

United States Patent

Preeman

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[54] **ASPHALT PLANT DRIER WITH
VARIABLE LIFTERS**

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[52] U.S. Cl. **34/132, 263/33 R**

[51] Int. Cl. **F26b 11/02**

[58] Field of Search **263/33 R; 34/132, 137**

[56]

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[57]

ABSTRACT

A countercurrent gravity-feed, drum-type drier for flowable solid material comprising a rotatable shell, inclining downwardly from its inlet or feed end to its outlet end, having mounted circumferentially to the inner wall of the shell pivotally mounted lifter plates adjacent its inlet end.

17 Claims, 9 Drawing Figures

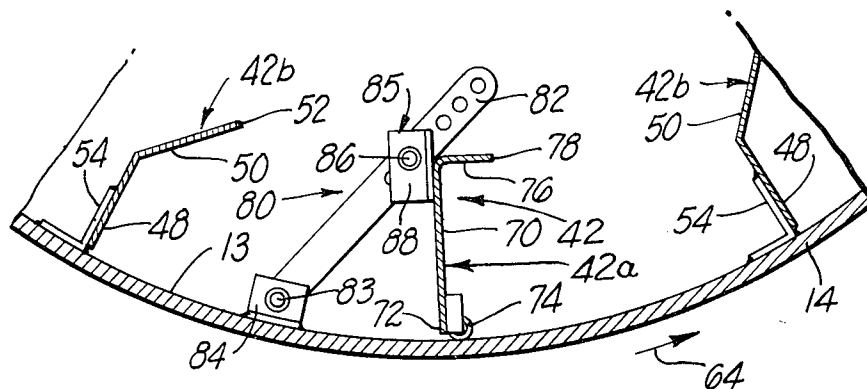


FIG. 1.

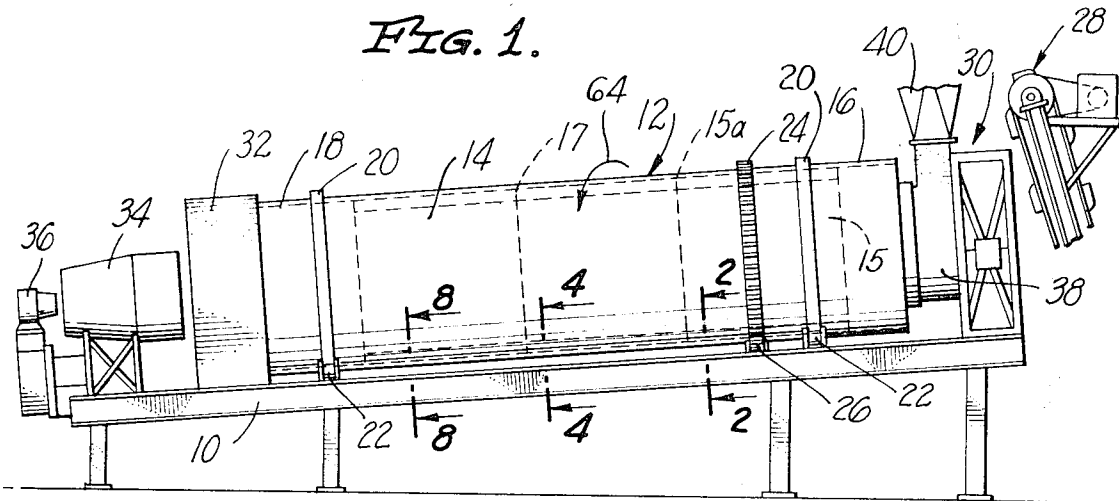


FIG. 6.

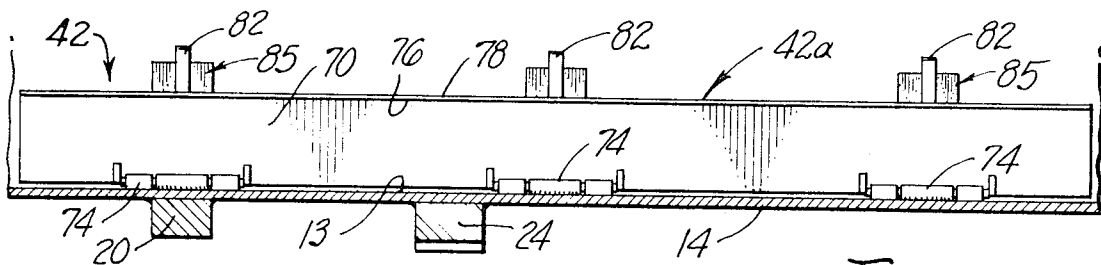
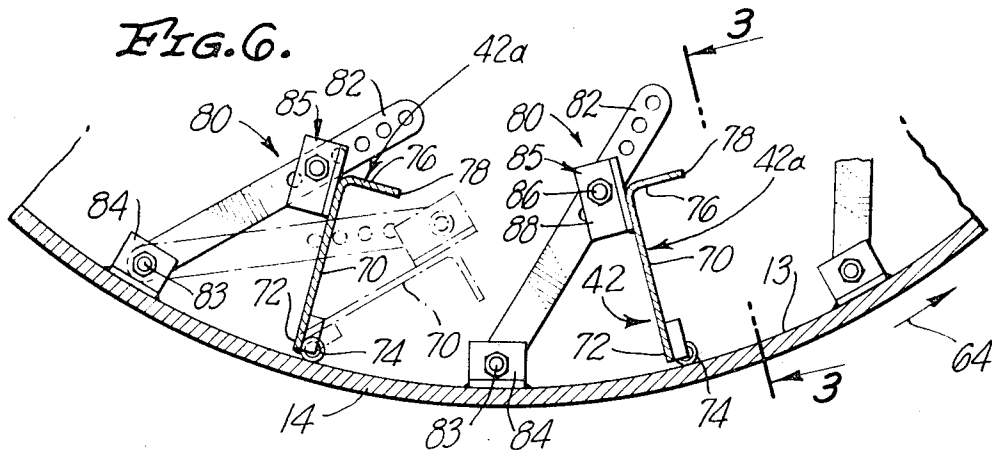
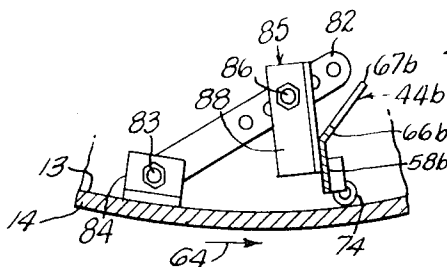


FIG. 3.

