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Thompson

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[54] FLIGHTING FOR DEHYDRATOR DRUM

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[21] Appl. No.: **135,078**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 773,188, Nov. 4, 1968, Pat. No. 3,593,430.

[52] **U.S. Cl.**.....**34/108,** 34/136

[51] **Int. Cl.**.....**F26g 11/02**

[58] **Field of Search**.....34/108, 126–128, 34/136–138, 134, 5

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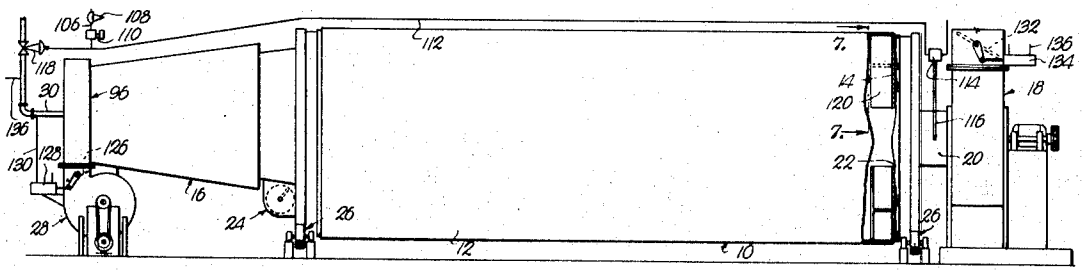
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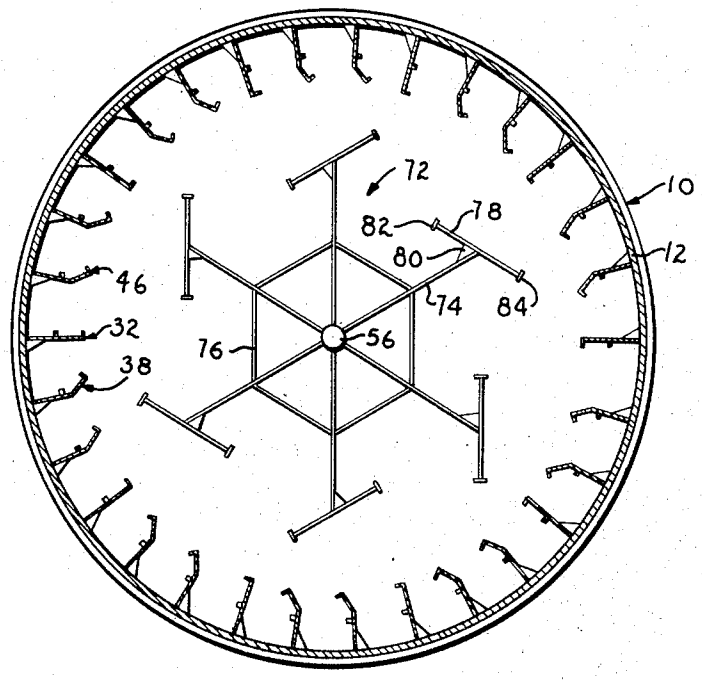
Primary Examiner—Milton Kaufman
Assistant Examiner—Theophil W. Streule
Attorney—Bradley and Wharton

[57] **ABSTRACT**

A dehydrator includes a drum having an inlet and an outlet mounted for rotation about its longitudinal axis. Internal flighting for facilitating uniform drying of material passed through the drum includes a plurality of circumferentially spaced vanes which are rigid with the inner surface of the drum. At least a portion of the vanes are provided with laterally extending cleats which break up clumps of material falling off the vanes. Centrally disposed in the drum is another arrangement of flighting which acts as a retainer for catching material which gravitates from the aforementioned vanes. The central flighting comprises a shaft with a plurality of longitudinally extending axially projecting plates having one or more interference structures traversing the plane of a plate at oblique angles. When a pair of structures are utilized they are disposed in either parallel or perpendicular relationship to each other.

9 Claims, 11 Drawing Figures





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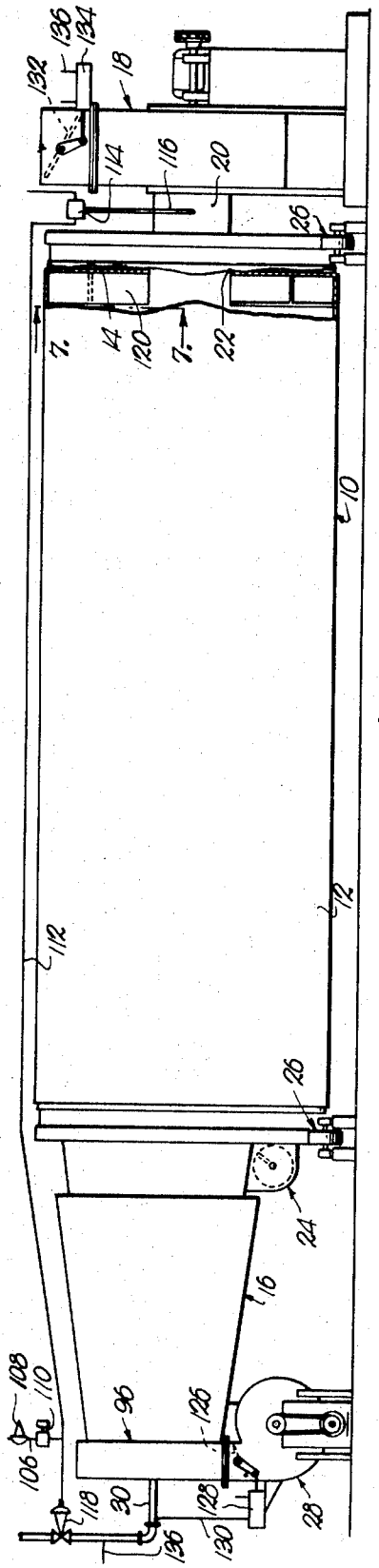


