

March 10, 1959

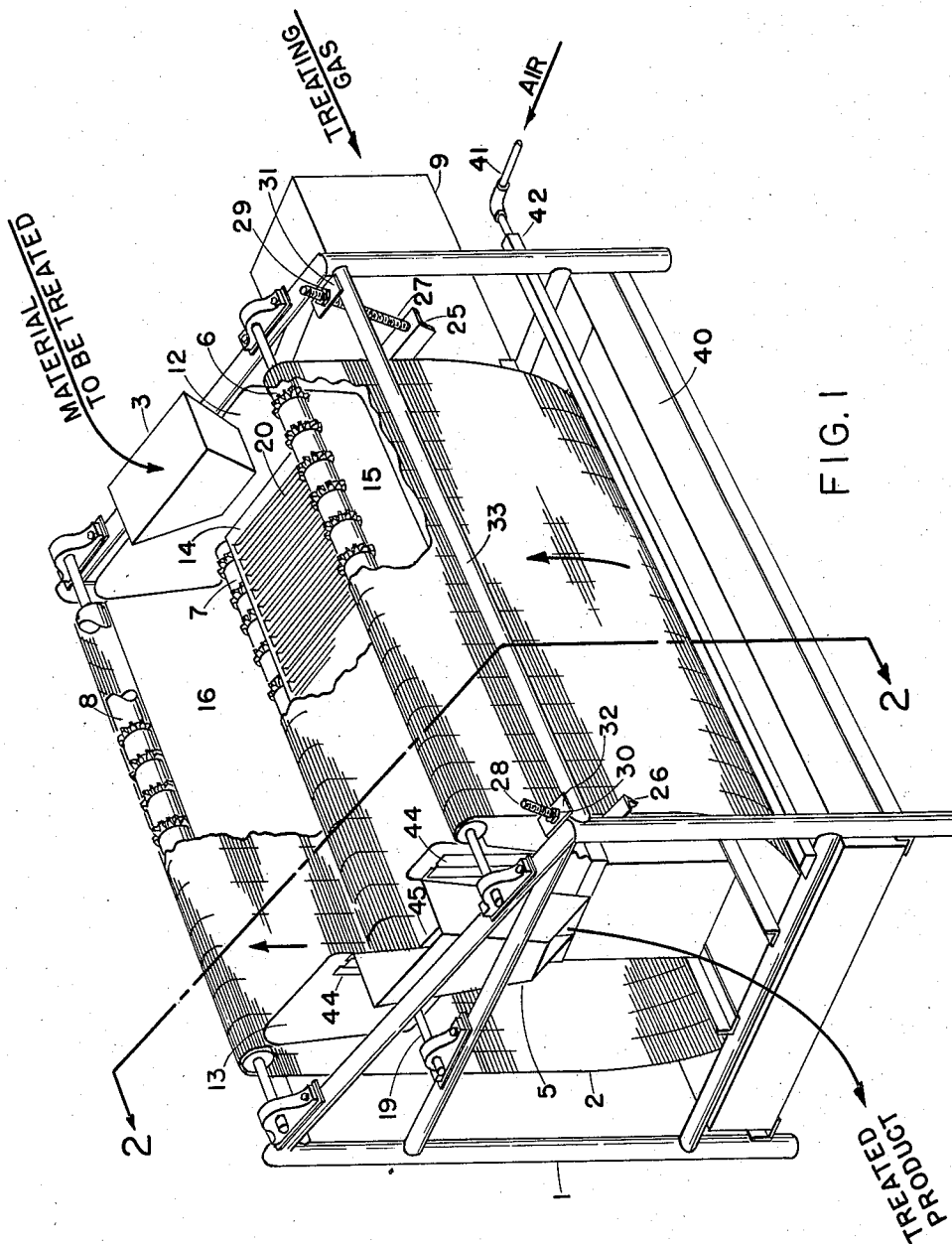
E. LOWE ET AL

2,876,558

APPARATUS FOR TREATING PARTICULATE MATERIAL WITH GASEOUS MEDIA

Filed Jan. 18, 1956

5 Sheets-Sheet 1



E. LOWE &
E. L. DURKEE
INVENTORS

BY
24 August
R. Hoffmann
ATTORNEYS

2,876,558

5 Sheets-Sheet 2

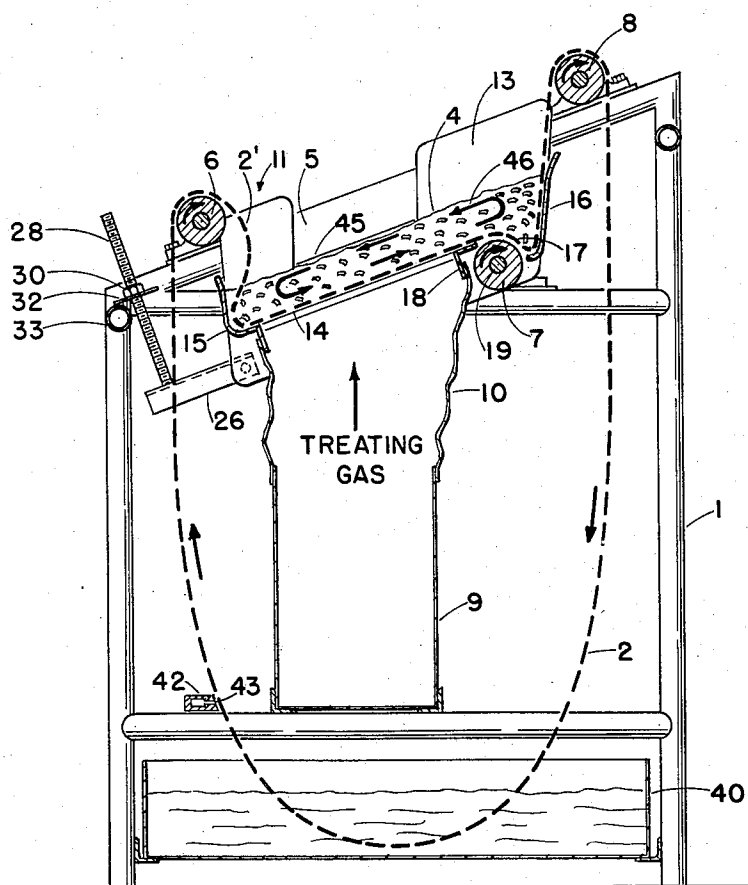


FIG. 2

