

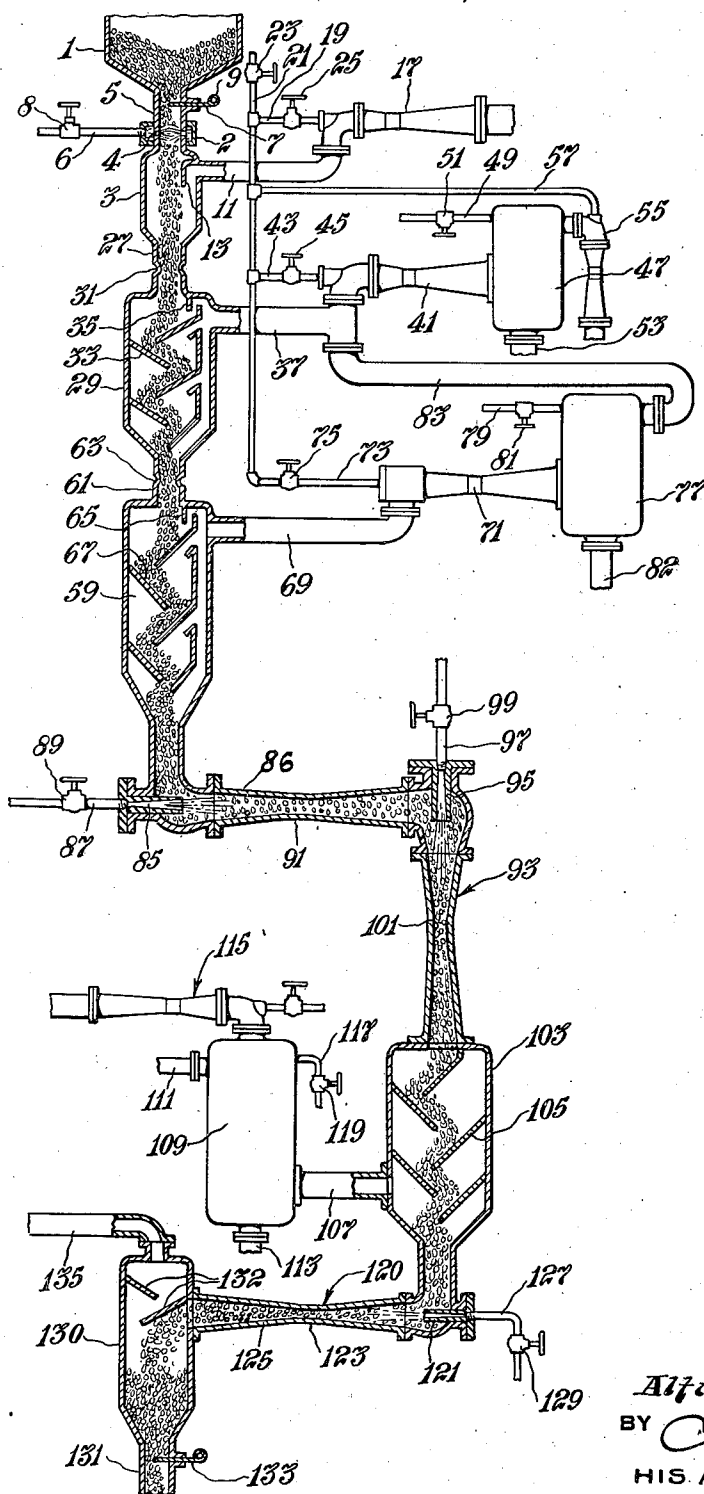
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VACUUM MOISTENING APPARATUS

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VACUUM MOISTENING APPARATUS

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This invention relates to a vacuum moistening apparatus, and, more particularly, to an apparatus for processing grain, and the like, by removing fluids and moisture entrained in the grain and moistening the grain.

As a part of the manufacture of certain grain products, it is desirable to treat the grain in its natural state to remove fluids, kill or remove harmful bacteria, fungi, and the like, and to moisten the grain. This is accomplished by wetting the grain and subjecting it to a low absolute pressure to remove air and inherent moisture in the grain, heating the grain to drive off any air remaining and kill living organisms and further moisten the grain so that it will have a predetermined desired moisture content.

