May 7, 1935. K. R. BIXBY 2,000,817

APPARATUS FOR DRYING LOOSE MATERIAL

Filed June 27, 1933 3 Sheets-Sheet 1

Fig. 1.

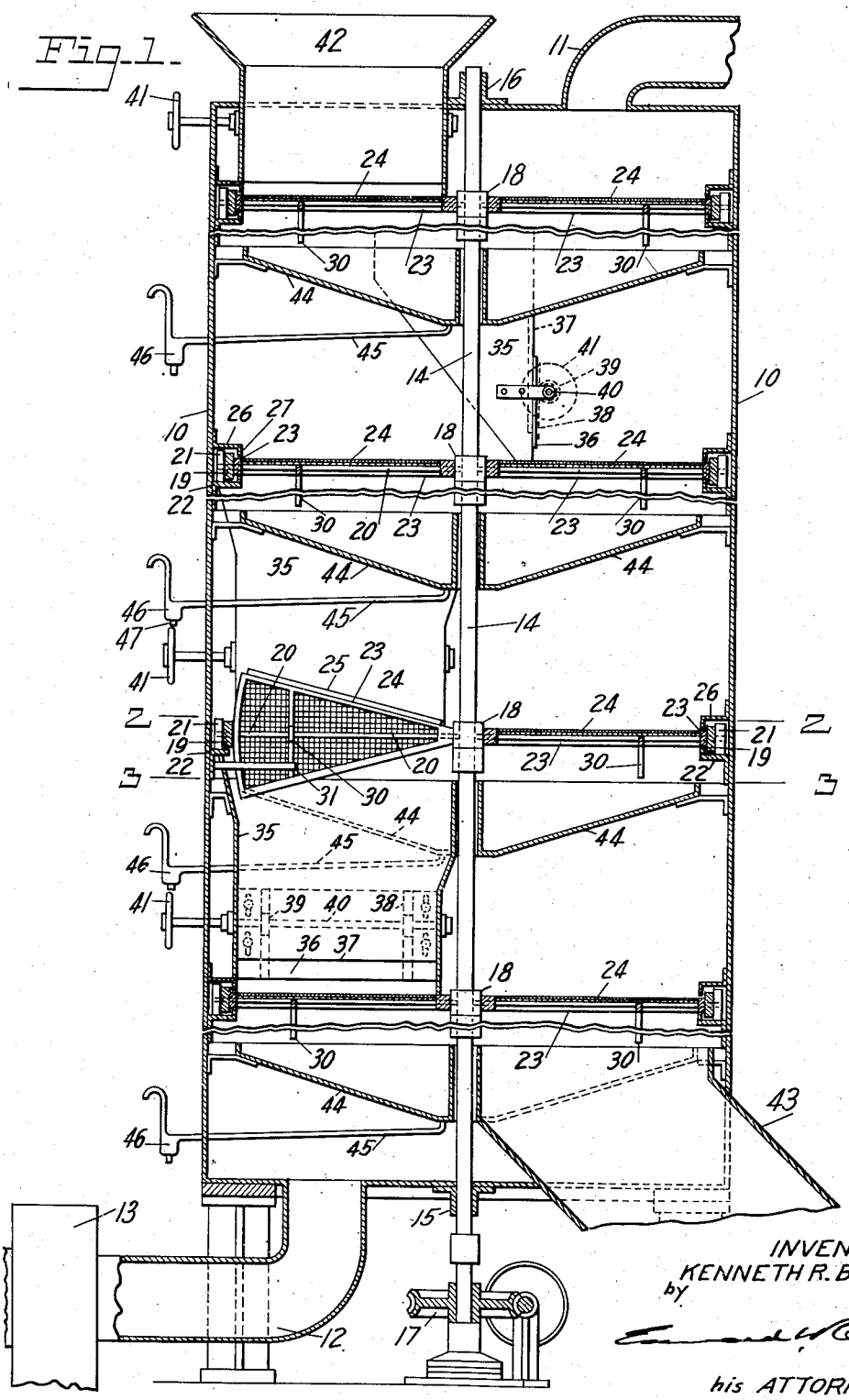

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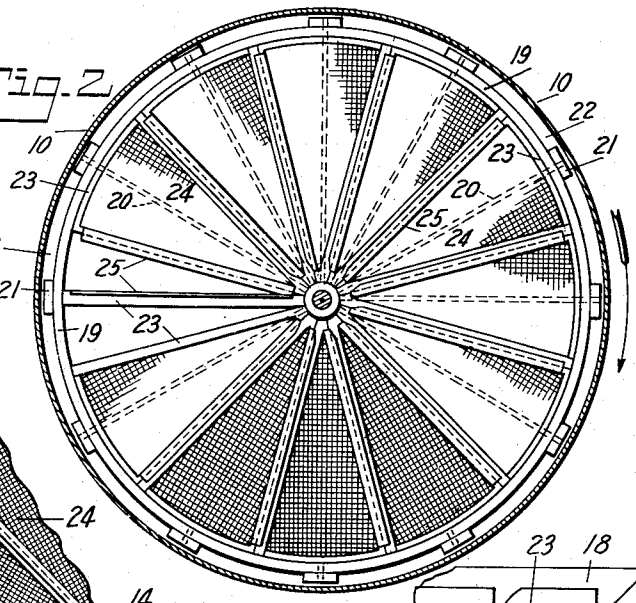
