May 7, 1963 F. R. OFNER 3,088,220

SUPERSONIC VIBRATING DRYING SYSTEM

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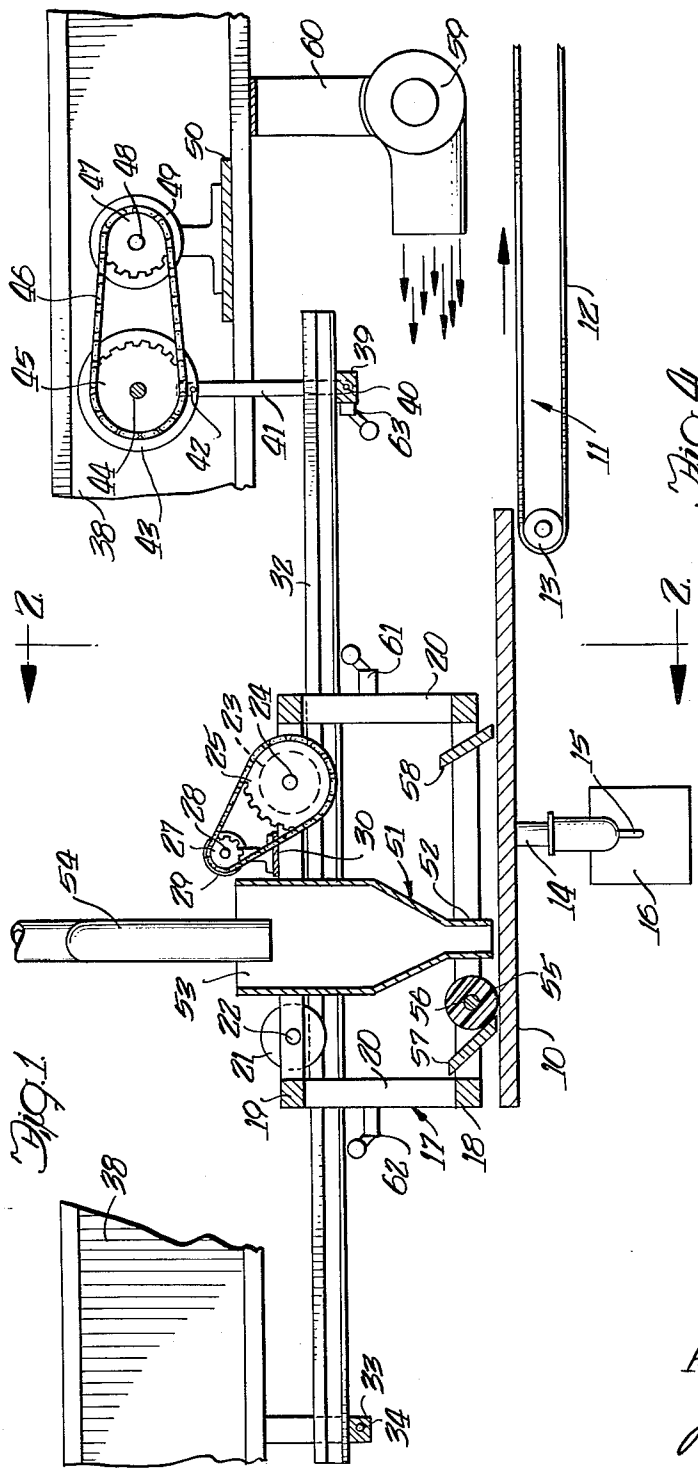


Fig. 1.

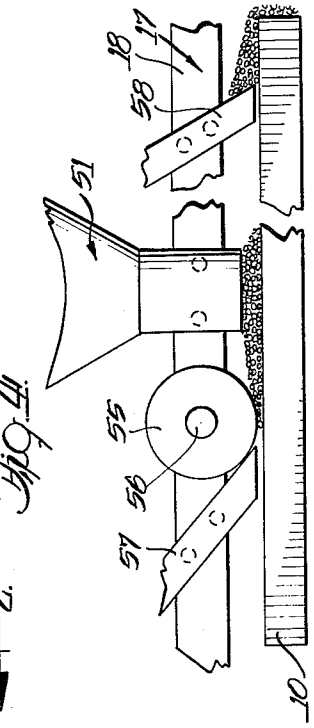


Fig. 4.