Apparatus for processing grain in this manner may be divided into two general types, the batch type and the continuous type. In the batch type the grain must be inserted in the apparatus while the apparatus is inactive and, after processing, the apparatus must be rendered inactive before the grain can be removed. In the continuous type of apparatus, the grain is processed as it flows through the apparatus. In this form the grain is continuously fed to the apparatus for processing and is continuously being discharged from the apparatus after processing. This latter type of apparatus, needless to say, will handle a greater quantity of grain for a given period of time and requires much less attention to operate.

The present invention relates to the continuous type of apparatus and an object of the invention is to provide such apparatus in which the grain is processed as it flows therethrough.

Another object is to provide a grain processing apparatus of the continuous flow type wherein the grain is subjected to a vacuum.

A further object is to provide a grain processing apparatus of the continuous flow type wherein the medium employed to heat the grain assists in the movement of the grain through the apparatus.

Still another object is to provide a grain processing apparatus wherein the force of gravity is utilized to move the grain through the apparatus.

Yet another object is to provide a grain processing apparatus of the continuous flow type wherein the grain is sprayed with water before it is subjected to a low absolute pressure, or while it is under a low absolute pressure, and is then heated and moistened before being subjected to atmospheric pressure prior to discharge from the apparatus.

Another object is to provide a grain processing

apparatus which is simple and economical to operate and requires a minimum of attention.

These and other objects will appear from the following description of which the drawing forms a part.

In the drawing, the bin, or hopper, 1 is designed to receive the grain to be processed from a grain elevator or a continuous belt. Directly below the bin 1 is a primary evacuating chamber 3 to which the bin is connected by the throat 5.

Extending through the wall of the throat is a damper, or gate 7, provided with a handle 9. This damper serves to control the rate of flow of the grain from the hopper 1 to the primary evacuating chamber 3 and the distance that it extends into the throat 5 is slidably adjustable.

Surrounding the throat at a point below the damper is an annular casing 2 which communicates with the interior of the throat through the orifices 4 formed in the wall of the throat. Water is supplied to this casing through the water supply line 6 and the rate of flow is governed by the valve 8. With this arrangement it is possible to spray the grain flowing through the throat with water.

At one side of the primary evacuating chamber 3 is the conduit 11 opening into the chamber. A lip 13 is formed in this chamber so as to protect the conduit 11 and prevent any grain from falling into this conduit. At the other end of the conduit is the steam evacuator 17. The steam evacuator is shown as discharging to the atmosphere but, if it is desirable, it may discharge to an after-condenser (not shown).

Steam to actuate the evacuator 17 is supplied through the pipe 19 which is connected to the steam supply conduit 21. Appropriate valves 23 and 25 are provided respectively in the steam supply conduit 21 and the pipe 19 so that the flow of steam therethrough may be controlled.

The evacuator 17 serves to remove air and some moisture in the primary evacuating chamber, and may be of such design that the pressure in the evacuating chamber 3 will be constantly maintained at 15" of mercury absolute pressure.

The second throat 27 connects the primary evacuating chamber 3 with the secondary evacuating chamber 29. A restriction 31 formed by an annular depression in the wall of the throat 27 serves to keep the throat full of grain and retard the leakage of air from primary evacuating chamber 3 to evacuating chamber 29. Within the secondary evacuating chamber 29 are placed baffles 33 to lengthen the path of the grain through the chamber.

The chamber 29 is provided with a lip 35 corresponding to the lip 13 in chamber 3 and the baffles 33 are so designed as to prevent any possibility of the grain entering the conduit 37 that opens into the chamber at one side thereof.

The conduit 37 is connected to a secondary steam evacuator 41. The steam evacuator 41 has a supply pipe 43 and control valve 45 through which steam is conducted from the steam supply conduit 21 and to which it is connected.

The discharge from the secondary evacuator 41 is directed to an inter-condenser 47 supplied with water through pipe 49 having a regulating valve 51 and discharging the water and condensate from the tail-pipe, or drain, 53 to a sump or sewer line (not shown).