E. LOWE &
E. L. DURKEE
INVENTORS

BY
- a *deputy* ATTORNEYS
R. Hoffman

March 10, 1959

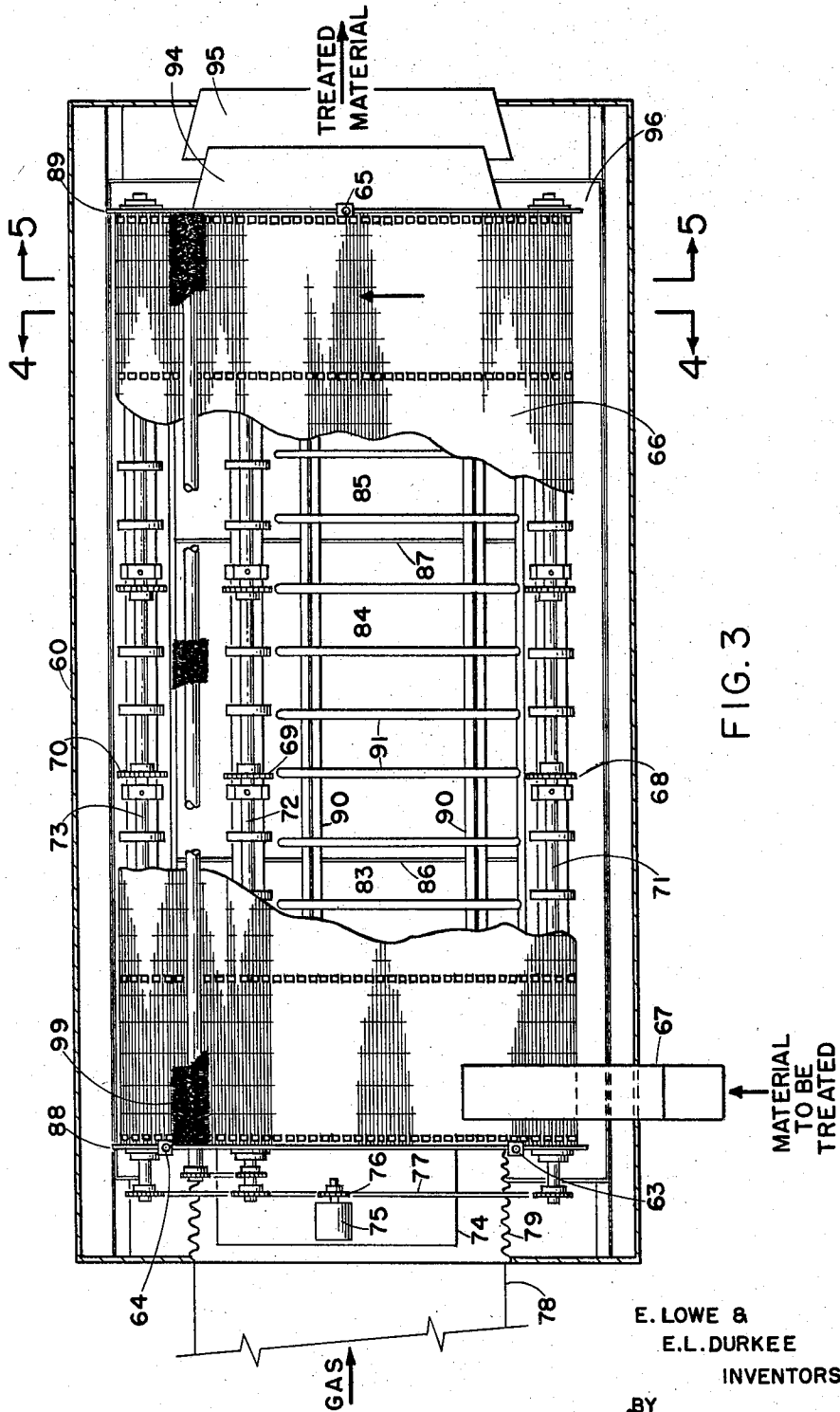
E. LOWE ET AL

2,876,558

APPARATUS FOR TREATING PARTICULATE MATERIAL WITH GASEOUS MEDIA

Filed Jan. 18, 1956

5 Sheets-Sheet 3



E. LOWE &
E.L. DURKEE
INVENTORS

BY
R. Hoffman
ATTORNEYS

March 10, 1959

E. LOWE ET AL

