Sept. 10, 1957 J. I. YELLOTT 2,805,897

PNEUMATIC FLUIDIZED MATERIAL HANDLING SYSTEM

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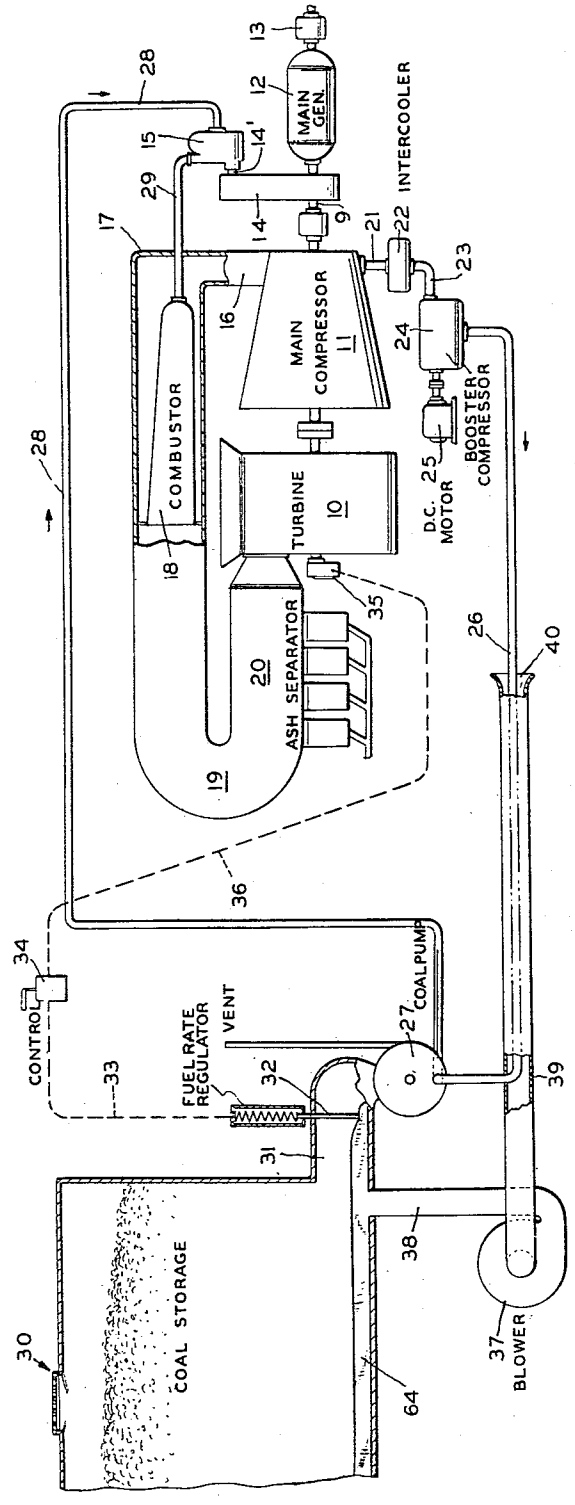

FIG. 1.

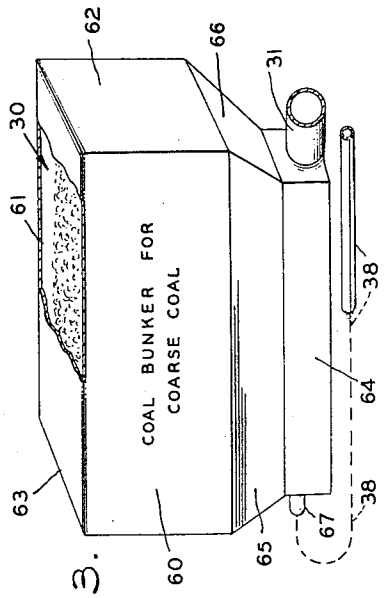

FIG. 3.

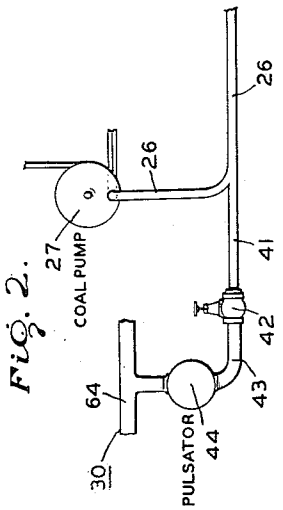

FIG. 2.

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PNEUMATIC FLUIDIZED MATERIAL HANDLING SYSTEM

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Fig. 5.

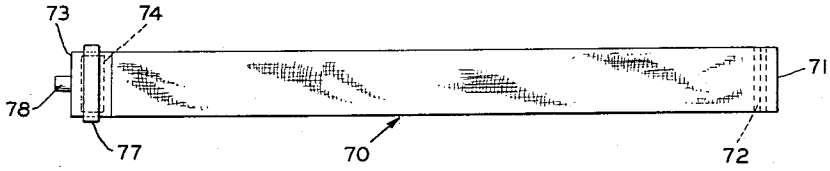


Fig. 4.

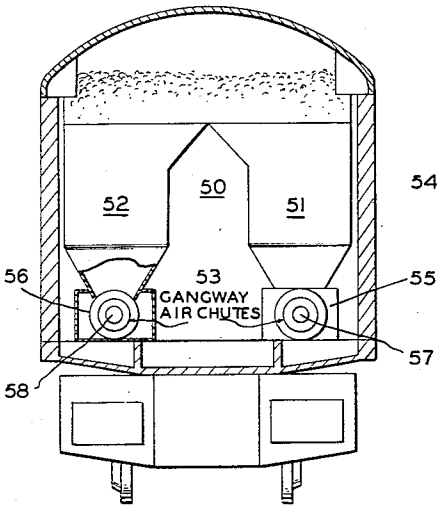


Fig. 6.

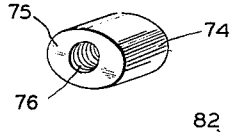


Fig. 7.

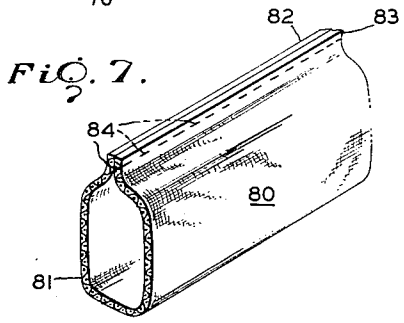


Fig. 8.

