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Rainville et al.

[11] **3,793,742**

[45] **Feb. 26, 1974**

[54] **HOPPER DRYER FOR PARTICULATE MATERIAL**

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[73] Assignee: **Universal Dynamics Corporation**, Woodbridge, Va.

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[52] **U.S. Cl.** ..... **34/57 R**, 302/47, 222/195

[51] **Int. Cl.** **F26b 17/10**

[58] **Field of Search** .. 263/21 A; 34/10, 57 R, 57 A, 34/57 D, 57 E; 222/195, 200; 23/288 S; 302/45, 47, 53; 432/15, 58

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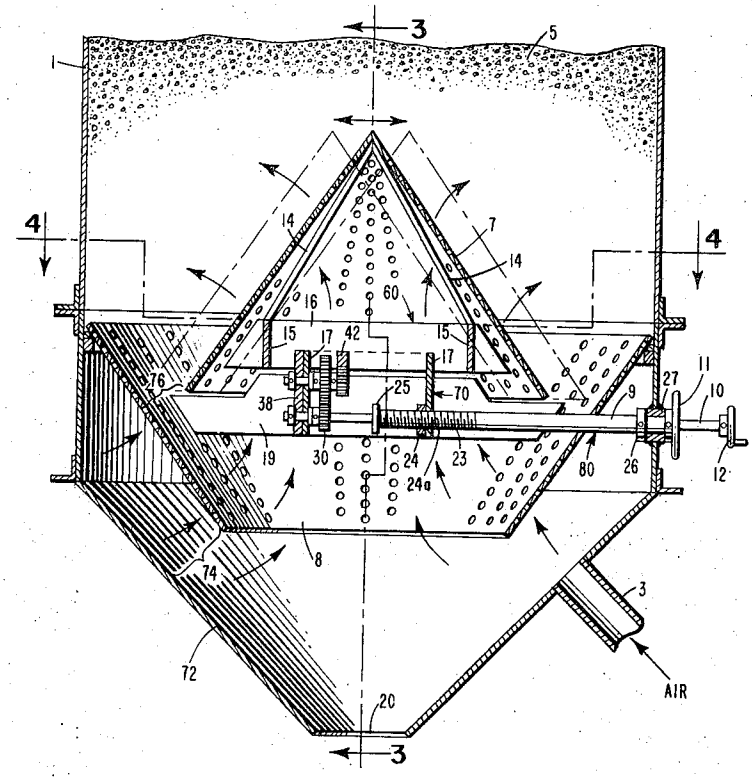
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Primary Examiner—William F. O'Dea
Assistant Examiner—William C. Anderson
Attorney, Agent, or Firm—William D. Stokes

[57] **ABSTRACT**

Improved drying apparatus is disclosed which maintains the even flow of material to be dried through a drying vessel in countercurrent flow to a drying gas and maintains the residence time of material in the vessel at a constant value. In prior art systems, material tends to accumulate along the periphery of the drying vessel. In accordance with the present invention, a moveable means is placed at the bottom of the drying vessel which effects a predetermined and selectable spatial non-uniformity in the flow of material through the hopper body. The improved apparatus has the effect of preventing peripheral accumulation of the material or "hilling" in the dryer to the end that there is uniform flow and drying of the material passing therethrough.