Fig. 2.



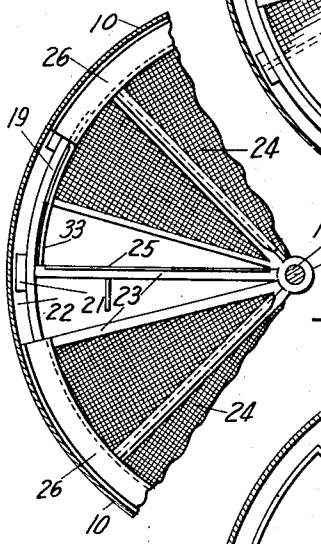


Fig. 4.

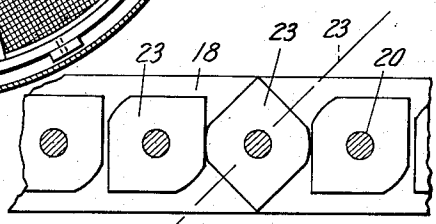


Fig. 2a.

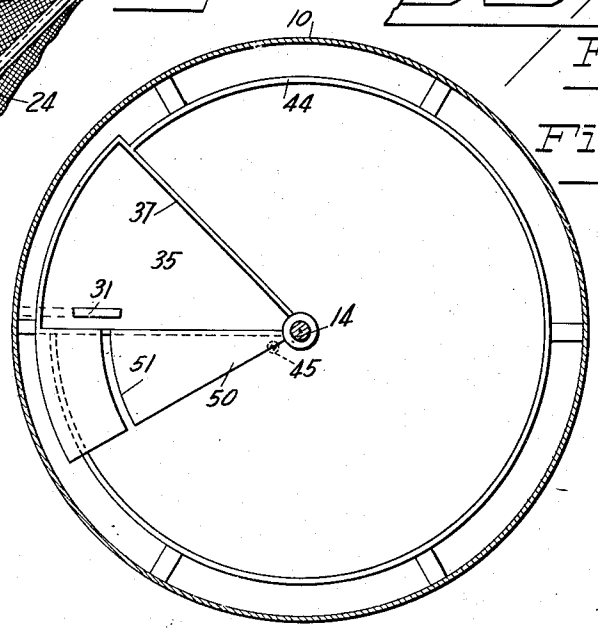


Fig. 3.

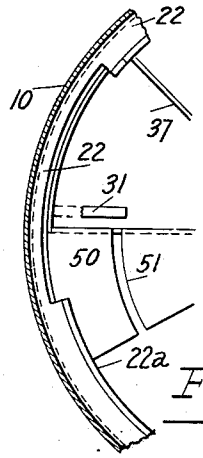


Fig. 3a.