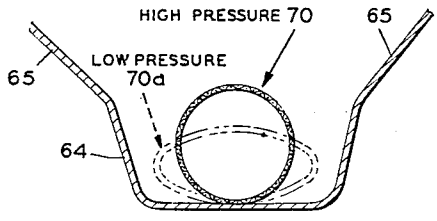
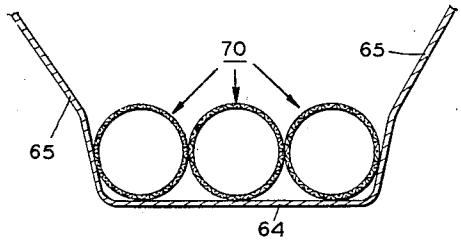


Fig. 9.



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PNEUMATIC FLUIDIZED MATERIAL HANDLING SYSTEM

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FIG. 10.

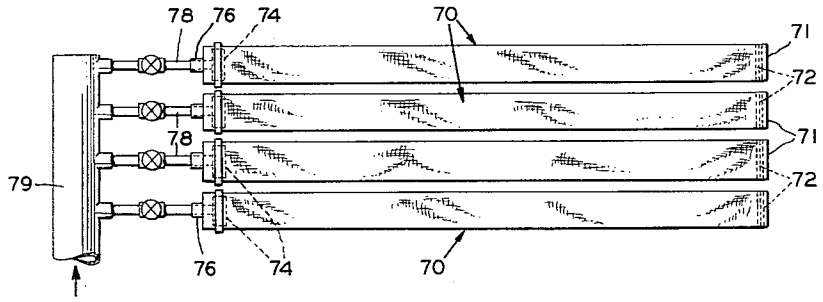


FIG. 11.

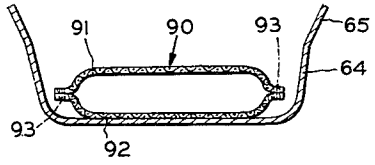


FIG. 12.

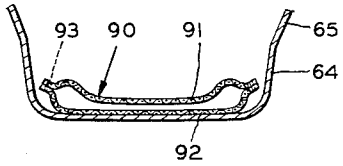


FIG. 13.

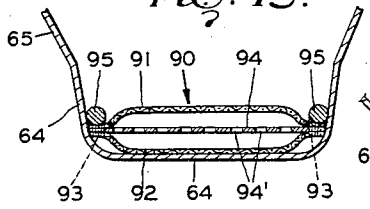
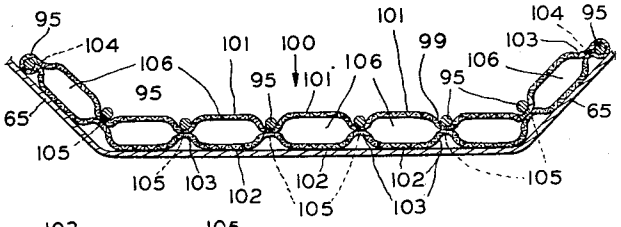


FIG. 15.



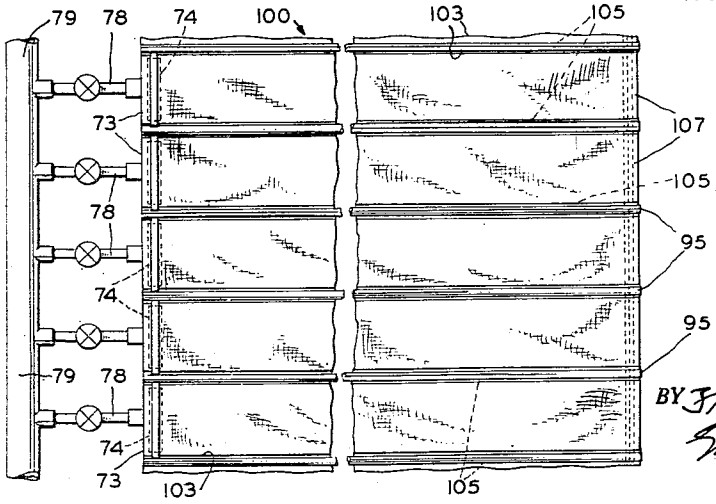


FIG. 14.

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PNEUMATIC FLUIDIZED MATERIAL HANDLING SYSTEM

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FIG. 16.

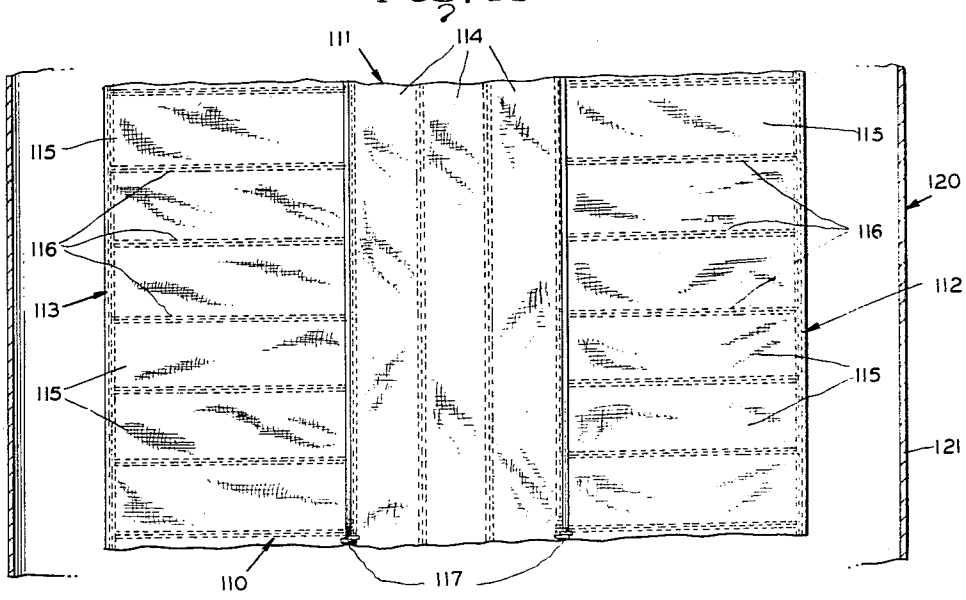


FIG. 17.

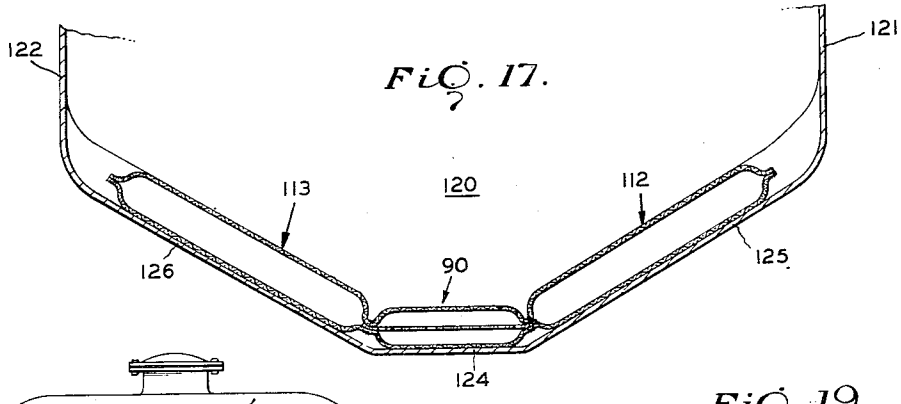


FIG. 18.