FIG. 9.



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FIG. 4.

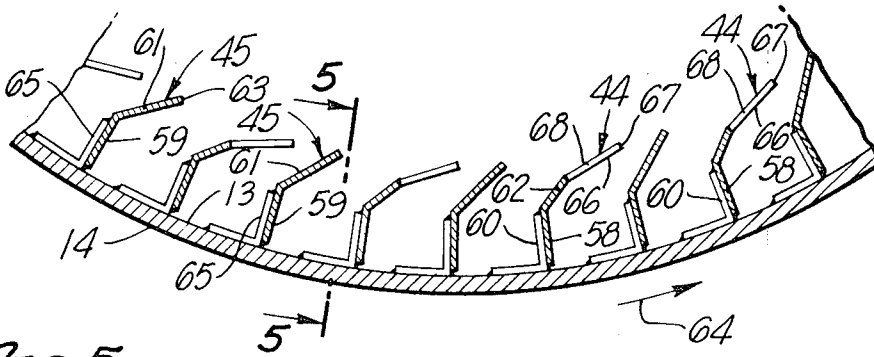


FIG. 5.

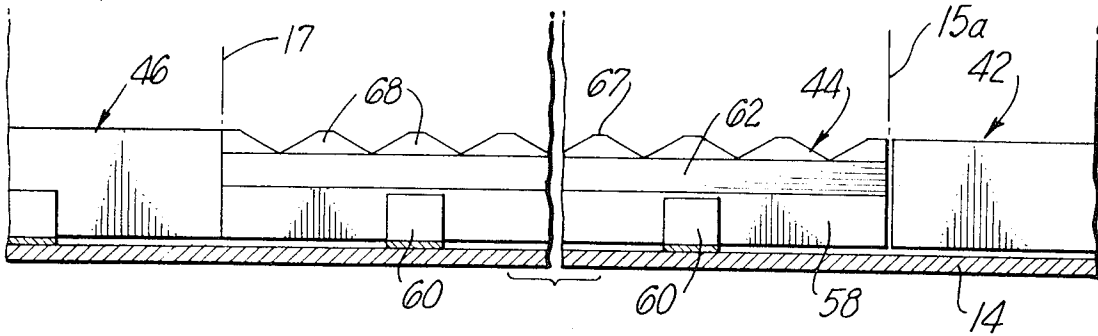


FIG. 2.

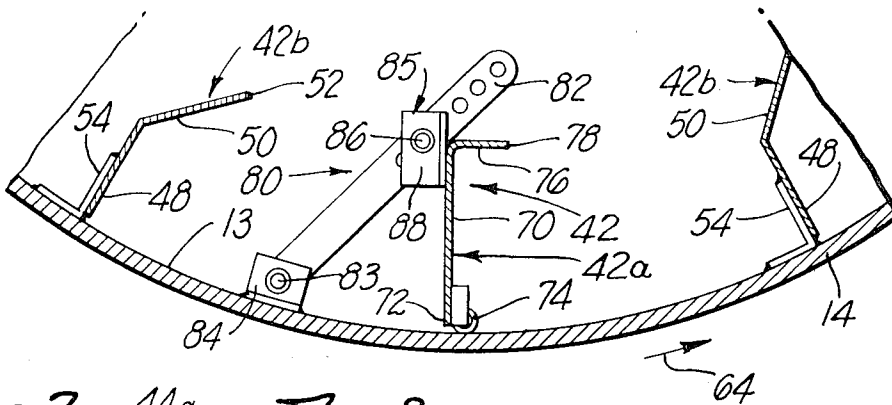


FIG. 7.

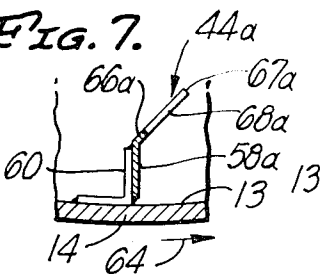
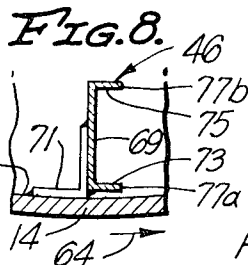


FIG. 8.



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ASPHALT PLANT DRIER WITH VARIABLE LIFTERS

The present invention relates to an improvement in a drier for flowable solid materials and since the invention has been embodied in and is particularly applicable to an apparatus for heating and drying the aggregate or aggregates utilized in aggregate-asphalt mixtures, it will be considered in such connection herein for convenience.

In general, the invention contemplates an improvement in an aggregate drier which includes a generally cylindrical shell mounted for rotation about its longitudinal axis with such axis inclined downwardly from the inlet end of the shell to the outlet end thereof so that the aggregates being dried and heated progress from the inlet end of the shell to the outlet end thereof under the influence of gravity as the shell is rotated about its longitudinal axis. Fixed and adjustable lifter plates are provided within the shell for lifting the aggregates and dropping them through a stream of hot gaseous fluid flowing longitudinally of the shell, such lifter plates operating in response to rotation of the shell. The hot gaseous fluid may be hot air, hot products of combustion of a suitable fuel in air, or the like, the flow of hot gaseous fluid longitudinally of the shell and the flow of aggregates longitudinally thereof being countercurrent. In other words, the stream of hot gaseous fluid flows from the outlet end of the shell to the inlet end thereof.