2,876,558

APPARATUS FOR TREATING PARTICULATE MATERIAL WITH GASEOUS MEDIA

Filed Jan. 18, 1956

5 Sheets-Sheet 4

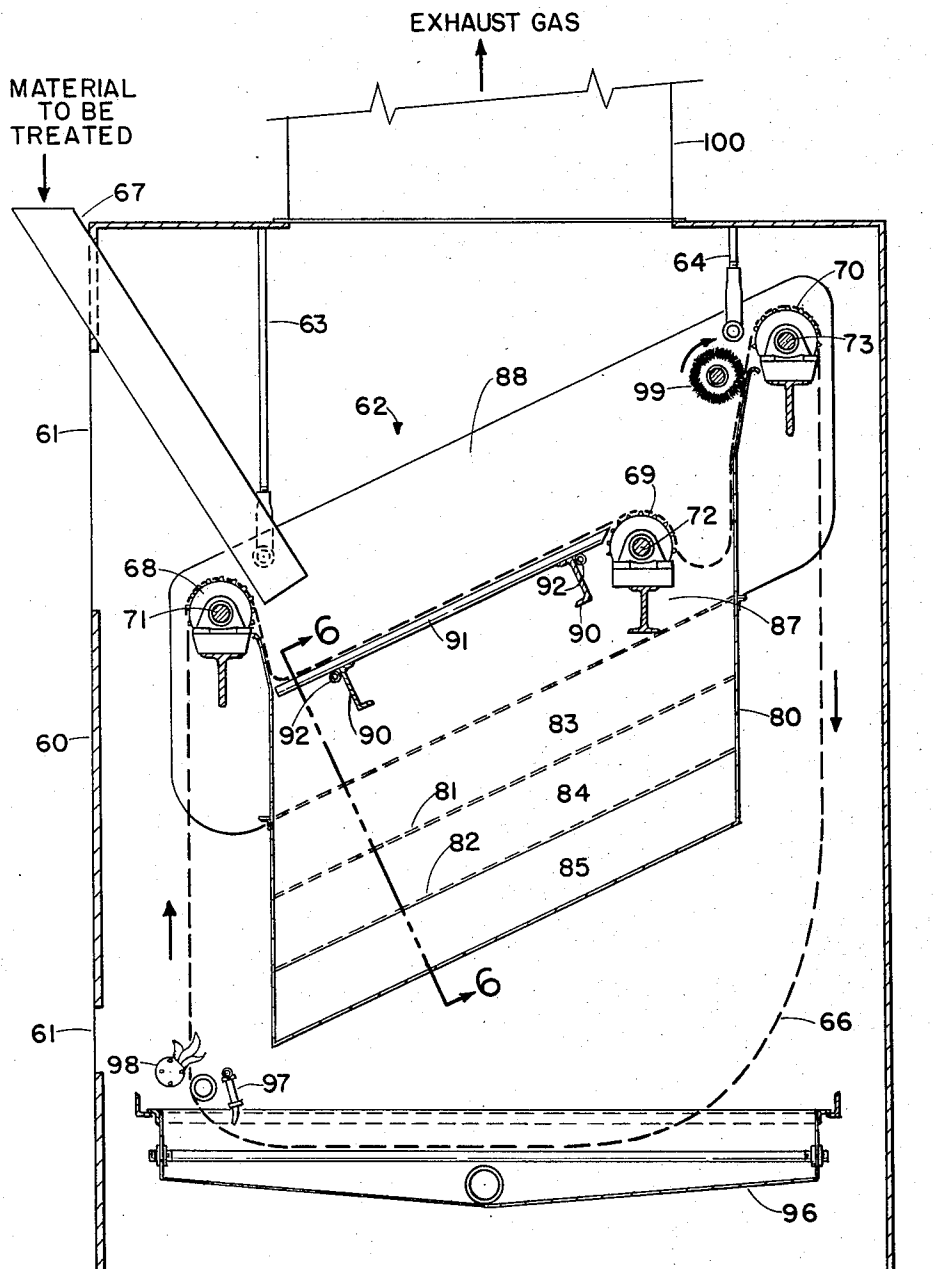


FIG. 4

E. LOWE &
E.L. DURKEE
INVENTORS

BY
24 August
R. Hoffman ATTORNEYS

March 10, 1959

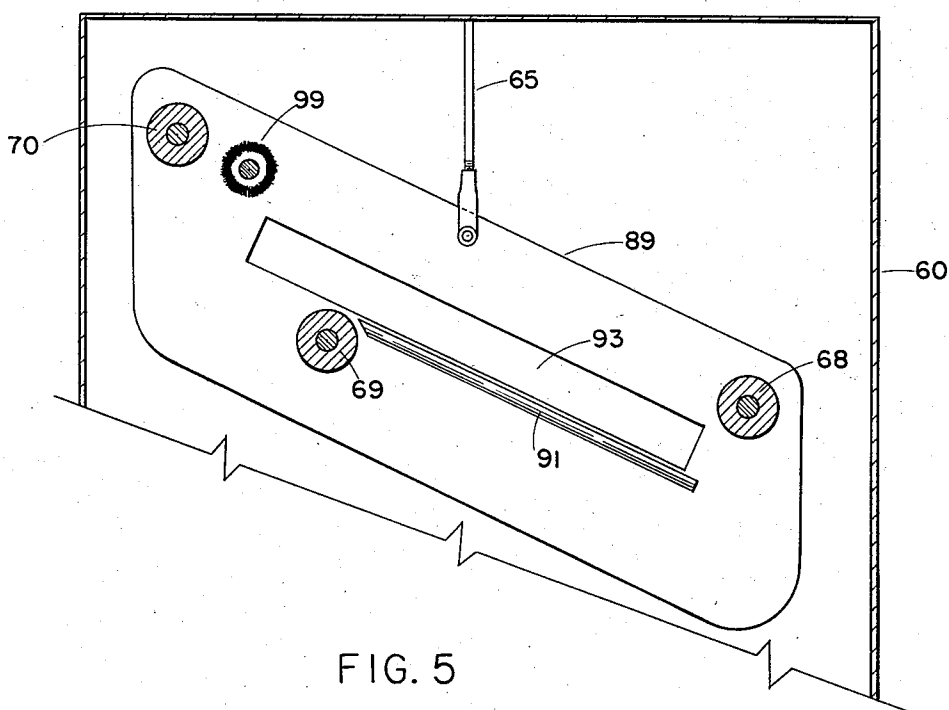
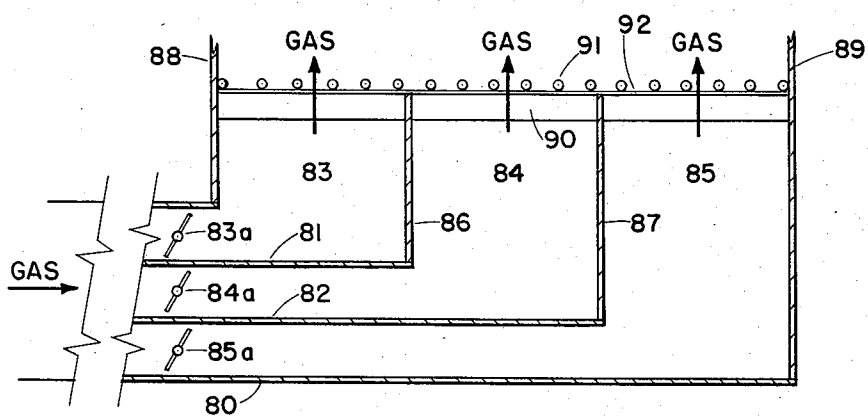
E. LOWE ET AL