Fig. 1.

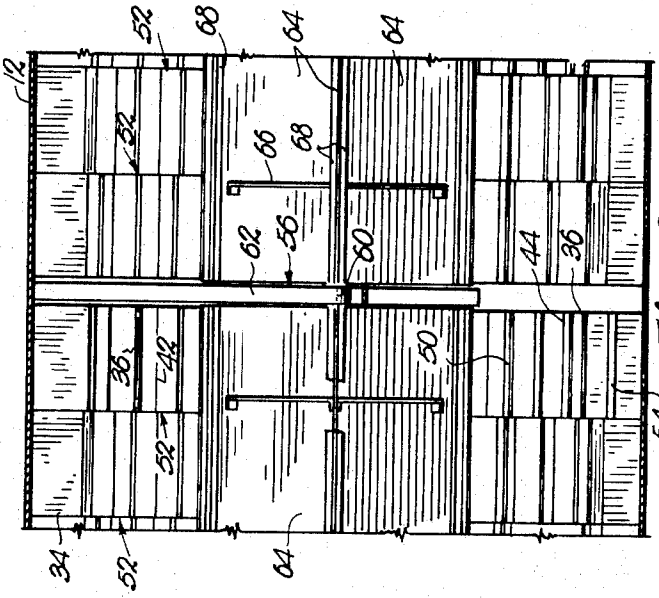


Fig. 3.

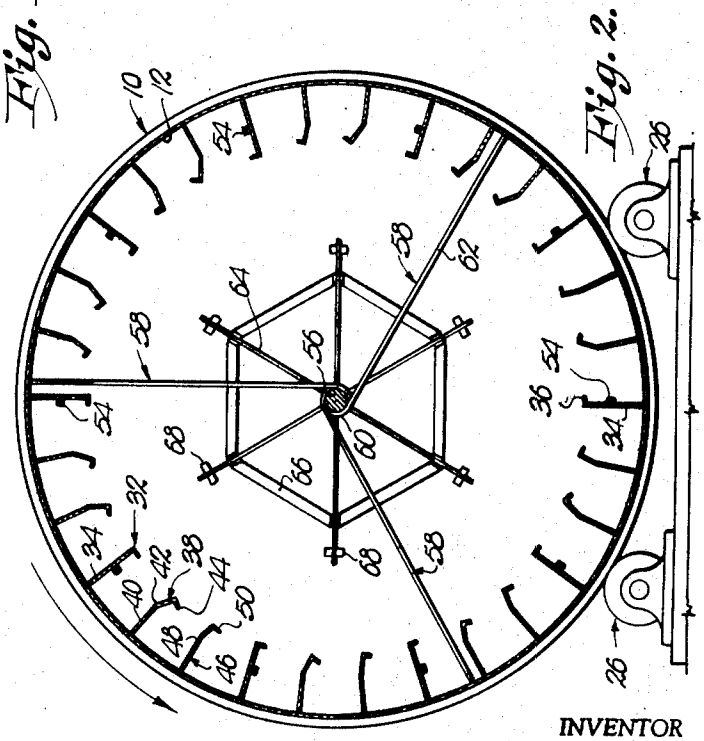


Fig. 2.

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Fig. 11.

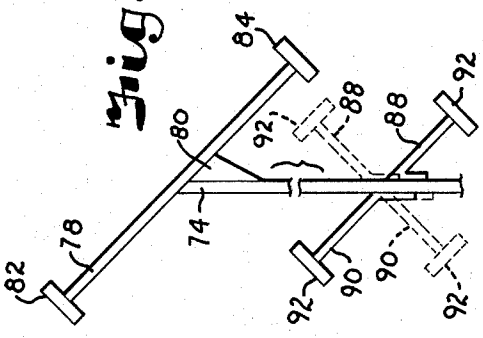


Fig. 6.

