June 28, 1966 N. C. IVES ET AL 3,257,733

DRYING APPARATUS AND METHOD

Filed Dec. 17, 1962 4 Sheets-Sheet 1

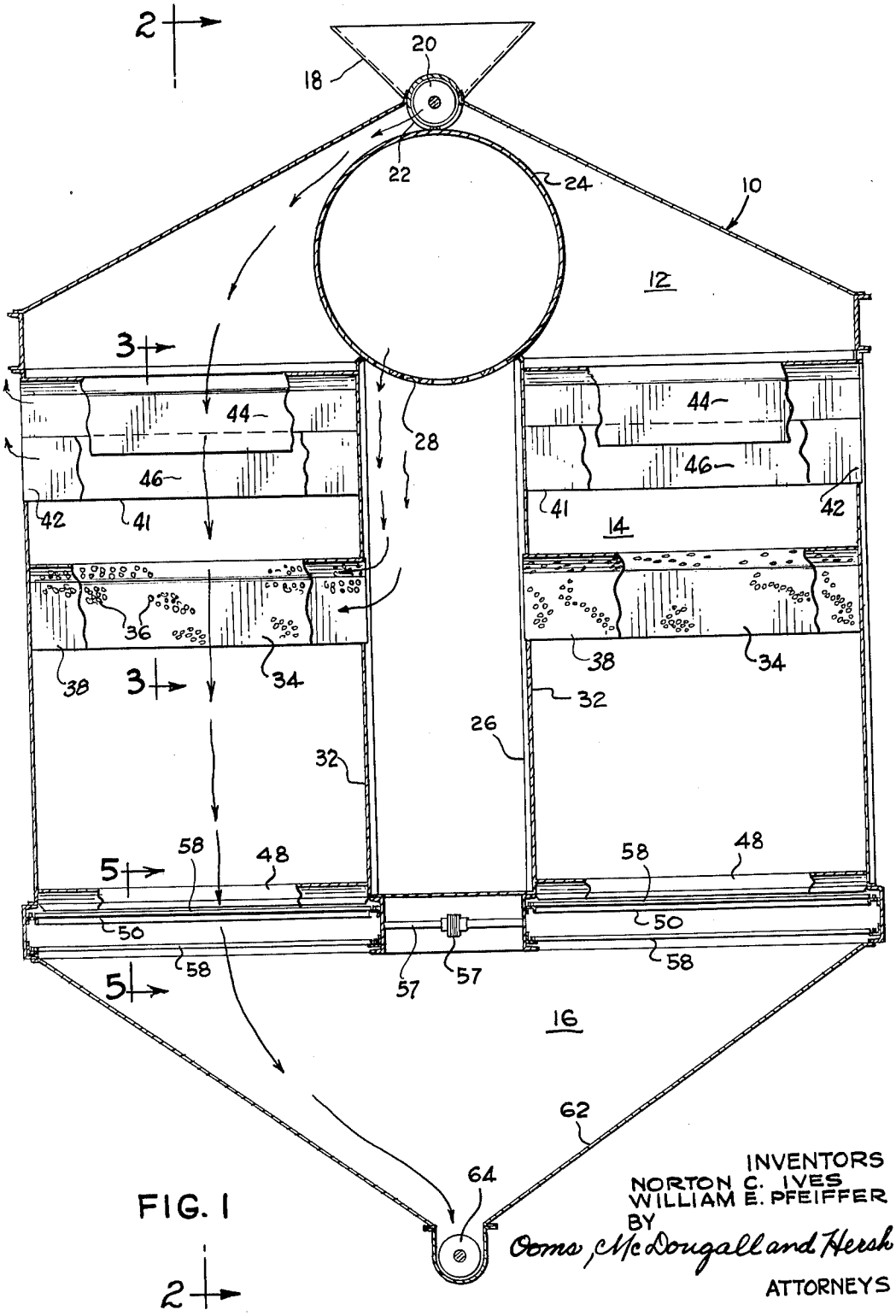

