

Sept. 10, 1957

J. I. YELLOTT

2,805,896

PNEUMATIC MATERIAL HANDLING SYSTEM AND APPARATUS

Filed Feb. 23, 1954

5 Sheets-Sheet 1

FIG. 1.

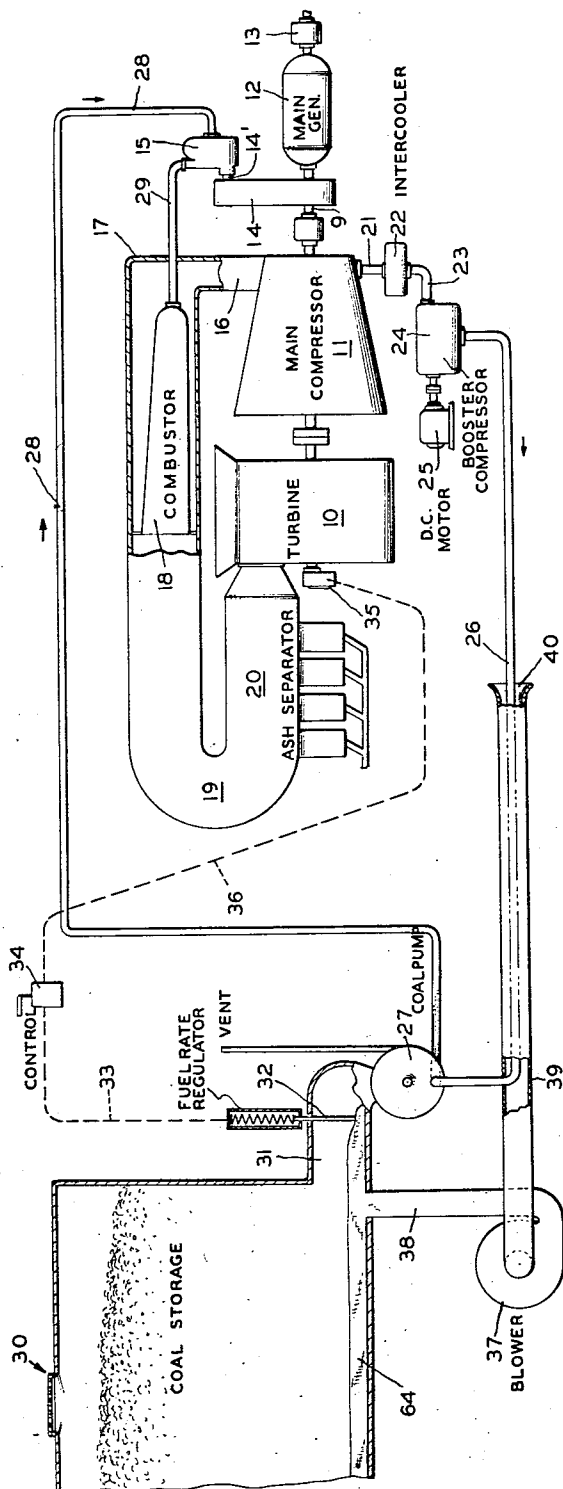


FIG. 3.

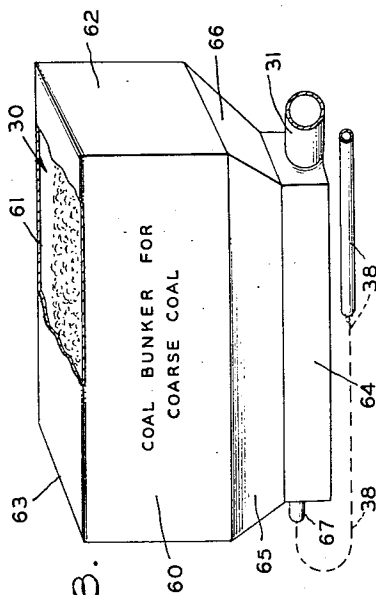
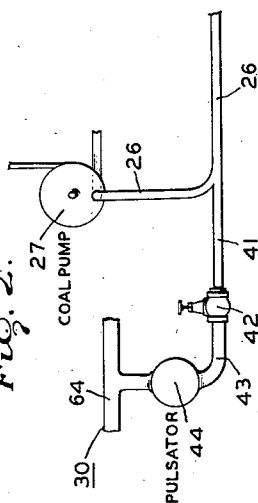


FIG. 2.



