Jan. 31, 1967 J. D. BUSSELL ETAL 3,300,873

GRAIN DRYER

Filed May 12, 1964

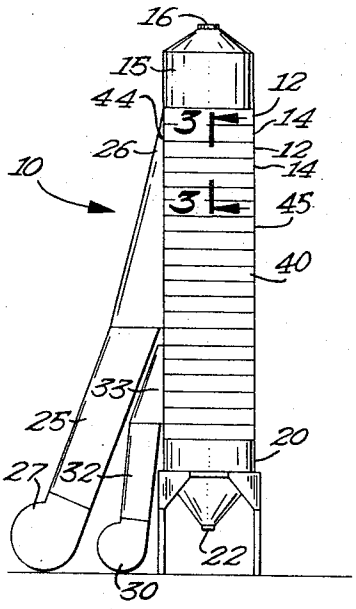


FIG 1

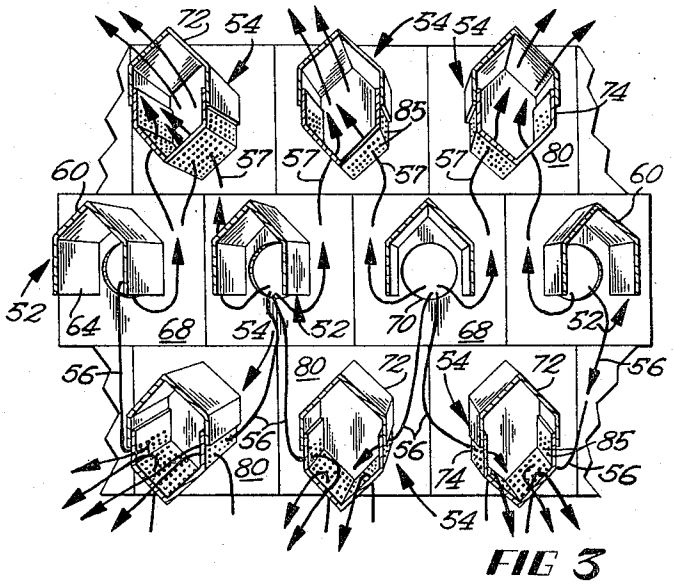


FIG 3

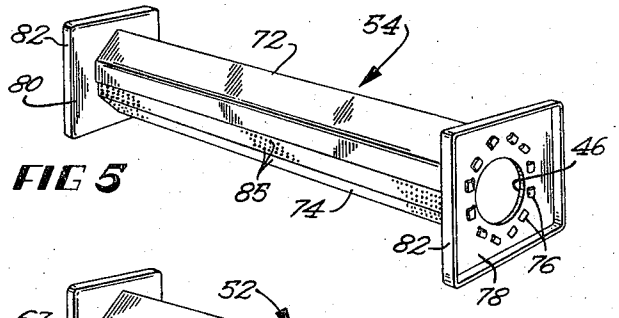


FIG 5

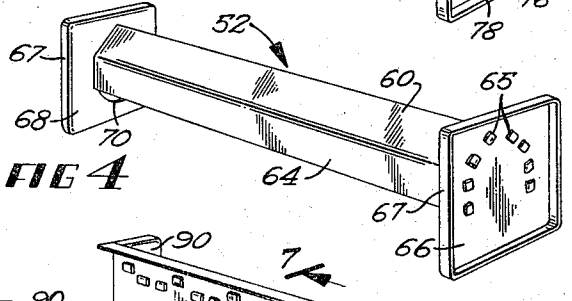


FIG 4

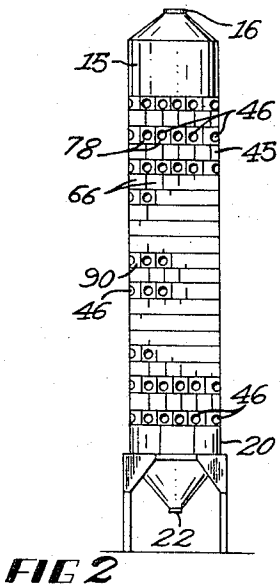


FIG 2

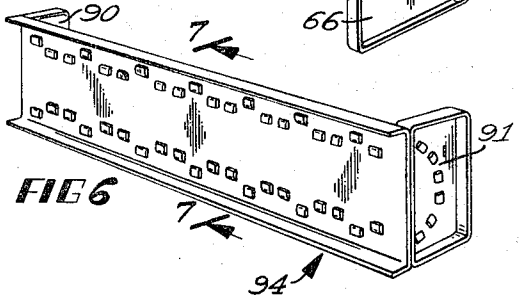


FIG 6

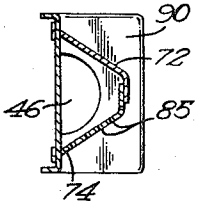


FIG 7

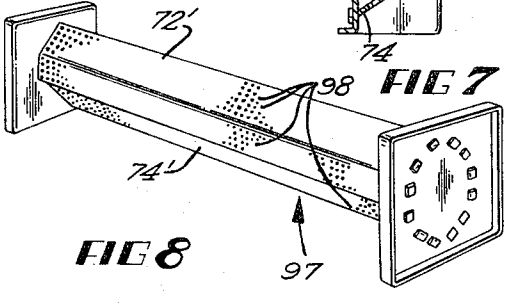


FIG 8

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GRAIN DRYER

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Our invention relates to grain dryers and more particularly to an improved rack type grain dryer having air intake and exhaust members through which tempered air is circulated to pass through the grain with a greatly increased velocity of air flow to improve drying efficiency while preventing particles of the grain from being discharged at the air outlet.

Grain dryers and rack type grain dryers specifically have been well known and in use for some time. In drying apparatus of this type, a source of drying air which may be tempered is circulated through the grain or granular material and discharged from the dryer at a point apart from the outlet for the grain. Efficiency of the dryer and its capacity is for the most part limited by the velocity of the flow of drying air through the grain and the design of the racks through which the drying air and the exhaust air passes. As velocity of air flow through the dryer increases above a normal point, the granular material is picked up by this air flow and discharged at points other than the grain outlet of the dryer resulting in loss of granular material and increasing dust discharge from the same.

The present invention is directed to an improved grain dryer which utilizes improved intake and exhaust racks to provide for better distribution and movement of the grain through the tower of the dryer, while increasing the velocity of drying air therethrough to increase the efficiency of drying and at the same time prevent grain and dust from being discharged from the air discharge of the dryer. This improved grain dryer may be utilized with tempered air, both heated and cooled, to obtain maximum drying efficiency. At the same time, the design of the exhaust rack permits a considerably increased velocity of drying air to substantially reduce drying time and increase the dryer's capacity to dry. The improved rack of the tubular members incorporated therein are perforated in such a manner and positioned relative to one another to provide for maximum distribution of the drying air. The flow of the granular material across the drying rack and tubular members therein wipes granular material from the perforations in the tubular members to prevent obstruction to air flow and insure uniform drying of the grain.

