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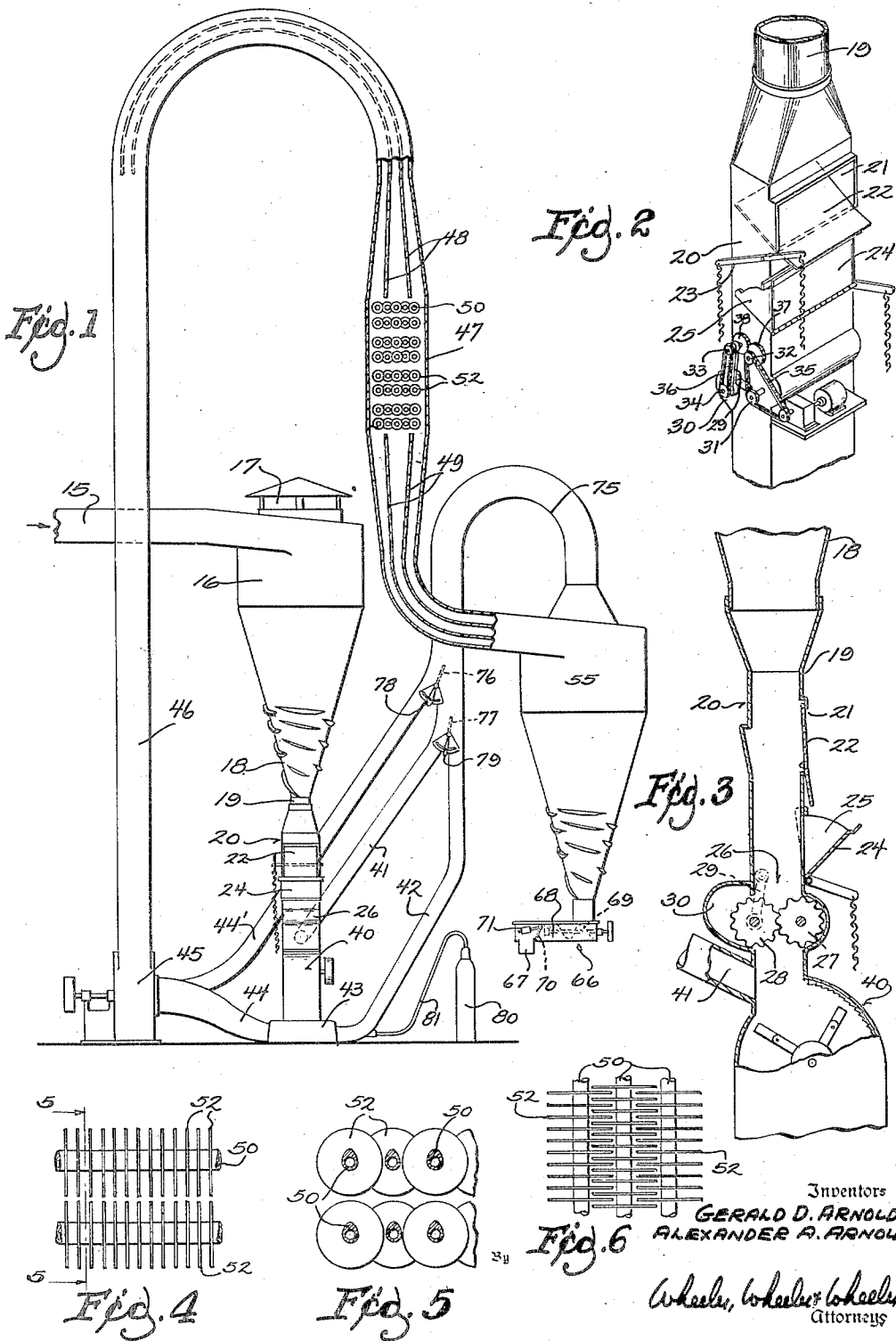
G. D. ARNOLD ET AL