Obviously, there will be some non-condensable gases discharged to the inter-condenser 47 and, in order to remove these gases, the steam ejector 55 is appropriately connected at one side to the inter-condenser. Steam is supplied to actuate this ejector through the pipe 57 connected directly with the steam supply conduit 21.

A third or tertiary evacuating chamber 59 lies below the secondary evacuating chamber 29 and is connected thereto by the throat 61 having a restriction 63 similar to the restriction 31 in the throat 27. This chamber is provided with a lip 65 and baffle plates 67 in the same manner as the secondary evacuating chamber 29. It also has a communicating conduit 69 which corresponds to the conduits 11 and 37 to connect the chamber with a tertiary steam evacuator 71 corresponding to evacuators 17 and 41. Steam is supplied to actuate the evacuator 71 through pipe 73 and the flow there-through is controlled by an appropriate valve 75.

The condenser 77 receives the discharge from the evacuator 71 and the condenser is cooled by cooling water supplied through the cooling water supply line 79 having a control valve 81. Condensate and cooling water are discharged from the condenser 77 through the tail, or discharge pipe, 82. The non-condensable gases in the condenser 77 are removed therefrom by the secondary steam evacuator 41 which communicates directly therewith by means of the pipe 83.

With this arrangement the grain flows by gravity from the bin 1 through the throat 5 to the primary evacuating chamber 3. The rate of flow, as above pointed out, is regulated by the damper 7 and, as the grain flows through the throat, it is moistened by the water sprayed thereon from the orifices 4. The reason for spraying water on the grain is to moisten the grain so that water will fill the interstices between the individual grains and minimize fluid leakage through the grain as it passes through throat 5 from a zone of high pressure (atmosphere) to a zone of lower pressure (chamber 3). In other words, the grain is moistened and the damper provided in order to have an "air lock" between the bin 1 and the chamber 3 which is merely a means to prevent the flow of air there-between through the throat 5. Of course, any form of flow controlling device such as rotary vanes (not shown) may be used and the damper is only one illustration. If this were not done, there would be a continual fluctuation of pressure in chamber 3 since air at atmospheric pressure would enter with the grain.

As the grain flows through chamber 3 a certain amount of this surface moisture will evaporate and be removed, but sufficient surface moisture will remain on the grain so that there

will be no substantial leakage through throats 27 and 61 between their respective connected evaporating chambers as the grain flows there-through, thus preventing any tendency toward equalization of pressures in the evaporating chambers.

During operation of the apparatus the evacuators are constantly removing fluid from the evaporating chambers and, as the pressure in each successive chamber is lower than the pressure of the preceding chamber, a portion of the surface moisture on the grain is evaporated whenever the grain, in its flow through the apparatus, reaches a zone of low pressure, that is, when the vapor pressure of the surface moisture exceeds the vapor pressure existing in such zone, evaporation of a portion of the surface moisture occurs and equalizes the vapor pressure of the surface moisture with the vapor pressure of the zone. Evaporation of this moisture results in cooling the surface of the grain but this cooling does not affect the interior of the grain particles due to the insulating properties of the grain. The surface moisture evaporation will continue until the temperature has been lowered to such an extent that vapor pressure is materially decreased. When this occurs, practically none of the remaining water on the grain surfaces can be evaporated or removed. However, throughout the process, the lowering of the temperature of the water on the grain surface has no material effect on the temperature of the inherent moisture in the grain which is at a higher temperature. Consequently, the inherent moisture will flash and escape from the grain and will carry with it any air present in the kernels of the grain.

As a result, when the grain is finally discharged from the tertiary evacuating chamber practically all of the air and some of the inherent moisture in the grain will have been removed but some of the moisture on the grain surfaces will remain.

During the above procedure the grain will have been moved through the apparatus by gravity, assisted by the difference in pressure existing between the successive evaporating chambers, but, as will be seen from the drawing, at the discharge end of the tertiary evacuating chamber a steam nozzle 85 is provided in the steam ejector, generally indicated at 86, to which steam is led by the conduit 87 in order to continue the movement of the grain. An appropriate regulating valve 89 controls the introduction of steam into the grain and the steam propels the grain through the throat 91 to the inlet of the steam ejector, generally indicated at 93.

