May 7, 1929. E. S. MILLER 1,711,574

METHOD AND APPARATUS FOR CONDITIONING GRAIN

Filed April 19, 1927

Fig. 1.

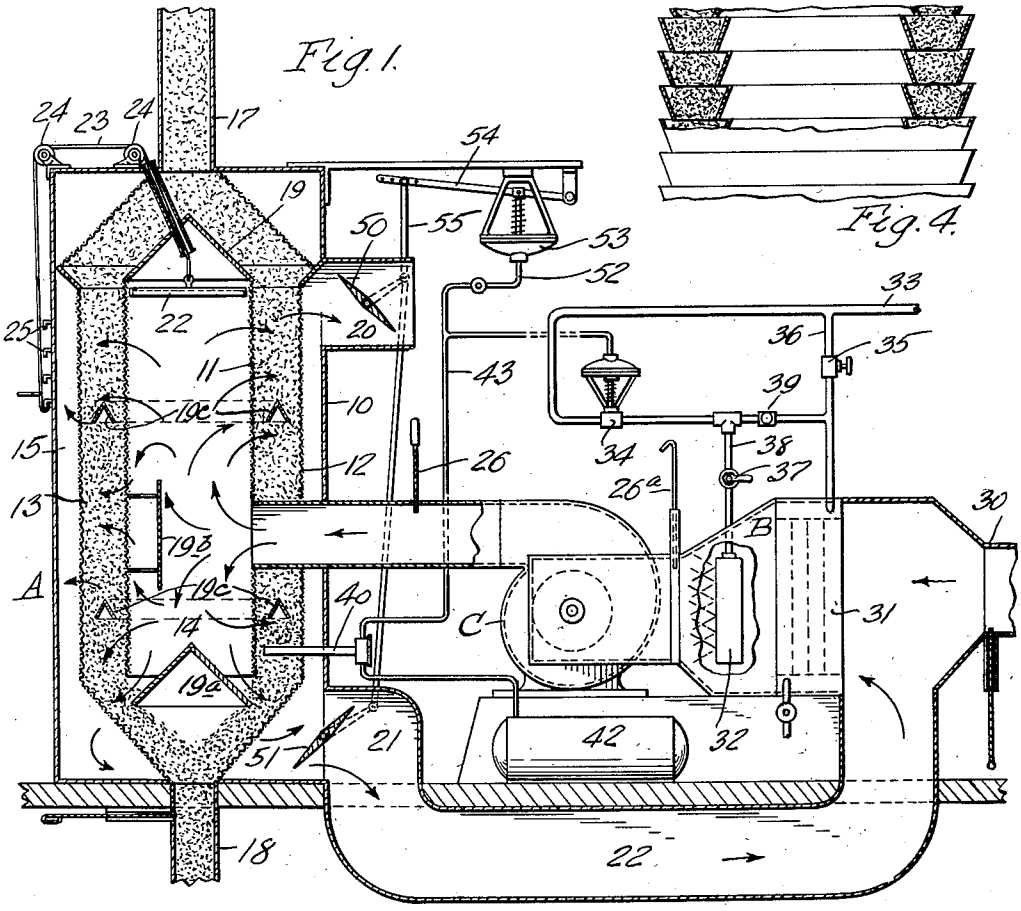
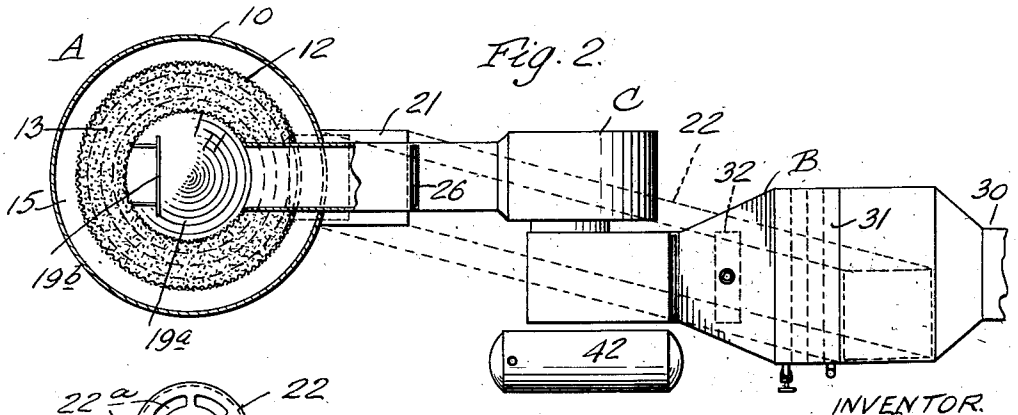


Fig. 4.