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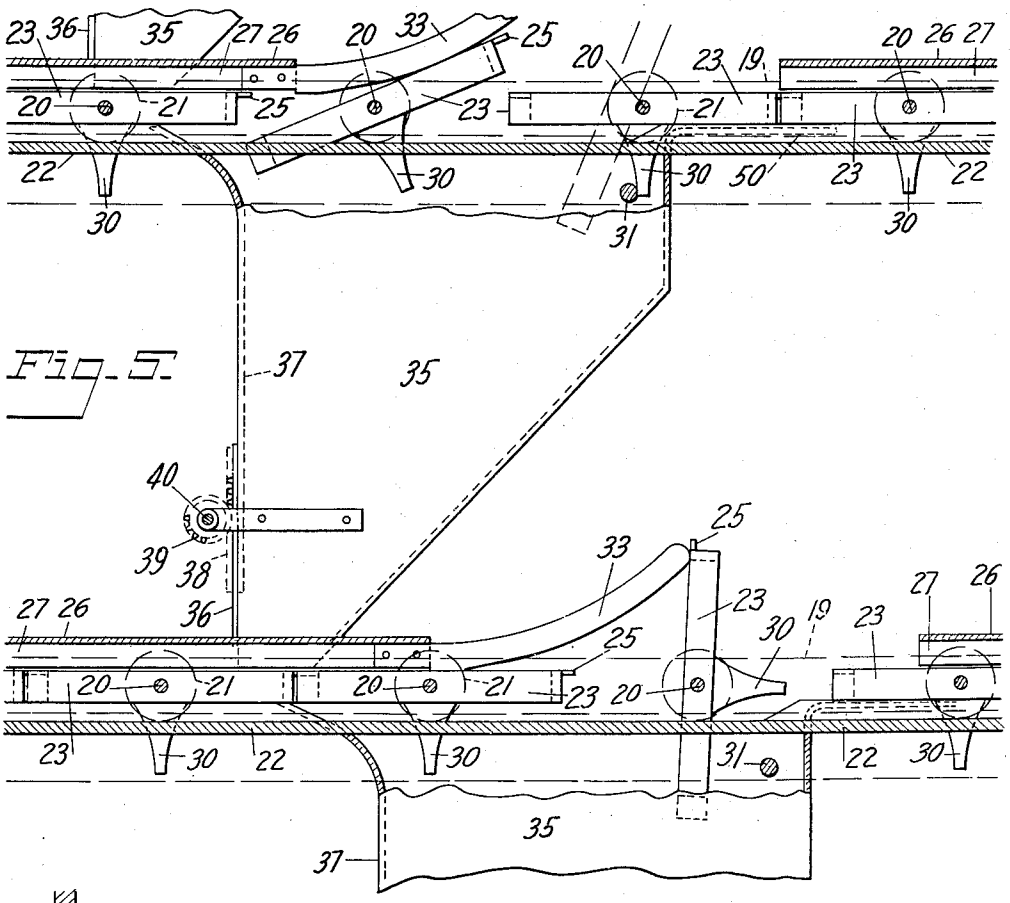

Fig. 5.

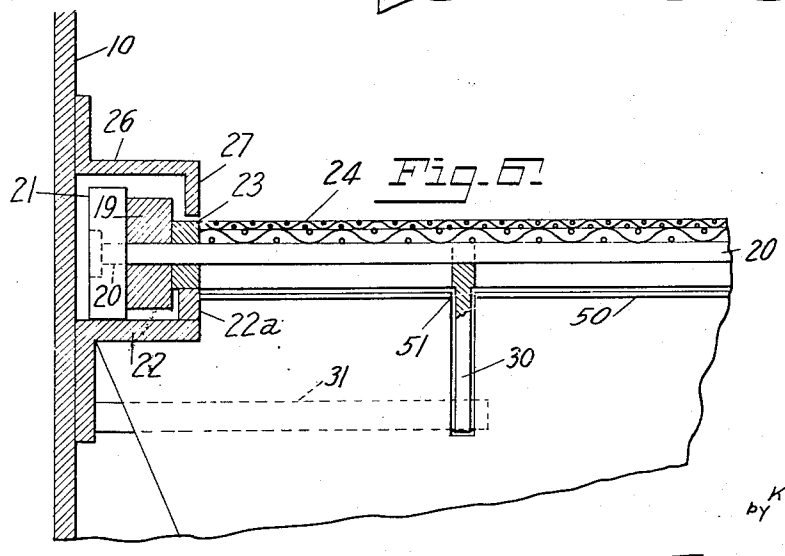

Fig. 6.