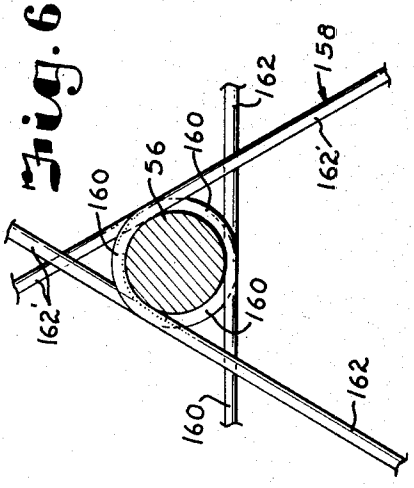
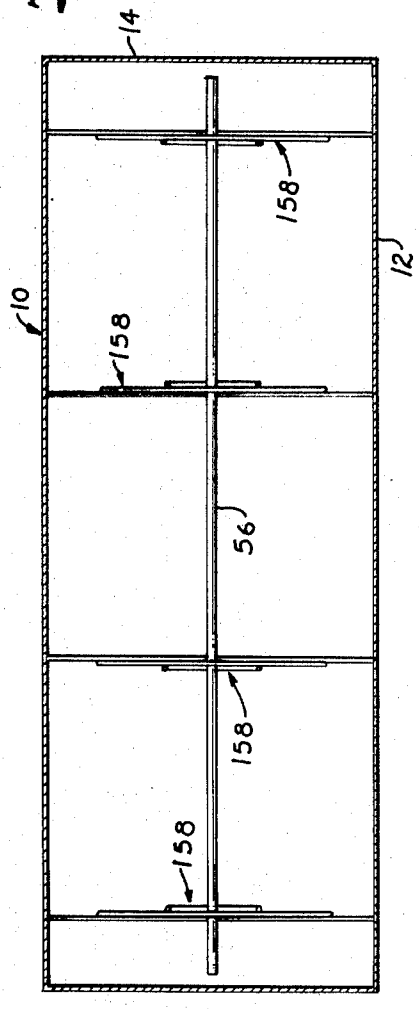


Fig. 4.



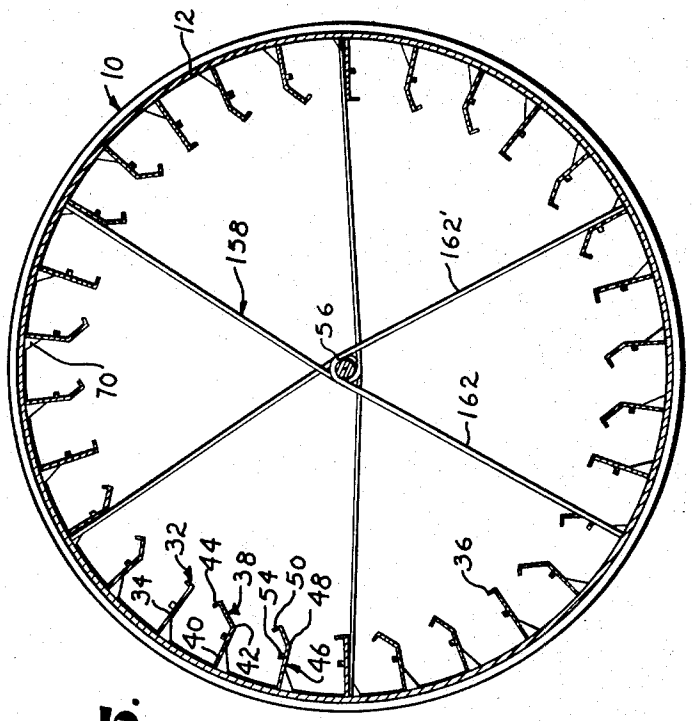


Fig. 5.

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Fig. 7.

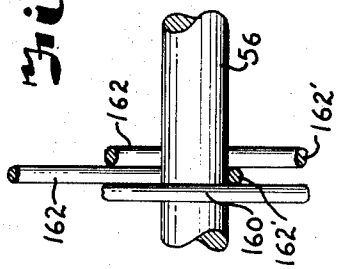


Fig. 9.

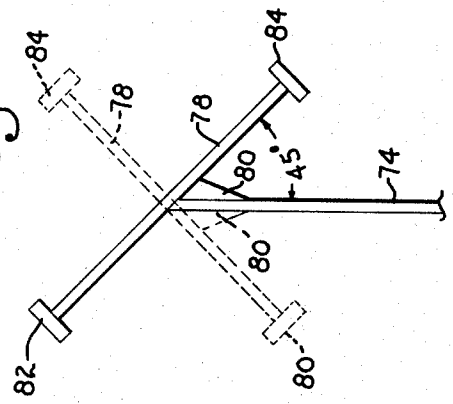


Fig. 8.