2,770,543

RECIRCULATING CONVECTION CURRENT COOLER AND METHOD

Filed Nov. 24, 1950

4 Sheets-Sheet 1



Inventors
GERALD D. ARNOLD
ALEXANDER A. ARNOLD
Wheeler, Wheeler & Wheeler
Attorneys

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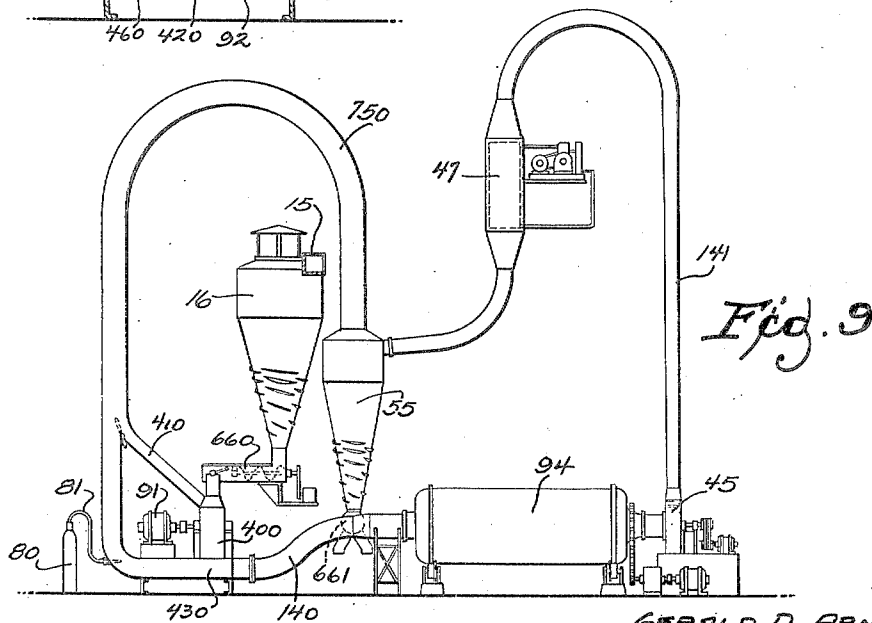
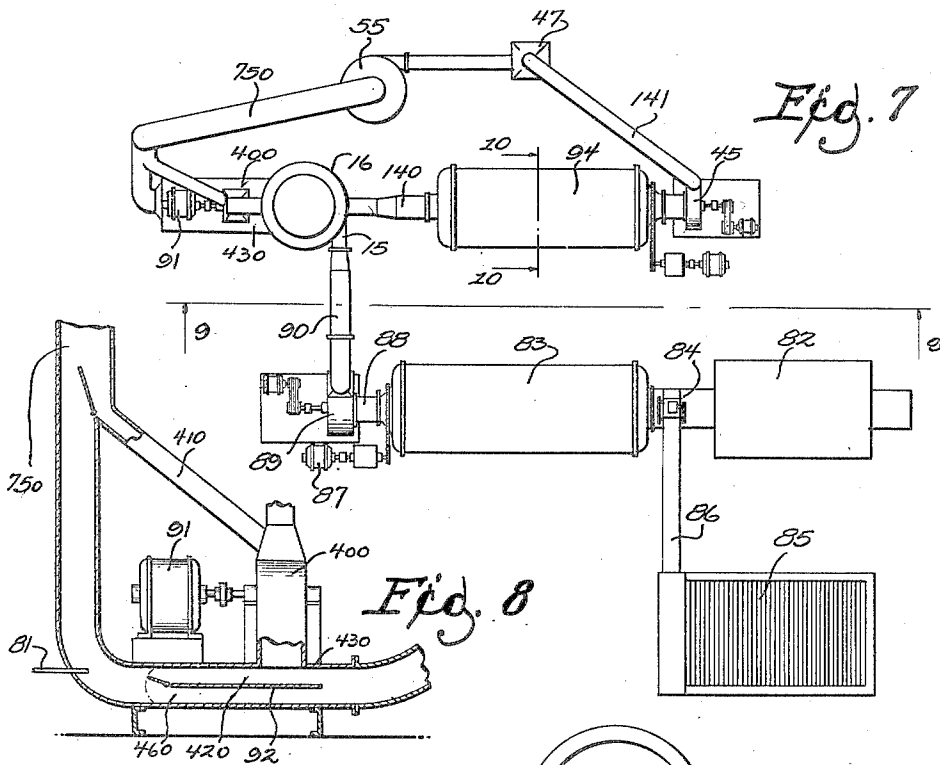
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4 Sheets-Sheet 2