Fig. 2.



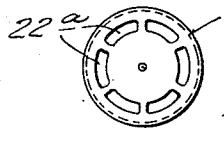


Fig. 3.

INVENTOR.
Edgar S. Miller
by Parker & Prochnow
ATTORNEYS.

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UNITED STATES PATENT OFFICE.

EDGAR S. MILLER, OF KANSAS CITY, KANSAS, ASSIGNOR TO CARRIER ENGINEERING CORPORATION, OF NEWARK, NEW JERSEY.

METHOD AND APPARATUS FOR CONDITIONING GRAIN.

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It is a fact well known to those familiar with the process of manufacturing flour from wheat and other grains that the optimum condition for facilitating the reduction and separation of the grain into flour and by-products is dependent upon the temperature and moisture content of the grain and upon the distribution of the moisture within the individual kernels. It is also well recognized that these factors cannot be predetermined with any considerable degree of accuracy.

According to the present practices, the grain is usually dampened with water some hours before the milling operation is begun, the purpose being the mellowing of the interior portions, known as the endosperm, thus making the outer covering, or bran-coat and the germ, comparatively more resistant to disintegration than is the endosperm. If insufficient moisture is used, or if the grain is reduced when its temperature is rather low, the bran-coat and germ tend to pulverize, making their separation from the pulverized endosperm very difficult or impossible. Under such conditions the flour contains much pulverized bran or germ, resulting in a deterioration of color and an increase of certain substances inimical to the proper development of the doughs made from such flour. These so-called impurities are detected as ash, procured by burning a portion of the flour under certain well-known conditions. On the other hand, when too much moisture is used in tempering the grain, two distinct objectionable results follow: The endosperm is rendered soft and cohesive, making its reduction and separation difficult, and the bran-coat and germ, and particles thereof are made somewhat adhesive by the presence of free moisture upon their surfaces. Either condition results in a poor flour yield. The endosperm particles, being somewhat platic, resist reduction. Even when reduced, they tend to "lump," preventing their free passage through the meshes of the bolting medium. Passing over the cloth and to the subsequent operations, many of them find their way to by-products, thus increasing the percentage of feed and decreasing the percentage of flour. The particles of bran-coat and germ, in their passage over the separating medium in company with the particles of endosperm, carry many of these with them, because the moisture present upon the surfaces of the bran-and-germ particles render them somewhat adhesive.

A too high temperature in the grain also renders the endosperm particles soft and pliant, retarding reduction and interfering with the proper separation. This condition also results in a low flour yield.

It is well known that the individual kernels of wheat and other grains vary greatly in physical characteristics. Both in the so-called hard grains and in the so-called soft grains, particularly in wheats, a wide difference in specific weight of endosperm, due to a more or less compact structure, obtains. The experienced miller knows that the hardest kernels require the most moisture for bringing about an optimum physical condition for milling, and that the softest berries require the least. Those of intermediate structure naturally require proportionate amounts of moisture. Further, since heat also tends to soften the grains, the hardest berries should be the warmest, and the softest berries the coolest, with those of intermediate structure at proportionate temperatures. It is a well established fact that moisture will penetrate a soft berry more quickly than a hard one, and also that the diffusion of moisture from a soft kernel is at a higher rate than it is from the hard grains. Moreover, moisture penetration is hastened when the quantity of available moisture, in the form of water, is large.

In the usual method of heating grain, the kernels are brought into contact with some comparatively hot surface, such as metal heated by steam, water or other heating medium. Since only a small portion of the surface of the kernels can come in contact with the heated surfaces at one and the same time, it is obvious that certain portions of the grain must become very hot in order to raise the average temperature of the mass to the point desired. This often results in injury to the endosperms, or flour-producing portions of the grain, for it is well known that some of the grain's most valuable constituents will coagulate at temperatures lower than the usual temperatures of the heating surfaces, and that coagulation renders these constituents less valuable.