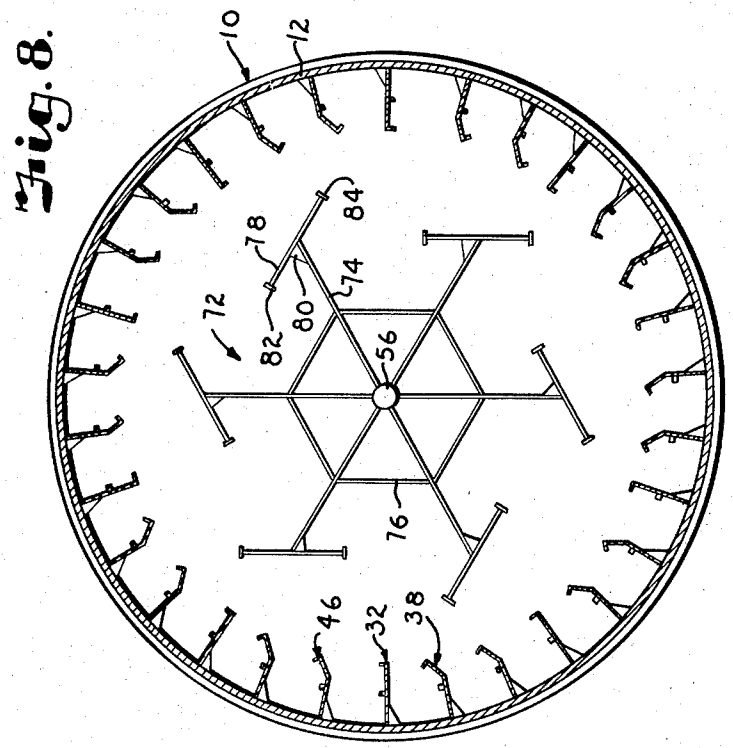
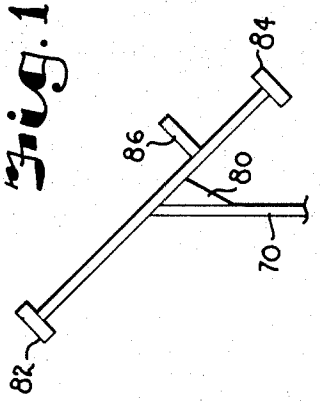


Fig. 10.



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FLIGHTING FOR DEHYDRATOR DRUM

This application is a continuation in part of my previously filed application Ser. No. 773,188 entitled "Crop Dehydrator" and filed Nov. 4, 1968 now U.S. Pat. No. 3,593,430.

An important consideration in the drying of any material is proper distribution of the material to be dried within the drying zone. Distribution is a particular problem in the drying of crops such as alfalfa because of the tendency for the crop to bunch together. This results in inadequate drying of some of the alfalfa and overdrying and even charring of some of the alfalfa.

It is the normal process to dry crops such as alfalfa within elongated rotatable drying drums which continuously rotate to help distribute the crop being dried. It has also been the practice to incorporate flighting around the periphery of the drying drum to further facilitate even distribution. In spite of improvements in the field of dehydrating apparatus, it is recognized that even distribution of a material to be dried, and particularly crops such as alfalfa which tend to bunch, is a problem which has not been completely solved.

It is therefore an object of the present invention to provide a dehydrator having flights of vanes strategically positioned and shaped to distribute the material as uniformly as possible across the entire cross section of the drum to cause maximum transfer of heat from the hot gases of combustion to the material as the latter travels through the rotating drum.

In carrying out the preceding object it is also another object of the invention to provide vanes configured to permit automatic separation of relatively light or leafy material from heavier or stemmy material so that the lighter particles may be carried out of the drum by the air stream in advance of the heavier particles, which require further time in the drum to achieve a uniformly dried product.

Still another object of the invention is a flighting arrangement for a rotating drying drum which incorporates cleat structure on the vanes of the flighting to facilitate breakup of any bunches of the material being dehydrated.

An important aim of this invention is also to provide a drying drum having flighting arranged both around the periphery of the drum and centrally within the drum to assure breakup of the material being dehydrated as it falls from the outer peripheral flighting as the drum rotates.

It is also one of the aims of the present invention to permit uniform pneumatic conveying of a material to be dried through a drying drum by incorporating flighting within the drum to assure that all of the material being dried falls a uniform distance as it gravitates from one side of the drum to the other as the drum rotates.

As a corollary to the aim of the invention set forth above, one of the objects of the invention is also to maximize the minimum distance which any material falls in gravitating from one side of the drum to the other, yet assuring that this distance is uniform for all of the material.