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Fig. 2.

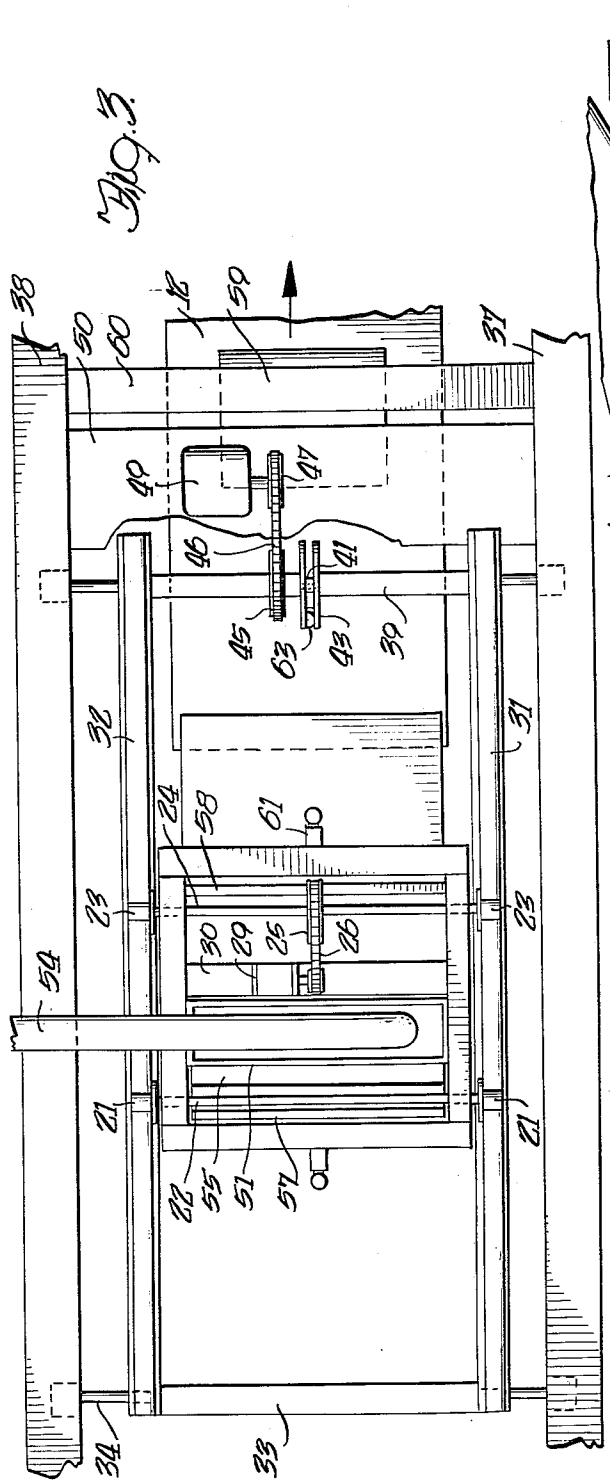
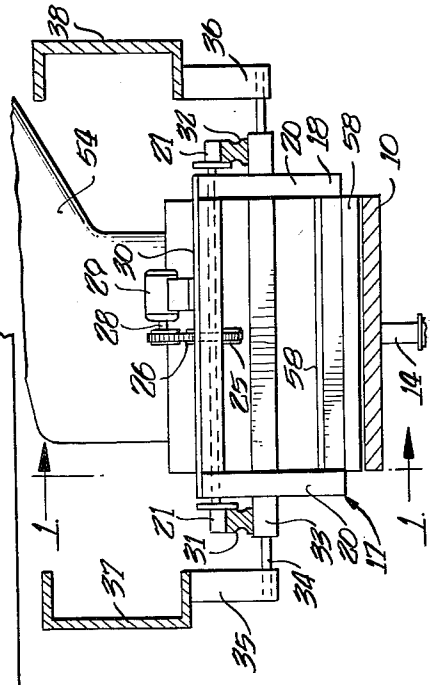


Fig. 3.