INVENTOR.

John I. Yellott

BY *Frederick A. Norton and*
Wm. J. Boyle
ATTORNEYS

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J. I. YELLOTT

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FIG. 5.

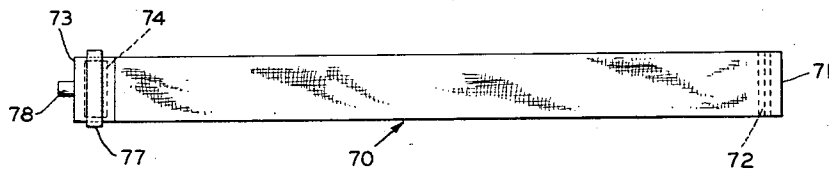


FIG. 4.

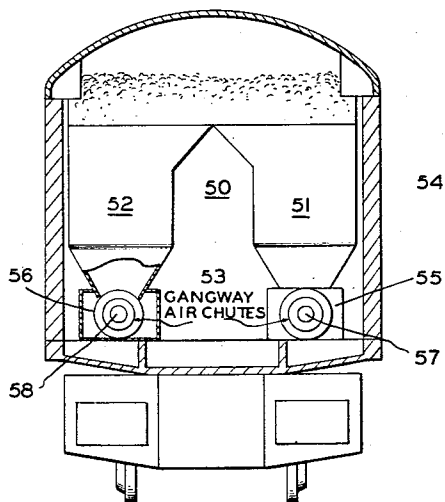


FIG. 6.

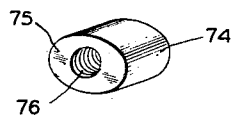


FIG. 7.

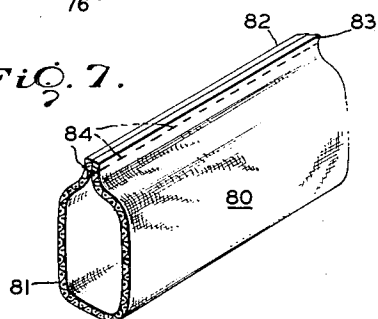


FIG. 8.

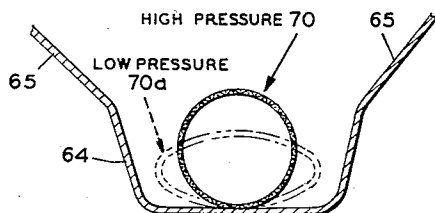
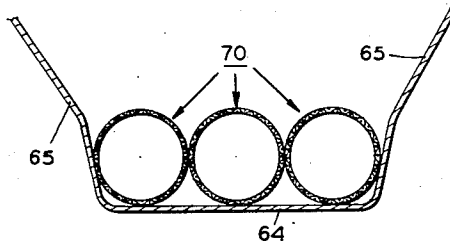


FIG. 9.



INVENTOR.

John I. Yellott.

BY *Frederick A. Norton and*
Charles J. Boyle
ATTORNEYS

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J. I. YELLOTT

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FIG. 10.

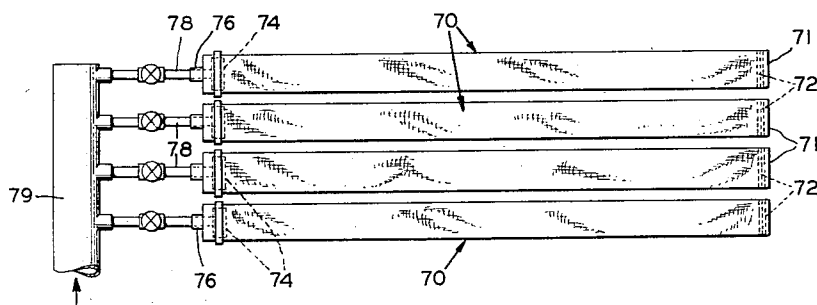


FIG. 11.