In the drawings:

FIG. 1 is a fragmentary, side elevational view on a reduced scale and partially schematic of a dehydrator system incorporating the principles of this invention, parts being broken away and revealed in cross section to reveal details of construction;

FIG. 2 is a vertical, cross-sectional view through the dehydrator drum transversely thereof;

FIG. 3 is a fragmentary, vertical cross-sectional view through the drum longitudinally thereof, the flighting appearing in elevation;

FIG. 4 is a schematic vertical cross-sectional view taken longitudinally of the drum with the internal flighting removed to illustrate an alternative form of hanger arrangement for supporting the central shaft upon which a portion of the flighting is mounted;

FIG. 5 is an enlarged, vertical cross-sectional view taken transversely of the drying drum with the central flighting removed and illustrating in further detail the alternative hanger arrangement for securing the central shaft axially of the drum;

FIG. 6 is an enlarged, fragmentary view looking at the end of the central shaft and further illustrating the hanger arrangement;

FIG. 7 is an enlarged, fragmentary side elevational view of the shaft and hanger arrangement;

FIG. 8 is an enlarged, vertical cross-sectional view taken transversely of the drying drum and illustrating an alternative form for the central flighting which is disposed about the axially aligned shaft;

FIG. 9 is an enlarged, fragmentary, side elevational view of the sloping T-bar which forms a part of the central flighting, with an alternative position for the transverse member illustrated in broken lines;

FIG. 10 is an enlarged, fragmentary, side elevational view similar to FIG. 9 and illustrating an optional intermediate cleat shown disposed on the T-bar; and

FIG. 11 is an enlarged, fragmentary, side elevational view similar to FIGS. 9 and 10 and illustrating an optional second transverse member disposed on the T-bar with an alternative position for this optional member being shown in broken lines.

Referring initially to FIG. 1 of the drawings, the dehydrator of this invention includes an elongated, cylindrical drum **10** having a sidewall **12** and an outlet end wall **14**. A furnace **16** communicates with the inlet end of drum **10** and a fan broadly designated **18** is interposed in a material discharge conduit **20** which communicates with the outlet end of drum **10** through a discharge opening **22** best seen in FIG. 7. A material inlet conveyor **24** is provided adjacent furnace **16** at the inlet end of drum **10** for the purpose of introducing the material to be dehydrated into the drum. The latter is mounted for rotation about its longitudinal axis on roller means **26** and is powered by drive means (not shown) to effect rotation of the drum in the direction of the arrow in FIG. 2.

Furnace **16** includes a blower **28** for providing air to be mixed with the fuel which is introduced into furnace **16** through a fuel line **30**. The hot gases of combustion are directed into the interior of drum **10** for drying the material as the latter progresses through the drum. To this end, blower or fan **18** serves to draw the gases through the drum so that the dried material is drawn toward outlet opening **22** and into conduit **20**. It will be understood that conduit **20** may communicate with a cyclone separator or the like (not shown) so that the dehydrated material may be separated from the airstream for further processing as may be desirable or required.

In the drying of hay or other materials it is particularly important that as much surface area of the materi-

al particles as possible be exposed to the drying influence of the hot gases passing through the drum. To this end, the interior of drum **10** is provided throughout its length with a flighting adapted to engage the material upon rotation of the drum and to distribute the material as uniformly as possible across the entire hollow cross section of the drum. Manifestly, upon lifting of the material to a given position as the drum rotates, the material is dropped for gravitation toward the bottom of the drum. The material is thereupon again lifted by the flighting for subsequent distribution to permit gravitation of the particles of material through the hot stream of gases and toward the bottom of the drum whereupon the process continues successively until the material is sufficiently dehydrated to be carried to the discharge end of the drum by the hot gases.

The flighting to accomplish the foregoing operation on the material in the drum includes a plurality of vanes secured in annular rows to the inner surface of the cylindrical drum wall **12**. Each row of vanes includes a series of differently shaped vanes. Thus, a vane **32** comprises a substantially flat generally planar panel **34** having one end thereof secured as by welding or the like to the inner surface of wall **12**. The panel **34** extends radially inwardly of the drum and terminates in a lip **36** at the end of panel **34** remote from wall **12**. Thus, the outermost end of each vane travels in a first circular path during rotation of the drum.

The next successive vane **38** in the row proceeding in a counterclockwise direction is spaced circumferentially from vane **32** and comprises a panel **40** having one marginal edge thereof secured as by welding or the like to the inner surface of sidewall **12** similar to the attachment of panel **34** to the drum. It should be noted, however, that the panel **40** is provided with a line of bend **42** in spaced relationship from wall **12** and from the innermost end of the panel. Thus, the panel comprises a portion extending radially inwardly of the drum and a second portion deviates at an angle from the direction of the first portion as illustrated clearly in FIG. **2**. The outermost end of panel **40** is provided with a lip **44** similar to lip **36** of panel **34**.

The next successive vane **46** of the series of vanes is similar to vane **38** in that it is provided with a line of bend **48** intermediate its ends. However, the angle of bend of the portions of the vane **46** is such that the vane is straighter than vane **38**. Again, vane **46** is provided with a lip **50** at its innermost end. Although the specific arrangement of the different vanes in the series depicted has been found desirable, other arrangements for the vanes will also produce advantageous results.

Referring to FIGS. **2** and **3**, it may be seen that each row **52** of vanes may be identical to the adjacent rows but it has been found to be desirable that each successive row longitudinally of the drum be rotated with respect to the preceding row. Thus, a vane **32** is not directly adjacent an identical vane **32** of the adjacent row. Rather, it is adjacent a vane **38** or a vane **46**. Similarly, the vanes **42** and **46** are disposed beside dissimilar vanes of the adjacent row.