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Patented May 7, 1935

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UNITED STATES PATENT OFFICE

2,000,817

APPARATUS FOR DRYING LOOSE MATERIAL

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Application June 27, 1933, Serial No. 677,877

9 Claims. (Cl. 34—15)

This invention relates to a method and apparatus for drying loose material, such as coal. In preparing coal for the market it is sometimes desirable to subject the same to a drying operation to remove excess moisture, this being particularly true when it has been necessary to wash the coal. Driers of various kinds have been constructed for this purpose, but, for the most part at least, these driers have been unsatisfactory in operation and inefficient because they remove a relatively small part only of the moisture.

One object of the present invention is to provide a method for drying loose material, such as coal, which will be simply and easily performed and which will remove all or a relatively large part of the moisture.

A further object of the invention is to provide such a method in which the drying of the material will be accomplished in a plurality of successive drying operations and the material will be turned and mixed between successive drying operations so that the component parts of the material will occupy different relative positions and different portions thereof will be exposed to the direct action of the drying medium during the successive drying operations.

A further object of the invention is to provide a simple and efficient apparatus for carrying out this method.

A further object of the invention is to provide a drier in which the loose material will be supported in a plurality of layers which will be simultaneously subjected to the action of a drying medium, the moisture drained therefrom and the material delivered from one layer to the other.

A further object of the invention is to provide a drier of such a construction that the drying medium will be forced to pass through the loose material in each layer as the drying medium passes from one end of the drier to the other end thereof.

A further object of the invention is to provide such a drier in which the means for discharging the material from one layer to the other will cause the material to be turned and mixed as it passes from one layer to the other.

A further object of the invention is to provide such a drier which will be continuous and automatic in its operation.

Other objects of the invention will appear as the method and apparatus is described in detail.

In the accompanying drawings Fig. 1 is a vertical sectional view taken centrally through a drier embodying my invention; Fig. 2 is a transverse sectional view taken on the line 2—2 of Fig. 1; Fig. 3 is a transverse sectional view taken on the line 3—3 of Fig. 1; Fig. 4 is a transverse sectional view of a portion of the drier showing in plan the means for controlling the movement of the tilting section of the material supporting device; Fig. 5 is a vertical sectional view showing two of the material supporting devices and the means for controlling the tilting sections thereof; and Fig. 6 is a sectional detail view of the outer portion of one of the material supporting devices.

In these drawings I have illustrated one form of apparatus for carrying out my method, this apparatus being designed primarily for drying coal. It will be understood, however, that this particular apparatus has been chosen for the purpose of illustration only and that it may take various forms without departing from the spirit of the invention.

In drying the material according to the present method the material is supported in a plurality of relatively thin layers, preferably arranged at different levels, and a drying medium, such as heated air, is passed through the material in the several layers, the liquid drained therefrom and successive portions of the material in each layer delivered to a succeeding layer, the material being turned and mixed as it passes from one layer to the other so as to cause the component parts of the mass of material to occupy different positions in the different layers. Preferably the material is continuously supplied to the first layer and is continuously discharged from each upper layer to the next succeeding lower layer and is discharged from the lowermost layer to the point of delivery.

The particular apparatus here illustrated for carrying out the method comprises a housing 10 which, in the present drier, is in the form of a vertical cylinder. This housing is provided near its respective ends with an inlet and an outlet for heated air, which constitutes the drying medium. While I have herein characterized the drying medium as heated air it will be obvious that any suitable gaseous drying medium may be employed, such as exhaust gases. As here shown, the inlet is in the top wall of the cylindrical housing and is connected with a conduit 11 through which the heated air is delivered from a suitable source of supply. The outlet is in the lower wall of the cylindrical housing and is connected with a conduit 12 through which the air is discharged. Any suitable means may be provided for maintaining a circulation of heated air through the housing, such as a suction fan 13 connected with the discharge conduit 12.