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SUPERSONIC VIBRATING DRYING SYSTEM

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This invention relates to a method and to apparatus for drying materials—granular or pulpy materials, for example—and is particularly useful in drying grain and grain materials.

There are many instances where it is desirable or necessary to dry materials, and in particular materials of a granular or particulate character. For example, in converting wheat into flour, one of the steps employed (in a wet washing process) is to wash the grain with water, and often thereafter this grain or recovered portions thereof that normally are lost or wasted, must be dried. An example of a flour mill waste recovery process employing a drying step is disclosed in my copending patent application Serial No. 325,773, filed December 13, 1952, now Patent No. 2,835,985. Conventionally, the drying is accomplished in an oven or other heat type dryer.

As is well known, the standard commercial dryers are bulky, expensive, are costly to operate because of the necessity of developing heat, and particularly in the warmer climates or summer months are uncomfortable to work about. More important, however, is that such dryers require a substantial period of time in which to drive off the moisture contained by material placed therein, and to thereby effectuate the drying thereof. It will be apparent that such time is costly for it limits production.

There is a need for an improved means for drying materials speedily and conveniently, and the provision of such a means is one of the objects of this invention. Another object of the invention is that of providing a method and apparatus for quickly drying materials in a convenient and inexpensive manner and without the development of excessive heat therefor. Still another object is to provide a method and apparatus for accomplishing such results that is able to dry materials almost instantaneously whereby drying operations may be effectuated with substantially no time loss.

A further object of the invention is to provide a means for drying materials employing ultra-sonic energy waves, such waves being effective to substantially instantaneously vaporize moisture subjected thereto. Still a further object is to provide a method of drying materials in which moistened materials are brought into the range of ultra-sonic energy waves, and thereafter such waves are applied directly to the moisture—that is, no air or other corresponding barrier separates the energy from the moisture—whereby the moisture in the material is immediately driven off. Yet a further object is in the provision of apparatus comprising a receiver member in conjunction with means for squeezing a wetted material thereonto, and in which an ultra-sonic generator device is connected with such receiver for imparting ultra-sonic energy waves thereto—such apparatus preferably including a fan or blower for carrying away the moisture removed from the materials during the drying thereof. Additional objects and advantages will become apparent as the specification develops.

An embodiment of the invention is illustrated in the accompanying drawings, in which—

FIGURE 1 is a longitudinal sectional view taken along the line 1—1 of FIGURE 2 of exemplary apparatus embodying the invention; FIGURE 2 is a transverse sectional view taken along the line 2—2 of FIGURE 1; FIGURE 3 is a top plan view of the apparatus; and FIGURE 4 is an enlarged broken side view in elevation showing in detail certain of the steps performed by the apparatus in carrying out the drying method.

The apparatus illustrated in the drawings is intended to be exemplary of arrangements that may be successfully employed to carry out the functions of delivering wet or moistened material to a receiver plate, for spreading it into intimate contact therewith, and for removing the dried material therefrom. Between the steps of spreading the material onto the receiver plate and removing it therefrom, the moisture is driven off of the material by the ultra-sonic energy waves imparted to the plate by an ultra-sonic generator and coupling device. By referring to the drawings, the apparatus will now be described in detail.

The receiver or plate is designated with the numeral **10**, and in the form shown it comprises a generally rectangular, horizontally disposed planar member suitably supported. Adjacent one end of the plate **10** is a means for receiving and for removing dried material, and in the illustration this means comprises a conveyor **11** having an endless belt **12** entrained about a roller **13**. At its opposite end (not shown) the belt will be entrained about a similar roller which will be driven so as to move the belt **12** in the direction of the arrow. Secured to the underside of the receiver plate **10** is a probe **14** connected by a cable **15** to a generator **16**.