FIG. 1

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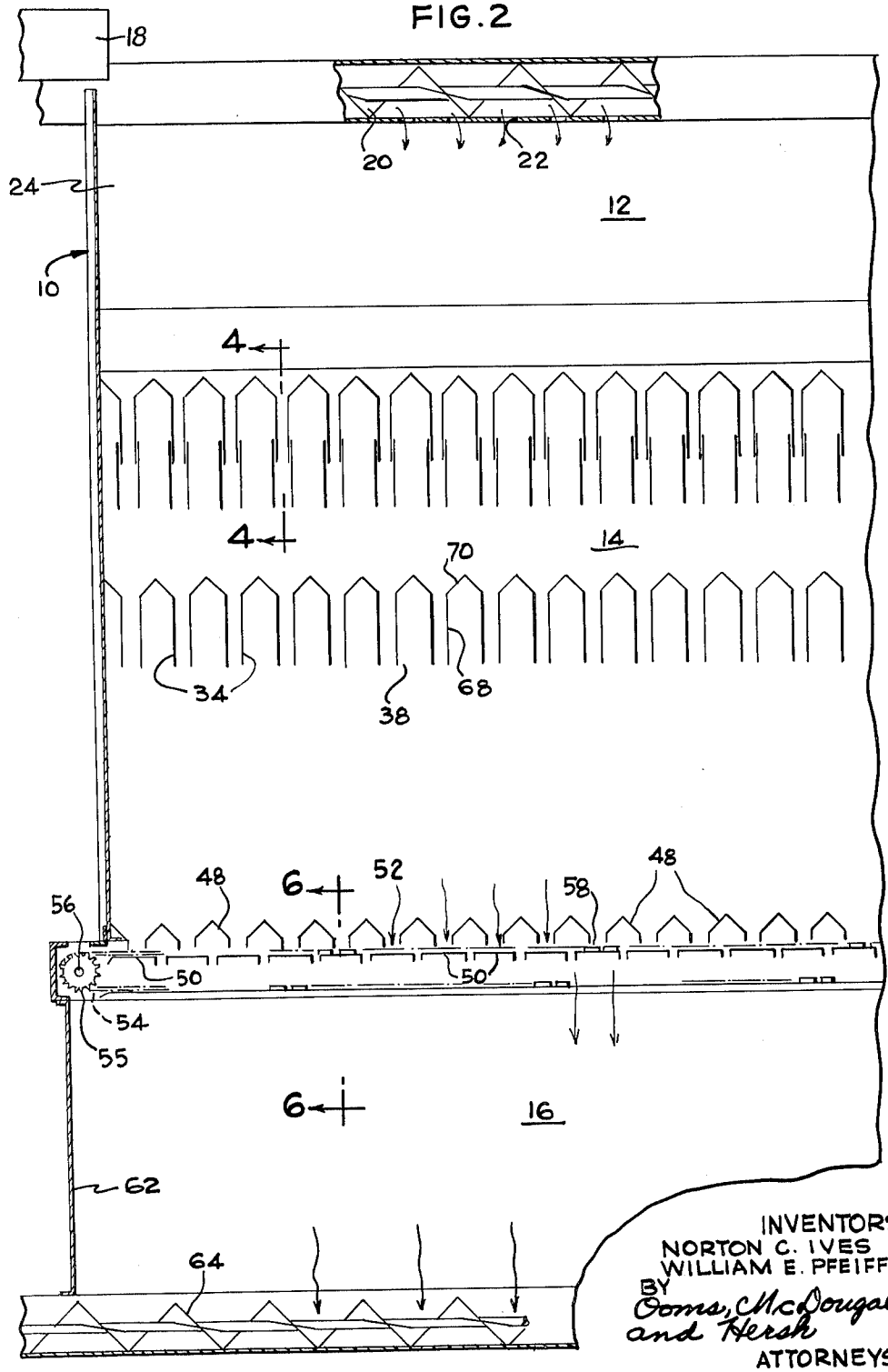
FIG. 2