In carrying out my process, I cause an intimate contact of the grain with air or other gas properly conditioned as to moisture con-

tent and temperature, for which purpose any suitable means of providing the requisite quantity of air or gas having the necessary properties may be employed, and any method and means which will bring this air into contact with the grain for the required period of time and cause a relative motion between this air and the grain mass with a velocity which will cause the temperature of the grain to make a close approach to the wet-bulb temperature of the entering air may be employed.

Heating, cooling and evaporation of moisture from the grain are all accomplished by means of air currents, the quantity of air used, its velocity through the mass of grain, and the properties of the air used being coordinated to the mass and specific heat factor of the grain to secure the results sought.

In my process the grain mass may be employed as a medium for presenting moisture to the air currents passing through it so that, in effect, the grain mass becomes a humidifying device. Air passing through the mass vaporizes a part of the liquid water contained in or on the grain. The heat required for the vaporization of the liquid comes from the air or the grain, and of course, becomes latent. The temperature of the air and of the grain thus tends to conform to the wet bulb temperature of the entering air. When the grain is warmer than the wet bulb temperature of the entering air and is contributing heat to the water being vaporized, the temperature of the grain will automatically approach the wet bulb temperature of the entering air within a few degrees. When the grain is somewhat colder than the wet bulb temperature of the entering air and is receiving heat from the air (which is also providing the heat required for the vaporization of moisture), the temperature of the grain will be somewhat lower than the wet bulb temperature of the entering air, though it will also approach this temperature within a few degrees.

Therefore, in my process the temperature of the grain is controlled by controlling the wet bulb temperature of the entering air. For example, a thermostat placed in the grain mass, or in the air passed through the grain mass, and set for any desired temperature, can be made to increase the wet bulb temperature of the entering air by the operation of controls to a heater and a humidifying device to a point necessary for the maintenance of the given temperature of the grain. Conversely, when the temperature of the grain begins to rise above the desired point, the thermostat will cut off heat from the heaters and moisture from the humidifying device, thus reducing the wet bulb temperature of the entering air in relation to the dry bulb temperature thereof to a point necessary for the maintenance of the given temperature of the grain, or to the point established by natural conditions at that particular time or to any point to which the entering air may be cooled artificially by the provision of cooling means.

Since evaporation of moisture from the grain will depend upon the relation of the dew point temperature to the dry bulb temperature of the entering air, it can be controlled for any desired point within the limits of the apparatus, as for instance, by controlling with a thermostat or humidostat, or both, the heat and percentage of relative humidity of the entering air.

Whether cooling or heating is being accomplished, my process contemplates some evaporation of moisture at all times. If the grain has been made too damp by the usual tempering process, or otherwise, the operator may at will remove any amount of moisture, up to the limits of the apparatus, in a few minutes' time. In summer, when the grain is usually too warm, the maximum evaporation may be had even while reducing the temperature of the grain. This is accomplished by increasing the dry bulb temperature of the entering air without increasing its dew point temperature. The amount of evaporation accomplished in my process is, in fact, controlled by controlling the relation of the dry bulb temperature to the dew point temperature of the entering air. Any amount of evaporation from minimum to maximum may thus be obtained at any time, whether cooling or heating is being accomplished by my process.

If an insufficient amount of moisture has been added to the grain by the usual tempering process, the condition may be rectified by adding considerably more than the deficiency a few minutes before the grain enters the conditioning process, and then evaporating the excess moisture. The comparatively large quantity of water added will cause rapid penetration of the grain. In the period of time required for its passage through the conditioning process, the grain will give up to the air currents only the moisture near the surface, allowing the residue to remain in the endosperm of the grain. No moisture will be present upon the surface of the bran-coat and germ, and adhesion of endosperm particles when the grain is broken will be avoided.

My method of conditioning grain will be further explained in connection with the description of the construction and operation of the apparatus shown in the accompanying drawings as one embodiment of apparatus suitable for carrying out the method. Said apparatus which constitutes part of my invention may be described as follows:

In the accompanying drawings:

Fig. 1 is a diagrammatic, sectional elevation of the apparatus.

Fig. 2 is a sectional plan view thereof on line 2—2, Fig. 1.

Fig. 3 is a plan view of the adjustable disk for regulating the area of contact between the grain and the air.