The steam ejector 93 comprises a nozzle 95, appropriately supplied with steam through the pipe 97 and valve 99, and the throat, or diffuser, 101. The discharge end of the steam ejector 93 communicates directly with a steam chamber 103 having baffles 105 to lengthen the path of travel of the grain therethrough. In this manner the nozzle 95 directs steam into the grain and carries it to the steam ejector 93, which in turn propels the grain, while moistening it, into the steaming chamber 103. Thus, the steam not only moves the grain through the apparatus, but it also serves to drive the surface moisture into the grain in order that the desired moisture content may be obtained.

Near the lower portion of the steaming chamber 103 is a connection 107 opening into the condenser 109 and through which the steaming

chamber communicates with the condenser 109. Cooling water is supplied to the condenser 109 by the inlet 111 and is removed with the condensed liquids through the tail-pipe 113 to an appropriate sump (not shown). At the top of the condenser is a steam ejector 115 to remove non-condensable gases and discharge them to the atmosphere in the same manner as the ejector 55.

When the grain leaves the tertiary evacuator chamber it is at a low absolute pressure, and although the addition of the steam supplied through nozzles 85 and 95 will tend to increase this pressure, the pressure in the steam chamber 103 will not increase to atmospheric pressure. The pressure or vacuum in the steam chamber may be increased or decreased by adjusting valve 119 in the air bleed pipe 117 provided at the top of condenser 109. Thus, the amount of vacuum in the steaming chamber may be constantly controlled so that the pressure of the steam necessary to moisten the grain may be attained.

Upon reaching the bottom of the steaming chamber 103, the grain has been thoroughly moistened and, since the excess steam not necessary for moistening is removed to the condenser 109, the grain is now ready to be discharged from the apparatus. At this point the grain being at a low absolute pressure must be re-subjected to atmospheric pressure before discharging it from the apparatus. To this end the ejector 120 having a nozzle 121 is located at the bottom of the steaming chamber 103 and is arranged to direct its exhaust through a throat 123 and diffuser 125.

Instead of actuating the ejector 120 by steam which would further moisten and overheat the grain, the nozzle 121 is supplied with a fluid such as air under pressure by the pipe 127 controlled by the valve 129. The air under pressure discharged from the nozzle will force the grain through the throat 123 and diffuser 125 into the atmospheric chamber 130. The expansion of the compressed air through nozzle 121 will result in considerable reduction of temperature, which in turn will cool the grain and prevent undue loss of moisture during and after ejection. At the top of this chamber is an air vent line 135 and within the chamber are plates 132 so disposed that any grain blown out of the diffuser into the chamber cannot be blown up into this air vent to be lost, or retard the discharge of air.

The bottom of the atmospheric chamber 130 gradually converges into a throat or discharge pipe 131 having a regulating damper 133 similar in construction and function to the damper 7.

With this arrangement, therefore, the grain may be moistened to any particular degree by controlling the amount of steam to which it is subjected by the design of the steam entry nozzles 85 and 95 and by regulation of the pressure in chamber 103, and when the grain is removed from the system it is adequately moistened and at atmospheric pressure.

I claim:

1. In a grain moistening apparatus, the combination of a plurality of chambers arranged vertically in series for continuously moving the grain therethrough by gravity, means to evacuate each chamber to progressively lower pressures, means including a steam ejector to discharge and moisten the grain from the final chamber of said series, and fluid pressure operated means to remove the grain from the last means and subject the grain to atmospheric pressure.

2. In a grain moistening apparatus, the com-

bination of a plurality of chambers arranged vertically in series for continuously moving the grain therethrough, means to reduce the pressure in each chamber to a lower pressure than the pressure of the preceding chamber of said series, a steaming chamber for moistening the grain, steam ejector means to remove the grain from the last said chamber of said series and discharge it to said steam chamber, a discharge chamber, and means to remove the grain from the steam chamber and discharge it to the discharge chamber wherein the grain is subjected to atmospheric pressure.