A primary object of the invention is to provide a drier of the foregoing nature wherein the lifter plates or lifters are so constructed and arranged that adequate draft for the hot gaseous fluid is maintained to prevent plugging of the drier. Prior driers, such as my drier described in U.S. Pat. No. 3,025,611, which is a drum-type or cylindrical shell-type drier with permanently mounted or fixedly mounted straight lifter plates adjacent the inlet end of the drum or shell and serrated or saw-toothed lifter plates adjacent the outlet end of the drum, have partially solved this problem of plugging. However, the conventional driers are not versatile enough to handle materials with wide variance in aggregate and moisture content without substantial and expensive modification to the drier. The present invention overcomes this lack of versatility by a surprisingly simple, but highly effective, improvement in conventional driers.

More particularly, an important object of the invention is to provide a drier wherein the lifters adjacent the inlet or feed end and the outlet or discharge end of the shell have straight discharge edges and wherein the lifters in the intermediate portion or zone of the shell have alternately serrated or saw-tooth discharge edges and straight edges, the improvement which comprises having at least some of the straight lifter plates adjacent the inlet or feed end adjustable relative to the angle between the lifter plate and the shell.

A further object of this invention is to provide a drier having three drying zones, each drying zone providing the minimum draft resistance and greatest contact between the material being dried and the hot drying gases for the material at a particular stage in its drying.

The higher the moisture content of the material being dried, the more draft resistance the material offers as the material is allowed to fall across the shell adjacent the inlet or feed end of the shell. With increasing draft resistance, the drying rate of the drier is decreased. Conventional driers have not satisfactorily solved the problem of making the drying rate independent of the draft resistance caused by the wetness of the material. The drier of the above-cited patent partially solved this problem by causing the wet material to fall down across the shell adjacent the inlet end in relatively thin sheets, but even that drier could not handle materials of different wetness or moisture content with equal drying efficiency. Thus, an important object of the drier of this invention is to provide means for handling materials of different moisture content and/or aggregate content with substantially equal efficiency.

With the foregoing construction, the wetter material being handled adjacent the inlet end of the shell, which wetter material tends to offer more draft resistance, is caused to cascade downwardly from the straight lifter plates in sheets to minimize the draft resistance in the "wet" end of the shell. By

adjusting the straight lifter plates as disclosed and described herein, the sheet thickness of the cascading material can be regulated, the sheet thickness being thinned with increasingly wetter material to minimize draft resistance. In the intermediate portion or zone of the shell, however, the partially dried material being handled offers less draft resistance and, in this region, the combination of fixed lifters and straight saw-tooth lifters or lifter plates causes the aggregates to "rain" downwardly in sheets or streams of intermediate thickness to obtain more intimate contact between the aggregates and the hot gaseous fluid. Adjacent the outlet or "dry" end of the shell, the almost dried material, which is substantially drier than the material in the inlet and intermediate zones, offers minimal draft resistance. Accordingly, in the outlet zone, channel lifters are employed which cause the material to rain down in relatively thick sheets which insure maximum contact between the material and the hot gaseous fluid.

Thus, the present invention reduces draft resistance adjacent the inlet or "wet" end of the shell, where the water content of the aggregates tends to produce maximum draft resistance, by employing adjustable straight lifter plates to minimize the obstruction to the flow of the hot gaseous fluid. On the other hand, adjacent the outlet or "dry" end of the shell, where the reduced water content of the aggregates tends to reduce draft resistance, the invention provides nonadjustable channel lifters to obtain more intimate contact between the aggregates and the hot gaseous fluid for more effective heating and drying.

Another object of the invention is to provide straight lifter plates which are pivotally mounted to the inner circumferential wall of the shell along the shell's longitudinal axis and which extend radially inwardly therefrom, and which have inner portions which project circumferentially of the shell in the direction of rotation of the shell about its longitudinal axis and which terminate in straight inner edges. The pivotally mounted straight lifter plates are fixed and retained in position by retainer means connected between the inner circumferential wall of the shell and the pivotally mounted straight lifter plates. The pivotally mounted straight lifter plates can be adjusted from a position substantially perpendicular to the inner circumferential wall or to an acute angle of about 45° to the inner circumferential wall with the straight lifter plates inclined in the direction of rotation, or to any of a plurality of positions therebetween. Positions of inclination, that is, angles of less than 90°, are employed when thinner sheets of cascading material are required.

Another important object of the invention is to provide a drier where at least one-half of the straight lifter plates adjacent the inlet end are pivotally mounted. In the preferred embodiment of the present invention, when one-half of the lifter plates are pivotally mounted, they are alternately disposed circumferentially of the shell; that is, every other straight lifter plate is pivotally mounted.

Another object of the invention is to provide pivotally mounted straight lifter plates having outer portions pivotally mounted to the inner circumferential wall by hinge means and extending radially inwardly therefrom, and inner portions which are angled from the outer portions and project generally circumferentially of the shell in the direction of rotation of the shell and which terminate in straight inner edges, and to provide fixed or nonpivotable straight lifters or lifter plates having outer portions substantially perpendicular to the circumferential wall of the shell and extending radially inwardly therefrom, and inner portions which project generally circumferentially of the shell in the direction of rotation of the shell and which terminate in straight inner edges. A related object is to provide pivotally mounted straight lifter plates which are substantially L-shaped in cross section and which face generally in the direction of rotation of the shell and to provide fixed or nonpivotable straight lifter plates which are L-shaped or wide V-shaped in cross section and which face in the direction of rotation of the shell.

Another object is to provide sawtooth lifter plates which include outer portions substantially perpendicular to the circumferential wall of the shell and extending radially inwardly therefrom, intermediate portions which project inwardly and circumferentially of the shell in the direction of rotation of the shell, and inner portions which project generally circumferentially of the shell in the direction of rotation of the shell, said inner portions terminating in serrated inner edges.