Fig. 4 is a fragmentary, sectional elevation of a grain conditioner of modified construction.

The apparatus comprises a grain conditioner or device A in which the contact of the grain with the air is produced, an air conditioner or device B in which the air is conditioned to provide the required temperature and moisture content thereof, and a fan or blower C by which the air is circulated through the air conditioner B and the grain conditioner A.

The grain conditioner may comprise, as shown, an outer casing 10 which may be made of sheet metal or other suitable material, and may be of upright cylindrical or other suitable form, and inner and outer walls or shells 11 and 12 which are arranged within the casing 10 and spaced from the latter, and from each other so as to provide between the walls 11 and 12 a space 13 in which the grain is confined and through which preferably the grain is adapted to move or travel during the treatment, and an inner air space or chamber 14 within the inner shell 11 and an outer air space 15 between the outer wall or shell 12 and the casing. The inner and outer walls or shells 11 and 12 may be of any suitable construction or material provided with perforations or openings permitting the passage of the air from one to the other of the air chambers through the grain in the space 13 between the two perforated walls. For instance, these walls can be made of wire mesh material, as indicated in Figs. 1 and 2, or they can be composed of frusto-conical or converging metal rings separated by narrow openings or spaces through which the air can pass, as shown in Fig. 4. In the construction shown, the upper end of the outer wall or shell 11 is contracted and connects with a grain inlet pipe or duct 17, while the lower end of the shell is contracted and connects with a grain outlet pipe or duct 18, and the upper end of the inner wall or shell 11 is provided with an upwardly contracting top or deflector 19 so that the grain is adapted to enter through the inlet pipe 17 and fill the annular grain space 13 and discharge through the lower or outlet pipe 18. An inverted cone 19^a partially closes the lower end of the chamber 14, and also acts as a means of preventing an excessive quantity of air from coming in contact with the exposed surfaces of wheat in the contraction leading to outlet pipe 18. An air deflector plate 19^b is also shown in the chamber 14 opposite the discharge end of the air supply pipe. The discharge or withdrawal of the grain through the outlet pipe can be controlled by any suitable means whereby the movement of the grain through the conditioner can be regulated so as to require a predetermined period of time for its passage through the conditioner A, and the discharge may be operated so as to cause a continuous slow travel or passage of grain through the conditioner. Suitable deflectors 19^c are preferably interposed at intervals in the grain space 13 for the purpose of equalizing the downward flow of the grain.

The fan C discharges the air which has been conditioned in the air conditioner B into the inner chamber 14 of the grain conditioner A in which a pressure is created and from which the air passes through the body of grain in the space 13 into the outer casing 10, from which the air can escape through suitable outlets as 20 or 21. As shown, the outlet 20 permits the escape of the air into the surrounding atmosphere, while the outlet 21 is shown as being connected by a return pipe 22 to the inlet end of the air conditioner B so that if desired, the moisture-ladened air escaping from the casing can be returned to the air conditioner and again used.

The grain conditioner A may be of any other suitable construction, and the area of the grain and air chambers or spaces in the grain conditioner may be varied to suit the existing conditions. The cubical capacity of the grain space or chamber 13 should be sufficient to expose just the proper amount of grain to the air currents for the requisite period of time, and the thickness of the wall of grain interposed to the air passing through the same from one air chamber to the other should be in ratio to the static pressure of the air maintained in the inlet or pressure chamber 14. Means are provided for altering the area of the perforated wall or shell 11 which receives the full pressure of the air coming from the fan in order to bring a greater or less quantity of grain under the influence of the air current to suit the existing conditions. The means shown for this purpose consists of a horizontal disk 22 which is adapted to be adjusted vertically to different elevations in the air pressure chamber 14. The disk shown is provided with apertures 22^a to allow any grain which might fall upon the disk to pass through the same so as to discharge from the grain conditioner. As shown, this disk is supported by a flexible cable or connection 23 which passes through a guide tube in the upper portion of the grain conditioner and over suitable guide pulleys 24 on the top of the casing 10 and is provided at its outer end with a hook adapted to be engaged with retainers 25 on the outside of the vertical wall of the casing 10. The disk can be supported at the desired elevation in the air pressure chamber by engaging the hook on the end of the cable with one or the other of the retainers 25. Any other suitable means for supporting the disk 22 at different elevations in the air pres-

sure chamber may be employed. This adjustable disk enables the operator to adjust the device for a greater or smaller capacity, as may be required by the demands of the mill in which the apparatus is used. When the area of the perforated wall or shell 11 is altered, the required static pressure of the air within the pressure chamber 14 may be readily changed by means of a suitable gate or damper controlling the admission of air from the fan to the grain conditioner. A damper 26 is shown for this purpose in the fan discharge pipe, but the damper could be arranged elsewhere, for instance, in the fan inlet, as indicated at 26a.