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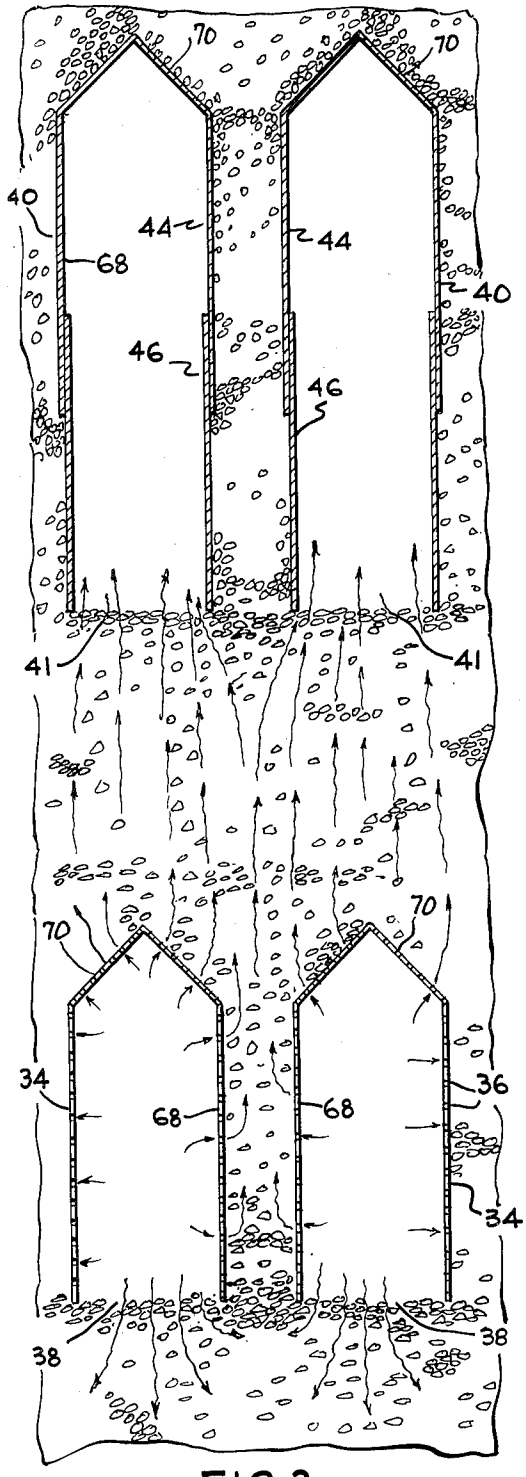