The generator **16** is an oscillator adapted to produce electrical energy having an ultra-sonic frequency. The specific generator for accomplishing this result may be conventional, and as such, a detailed description thereof need not be included in this disclosure since known to those skilled in the art. The output of the generator is carried through the cable **15** to the probe which may comprise a crystal having on each side thereof a metal plate. An oscillating energy is impressed across the crystal, which may be a piezo-electric quartz crystal, whereby this energy causes the crystal to pulsate or vibrate at the ultra-sonic frequency of the generator. The resulting mechanical vibrations are transmitted directly to the plate **10**, for the crystal is mechanically connected thereto. Thus, the receiver plate **10** contains vibratory energy having an ultra-sonic frequency.

In the form of the device shown for depositing moist material onto the upper surface of the plate **10**, and for removing it therefrom after being dried, a frame **17** is employed that may have a generally rectangular bottom frame member **18**, corresponding top frame member **19**, and a plurality of vertically oriented frame elements **20** connecting the bottom and top frame portions together. These members are interconnected so as to make a rigid frame.

The upper frame portion **19** is equipped with a pair of rear wheels **21**, one of which is disposed on each side thereof, exterior of the frame and mounted for rotation on an axle or shaft **22** extending transversely across the upper frame and through the side wall portions thereof. This upper frame is also provided with a pair of front wheels **23** carried by an axle **24** journalled for rotation in the side walls of the frame and extending transversely thereacross. Intermediate the side walls of the upper frame **19**, the shaft **24** is equipped with a sprocket wheel **25** having an endless link chain **26** entrained thereabout. The chain **26** is also entrained about a drive sprocket **27** mounted on the shaft **28** of a motor **29** rigidly secured to a plate **30** extending transversely across the upper frame **19** and rigidly secured thereto.

It will be apparent that when the motor is energized, the drive sprocket **27** through the chain **26** rotates the sprocket wheel **25**, whereby the wheels **23** are rotatably driven. As is noticed most clearly in FIGURE 2, the front wheels **23** are also mounted exteriorly of the upper frame **19** and ride on a pair of rails **31** and **32**, as do

the rear wheels 21. The rails or tracks 31 and 32 are disposed in parallel, generally horizontal relation; and adjacent the rear ends thereof are rigidly secured to a transverse support member 33 provided with a bore extending therethrough in which a support shaft 34 is journalled for rotation. The shaft 34 is seen to extend outwardly from the transverse support 33 on each side thereof, and at its opposite ends is secured to the hangers or brackets 35 and 36 that are rigidly secured, respectively, to the horizontal support beams 37 and 38. It will be apparent that the rails 31 and 32 are rigidly connected together by the transverse support member 33 and are adapted to rotate about the longitudinal axis of the support shaft 34.

Adjacent the opposite or forward ends thereof, the rails or tracks 31 and 32 are rigidly secured to a transversely extending support member 39 provided with a bore extending therethrough that rotatably receives a shaft 40 extending outwardly from the member 39 on each side thereof in a manner similar to that of the shaft 34. Secured to the shaft 40 at each end is a link 41 pivotally secured by a pin 42 to a wheel 43 secured to shaft 44 extending between the beams 37 and 38 and journalled for rotation in appropriate bearings provided thereby. Intermediate its ends, the shaft 44 is equipped with a sprocket 45 having a link chain 46 entrained thereabout that at its opposite end is entrained about a drive sprocket 47 carried by the shaft 48 of a motor 49 mounted on a plate 50 that may extend between the horizontal beams or channels 37 and 38 and is rigidly secured thereto.