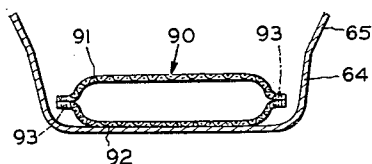


FIG. 12.

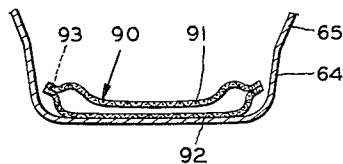


FIG. 13.

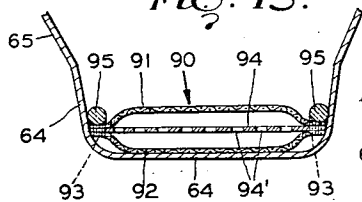


FIG. 15.

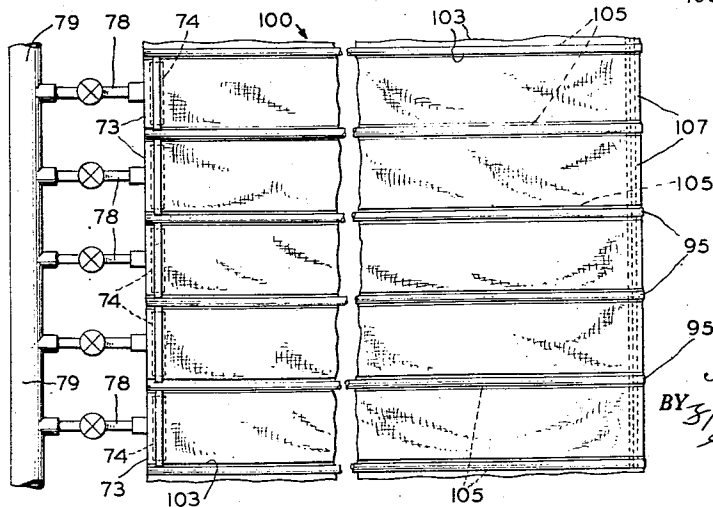
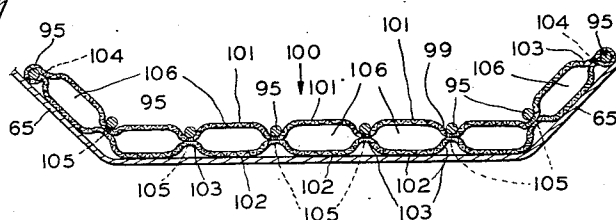


FIG. 14.

INVENTOR.

John I. Yellott

BY *Frederick A. Norton and*
Charles J. Boyle
ATTORNEYS

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J. I. YELLOTT

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FIG. 16.