It is therefore an object of this invention to provide an improved grain dryer.

Another object of this invention is to provide in an improved grain dryer, an improved exhaust rack which facilitates an increased volume of air flow through the dryer.

A further object of this invention is to provide in an improved air dryer an exhaust rack which prevents blowing of the grain and dust from the grain through the air discharge.

A still further object of this invention is to provide an improved air dryer with an exhaust rack having tubular duct members with perforated bottoms which permit uniform distribution of the drying air through the grain drying tower and the grain therein while facilitating movement of the grain through the tower from the inlet to the outlet thereof to increase the efficiency of the drying operation.

Another object of this invention is to provide an air duct construction which may be readily formed and

mounted in rack form to provide a simplified intake and exhaust rack structure for a grain drying tower.

A still further object of this invention is to provide an improved grain dryer which is simple in design and economical to construct and maintain and which greatly increases the efficiency of drying.

These and other objects of this invention will become apparent from a reading of the attached description together with the drawings wherein:

FIGURE 1 is a side elevation view of the improved grain dryer;

FIGURE 2 is a front elevation view of the improved grain dryer;

FIGURE 3 is a sectional view in partial perspective of the grain dryer taken along the lines 3—3 of FIGURE 1;

FIGURE 4 is a perspective view of an intake tube portion of an intake rack showing constructional details of the same;

FIGURE 5 is a perspective view of an exhaust tube portion of an exhaust rack showing constructional details of the same;

FIGURE 6 is a perspective view of an exhaust tube positioned adjacent the edge of the tower in the edge of an exhaust rack;

FIGURE 7 is a sectional view of the tube of FIGURE 6 taken along the lines 7—7 therein; and

FIGURE 8 is a perspective view of an alternate embodiment of a tube for the improved grain dryer.