2,876,558

APPARATUS FOR TREATING PARTICULATE MATERIAL WITH GASEOUS MEDIA

Filed Jan. 18, 1956

5 Sheets-Sheet 5



E. LOWE &
E.L. DURKEE
INVENTORS

BY
J. A. Higgins
R. H. Hoffman ATTORNEYS

1

2,876,558

APPARATUS FOR TREATING PARTICULATE MATERIAL WITH GASEOUS MEDIA

Edison Lowe, El Cerrito, and Everett L. Durkee, El Sobrante, Calif., assignors to the United States of America as represented by the Secretary of Agriculture

Application January 18, 1956, Serial No. 560,045

6 Claims. (Cl. 34—236)

(Granted under Title 35, U. S. Code (1952), sec. 266)

A non-exclusive, irrevocable, royalty-free license in the invention herein described, throughout the world for all purposes of the United States Government, with the power to grant sublicenses for such purposes, is hereby granted to the Government of the United States of America.

This application is a continuation-in-part of our prior, co-pending application for patent Serial No. 479,688, filed Jan. 3, 1955, now abandoned.

This invention relates to apparatus for treating particulate solid materials with gaseous media and the general object of the invention is the provision of a continuous belt trough device especially useful for treating fruits or vegetables, such as peas, lima beans, carrots, sliced cabbage, prunes, apricots, sliced apples, chopped water-cress, meats, nuts, cereals; and other solid particulate materials. The treatment effectuated by the device may be, for example, dehydration, freezing, blanching, cooking, smoking, or combinations of such treatments, as is determined by the composition and/or physical condition of the gaseous medium applied to the material under treatment.

A particular object of the invention is the provision of apparatus of the above type wherein the particulate material under treatment is maintained in the form of a bed having a uniform depth and wherein adjustment means is provided so that the uniform bed depth can be maintained with different materials and with different conditions of operation. A particular feature of the adjustment means is that the bed depth can be regulated while the device is in operation without interfering with the flow of material, traverse of the belt, treatment of the material, or other operations or functions of the device.

One advantage of the invention is that many different types of materials can be treated and in every case each piece of material is treated to the same extent because the material is continuously mixed while maintained in a bed of uniform depth whereby each particle is contacted with essentially the same amount of the gaseous medium.

Another feature is that the material is not crushed nor broken during treatment because the mixing is gentle yet thorough. The device is thus particularly adapted to the treatment of fruit and vegetable materials where it is important to preserve the size and shape of the pieces. For example, in drying apple slices on the present device the edges of the slices are not rounded off as with known drying devices which exert excessive forces during mixing.

A further feature is that the device can be operated for long periods of time without requiring shut-downs for cleaning because the belt can be cleaned during operation without interference with the treatment process; this is very important in food processing where sanitary conditions must be maintained. Further, by operating for long periods of time without shut-down, important economic benefits are gained and the amount of sub-standard product produced at periods of shut-down and

2

start-up, when thermodynamic or other treatment conditions are transient and not in equilibrium, is reduced to a minimum.

An additional aspect of the invention is that the device is flexible in that it is capable of handling a wide variety of solid materials and the degree or type of treatment can be readily changed during operation by control of such factors as gas volume and temperature, gas composition, slope and speed of the belt, and rate of feed of the material being treated.

Further objects, features, and advantages of the invention will be apparent from the description herein, considered together with the annexed drawing. In the drawing:

Fig. 1 is a three-dimensional view of one form of apparatus in accordance with this invention, parts being broken away for clarity of representation.

Fig. 2 is a cross-section taken on plane 2—2 of Fig. 1.

Figs. 3, 4, 5, and 6 depict another modification of apparatus within the scope of the invention. Fig. 3 is a plan view of the device; Fig. 4 is a cross-section taken on plane 4—4 of Fig. 3; Fig. 5 is a cross-section taken on plane 5—5 of Fig. 3; Fig. 6 is a cross-section on a reduced scale taken on plane 6—6 of Fig. 4. In all four figures, parts are omitted or broken away for clarity of representation.

Referring with more particularity to the drawing, in which like numerals represent like parts, the device of Figs. 1 and 2 includes a frame 1 which carries an endless flexible mesh belt 2 which is continuously traversed in the direction as shown by the arrows. The upper bight of the belt is formed into a trough the base of which is in the form of an inclined plane as clearly evident in Fig. 2.