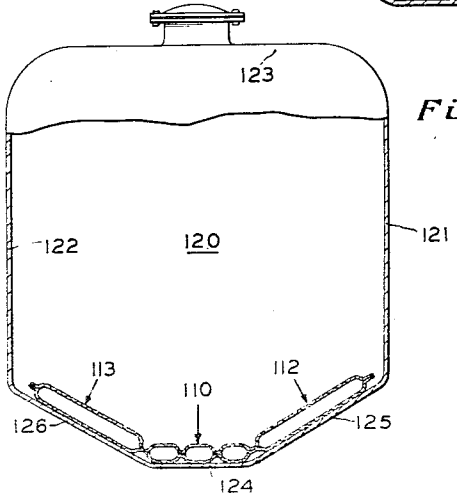
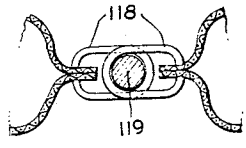


FIG. 19.



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PNEUMATIC FLUIDIZED MATERIAL HANDLING SYSTEM

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Fig. 21.

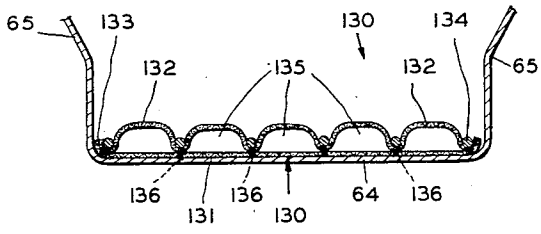


Fig. 22.

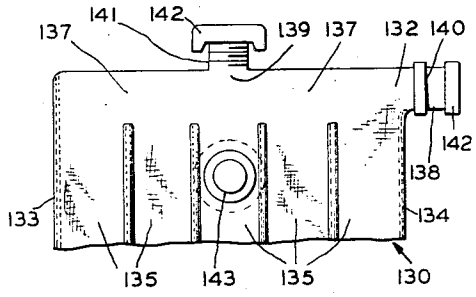
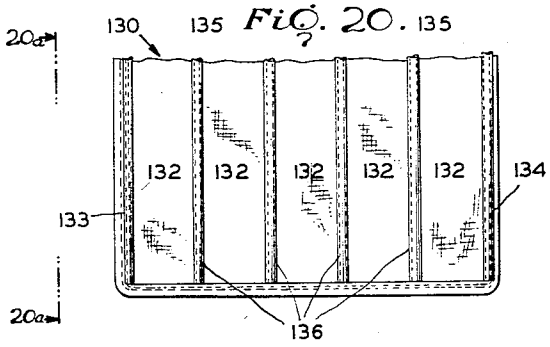


Fig. 20.



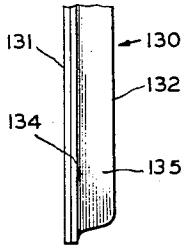


Fig. 20a.

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United States Patent Office 2,805,897 Patented Sept. 10, 1957

2,805,897

PNEUMATIC FLUIDIZED MATERIAL HANDLING SYSTEM

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Original application February 23, 1954, Serial No. 411,930. Divided and this application September 27, 1954, Serial No. 458,479

20 Claims. (Cl. 302—29)

This invention relates to a system for discharging bulk materials maintained in an aerated or fluidized state, and without the use of mechanical transfer equipment, as well as to novel aerators.

The pneumatic handling of discrete solids, such as crushed and powdered coal, cement, minerals, grains, and other flowable materials, can be economically accomplished by suspending the particulate matter in an upflowing bath of gaseous fluid, whereby the air-suspended, or so-called "fluidized" mass is caused to flow, simulating a true liquid, and is dischargeable by gravity into draw-off conduits.

A major difficulty in the handling of fluidized solids is the tendency of a great many materials, such as coal and cement, to compact and bridge over in a container, bunker, tank, silo, or conveying chute. To function properly, the levigating medium, such as air, or other suitable gasiform fluid, must be introduced underneath the body of discrete material as a multiplicity of microscopic rising streams. The desired uniformity of upward flow, evenly distributed over the entire surface of the bottom of a containing bunker, chute, bin, tank, silo, or other container, is usually affected by forming the bottom of the container with a false bottom of air-permeable material and forcing air therethrough from a subjoined plenum chamber or wind-box formed by and between the false bottom and the side and bottom walls of the casing or container. Usually, the bottoms of the containers are formed with integral or detachable trough sections, over which the air-pervious false bottoms are hermetically secured.

There have been many materials used and proposed for use in the false bottoms, distributing plates, or other members adapted for the uniform distribution of pressure air as myriads of infinitely small streams. Among these materials may be mentioned flexible fabrics of various kinds, usually maintaind under rigid tension to provide weight-bearing, material-supporting surfaces. Multiply canvas and nylon are indicated as preferred materials. Self-supporting, rigid materials, such as porous mineral aggregates, either natural or artificial, and in suitable thickness, are highly recommended and widely used.

With all these prior art proposals, material handling by pneumatic means is not, as yet, wholly satisfactory. Abrasion and wearing out of the air-pervious false bottoms, of any type, usually requires shutting down of an entire installation before dismantling and replacement of damaged parts can be properly effected and operation resumed. The relatively fixed, permanent, pneumatic material-handling installations of the prior art, while affording definite advantages over mechanical handling systems, do not permit the full realization of the simplicity and economy of operation available in a properly designed pneumatic handling and/or conveying system. Additionally, pneumatic material-handling installations of the types presently available, require special design, fabrication, installation and maintenance features, and cannot be

substituted, either in whole or in part, in existing mechanical installations.

It has now been found that fluidization of bulk solids, in discrete form, can be effected in a novel manner, in any suitable type of container, whether bunker, silo, tank, chute, bin, or other closed casing, by eliminating air-pervious false bottoms, hitherto required, and replacing them with air-pervious mattresses, tubes (desirably collapsible and distensible), or other hollow members formed of woven fabric materials. These novel members are laid in place in the bottoms of suitable bunkers, tanks, chutes, bins, or the like, and connected to suitable pressure air or other gasiform fluid supplies. Because of the use of fabrics, and taking advantage of the natural tendency of such materials to be in a normally limp, collapsed condition, even when fabricated to form individual or multiplex tubes, as will appear more in detail hereinafter, specially improved results in pneumatic material handling and storage systems are obtained by the practice of the invention herein disclosed and claimed.