Certain of the vanes are provided intermediate their lengths with cleats **54** which may be formed of key stock material welded to the leading surface of the vane. The cleats **54** serve to retard the slippage of the material along the surface of the vane for a purpose to be more fully explained hereinafter.

A longitudinally extending shaft **56** is disposed axially of drum **10** and is secured to the latter by a plurality of hangers **58**. Each hanger **58** includes an arcuate portion **60** having one end thereof secured to the outer surface of shaft **56** by welding or the like and an integral straight portion **62** having its outermost end welded to the inner surface of drum **10**. It will be understood that as many hangers **58** are provided as are necessary for securing the shaft in its proper position. Further, the provision of the arcuate portion **60** disposed in a wrapped-around manner adjacent the outer surface of shaft **56** insures that the latter is maintained in its proper axial position even when the hangers **58** and shaft **56** are exposed to the extreme temperatures caused in drum **10** by the hot dehydrating gases provided by furnace **16**. It should be noted that the straight portions **62** of hangers **58** extend tangentially of shaft **56** so that heating of the hangers **58** merely causes a rotation of shaft **56** without moving the latter from its axial position.

Shaft **56** mounts a plurality of vanes **64** extending radially outwardly from the shaft. The vanes **64** are connected with brace members **66** as illustrated best in FIG. **2**. Further, each vane **64** is provided with a cleat **68** on its leading and its trailing surface to reduce the slippage of material on the vane. Shaft **56** rotates with the drum **10** thereby rotating the vanes **64**.

Referring now to FIGS. **4–7** where the alternative hanger arrangement for the shaft **56** is illustrated, it is seen that the shaft is again held by a plurality of hangers **158**. Each hanger **158** includes an arcuate portion **160** which at least partially surrounds the shaft **56**, and a pair of longitudinally extending straight portions **162** and **162'** which are integral with and extend from the opposite ends of the arcuate portion **160**. The outermost ends of the straight portions **162** and **162'** are rigidly secured to the inner surface of the sidewall **12** by welding or other appropriate means. It may also be desirable to spotweld the arcuate portion **160** to the shaft **56**. It is desirable to provide three of the hangers **158** at each supporting location of the shaft **56** with the hangers being disposed in a complemental arrangement as best illustrated in FIG. **6**. In this manner, the arcuate portions **160** essentially completely surround the shaft **56**, and as is clear from viewing FIG. **7**, the shaft is precluded from moving in any direction away from the center of the drum **10**.

It will also be noted from viewing FIG. **5**, that each of the vanes **32**, **38** and **46** is provided with a cleat **54** as previously described for the embodiment of FIGS. **1–3**. In this alternative form, however, instead of utilizing the cleats **54** only on selected vanes, each of the vanes is provided with the intermediate cleat **54**. It has also been found desirable in certain instances to provide a gusset plate **70** between each of the vanes **32**, **38** and **46** and the drum wall **12** to strengthen the vanes and reduce the possibility of breakage.

In FIGS. **8** and **9** an alternative central flighting arrangement has been illustrated and designated generally by the numeral **72**. The central flighting **72** comprises a plurality of longitudinally extending, radially projecting vanes or plates **74** which are secured to the shaft **56** at one end by fluting, welding or the like and are further supported by a plurality of brace bars **76** which extend between successive plates **74** and are welded to the latter. The other end of each plate **74** ex-

tends outwardly into the drum for travel in a second circular path spaced circumferentially inwardly from the path of travel of the ends of the vanes secured to the inner surface of the drum. It is to be understood that each of the plates **74** which is visible in FIG. **8** is the first in a longitudinally extending row of the plates. Thus there are a plurality of the plates **74** disposed in end-to-end, closely spaced relationship in rows which extend longitudinally of the shaft **56**. Each of the plates **74** is provided with a plurality of interference structures such as cross members **78** disposed at the outermost ends of the plates **74** and secured thereto by welding or the like, with gusset plates **80** providing structural support. It is to be understood that while only one of the cross members **78** is illustrated at the end of each of the plates **74** in FIG. **8**, a number of the members **78** would normally be disposed in closely spaced relationship at intervals along the entire length of each of the plates. Similarly, a number of cross braces **76** are normally provided at spaced intervals along the length of the shaft **56**. The cross members **78** are generally planar, longitudinally extending structures of any desired cross section. Thus, each of the members **78** cooperates with the plate **74** to form a T-bar which is highly instrumental in facilitating an even distribution of a crop such as alfalfa while preventing bunching of the alfalfa as it is distributed in the drum **10**. Each of the members **78** is provided with laterally extending cleat projections **82** and **84** at its respective ends. As illustrated in FIG. **10**, it is sometimes desirable to provide a third cleat projection **86** which extends laterally of the member **78** intermediate the previously two mentioned cleat projections **82** and **84**.