The improved grain dyer of the present invention is of the rack type which utilizes improved designs of the intake and exhaust tubes to facilitate an increased volume of drying air through the granular material or grain to be dried within a tower. Thus in FIGURES 1 and 2, there are shown schematically a drying tower, indicated generally at **10**, which tower houses a plurality of racks therein identified as exhaust racks **12** and intake racks **14** positioned in alternate layers throughout the extent of the tower. As will be seen in FIGURE 1, the tower has an inlet section **15** at the top thereof with an inlet port **16** therein into which grain is introduced for drying purposes. The term grain as used herein applies to corn, wheat, and all small grains in which it is desired to remove the moisture to prevent spoilage in processing or storage. The improved grain dryer in addition to the inlet section **15** and the plurality of racks **12** and **14** forming the main structure of the tower includes a grain flow discharge section, indicated generally at **20**, with a dryer discharge outlet port **22** at the bottom thereof. The actual details of the inlet section **15** are omitted since these may take varying forms and it will be understood that any storage or distribution unit at the top of the drying tower capable of storing and distributing grain through the drying section of the tower may be utilized. Further, the grain flow discharge regulating section **20** and the discharge port **22** are shown schematically since their details form no part of the present invention and varying types of apparatus may be utilized for this purpose. The drying section normally includes a section of the racks through which the drying air is circulated, such as warm air, and FIGURE 1 shows schematically an air duct **25** connected to a circulating source **27** of warm air which terminates in a bonnet or plenum section **26** along the side of the tower for the purpose of directing tempered or warm air through a portion of the extent of the tower or the air intake and outlet racks. Further, in FIGURE 1, a source of cooling air is directed through a cooling portion or section of the intake and exhaust racks of the extent of the dryer tower, this source being shown at **30** and including an air duct **32** extending to a cooling air bonnet **33** at the side of the tower to cool the warmed grain as it is dried prior to the discharge through the discharge

section 20. The details of the air tempering apparatus are also omitted for simplicity, and it will be understood that varying forms of this apparatus may be utilized in the drying tower. As will be seen in FIGURES 1 and 2, the tower is generally square in horizontal cross section and is sealed or formed solid at two sides thereof, such as is indicated at 40, with the remaining two sides providing the air intake and exhaust for the drying and cooling air of the dryer. Thus, as is shown in FIGURE 1, the side surface of the tower 44 represents the air intake side while the opposite side surface such as is indicated at 45 and shown in elevation view in FIGURE 2 represents the air discharge section of the tower having a plurality of discharge apertures or holes 46 therein, as will be hereinafter more fully described.

The sectional view of FIGURE 3 shows a partial cross section of the interior of the drying tower and the relationship between tubular members or ducts 52, 54 of the intake and exhaust racks 14, 12 respectively. It will be understood from FIGURES 1 and 2, that there are a plurality of intake and exhaust racks extending along the vertical extent of the rectangular shaped or square tower, each rack being disposed substantially horizontal and having a plurality of parallel extending tubular members or ducts extending from the intake to the exhaust or air outlet side of the tower. Each rack contains a plurality of tubular ducts which are spaced apart and parallel to one another and positioned in between or aligned vertically with the spacing between ducts in the adjacent racks. These create air flow patterns such as is indicated by the lines 56, 57 which indicate the direction of air flow from an intake duct around the edges around the bottom of the same and around the edges or sides of the duct up or down through the granular material within the tower to the bottom portion of the vertically adjacent rack in the exhaust section. As will be hereinafter defined, the actual constructions of the intake and exhaust racks may vary in accordance with varying versions or embodiments of the present invention. Thus, as will be seen in FIGURES 1, 2 and 3, the racks in their staggered relationship with respect to the racks above and below tend to mix the grain or granular material as it is allowed to flow through the grain tower. The racks have holes or apertures at opposite ends respectively so that all of the intake holes relative to the intake duct members 52 are present or open to the plenums 26, 33 adjacent the side of the tower to provide for introduction of tempered air through the tower. These ducts are normally enclosed on the top and sides thereof but open at the bottom as will be best seen in FIGURE 4. Thus, each tubular member forming the intake rack 14 is identical to the single tubular member shown generally at 52 in FIGURE 4. It is comprised of a V shaped member 60 whose top sides are approximately 45° from the horizontal with parallel extending sides therefrom, such as is indicated at 64, which have no bottom connecting part. This tubular member may be formed of sheet metal and includes tabs 65 at the extremities thereof which fit through cooperating slots in rectangular or square end plates 66, 68 having flanges 67 thereon with the tabs being crimped over to fit the end plates to the tubular member 60. As will be seen in FIGURE 4, the end plate 66 is solid such that the tubular member 60 is closed at this extremity while the end plate 68 has an aperture 70 therein. A plurality of such tubular members are positioned in side by side relationship and suitably interconnected through the flanges 67 of the end plates by suitable means, such as screws (not shown), to form the rack 14 extending across the rectangular tower. The angle of the top of the tubular member 60 may vary slightly but it will be greater than the normal angle of repose of the various grains or granular materials to be dried in the tower.