Inventors

GERALD D. ARNOLD
ALEXANDER A. ARNOLD

By

Wheeler, Wheeler & Wheeler

Attorneys

Nov. 13, 1956

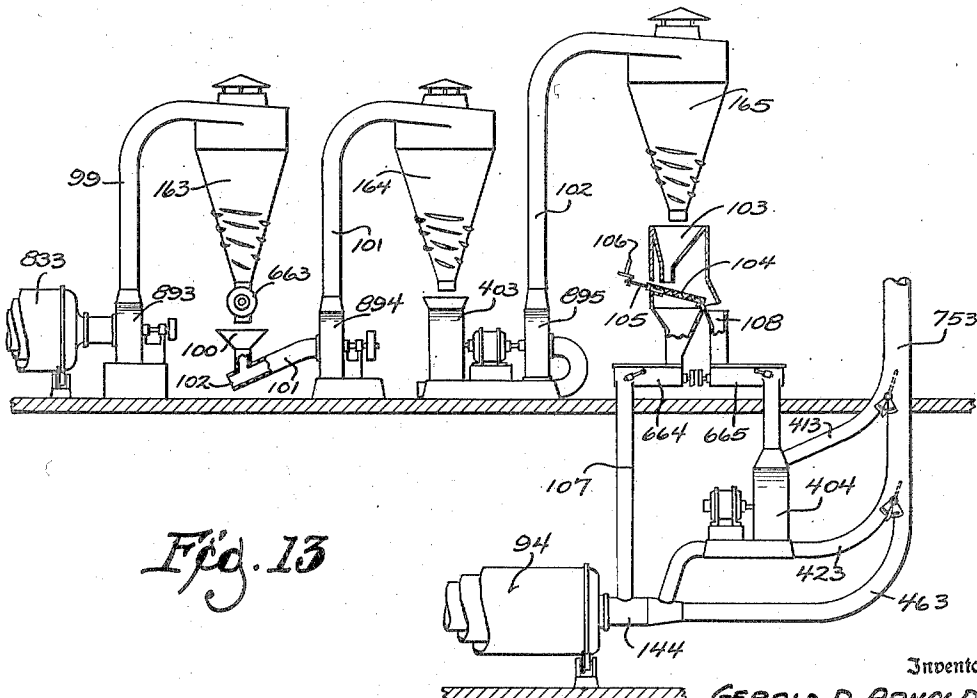
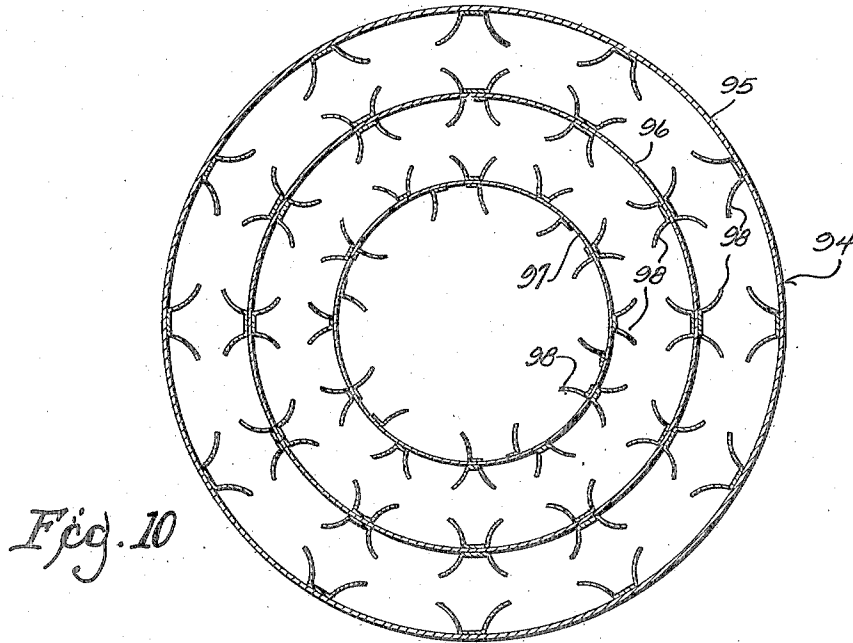
G. D. ARNOLD ET AL