As clearly shown in FIG. **9**, the member **78** is disposed to transverse the plane of the plate **74** to which it is attached at an oblique angle. While reasonable variations in the angle can be tolerated, it has been found that an angle of approximately 45° is particularly advantageous for optimum results in facilitating even distribution of a material to be dehydrated. As indicated by the phantom illustration in FIG. **9**, this 45° angle between the member **78** and the plate **74** can be formed by sloping the member **78** in either one of two directions. While various positions intermediate the two positions shown in FIG. **9** for the member **78** are acceptable, in general an angle of from 25° to 45° between the member and a corresponding plate **74** is desirable.

Referring now to FIG. **11** wherein an alternative arrangement for the central flighting **72** is illustrated, it is seen that in addition to the interference structure formed by the member **78**, a second interference structure which is formed by a pair of aligned cross members **88** and **90** is disposed in spaced relationship to the member **78** inwardly therefrom along the plate **74**. Although the members **88** and **90** are shown in aligned relationship in FIG. **11**, it is to be understood that while this is the preferred arrangement, the members can be disposed at other locations along the plate **74**. Each of the members **88** and **90** is of generally the same configuration as the cross members **78**, although slightly shorter in length, and is rigidly secured to the plate **74** in a manner similar to the member **78**. Each of the members **88** and **90** is provided with a laterally extending cleat projection **92** at its end which projections generally complement the projections **82** and **84** on the members **78**. The common plane of the members **88** and **90** transverses the plane of the plate **74** at an oblique angle as previously described for the member **78**. The angle between each of the members **88** and **90** and the corresponding plate **74** is again preferably 45°, and in no case should it be less than 45°, although this angle may be formed with the members **88** and **90** disposed either parallel or perpendicular to the member **78** as shown by the phantom illustration in FIG. **11**.

In operation, fuel is burned in the furnace **16** and the hot combustion gases are directed into the drum by blower **28**. The material to be dried is conveyed to the interior of the drum by conveyor **24**, and the drum **10** is rotated on its longitudinal axis to distribute the material throughout the interior of the drum. The fan or blower **18** is also operated to insure a sufficient flow of combustion gases and air longitudinally of the drum to pneumatically convey the material being dried.

The rotating drum constantly moves the vanes in a counterclockwise direction as viewed in FIG. **2** so that the material in the drum is picked up by the vanes as they rotate along their lowermost positions within the drum. The material is retained on the vanes as the same is lifted thereby until the vane reaches a position along its path of travel where the vane drops the material for gravitation across the drum toward the bottom of the drum. The different shapes of the vanes insure that the material release point for the various vanes is reached at different positions of rotation of the drum. Thus, a substantially uniform curtain of material in relatively small clumps is alternatively picked up and then released by the successive vanes for gravitation across the drum. It has been found that clumps of material being dried have a tendency to slide toward the edges of the vanes **32**, **38** and **46**, and in some instances a clump of material will actually pivot over the upwardly projecting lips **36**, **44** and **50** respectively to continue as a clump as it gravitates across the drum. For this reason, the cleats **54** are extremely important in assuring a breakup of any bunches of material before the lip of the respective vane is reached. The result is that the material tends to dribble downwardly from the terminal edge of the vane and clumping is largely eliminated.

Since the conveying media comprised of combustion gases and air from the atmosphere is regulated so as to be incapable of supporting the material being dried against gravitation until a portion of the water has been removed from it, a portion of the material gravitates from the vanes **32**, **38** and **46** toward the center of the drying drum.

The central vanes **64** or **74**, however, prevent the material from gravitating to the bottom of the drum when it is first dropped by the vanes **32**, **38** and **46**. The vanes **64** or **74** retard the travel of the material to the bottom of the drum by catching the material at an intermediate point along its path of travel. After the material is caught by the vanes **64** or **74**, the latter carry the material over as the drum continues to rotate for subsequent release to gravitate to the bottom of drum **10**. This subsequent release of the material occurs at a point in time subsequent to the release of the material by the corresponding vanes **32**, **38** and **46**. The shortened paths of gravitation of the material insures that

the gas flow through the drum does not have sufficient time to act on the material while falling to move the material through the drum at too fast a rate for proper drying.

The utilization of the central vanes **74** with members **78** disposed transversely thereof has been found to be particularly useful in facilitating even distribution of material throughout the drum **10**. It will be appreciated that the cross members **78** at the ends of the vanes **74** provide an extension of the vanes in the direction of the peripheral vanes **32**, **38** and **46**, thereby reducing the possibility of any of the material falling past the vanes **74** without being caught. At the same time, the members **78** interfere substantially with the dumping of material from the vanes **74** as the latter rotate through their circuitous paths of travel, thus further breaking up any clumps of material and achieving the same "-dribbling" action in the lower half of the drum **10** as is achieved in the upper half by the vanes **32**, **38** and **46**.

The incorporation of the optional intermediate cleats **86** and the optional interference structure comprised of cross members **88** and **90** depends largely on the nature of the material being dried and the need for further breakup and distribution of the material.