The tubular members 54 forming the exhaust rack 12 are shown in one version in FIGURE 5 as incorporating a top V shaped member 72 and a bottom V shaped member

74 which members are positioned together with the sides of the top member overlying the sides of the bottom member to form a complete enclosure. These members are connected respectively through tabs 76 thereon to end caps 78, 80 having flanges 82 thereon. As will be seen in FIGURE 5, the bottom V shaped member includes a plurality of perforations extending throughout the entire extent of the same, such as indicated at 85. In the assembled relationship of the tubular member 72, 74 with the end caps 78, 80, a complete tubular member is formed which is closed at the bottom except for the perforations 85 in the lower or bottom V shaped member 74 which extend up through the sides of the same to the edge of the upper V shaped member 72. End cap 80 is solid or closed closing the resulting tubular member 54 at this point and the end cap 78 has the aperture 46 therein which is shown as exposed to the exhaust side 45 of the tower. The exhaust rack 12 of the tower is made up of a plurality of the tubular members or ducts 54 which are connected together in a side by side relationship through suitable securing means attached to the flanges or through the flanges 82 thereof to form an assembled exhaust rack.

FIGURE 6 shows a perspective view of the end ducts of the exhaust rack which are one half the size of the center ducts, as will be evident from the disclosure in FIGURE 2. In this construction, as is shown by the sectional view of FIGURE 7, half of the generally diamond shaped member is formed by the equivalent of one half of an upper and lower V shaped member for the duct member 54 with the lower half of the same including the perforations or apertures 85 therein. The end caps 90, 91 for this duct member, which is identified at 94, are respectively open with an aperture 46 and closed at the opposite extremity to provide the same passage as in the duct members 54. The half ducts at the edges or the ends of the racks provide the desired spacing vertically with respect to the intake ducts to provide the staggered relationship of intake and exhaust duct members which give a maximum circulation of air through the granular material in the tower.

The physical size of the apertures or perforations 85 in the exhaust duct members in this embodiment of the invention, are such that the apertures 85 are smaller than the size of the grain or granular material being dried in the tower. Further, the total cross sectional area of all of the apertures or perforations along the bottom of a duct member 54 or 94, that is in the V shaped member 74 or half member forming the same, will be greater than the cross sectional area of the aperture 46 in the end plate 78 or 90 such that these apertures will not cause any substantial restriction to air flow through the duct. In addition, the sizing of the apertures 85 are such that with the desired velocity of the drying air through the grain, no grain and very little dust from the grain will be carried through exhaust apertures or holes 46 to the atmosphere through the surface of the tower 45. Similarly, the angle of the bottom V shaped member 74 of the exhaust tubular members or ducts 54 may be substantially the same as the top members or slightly less than the angle that the top V shaped members make to the horizontal. The grain flowing through the tower due to the continuous movement of the same and its moisture content will provide for exerting a pressure on the V shaped pre-formed steel tubular structures to wipe the surface clean, keeping the perforations or apertures 85 from being plugged by the grain particles.

