

[54] **APPARATUS FOR DRYING GRAIN**

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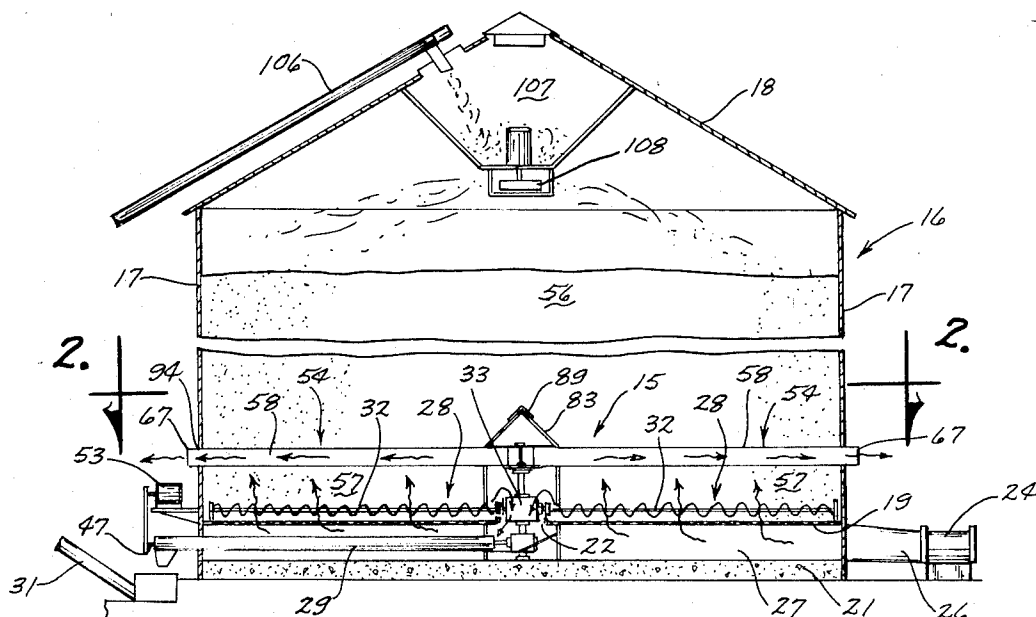
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