Still another object of the invention is to provide fixed straight lifter plates which include outer portions substantially perpendicular to the circumferential wall of the shell extending radially inward therefrom, and inner portions which project at an angle from the outer portions and circumferentially of the shell in the direction of rotation of the shell, said inner portions terminating in straight edges.

In the preferred embodiment of the present invention the sawtooth lifter plates and the fixed straight lifter plates are mounted alternately circumferentially of the wall of the shell.

A further object of the invention is to provide a drier having channel lifter plates adjacent its outlet end. The channel lifters include outer portions substantially perpendicular to the circumferential wall of the shell and extending radially inwardly therefrom, outer edge portions which project substantially perpendicularly from the outer portions proximate to the wall and circumferentially of the shell in the direction of rotation of the shell, and inner edge portions which project substantially perpendicularly from the outer portions distal to the wall and circumferentially of the shell in the direction of rotation, the outer edge portions and inner edge portions terminating in straight edges.

A further object of the invention is to provide a drier wherein the sawtooth lifter plates and the fixed straight lifter plates are circumferentially staggered relative to the straight lifter plates. In the preferred embodiment of the present invention the sawtooth lifter plates and the fixed straight lifter plates are circumferentially staggered relative to both the straight lifter plates and the channel lifter plates.

Still another object is to provide a drier having three zones, an inlet zone adjacent the inlet end, an outlet zone adjacent the outlet, and an intermediate zone separating the inlet zone and the outlet zone. In the preferred embodiment of the present invention the straight lifter plates will be disposed in the inlet end, the sawtooth lifters and the fixed straight lifters will be disposed in the intermediate zone, and the channel lifters will be disposed in the outlet zone.

A further object of the invention is to provide a drier wherein the sawtooth lifter plates and the straight lifter plates are circumferentially staggered relative to each other.

A further important object of the present invention is to provide a method of drying solid flowable material which comprises cascading the moist material in sheets, increasing the thickness of the cascading sheets as the material becomes drier, and blowing a heated gaseous fluid across the cascading sheets of material. As the material is being cascaded, it is moved longitudinally from a region of wet or moist material to a region of dry material, and the heated gaseous fluid flow is countercurrent to the flow of material, that is, the heated gaseous fluid is blown in and through the region of dry material to and through the region of wet material. With increasingly wetter or moister material the thickness of the cascading sheets in the region of wet material is proportionately decreased to keep draft resistance at a minimum as discussed herein.

The foregoing improvements, objects, advantages, features and results of the present invention, together with various other improvements, objects, advantages, features and results thereof which will be evident to those skilled in the drier art in the light of this disclosure, may be attained with the exemplary embodiment of the invention described in detail hereinafter and illustrated in the accompanying drawing, in which:

FIG. 1 is a side elevational view of a drier which embodies the invention;

FIG. 2 is an enlarged, fragmentary, sectional view taken along the arrowed line 2—2 of FIG. 1;

FIG. 3 is a fragmentary sectional view taken along the arrowed line 3—3 of FIG. 2;

FIG. 4 is a fragmentary sectional view taken along the arrowed line 4—4 of FIG. 1;

FIG. 5 is a fragmentary sectional view taken along the arrowed line 5—5 of FIG. 4; and

FIG. 6 is an enlarged, fragmentary, sectional view taken along the arrowed line 2—2 of FIG. 1 showing an alternative arrangement of the straight lifters.

FIG. 7 is an enlarged, small section, fragmentary sectional view similar to FIG. 5 illustrating the modified sawtooth lifter plates;

FIG. 8 is an enlarged, small section, fragmentary sectional view taken along the arrowed line 8—8 of FIG. 1; and

FIG. 9 is a fragmentary sectional view similar to FIG. 4 illustrating a pivotally mounted sawtooth lifter plate.

In the drawing, the numeral 10 designates a frame on which is mounted an aggregate drier 12 comprising a generally cylindrical shell 14 having an inlet of feed end 16 and an outlet or discharge end 18. The shell has an inlet zone 15 between line 15a and the inlet end 16, an outlet zone between line 17 and the outlet end 18, and an intermediate zone separating the inlet and outlet zones. The shell 14 is rotatable about its longitudinal axis and slopes downwardly from its inlet end 16 to its outlet end 18 so that material being heated and dried moves from the inlet end of the shell to the outlet end thereof by gravity in response to rotation of the shell.

The shell 14 may be mounted for rotation in the foregoing manner in any suitable manner, as by providing it with circumferential rails 20 which engage flanged rollers 22 on the frame 10. The shell 14 carries a ring gear 24 meshed with a driving gear 26 rotatably mounted on the frame 10, whereby to rotate the shell about its longitudinal axis.

The drier 12 may be supplied with aggregates, or other material to be dried, by a bucket conveyor 28 discharging into an inlet hopper 30 in communication with the inlet end 16 of the shell 14, although the aggregates may be supplied in other ways also. The outlet end 18 of the shell 14 communicates with a discharge means 32 of any suitable construction, the aggregates dried within the shell 14 leaving the drier 12 by way of such discharge means.

A heating means 34, supplied with air by a blower 36, communicates with the outlet end 18 of the shell 14, the stream of hot gaseous fluid produced by the heating means and the blower being discharged from the inlet end 16 of the shell through an exhaust means 38 communicating therewith. The exhaust means 38 communicates with a stack 40 which may lead to any suitable point of disposal of dust, and the like.

It will be noted that the flow of aggregates and the flow of the hot gaseous fluid are countercurrent, the aggregates flowing downwardly from the inlet end 16 to the outlet end 18 of the shell 14, and the hot gaseous stream flowing upwardly through the shell from the outlet end 18 of the shell to the inlet end 16 thereof. Thus, the nearly dried aggregates adjacent the outlet end 18 of the shell 14 are exposed to the hottest portion of the gaseous stream to achieve final drying thereof.