Mounted within the housing and arranged at

different levels therein is a plurality of material supporting devices each comprising means for supporting material to be dried in a relatively thin layer and for moving the material in the plane of the layer, and for discharging successive portions of material after each of said portions has traveled a predetermined distance. In the arrangement here shown, the supporting device is movable and the material supported thereby moves with the supporting device. When the cylindrical housing is employed, as in the present case, the several supporting devices are circular in form and are mounted for rotation about a common axis, they being preferably connected with a single vertical shaft **14** mounted in bearings **15** and **16** at the lower and upper ends of the housing, the shaft being driven at a slow speed through worm gearing **17** which is connected with a suitable source of power. Each supporting device comprises a skeleton main frame which includes an inner member or hub **18** rigidly secured to the shaft **14** for rotation therewith and an annular outer member or ring **19** arranged adjacent to but spaced a short distance from the cylindrical wall of the housing. Radial shafts **20** are mounted in the inner and outer members of this main frame and extend outwardly beyond the outer frame member or ring **19** and are provided on their outer ends with rollers **21** which are supported by and travel on annular tracks **22**, which thus serve to support the outer edge of the material supporting device and are here shown as comprising angle irons rigidly secured to the cylindrical wall of the housing. Rigidly secured to each radial shaft **20** is a sector-like section of the supporting device which is tiltable about the axis of the shaft. Each of these sections comprises a tapered or sector-shaped frame **23**, the inner and outer end members of which are provided with openings forming bearings for the shaft. Secured within each sector-shaped frame is a sheet of foraminous material, such as fine mesh wire fabric **24**, each section thus constituting a tiltable screen. The several sector-shaped sections have their lateral edges arranged close one to the other but spaced apart a sufficient distance to permit of each screen to tilt with relation to the adjacent screens. The rear edge of each screen is preferably provided with a flange or lip **25** which overlaps the forward edge of the adjacent screen and thus closes the space between the two screens. When the several screens are in their horizontal or material supporting positions they constitute the entire material supporting surface of the material supporting device.

The material to be dried is delivered to each rotatable supporting device at a fixed point in its travel and when the material has moved with the supporting device through the major portion of its travel successive portions thereof are discharged from the supporting device, this being accomplished by causing the several tiltable screen sections to be successively tilted at a predetermined point in the travel of the supporting device. Any suitable means may be provided for maintaining the tiltable sections normally in their horizontal or material supporting positions and for causing the same to be successively tilted at the desired point in their travel. Preferably this is accomplished by mounting on the cylindrical wall of the housing, adjacent to each rotatable supporting device, a substantially annular retaining device which engages the outer edges of the tiltable screen sections and retains the same normally in horizontal positions. The retaining device is of a length slightly less than the circumference of the housing and the ends thereof are spaced apart at the point where the material is to be discharged to permit the sections to tilt. In the present construction I have utilized the anular track **22** as the retaining device and for this purpose the track is of such a width that its inner edge extends beneath the outer portions of the tiltable screen sections and this inner edge of the track is provided with an upwardly extending part, such as a wear plate **22*a***, arranged to engage the tiltable sections and hold the same in horizontal positions. The inner edge or retaining portion of the track, and the wear plate, are cut away adjacent to the point at which the material is to be discharged, to permit the sections to successively tilt as they arrive at the point of discharge.

For the purpose of preventing the passage of air about the edge of the material supporting device I have provided the same with a seal which is here shown as an annular bar **26** Z-shaped in cross section and having an outer flange rigidly secured to the cylindrical wall of the housing and an inner flange **27** arranged on the inner side of the outer member **19** of the main frame of the supporting device and extending downwardly below the surface of the material on the supporting device. The bar **26** thus bridges the space between the outer edge of the supporting device and the wall of the housing so as to prevent the passage of air about the edges of the supporting device. Adjacent to the point at which the material is to be discharged from the supporting device the flange **27** of the bar **26** is cut away so that it will not interfere with the tilting of the screen sections as they pass beyond the end of the retaining device.