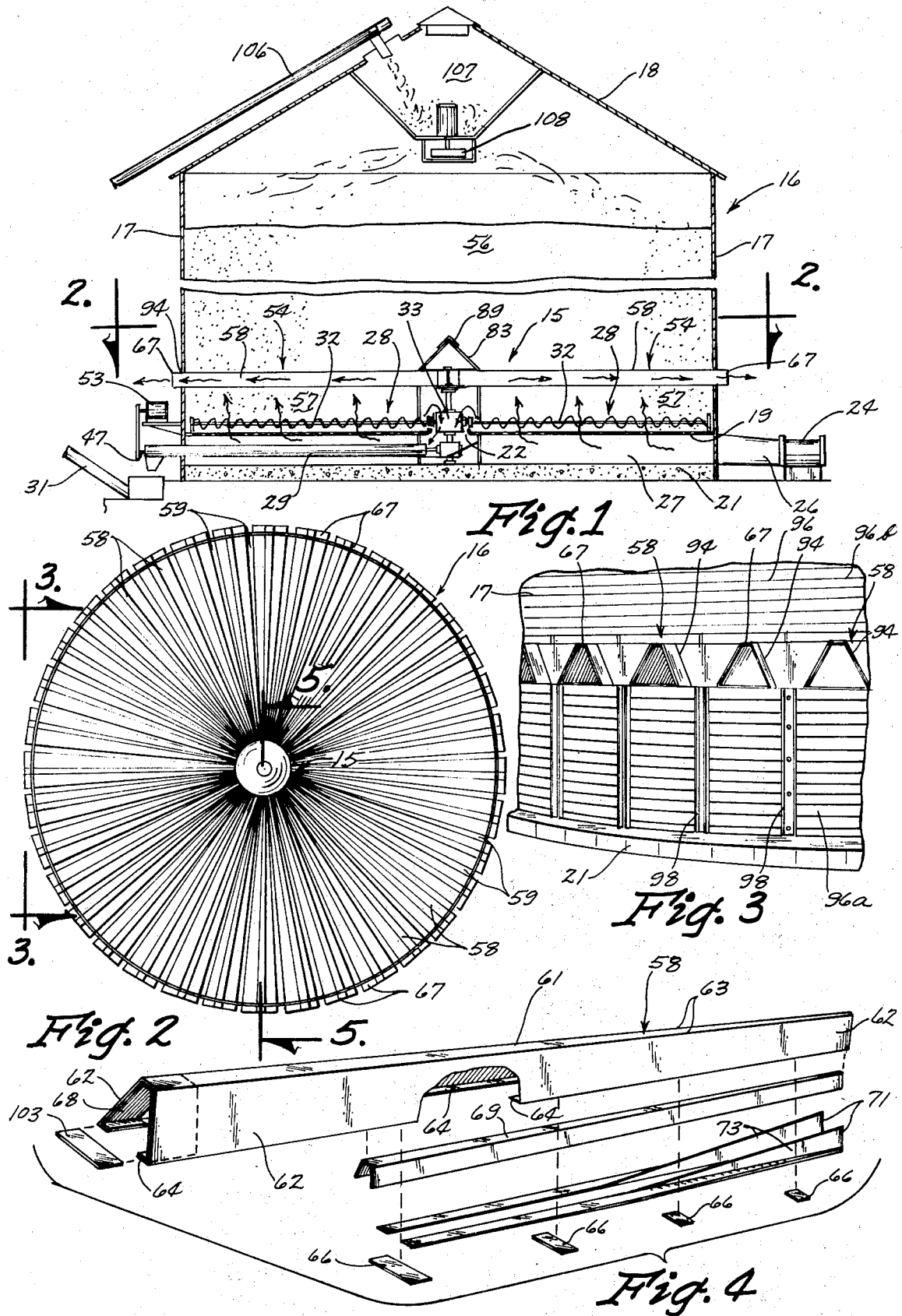
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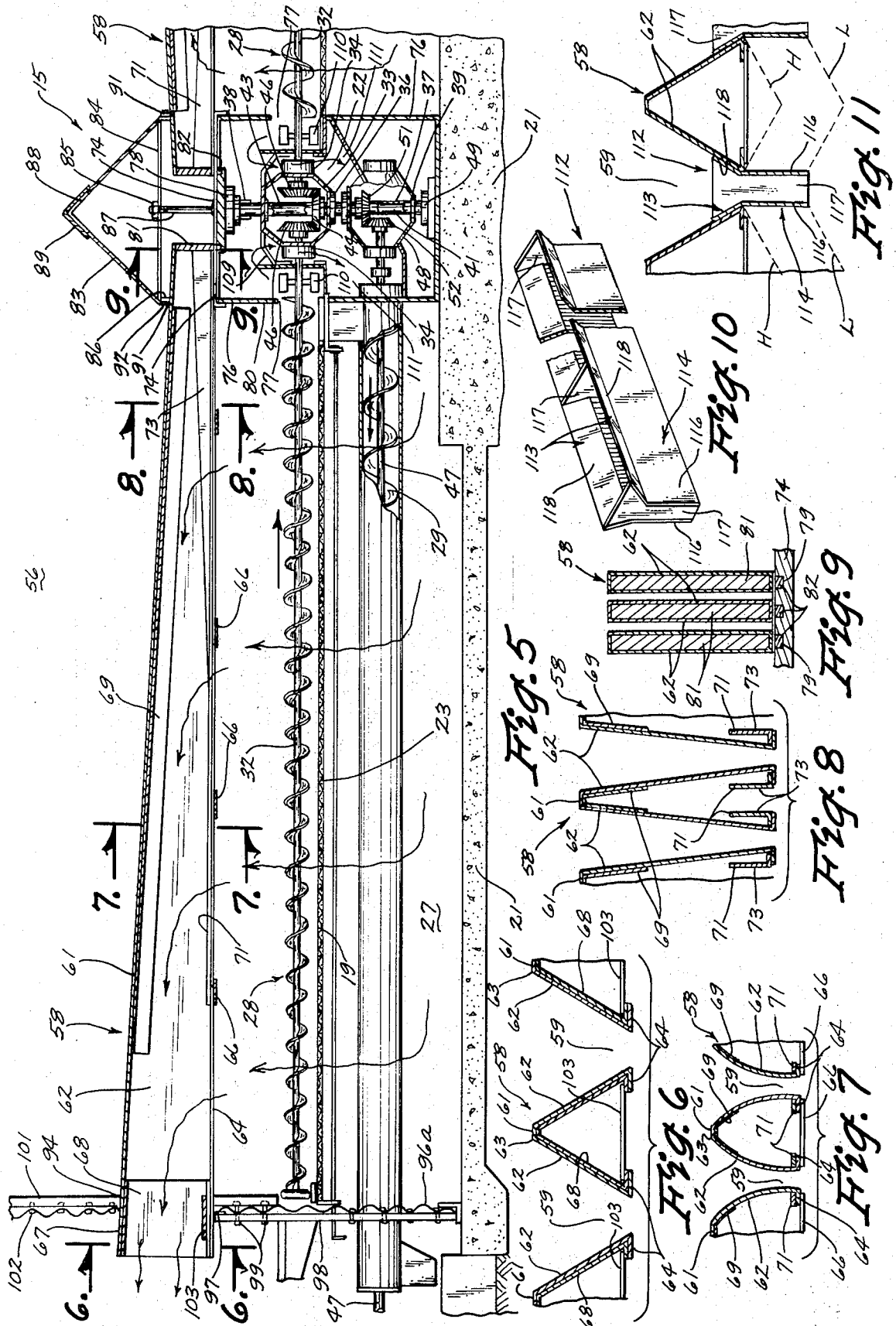
[57] **ABSTRACT**