Material to be treated is fed into the trough via hopper 3. This material is continuously transported along the length of the trough (right to left in Fig. 1) while being continuously mixed and subjected to contact with a gaseous treating medium. During its traversal through the trough, the material is maintained as a bed 4 having essentially uniform depth. Due to the motion of belt 2, the material does not remain quiescent but is subject to continuous mixing. Thus the material at the bottom of the bed and nearest to the belt tends to ride up the belt in the direction of belt travel. When this material reaches the upper part of the trough (above roller 7) it is lifted to the top of the bed and slides down the upper surface of the bed toward the lower part of the trough. The ascending and descending paths of the material in the trough are shown by arrows 46 in Fig. 2. This gentle but thorough and continuous mixing action contributes greatly toward obtaining uniform treatment. The material in the bed circulates as described above and also has a component of motion toward the discharge end of the device caused either by feeding the material at such rate that the bed 4 is slightly deeper in the vicinity of feed hopper 3 than it is at the discharge end near hopper 5, or by sloping the device so that the feed end (near hopper 3) is higher than the discharge end (near hopper 5). The treated material is thus discharged via hopper 5.

The means for supporting and traversing belt 2 includes toothed rollers 6, 7, and 8 journaled on frame 1. These rollers are each positively rotated in the same direction and at the same speed by a suitable source of power such as a variable speed electric motor equipped with belts and pulleys (not illustrated).

The gaseous treating medium is forced into duct 9 by a blower or other suitable mechanism (not illustrated) and the medium then flows upwardly through flexible connector 10, made of rubberized fabric or the like, through the bed of material 4 causing the desired treat-

ment of the material, for example, dehydration of the material where the gaseous medium is hot, arid air or other suitable gaseous dehydrating medium.

The means for maintaining belt 2 in the form of a trough with a planar base is described as follows:

The pan, generally designated as 11, is composed of feed-end plate 12, discharge-end plate 13, slotted base plate 14, and side members 15 and 16, all of these being joined together to form a unitary structure. The base plate 14 is provided with slots 20 (Fig. 1) so that the gaseous medium can pass through this member and eventually through belt 2 overlying it. There is a slot 17 between the base plate 14 and side member 16 (Fig. 2), whereby to permit the teeth on roller 7 to contact and drive belt 2. Flanges 18 depending from base plate 14 provide the means to connect flexible connector 10 with this member and so direct the gas stream through the material lying on belt 2 above plate 14.

It is evident that since base plate 14 provides a plane surface, the portion of the belt 2 lying thereon assumes a plane surface. Thus the bed of material 4 has a uniform depth in the area where it is subjected to the flow of gaseous medium from duct 9; hence uniform treatment occurs, each piece of material being subjected to contact with essentially the same amount of gaseous medium. For example, where the device is used as a dehydrator and the gaseous medium is hot air or other suitable gaseous dehydrating agent, each particle of material is dehydrated to the same extent, because each particle is contacted with essentially the same volume of hot air.

It is also to be noted that the arrangement of the belt drive rollers is particularly adapted to cause the belt to assume a plane surface during its traverse over base plate 14. Thus each of the rollers 6, 7, and 8 is positively driven in the same direction and at the same speed. This means that the belt will not tend to pull away from base plate 14 as it might if for example roller 6 were not positively driven. It is also to be noted that the top surface of roller 7 is essentially in the same plane as the top surface of base plate 14; this means that the belt 2 does not tend to be lifted but maintains its position lying on the floor of plate 14.

As mentioned briefly above, one of the features of the present invention is that the slope of plate 14 (and hence the slope of bed 4) can be adjusted easily. The importance of this feature is that thereby a bed of material of uniform depth can be maintained with any type of material. Thus the device can be adjusted so as to correlate it with the speed of the belt and with the angle assumed by the bed of circulating material so that regardless of the type of material used the material will not pile up at the low or the high end of the trough but will maintain a uniform depth throughout. To illustrate this point—with a constant belt speed of 3 ft./min. in drying sliced apples, plate 14 is maintained at approximately 30° from the horizontal to keep the apple slices in a bed of uniform depth. Under the same conditions but for drying peas, the plate 14 is maintained at approximately 20° to maintain uniform bed depth with this commodity. The angle assumed by the bed of circulating material is somewhat analogous to the angle of repose of a mass of static material. In the latter case the criterion of the angle is the nature of the material (particle size, shape of particles, etc.) whereas in the former case the angle depends not only on the nature of the material but also on the speed of the belt which supports the bed and to some degree on the surface characteristics of the belt. In general the angle assumed by the bed of circulating material is steeper than the angle of repose of the same material.

The means for accomplishing the slope adjustment is explained as follows:

End plates 12 and 13 are drilled so that shaft 19 which is splined to roller 7 passes freely through these plates. By this means the entire pan 11 can be rotated about the

axis of shaft 19 to tilt the base plate 14 to different angles. To control the degree of tilt there are provided brackets 25 and 26 attached to end plates 12 and 13, respectively. These brackets bear threaded rods 27, 28, nuts 29, 30, and plates 31, 32, the last resting on horizontal member 33 of frame 1. By rotation of nuts 28 and 29 the base plate 14 and hence the plane surface of belt 2 resting on it can be adjusted to any desired degree of slope. Belt 2 is arranged with a slack portion at 2' whereby to allow the distance between roller 6 and the base plate 14 to be varied when a change in tilt is made. If the amount of slack is not sufficient, as for example, where base plate 14 is tilted to a large angle from the horizontal, the power may be turned off for a moment or two to stop belt 2 and then the belt may be manually re-positioned on roller 6 to provide enough slack so that the bottom of the belt will lie flat on base plate 14.