The shell 14 carries internally thereof circumferentially spaced, longitudinally extending, straight lifter plates 42, FIG. 2, in the inlet zone 15, circumferentially spaced, longitudinally extending, sawtooth lifters 44 and fixed straight lifter plates 45, FIG. 4, in the intermediate zone, and circumferentially spaced, longitudinally extending, channel lifter plates 46, FIG. 8, in the outlet zone; the sawtooth lifters 44 and the fixed straight lifters 45 being disposed and staggered circumferentially, relative to the straight lifters 42 and the channel lifters 46 for the reasons hereinbefore indicated.

At least one-half of the straight lifter plates 42 are adjustable or pivotally mounted straight lifter plates 42a; the remaining straight lifter plates, if any, are fixed, that is, nonadjustable or nonpivotally mounted, straight lifter plates 42b. In the preferred embodiment of the present invention one-half or all the straight lifter plates 42 are pivotally mounted straight lifter plates 42a, as shown in FIG. 2. When one-half of the straight lifter plates are adjustable lifter plates, they are pivotally

mounted alternately circumferentially of the shell providing for alternating adjustable and nonadjustable lifter plates. In an alternate embodiment of the present invention, FIG. 6, each straight lifter plate is an adjustable straight lifter plate 42a.

Each adjustable pivotally mounted straight lifter plate 42a comprises an outer portion 70 which is pivotally mounted at its outer edge 72 to the inner circumferential wall 13 of the shell 14 by pivoting means, such as a hinge means 74, and an inner portion 76 which projects at an angle from the outer portion 70 and projects generally circumferentially of the shell in the direction of rotation 64 of the shell about the longitudinal axis. The angle between the outer portions 70 and the inner portions 76 is within the range of 90° to 180°, preferably about 90°. The inner portions 76 of the adjustable lifters terminate in straight inner edges 78. The pivotally mounted straight lifter plates 42a are retained in any of a plurality of positions by retaining means connected between each of the pivotally mounted straight lifter plates 42a and the inner circumferential wall 13. The retaining means can be any device or linkage that will retain the straight lifter plate in any of a plurality of positions. In the preferred embodiment of the present invention the retaining means is a retaining assembly 80 which is comprised of a retaining strut 82 pivotally mounted at its first end to the inner circumferential wall 13 by pivot mounting means such as a combination of a pivot bracket 84, attached to the inner circumferential wall 13 having a bolt hole, and a bolt 83; the bolt 83 is disposed through the bolt holes in the bracket 84 and through the pivot bolt hole of the retaining strut 82 located at its first end. The retaining strut 82 is removably mounted at its second end to its associate straight lifter plate 42a by removable mounting means 85 such as a combination of a lifter bracket 88, attached to the pivotally mounted straight lifter plate 42a, having a bolt hole and a second bolt 86; the second bolt 86 is disposed through the bolt hole of the lifter bracket 88 and through any one of a plurality of bolt holes spaced apart lengthwise in the retaining strut 82 at its second end. The removable mounting means 85 allows each of the pivotally mounted straight lifter plates 42a to be positioned at any one of a plurality of relative positions with respect to the shell. Each of the pivotally mounted straight lifter plates can be adjusted to a position wherein the outer portion 70 is substantially perpendicular to the inner circumferential wall 13 or to a position wherein the outer portion 70 is at an acute angle, generally of 30° to the inner circumferential wall 13, generally in the direction of the shell's rotation 64, or to any of a plurality of positions intermediate between 90° and 30°.

Each permanently mounted straight lifter plate 42b, that is, nonpivotally mounted or nonadjustable, comprises an outer portion 48 which is substantially perpendicular to the circumferential wall 13 of the shell 14 and which extends radially inwardly therefrom, and an inner portion 50 which projects generally circumferentially of the shell from the outer portion 48 in the direction of rotation 64 of the shell about its longitudinal axis. The inner portions 50 of the straight lifter plates 42b terminate in straight inner edges 52. The angle between the inner portion 50 and outer portion 48 is between 90° and 180°, preferably about 135°.

In the construction illustrated, each straight lifter plate 42b is mounted between pivotally mounted straight lifter plates 42a and is mounted on one or more brackets 54 suitably secured to the shell 14.

Each of the sawtooth lifter plates 44 includes an outer, substantially radial, inwardly projecting outer portion 58 which is secured to one or more brackets 60 on the inner surface of the circumferential wall 13 of the shell 14. Each of the sawtooth lifter plates 44 includes an intermediate portion 62 which projects inwardly and circumferentially of the shell from the outer portion 58 in the direction of rotation 64 of the shell. In order to achieve optimum aggregate capacity for each of the lifter plates 44, the intermediate portion 62 thereof preferably makes an angle of approximately 45° with the shell 14. Each of the sawtooth lifter plates 44 further includes an inner portion

66 which projects generally circumferentially of, and slightly inwardly of, the shell 14 from the corresponding intermediate portion 62 in the direction of rotation of the shell. Each inner portion 66 terminates in an inner edge 67 which is serrated to provide teeth 68 spaced apart longitudinally of the corresponding lifter plate, the inner edge 67 of each inner portion 66 being serrated substantially to the intermediate portion 62 of the corresponding lifter or lifter plate.

Referring to FIG. 7, wherein there is illustrated an alternative embodiment of the present invention, each of the sawtooth lifter plates 44a will include a substantially radially extending, inwardly projecting outer portion 58a which is secured to one or more brackets 60 on the inner surface of the circumferential wall 13 of the shell 14. Projecting generally inwardly and generally circumferentially in the direction of the rotation of the shell 14 from the outer portion 58a is an inner portion 66a. Each inner portion 66a terminates in an inner edge 67a which is serrated to provide teeth 68a spaced apart longitudinally of the corresponding lifter plate, the inner edge 67a of each inner portion 66a being serrated between half way to and all the way to the outer portion 58a of the corresponding sawtooth lifter 44a. The angle between the outer portion 58a and the inner portion 66a is between 90° and 180°, preferably about 105°.

Since the outer portions 58 of the sawtooth lifter plates 44 are generally perpendicular to the shell 14, packing of wet material in the corners formed by these lifters and the shell is minimized.