The method and apparatus provides a continuous counterflow grain drying system for a round bin. An air duct assembly positioned transversely of and over the cross-sectional area of the bin functions as a partition to form an upper wet grain supply chamber and a lower grain drying chamber. The duct assembly is comprised of a plurality of radially extended duct members having open lower sides and circumferentially spaced so as to form grain passages, between adjacent duct members, interconnecting the upper wet grain supply chamber and the lower grain drying chamber. Heated air from the bin floor moves continuously upwardly through the lower drying chamber for discharge to the atmosphere through the duct members, concurrently with a uniform continuous downward flow of grain from the wet grain supply chamber into the lower grain drying chamber and a continuous and uniform removal of dried grain from the bin floor.

3 Claims, 11 Drawing Figures







APPARATUS FOR DRYING GRAIN

SUMMARY OF THE INVENTION

The grain drying apparatus of the invention provides for the continuous and efficient uniform counterflow drying of grain in a round storage bin. The lower grain drying chamber is of a depth relative to the volume rate of heated air flow such that the air, on approaching or reaching a saturated condition, is discharged from the duct assembly. A uniform removal of grain from the bin floor takes place at a volume rate substantially equal to the volume rate of flow of wet grain from the wet grain supply chamber into the lower grain drying chamber so as to provide a constant depth of grain in the drying chamber. The grain depth may be varied to accommodate variations in the supply of heated air and rate of grain flow, and the grain passages are of a size relative to the air exhaust passages to provide a reduced resistance to the air flowing through the grain drying chamber. With drying air continuously and uniformly flowing upwardly in the grain drying chamber counter to a continuously uniform downward flow of wet grain to be dried, the time period of grain drying is substantially constant so that the grain removed from the lower chamber is uniformly dried to a predetermined optimum moisture content.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical sectional view of a circular grain storage bin showing the grain drying apparatus of this invention in assembly relation therewith;

FIG. 2 is a sectional view taken on the line 2—2 in FIG. 1 showing in top plan an air duct assembly that forms part of the grain drying apparatus of this invention;

FIG. 3 is a detail elevational view as seen along lines 3—3 in FIG. 2;

FIG. 4 is an exploded perspective view of an air duct member that forms part of the air duct assembly;

FIG. 5 is an enlarged foreshortened longitudinal sectional view of the grain drying apparatus with some parts broken away to more clearly show its construction;

FIGS. 6, 7, 8 and 9 are enlarged sectional detail views, drawn to different scales, taken respectively on the lines 6—6, 7—7, 8—8 and 9—9 in FIG. 5;

FIG. 10 is a foreshortened perspective view of an insert for vertically extending a grain passage in the air duct assembly; and

FIG. 11 is illustrated similarly to FIG. 6 and shows the insert of FIG. 10 positioned in a grain passage.