It is particularly to be noted that since base plate 14 and connected parts are hinged on shaft 19 which also bears roller 7, changing the slope of plate 14 will not affect engagement of belt 2 with roller 7. Thus no matter what angle of slope is used, belt 2 will ride properly on roller 7 and no adjustment at this point is needed. Likewise, no matter how the slope of plate 14 is changed, the belt 2 will still lie on the floor of this plate.

In order to continuously clean belt 2 there is provided pan 40 filled with hot water or other cleansing liquid. Belt 2 continuously travels through the water in its course from roller 8 to roller 6. Air is forced by pipe 41 into slotted conduit 42 the air being blown out of slot 43 against belt 2 drying it and blowing away particles of debris, etc. If desired, the pan of water and air blast may be supplemented by steam jets, rotating brushes, sprays of water or the like.

Usually, the trough portion of belt 2 from one edge to the other is maintained level, that is, the edge of the belt at the feed end (near plate 12) and the edge of the belt at the discharge end (near plate 13) are at the same elevation. The passage of the material from the feed end to the discharge end is caused by feeding the material at such a rate that the bed of material is slightly higher at the feed end than at the discharge end. However, if desired the trough may be sloped so that the discharge end is somewhat lower than the feed end by providing the legs of the device with adjustable feet.

As shown in the drawing, the material being treated is subjected to a blast of gas from a single source. If desired duct 9 and connector 10 may be compartmentized so that as the material progresses from feed end to discharge end, it is subjected to gas at different temperatures and/or volumes. Mechanism for accomplishing such a result is disclosed below in connection with the modification of Figs. 3 to 6.

To regulate the depth of material in bed 4, hopper 5 is vertically adjustable in guides 44. Plate 45 which is integral with hopper 5 thus acts as a wiper to control the depth of bed 4.

The entire device may, if desired, be surrounded with a housing having suitable inlets for material to be treated and treating gas and outlets for treated material and exhaust gas. The advantage of a housing is that the exhaust gas may then be carried by a suitable duct out of the building or used for other purposes. Also, where a housing is used, the exhaust gas may be recirculated into the device after suitable regeneration treatment. For example, where the device is used as a freezer, the exhaust gas may be re-cooled and then circulated back to duct 9 for freezing of the particles in the bed.

As noted hereinabove, the device of this invention is of a versatile nature and may be employed to effectuate diverse types of operations which involve contacting particulate solid material with a gaseous agent. Also as noted above, by providing means for maintaining the particulate material in the form of a bed having uniform depth,

each particle is subjected to the same degree of treatment. One aspect of the invention concerns the use of the device as a dehydrator for evaporating moisture from particulate material especially fruits, vegetables, meats, nuts, cereal grains, and so forth. In dehydration applications, the gaseous agent forced upwardly through bed 4 is usually hot air or other hot gas suitable for dehydrating purposes.

Another application of the device is its use as a freezer. In this case, the gaseous medium is air, carbon dioxide, trichloromonofluoromethane, trichlorotrifluoroethane, etc., in a refrigerated state. By the continuous mixing of the material in the bed during contact of the refrigerated gas and material, the particles are rapidly and uniformly frozen without sticking together, that is, the product is a free-flowing mass of individual frozen particles essentially free from aggregates of individual particles.

A further aspect of the invention concerns the use of the device as a cooker or blancher. In such case, the gaseous agent is steam, mixtures of steam and hot air, or other hot, preferably humid, gas or vapor.

An additional aspect of the invention concerns the use of the device to treat particulate materials with various chemical agents. For example, in the processing of fruits and vegetables it is often desired to impregnate the food particles with agents which inhibit enzyme activity; agents which inhibit browning; agents which inhibit rancidification of fat components in the food; flavoring agents; preservative agents; and so forth. In such applications, the agent in question is incorporated into the gas stream entering via duct 9. Examples of agents which may be so employed are: sulphur dioxide to inhibit browning of the food particles; butylated hydroxyanisole, propyl galate, or other volatile organic fat-stabilizing antioxidant to minimize rancidification of fat constituents in the food particles; wood smoke, pyroligenous acid, acetic acid, etc. to act as flavoring and preserving agents; lemon oil, orange oil, cinnamon oil, or other volatile essential oils or fruit essences in order to impart desired flavors to the food particles.

In any of the diverse applications of the device of this invention, the gaseous medium which contacts the particles in bed 4 need not necessarily be entirely in the gaseous state. Thus the medium may consist of a major proportion of a gaseous substance having suspended in it a minor proportion of minute droplets of liquid material such as water; refrigerant (liquid trichloromonochloromethane, liquid trifluorotrifluoroethane, etc.); sulphurous acid solution; acetic acid; organic antioxidant, flavoring substance; and so forth.

It is obvious that by providing suitable sources of different gaseous media and valve arrangements between these sources and duct 9, the particulate material may be subjected to a series of distinct operations by changing the character of the gas stream as the treatment progresses. As an example of such operation—raw diced carrots are placed in the device and belt 2 is traversed to continuously maintain the diced carrots as a bed 4 of uniform depth. The carrots are then successively subjected to: (a) air containing sulphur dioxide or steam to inactivate the enzymes in the carrots; (b) hot air to dehydrate the carrots to the extent that their weight is halved by evaporation of moisture; and (c) cold air at about minus 20° F. to rapidly freeze the partially dehydrated carrots. During these operations, the diced carrots are continuously maintained as a bed of uniform depth and discharge hopper 5 is so adjusted that the carrots are kept in the bed. After the freezing is completed, hopper 5 is lowered and the dehydrofrozen carrots are discharged and packaged. Other applications of the device for conducting sequential operations with different gaseous media will be obvious from the above description.

Reference is now made to Figs. 3, 4, 5, and 6 which depict a second modification of apparatus within the ambit of the invention. The apparatus of these figures can

be employed for effectuating any of the aforementioned types of gas treatment as applied to particulate solid material.