A special feature of the invention herein is in the use of a pulsating air flow in and through the air-pervious tubes. A pulsating flow of any desired degree of amplitude can be obtained by the use of a pulsator in the fluidizing air line, in advance of the delivery to the tubes. Pulsation of the fluidizing air flow will give the effect of vibration, or rapping, as a result of cyclic collapsing and distension of the tubes. By using the pulsations of the pulsating air flow, in and through the tubes, the entire overlying mass of discrete solids is broken up and displaced, and, because of the aeration of the mass, the fluidized body of discrete material will move or flow towards the discharge opening.

The form and assembly of the tubes may assume a variety of arrangements, depending primarily upon the type of container or chute used, and the class of discrete material to be handled. As the tubes, either singly, or in any desired assembly, are essentially independent of container structure, they can be prefabricated and made up in various types, which can be assembled, as desired, for use in any given installation. The method of operation of the devices herein disclosed is susceptible of a wide variety of procedural changes and modifications, both as to air pressures used, and in the manner and form of effecting pulsations of desired amplitudes and time sequences or cycles.

It is, therefore, among the features of novelty and advantage of the present invention to provide novel demountable aerators for fluidizing equipment and method of operating same.

Further objects of the invention include the use of aerators comprised of air-pervious fabric tubes, individually, or in any desired combination and arrangement, and their incorporation, as separate entities, in the bottoms of containers and chutes, used for the storing and transfer of fluidizable discrete solids.

Other features of novelty and advantage include the fabrication of normally limp areators in the form of air-pervious mattresses, pillows, or bolsters, and comprising one or more tubes, which devices are adapted to form removable beds and sidewall buffers for the double purpose of supporting overlying bodies of discrete solids, and aerating the said bodies under conditions of uniform or pulsating air flow, as any given set of operating conditions may dictate.

A special feature of novelty and advantage of the invention herein resides in the fabrication of aerators from air-pervious woven fabrics, either in hose or tubular form, as well as in the form of apposed sheets of single or multiple-ply fabrics, such as canvas, nylon, or other like materials having the necessary wear characteristics, which

sheets are spacedly secured together, along parallel lines, to form multiplex tubes in a unitary structure.

Additional features of novelty and advantage of the invention herein comprehend the formation of aerating or fluidizing devices, herein generically identified by the term aerators, in bin-type containers and chutes, under conditions such that the devices can be detachably locked in place, and also comprehends the formation of such devices in single or composite members of appreciable width and length, with or without included transverse stiffening inserts or plates, and also with air-impervious bottom faces of rigid or semi-rigid material, for apposition to the bottom of bin-type containers and chutes, whereby the entire air-floating or levigating action of the air is directed upwardly into the overlying mass of discrete solids.

Yet another feature of novelty and advantage of the present invention resides in the formation of composite aerators comprised of identical unit aerators which are marginally joined by interfitting, hinged joints.

With these and other features of novelty and advantage in view, which may be incident to the improvements herein, the invention consists in the parts and combinations to be hereinafter set forth and claimed, with the understanding that the several necessary elements comprising the invention, may be varied in construction, proportions and arrangements, as well as in mode of operation, without departing from the spirit and scope of the appended claims.

In order to make the invention more clearly understood, there is shown in the accompanying drawings means for carrying out the same into practical effect, without limiting the improvements in their useful applications to the particular constructions, which, for the purpose of explanation, have been made the subject of illustration.

In the drawings, like numerals refer to similar parts throughout the several views, of which

Figure 1 is a schematic showing of a coal-burning gas turbine power plant incorporating the novel pneumatic fluidizing and transport features of the present invention;

Fig. 2 is a schematic detail of fluidizing air supply means incorporating a pulsator;

Fig. 3 is a side elevation of a V-bottomed coal bunker;

Fig. 4 is a vertical cross section through a coal supply car, and showing a bifurcate bunker with a gangway between the legs of the bunker, each leg being provided with novel air fluidizing and transport means;

Fig. 5 is a perspective view of a tubiform air-pervious aerator with an air inlet;

Fig. 6 is an elevation of the air inlet of Fig. 5;

Fig. 7 is a fragmentary perspective of a tubiform fabric aerator having a single side seam;

Fig. 8 is an idealized cross-section of the bottom trough of a bunker showing an air-pervious, tubiform aerator, fully distended, its partially deflated or collapsed condition being indicated in dotted lines;

Fig. 9 is an idealized cross-section of a troughed bunker bottom with an aerator assembly comprised of a plurality of laterally abutted, distended, air-pervious tubes mounted therein;

Fig. 10 is a plan view of the aerator assembly of Fig. 9 with its air supply;

Fig. 11 is a view similar to Fig. 9, showing a generally flat, bilaterally seamed tubiform or pillow-type aerator in inflated condition;

Fig. 12 is a view similar to Fig. 11 showing the aerator in deflated, wholly collapsed condition;

Fig. 13 is a view similar to Fig. 11, showing the aerator provided with a foraminous plate as an inner spreader, and with bilateral hold-down means;

Fig. 14 is a plan view of an aerator comprised of multiple tubes, with air supply means therefor;

Fig. 15 is an idealized cross-section of the aerator device of Fig. 14, as mounted in the bottom of a bunker;

Figs. 16 and 17 are views, respectively, similar to Figs. 14 and 15, and showing a modified, hinged form of multiple tube aerator;

Fig. 18 is an idealized vertical cross-section of a bin embodying a composite aerator of the type comprised of longitudinal tubes in a central section, with bilateral sections hingedly joined to the central section and severally comprised of transversely disposed tubes;

Fig. 19 is a fragmentary detail of a hinge joint as used in the composite aerators of Figs. 16–18;

Figs. 20 and 21 are, respectively, plan and cross-section views of a modified multiple tube aerator, with a flat, semi-rigid, air-impervious bottom, and a tubiform, air-pervious, inflatable and distensible top, and

Fig. 22 is a fragmentary detail of one end of a multiple tube aerator, showing a variety of air-inlet means.

Turning now to the drawings, there is shown in Fig. 1, diagrammatically, a novel power plant for generating electric locomotives, the generator being powered by a gas turbine utilizing motive fluid generated in a coal-burning combustor. The power plant is comprised of a gas turbine **10**, directly coupled to and driving a low pressure, secondary air compressor **11**. A main D. C. generator **12**, for motive power, is driven by the turbo-compressor shaft **9**, as is the auxiliary D. C. generator **13**. A gear box **14** houses reduction gearing, not shown, which directly couples the turbo-compressor shaft with the shaft **14'**, of a novel rotary pneumatic-mechanical pulverizer **15**. The unit pulverizer **15** is more particularly described and claimed in my companion application Serial No. 423,978 filed February 23, 1954, for Powdered Coal-Burning Gas Turbine Power Plant With Pneumatic Coal Conveying System Therefor. A secondary air duct **16**, conveys diluting and cooling air from the compressor **11** to combustor casing **17** in which is mounted a combustor **18**. The combustor **18** is preferably of the type disclosed and claimed in the application of F. D. Buckley, Serial No. 257,165, filed Nov. 19, 1951, for Cold Wall Combustor With Flexibly Mounted Flame Tube. The combustor delivers fly ash and incompletely burned powdered fuel and aggregates, suspended in the motive fluid, through a U-duct **19**, into a battery **20**, of reverse flow vortical whirl separators, as more particularly set forth and claimed in the application of John I. Yellott and Peter R. Broadley, Serial No. 330,077, filed Jan. 7, 1953, for Coal Burning Gas Turbine Power Plants, etc. The cleaned motive fluid from the separator is delivered to the turbine, and the spent fluid is vented to the atmosphere.