30 Claims, 10 Drawing Figures



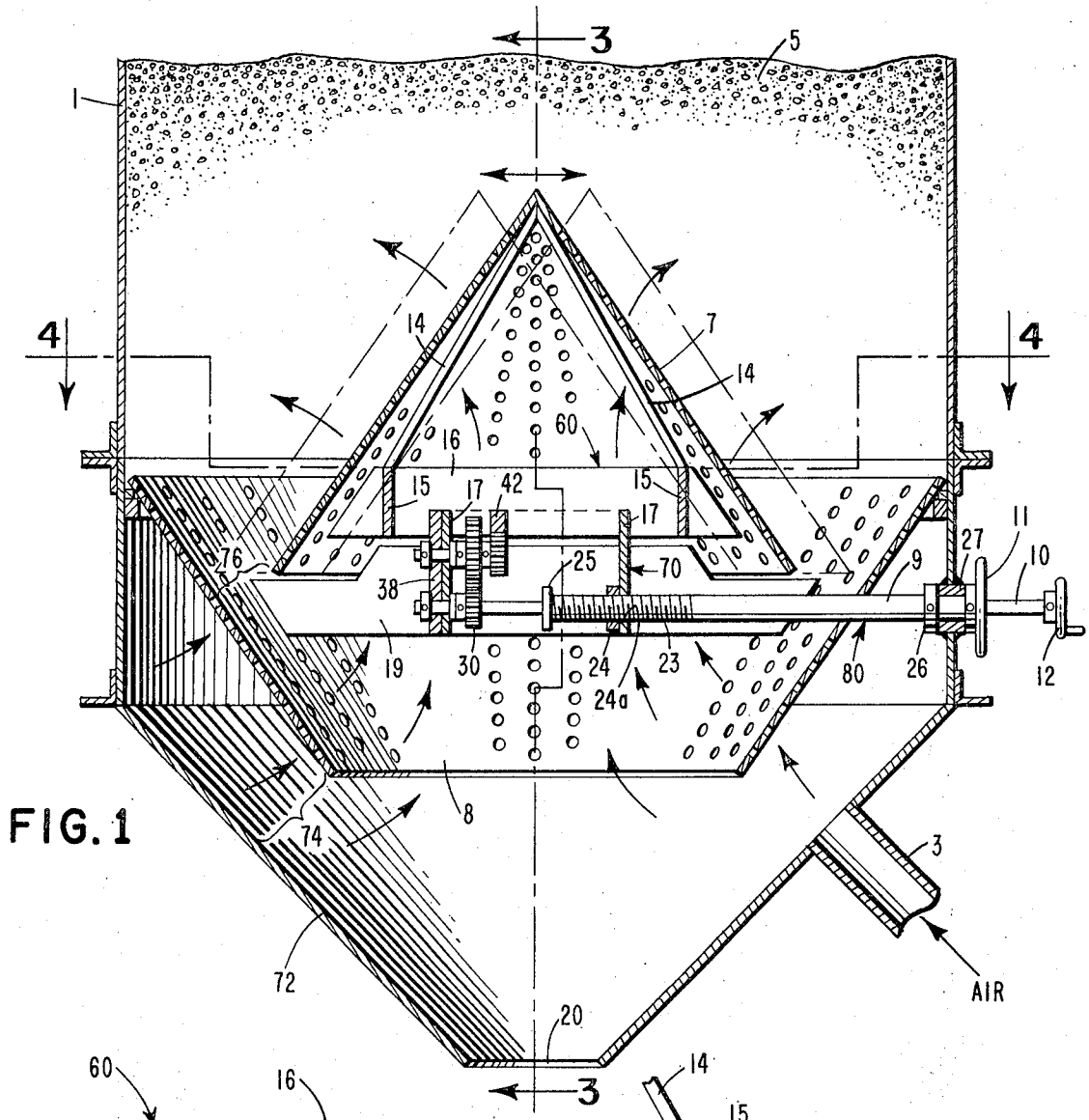

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