The air conditioner B is provided with a fresh air inlet opening 30, and the fan is adapted to draw the air for delivery to the grain conditioner either through this opening or through the return air duct 22, as may be desired. Within the air conditioner is provided a heater 31 for heating the air, and a device 32 for moistening or humidifying the air. In the apparatus shown, steam is employed both for heating and humidifying the air, and the steam is supplied from a pipe 33 to the heater 31 and humidifier 32. An automatically controlled valve 34 controls the supply of steam to both the heater and humidifier, and an additional hand control is also provided for the heater, as by a hand valve 35 arranged in a branch pipe 36 and for the humidifier, as by a hand valve 37 in a branch pipe 38 leading to the humidifier. 39 represents a check valve in the steam supply pipe between the humidifier and the heater.

The automatic valve 34 is controlled by a thermostatic and/or humidostatic regulator 40 of any suitable type which is or are arranged so as to be affected by the temperature of the grain or the condition of the air leaving the grain, or by both. As shown, the regulator 40 extends into the grain in the space 13 in the grain conditioner and controls the passage of compressed air from a compressed air reservoir 42 through a pipe 43 to the diaphragm or motor of the automatic valve 34. The regulator may be set for a desired temperature of the grain or air, and if the temperature rises above or falls below the point for which the regulator is set, the regulator will cause the automatic valve 34 to operate to decrease or increase the supply of steam to the heater 31 and humidifier 32 so as to maintain the condition for which the regulator is set. While in the apparatus shown, steam is used for heating and humidifying the air, the necessary heat may be obtained from any other convenient source such as water, electricity or hot gases, and the air could be humidified by atomized water or an electrical heating device for vaporizing the water into the air current in the air conditioner, in which cases the heating and humidifying devices would be controlled by suitable valves or switches under the control of the regulator 40.

In the apparatus shown, the regulator 40 also controls dampers 50 and 51 which control the escape of air through the outlets 20 and 21 respectively from the casing of the grain conditioner. For this purpose the compressed air pipe 43 is connected by a pipe 52 to an air motor 53, the movement of which is transmitted through a lever 54 and rod 55, or any other suitable mechanism, to the dampers 50 and 51. These dampers 50 and 51 are connected up to the actuating motor so that as one damper closes the other will open. By this means the moisture content of the air being delivered to the grain conditioner may be increased or diminished by using more or less of the moist, return air from the grain conditioner.

The return air and its control mechanism may be used to supplement the action of the humidifier 32, or either the return air control, or the humidifier 32 may be employed independently of the other, in which case the return air control may be dispensed with when the humidifier 32 is employed or the humidifier 32 may be dispensed with when the return air control is used.

When the conditioner is functioning to cool the grain to the capacity of the apparatus, neither heat nor moisture will be added to the air being delivered to the grain conditioner. The velocity of air passing through the wall of grain must be adjusted exactly to the requirements. The requisite velocity is obtained by adjustment of the disk 22 to vary the area of the perforated wall 11 receiving the full pressure of the air from the pressure chamber 14 and regulating the static pressure of the air in this chamber by appropriate adjustments of the dampers 26 or 26a in the air ducts. The quantity of air passing through the wall of grain may thus be regulated to provide just sufficient evaporation of moisture from the grain to absorb from it sufficient heat, as latent heat of vaporization, to produce the desired temperature of the grain within the limits of the apparatus. When considerable evaporation of moisture from the grain is required, as for rectifying a too wet condition of the grain, the heater 31 may be manipulated by the operator to cause a rise in the dry bulb temperature of the air delivered to the grain conditioner A without raising the dew point temperature of this air. This can be accomplished by adjustment of the hand valve 35 in the apparatus shown, by which more or less steam can be admitted to the heater.