Thus, the exhaust duct permits an increased volume of drying air flow through a given quantity of grain to decrease the drying time of the same. The open intake ducts permit a uniform flow of air through the grain as indicated by the arrows or lines 56, 57 in FIGURE 3 to the exhaust ducts 54 and 94 which air flow will pick up moisture from the granular material and exhaust it to atmosphere without removing the grain from the tower or blowing dust or particles in the grain through the exhaust ducts 54, 94 to atmosphere.

In the preferred embodiment of the present invention,

the warm drying air is transmitted through the intake racks **14** or the tubular ducts **52** thereof by virtue of the holes **70** in the ends of the ducts or the caps **68** forming the same to allow the air to travel along the extent of the V shaped duct member **60** and through the grain or granular material to the vertically adjacent exhaust racks. This air flow will enter the exhaust duct members through the perforations **85** therein carrying the moisture away from the grain, which moisture laden air will be exhausted through the exhaust ports or holes **46** in the surface **45** of the tower. The volume of air that can normally be forced through the grain to remove the moisture from the grain is normally restricted by the velocity of the air as it leaves the grain and is exhausted through the exhaust opening. In prior air dryers, this maximum velocity for different grain materials and dryer designs was limited to the range under 3,000 feet per minute. At velocities above these figures, the grain became airborne and was blown out of the dryer. With the present invention and the specific design of the exhaust racks, the enclosed exhaust tubular members **54**, **94** with the perforations or apertures **85** therein prevent the discharge of grain or particles thereof through the exhaust ducts to atmosphere while permitting a substantially higher velocity of drying air through the grain to reduce drying time and to remove more moisture. Since the total open area of all of the openings or the perforations **85** in a single rack are sufficiently greater than the area of the exhaust holes **46** in a rack, the perforations do not offer any substantial restriction or resistance to the drying air flow through the grain. The tubular members are V shaped at such an angle that the flow of the granular material will follow along the sides of each of the tubular members uniformly distributing the grain flow for maximum drying efficiency and at the same time providing for movement of the grain across the perforations to prevent plugging of the perforations or apertures **85**. The cooling section of the tower provides for a cooling of the grain as it moves through the dryer to prevent spoilage and the discharge section as well as the intake section provide for uniform flow and distribution of the grain through the drying racks of the tower.

An alternate construction for an intake rack **14** replaces the ducts **52** with an identical design of that of the exhaust rack using tubular members **54**. Thus as an alternate construction, the tubular members forming the intake and exhaust racks **14**, **12** would both be completely enclosed except for the perforations on the bottom of the tubular ducts which perforations would be of such size as to retain the grain from entering the exhaust ducts to be discharged to atmosphere while offering substantially no impedance or resistance to drying air flow, either heating or cooling in the tower.

As a still further alternate embodiment of the improved air dryer, an exhaust duct **97** may be formed as shown in FIGURE 8, with two V shaped members **72'**, **74'** having perforations **98** in both the top and bottom V shaped members to allow for a still greater flow of air into the exhaust tubular members. In this embodiment, the apertures or perforations **98** would be smaller than the size of the granular material and be uniformly distributed along the extent of the tubular member. Grain flow across the same by virtue of the vertical movement of the grain from the inlet port **16** to the outlet port **22** of the tower would provide a wiping action across the perforations to prevent plugging of the perforations or apertures therein. This construction would be also utilized for the intake duct members in the intake racks **14** of the tower. When both the intake and exhaust ducts are formed in the manner of the duct shown at **97**, a slightly different air flow pattern is provided inasmuch as the intake air can be exhausted from the tubular member through the perforations **98** therein in all directions and will be received by vertically adjacent tubular members in accordance with and in proportion to the resistance to flow of the drying air in the grain.

In the preferred construction of the improved grain dryer, the duct members of the intake and exhaust racks **14** and **12** are formed from sheet metal material through a conventional cutting and bending operation and attached to similarly formed end caps to provide the assembled duct members. Such duct members may be assembled to exhaust and intake racks merely by positioning the same in a side by side relationship and connecting the respective end caps through their flanges through suitable means. Similarly, the tower construction may be completed by the attaching of intake and exhaust racks through the flanges of the end caps to provide a complete structure of alternate intake and exhaust racks with the intake and exhaust apertures or holes positioned on opposite surfaces thereof. A tower so assembled is fed by an air plenum connected directly to a tower frame. The exhaust side of the tower may include a suitable wall portion with accompanying apertures, or the exposed ends of the racks with the holes **46** therein. The various duct configurations, that is the shape of the duct and the respective open and closed constructions, will provide for increased air flow above that normally obtainable in present day dryers to increase drying efficiency in the drying tower.