Each fixed straight lifter plate 45 comprises an outer portion 59 which is substantially perpendicular to the circumferential wall 13 of the shell 14 and which extends radially inwardly therefrom, an inner portion 61 which projects generally circumferentially of the shell from the outer portion 59 in the direction of rotation 64 of the shell about its longitudinal axis. The inner portions 61 of the fixed straight lifter plates 45 terminate in straight inner edges 63. The inwardly projecting outer portion 59 is secured to one or more brackets 65 on the inner surface of the circumferential wall of the shell 14. The angle between the outer portions 59 and the inner portions 61 is between 90° and 180°, preferably about 105°.

Each of the channel lifter plates 46 (FIG. 8) includes an outer, substantially radially inwardly projecting outer portion 69 which is secured to one or more brackets 71 on the inner surface of the circumferential wall 13 of the shell 14. Each of the channel lifter plates 46 includes an outer edge portion 73 which projects substantially perpendicularly from the outer portion 69 proximate to the wall 13 and circumferentially of the shell 14 in the direction of rotation 64 of the shell 14. Each of the channel lifter plates 46 further includes an inner edge portion 75 which projects substantially perpendicular to the outer portion 69 distal to the wall 13 and generally circumferentially of the shell 14 in the direction of rotation 64 of the shell 14. The outer portions 73 and the inner edge portions 75 terminate in straight edges 77a and 77b, respectively.

Referring to FIG. 9, in an alternative embodiment of the present invention, a plurality of pivotally mounted sawtooth lifter plates 44b (only one lifter plate being shown) are mounted within the inner circumferential wall 13 of the shell 14. The sawtooth lifter plates are spaced apart circumferentially of the shell and extend longitudinally thereof. Each of the sawtooth lifter plates includes an outer portion 58b which is pivotally mounted to the inner circumferential wall 13 and extending radially inwardly therefrom. Each of the lifter plates is spaced apart circumferentially of the shell and extends longitudinally therein. Each of the sawtooth lifter plates being pivotally mounted to the circumferential wall along longitudinal axis. The sawtooth lifter plates can be pivotally mounted to the shell in the same manner as the straight lifter plates 42a are pivotally mounted by hinge means 74 to the shell as shown in FIGS. 2 and 6. Each of the pivotally mounted sawtooth lifter plates includes an inner portion 66b which projects inwardly from said outer portion and circumferentially of the shell in a direction of rotation of the shell 64

about the longitudinal axis thereof. The inner portion of each of the sawtooth lifter plates terminates in a serrated inner edge 67b, which is similar to the serrated inner edge 67 of sawtooth lifter plate 44 illustrated in FIG. 5. Each of the pivotally mounted sawtooth lifter plates is retained in position by retaining means connected between each pivotally mounted sawtooth lifter plate and the inner circumferential wall 13 for fixing and retaining each of the lifter plates in any one of a plurality of positions relative to the shell 14. The retaining assembly 80 (described above in FIG. 2 and FIG. 6 with the corresponding numbered elements illustrated in FIG. 9) can be employed as retaining means for the pivotally mounted sawtooth lifter plates.

The nonadjustable straight lifters 42b, the sawtooth lifters 44, the fixed straight lifters 45 and the channel lifters 46 are attached or secured to their respective brackets 54, 60, 65 and 71 by conventional means. For example the lifters can be welded to the brackets, bolted to the brackets or secured by metal screws.

The sawtooth lifters 44 and the fixed straight lifters 45 are preferably about equal in height. Similarly, the adjustable straight lifters 42a and the nonadjustable straight lifters 42b are preferably about equal in height. In the preferred embodiment of the present invention, the heights of all the lifters are about equal.

Considering the operation of the invention, it will be seen that, as the shell 14 rotates, the lifter plates 42, 44, 45, and 46 act as buckets and scoop up the aggregates being heated and dried, the lifters carrying the aggregates upwardly. Continued rotation of the shell 14 first causes the buckets formed by the lifters to turn on their sides and then invert, the aggregates being dumped therefrom as this takes place. The aggregate is dumped in cascading sheets with thinner sheets toward the inlet end 16 and thicker sheets toward the outlet end 18.

The straight lifter plates 42 distribute the falling aggregates which are relatively wet adjacent the inlet end 16 of the shell 14, in relatively thin streams. Such streams minimize the draft resistance provided by the relatively wet aggregates adjacent the "wet" or inlet end 16 of the shell 14 to provide maximum draft in this region. Since at least one-half of the straight lifter plates are adjustable, the relative thinness of the cascading sheets or streams can be regulated, "thinner" streams being provided by adjustment of the pivotally mounted straight lifter plates to angles of less than 90°.

The combination of the sawtooth lifter plates 44 and the fixed straight lifter plates 45 in the intermediate zone distributes the falling aggregate, which is moderately wet, in sheets of moderate thickness; that is, in streams thicker than the streams in the inlet zone but thinner than the streams in the outlet zone. The streams or sheets in the intermediate zone which offer moderate resistance to the draft of the hot gaseous fluid, provide more contact between the aggregate and the hot gaseous fluid than is obtained in the inlet zone.

On the other hand, the channeled lifter plates distribute the relatively dry aggregates adjacent the "dry" or outlet end 18 of the shell 14 in relatively wide streams having large horizontal cross-sectional areas. Consequently, the aggregates rain downwardly in a substantially uniform pattern throughout the entire hot gaseous stream flowing longitudinally through the shell 14 adjacent the outlet end 18 thereof, thereby obtaining maximum contact between the aggregates and the hot gaseous stream. The drier aggregates adjacent the "dry" end 18 of the shell 14 do not offer as much draft resistance as the relatively wet aggregates adjacent the "wet" end 16 of the shell so that the channeled lifter plates 46 do not affect draft conditions excessively, while providing the desired intimate contact between the aggregates and the hot gaseous stream.