When the motor 49 is energized, it rotates the shaft 44 through the sprockets 45 and 47 and link chain 46, whereby the wheels 43 rotate to cause the links 41 to be moved upwardly whereby the forward ends of the rails 31 and 32 are elevated; that is, the rails are pivoted about the axis of the shaft 34 at the rear end thereof.

Intermediate the ends of the frame 17 and disposed between the side walls of the lower and upper frame portions 18 and 19 thereof, is a hopper 51 that may have a restricted end portion 52 disposed slightly above the plate 10, and an enlarged end portion 53 disposed above the upper frame portion 19. The hopper is rigidly secured to the frame 17 by any suitable means such as screws. The hopper is adapted to deposit moist or wet materials onto the upper surface of the plate 10, and may have such wet material delivered thereto in any appropriate manner such as by a conduit or chute 54 that may be flexible or that may be pivotally mounted adjacent its inlet end so that it can swing freely from side to side as the frame 17 moves over the rails 31 and 32 in a manner to be described more fully hereinafter.

Disposed just rearwardly of the hopper 51 and adjacent thereto is a squeezer or roller 55 carried by a shaft 56 extending between and journalled for rotation in the side walls of the lower frame 18. The roller 55 may be formed from a resilient material such as rubber, and its function is to squeeze wet material emitted from the hopper 51 onto the surface of the plate 10. Carried by the lower frame 18 for scraping engagement with the roller 55 is a doctor blade 57 for preventing the adherence of wet material thereto. The roller 55 may be driven, but in the form shown is intended to be positioned in such close proximity to the upper surface of the plate 10 that it will be rotated thereby as the frame moves longitudinally along the track members. Adjacent the forward end of the frame is a scraper or blade 58 for pushing dried material from the plate 10 and onto the endless conveyor belt. The doctor blade 57 and scraper blade 58 may be secured to the frame portion 18 by screws, if desired.

It has been brought out that the function of the apparatus is to dry material, and in so doing moisture is driven therefrom. Preferably, some means should be provided for carrying away the moisture entering the ambient air about the plate 10, and for this purpose a centrifugal blower 59 may be furnished. In the illustration given, the blower 59 is suspended from the support channel 38 by a bracket 60 rigidly secured thereto and to the casing of the blower.

It is desired to provide substantially automatic operation for the apparatus, and to accomplish that result appropriate circuits for the motors, etc. will be provided, and this circuitry will have a plurality of switches arranged therein. One such switch is designated with the numeral 61, and it is carried by one of the vertically oriented frame elements 20 so as to engage and be triggered by the transversely extending support 39 when the apparatus advances theretoward. The function of the switch 61 is to reverse the direction of rotation of the motor 29 (which will then be a reversible motor), whereby it rotates the wheels 23 in an opposite direction so as to move the frame 17 toward the left as viewed in FIGURE 1. Another switch is designated with the numeral 62, and it is also connected in circuit with the motor 29 so as to change the direction of rotation thereof and cause it to rotate the wheels 23 in a direction that will move the frame 17 toward the right as viewed in FIGURE 1. The switch 62 may be carried by one of the vertical frame elements 20 so as to be engaged and triggered by the transversely extending support member 33.

Still another switch 63 is secured to the forward support member for the rails, and it is positioned thereon so as to be engaged by one of the vertical frame elements 20 when the frame approaches the limit of its movement toward the right, as viewed in FIGURE 1. This switch causes the motor 49 to be energized when it is triggered, and these circuits permit it to rotate through one revolution—or more particularly, it is arranged with a gear reducer and remains energized long enough so that the wheels 43 rotate through one complete revolution. This rotation of the wheels 43 will cause the forward ends of the rails 32 to move from the position shown to an elevated position, and to then return again to the horizontal orientation illustrated. During such cycle of operation, the frame 17 will move from the right to the left terminus of its path of travel.