I have here shown the forward edge of each screen section as weighted, by thickening the forward frame member, so that as soon as the axis of the screen has passed the end of the retaining device the screen will automatically tilt. However, in order to avoid the possibility of the screen being so balanced, as by an unequal distribution of the material thereon, that it will not tilt automatically, I prefer to provide positive means for tilting the same. As here shown, a trip arm **30** is rigidly secured to and depends from each tiltable screen and is adapted to engage a fixed member, such as a rod **31**, and to ride over the same as the supporting device rotates. The movement of the trip arm over the rod **31** will positively tilt the screen so that the material thereon will be discharged. After the material has been discharged from the screen it is immediately returned to its horizontal or material supporting position. In the present apparatus this is accomplished by a guide **33** which extends rearwardly and upwardly above the space between the ends of the retaining device and lies in the path of the elevated edge of the tilted screen, so that it will be engaged by the screen and will restore the same to its horizontal position as the screen is advanced.

Arranged beneath each material supporting device, at that point where the screens are tilted, is a chute or hopper **35** which receives the material discharged from the tilted screen and delivers the same onto the next lower supporting device. The discharge end of the hopper is arranged adjacent to the lower supporting device just beyond the point at which the material is discharged from the lower device, so that additional material will be delivered each tiltable sec-

tion soon after it has been restored to its horizontal position. The forward wall of the hopper 35, that is, the wall toward which the tilted screen moves, is spaced from the surface of the supporting device a distance determined by the desired thickness of the layer of material on the supporting device and thus serves to distribute the material on the supporting device in a layer of uniform thickness. Preferably this forward wall of the hopper is vertically adjustable to enable the thickness of the layer of material to be varied and, as here shown, the lower portion 36 of the forward wall is separate from the upper portion 37 of that wall and slidably mounted on that upper portion. The movable portion 36 is provided with toothed racks 38 which mesh with pinions 39 on a shaft 40 which extends outwardly beyond the cylindrical wall of the housing 10 and is there provided with a hand wheel 41 by means of which the discharge opening of the hopper may be regulated.

In the arrangement here shown each screen section is tilted as it passes the rear wall of the hopper and is restored to horizontal position just before it reaches the front wall of the hopper. For the purpose of preventing the air from passing through the opening formed in the supporting device by the tilted screen or screens, and thus escaping about the walls of the hopper without passing through the material on the supporting device, the rear wall of the hopper is provided at its upper edge with a rearwardly extending part 50 which is arranged close to the lower side of the supporting device and extends beneath the next succeeding screen, thus forming a seal which prevents the passage of any substantial amount of air about the rear wall of the hopper. The upper portion of the front wall of the hopper is curved, or otherwise extended, forwardly so that its upper edge lies beneath and close to a screen section which has been returned to horizontal position and has received material from the upper hopper 35, thus forming a seal which prevents the passage of any substantial amount of air about the front wall of the hopper. The rear wall of the hopper and the rearwardly extending part 50 are provided with a slot 51 to permit the trip arms 30 to pass the same but this slot is very narrow and will permit the passage of only very small amounts of air.

The hopper normally contains material in such quantity as to substantially prevent the passage of air through the hopper and any air that does escape through the hopper must pass through the material therein. The inner ends of the screen sections lie close to the respective hubs 18, the spaces between the outer ends of the screen sections and the wall of the housing are sealed by the members 26, and spaces between the screen sections and the walls of the hopper are sealed as described. Consequently no substantial amount of the drying medium can pass about any edge of any supporting device and substantially all of the drying medium is thus forced to pass through the material on the supporting devices, due to the differential pressures created on opposite sides of the supporting devices by the suction apparatus which is connected with the lower portion of the housing.

The material is delivered to the uppermost supporting device through a chute or hopper 42 which is so arranged with relation to this uppermost supporting device that it will deliver the material onto the tiltable screens immediately after those screens have been restored to horizontal position. The material may be supplied to the hopper by any suitable means, as by a conveyor, not here shown. The material is discharged from the lowermost supporting device in the same manner as it is discharged from the upper supporting devices but instead of being delivered to another supporting device it is delivered to a chute 43 which delivers the same to a suitable point of discharge outside of the housing.

Suitable drain pans 44 are arranged within the housing beneath the respective supporting devices to receive the water or other liquid which drains from the material on those supporting devices. Each of these drain pans extends beneath the entire screen surface of the supporting device beneath which it is arranged with the exception of that point at which the screens are tilted, and the outer edges of the drain pans are spaced from the walls of the housing to permit the free passage of air about the same. Each drain pan has an inclined bottom and is connected at its lower part with a pipe 45 which extends to the exterior of the housing 10 and is there provided with a sediment trap 45 having a drain cock 47. The pipes 45 may discharge into the atmosphere or they may be connected with a suitable drain pipe, not here shown.