FIG. 1

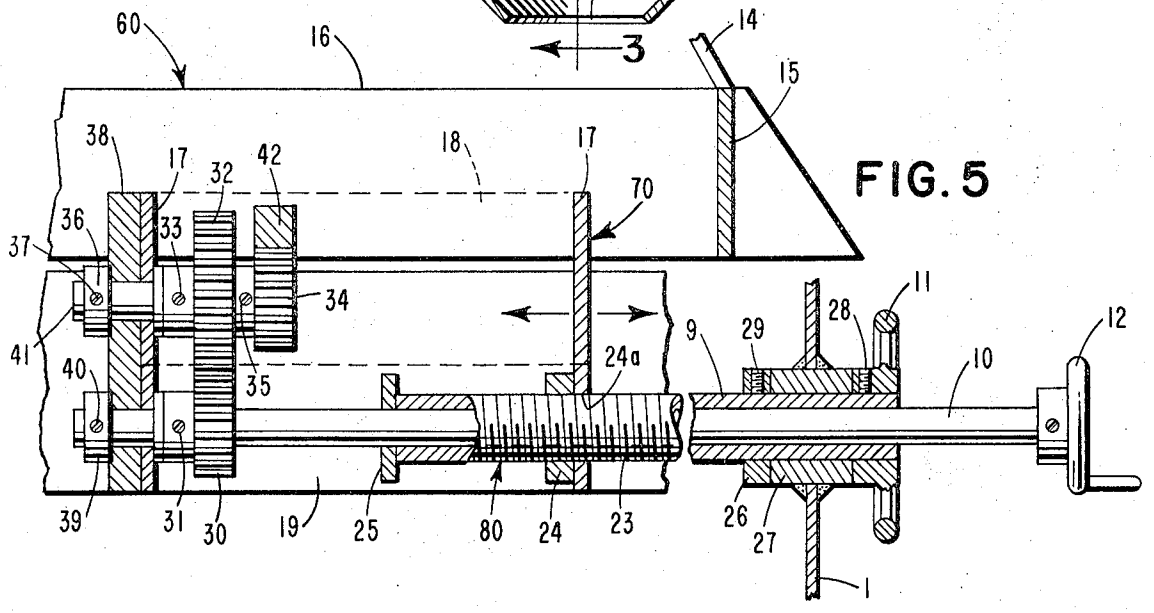
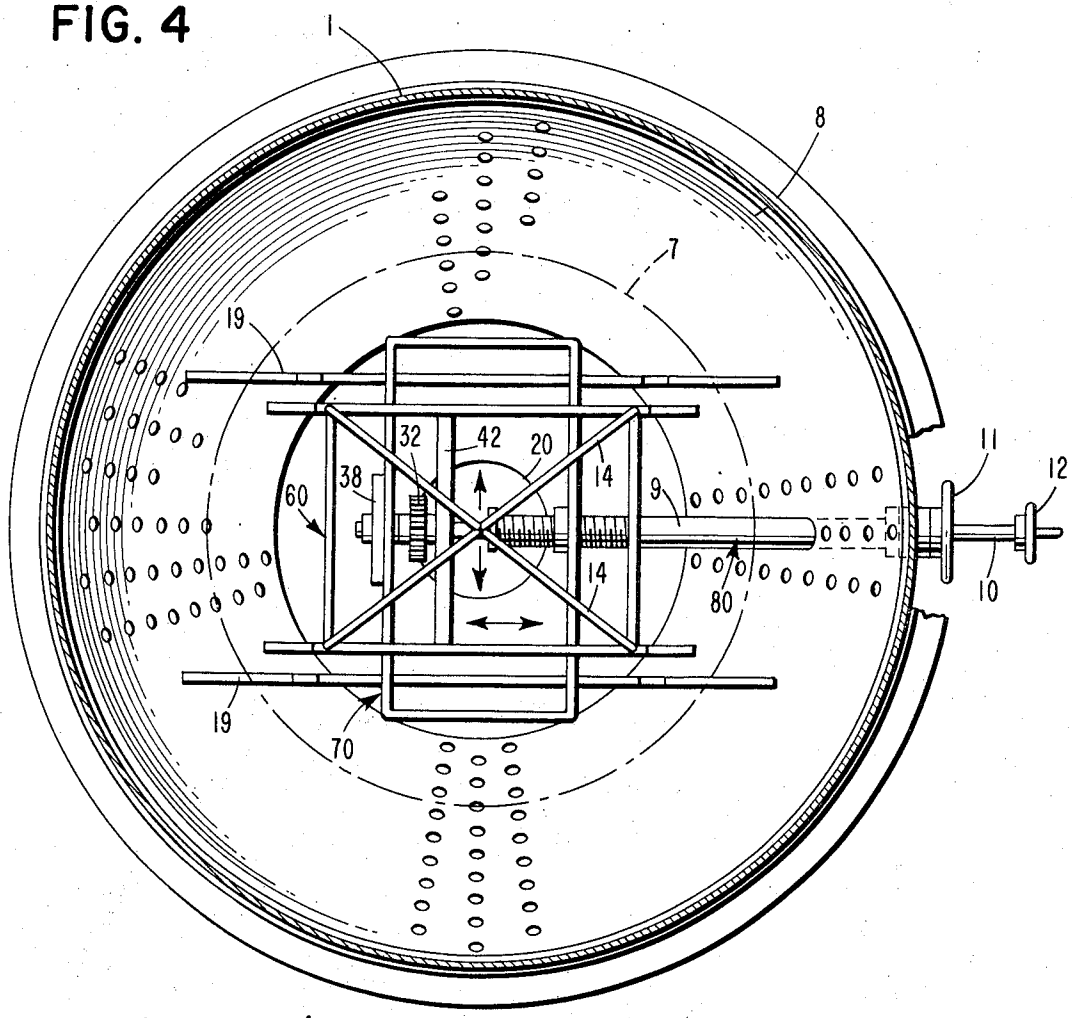