In operation of the apparatus, it will be assumed that the frame member 17 is moving toward the right as the apparatus is viewed in FIGURE 1. The condition of the apparatus is also seen at such time in FIGURE 4, and it will be apparent that wet material is then being deposited onto the plate 10 from the hopper 51. As this wet material is fed to the upper surface of the plate 10 from the hopper, the roller 55 squeezes it downwardly into intimate contact with the surface of the plate, and the doctor blade 57 keeps the roller free of the wet material. At the same time, material that has been deposited on the plate in a prior cycle of operation and which has been dried, is being scraped from the plate and will be forced over the end thereof and downwardly onto the conveyor belt 12.

As the frame 17 approaches the forward ends of the rails 31 and 32, all of the dried material has been removed from the plate by the scraper 58, and the plate in its entirety is covered with a layer of wet material. When the switches 61 and 63 are triggered by movement of the frame 17 into its extreme position at the right or forward end of the track, the motor 49 is energized whereby the wheels 43 function to elevate the forward ends of the rails. At the same time, triggering of the switch 61 causes the motor 29 to reverse its direction of rotation, whereby it rotates the wheels 32 so as to move the frame toward the left or rearwardly along the rails. This movement toward the left is accomplished while the forward ends of the rails are in an elevated position, whereby the roller 55 and scraper 58 are clear of the plate 10 and any wet material deposited thereon.

As the frame moves into its extreme position at the

rear ends of the rails, the switch **62** is triggered and this causes the motor **29** to again reverse its direction of rotation so as to now cause the frame to again move toward the right along the rails. As such movement toward the right is initiated, the motor **49** has returned the wheels **43** to the initial position shown whereby the rails are again horizontally disposed, and it becomes deenergized. If desired, the hopper **51** may be equipped with a solenoid controlled valve or closure member so that wet material is disposed therefrom only when the frame **17** is moving toward the right or toward the forward ends of the rails. During the entire cycle of operation, the blower **59** may be energized so as to provide a moving stream of air over the plate **10** effective to carry away moisture vaporized from the wet material deposited thereon.

As soon as the wet material is deposited onto the plate **10** and is squeezed into intimate contact with the upper surface thereof, the moisture is almost instantaneously driven therefrom by the ultra-sonic energy imparted to the plate. Exactly what the explanation is for this substantially instantaneous vaporization of the moisture is not known. It may be that passing ultrasonic waves through the liquid contained by the wet material sets up planes of condensation and rarefaction which are close together, and in some manner increases the temperature of the liquid to the boiling point, at which time the vapor pressure of the liquid is equal to the external pressure whereby the liquid boils so as to be vaporized. Whatever the explanation, it is known that the ultra-sonic energy waves cause such instantaneous vaporization of the moisture, whereby the material is immediately dried and may be removed from the plate.

The crystal, as has been brought out, is connected to the plate, and the alternating electromotive force impressed thereon has the same frequency as the natural frequency of oscillation of the crystal, whereby it is set into mechanical vibration and imparts it to the plate. The precise frequency of the crystal is determined by its elasticity and density, as is well known, and the crystal and the generator will be selected so as to have a frequency within the ultra-sonic range. As a specific example, the frequency may be a million cycles per second, and this frequency has been found to produce satisfactory results.

The power of the ultra-sonic energy applied to the plate **10** will depend upon the size of the plate, and may be in the order of about two watts per square centimeter of plate area, which has been found effective. The speed of vaporization of the moisture will to some extent be dependent upon the magnitude of the energy delivered to the plate, and in general it may be said that the speed of vaporization increases in correspondence with increases in the magnitude of the energy.

The steps in the process are illustrated clearly in FIGURE 4, and it is there seen that the roller **55** is operative to squeeze the wet material into tight or intimate contact with the plate **10**. It has been found that an air barrier interposed between the plate and the moistened material sharply attenuates the effects of the ultra-sonic energy so that the function of the roller is to press the material into contact with the plate so that the moisture is in direct contact with the plate.

The apparatus and method described are effective to achieve rapid and efficient drying of moistened materials, and are capable of achieving a dryness such that the moisture in the dried material is less than 20%.

