of the materials in said tank is operative to withdraw materials from said tank.

2. The blending apparatus as defined in claim **1** wherein said means comprises said outlet ends of said conduits disposed in communication with the interior of said receiver and arranged with the discharge openings thereof in symmetrical relationship and at substantially the same level, and outlet means in said receiver for withdrawing the material from said receiver at a controlled rate, said level of the material within said receiver controlled by said outlet means to remain in at least partial blocking relationship relative to said discharge openings of said conduits.

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