FIG. 3

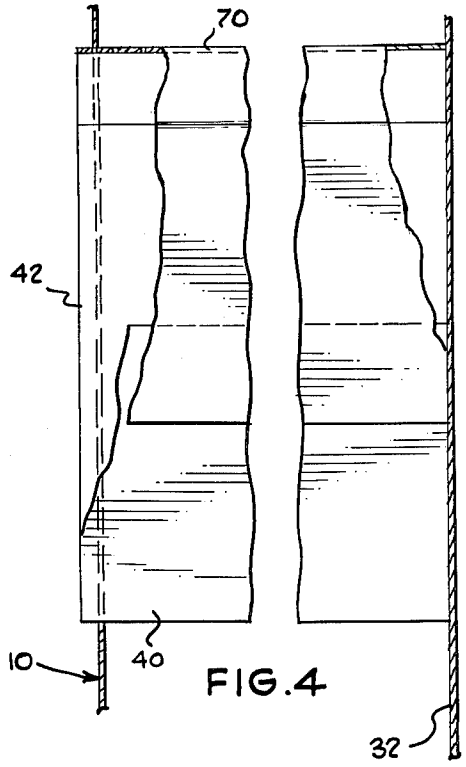

FIG. 4

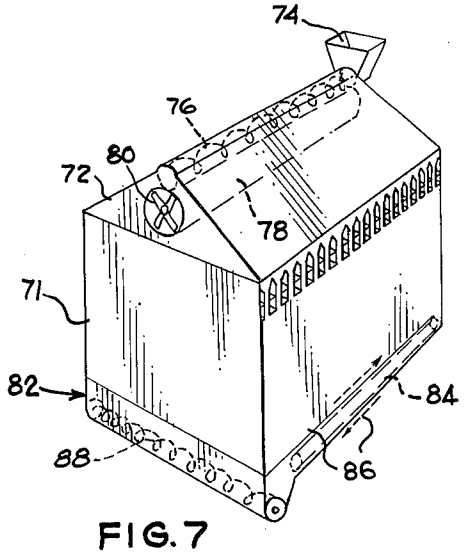

FIG. 7

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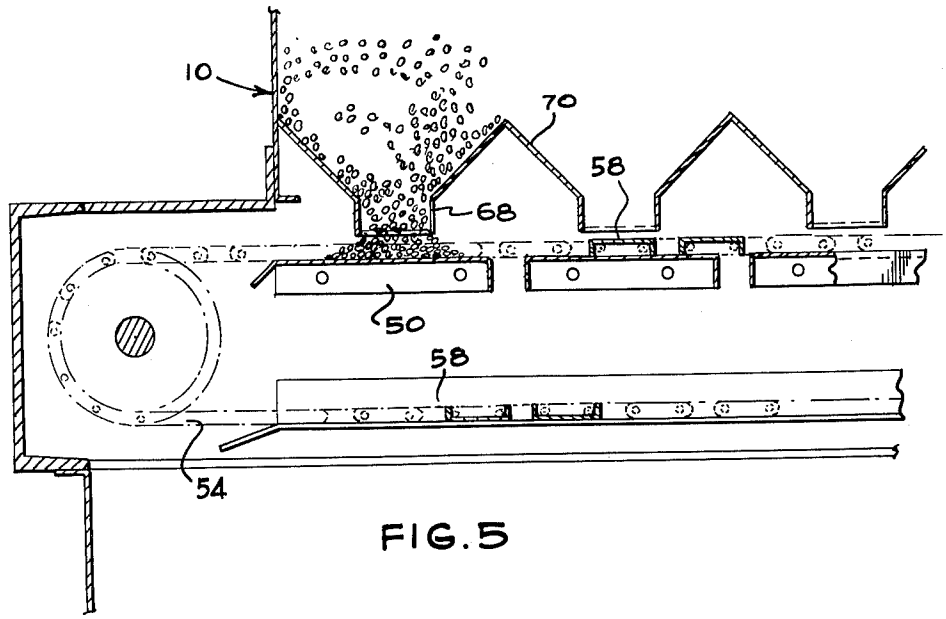