When the apparatus is functioning to heat the grain, the amount of evaporation may be regulated by the operator by introducing more or less moisture into the air delivered to the grain conditioner. This can be accomplished by appropriate adjustment of the

hand valve 37 controlling the supply of steam to the humidifier 32, or by other suitable means for varying the humidification of the air in the air conditioner. The moisture content of the air may also be controlled by controlling the amount of return air used, for which purpose the operator can appropriately adjust the air dampers 50 and 51, which may be constructed in any suitable manner to permit the hand adjustment thereof.

By the apparatus described, the pressure of the air in the air pressure chamber 14 and the flow of the air from this chamber through the grain can be regulated so as to control, as desired, the rate of flow of the air through the body of grain, and the length of time of contact of the air with the grain, and both the temperature and the moisture content of the air can be regulated to give the required dry bulb and wet bulb or dew point temperatures of the air in contact with the grain.

In the hereindescribed process for conditioning wheat and other grains, I provide means for altering the moisture content and the temperature of the grain shortly before the milling operation is begun, or at any time preceding the milling operation. By this process the miller may remove the required amount of moisture from grain which is too wet in a few minutes' time, or he may add to the moisture content of grain which is too dry a few minutes before it comes to the conditioning apparatus and then evaporate a certain amount of moisture from the grain. In this way he may insure that the necessary amount of moisture will actually penetrate the berries, since the processing apparatus will remove the excess moisture from the exterior of the grain. The complete operation may be accomplished in a few minutes instead of the usual few or several hours' time previous to the beginning of the milling operation. By my process the temperature of the grain may be altered in a few minutes, cooling it when its temperature is too high and warming it when the temperature is too low. My process contemplates the heating of the grain by surrounding each kernel with warm air with a controlled percentage of relative humidity. The wet bulb temperature of this air will be but a few degrees higher than the temperature desired in the grain.

Since it is known that diffusion of moisture is most rapid in grains having a loose texture of endosperm, my process contemplates the removal of the most moisture from the softest kernels, and the least from the hardest ones, with proportionate moisture removal from those kernels having an intermediate texture. Moreover, since the temperature of each individual kernel being processed must be in exact ratio to the amount of moisture evaporated from it during the process, my process will remove the most heat from the softest berries and the least heat from the hardest ones, with proportionate heat removal from those having intermediate textures. My process contemplates delivery of the softest kernels with the least moisture and the lowest temperature, the hardest kernels with the most moisture and the highest temperature, with proportionate percentages of moisture and with proportionate temperatures in the kernels with intermediate textures.

For the reasons hereinbefore explained, and because the atmospheric conditions prevailing during the period when the actual milling operation is being performed often make a modification of moisture or temperature, or both, desirable, a wide range of temperatures and percentages of moisture in the grain are required to meet varying conditions. The nature of the milling process also determines to some extent the optimum condition of moistures and temperatures in the grain being milled. For example, the more severe the treatment undergone by the grain and its constituents in their passage through the mill, the greater the amount of heat that will be generated by the machines accomplishing the reductions. Since some of this heat will be transmitted to the stocks, it is apparent that the milling process will tend to raise their temperatures, more or less, according to the severity of the treatment accorded them. This may make a lower or a higher initial temperature of the grain desirable.

Working under normal conditions of atmosphere, and with what may be termed a conventional American milling program, grinding a so-called hard American wheat the majority of the kernels of which are of a texture usually designated as "vitreous", an average temperature of about 80 degrees F., and an average moisture content of about 15 percent in the wheat mass provides conditions very nearly ideal. With a much softer variety of grain, or under different atmospheric conditions, a much lower temperature, or a lower percentage of moisture in the grain might be desirable. Conversely, when a much harder grain is being milled, or when atmospheric conditions are such that evaporation for the products of the broken grain is too high or too low, higher temperatures with higher percentages of moisture, or higher percentages of moisture with either a higher or lower temperature may sometimes be required. Different systems of milling may also require different combinations of temperature and moisture in the mass of grain.

My process contemplates a manipulation of moisture content and temperature of the grain previous to the beginning of the reducing and separating process. The most desirable conditions of moisture and temperature of the grain to be milled cannot be stated with accuracy because of the wide differences

of physical structure presented by grains of different types, because of the wide variation in the various milling programs and in milling practice, and because atmospheric conditions are often variable, but my process enables the operator to provide a physical condition in the grain suitable to any and every condition likely to be encountered in a commercial milling establishment.