In considering this invention it should be remembered that the present disclosure is intended to be illustrative only and the actual materials, constructional details and the variations in form of the same are intended to be illustrative only. Therefore the scope of the invention should be determined by the appended claims.

We claim:

1. A dryer for granular material having a tower with an inlet port at the top thereof and an outlet port at the bottom thereof and a plurality of racks of tubular members uniformly spaced between said inlet and outlet ports and adapted to convey drying air into and out of said tower and through the granular material which is moved in the tower from the inlet port to outlet port, the improvement comprising duct members in certain of said racks forming exhaust ducts for the drying air circulated through said tower, said duct members in said exhaust racks being formed of a pair of V shaped elongated members positioned to form V shaped tops and bottom and with parallel sides, a plurality of apertures positioned along the bottom V shaped elongated members which apertures are smaller than the size of the granular material which flows through said tower from the inlet to the outlet port thereof, and aperture means at one end of each of said duct members forming exhaust ports in which the cross sectional area of the aperture is less than the total cross sectional area of all of the apertures in a bottom V shaped elongated member.

2. The structure of claim **1** in which the duct members in the exhaust rack include end caps to which the V shaped elongated members are attached to form the enclosed tubular structure and with one of the end caps having the exhaust port therein and in which the end caps have flanges to permit adjacent duct members to be connected to one another to form the exhaust rack with the tubular members being uniformly spaced apart and parallel to one another.

3. The structure of claim **2** in which the V shaped members forming the duct members of the exhaust rack are shaped to distribute flow of the granular material uniformly to both sides of the duct member as the granular material flows past the exhaust rack.

4. A dryer for granular material comprising, a rectangular tower having an inlet port at the top thereof and an outlet port at the bottom thereof, a plurality of horizontal racks positioned across the tower between two sides thereof and spaced vertically from one another, each of said racks containing a row of parallel spaced duct members with the duct members of each row being spaced between duct members in adjacent rows, each of the duct members in a rack being closed at the same extremity with alternate rows being closed at opposite extremities to provide respectively intake and

exhaust racks of duct members, plenum means connected to one side of said tower and in common with the intake duct racks to discharge tempered air into said duct members of the intake racks, the duct members in the exhaust racks on the adjacent rows with their ends closed to said plenum being opened at the opposite extremity through the opposite side of said tower to form air discharge openings for the exhaust racks, all of said duct members having tops shaped to distribute flow of granular material substantially uniformly to both sides of said duct members, and the duct members forming the air discharge ducts in the exhaust racks being completely enclosed within the tower and having a plurality of apertures along the bottom surface thereof which apertures are smaller than the size of the granular material adapted to flow through said tower from said inlet to said outlet port, the total area of the plurality of apertures in each duct member in each of the exhaust racks being greater than the cross-sectional area of the discharge opening at the end of each duct member in the exhaust rack, said duct members in the exhaust racks being formed of two V shaped members connected together at their outer edges to form V shaped tops and bottoms with parallel sides in between and with the angle of V shaped design to the horizontal being greater than the natural angle of repose of the granular material flowing in the dryer and with the perforations in the bottom V member of the tubular member being smaller than the size of the granular material flowing in the dryer such that the grain pressure against the walls wipes the walls and keeps the perforations free from plugging with the grain material.

5. The dryer of claim 4 in which the apertures in the bottom of the exhaust duct members are small enough in size as to preclude the entrance of grain material therein but large enough to offer no appreciable additional resistance to air flow from said inlet ducts to atmosphere.

6. The dryer of claim 5 in which the duct members are formed of thin sheet metal material bent to form V shaped configuration in the duct member.

7. The dryer of claim 6 in which the exhaust duct members adjacent the opposite side walls of the tower remote from the plenum and the openings in the exhaust racks are half ducts.

8. The dryer of claim 6 in which the V shaped members forming the tubular members are connected to end caps in which one end cap has an aperture therein and the other end cap is closed to form the completed duct member and in which the end caps are attached to one another to form the racks extending across the tower.

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