Thus, the present invention, by utilizing the pivotally mounted straight lifter plates 42 adjacent the "wet" or inlet end 16 of the shell 14 to minimize draft resistance where the draft resistance tends to be high, by utilizing sawtooth lifter plates 44 and fixed straight lifter plates 45 in the intermediate zone where the draft resistance tends to be lower, and by

utilizing the channel lifter plates 46 adjacent the "dry" or outlet end 18 of the shell, where the draft resistance is relatively minimal, provides both adequate draft throughout the length of the shell and intimate mixing of the aggregates and the hot gaseous stream to provide efficient drying.

For optimum results, the straight lifters 42 occupy about one-third and the channel lifters 46 occupy another one-third the length of that portion of the shell 14 which contains the lifters 42, 44, 45, and 46. In one of the preferred embodiments of the invention, the straight lifters 42 do not extend longitudinally to the edge of the shell 14 at its inlet end 16, and the channel lifters 46 do not extend longitudinally to the edge of the shell 14 at its outlet end 18.

Although an exemplary embodiment of the invention has been disclosed herein for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in such embodiment without departing from the spirit of the invention. For example, this invention also contemplates a drier wherein all or a portion of the lifter plates of more than one drying zone, whether they be straight lifter plates, sawtooth lifter plates, channel lifter plates or the like, are pivotally mounted to provide a universal drier that can be adapted to aggregate of varying sizes, moistures, densities, and chemical makeup.

I claim:

1. A device including a frame:

a generally cylindrical shell having an inner circumferential wall, a longitudinal axis, inlet and outlet ends, an inlet zone adjacent the inlet end, an outlet zone adjacent the outlet end, and an intermediate zone separating the inlet and outlet zones;

means for mounting the shell on a frame for rotation about the shell's longitudinal axis, the longitudinal axis sloping downwardly from the inlet end to the outlet end;

means for circulating a heated gaseous fluid through the shell from the outlet end to the inlet end;

a plurality of straight lifter plates within and carried by the inner circumferential wall in the inlet zone, the straight lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the lifter plates including an outer portion which is mounted to the inner circumferential wall and an inner portion which is angled to the outer portion and projects generally circumferentially of the shell in the direction of rotation of the shell about the longitudinal axis, the inner portion of each of said straight lifter plates terminating in a straight inner edge; and

the improvement which comprises pivotally mounting at least one-half of the straight lifter plates to the inner circumferential wall, said pivotally mounted lifter plates being retained in any one of a plurality of positions relative to the shell by retaining means connected between each of the pivotally mounted straight lifter plates and the inner circumferential wall.

2. A device as defined in claim 1, wherein one-half of the straight lifter plates are pivotally mounted alternately circumferentially of the shell.

3. A device as defined in claim 1, wherein each of the lifter plates is pivotally mounted.

4. A device as defined in claim 1, in which the straight lifter plates are pivotally mounted on their outer portions to the inner circumferential wall about the longitudinal axis by hinge means.

5. A device as defined in claim 1, in which each of the retaining means comprises a retaining strut pivotally mounted at one end to the inner circumferential wall and removably mounted at the other end to its associated pivotally mounted straight lifter plate; and

means for removably mounting the other end of the strut to the straight lifter plate at any one of a plurality of relative positions.

6. A device as defined in claim 1 in which the straight lifter plates are pivotally mounted to the inner circumferential wall

by hinge means, and each of the retaining means comprises a retaining strut pivotally mounted at one end to the inner circumferential wall and removably mounted at the other end to its associate straight lifter plate, and means for removably mounting the other end of the strut to its associated straight lifter plate at any one of a plurality of relative positions.

7. A device as defined in claim 6 in which the means for removably mounting comprises a bracket with a bolt hole attached to the straight lifter plate;

a retaining strut pivotally connected at one end to the inner circumferential wall, said strut having a plurality of bolt holes spaced apart lengthwise thereof at its other end; and a bolt disposed in the bolt hole of the bracket and in any one of the plurality of bolt holes in the strut.

8. A device as defined in claim 1, which includes a plurality of sawtooth lifter plates within and mounted on the inner circumferential wall of the shell in the intermediate zone, the sawtooth lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the lifter plates including an outer portion which is mounted to the inner circumferential wall and is substantially perpendicular thereto, and which extends radially inward therefrom, and including another portion which projects from said outer portion thereof inwardly and circumferentially of the shell in the direction of rotation of the shell about the longitudinal axis thereof, the inner portion of each of the sawtooth plates terminating in a serrated inner edge;

a plurality of fixed straight lifter plates within and carried by the inner circumferential wall in the intermediate zone, the fixed straight lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the lifter plates including an outer portion which is mounted to the inner circumferential wall, and an inner portion which is at an angle to the outer portion and projects generally circumferentially of the shell in the direction of rotation of the shell about the longitudinal axis, the inner portion of each of said straight lifter plates terminating in a straight edge, said sawtooth lifter plates and fixed straight lifter plates being mounted alternately circumferentially of the shell.

9. A device as defined in claim 1, including a plurality of channel lifter plates within and carried by the inner circumferential wall in the outlet zone, the channel lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the channel lifter plates including an outer portion which is mounted to the inner circumferential wall, an outer edge portion which projects substantially perpendicularly and circumferentially of the shell in the direction of rotation from the outer portion proximate to the inner circumferential wall, and an inner edge portion which projects substantially perpendicularly and circumferentially of the shell in the direction of rotation from the outer portion distal to the inner circumferential wall, said outer edge portions and inner edge portions terminating in straight edges.

10. A device including a frame:

a generally cylindrical shell having an inner circumferential wall, a longitudinal axis, inlet and outlet ends, an inlet zone adjacent the inlet end, an outlet zone adjacent the outlet end, and an intermediate zone separating the inlet zone and the outlet zone;

means for mounting the shell on a frame for rotation about its longitudinal axis;

means for rotating the shell;

the longitudinal axis sloping downward from the inlet end to the outlet end;

means for introducing a material to be dried into the inlet end;

a plurality of pivotally mounted lifter plates within the shell and carried by the inner circumferential wall, the lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the lifter plates being pivotally mounted to the inner circumferential wall along the longitudinal axis; and

retaining means connected between each pivotally mounted lifter plate and the inner circumferential wall for fixing and retaining each of the lifter plates in any one of a plurality of positions relative to the shell.