FIG. 5

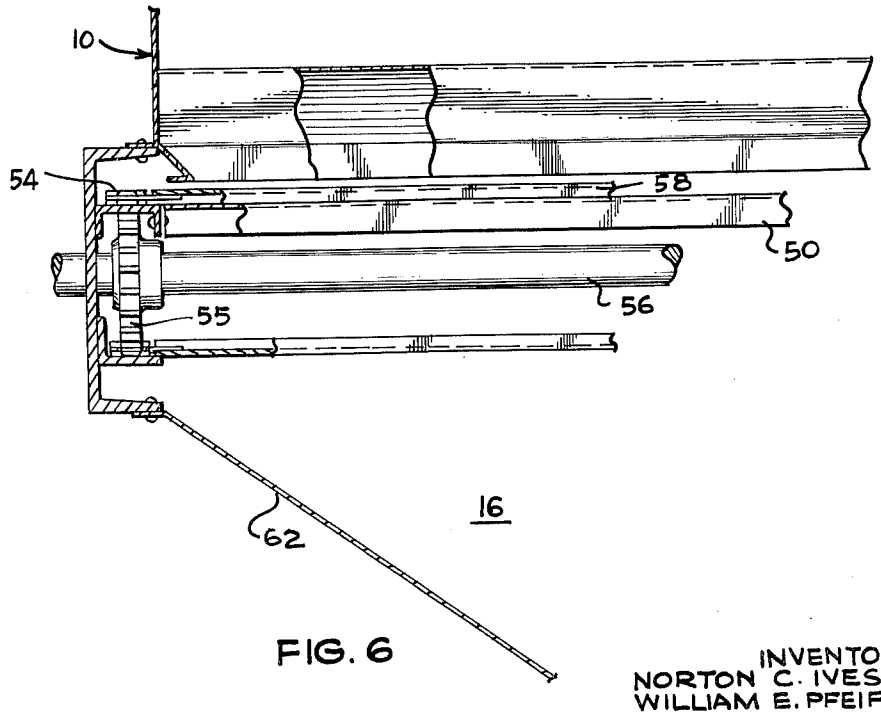

FIG. 6

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DRYING APPARATUS AND METHOD

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4 Claims. (Cl. 34—12)

This invention relates to an apparatus for the drying of grain and the like. In particular, the invention is directed to a dryer apparatus which is uniquely suitable for the handling of corn, seed, wheat, milo, soy beans, oats and a wide variety of other grains susceptible to a drying operation.

In the storing and handling of grain, it is important that the moisture content therein be controlled. In certain instances, the moisture level must be maintained below a certain point so as to reduce the danger of rotting or the formation of hot spots within the grain. In other instances, it is desired that the moisture content be maintained within certain specific upper and lower limits. Thus, in the preparation of popping corn, it is necessary that a critical amount of moisture be contained in the corn in order to provide ideal results.

Structures devised by the prior art for the drying of grain and the like are characterized by a variety of difficulties. In many instances, the devices are inefficient for the reason that an undue amount of heat must be utilized in order to bring the moisture content of all the grain to a desired level. Thus, the means for distributing heated air or the like through the grain have, in some instances, not operated in a uniform manner and excess heat must be applied to some areas while heat in other areas is wasted. Where attempts have been made to improve efficiency, it has been found that the best operating structures were unduly expensive.

It has also been found that prior art devices are generally unsatisfactory for operations which require the maintenance of a moisture content within a certain critical range. In many instances, such devices have been effective in providing an average moisture content within desired range; however, certain portions of the substances being dried were found to be above or below the desired moisture content. Thus, certain prior art structures have not been capable of providing a uniform moisture content throughout the extent of a dryer apparatus.

It is a general object of this invention to provide an improved dryer apparatus which is uniquely suitable for the drying of a wide variety of grain products.

It is a more particular object of this invention to provide a dryer apparatus which is characterized by an improved operating system whereby highly efficient and economical drying of grain can be effected.

It is a further object of this invention to provide a grain drying apparatus which is adapted to remove moisture from grain products in an extremely uniform manner whereby the resulting dried product is characterized by a uniform moisture content and whereby an extremely efficient drying operation is realized.

These and other objects of this invention will appear hereinafter and for purposes of illustration, but not of limitation, specific embodiments of this invention are shown in the accompanying drawings in which:

FIGURE 1 is an elevational view in section of a dryer apparatus characterized by the features of this invention;

FIGURE 2 is a fragmentary cross-sectional view of the dryer apparatus taken about the line 2—2 of FIGURE 1;

FIGURE 3 is an enlarged cross-sectional view taken about the line 3—3 of FIGURE 1 and illustrating in detail the air ducts of the apparatus;

FIGURE 4 is an enlarged detail view of an air duct taken about the line 4—4 of FIGURE 2;

FIGURE 5 is an enlarged fragmentary view taken about the line 5—5 of FIGURE 1 and illustrating the grain removing means of the apparatus;

FIGURE 6 is an enlarged fragmentary view taken about the line 6—6 of FIGURE 2 illustrating further details of the grain removing means; and

FIGURE 7 is a perspective view of a dryer apparatus illustrating an alternative grain removing means.

The drying apparatus of this invention comprises a housing which includes means at its top for delivering grain whereby the grain is adapted to travel from the top to the bottom of the housing. One important feature of this invention relates to the provision of duct means disposed at an intermediate position within the housing. These duct means are provided with openings whereby air for drying is adapted to be distributed by the duct means into contact with the grain moving through the housing. One portion of the drying air is adapted to be passed upwardly whereby it moves in a counterflow with respect to the grain. Other portions of the drying air are adapted to be moved downwardly in parallel flow with the grain, and this combination has been found to provide uniquely suitable drying results.