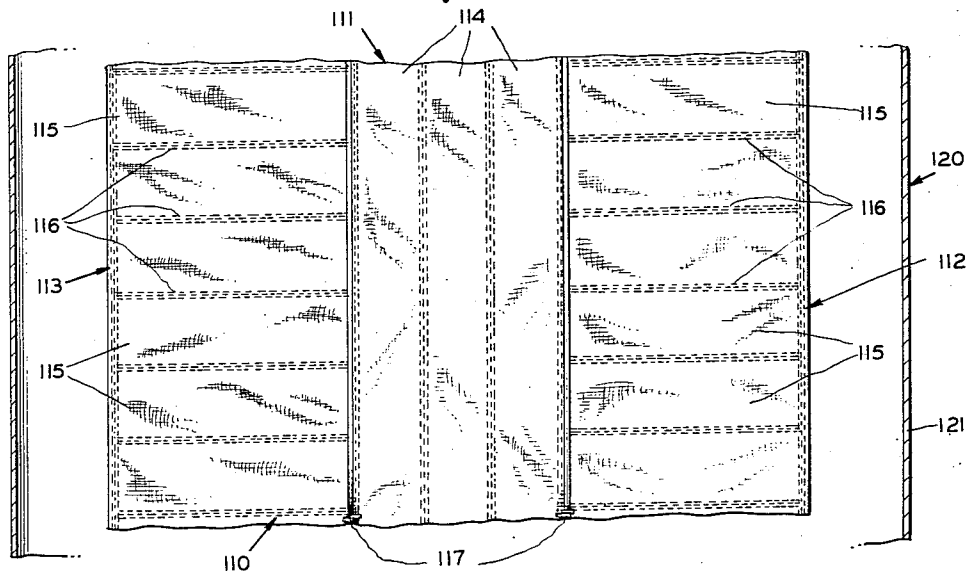


FIG. 17.

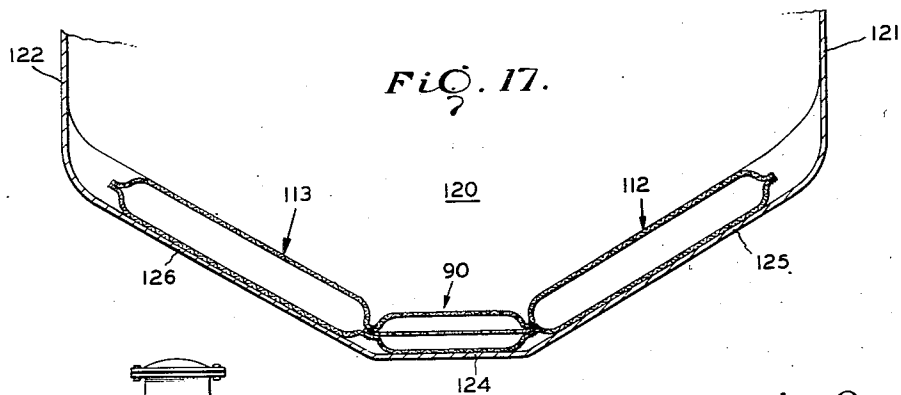


FIG. 18.

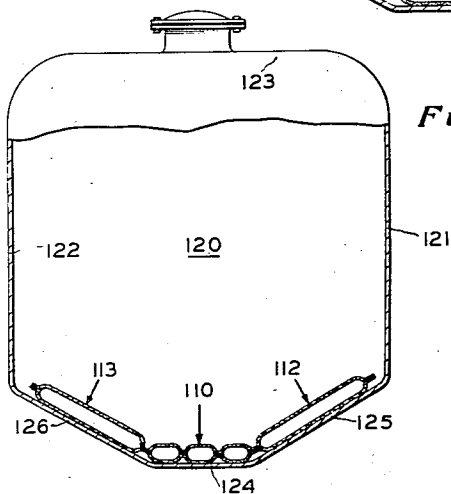
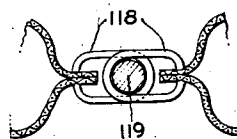


FIG. 19.



INVENTOR.
John I. Yellott.
BY Frederick R. Norton and
Klaus J. Boye
ATTORNEYS

Sept. 10, 1957

J. I. YELLOTT

2,805,896

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FIG. 21.

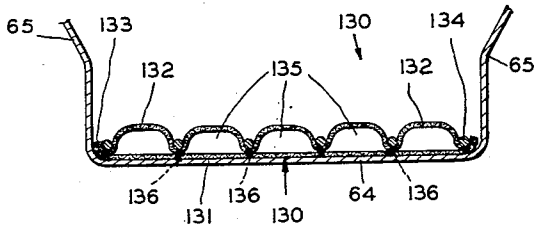


FIG. 22.

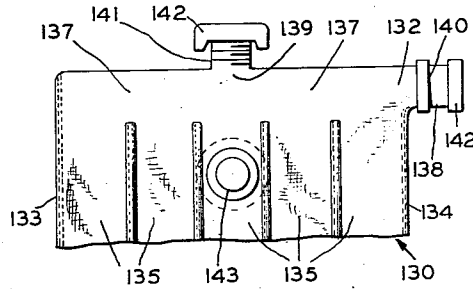


FIG. 20.