The combustor **18** is specially adapted to burn a gasiform combustible comprising a streaming entrainment of pulverized coal particles in a pressurized stream of combustive, or so-called primary air, and at a pressure slightly above that of the secondary air which forms the atmosphere within the combustor casing **17**. One method of preparing such a combustive air-borne suspension of pulverized coal is readily apparent from the drawings, in which a novel, wholly pneumatic, non-mechanical coal preparation and feeding system is illustrated, and which system operates in the following manner:

A side stream of secondary air is withdrawn from compressor **11** through line **21**, intercooler **22**, and line **23**, to the booster compressor **24**, driven by D. C. motor **25**. The so-formed, and relatively cool (<140° F.) conveying air is then delivered through line **26** to the coal pump **27**, where it picks up a controlled charge of crushed coal and delivers the resulting streaming entrainment of primary air-borne coal particles through line **28** to pneumatic-mechanical unit pulverizer **15**. It is noted that the inlet to pulverizer **15** incorporates a convergent nozzle pulverizer of the type disclosed and claimed in my prior Patent 2,651,176, issued Sept. 8, 1953, for Coal-Fired Gas Turbine Power Plants. From the pulverizer **15**, the combustible air-borne suspension of pulverized coal in combustive air is delivered to combustor **18** through line

29. A bunker 30 is provided with a valved outlet 31, controlled by slide valve 32, and discharges into coal pump 27, which may be of the type shown in my application, Serial No. 130,215, filed Nov. 30, 1949, for Gas Turbine Power Plant, now Patent 2,652,687 issued Sept. 22, 1953. The valve 32 is regulated through connection 33 by throttle control 34, and by governor 35 on the turbine shaft, through connection 36. In this manner, the amount of coal fed to the combustor is directly maintained as a function of the desired load on the turbine.

Fluidizing and conveying air for the bunker may be delivered by aerating blower 37 through line 38. The blower intake may open directly into the ambient air, or, as shown in Figs. 1 and 2, special means for supplying air may be provided. In the form shown in Fig. 1, an intake pipe 39 having a bell mouth 40, is mounted on and around the major part of conveying air line 26, serving to cool the latter and its contained flowing air stream, so that the coal picked up in coal pump 27 is suspended in a relatively cool stream of air, and danger of premature or spontaneous combustion of fine particles of coal is prevented. In the fluidizing air supply shown in Fig. 2, a bleed-off line 41 is provided with a pressure regulator 42 which discharges into the bunker 30 through line 43. For purposes to be described more in detail hereinafter, the line 43 may incorporate any suitable pulsator, designated generally by the numeral 44. The aerating blower 37 can be regulated to deliver fluidizing air at any desired pressure and rate of flow.

The system illustrated in Fig. 2, and described immediately hereinabove, is operated as follows: With a flow of 125 C. F. M. of conveying air through line 26, and pressure regulator 42 set to deliver a flow of 5 C. F. M. to the fluidizing line 43, a flow of 120 C. F. M. of conveying air will be delivered to combustive air feed line 28 through coal pump 27. Because of the drop in pressure of the fluidizing air side stream, on its passage through reducing valve or pressure regulator 42, the volume of the fluidizing air stream is greatly increased, and its temperature is considerably reduced, so that it is supplied to the bunker in a relatively cool state.

From the above, it will be seen that the pneumatic handling, transport and delivery of particulate coal to a combustor of a motive fluid generator for gas turbines can be effected in a simple manner, by the bleeding off of a fractional amount of the conveying air of the system, or by utilizing a low power aerating blower, which can be operated to deliver a fluidizing air stream of the order of 20 C. F. M.

The foregoing description sets out the background of one system in which the novel fluidizing and material-conveying aerator devices of the present invention play a distinctly enhancing role. In the following description, stress will be laid on the structural details of the novel air-pervious fluidizing aerator devices, as incorporated in coal bunkers and conveying chutes, and essentially as independent, readily removable and replaceable devices which do not require the shutting down or dismantling, in whole or in part, of a bunker, bin, chute conveyor, or other receptacles, when the system is plugged up, or otherwise rendered inoperative, as in the case where fluidizing membranes are built into bunkers and chutes, as substantially integral parts thereof.

As noted hereinabove, the present system was developed primarily for the non-mechanical handling of crushed and pulverized coal in storage and coal-feeding devices incorporated as elements of coal-burning gas turbine power plants utilized to furnish power for generators of generating electric locomotives. While such preferred use is eminently desirable, it will be readily apparent that the improved fluidizing and air-conveying system herein, as well as the structural aerator members and devices appurtenant thereto, will also provide enhanced, non-mechanical handling and transport (conveying) means

and method for cement, crushed and powdered minerals and chemicals, flour, grains, and other discrete particulate solid materials.

In Figs. 3 and 4, there is shown a conventional coal bunker 30, and a bifurcate bunker 50, respectively. As shown more particularly in Fig. 3, the bunker 30 has side walls 60, 61, end walls 62, 63, and a bottom trough, indicated generally at 64. The side and end walls are joined to the top of the trough by sloping side wall sections 65, and sloping end wall sections 66. The trough 64 has an entrant 67 for fluidizing air coupled to fluidizing air supply line 38, and a discharge outlet 31, for fluidized coal. As described under Fig. 1, the outlet 31 will discharge into the coal pump 27, the quantity of coal fed being determined by the setting of slide valve 32, supra.

In the form shown in Fig. 4, the bifurcate bunker 50, has its legs 51, 52, of the same general construction as bunker 30, and the subjoined troughs are designated 55, 56, respectively. For purposes of ready identification, the fluidizing air entrants for troughs 55, 56, are respectively designated 57, 58. The spaced legs 51, 52, of bunker 50, define a passageway 53, therebetween. The bunker 50, is shown as incorporated in a coal car 54, of a locomotive, access being had to the bunker through suitable openings in the top, which may or may not be closed. As already noted, it is a feature of the invention to carry bunker coal at ambient atmosphere pressure.