As used in the claims, the term "air" is to be understood to include other gaseous mediums capable of being conditioned and operating to condition the grain as to its temperature and moisture content in the manner hereinbefore described.

I claim as my invention:

1. The hereindescribed method of conditioning grain which comprises subjecting grain to intimate contact with air, controlling the treatment of the grain by the air so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and regulating the wet bulb temperature of the air so as to obtain a desired temperature of the grain.

2. The hereindescribed method of conditioning grain which comprises causing an intimate contact of the grain with a current of air in the presence of moisture controlling the treatment of the grain by the air so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and regulating the wet bulb temperature of the air so as to obtain a desired temperature of the grain.

3. The hereindescribed method of conditioning grain which comprises subjecting grain to contact with a current of air so that the air is caused to pass through the grain, and controlling the rate of flow of the air through the grain and the period of contact of the air with the grain, so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and regulating the wet bulb temperature of the air so as to obtain a desired temperature of the grain.

4. The hereindescribed method of conditioning grain which comprises causing a current of air to flow through a mass of grain, controlling the pressure and the area of contact of the air with the mass of grain, so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and regulating the wet bulb temperature of the air so as to obtain a desired temperature of the grain.

5. The hereindescribed method of conditioning grain which comprises causing a current of air to flow through a moving stream of grain, controlling the period of contact of the air with the grain, so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and regulating the wet bulb temperature of the air so as to obtain a desired temperature of the grain.

6. The hereindescribed method of conditioning grain which comprises subjecting grain to contact with a current of air, controlling the treatment of the grain by the air so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and automatically regulating the wet bulb temperature of the entering air so as to obtain a desired temperature of the grain.

7. The hereindescribed method of conditioning grain which comprises subjecting grain to contact with a current of air, controlling the passage of the air through the grain, so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and conditioning the air under the control of the temperature of the grain so as to obtain a desired temperature of the grain.

8. The hereindescribed method of conditioning grain which comprises passing a current of air through the grain, regulating the rate of flow of the air through the grain and the period of contact of the air with the grain, so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and regulating the condition of the air so as to obtain a desired temperature of the grain.

9. The hereindescribed method of conditioning grain which comprises subjecting grain to contact with a current of air, controlling the treatment of the grain by the air so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and regulating relation between the dry bulb temperature and the dew point of the entering air to obtain a desired moisture content of the grain.

10. The hereindescribed method of conditioning grain which comprises first moistening the grain so that the grain will contain an excess of moisture, then subjecting the grain to contact with a current of air for evaporating a portion of the moisture from the grain, controlling the treatment of the grain by the air so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and controlling the temperature of the grain by regulating the wet bulb temperature of the entering air.

11. The hereindescribed method of conditioning grain which comprises subjecting grain to contact with a current of air, controlling the treatment of the grain by the air so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, and regulating the dry bulb temperature and the dew point of the entering air to control the temperature and moisture content of the grain.

12. The hereindescribed method of conditioning grain which comprises subjecting grain to contact with a current of air, controlling the treatment of the grain by the air so as to cause the temperature of the grain to approximate the wet bulb temperature of the entering air, increasing the temperature of the entering air sufficiently to raise the temperature of the grain to the required degree, and increasing the dew point of the entering air to prevent excessive reduction of the moisture content of the grain.

13. The hereindescribed method of conditioning grain which comprises subjecting grain containing moisture to intimate contact with air for a sufficient period of time to cause the temperature of the grain to closely approach the wet bulb temperature of the entering air, and regulating the wet bulb temperature of the air so as to obtain a desired temperature of the grain.

14. The hereindescribed method of conditioning grain which comprises causing intimate contact of the grain containing moisture with air until the temperature of the grain approximates the wet bulb temperature of the air, and conditioning the air before contact with the grain so as to obtain a desired temperature of the grain.

15. The hereindescribed method of conditioning grain which comprises causing intimate contact of the grain containing moisture with air until the temperature of the grain approximates the wet bulb temperature of the air, and conditioning the air as to its temperature and moisture content before contact with the grain so as to obtain a desired temperature and moisture content of the grain.