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FIG. 5

FIG. 4



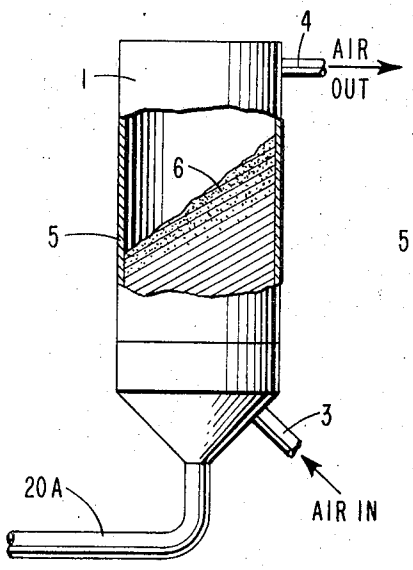


FIG. 2A

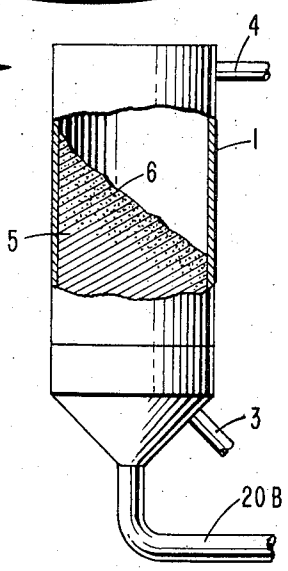


FIG. 2B

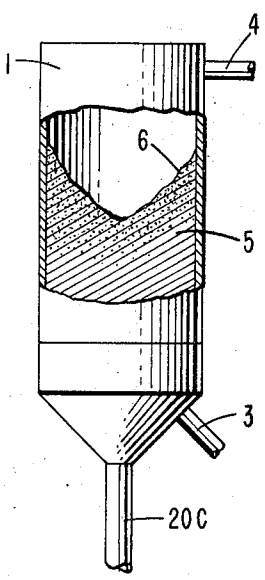


FIG. 2C

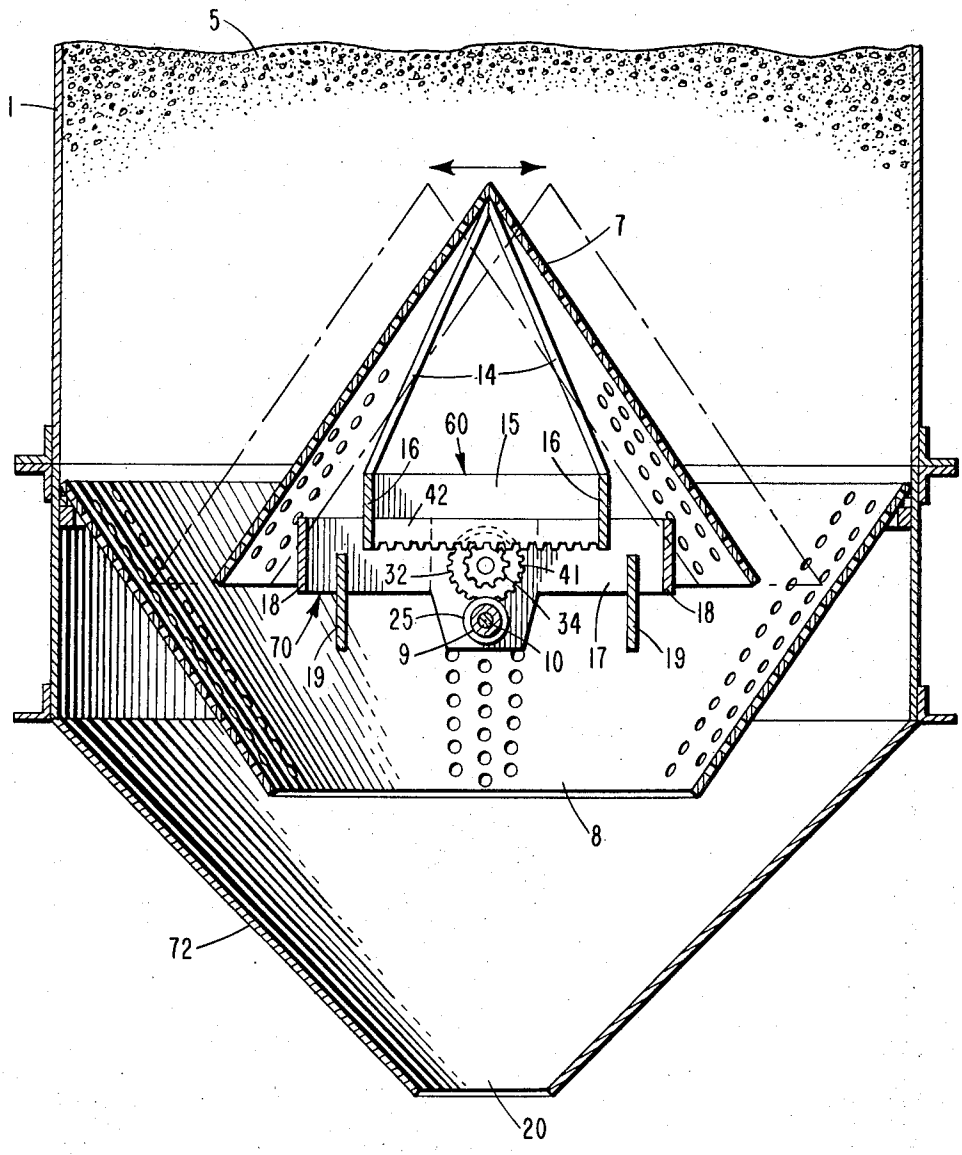


FIG. 3

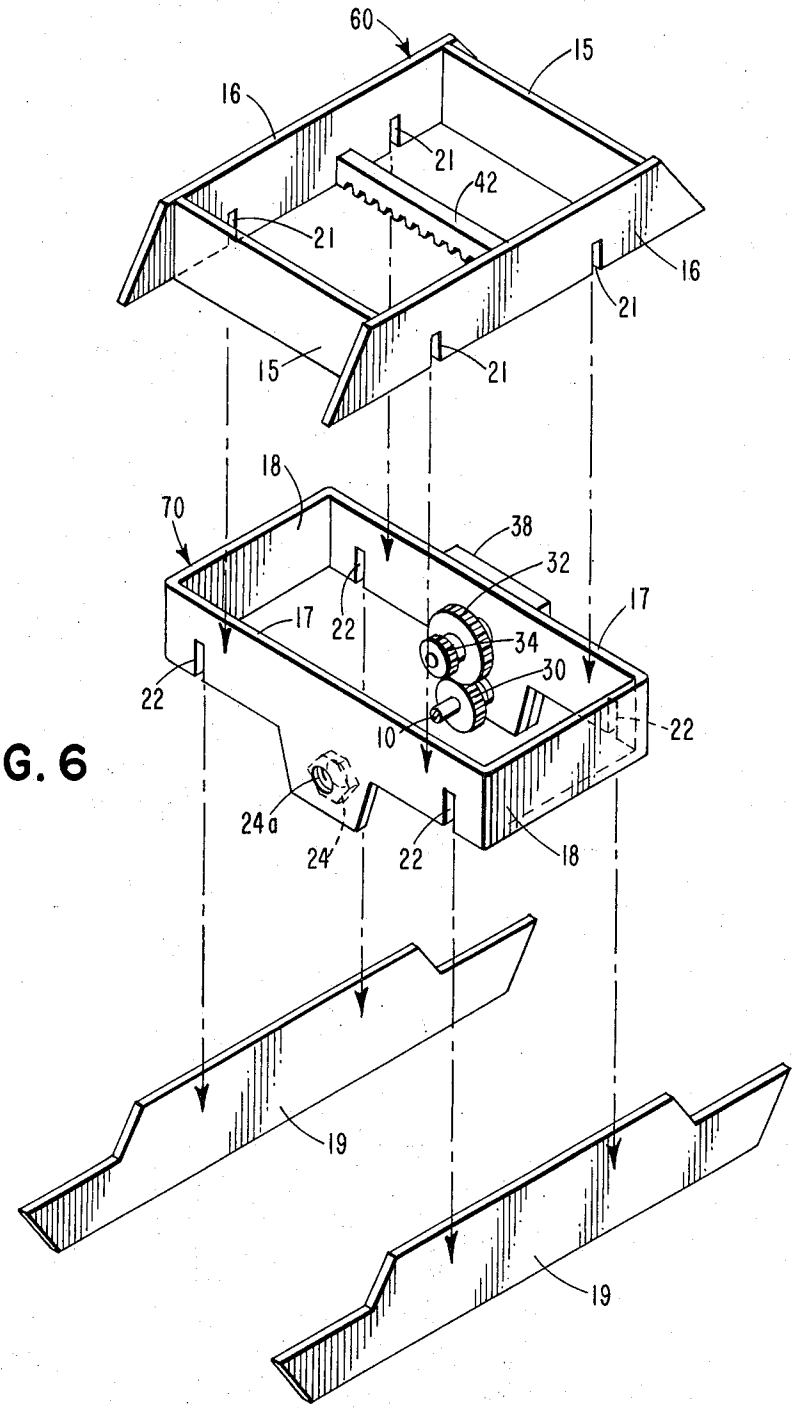
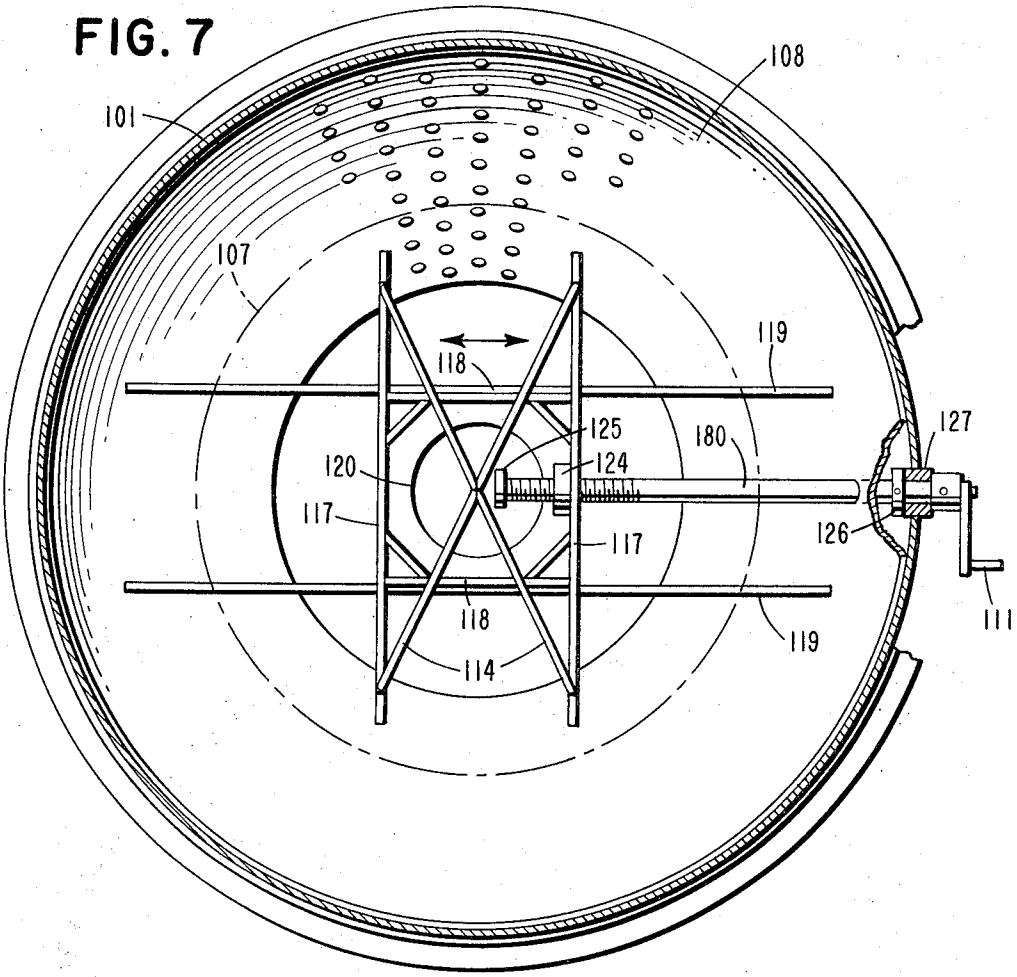

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FIG. 6

FIG. 7


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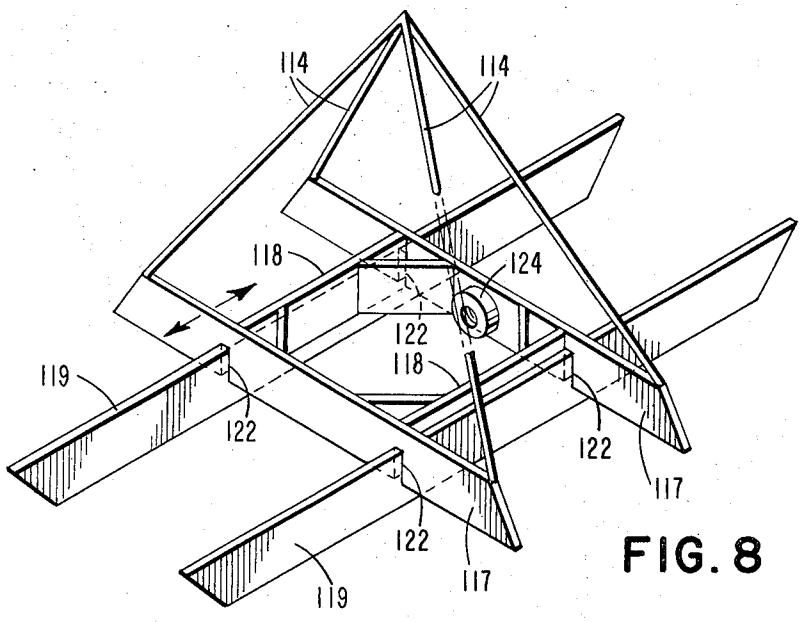

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FIG. 8

HOPPER DRYER FOR PARTICULATE MATERIAL

The present invention relates to an improved apparatus for drying particulate material. More specifically, the invention is concerned with an improved drying apparatus which provides uniform flow of material through the dryer. In particular, the invention is concerned with a dryer for heat-sensitive particulate material where it is relatively critical to control the residence time of the material in the dryer.