Turning to the showings in Figs. 5–22, the details of the novel air-pervious aerators comprising distensible unitary and multiple tubes, and their preferred mounting in containers and chutes, will now be described.

One form of aerator is a single tube, comprised of a suitable length of air-pervious, woven canvas hose 70, and having an end 71, closed by one or more rows of stitching 72, or sealed by any suitable cement. The method of closure may include folding the end back on the tube, and stitching, or rolling the end back and clamping or stitching. The tube has an open or inlet end 73, into which is fitted a metallic insert 74 (Fig. 6), of generally cylindrical shape, and having a closed end 75 provided with a threaded aperture 76. The insert 74 may be clamped in place in member 70, or secured by wire wrapped around the outside of the hose, all as indicated generally by the numeral 77.

A second form of single tube aerator is illustrated in Fig. 7, and is designated generally by the numeral 80. This type is comprised of a fabric sheet of air-pervious material, of suitable length and width, folded longitudinally, along fold line 81, with marginal edge 82, 83, aligned and secured together, in any suitable manner, as by sewing, indicated at 84, to form a tube. One end of the so-formed tube may be closed in the usual manner, and an air inlet fitting inserted in and secured in place at the other end. As will appear more fully hereinafter, a gasketed inlet may be secured anywhere along the body of the sheet, before folding, and the apposed side edges and both ends of the folded over member secured by sewing, or in any other manner. The material for the tubiform aerators will normally be of a limp-air-pervious fabric, and can be fabricated readily in the manner indicated.

The mounting of individual aerators in the troughs of bunkers will now be considered. To simplify the description, the trough section of bunkers are shown schematically, as single units, and are collectively and generally identified by the numeral 64, (Fig. 3). In the showing of Fig. 8, an air-pervious aerator tube 70 is shown in fully expanded or dilated condition, its partially deflated condition being indicated by the substantially oval cross-section in dotted lines, and identified by the numeral 70a. Figure 8 illustrates the normal "breathing" action of the tube under the influence of a pulsating

air supply. It will be seen that an overlying mass of discrete particles will be vertically displaced by the rise and fall of the upper surface of the tube, as the fluidizing air dilates the tubes, and seeps therethrough, whereby to fluidize the particulate mass, and as the tube collapses when the air supply is diminished or cut off, according to the method of pulsation of the air.

In Figs. 9 and 10, a number of individual aerator tubes 70, are disposed in a troughed bottom 64 of a bunker, and each is provided with a valved connection, designated generally by the numeral 78, which connections, are, in turn, coupled to air supply manifold 79, and to the threaded apertures 76 of metallic inserts 74.

In Figs. 11, 12, and 13, generally flat aerator tubes or pillows 90, are shown as comprised of top and bottom air-pervious fabric sheets 91, 92, respectively, which are substantially co-extensive with the bottom surface of the bunker or its trough. The sheets 91, 92, are joined along their marginal edges, as by sewing, indicated generally by the numeral 93, to form closed tubes. Fig. 11 schematically illustrates the distension of an aerator tube 90, under an air pressure of more than 2 p. s. i., while Fig. 12 shows the same tube substantially completely deflated and collapsed under an applied air pressure of less than 2 p. s. i. Under such operating conditions, a vertical rise of ½ inch, in distended condition, will suffice to keep an overlying particulate mass thoroughly broken up and fluidizable by the upflowing air from the aerator. With the form of aerator tube shown in Figs. 11 and 12, some bilateral contraction will be experienced with maximum distension or inflation, and finer particles of the superjacent particulate mass will flow down around the marginal edges to the bottom of the bunker or other container. While such a condition is not necessarily harmful in normal operation, it may be found desirable, on occasion, to prevent any lateral contraction of the aerator. This can best be effected by utilizing the form of the device illustrated in Fig. 13. In this form of the invention, the desired fixed width of the tube is secured by incorporating a stiff metal sheet 94, of the desired dimensions, in the member 90, during fabrication. The metal sheet 94 is desirably provided with holes 94' extending over its entire surface, so that it provides a foraminous transverse spacer and support for the aerator, while permitting uniform air pressure upon both air-pervious surfaces of the member. Where the fluidizing aerator members or devices 90, and the like, expose any considerable area to the air-lift or levigating action of the outwardly seeping air, longitudinal hold-downs 95, may be secured along the sides, as shown in Fig. 13. These hold-downs may comprise metal rods of sufficient weight for the intended purpose, or, if too light, may be detachably secured to the wall of the container.

A particularly advantageous feature of the present invention resides in the fact that aerators comprised of both individual and multiple tubes can be fabricated readily from air-pervious fabrics. Sail canvas, nylon sheetings, and fabric sheetings generally, can be used in single sheet or multiple-ply thickness. Where multiple plies are used, each composite sheet may be quilted to give an increased strength and permit easier handling and fabrication. Apposed sheets of air-pervious fabrics, either single ply or multiple ply, are sewed, or otherwise secured along the marginal edges, the closed end usually being reinforced by folding the double sheet back on itself, and sewing, or otherwise securing the thickened end. The individual tubes of the aerators are formed by spaced, parallel longitudinal rows of stitching, or other suitable securing means. To increase the bursting or tearing strength of the assembly, the longitudinal rows of stitching may be doubled or tripled. Such multiple stitching between the individual tube sections will also provide a desirable spacing between the sections, so that the surfaces of the aerator will be essentially corrugated or scalloped. Each tube section of an aerator will be fitted with air inlet means in the manner described hereinabove.

One form of the novel multiple aerator or fluidizer is illustrated in Figs. 14 and 15, and is designated generally by the numeral 100. This member, as shown, is comprised of top and bottom sheets 101, 102, respectively, and joined along their aligned side edges 103 by rows of stitching, 104. Intermediate longitudinal rows of spaced parallel stitching, designated generally by 105, divide the member 100 into a plurality of mutually abutted, air-pervious tube sections 106. As shown in Fig. 15, the tube sections 106 are of uniform cross-section, but the invention comprehends the forming of the tube sections if differential cross-section, as where the lateral tube sections are intended to lie on and over the bottom sections of the side walls, of a bunker or bin, and such lateral tube sections are made larger than the central sections. Such differential sizing is readily effected by varying the spacing between the central rows of longitudinal stitching which form the seams dividing the member into a plurality of mutually abutted tubes. As shown in Fig. 14, air is supplied to the aerator assembly from a supply header 79, through valved feeder lines 78, which are hermetically secured in the metallic inserts 74 being secured in the opening of the tubes 106.

The normally limp fabrics used herein can be strengthened along the marginal edges by folding the edges over on themselves, and the closed ends of the assemblies will usually be secured by plural rows of stitching 107.