DETAILED DESCRIPTION OF THE INVENTION

With reference to the drawings, the grain drying apparatus of this invention, indicated generally as 15, is shown in FIG. 1 in assembly relation with a circular grain storage bin 16 having a sidewall 17, a roof structure 18 and a false bottom wall or floor 19 spaced above a bin foundation 21. The floor is formed with a central opening 22 and is perforated, as indicated as 23, to provide for ventilation upwardly therethrough of either atmospheric or heated air. For the supply of heated air there is provided a heater unit 24 having an outlet 26 open to the space 27 which is formed between the bin floor 19 and the foundation 21.

A pair of radially extended sweep augers 28 arranged in axial alignment are rotatably mounted within the bin immediately adjacent to the floor 19. Each auger 28 is adapted to be rotated about its own axis and also to travel angularly over the floor in a horizontal plane to remove during each revolution thereof about the bin a uniform layer of grain from above the floor. The grain removed by the sweep augers 28 is delivered through the central opening 22 to a radially extended unloading auger 29 that is located in the space 27 and is operable to move the grain exteriorly of the bin 16 and into the hopper of a conveying auger shown generally at 31.

As shown in FIG. 5, a sweep auger 28 includes a shaft 32 having an inner end located within a gear housing 33 and rotatably supported in the bearing 34. The housing 33 is positioned above the bin floor 19 and is rotatably carried at 36 on a vertical drive sleeve 37 which has an axis coincident with the vertical axis of the grain bin 16 and in turn of the floor central opening 22. The sleeve 37 is mounted on upper and lower bearings 38 and 39, respectively, for rotation about a stationary vertical column or supporting post 41, the lower end of which is supported on the foundation 21 while its upper end 43 projects upwardly from the gear housing 33. A bevel gear 44 carried on the rotatable drive sleeve 37 within the housing 33 is engageable with a pair of beveled gears 46 that are mounted on and correspond to the sweep auger shafts 32.

The unloading auger 29 has the inner end of its shaft 47 projected within a gear housing 48 which is located below the bin floor 19. The housing 48 is rotatably carried at 49 on the drive sleeve 37 which, within the housing 48, carries a bevel gear 51 in meshed engagement with a bevel gear 52 mounted on the inner end of the auger shaft 47. On rotation of the auger shaft 47 the sleeve 37 is rotated to provide for the rotation of the sweep augers 28 about their respective axes. Rotation of the sweep augers 28 across the bin floor 19 is accomplished by the torque reaction effected by the bevel gear assembly within the gear housing 33. The unloader auger 29, as illustrated in FIG. 1, may be driven by an electric motor 53 located outside of the bin 16.

To remove a bottom layer of grain of a uniform thickness from the area adjacent the bin floor 19, a sweep auger 28 must be of a construction capable of transferring inwardly, from any given point along its length, all of the grain picked up by the auger portion extended outwardly from such point plus the grain gathered by that portion of the auger extended inwardly from such point. In other words, any given axial section of a sweep auger 28 should have a grain carrying capacity or volume that is sufficient to receive all of the grain being moved by the next adjacent axial section outwardly therefrom plus the volume of grain that is to be gathered and moved by the given axial section. For a detailed description of the construction and operation of the sweep augers 28, reference is made to Charles C. Shivers U.S. Pat. No. 3,563,399.

The bin 16 (FIG. 1) is divided or partitioned by an air duct assembly 54 into an upper or wet grain supply chamber 56 and a lower or grain drying chamber 57. The air duct assembly 54 is positioned horizontally of the bin and above the bin floor so as to be spaced upwardly from the sweep augers 28. For a purpose to appear later the grain drying chamber 57, which has end walls defined by the bin floor 19 and air duct assembly 54 is of an appreciably smaller volume than the wet

grain supply chamber 56, the end walls of which are defined by the air duct assembly 54 and the bin roof structure 18.

The duct assembly 54 (FIG. 5) is comprised of a plurality of elongated duct units 58, each of which is of a generally inverted V-shape in cross section, as shown in FIG. 6. The duct units or members are arranged radially of the bin 16 in a circumferentially spaced relation (FIG. 2) so as to form between adjacent duct units elongated radially extended grain passages 59 for interconnecting the wet grain supply chamber 56 and the grain drying chamber 57.