11. A device as defined in claim 10, wherein some of the lifter plates are pivotally mounted and others are rigidly mounted, alternately circumferentially of the shell.

12. A device as defined in claim 10, wherein the plurality of pivotally mounted lifter plates includes a plurality of straight lifter plates within the shell and carried by the inner circumferential wall, the straight lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the straight lifter plates including an outer portion which is carried by the inner circumferential wall, and an inner portion which is at an angle to the outer portion and projects generally circumferentially of the shell in the direction of rotation of the shell about the longitudinal axis, said straight lifter plates being pivotally mounted to the inner circumferential wall along the longitudinal axis.

13. A device as defined in claim 10, wherein the plurality of pivotally mounted lifter plates include a plurality of sawtooth lifter plates within and mounted on the inner circumferential wall of the shell, the sawtooth lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the sawtooth lifter plates including an outer portion which is pivotally mounted to the inner circumferential wall and which extends radially inwardly therefrom, and including an inner portion which projects from said outer portion thereof inwardly and circumferentially of the shell in the direction of rotation of the shell about the longitudinal axis thereof, the inner portion of each of the sawtooth lifter plates terminating in a serrated inner edge.

14. A device as defined in claim 10, wherein the plurality of pivotally mounted lifter plates include a plurality of channel lifter plates within and carried by the inner circumferential wall, the channel lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the channel lifter plates including an outer portion which is pivotally mounted to the inner circumferential wall, an outer portion projecting substantially perpendicularly from the outer portion proximate to the inner wall and circumferentially of the shell about its longitudinal axis in the direction of rotation of the shell, an inner edge portion projecting substantially perpendicularly from the outer portion distal to the inner wall and circumferentially of the shell in the direction of rotation of the shell about its longitudinal axis, said outer edge portion and said inner edge portion terminating in straight inner edges.

15. A device as defined in claim 10, wherein the plurality of pivotally mounted lifter plates include a plurality of straight lifter plates within the shell and carried by the inner circumferential wall in the inlet zone, the straight lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the straight lifter plates including an outer portion which is carried by the inner circumferential wall, and an inner portion which is at an angle to the outer portion and projects generally circumferentially of the shell in the direction of rotation of the shell about the longitudinal axis, said straight lifter plates being pivotally mounted to the inner circumferential wall along the longitudinal axis;

a plurality of sawtooth lifter plates within and mounted on the inner circumferential wall of the shell in the intermediate zone, the sawtooth lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the sawtooth lifter plates including an outer portion which is pivotally mounted to the inner circumferential wall and which extends radially inwardly therefrom, and including an inner portion which projects from said outer portion thereof inwardly and circumferentially of the shell in the direction of rotation of the shell about the longitudinal axis thereof, the inner portion of each of the sawtooth lifter plates terminating in a serrated inner edge; and a plurality of channel lifter

plates within and carried by the inner circumferential wall in the outlet zone, the channel lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the channel lifter plates including an outer portion which is pivotally mounted to the inner circumferential wall, an outer portion projecting substantially perpendicular from the outer portion proximate to the inner wall and circumferentially of the shell about its longitudinal axis in the direction of rotation of the shell, an inner edge portion projecting substantially perpendicular from the outer portion distal to the inner wall and circumferentially of the shell in the direction of rotation of the shell about its longitudinal axis, said outer edge portion and said inner edge portion terminating in straight inner edges.

16. A device as defined in claim 10 wherein the pivotally mounted lifter plates are a plurality of straight lifter plates within the shell carried by the inner circumferential wall in the outlet zone, the straight lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the straight lifter plates including an outer portion which is carried by the inner circumferential wall, and an inner portion which is at an angle to the outer portion and projects generally circumferentially of the shell in the direction of rotation of the shell about the longitudinal axis, said straight lifter plates being pivotally mounted to the inner circumferential wall along the longitudinal axis.

17. A device as defined in claim 16, including a plurality of sawtooth lifter plates within and mounted on the inner circumferential wall of the shell in the intermediate zone, the sawtooth lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the lifter plates including an outer portion which is mounted to the inner circumferential wall and is substantially perpendicular thereto, and which extends radially inwardly thereof, and including an inner portion which projects from said outer portion thereof inwardly and circumferentially of the shell and in

the direction of rotation of the shell about the longitudinal axis thereof, the inner portion of each of the sawtooth lifter plates terminating in a serrated inner edge;

a plurality of fixed straight lifter plates within and carried by the inner circumferential wall in the intermediate zone, the straight lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the straight lifter plates including an outer portion which is mounted to the inner circumferential wall and is substantially perpendicular thereto, and which extends radially inwardly therefrom, and an inner portion which is at an angle to the outer portion and projects generally circumferentially of the shell in the direction of rotation of the shell about the longitudinal axis, the straight lifter plates and the sawtooth lifter plates extending radially inwardly from the inner circumferential wall of the shell about equal distances, said fixed straight lifter plates and sawtooth lifter plates being mounted alternately circumferentially of the shell; and

a plurality of channel lifter plates within and carried by the inner circumferential wall in the outlet zone, the channel lifter plates being spaced apart circumferentially of the shell and extending longitudinally thereof, each of the channel lifter plates including an outer portion which is mounted to the inner circumferential wall and is substantially perpendicular thereto, an outer edge portion projecting substantially perpendicularly from the outer portion proximate to the inner wall and circumferentially of the shell about its longitudinal axis in the direction of rotation of the shell, and an inner edge portion projecting substantially perpendicularly from the outer portion distal to the inner wall and circumferentially of the shell in the direction of rotation of the shell about its longitudinal axis, said outer edge portion and said inner edge portion terminating in straight inner edges.

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