An additional important factor of the instant invention relates to the provision of means for unloading the grain at the bottom of the housing after the grain has been contacted by the drying air. The grain removing means comprises pusher elements which are mounted on an endless conveyor. These elements are adapted to sweep the grain from a plurality of spaced-apart collector pans which are situated at the bottom of the housing. The grain is adapted to pass between the collector pans when moved by the pusher elements and will drop to a lower level in the housing whereby it can be conveyed to storage or other facilities. It has been found that the particular arrangement of collector pans and pusher elements provides a uniquely suitable means for uniformly moving the grain through the drying apparatus. The removing means thus cooperates with the unique air flow system whereby uniformity in the moisture content of the grain and efficiency in the drying operation can be achieved.

The accompanying drawings illustrate structures which are characterized by the above features and which include several other important aspects. The structure shown in FIGURES 1 through 6 comprises a housing **10** consisting of an upper grain delivery zone **12**, a drying zone **14** and a grain removal zone **16**. The upper zone **12** includes a hopper **18** into which the grain to be dried is poured. A screw conveyor **20** is adapted to uniformly pass grain from the hopper through slots **22** and into the interior of the housing. In the embodiment illustrated, an air supply drum **24** is included beneath the conveyor **20**, and, accordingly, the grain is distributed over the external surfaces of this drum as it passes into the housing. As will appear, the apparatus operates while filled with grain from top to bottom and a pressure switch or other means can be utilized for automatically operating the conveyor **20** in order to maintain a relatively constant level of grain in the upper portion of the housing.

The supply drum **24** communicates with an air supply channel **26** through ports **28** formed in the bottom of the drum. A heater and fan arrangement is to be provided whereby air in the supply channel **26** will be suitable for drying grain passing through the housing.

A pair of interior walls **32** are provided for defining the channel **26**. These walls and the external walls of the housing support a set of intermediate ducts **34** which communicate with the channel **26**. The ducts **34** are provided with perforations **36** and also define open bottoms **38**.

A set of exhaust ducts **40** defining open bottoms **41** are disposed in the drying zone of the housing above the

ducts 34. These exhaust ducts communicate with the outside atmosphere through openings 42 formed in the exterior walls of the housing. These exhaust ducts include upper sections 44 and lower sections 46 which telescope with respect to each other. The friction fit of these members or other means, such as locking pins, serve to permit holding of the lower sections 46 in various vertical positions. With this arrangement, various different spacings between the ducts 34 and the sections 46 can be achieved. Adjusting of the vertical position of the sections 46 can be accomplished by means of the access provided through the open ends 42 which are exposed to the exterior of the housing.

At the bottom of the drying zone 14, there are provided a plurality of spaced-apart members 48. It will be noted that these member as well as the ducts 34 and 40 are vertically aligned whereby straight paths from the top to the bottom of the drying zone are provided. Located beneath the members 48, there are provided a plurality of spaced-apart collector pans 50. The upper flight of a conveyor apparatus 52 moves between the members 48 and the pans 50. This conveyor consists of a chain 54 which is driven by means of sprockets 55. The sprockets are mounted on shafts 56 which are in turn connected by coupling means 57.

A plurality of rectangular pusher elements 58 are arranged in spaced-apart pairs on the chain 54. The members 48 and the pans 50 are sufficiently spaced to provide for movement of the pusher elements between these structures.

Beneath the conveyor 52, there is provided a bin 62 and a screw conveyor 64. The conveyor 64 is adapted to move grain delivered to the bin out of the zone 16 to storage means or other facilities.

FIGURE 7 illustrates an alternative form of the invention which comprises a housing 71 defining a grain delivery zone 72. As in the previous embodiment, this zone includes a hopper 74, a screw conveyor 76, and an air supply drum 78. A fan 80 and heating means (not shown) provide for the passing of hot air into the drying zone of the apparatus.