Referring to FIGS. 4 and 5, it is seen that a duct member 58 has a flat apex section 61 which slopes or tapers so as to have a smaller width at the inner end relative to the outer end thereof. Likewise, it is seen that the sides or leg sections 62 converge inwardly toward the inner end of a duct member 58, along with having upper edges 63 thereof sloped in a downward and inward direction.

A duct member 58 may be formed from a single piece of sheet metal of a relatively heavy gauge thickness providing adequate support for the wet grain in the upper chamber 56. However, a structurally strong duct of a lesser total weight can be made from sheet metal or about sixteen to eighteen gauge, by adding suitable reinforcing members or plates formed of a twelve to fourteen gauge material, as illustrated in FIG. 4.

As shown in FIGS. 5 and 6, the leg sections 62 of a duct member 58 have lower edges terminating in inwardly extended lateral flanges 64 which are connected together by transverse brace members 66 spaced longitudinally of a duct member. The outer end of a duct member, indicated at 67, is reinforced in thickness by a mating V-shape insert 68. With reference to FIGS. 4 and 5, in the light of FIGS. 7 and 8, it is seen that the apex section 61 over substantially the length of a duct member 58, and inwardly from the insert 68 at the duct outer end 67, is provided with a reinforcing insert 69 which is nested within the apex section 61. Substantially coextensive in length with and located below the apex insert 69 are a pair of longitudinally extended brace members 71 corresponding to the leg section flanges 64. As shown particularly in FIG. 7, the side sections 62 of a duct member 58 tend to form an arch over the central portion of a duct member 58 so as to increase the load carrying ability of a duct member at such portion. It will be further noted that the longitudinal brace members 71 are integrally formed with vertical flanges (FIG. 4) which, as appear in FIG. 8, complement and reinforce the leg sections 62 at the inner end of a duct member 58.

In the installation of the duct members 58 within the grain bin 16 the inner ends of the ducts are supported in resting engagement on the top surface of a disc member 74 located within a cylindrical housing or basket 76 (FIG. 5) arranged concentrically relative to the floor central opening 22 and of a size to enclose the gear housing assemblies 33 and 48. The housing 76 is supported on the foundation 21 and, as seen in FIG. 5, is formed with diametrically opposite openings 77 for receiving corresponding inner ends of the sweep augers 28. The plate or disc 74 has its central portion carried on a platform 78 fitted over the upper end of the supporting post 41 and is formed in its upper surface with an annular row of holes or cavities 79 concentrically arranged relative to the axis of the supporting post 41.

The inner end of each duct member 58 has a round pin or dowel 81 (FIGS. 5 and 9) located between and secured as by weldments to the leg sections 62. A dowel member 81 is of a size to constitute a closure or end wall for the inner end of a duct member and of a length to provide a lower extension 82 adapted to be received within a corresponding one of the cavities 79 in the disc member 74.

A conical cap member 83 for the housing 76 includes a base plate 84 and a depending peripheral rim 86 the lower edge of which rests on the top surfaces of the duct members 58 at the inner ends thereof. The cap is clamped against the duct members by means including a stud 87 projected upwardly from and secured to the disc 74 for extension through a center opening formed in the base 84 to receive a nut 85 which is accessible for manipulation through an upper opening 88 in the cap 83. This opening is then closed by a mating cover 89.

As previously described, the duct members 58 are circumferentially spaced about the bin 16 so as to form therebetween grain passages 59. The inner end of each of these passages 59 is closed by a corresponding end plate 91 having its upper end secured to the rim 86 by means of a bolt or the like 92 and projected downwardly with its lower end in bearing engagement with the outer surface of the circular side wall 80 of the housing 76. The end plates 91 thus constitute an upright extension for the wall 80 having openings therein for receiving corresponding inner ends of duct members 58.

The outer ends 67 of the duct members 58 are projected through corresponding openings 94 circumferentially spaced in the bin wall 7 (FIGS. 1 and 2). In a usual construction, the wall 17 is comprised of a series of vertically stacked ring units 96 with adjacent units having overlapping ends attached together by bolt assemblies (not shown). To accommodate the duct assembly 54 of this invention, it is only necessary to separate the lowermost ring unit, indicated as 96a in FIG. 3, from the next adjacent ring unit, shown at 96b, and insert therebetween a flat annular member 95 formed with circumferentially spaced inverted V notches of a size to receive therethrough the outer ends 67 of the duct members 58.