A great many industrial processes require the drying of heat-sensitive particulate material. In general, the drying techniques employed involve the use of a heated gas in contact with the wet material. In the known techniques, the heated gas is usually introduced at the bottom of the vessel in countercurrent flow relationship to the moist material introduced at the top of the vessel. In such apparatuses a deflecting baffle member is usually provided adjacent the bottom of the vessel through which the drying gas is passed to disperse the material for maximum drying.

In theory, the flow of the material passing downwardly through the dryer and out the bottom thereof should be uniform, and contact with the countercurrently flowing heated gas should be uniform. In other words, the residence time of the particles within the dryer should be the same. In order that it be uniformly dried, the particulate material must be in contact with the drying gas for a fixed period of time. This can only be achieved by a uniform residence time in the drying vessel. While the above described dryer is probably the principal drying apparatus used in industry today for particulate material, such dryers have not been able, until the present invention, to uniformly dry particulate material. In fact, where such apparatus has been used to dry heat-sensitive plastic material, the material is often unsuitable for the intended use due to the inability to achieve a uniform residence time and hence degree of drying.

It was discovered that, notwithstanding a constant loading of the hopper and a constant take-off of the material, the material accumulates or congregates on the periphery of the dryer. The result of this is that the residence time of the particles varies over a wide range to the end that the drying is extremely non-uniform. It was unexpectedly discovered that the accumulation of material in the dryer is solely dependent upon the direction of flow of the "dried" material after it leaves the drying vessel. This is so even where the material outlet pipe and the material flows downwardly from the dryer outlet. This accumulation phenomena occurs in substantially all of the known dryers of the type described. Where the material outlet is directed downwardly the material congregates collecting evenly along the outer walls of the dryer. Where the material outlet conduit is turned so that the material flows from the dryer at an angle, the material within the drying vessel will accumulate or congregate on a portion of the outer peripheral walls, the portion of the walls dependent solely upon the direction of flow of the material through the outlet pipe. In other words, in the known countercurrent flow drying devices the material to be dried will accumulate, congregate, or "hill" in the dryer allowing the more recently introduced moist material to pass through the dryer undried while the drier material remains in the vessel. This "hilling" on one side or all sides of the dryer reduces the effective size

of the dryer and the residence time of the material in the dryer, thus reducing the maximum rate at which material can be dried.

In accordance with the invention an improved drying apparatus is provided which successfully overcomes the disadvantages of the known devices by preventing accumulation of material to be dried. A perforated baffle element is disposed at the bottom of a hopper dryer. This perforated element, along with a truncated element which is also perforated defines an annular gap for the passage of material. Air is introduced at the bottom of hopper and passes through the perforated elements and comes into contact with the material to be dried. Spatial unevenness in the flow of material to the hopper is compensated for by moving the baffle element relative to the truncated element, thus favoring that the flow of material in a given sector of the hopper. In this manner, accumulations in any given part of the hopper can be eliminated. Thus an improved drying apparatus is provided which has increased efficiency due to the fact that material is caused to flow evenly through the hopper. The tendency of material to accumulate on the periphery of the hopper-dryer is eliminated thus resulting in the presence in all parts of the hopper of particulate material, which can beneficially employ the drying action of the circulating warm air. This is in contrast with prior art systems where the airstreams circulating along the periphery come into contact with only dried material, and results in increased efficiency because airstreams circulating along the sidewalls of the hopper-dryer come into contact with and dry undried material. For the preferred embodiment the perforated baffle element is a cone and the truncated element is a truncated cone. The description hereinafter will be with respect to such conically shaped means.

Uniform flow of particulate material through the hopper-dryer is achieved by providing the hopper-dryer with a moveable cone means at its base. The cone can move in all directions from its center position and by moving it away from a wall where material is accumulating, the accumulation can be halted and reduced. Thus, the tendency of the undried materials to flow through a restricted channel in the hopper-dryer is effectively eliminated, and complete use of the dryer is achieved. Alternatively, the cone can be moved only along a defined line and due to the predictable nature of the accumulation, this action alone can be effective to halt accumulation.

It is the principle object of this invention to provide a novel hopper apparatus for feeding material and insuring uniformity fo the residence time of material in the hopper.

Another object of this invention is to provide an apparatus which promotes efficient drying of particulate material in hopper-dryers through the use of a movable cone which prevents accumulations of material against the sidewalls of the hopper-dryer.

A further object of the present invention is to provide a hopper-dryer capable of increased output.

These and other objects and features of this invention will appear more fully from the following specification, claims, and the accompanying drawings wherein:

FIG. 1 is a sectional view depicting a drying apparatus in accordance with this invention;

FIGS. 2A, 2B, and 2C are schmatic illustrations in prior art apparatus of the problems sought to be eliminated by the present invention;

FIG. 3 is a sectional view of the drying apparatus of the present invention taken along line 3—3 in FIG. 1;

FIG. 4 is a sectional view of the apparatus of the present invention taken along line 4—4 in FIG. 1;

FIG. 5 is a detail partially in section of the cone-moving gear structure of the present invention;

FIG. 6 is an exploded view of the moveable frame structure which supports the cone;

FIG. 7 is a sectional view of an alternate embodiment of the present invention; and

FIG. 8 is a view of the cone moving support structure of the alternate embodiment of FIG. 7.