16. In an apparatus for conditioning grain, the combination of means for causing the passage of air through the grain and causing an intimate contact between the air and the grain, means for regulating the rate of flow of the air through and the period of contact of the air with the grain whereby the temperature of the grain will approach the wet bulb temperature of the air, and means for conditioning the air before contact with the grain so as to obtain a desired temperature of the grain.

17. In an apparatus for conditioning grain, the combination of means for causing the passage of air through the grain and causing an intimate contact between the air and the grain, means for regulating the passage of the air through the grain whereby the temperature of the grain will approach the wet bulb temperature of the air, and means for regulating the wet bulb temperature of the air before contact with the grain so as to obtain a desired temperature of the grain.

18. In an apparatus for conditioning grain, the combination of means for causing the passage of air through the grain and causing an intimate contact between the air and the grain, means for regulating the passage of the air through the grain whereby the temperature of the grain will approach the wet bulb temperature of the air, and means controlled by the temperature of the grain after treatment by the air, or by said air, for regulating the wet bulb temperature of the air before contact with the grain so as to obtain a desired temperature of the grain.

19. In an apparatus for conditioning grain, the combination of means for causing the passage of air through the grain and causing an intimate contact between the air and the grain, means for regulating the passage of the air through the grain whereby the temperature of the grain will approach the wet bulb temperature of the air, a thermostat influenced by the temperature of the grain after treatment by the air, or by said air, and means controlled by said thermostat for regulating the wet bulb temperature of the air before contact with the grain so as to obtain a desired temperature of the grain.

20. In an apparatus for conditioning grain, the combination of means for causing the passage of air through the grain and causing an intimate contact between the air and the grain, means for regulating the passage of the air through the grain whereby the temperature of the grain will approach the wet bulb temperature of the air, a thermostat influenced by the temperature of the grain after treatment by the air, and air heating and humidifying means controlled by said thermostat for regulating the wet bulb temperature of the air before contact with the grain so as to obtain a desired temperature of the grain.

21. In an apparatus for conditioning grain, the combination of means for causing the passage of air through the grain and causing an intimate contact between the air and the grain, means for regulating the passage of the air through the grain whereby the temperature of the grain will approach the wet bulb temperature of the air, a thermostat or humidostat influenced by the temperature of the grain after treatment by the air, or by said air, air heating and humidifying means controlled by said thermostat or humidostat, for regulating the temperature and moisture content of the air before contact with the grain, and additional regulating means for said heating and humidifying means.

22. In an apparatus for conditioning grain, the combination of means for causing the passage of air through the grain and causing an intimate contact between the air and the grain, means for regulating the rate of flow of the air through and the period of contact of the air with the grain whereby the

temperature of the grain will approach the wet bulb temperature of the air, an air heater and an air moistener for respectively heating and humidifying the air, and regulating means influenced by the grain after treatment for said heater and moistener for controlling the temperature and moisture content of the air before contact with the grain.

23. In an apparatus for conditioning grain, the combination of means for causing the passage of air through the grain and causing an intimate contact between the air and the grain, means for regulating the passage of the air through the grain whereby the temperature of the grain will approach the wet bulb temperature of the air, an air heater and an air moistener for respectively heating and humidifying the air, means for returning air after contact with the grain to said heater and moistener, and regulating means for the heater, moistener and air return means for controlling the temperature and moisture content of the air before contact with the grain.

24. In an apparatus for conditioning grain, the combination of a grain conditioner comprising a chamber for the grain having provision for the escape of air, and an air chamber separated from said grain chamber by a partition wall having openings for the passage of air into said grain chamber, means for supplying air to said air chamber, means for regulating the admission of air to the air chamber, means for varying the area of said partition wall through which the air can pass to said grain chamber, and means for regulating the temperature and moisture content of the air before contact with the grain.

25. In an apparatus for conditioning grain, the combination of a grain conditioner comprising a grain chamber having provision for the escape of air, means for causing grain to pass in a moving stream through said chamber, and an air chamber separated from said grain chamber by a partition wall having openings for the passage of air into said grain chamber, means for supplying air to said air chamber, means for regulating the admission of the air to the air chamber, means for varying the area of said partition wall through which the air can pass to said grain chamber, and means for regulating the temperature and moisture content of the air before contact with the grain.

EDGAR S. MILLER.