In this embodiment, the grain removal zone 82 includes an endless conveyor 84 moving in the direction of the arrows 86. A screw conveyor 88 provides for removal of the grain in a manner to be described.

In the operation of the structure shown in FIGURES 1 through 6, the grain is introduced through the hopper 18 and the housing is filled with the grain from top to bottom. The drying operation is initiated by forcing heated air through the supply drum 24 into the channel 26 and then into the ducts 34. As best illustrated in FIGURE 3, air entering the ducts 34 is passed through the perforations 36 upwardly through the grain situated between the ducts 34 and the open bottom 41 of the exhaust ducts 40. It will be apparent that this portion of the heated air moves in counterflow with respect to the grain.

The open bottom 38 of the ducts 34 permits parallel flow of air downwardly toward the bottom of the housing. In this phase of the operation, the grain is adapted to be dried to some extent; however, this lower portion of the drying zone also acts as a cooling zone. Thus, as the grain travels downwardly toward the grain removal zone, it begins to cool off and, by the time the grain is actually removed from the apparatus, it will have reached a temperature more suitable for storing purposes.

Portions of the grain reaching the bottom of the drying zone pass between the members 48 and accumulate on the pans 50. These portions are then engaged by an oncoming set of pusher elements 58 whereby the grain is adapted to fall between adjacent pans 50. The provision of the pusher elements in spaced-apart sets provides for a high degree of uniformity in the removal of the grain from the drying zone. Thus, grain is constantly fed through each of the openings between the members 48, and this grain is constantly removed from each of the collector pans 50. Accordingly, none of the areas within the drying zone are favored with respect to removal of the grain, and, therefore, the grain moves through the drying zone with substantially constant relationship between the respective levels within the housing.

The screw conveyor 64 of the apparatus shown in FIGURES 1 through 6 provides for uniform removal of the grain. The structure shown in FIGURE 7 also provides a screw conveyor for removal of the grain after the pusher elements sweep the grain off the collector pans; however, this screw conveyor 88 is disposed laterally across one end of the housing with its axis perpendicular to the movement of the conveyor 84. As suggested by the arrows 86, the pushers in the upper flight of the conveyor operate to sweep the grain from the collector pans, and this grain then passes between the collector pans to the bottom of the housing. The pushers on the lower flight of the conveyor 84 are then adapted to sweep the grain from the bottom of the housing into communication with the screw conveyor 88. It will be apparent that this arrangement substantially decreases the space taken up by the dryer apparatus. Thus, the downwardly extending walls defined by the bin 62 are eliminated and a flat bottom wall is substituted in accordance with the construction shown in FIGURE 7.

It will be noted that the ducts and the members 48 each define vertically disposed side walls 68 and converging upper portions 70. The particular design of these elements provides for smooth flow through the apparatus and contributes to the uniformity achieved in the drying operation.

It will be obvious that many variations in the described apparatus can be made within the scope of the instant invention. For example, it is contemplated that the members 48 provide an exhaust means for the air passing in parallel flow with the grain. It will be appreciated that openings in these members 48 must be designed whereby they will not be blocked by the grain moving past these members.

A wide variety of sizes for the housing confining the dryer apparatus are also contemplated. In one specific example of an application of this invention, a housing 12 feet long, 10 feet wide and 10 feet high was employed. Where the modification shown in FIGURE 7 is employed, about 2 feet can be eliminated from the heighth of the apparatus and the portability thereof can, therefore, be increased.

The elements within the housing are also capable of assuming a wide variety of dimensions. One form of the invention which provides for suitable handling of the grain includes the use of ducts which are 4¾ inches wide and which are spaced apart 2¼ inches. The pusher elements employed in the apparatus were 2 inches wide and ½ inch high with the elements in a pair spaced ¾ inch apart and with the sets of pushers disposed about 3 feet apart on the conveyor chain. 6 inch wide collector pans spaced about 1 inch apart are advantageously used with pushers of these specific dimensions.