Normally, the aerating devices of the invention herein are coextensive in area with the bottoms of the containers or chutes in which they are installed. As shown in Fig. 15, they may be made wide enough to not only cover the bottom of a bin or bunker, but to extend up an appreciable height along the side walls, the bottom sections of the walls being usually tapered inwardly of the container.

The principles of the present invention can also be incorporated or embodied in novel composite aerators which are especially suited for use in emptying bins, replacing the mechanical equipment hitherto required. Such improved material-moving equipment is illustrated, in plan view, in Fig. 16.

Turning now to Figs. 16, 17, and 18, an aerator 110 will be seen to be comprised of a central section 111, and bilaterally conjoined side sections 112, 113. The central section 111 is comprised of longitudinal tube elements 114, for aerating and discharging the overlying body of discrete solids, and this central section is substantially coextensive in area with the bottom of the bin, bunker, or other container in which it is installed. The usual air-supply connections, not shown, are fitted into the elements 114, all as described hereinabove. The side sections 112, 113, are severally comprised of transversely disposed tubiform aerator elements, designated generally by the numeral 115, and mutually conjoined and separated from each other by the usual rows of stitching 116, or other securing means. The side sections 112, 113, extend the length of the center section 111, but their width is determined by the type of bin in which they are to be installed, and particularly by the width and slope of the converging side sections of the bin walls. As shown in cross-section in Fig. 19, a bin 120, having vertical side walls 121, 122, and apertured top 123, and a flat, central bottom section 124, has relatively flat side bottom sections 125, 126, joining the side walls and the bottom. Because of the relative flatness of the entire bottom, as shown, the contained mass of discrete solids tends to remain put along the side walls and cannot be moved with any degree of facility. This condition is aggravated in coal cars, bunkers, and other bins and containers, where the relatively high angle of

repose of crushed coal (about 45°) militates against any ready flow of the coal towards the center of the bin and the discharge outlet. By installing an improved composite aerator **110** in the bottom of a relatively flat-bottomed bin, the overlying particulate mass is aerated over its entire horizontal cross-section, and made readily flowable. By orienting the side aerating elements transversely, and the center aerating elements longitudinally of the bin, the mass of aerated coal, or other discrete solids, is caused to flow toward the central longitudinal axis of the bin, and therealong (the central axis) towards the discharge outlet.

The aerating sections **111**, **112**, and **113**, may be formed as a unitary construction, with separate air supplies to each of the sections, or means may be provided for a common air supply for the unit **110**, the several sections being interconnected to permit free passage of air therein and therebetween.

Where the bins have any appreciable cross-sectional area, the fabrication of unduly large unitary or integral aerators of multiple sections, as envisioned hereinabove, may be found to be uneconomical, and/or mechanically inept. This situation is readily remedied by the practice of the present invention, wherein small unit aerators may be fabricated, conjoined and assembled into composite units of any desired dimensions. In fact, the aerators of the invention herein can be made in a relatively small, standard size, and any sufficient number coupled together to make a composite member of the requisite dimensional area. This desirable result is accomplished by providing the marginal edges of an aerator of predetermined, standard size with hinges, indicated generally by the numeral **117**. The hinges, as shown in detail in Fig. 19, comprise rows of stables **118**, secured to the marginal edges of an aerator, as by bending of or forcing the free ends into and through the fabric. The looped portions of the staples extending outwardly from the edges of the aerators form loops which are adapted to interfit and register with like members of an apposed aerator. A locking rod or pin **119**, is then passed through the interfitted registering loops, thus hingedly locking the abutted aerators together.

It will be appreciated that standard aerator units can be made up of a size and weight such that one man can carry one or more of them, and install them in place without the use of tools, or the help of fellow workmen. The preferred type of hinge is available on the market, being a standard items for use in flexibly joining leather, canvas, and rubber belting, and the like. The use of such a hinge joint for the purposes hereinabove described, gives rise to a wholly novel type of aerator construction. Where necessary, the usual hold-down members may be used for the installation, although it is believed that the locking rods **119** may be sufficiently heavy to serve as hold-downs. Where aerator units are coupled by hinge joints, or other securing means, interflow of fluidizing air between units may be effected by the use of sections of hose, such a brake hose, and the aerators may be provided with gasketed couplings of any suitable type and number. It will, of course, be understood that the several aerators may have direct hose coupling to an internal or external (of the bin) pressure air supply, and such hoses, or metal pipes may be introduced into a container from the top thereof, as well as being fixedly secured in the walls or bottom of the container.

The aerators of the present invention, as disclosed hereinabove, are of air-pervious, limp material, which is distensible when pressure air is applied, whereby air passing through the fabric permeates the overlying mass of discrete particulate soilds, and, under sustained conditions of air pressure and flow, fluidizes the same. Where extended surface areas are to be covered by the novel aerators herein, the buoyant or levigating effect of air issuing from the undersides of the aerators is essentially lost, as such air will collect and discharge upwardly into the overlying bed of solids as continuous air streams or large bubbles which have no fluidizing effect, and tend to destroy or lessen such effect as imparted by the upflowing air from the top surfaces of the aerators. Where the aerators are to be used in temporary duty, and are to be subject to dragging around and rubbing on and over rough surfaces, it is desirable to make the bottoms of the flat or pillow-type aerators of wear and abrasion-resistant material.

Turning now to Figs. 20, 21, and 22, there is shown, in fragmentary detail, a novel aerator **130**, characterized by an air-impervious, self-supporting, and abrasion-resistant bottom **131**, and an air-pervious, tubed top **132**. The bottom may be comprised of semi-rigid material, such as rubberized canvas belting, or the like, and the top is made of the usual air-pervious, limp fabric. The limp bottom type may also be used, with the bottom rubberized, or otherwise non-pervious to air, and the top air-pervious, but semi-rigid and self-supporting. The marginal edges of the top may be folded in on themselves and sewed in place on the bottom, as by stitching **133**, or a strip of welting **134**, may be applied on and over the edges of the limp fabric, and then sewed, or otherwise secured. The tubes **135**, in the top are formed by spaced, parallel double rows of stitching **136**. In the assembly of the aerators, the component parts are preferably cemented together, and later sewed or mechanically secured. Spaced stiffening and hold-down rods **130*a*** may be set in the troughs formed by and between the tubiform elements, and the rods may be clipped onto the aerators in any suitable manner.