The drier may comprise any desired number of supporting devices, the number of such devices being usually determined by the character of the material which is to be dried and the number of drying operations which are necessary to thoroughly dry the same.

In the operation of the apparatus the several supporting devices are rotated and air caused to circulate through the housing. Material is supplied to the uppermost device through the hopper 42 and as the supporting device rotates to move the material slowly toward the point of discharge the air passes through the material and through the foraminous surface of the supporting device and the water drains from the material into the drain pan 44. As the supporting device rotates the several screen sections are brought successively into discharging position and there automatically tilted to discharge the material through the hopper 35 onto the next lower supporting device. The tilting of the screen turns the material to a sharply inclined position and as it passes from the tilted screen to the lower supporting device the parts thereof are mixed so that they will occupy relative positions on the lower supporting device different from those which they occupied on the upper supporting device. Each successive supporting device operates in the same manner to further dry the material and to discharge the same onto a succeeding supporting device. By the time the material reaches the point of discharge of the lowermost supporting device it has been thoroughly dried and is delivered to the chute 43 which conducts it to the exterior of the housing. The operation is continuous and automatic and the method of subjecting the material to successive drying operations, in each of which the water is drained from the material and the material partly dried and then thoroughly mixed as its passes to a succeeding operation, results in the very thorough drying of the material, and while the supporting devices are rotated at a slow speed, usually about two complete rotations a minute, the continuous oper-

ation enables relatively large quantities of material to be dried in a given time.

While I have described my method and one form of apparatus for performing the same I wish it to be understood that I do not desire to be limited to the details thereof as various modifications may occur to a person skilled in the art.

Having now fully described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a drier, a housing, a plurality of foraminous material supporting devices movably mounted in said housing at different levels, means for passing a gaseous drying medium through said foraminous supporting devices and the material supported thereon, means for actuating said supporting devices, each supporting device comprising a plurality of sections and each section being movable with relation to the other sections to discharge the material supported thereby, means for controlling the relative movements of said sections and causing the same to be successively actuated to discharge said material at a given point in the travel of said supporting device, and a chute arranged beneath the point of discharge of each supporting device to receive the material therefrom and deliver the same to the next lower supporting device, said chute having its upper edge so arranged about said point of discharge as to prevent the passage of said drying medium between the upper end of said chute and the adjacent supporting device.

2. In a drier, a housing, a plurality of material supporting devices rotatably mounted in said housing at different levels, each supporting device comprising a plurality of tiltable sections having foraminous bottoms, means for rotating said supporting devices, means for causing each section of each supporting device to tilt when it arrives at a predetermined point of discharge, the points of discharge of the several supporting devices being in staggered relation, a chute supported beneath the point of discharge of each supporting device and having its lower end adjacent to and beyond the point of discharge of the next lower supporting device, said lower end being normally closed by the material therein, means for circulating a gaseous drying medium from the upper portion of said housing to the lower portion thereof, said chute having its upper edges close to horizontal sections on opposite sides of said point of discharge to prevent the drying medium from passing about the tilted section to the exterior of said chute, and means to prevent the passage of said drying medium about the edges of said supporting devices, so that substantially all of said drying medium will pass through the material on said supporting devices.

3. In a drier, a housing a vertical shaft rotatably mounted in said housing, a plurality of radial shafts arranged about said vertical shaft and supported at their inner ends thereby, a sector-shaped screen mounted on each radial shaft for tilting movement about the axis of said shaft, a member carried by said housing and serving to retain said screens normally in horizontal positions, a portion of said member being cut away to permit said screens to successively tilt at a predetermined point in their travel, means arranged beneath the path of said screens to tilt one edge of each screen upwardly when it arrives at said point in its travel, and an inclined guide arranged above the path of said screens to engage the tilted screen and restore the same to its horizontal position.