As previously indicated, the present invention provides distinct advantages due to the use of adjustable exhaust ducts. Thus, it has been recognized that the primary zone of drying consists of the zone between the upper surface of the air ducts and the open end of the exhaust ducts. It has also been recognized that the degree of drying can be controlled by varying the distance between the air ducts and the exhaust ducts. This variation in the primary drying zone can be correlated with the temperature of the incoming air, and changed in accordance with the amount of moisture to be removed to provide a highly effective means for accurately controlling the drying operation.

As previously indicated, the portion of the drying zone beneath the ducts 34 also acts as a cooling zone for the grain. It is contemplated that the ducts 34 be divided

whereby heated air will pass only upwardly and a separate source of cooled air can then be provided for parallel flow whereby the grain can be more rapidly cooled. The apparatus illustrated, however, has been found to be completely practical for all conventional drying operations encountered.

There has been described an apparatus which has been found to provide clear improvements in the drying or grain products from the standpoint of quality of the dried grain and from the standpoint of economy and efficiency in the drying operation. The quality of the grain has been found to be extremely suitable since the apparatus is capable of maintaining substantial uniformity in moisture content, is adapted to provide grain products with uniform moisture contents within narrow critical ranges, and is adapted to deliver the grain in a cooled state whereby storage or other subsequent handling is greatly facilitated. The apparatus, by providing highly effective and uniform contact between heated air and the grain, eliminates the need for employing excessive temperature in a drying operation. Accordingly, the apparatus provides a drying operation which does not present the danger of overheating and consequent deterioration in quality of the grain.

The results of this invention have been found to be due to the cooperation between the air flow structure, the design and disposition of the ducts and members **48** and the type grain removal employed. It will be apparent that the uniformity in drying and in movement of grain in a given cross section through the apparatus depends on the ability of the heated air to contact the grain in a uniform manner and for a substantially constant duration, and also depends on the ability of the grain removing means to remove equal portions of the grain all along the length of the apparatus whereby there is no preferred removal of grain from any given section in the apparatus.

It will be understood that various modification may be made in the above described structure which provide the characteristics of this invention without departing from the spirit thereof particularly as defined in the following claims.

That which is claimed is:

1. A grain drying apparatus comprising a housing and means for delivering grain to the top of said housing whereby it is adapted to travel from the top to the bottom of the housing, duct means situated in the path of movement of said grain intermediate the top and bottom of said housing, openings formed in said duct means whereby air is adapted to pass upwardly and downwardly out of said duct means, means for introducing air into said duct means to provide for said upward and downward movement, exhaust ducts disposed above said first mentioned duct means for removing upwardly flowing air from said apparatus, said exhaust ducts defining open bottoms for receiving said upwardly moving air and including means for vertically adjusting the distance between said open bottoms and the top of said first mentioned duct means, and grain unloading means disposed at the bottom of said housing.

2. An apparatus in accordance with claim **1** wherein said grain unloading means comprise an endless conveyor and pusher means connecting to said conveyor, spaced-apart collector pans disposed at the bottom of said housing and adapted to be traversed by the pushers situated in the upper flight of said conveyor whereby said pushers are adapted to sweep said grain off said pans into the spaces defined between the pans, and including additional spaced-apart ducts situated above said collector pans whereby said grain is adapted to pass between said last mentioned ducts and is distributed on said pans before contact with said pushers.

3. An apparatus in accordance with claim **1** wherein said first mentioned duct means and said exhaust ducts are arranged in three parallel rows across said housing, with ducts in each of said rows being uniformly spaced apart and being vertically aligned with corresponding ducts in the other rows.

4. A method for the drying of grain and the like comprising the steps of providing a dryer housing, passing the grain vertically downwardly through said housing, providing a first duct means at an intermediate level across said housing, said first duct means having upwardly directed openings and also lower openings, providing a second duct means having lower openings longitudinally above said first duct means, introducing heated air into said first duct means under sufficient pressure to permit a portion of said air to be forced through said upper openings and then through the grain, and also to permit a second portion of said air to be forced through said lower openings and downwardly initially concurrently with the movement of said grain, withdrawing all of the moisture-laden air through said duct means to the atmosphere, and uniformly removing said grain all along the extent of said housing.

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