As shown more particularly in Fig. 22, fluidizing air may be introduced into the aerators in a variety of ways. In this showing the tubes **135** are shown opening into a plenum chamber **137**, formed at one end of the device. This chamber may be provided with a lateral opening **138**, or an end opening **139**, severally fitted with gasketed connections **140**, **141**, which can be severally capped by caps **142**. A top inlet is preferred, and is designated by the numeral **143**. When set up for use, air connection is made to the chosen inlet, and the other inlets are capped. The aerators are then mounted in place, in the bin or other open-topped container, and a charge of discrete solids is introduced into the container, the discharge outlet of the container being closed. When the bin is to be emptied, the discharge outlet is coupled to a chute or transfer pump, the air supply is connected to the aerator system, and the contents of the bin are fluidized by the air delivered by the aerator system. The fluidized solids will flow out through the discharge outlet, or outlets, and without mechanical work other than that required to hook up the system, as indicated. The discharge outlets may be disposed in any part of the bottom of the bin, as well as in the immediately adjacent side walls. Because of the special fluidizing action of the air delivered by the aerators, specially designed bins are not required for storage of discrete solids, and any container having the desired cubage can be used for storage.

Where pit-type storage is contemplated, the aerators will be used to form a base or air-pervious pillow or mattress at the bottom of the pit, and suitable air connections made thereto. The fluidized solids can be withdrawn by pneumatic suction means, and in much shorter time, due to the increased mobility of the solids in the fluidized state.

The aerators of the invention herein are especially adapted for use in bulk storage of food materials, such as grains, flour, and other materials. As is well known, such food materials suffer enormous losses due to infestation by weevils, various types of beetles, and other forms of insect and animal life. This infestation can be reduced to a minimum, and proper sanitization of edible food products maintained by fumigation. Using aera-

tors of the types herein disclosed, as fixed or detachable elements of storage bins, cars, silos, and other containers, whether stationary or mobile, suitable gasiform fumigants can be introduced into the stored food products, and under conditions of positive control. In such use, care will be taken that the materials used in the fabrication of the aerators will not be reacted on by the fumigants. This precaution will also be observed where the aerators are to be used for the chemical treatment, and/or reaction of any type of minerals, in fluidized form, with gasiform reagents which may also serve as fluidizing gases. Under chemical treatments, it may be found desirable to use mixtures or sequences of gasiform fluids, and the aerator structures of the invention herein lend themselves most readily to such use.

It will be readily apparent that the improved aerators herein are susceptible of use in a wide variety of industrial and technical installations, a preferred use being in the fluidizing of crushed coal (≤⅜ in. particle size) in bunkers of coal-burning, gas turbine power plants, and particularly in such plants as incorporated and used in generating electric locomotives. A notable characteristic of the aerators herein, whether unitary or segmented, resides in the fact that they can be fabricated from readily available materials, at a minimum cost, and can be emplaced and replaced in any type of installation by a single workman, and without involving dismantling of the container, bin, bunker, or chute, in which they are installed.

There has been described and illustrated devices capable of performing all of the specifically mentioned objects of this invention as well as others which are apparent to those skilled in the art. Various uses of the present invention may be made employing the described structure. Accordingly, it is apparent that variations as to operation, size and shape, and rearrangement of elements may be made without departing from the spirit of the invention. Therefore, limitation is sought only in accordance with the scope of the following claims.

This application is a division of my prior application S. N. 411,930, filed February 23, 1954, for improved Pneumatic Material Handling System and Apparatus.

What is claimed is:

1. Bulk discrete material handling system of the character described, including in combination, a bottomed, vented container; discrete material inlet and discharge means for the container, said discharge means being contiguous to the bottom of the container; and air-dispersing and fluidizing means including at least one aerator, comprising a normally-limp tube-like member of air-pervious material disposed in the bottom of the container.

2. Material handling system according to claim 1, characterized by the fact that the container includes a trough-like depression in the bottom thereof, and the air-pervious tube is disposed in the trough.

3. Material handling system according to claim 1, characterized by the fact that a source of pressurized gasiform fluid is coupled to the air-pervious tube-like member at one end thereof, and the other end of the member is closed.

4. Material handling system according to claim 1, characterized by the fact that the bottomed container has at least one vent in the top, said vent being normally open to the atmosphere.

5. Bulk discrete material handling system of the character described, including, in combination, a bottomed, vented container; a body of discrete material in the container; discrete material inlet and discharge means for the container, said discharge means being contiguous to the bottom of the container; air-dispersing and fluidizing means comprising at least one tube-like member of textile material disposed in the bottom of the container, and a source of pressurized air coupled to one end of the tube-like member, the other end thereof being closed, said tube-like member being normally wholly collapsed under the weight of the overlying discrete material.

6. Material handling system according to claim 5, characterized by the fact that the normally collapsed tube-like member is distensible under the action of the pressure air, and the air is dispersed therethrough into and fluidizes the overlying body of discrete material.

7. Bulk discrete material handling system of the character described, including, in combination, a vented, bottomed container having a trough-like bottom, and side walls with at least the lower portions thereof disposed at an angle less than the normal angle of repose of the material to be handled; a body of discrete material in the container; discrete material inlet and discharge means for the container; a source of pressurized air; air-dispersing and fluidizing aerator means comprising at least one distensible hollow member of normally limp air-pervious material disposed in the said trough-like bottom; and valved conduit means connecting the air source and the air-pervious hollow member.

8. Material handling system according to claim 7, characterized by the fact that the discrete material is coal having a particle size of ≤⅜ in., and the normally limp hollow member is made of textile material.

9. Material handling system according to claim 8, characterized by the fact that the hollow member is woven and is normally collapsed under the weight of the overlying body of coal, and is distended when compressed air is delivered thereto.

10. Material handling system according to claim 7, characterized by the fact that a plurality of hollow tube-like members are disposed in and cover the trough-like bottom of the container, and each tube-like member is separately coupled to the pressurized air source.

11. Material handling system according to claim 10, characterized by the fact that the hollow tube-like members are mutually separate and distinct.

12. Material handling system according to claim 10, characterized by the fact that the plurality of hollow tube-like members are conjoined in a unitary member.

13. Material handling system according to claim 12, characterized by the fact that the conjoined tube-like members of the aerator are formed by and between apposed sheets of woven textile material joined by spaced parallel seams, and one end of the assembly is closed by a transverse seam.

14. Material handling system according to claim 13, characterized by the fact that the conjoined tube-like members of the aerator are secured by discontinuous seams, whereby the fluidizing air is permitted to interflow between the tubes.

15. Material handling system according to claim 7, characterized by the fact that an aerator comprised of a plurality of laterally conjoined tubes is disposed over the bottom and lower portions of the contiguous side walls of the container, and each tube is separately coupled to the pressure air supply.

16. Material handling system according to claim 15, characterized by the fact that the conjoined tubes form a mattress.

17. Material handling system according to claim 16, characterized by the fact that the mattress is formed of normally limp, air-pervious textile material.

18. Material handling system according to claim 15, characterized by the fact that the tubes are distensible into tubes of varying diameter.

19. Material handling system according to claim 18, characterized by the fact that the outside tubes of the assembly, when distended, are larger than the inner ones.

20. Material handling system according to claim 7, characterized by the fact that the distensible tubes are substantially the full width of the containing troughed bottom.

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