A ring member 97 of an angle iron construction is extended about the top peripheral surface of the lower ring unit 96a in a supported position on a plurality of channel member supports 98 extended vertically in a circumferentially spaced relation about the ring unit 96a and secured thereto by bolt assemblies 99. The upright flat ring 95 is then positioned on the angle iron ring 97 after which the next lowermost ring unit 96b of the bin wall 17 is arranged with its lower end in overlapping relation with the upper end of the ring member 95. This assembly is maintained by means of channel member connectors 101, corresponding in number to the channel supports 98, and secured thereto by the bolt assemblies 99 (FIG. 5). The inserted ring member and the ring unit 96b are secured to the channel connectors 101 by bolt assemblies 102 with the outer end 67 of a duct member 58 projected outwardly of the bin through the opening formed by the notches in the ring member 95 and associated portion of the angle iron ring 97. A spreader plate 103 (FIGS. 5 and 6) is driven between the leg sections of the insert 68 at the outer

end of a duct 58 to spread and hold the leg sections 62 into a rigid and firm engagement with the bin wall.

It is seen, therefore, that each duct member 58 has the underside thereof completely open to the grain drying chamber 57, the inner end thereof closed by a dowel 81 and its outer end 67 to open to the atmosphere. As a result of the inwardly tapered construction of a duct member 58 the grain passages 59 formed therebetween are of a generally elongated rectangular shape in plan view, as appears in FIG. 2 with the inner end of a grain passage defined by a corresponding end plate 91 and its outer end by the bin wall 17. It is also apparent that the longitudinal sectional area of a grain passage 59 is appreciably less than the longitudinal sectional area of an air duct 58 so that the duct assembly 54 constitutes what might be termed a slotted floor for supporting the wet grain in the upper wet grain chamber 56. However, the grain passages 59 are of a size to permit an unrestricted flow of wet grain into the grain drying chamber 57 at a volume rate substantially equal to the volume rate of grain removed by the sweep augers 28. In turn, the rate of grain removal is dependent upon the time period required to dry the grain during its downward passage in the grain drying chamber 57.

In this respect, it has been found that the practical range of drying velocities for deep beds of grain, namely, the velocities that can be provided with an economically feasible size of fan and motor for operating the same, is around 10 to 30 feet per minute. For shallow beds of grain 6 inches to 12 inches deep the practical range of air velocity may be around 100 to 150 feet per minute. Other pertinent factors being held constant, the drying capacity of a grain drying system is directly proportional to drying air velocity. The air duct assembly 54 in connection with the shallow drying chamber 57 provides for a high velocity air flow through the grain to be dried along with obtaining a maximum drying efficiency from the heated air ventilated through the bin floor 19. Stated otherwise, the heated air at the time of its flow into the duct assembly 54 is at or approaching a saturation point. Additionally the shallow drying chamber and large area air inlets into the duct assembly 54 combine to provide a reduced resistance to the air flow through the corn to be dried.

In the operation of the drying apparatus 15 of this invention, and as illustrated in FIG. 1, grain from the grain delivery auger 106 is delivered into the hopper 107 at the upper end of the grain bin 16 from where it is acted upon by a spreader mechanism 108 for uniform distribution over the cross sectional area of the bin. The wet grain initially supplied to the upper chamber 56 passes through the grain passages 59 to fill the grain drying chamber 57. On completion of this filling operation, the chamber 57 functions as a garner from which the wet grain is later supplied to the drying chamber 57.

Heated air from the unit 24 is then admitted into the drying chamber 57 through the ventilated floor 19 for travel upwardly through the drying chamber 57 and into the duct assembly 54 for discharge to the atmosphere. When the grain adjacent the floor 19 has been dried to a desired moisture content the sweep augers 28 are operated to commence their function of removing a uniform layer of grain from adjacent the bin floor 19. In response to this uniform removal of grain, wet grain

is uniformly supplied from the supply chamber 56 to the drying chamber 57 through the grain passages 59. As shown in FIG. 5, the grain is delivered by the augers 28 into the housing 76 through the openings 77. Paddles 110 on the auger shafts 32 lift the grain onto an open dome member 109 that is arranged in a covering relation over the central floor opening 22 and about the gear housing 33. The grain, on passing through the dome member 109, and as indicated by arrows, travels downwardly through the central opening 22 and into a receiving chamber 111 within the housing 76 for pickup by the unloading auger 29.