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4 Sheets-Sheet 3



Inventors
GERALD D. ARNOLD
ALEXANDER A. ARNOLD
wheeler, wheeler & wheeler
Attorneys

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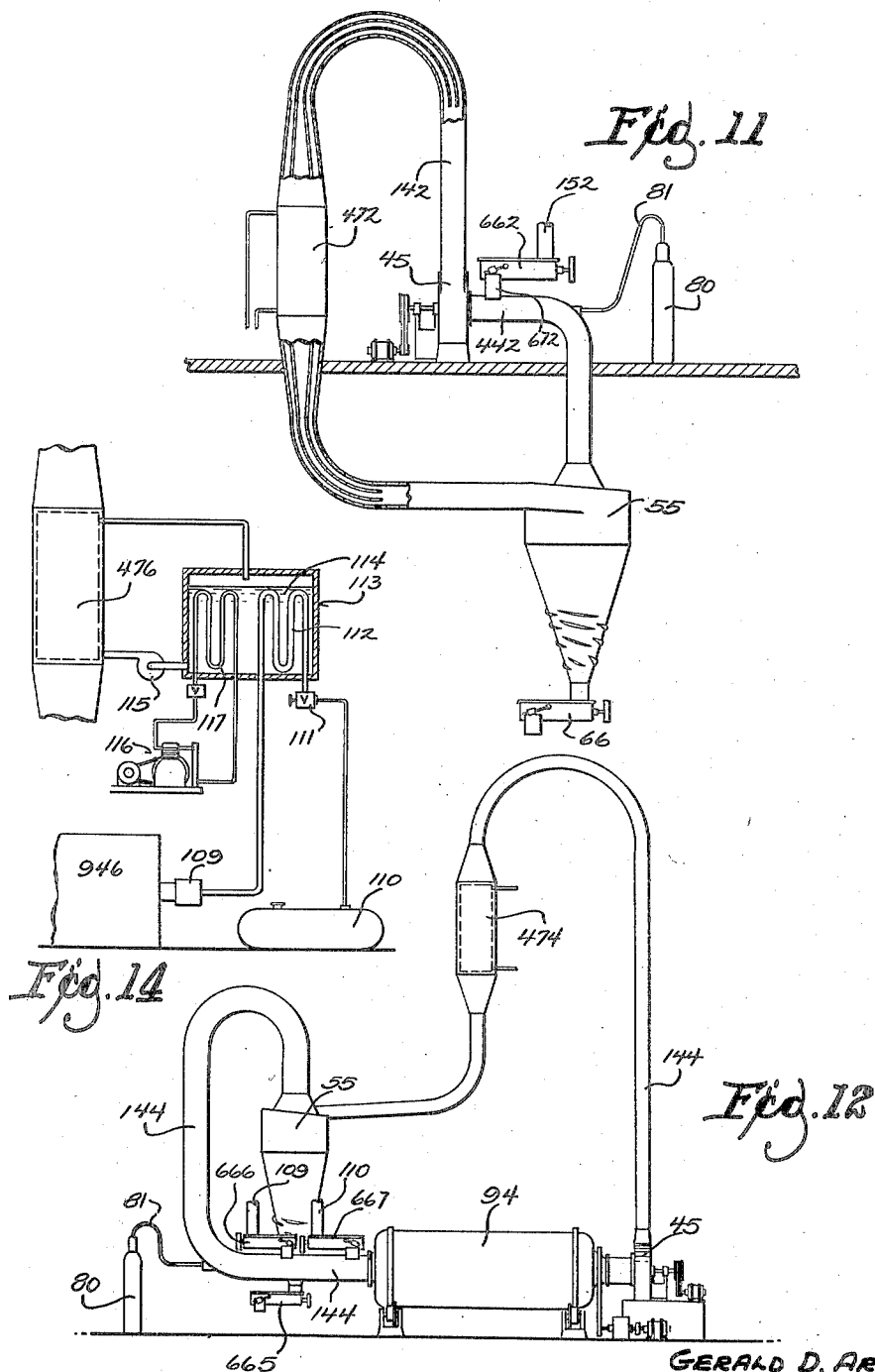