4. In a drier, a housing, a plurality of foraminous material supporting devices movably mounted in said housing at different levels, means for passing a gaseous drying medium through said foraminous supporting devices and the material thereon, means for actuating said supporting devices, means for discharging material from each supporting device to a lower supporting device when said material has been moved a predetermined distance by said upper supporting device, and means for closing the spaces between said supporting devices and said housing and about said discharge means, whereby said drying medium is caused to pass through the material on said supporting devices.

5. In a drier, a housing, a plurality of foraminous material supporting devices movably mounted in said housing at different levels, means for passing a gaseous drying medium through said foraminous supporting devices and the material thereon, means for actuating said supporting devices, means for discharging material from each upper supporting device to a lower supporting device, means for closing the spaces between said housing and said supporting devices and about said discharging means to prevent said drying medium from passing about the edges of said supporting devices, and a drain pan beneath each supporting device to receive liquid therefrom, each drain pan being arranged to permit the flow of drying medium about the same and having an outlet leading to the exterior of said housing and provided with a seal to permit the escape of liquid from said pan but to prevent air from entering said housing through said outlet.

6. In a drier, a housing, a plurality of foraminous material supporting devices movably mounted in said housing at different levels, each supporting device comprising a plurality of tiltable sections, means for imparting movement to said supporting devices, means for causing each section of each supporting device to tilt when it arrives at a predetermined point in the travel of said device, the point at which the sections of each upper device are tilted being so arranged that the material on a tilted section will be discharged onto a lower supporting device, means for delivering a gaseous medium to said housing and subjecting the same to pressure on one side of each supporting device, and means for preventing said drying medium from passing between said supporting devices and said housing and from passing through the openings formed in said supporting devices by the tilting of said sections.

7. In a drier, a cylindrical housing, means for causing a gaseous drying medium to pass lengthwise through said housing, a vertical shaft rotatably mounted in said housing, a plurality of material supporting devices mounted about said shaft at different levels, each supporting device comprising a plurality of tiltable sections having foraminous bottoms, means for connecting the inner ends of said sections with said shaft and for preventing the passage of said drying medium between said shaft and said sections, sealing means bridging the space between the outer ends of said sections and the walls of said housing, means for causing each section of said supporting device to tilt at a predetermined point of discharge, the points of discharge of the several supporting devices being in staggered relation, and a chute arranged beneath the point of discharge of each supporting device and having its

lower end adjacent to and slightly beyond the point of discharge of the next lower supporting device, said chutes having parts arranged beneath and adjacent to the sections of the upper supporting devices which are on opposite sides of the tilted sections to prevent said drying medium from passing between said chutes and said upper supporting devices.

8. In a drier, a cylindrical housing, a vertical shaft rotatably mounted in said housing, a hub rigid with said shaft, an annular frame surrounding and spaced from said shaft, a plurality of radial shafts mounted at their respective ends in said hub and said frame and projecting outwardly beyond said frame, an annular track member carried by said housing and supporting the outer ends of said radial shafts, a plurality of sector shaped screens mounted on the respective radial shafts for tilting movement about the axes of said shafts, said track member having a part engaging each screen on opposite sides of its axis to hold the same normally in a horizontal position, said track member also having a portion cut away to permit said screens to tilt at a predetermined point in their travel, and an inclined guide extending above the cut away portion of said track to engage the tilted screens and restore the same to horizontal positions.

9. In a drier, a cylindrical housing, a vertical shaft rotatably mounted in said housing, a hub rigid with said shaft, an annular frame surrounding and spaced from said shaft, a plurality of radial shafts mounted at their respective ends in said hub and said frame and projecting outwardly beyond said frame, an annular track member carried by said housing and supporting the outer ends of said radial shafts, a plurality of sector shaped screens mounted on the respective radial shafts for tilting movement about the axes of said shafts, said track member having a part engaging each screen on opposite sides of its axis to hold the same normally in a horizontal position, said track member also having a portion cut away to permit said screens to tilt at a predetermined point in their travel, an annular sealing member extending inwardly from said housing and overhanging the outer end portions of said screens, said sealing member having a portion cut away adjacent to the cut away portion of said track to permit said screens to tilt, and a guide carried by said sealing member beyond said cut away portion thereof and extending upwardly and rearwardly to engage the screens and restore the same to their horizontal positions.

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