3. In a grain moistening apparatus, the combination of a series of vertically arranged chambers for continuously moving the grain therethrough by gravity, evacuators for the chambers, an ejector to remove said grain from the final chamber of said series, a grain moistening chamber to receive the grain removed from said series of chambers by the ejectors, a motivating ejector to remove the grain from the moistening chamber, and a delivery chamber to receive the grain from the motivating ejector and subject it to atmospheric pressure.

4. In a grain moistening apparatus, the combination of a grain hopper, a primary evacuating chamber arranged to receive grain from the hopper, a secondary evaporating chamber arranged to receive grain from the primary evaporating chamber, a tertiary evaporating chamber arranged to receive grain from the secondary evaporating chamber, evacuators to reduce the pressure in each said chamber adapted to reduce the pressure in said secondary ejector to a pressure less than the pressure in the primary chamber and in the tertiary chamber to a pressure less than the pressure in the secondary chamber, a steaming chamber to moisten the grain, steam ejectors to remove the grain from the tertiary chamber and discharge it to the steam chamber, a discharge chamber vented to atmospheric pressure, and an air actuated ejector to remove grain from the steam chamber, cool it and discharge it to the discharge chamber wherein the grain is subjected to atmospheric pressure before removal therefrom.

5. In a grain moistening apparatus, the combination of a plurality of chambers arranged in series to receive the grain, evacuators to reduce the pressure in each chamber to a pressure lower than the pressure of the preceding chamber of said series, a steam chamber, a pair of steam actuated ejectors to remove the grain from the last chamber of the series and discharge it to the steam chamber wherein the grain is moistened, a discharge chamber open to atmosphere, and an air actuated ejector to remove the grain from the steam chamber, cool it and discharge it to the discharge chamber wherein the grain is subjected to atmospheric pressure before removal therefrom.

6. In a grain moistening apparatus, the combination of a plurality of chambers arranged vertically in series for continuously moving the grain therethrough by gravity, means to wet the surface of the grain before entry into the chambers, means to evacuate each chamber to a progressively lower pressure than the preceding chamber to remove fluid from the grain passing therethrough, means including a steam ejector to discharge and moisten the grain after discharge from the final chamber of said series, and means to remove the grain from the last means

and subject the grain to atmospheric pressure before discharge from the apparatus.

7. In a grain moistening apparatus, the combination of a plurality of chambers arranged in series to receive the grain, means to wet the surface of the grain before entry into the first chamber of the series, means between adjacent chambers of the series to restrict the flow of grain, evacuators to reduce the pressure in each chamber to a pressure lower than the pressure of the preceding chamber of said series to remove fluid from the grain passing therethrough, a steam chamber, a pair of steam actuated ejectors to remove the grain from the last chamber of the series and discharge it to the steam chamber wherein the grain is moistened, a discharge chamber open to atmosphere, and an air actuated ejector to remove the grain from the steaming chamber, cool it and discharge it to the discharge chamber wherein the grain is subjected to atmospheric pressure before removal therefrom.

8. In a grain moistening apparatus, the combination of a grain hopper, a primary evacuating chamber arranged to receive grain from the hopper, means to wet the surface of the grain before entry into the primary evacuating cham-

ber, a secondary evaporating chamber to receive grain from the primary evaporating chamber, means between the primary evacuating chamber and the secondary evaporating chamber to restrict the flow of grain, a tertiary evaporating chamber arranged to receive grain from the secondary evaporating chamber, means between the second evaporating chamber and the tertiary evaporating chamber to restrict the flow of grain, evacuators to reduce the pressure in each said chamber adapted to reduce the pressure in said secondary ejector to a pressure less than the pressure in the primary chamber and in the tertiary chamber to a pressure less than the pressure in the secondary chamber to remove fluid from the grain passing therethrough, a steaming chamber to moisten the grain, steam ejectors to remove the grain from the tertiary chamber and discharge it to the steaming chamber, a discharge chamber vented to atmospheric pressure, and an air actuated ejector to remove grain from the steam chamber and cool and discharge the grain to the discharge chamber wherein the grain is subjected to atmospheric pressure before removal therefrom.

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