The construction and operation of the device of Figs. 3, 4, 5, and 6 is explained as follows:

The device includes a housing 60 provided with windows 61. Within the housing is a belt supporting and operating structure generally designated as 62, this structure being suspended from the top of housing 60 by rods 63, 64, and 65, adjustable in length.

Structure 62 carries an endless, flexible mesh belt 66 which is continuously traversed in the direction as shown by the arrows in Fig. 4. The upper bight of the belt is formed into a trough the base of which is in the form of an inclined plane as clearly evident in Fig. 4.

Material to be treated is fed into the system via chute 67. This material is continuously transported along the length of the trough (left to right in Fig. 3) while being continuously mixed and subjected to contact with a gaseous treating medium. During its traversal through the trough, the material is maintained as a bed having an essentially uniform depth exactly as described above in connection with the modification of Figs. 1 and 2. The circulatory motion of the material in the bed and the motion of the material from the feed end of the device toward the discharge end of the device are also as described in connection with the first modification.

The means for supporting and traversing belt 66 includes sprockets 68, 69, and 70 mounted on shafts 71, 72, and 73, respectively. The drive for these sprockets includes the following: On feed-end plate 88 is mounted a shelf 74 on which is located electric motor 75. This motor rotates shafts 71, 72, 73 and in the same direction and at the same speed by a series of sprockets 76 and chains 77. Motor 75 is preferably of the variable speed type so that the speed of the belt can be varied as desired.

The gaseous treating medium is forced into conduit 78 by a blower or other suitable mechanism (not illustrated) and the medium flows through flexible connector 79 into the duct generally designated as 80 which is carried by plates 88 and 89. Duct 80 (see Fig. 6) is divided into a series of compartments by members 81 and 82 so that there is formed three individual compartments 83, 84, and 85 through which the gaseous medium flows. Vertical partitions 86 and 87 are joined with the members 81 and 82, respectively, to discharge the three separate gas streams of compartments 83, 84, and 85 upwardly through three separate areas of the bed of material retained in the trough portion of belt 66. By compartmentizing the gas duct in this way a more uniform distribution of gas to the different areas of the bed is attained. Also such arrangement permits more flexibility in that by providing the separate ducts with valve arrangements (83a, 84a, 85a), different areas of the bed may be subjected to different amounts of gas or even different gases. Gas which passes through the bed of material is discharged from the housing by vent 100.

The means for maintaining belt 66 in the form of a trough with a planar base is described in more detail as follows:

The structure 62 includes feed-end plate 88 and discharge-end plate 89, these being joined together into a unitary structure by channels 90. Supported on channels 90 is a grid formed of a series of spaced bars 91 joined to rods 92. The entire grid structure may be lifted off channels 90 for cleaning purposes. The upper bight of belt 66 rides on top of bars 91 and so assumes the form of a trough with a planar base. The spacing of bars 91 permits free flow of the gas past the bars and through the belt into the bed of material. Also supported on plates 88 and 89 are shafts 71, 72, 73 which constitute part of the means for traversing belt 66 as previously described.

Material which has been treated as described is con-

tinuously discharged through orifice 93 in plate 89 (Fig. 5), slides down chute 94 attached to plate 89, and from there is discharged by discharge hopper 95 which is mounted in housing 60 (Fig. 3).

As mentioned hereinabove, one of the features of the invention is that the slope of the planar base of the trough of belt 66 can be adjusted easily and without interference with the operation of the device. In this modification, such adjustment is made by altering the length of rods 63, 64, and 65. Usually, rod 65 is kept at its original length since it is in the center of the trough and its connection with plate 89 serves as a pivot about which the trough can be rotated by suitable adjustment of the length of rods 63 and 64. In this way, the speed of the belt can be correlated with the type of material being processed so that the material maintains a bed of uniform depth in the trough portion of the belt. A feature of this modification of the invention is that the adjustment in slope can be made without affecting the position of the belt 66 on the sprockets 68, 69, 70. Thus in this device, by adjusting the length of rods 63, 64, 65, the position of structure 62 as a whole is altered, there is no relative movement caused between the belt and its position on bars 91. Thus adjustment of the slope does not in any way affect the drive of the belt nor the relation of the belt to the bed of material. For altering the slope of structure 62 in the direction from discharge end to feed end, similar adjustment of rods may be made. For example, to increase the slope from discharge end to feed end, rods 63 and 64 may be shortened each of the same degree while rod 65 is left in its original position.

In order to continuously clean belt 66 there is provided pan 96 filled with hot water or other cleansing liquid. The belt continuously travels through the water in its course beneath structure 62. A series of nozzles 97 are provided for forcing steam, hot water, compressed air, etc. against the belt to further clean it. Also provided is a burner 98 which directs gas flames against the belt to dry it after cleaning. Adjacent the upper end of the trough portion of the belt is a roller brush 99. This brush is rotated by motor 75 in the direction shown and serves to return to the bed particles of material which cling in the interstices of the belt.

Having thus described the invention, what is claimed is:

1. An apparatus having an exterior portion and an interior portion for treating particulate material in the interior of said apparatus with gaseous media comprising a duct for introducing a gaseous medium into the interior of said apparatus, said duct being provided with an opening across the top thereof; a planar, perforated, sloping base plate overlying said opening, the perforations in said base plate being smaller than said opening; an endless foraminous belt; means for continuously traversing said belt; means for maintaining part of said belt in the form of a trough having a planar base resting upon said base plate, the trough part of the belt being adapted to support a bed of particulate material; means for forcing a gaseous medium into said duct and through said opening, perforations, belt, and the bed of material supported thereon; and means for adjusting the slope of said base plate whereby to maintain the material in the trough in the form of a bed having an essentially uniform depth.