Now referring specifically to the drawings wherein like numerals denote like parts and particularly to FIGS. 2A, 2B and 2C, we note an illustration of the problem sought to be solved by the apparatus of the present invention. Material is accumulated in the main body of the hopper-dryer 1 and, as it is drawn from the dryer through pipe 2, "hilling" begins to occur thus defining a slope 6. Drying is accomplished through the introduction of air through duct 3. Air is withdrawn from the dryer through duct 4. As can be seen from the several representations in FIG. 2, "hilling" can occur in several ways dependent upon the path followed by outlet conduit 20A, 20B or 20C. The condition in all of these cases can be alleviated by the apparatus of the present invention.

Referring to FIG. 1 and FIGS. 3 through 6 we will now describe the operation of a hopper-dryer constructed in accordance with the present invention. Undried material 5 is caused to accumulate inside the body 1 of the dryer. Hot air in introduced through the conical wall bottom of hopper 1 at an angle from pipe 3, thus setting up a vortex in the bottom of the dryer. The hot air then proceeds up through the perforated truncated cone 8 and the perforated cone 7. Element 8 is located just above the bottom conical wall 72 of the hopper, and is spaced therefrom to form an annulus 74. As the hot air travels up through the particulate material 5, moisture is removed. After the air has gone through the material and performed its drying function, it can either be allowed to escape through the top of the hopper-dryer or may be removed by a pipe 4 seen in FIGS. 2A, 2B and 2C.

After being dried the particulate material passes through the annular gap between cone 7 and perforated element 8 to orifice 20 where it is discharged for use. Perforated cone 7 is supported by legs 14 which are rigidly secured to a top moveable frame 60 composed of perpendicular end walls 15 and transverse sidewalls 16. Transverse sidewalls 16 have slots 21 which allow them to rest on perpendicular walls 17 of intermediate moveable frame 70, which besides furnishing support also serve the purpose of functioning as guiderails for the reciprocal motion of frame 60 in a direction perpendicular to transverse elements 19 which support frame 70.

The bottom of cone 7 is of a smaller diameter than the diameter of conical element 8, in the plane of the bottom diameter. Thus, when cone 7 is centered in hopper 1, there is formed an annulus 76 for the passage of dried particulate material.

The frame 70 made up of transverse elements 18 and perpendicular elements 17 forms a support as well as a guide track for frame 60, composed of transverse walls 16 and perpendicular walls 15. Perpendicular walls 17 have slots 22 which mate with a pair of transverse elements 19 which serve as guiderails as well as support for the frame 70. Transverse elements 19 are secured to truncated cone 8. When it is desired to achieve displacement of the cone 7 in a direction parallel to guiderails 19, sleeve 9 is rotated by wheel 11. Sleeve 9 is threaded at 23 for a short distance from its end. These threads communicate with nut 24 which is welded to wall 17 in alignment with a hole 24*a* in wall 17. Thus, as wheel 11 is rotated, rotating sleeve 9, the frame is displaced transversely in a direction parallel with guiderails 19. As the frame 70 is displaced, so also is the frame 60. This in turn causes transverse displacement of the four supporting rods 14 and the cone 7 which they support.

At the threaded end of sleeve 9, a stop 25 is secured to insure that, during operation, the apparatus is not turned out of nut 24. Sleeve 9 is journaled in hopper wall 1, in a short sleeve 27 welded in said wall. In order to prohibit relative movement between the sleeve 9 and the outer wall of the hopper-dryer 1, both hand wheel 11 and collar 26 are secured on opposite sides of sleeve 27 to sleeve 9 by set screws 28 and 29 respectively. Sleeve 27 is welded to the outer wall of the dryer.

Displacment of the cone 7 in a direction perpendicular to guiderails 19 is accomplished by the rotation of crank 12. Crank 12 is secured to shaft 10, which turns inside sleeve 9. Gear 30 is secured by set screw 31 to shaft 10 and is thus caused to rotate along with it. Shaft 10 is journaled in the other wall 17 of frame 70. This wall 17 is reinforced by a plate 38 welded thereto. Collar 39 is secured to the end of shaft 10 by set screw 40. Mounted above shaft 10, in wall 17 and reinforcing plate 38, is a stub shaft 41. Gear 32 is secured to shaft 41 by set screw 33. Gear 32 along with collar 36 which is secured to shaft 41 by set screw 37 both serve to maintain the alignment of gears 32 and 34 with the remainder of the displacement gear mechanism. Gear 34 is secured to shaft 41 by set screw 35 and meshes with rack 42. Rack 42 is secured on its ends to walls 16 of frame 60. Thus, when crank 12 is rotated, shaft 10, which is slideably mounted inside sleeve 9, also rotates thus resulting in angular displacement of gear 30. This gear communicates with gear 32 thus resulting in angular displacementof rod 41 which is rotatably mounted. As shaft 41 rotates, gear 34 also rotates and, as it communicates with rack 42 it causes displacement of the rack perpendicular to guiderails 19. This rack is welded to walls 16 of the frame 60.

Turning hand wheel 11 and crank 12 together various numbers of turns and in various directions results in the movement of cone 7 to any desired point within conical element 8.

In operation of a dryer constructed in accordance with the present invention, the cone 7 would be moved transversely and perpendicularly until it is in a position directly opposite the point of accumulation which one desires to eliminate. This positioning presents a larger gap at the point of accumulation between cone 7 and conical element 8, allowing material to flow out faster in that area. In practical operation, this is most easily done after unloading of the dryer has begun and a portion of the material has been allowed to flow from the dryer. If, as illulstrated in FIG. 2C, accumulations have formed on all sides of the dryer one would simply dis-

place the cone first in one direction and then another and then perhaps even another direction until the accumulation is gone.