Fig. 11

Fig. 12

Fig. 14

Inventors
GERALD D. ARNOLD
ALEXANDER A. ARNOLD
Wheeler, Wheeler & Wheeler
Attorneys

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2,770,543

RECIRCULATING CONVECTION CURRENT COOLER AND METHOD

Gerald D. Arnold and Alexander A. Arnold, Wauwatosa, Wis.; said Alexander A. Arnold assignor to Gerald D. Arnold

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12 Claims. (Cl. 99—2)

This invention relates to a recirculating convection current cooler and method.

The present invention is an improvement on the subject matter of Patents Re. 22,383 and 2,318,576 and 2,363,037 and 2,363,281 and 2,363,282 and 2,368,699 and 2,400,382. In these various patents, concerned particularly with the refrigerated cooling of finely ground meal or produce by the pneumatic transportation of the material in an air stream cooled by passing it over a refrigerating coil, every attempt was made to protect the coils against accumulations of dust, the expedients used for this purpose including the separation of the material as fully as possible from the recirculating air before such air was permitted to traverse the coil, the use of special streamlined coil designs, and the operation of the coil at a temperature such as to minimize condensation thereon, it appearing that the presence of any moisture on the coil would increase the tendency of entrained dust to adhere to the coil surface.

It was found that notwithstanding these precautions, an objectionable deposit of dust would still build up, in the course of time, upon the coils, serving to insulate the coils and thereby greatly reducing their capacity to absorb heat from the circulating convection currents. According to the present invention, the coil is so located that all of the entrained material passes directly over the coil with the air, thereby mechanically scouring the heat exchange surfaces and keeping these clean and dry. The volume of the material handled will ordinarily be so great with respect to the amount of moisture condensing on the coils that the moisture will be removed in increments so minute as not appreciably to moisten the product. Thus the scouring action makes it possible to operate the coil at much lower temperatures than those heretofore used and, if recirculation is involved; the device will operate indefinitely without accumulations of frost, moisture, dust, or foreign matter on the coils. While we preferably operate the coils near, or only slightly below the freezing point, and preferably still use streamlined coil forms, neither the temperature nor the coil form is critical where all of the material to be chilled is caused to pass with scouring action over the coils.

In the drawings:

Fig. 1 is a diagrammatic view partially in section showing a material handling and cooling system embodying the invention.

Fig. 2 is an enlarged fragmentary detailed view in perspective showing a trap and gate assembly desirably incorporated in the feed to the hammer mill in the apparatus of Fig. 1.

Fig. 3 is a view taken in longitudinal section on a further enlarged scale through a portion of the apparatus shown in Fig. 2.

Fig. 4 is a fragmentary detailed view in side elevation on an enlarged scale of two of the tiers of the refrigeration coils shown in Fig. 1.

Fig. 5 is a view taken in section on the line 5—5 of Fig. 4.