The cleats **54**, **68**, **82–86**, and **90–92** on the respective vanes further tend to dribble the material from the vanes rather than releasing the same in a clump when the vane reaches a position for discharging material. This also serves to enhance the distribution of the material uniformly across the drum for maximum exposure of the material to the hot gases of combustion for dehydrating the material.

Not to be overlooked is the effect of the rows of vanes which are disposed in series and in offset relationship longitudinally of the drum. This arrangement for the vanes which are secured to the inner surface of the cylindrical sidewall **12** retards against the material from bunching as the material moves longitudinally through the drum.

From the foregoing description, it is apparent that a method of dehydrating a crop is presented which includes providing a drying zone at a sufficiently elevated temperature to effect removal of water from the crop. The drying zone is confined to a longitudinally extending cylindrical area and drying gases are directed longitudinally through the zone. Next, the crop to be dried is pneumatically conveyed through the drying zone with the conveying media being regulated so as to be incapable of supporting the crop against gravitation until a portion of the water has been removed therefrom. This results in a portion of the crop gravitating to the outer periphery of the drying zone. This portion of the material is then moved toward the center of the zone by elevating the same and then allowing it to gravitate through the conveying media toward the center of the zone. Before reaching the center, however, the portion is caught and held for a period of time during which it is rotated within the drying zone to further effect removal of water therefrom. The previously caught material is then dumped at a point circumferentially spaced from the point where it was caught to redirect it through the conveying media to the outer periphery of the zone.

The steps of moving a portion of the material through the conveying media toward the center of the zone, catching the portion as it travels toward the center, holding the previously caught material and then redirecting it toward the outer periphery of the zone, are continuously repeated until a sufficient amount of water has been removed from the material to allow the conveying media to support the same and remove the material from the drying zone.

By the present method even distribution of the material being dried is permitted to a degree heretofore not possible, and the detrimental bunching of materials such as alfalfa is largely eliminated. It is inherent in the method that the heavier stemmy materials commonly found in crops such as alfalfa and which require significantly more drying time than the relatively light leafy materials also present, are held within the drier for the additional time required, while the lighter material is removed through the conveying airstream. This greatly reduces the danger of the lighter leafy materials being charred from overdrying and at the same time assures that the heavier materials will be adequately dried.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In a dehydrator including an elongated drum having a material inlet and an outlet, means mounting the drum for rotation about its longitudinal axis, and furnace means for providing hot gases of combustion to the drum, means in the drum for distributing the material across the drum comprising:

a plurality of generally planar circumferentially spaced vanes extending around the inner surface of the drum,

one end of each vane being secured to said inner surface, the other end projecting inwardly therefrom, said other end traveling in a first circular path during rotation of the drum;

a lip carried by each vane respectively at the end thereof remote from the inner surface of the drum, each of said lips projecting at an angle from the plane of the corresponding vane to retard slippage of material from the vane until the latter reaches a material discharging position during rotation of the drum;

first cleat means carried by at least a portion of said vanes, said cleat means being secured to the surface of a respective vane in generally perpendicular relationship to the latter and disposed intermediate the drum and the lip;

a plurality of axially and radially disposed longitudinally extending generally planar retainer plates positioned in spaced relationship to each other and to said vanes for catching material gravitating from said vanes,

each of said plates having one end extending outwardly into said drums, said one end of said plate traveling in a second circular path spaced circumferentially inwardly from said first path;

generally planar longitudinally extending interference structure secured to each of said plates and extending transversely on either side of the latter to provide a drying area for said material prior to the material reaching the area between adjacent plates; and

second cleat means disposed on said structure and extending longitudinally of the latter in generally perpendicular relationship to the plane of the

structure to retard slippage of material from the structure during rotation of the drum.

2. The invention of claim 1, wherein said structure forms an angle from about 25° to 45° with said one plate.

3. The invention of claim 2, wherein said second cleat means comprises first and second cleat projections at opposite ends of said structure.

4. The invention of claim 3, and a third cleat projection intermediate said first and second projections.

5. The invention of claim 1, and second interference structure secured to said one plate in spaced relationship to the first-mentioned structure and traversing the plane of said one plate at an oblique angle.

6. The invention of claim 5, wherein said second structure is disposed in parallel relationship to the first-mentioned structure.

7. The invention of claim 5, wherein said second structure is disposed in perpendicular relationship to the first-mentioned structure.

8. The invention of claim 1, said retainer means comprising a shaft extending axially of the drum and including a plurality of elongated supports coupling said shaft with the drum, each support having one end secured to the shaft, an arcuate stretch adjacent said one end extending at least partially around the shaft, and a portion integral with said stretch spanning the distance across said drum, said portion being rigidly secured to said drum.

9. The invention of claim 8, wherein each of said supports includes a second portion integral with said stretch at the end of the latter opposite the first-mentioned portion and spanning the distance across said drum, said second portion being rigidly secured to said drum.

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