2. An apparatus having an exterior portion and an interior portion for treating particulate material in the interior of said apparatus with gaseous media comprising a duct for introducing a gaseous medium into the interior of said apparatus, said duct being provided with an opening across the top thereof; a planar, perforated, sloping base plate overlying said opening, the perforations in said base plate being smaller than said opening; an endless foraminous belt; means for maintaining part of said belt in the form of a trough having a planar base resting upon said base plate, the trough part of the belt being adapted to support a bed of particulate material;

means for forcing a gaseous medium into said duct and through said opening, perforations, belt, and the bed of material supported thereon; means for continuously traversing said belt including a positively-driven, rotatable toothed roller adjacent said base plate for driving said belt, the upper periphery of said roller being substantially tangent to said base plate whereby change in slope of said plate will not interfere with the driving of the belt by the roller; and means for adjusting the slope of said base plate whereby to maintain the material in the trough in the form of a bed having an essentially uniform depth.

3. An apparatus having an exterior portion and an interior portion for treating particulate material in the interior of said apparatus with gaseous media comprising a duct for introducing a gaseous medium into the interior of said apparatus, said duct being provided with an opening across the top thereof; a planar, perforated, sloping base plate having an upper end and a lower end, said base plate overlying said opening, the perforations in the base plate being smaller than said opening, the base plate being pivotable about an essentially horizontal axis adjacent the upper end thereof; an endless foraminous belt; means for maintaining part of the belt in the form of a trough having a planar base resting upon said base plate, the trough part of the belt being adapted to support a bed of material undergoing treatment; means for forcing a gaseous medium into the duct and through said opening, perforations, belt, and material supported thereon; means for adjustably pivoting said base plate to change the slope thereof whereby to maintain the material in the trough in the form of a bed having an essentially uniform depth; and means for continuously traversing said belt including a positively-driven toothed roller adjacent the upper end of said base plate, the upper periphery of said roller being substantially tangent to said base plate whereby change in the slope thereof will not interfere with the driving of the belt by said roller nor will change the position of the belt with relation to the base plate.

4. An apparatus having an exterior portion and an interior portion for treating particulate material in the interior of said apparatus with gaseous media comprising a duct for introducing a gaseous medium into the interior of said apparatus, said duct being provided with an opening across the top thereof; a planar, perforated, sloping base plate having an upper end and a lower end, said base plate overlying said opening, the perforations in said base plate being smaller than said opening; an essentially horizontal shaft adjacent the upper end of the base plate, the base plate being supported by and pivotable about said shaft; an endless foraminous belt; means for maintaining part of the belt in the form of a trough having a planar base resting upon said base plate, the trough part of the belt being adapted to support a bed of particulate material; means for forcing a gaseous medium into said duct and through said opening, perforations, belt, and material supported thereon; means for adjustably pivoting said base plate about said horizontal shaft to change the slope of said base plate whereby to maintain the material in the trough in the form of a bed having essentially uniform depth; and means for continuously traversing said belt in the general direction from said lower end of the base plate to the upper end thereof, said means including a positively-driven, rotatable toothed roller on said shaft, the upper periphery of said roller being substantially tangent to said base plate whereby change in the slope thereof will not interfere with the driving of the belt by said roller nor will change the position of the belt with relation to said base plate.

5. An apparatus having an exterior portion and an interior portion for treating particulate material in the interior of said apparatus with gaseous media for treating

9

particulate solid material with a gas comprising: an assembly for maintaining and treating the material in the form of a sloping bed having an essentially uniform depth, said assembly including a duct for introducing a gaseous medium into the interior of said apparatus, said duct being provided with an opening across the top thereof; a planar, perforated, sloping base plate overlying said opening, the perforations in said base plate being smaller than said opening; an endless foraminous belt, means for maintaining part of said belt in the form of a trough having a planar base resting upon said base plate, the trough part of the belt being adapted to support a bed of particulate material; means for traversing said belt along said base plate in the general direction from bottom to top of the slope thereof, said means including a positively-driven sprocket which engages the belt; means for adjusting the slope of said assembly as a unit without disturbing the position of the belt with relation to the sprocket and base plate; and means for forcing a gaseous medium into said duct and through said opening, perforations, belt, and material supported thereon.

6. An apparatus having an exterior portion and an interior portion for treating particulate material in the interior of said apparatus with gaseous media for treating particulate solid material with a gas comprising: a unitary assembly for maintaining and treating the material in the form of a sloping bed having an essentially uniform depth, said assembly including a duct for introducing a gaseous medium into the interior of said apparatus, said duct being provided with an opening across

10

the top thereof; a planar, perforated, sloping base plate overlying said opening, the perforations in said base plate being smaller than said opening; an endless foraminous belt; means for maintaining part of said belt in the form of a trough having a planar base resting upon said base plate, the trough part of the belt being adapted to support a bed of particulate material; means for traversing said belt along said base plate in the general direction from bottom to top of the slope thereof, said means including a positively-driven sprocket which engages the belt; a supporting member for supporting said assembly, said assembly being suspended as a unit from said supporting member by a plurality of hangers adjustable in length whereby the slope of the assembly may be adjusted as a unit and without disturbing the position of the belt with relation to the sprocket and the base plate; and means for forcing a gaseous medium into said duct and through said opening, belt, and the bed of material supported thereon.

References Cited in the file of this patent

UNITED STATES PATENTS

2,308,420	Hoopes	Jan. 12, 1943
2,424,228	Erismann	July 22, 1947
2,745,194	Lowe et al.	May 15, 1956

FOREIGN PATENTS

95,687	Sweden	May 7, 1939
566,662	Great Britain	Jan. 9, 1945