In order that an operator may determine exactly where cone 7 should be placed, suitable observation ports or windows or suitable indicators outside the hopper-dryer may be provided.

As noted above, if the material is removed from the dryer by a pipe which extends radially outward from the center of the dryer, accumulation will only occur along the line defined by the pipe. Hence, it would only be necessary for the cone to move back and forth along a single line of motion or with a single degree of freedom. Referring to FIGS. 7 and 8, we see an apparatus capable of such limited movement. This apparatus would be very simple and inexpensive to manufacture and operate.

In accordance with this embodiment in the invention, if one had a "hilling" problem as illustrated in FIG. 2A, one would construct the apparatus so that movement of the cone along the line defined by pipe **20***a* could be achieved. In this embodiment of the apparatus, the cone **107**, with truncated cone **108** in the main hopper body **101**, defines an annular gap for the passage of material. The cone **107** is supported by legs **114** which rest on frame **170**. Frame **170** is composed of perpendicular elements **117** and transverse elements **118**. There are two slots **122** in each perpendicular element **117**. Track elements **119** fit into these slots and thus provide support for the frame **170** and the cone **107** supported by support elements **114**. Frame **170** is moved back and forth along tracks **119** by the rotation of rod **180**. Rod **180** is threaded at one end and these threads mesh with nut **124** which is secured to the frame **170**. Rod **180** is rotated by crank **111** which also, in conjunction with sleeve **126**, which is secured to rod **180** prevents rod **180** from sliding back and forth. Rod **180** extends into the body of the hopper through sleeve **127** in which it is allowed to freely rotate.

Many modifications obvious to those skilled in the art may be made upon the system and apparatus of this invention without deviating from the scope and intent of the invention. Accordingly, the invention is not limited to the embodiment described above and shown in the drawings but by the following in which,

I claim:

1. Apparatus comprising:

a. a hopper having an inlet in the upper region thereof for introduction of particulate material and an outlet at the bottom thereof for the removal of said particulate material; and

b. selectively positionable moveable means in said hopper disposed in the path of said material for eliminating variations in the residence time of said material passing through said hopper.

2. Apparatus as in claim **1** wherein said moveable means effects a predetermined selectable spatial non-uniformity in the flow of material through said hopper body.

3. Apparatus as in claim **1** wherein said moveable means has at least one degree of freedom in its movement.

4. Apparatus as in claim **1** wherein said moveable means has at least two degrees of freedom in its movement.

5. Apparatus as in claim **4** wherein said two degrees of freedom in movement are each linear and define a plane perpendicular to the vertical center line of the hopper.

6. Apparatus as in claim **1** wherein said moveable means comprises a cone.

7. Apparatus as in claim **6** further comprising a truncated cone positioned around said cone.

8. Apparatus as in claim **7** wherein said cone and said truncated cone define an annular gap for the passage of material.

9. Apparatus as defined in claim **4** wherein the moveable means remains in its selected position until selectively repositioned.

10. Apparatus as in claim **8** further comprising means for drying the material in said hopper.

11. Apparatus as in claim **10** wherein said means for drying the material in said hopper comprises means for introducing hot air into and through the hopper.

12. Apparatus as in claim **10** wherein said cone is perforated.

13. Apparatus as in claim **7** wherein said truncated cone is perforated.

14. Apparatus as in claim **13** wherein said cone is perforated.

15. Apparatus as in claim **3** wherein said moveable means is selectively positioned by a threaded element which communicates with said moveable means.

16. Apparatus as in claim **3** further comprising rack and pinion means for selectively positioning said moveable means.

17. Apparatus as in claim **4** wherein said moveable means is moved by a threaded element which communicates with said moveable means and additional means for achieving said second degree of freedom.

18. Apparatus as in claim **17** wherein said additional means is a rack and pinion.

19. A dryer comprising:

a. a hopper having an inlet in the upper region thereof for the introduction of particulate material and an outlet at the bottom thereof for the removal of said particulate material;

b. selectively positionable moveable means in said hopper disposed in the path of said material for selectively eliminating variations in the residence time of said material passing through said hopper; and

c. drying means for introducing hot air into and through the hopper for drying material in the hopper.

20. Apparatus as in claim **19** wherein said moveable means effects a predetermined selectable spatial non-uniformity in the flow of material through said hopper body.

21. Apparatus as in claim **19** wherein said moveable means has at least one degree of freedom in its movement.

22. Apparatus as in claim **19** wherein said moveable means has at least two degrees of freedom in its movement.

23. Apparatus as in claim **22** wherein said two degrees of freedom in movement are each linear and define a plane perpendicular to the vertical center line of the hopper.

24. Apparatus as in claim **19** wherein said moveable means comprises a cone.

25. Apparatus as in claim **24** further comprising a truncated cone positioned around said cone.

26. Apparatus as in claim 25 wherein said cone and said truncated cone define an annular gap for the passage of material.

27. Apparatus as in claim 22 wherein the moveable means remains in its selected position until selectively repositioned.

28. Apparatus as in claim 21 wherein said moveable means is selectively positioned by a threaded element which communicates with said moveable means.

29. Apparatus as in claim 21 further comprising rack and pinion means for moving said moveable means.

30. Apparatus as in claim 22 wherein said moveable means is moved by a threaded element which communicates with said moveable means and additional means for achieving said second degree of freedom.

* * * * *