As previously stated, the depth of grain in the drying chamber 57 may be varied relative to the available heat supply to dry the wet grain to a desired moisture content. For this purpose each of the grain passages 59 may be provided with an insert or depending extension 112 (FIG. 10). An insert is of a generally funnel shape in transverse cross section having an upper inwardly flared portion 113 and a lower chute portion 114. Each insert is coextensive in length with a corresponding grain passage 59 and is comprised of a pair of side members 116 connected together by longitudinally spaced transverse brace members 117. The downwardly converging upper sections 118 of the side members 116 are of a tapered construction corresponding to the slope of the oppositely arranged leg sections 62 of adjacent duct members 58 which define the side walls of a grain passage 59.

On insertion or placement of an insert 112 with the flared portion 113 in a nested relation within the lower side of a grain passage 59 (FIG. 11) the chute portion 114 extends below such lower side so as to constitute a downward extension for the grain passage 59. The insert is retained against downward movement by the engagement of the sloped upper sections 118 of the side members with coacting portions of the leg sections 62 on an adjacent duct members 58.

Without the inserts 112 grain flowing through the passages 59 will accumulate or pile up in the grain drying chamber to the high level indicated in FIG. 11 by the dotted line H. With the inserts 112 positioned within the grain passages the grain level in the chamber 57 is lowered from the level H to the level L indicated by dot-dash lines. Thus by the provision of inserts 112 having chute portions 114 of different lengths the grain level in the grain drying chamber 57 may be varied to accommodate varying volume rates of downward grain flow and upward air flow.

Although the invention has been described with respect to a preferred embodiment thereof, it is to be understood that it is not to be so limited since changes can be made therein which are within the full intended scope of this invention as defined by the appended claims.

I claim:

1. A grain drying apparatus for a storage bin having a circular side wall and a horizontal ventilated floor with a central grain outlet comprising:

a. a horizontal duct assembly spaced above said floor over the entire cross-sectional area of the bin to form in said bin an upper wet grain supply chamber and a lower grain drying chamber, said duct assembly including a plurality of radially extended circumferentially spaced duct members, each of which has an inner end, an outer end and a bottom side open to said lower drying chamber, and a

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space between adjacent duct members forming a grain passage interconnecting said upper chamber and lower chamber, said grain passages and duct members relatively constructed to uniformly distribute grain from said upper chamber over said lower chamber,

- b. means projected upwardly from the center of said floor for supporting said duct members at the inner ends thereof,
- c. said bin side wall formed with circumferentially spaced openings corresponding to said duct members and of a shape and size to receive a corresponding outer end therein,
- d. means for supplying heated air for travel upwardly through said floor and into said lower drying chamber for flow through the grain therein and exhaust from the bin through said duct members, and
- e. means for uniformly moving the grain downwardly of said lower drying chamber comprising a sweep auger rotatable about the vertical axis of the storage bin and across said floor, said sweep auger having a spiral flighting of a construction to continuously remove a grain layer of uniform thickness from said floor for discharge into said central grain outlet.

2. The grain drying apparatus according to claim 1 including:

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- a. housing means on said center supporting means forming an inner end wall for each of said grain passages, and
- b. a top member for said housing means projected upwardly from said duct assembly for directing grain downwardly into said grain passages for flow into the rotational path of movement of said sweep auger.

3. The grain drying apparatus according to claim 1 including:

- a. an enclosure unit for the inner ends of said duct members carried on said supporting means and having a circular side wall formed with circumferentially spaced openings corresponding to said duct members and of a size and shape to receive the inner end of a duct member therein, said side wall of the enclosure unit having a lower edge adjacent to and spaced upwardly from the upper side of said spiral flighting, and
- b. a cone shaped top wall for said enclosure unit having a lower edge terminating at the upper edge of the circular side wall of said enclosure unit to direct grain from above said supporting means for flow downwardly between said duct member inner ends and about the enclosure unit into the rotational path of said spiral flighting.

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