While in the foregoing specification embodiments of the invention have been set forth in considerable detail both in terms of structure and method, it will be apparent to those skilled in the art that numerous changes may be made in those details without departing from the spirit and principles of the invention.

I claim:

1. In a method of drying a wetted material, the steps of spreading such wetted material along a receiver having a surface for the receipt of such material thereon, maintaining such wetted material in substantially continuous engagement with said surface, vibrating said receiver surface at an ultra-sonic frequency to impart an ultra-sonic frequency vibratory energy to such wetted material spread therealong to vaporize moisture carried thereby and thereby release such vaporized moisture therefrom, and changing the atmosphere about the vibrated material to remove the vapor released therefrom.

2. In a method of drying a wetted granular material, the steps of spreading such wetted material along a receiver having a surface for the receipt of such material thereon, maintaining such wetted material in substantially continuous engagement with said surface, vibrating said receiver surface at an ultra-sonic frequency to impart an ultra-sonic frequency vibratory energy to such wetted material spread therealong to vaporize moisture carried thereby and thereby release such vaporized moisture therefrom, changing the atmosphere about the vibrated material to remove the vapor released therefrom, and thereafter removing the thusly dried granular material from said receiver.

3. In a method of drying a wetted granular material, the steps of spreading a relatively thin layer of such wetted material along a receiver having a surface for the receipt of such material thereon to effect an intimate contact between such material and said receiver surface, vibrating said receiver surface at an ultra-sonic frequency to impart an ultra-sonic frequency vibratory energy to such wetted material spread therealong to vaporize moisture carried thereby and thereby release such vaporized moisture therefrom, passing a stream of air over such layer of material during the vibration thereof to remove the vapor released therefrom, and thereafter removing the thusly dried granular material from said receiver.

4. In material drying apparatus of the character described, a receiver providing a surface adapted to have wetted material deposited thereon, squeezer means comprising a roller for depositing such material on said surface and to force the material into intimate contact therewith, means for removing such material after drying thereof from said surface, an ultra-sonic frequency generator having a probe placed in vibration at such ultra-sonic frequency upon energization of said generator, and means connecting said probe to said receiver for imparting vibratory energy thereto for effecting drying of such wetted material deposited upon said surface.

5. In material drying apparatus of the character described, a receiver providing a surface adapted to have wetted material deposited thereon, means for depositing such material on said surface, means comprising a scraper for removing such material after drying thereof from said surface, an ultra-sonic frequency generator having a probe placed in vibration at such ultra-sonic frequency upon energization of said generator, and means connecting said probe to said receiver for imparting vibratory energy thereto for effecting drying of such wetted material deposited upon said surface.

6. In material drying apparatus of the character described, a receiver providing a surface adapted to have wetted material deposited thereon, means for depositing such material on said surface, means for removing such material after drying thereof from said surface, an ultra-sonic generator having a probe placed in vibration at such ultra-sonic frequency upon energization of said generator, means connecting said probe to said receiver for imparting vibratory energy thereto for effecting drying of such wetted material deposited upon said surface, and blower means for passing an air stream over said surface to remove vapor released from such material.

7. In apparatus for use in drying a wetted granular material, a receiver providing a generally planar surface, structure for depositing a relatively uniform layer of such wetted material along said surface, an ultra-sonic fre-

quency generator connected with said receiver for vibrating the same to impart ultra-sonic frequency vibratory energy to such wetted material to vaporize moisture carried thereby and thereby release such vaporized moisture therefrom, a blower for passing an air stream about such receiver and material deposited thereon to remove the released vapor from such material, and structure for displacing the vibrated material from said receiver surface.

8. In a method of drying material, the steps of providing a receiver having a material-receiving surface, placing a wetted material in engagement with said surface and maintaining such material in substantially continuous engagement therewith so that vibratory energy present at said surface is imparted to such wetted material to release moisture therefrom, vibrating said surface at an ultrasonic frequency to effect such energy impartation, and removing the released moisture from about the thusly vibrated material.

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