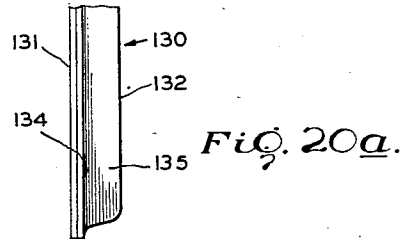
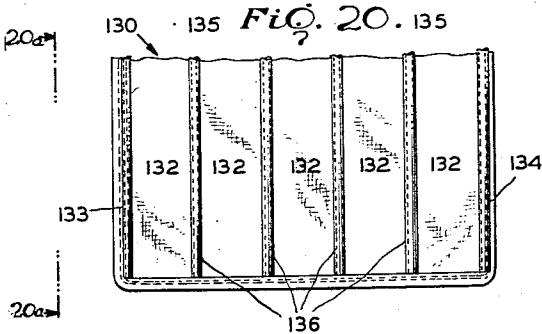


FIG. 20a.

INVENTOR.

John I. Yellott.

BY Frederick A. Norton and
Wesley J. Payne
ATTORNEYS

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2,805,896

PNEUMATIC MATERIAL HANDLING SYSTEM AND APPARATUS

John I. Yellott, New York, N. Y., assignor to Bituminous Coal Research, Inc., Washington, D. C., a corporation of Delaware

Application February 23, 1954, Serial No. 411,930

17 Claims. (Cl. 302—29)

This invention relates to unitary, normally limp, air-pervious, distensible aerators for fluidizing discrete solids, and particularly adapted for use in systems for discharging bulk materials maintained in an aerated state, and without the use of mechanical transfer equipment, as well as to assemblies of such aerators detachably intercoupled to form composite 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 up-flowing bath of gaseous fluid, whereby the air-suspended, or so-called "aerated" 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 aerated 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 effected 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 bottom 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 maintained 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 de-

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sign, fabrication, installation and maintenance features, and cannot be freely substituted, either in whole or in part, in existing mechanical installations.

It has now been found that aeration 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 aerating air line, in advance of the delivery to the tubes. Pulsation of the aerating 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 aerated 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 aerating equipment.

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

Other features of novelty and advantage include the fabrication of normally limp aerators 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 devices, herein generically identified by the term aerators, with detachable locking and securing means, whereby 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 bottoms 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 aeration and transport features of the present invention;

Fig. 2 is a schematic detail of aerating 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 aerating 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 a cross-sectional view 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 a cross-sectional view 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 a cross-sectional view 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 vertical cross-sectional view 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 tubulature 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 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, Ser. 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, Ser. 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 combustible, 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 combustible 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 pulverizer 15. It is noted that the inlet to pulverizer 15 incorporates a convergent nozzle of the type disclosed and claimed in my prior Patent No. 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 combustible 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, Ser. No. 130,215, filed Nov. 30, 1949, for Gas Turbine Power Plant, now Patent No. 2,652,687 issued Sept. 22,

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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.

The aerating 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 aerating 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 aerating 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 aerating 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 aerating 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 an aerating air stream of the order of 20 C. F. M.

The foregoing description sets out the background of one system in which the novel aerating 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 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 receptacle, when the system is plugged up, or otherwise rendered inoperative, as in the case where aerating 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 aerating 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

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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 coupled to the aerating supply line 38, and a discharge outlet 31, for aerated 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 aerating 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 edges 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 aerating air dilates the tubes, and seeps therethrough, whereby to aerate 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 $\frac{1}{2}$ inch, in distended condition, will suffice to keep an overlying particulate mass thoroughly broken up and aeratable 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 tube 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 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 of 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, the inserts being secured in the open end 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. 18, a bin 120, having vertical side walls 121, 122, an 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 towards 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 staples 118, secured to the marginal edges of an aerator, as by bending 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 opposed 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 item 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 aerating air between units may be effected by the use of sections of hose, such as 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 solids, and, under sustained conditions of air pressure and flow, aerates the same. Where extended surface areas are to be covered by the novel aerators herein, the buoyant or levigating effect of the 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 aerating effect, and tend to destroy or lessen such effect as imparted by the up-flowing 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 130a 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, aerating 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 aerated by the aerator system. The aerated 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 aerating 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 aerated solids can be withdrawn by pneumatic suction means, and in much shorter time, due to the increased mobility of the solids in the aerated 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 aerators 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 aerated form, with gasiform reagents which may also serve as aerating 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 aerating of crushed coal ($\leq 3\%$ 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 replaced 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.

What is claimed is:

1. A unitary distensible aerator for aeration of bulk solids, in discrete form, and particularly adapted for use in systems for pneumatic handling of discrete solids comprising a hollow, closed, normally limp, air-pervious member formed from sheet material, said member having means for introducing pressurized gasiform fluid interiorly thereof, whereby upon introduction of a pressurized gasiform fluid the member is distended, and the gasiform fluid is discharged therethrough.

2. Distensible aerator, according to claim 1, characterized by the fact that the air-pervious member is tubiform.

3. Distensible aerator according to claim 1, characterized by the fact that the air-pervious member is comprised of apposed sheets of air-pervious textile material joined along the edges, to form a pillow or mattress.

4. Distensible aerator according to claim 3, characterized by the fact that the air-pervious member is formed with spaced parallel seams defining a plurality of normally collapsed tubiform elements, and air inlet means for the said elements.

5. Distensible aerator according to claim 4, characterized by the fact that the tubiform elements are severally provided with separate air inlet means.

6. Distensible aerator according to claim 4, characterized by the fact that the spaced parallel seams are discontinuous, whereby the fluidizing air is permitted to interflow between the tubiform elements.

7. Distensible aerators of the character described, comprising conjoined sheets of air-pervious textile material gathered and spacedly seamed to form an assembly of parallel, joined tubes, and a foraminous sheet metal support disposed in the assembly between and substantially

coextensive with the conjoined sheets, whereby the assembly is made of fixed width and the individual, partitioned tubes are severally collapsible and distensible upon the application of a pulsating air supply thereto.

8. A composite aerator of the character described, comprising in combination, a plurality of conjoined aerators, each said aerator comprising an inflatable pillow-like member of air-pervious fabric; hinge joint elements secured along the marginal edges of each aerators and adapted for interfitting engagement with other like elements of apposed aerators; locking means for the inter-fitted hinge joint elements; and air inlet means in each aerator.

9. Composite aerator according to claim 8, characterized by the fact that the air inlets of the individual aerators are inter-connected.

10. Composite aerator according to claim 9, characterized by the fact that the interconnectors of the individual aerators are comprised of flexible tubing.

11. Composite aerator according to claim 10, characterized by the fact that the flexible tubing is armored.

12. Composite aerator according to claim 8, characterized by the fact that each inflatable pillow-like aerator is comprised of a plurality of parallel tubes.

13. Composite aerator according to claim 8, characterized by the fact that the aerators are hingedly conjoined to form central and bilateral side sections, each individual aerator being comprised of a plurality of parallel tubes, the aerators of the central section having their tubes parallel to the longitudinal axis of the assembly, and the aerators of the side sections having parallel tubes disposed at right angles to the said longitudinal axis.

14. Composite aerator according to claim 13, characterized by the fact that the component aerators are connected to a common air supply.

15. Composite aerator according to claim 8, characterized by the fact that the pillow-like members comprising the individual aerators are formed with air-impervious bottoms.

16. Composite aerator according to claim 15, characterized by the fact that the air-impervious bottoms are semi-rigid and wear- and abrasion-resistant, and the air-pervious, normally limp fabric tops of the pillow-like members are comprised of collapsed tubes, and the tubes are distensible by compressed aeriform fluids.

17. Composite aerator according to claim 16, characterized by the fact that the air-impervious bottoms are made of material having the characteristics of rubberized canvas belting.

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