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Fig. 6 is a fragmentary plan view of the coils shown in Figs. 4 and 5.

Fig. 7 is a diagrammatic view in plan of a complete dehydrating and cooling system for producing a chilled forage crop meal.

Fig. 8 is an enlarged view, partially in side elevation and partially in section through the hammer mill construction used in Fig. 7.

Fig. 9 is a view taken on the line 9—9 of Fig. 7 showing in side elevation the grinding and refrigeration portion of the Fig. 7 structure.

Fig. 10 is a large detailed view taken in section on line 10—10 of Fig. 7.

Fig. 11 is a view partially in side elevation and partially in section showing a modified embodiment of our invention.

Fig. 12 is a view in side elevation of a further modified embodiment of our invention.

Fig. 13 is a view partially in section and largely in side elevation showing a further modified embodiment.

Fig. 14 is a view partially in side elevation and partially in vertical section showing a further modified embodiment of our invention.

While the invention has particular utility in the cooling of ground alfalfa meal and other similar products for agricultural use, it is by no means limited to such products, but is concerned broadly with the refrigeration of any material which can be pneumatically advanced.

In the device of Fig. 1 pneumatically conveyed material may enter the system through the pipe 15 which leads tangentially into the convection cyclone 16, from which the original convection air escapes through the central outlet 17, while the solids to be cooled pass downward through the tapering throat 18 to pipe 19.

The pipe 19 leads to the control housing 20 which is separately illustrated in Figs. 2 and 3. There is a port at 21 controlled by a baffle or gate 22, movable by means of the control lever 23 between the open position in which it is illustrated in Fig. 2 and the normally closed position in which it is shown in Fig. 3. The purpose of this gate is to enable the operator to discharge excess materials from the system where the materials are arriving insufficiently dried or with such rapidity as to tend to clog the hammer mill or rotary trap hereafter described. The invention is not concerned with this gate, the use of which is entirely optional.

At another point, the housing 20 is provided with an outwardly opening gate 24 which has side walls at 25 to constitute a hopper through which material may be introduced into the system. It may be used when some of the material discharged through gate 22 is to be re-introduced into the system when the supply arriving through pipe 15 is no longer adequate to maintain the system operating at top capacity. Use of this gate is also optional.

Immediately below the valves or gates 22 and 24 is a trap device 26 comprising a pair of rolls, 27 and 28, having intermeshing teeth as best shown in Fig. 3. The roll 28 is mounted on arms 29 to swing laterally into the enlargement 30 of the housing 20 to accommodate heavy flow of material. In the position in which the rolls 27 and 28 are shown in Fig. 3 they are in substantial contact, with their teeth intermeshed, to substantially close the housing to preclude the passage of air in either direction through the trap when no material to be cooled is traversing the trap.

The rolls 27 and 28 may be positively driven by the external sprockets 31, 32, 33, 34, chains 35, 36 and gears 37, 38 shown in Fig. 2. Roll 28 is gravity-biased to the position shown but readily yields laterally under the thrust of solids traversing the casing 20 toward the hammer mill 40.

The hammer mill may be of any suitable construction to reduce the material to any desired degree of fineness. Since the friction developed in the mill is responsible for substantial increases in temperature (which may even involve fire hazards) it is desirable that at least some of the cooling air be introduced into the hammer mill to control temperatures therein, as well as to facilitate grinding and passing of the material through the screen.

Thus, air refrigerated in the manner hereafter to be described is admitted into the hammer mill 40 through pipe 41. Another component of refrigerated air is admitted through pipe 42 into the base portion 43 of the hammer mill to entrain the ground meal and deliver it through pipe 44 into the blower 45. To the extent that additional air may be required in the convection circuit, beyond that which can be conveniently passed through the hammer mill base 43, a bypass duct 44' may be used to deliver such additional air into pipe 44 adjacent blower 45.

The refrigerated air and entrained meal is discharged from blower 45 through pipe 46 which leads into the refrigerating mechanism 47. Since the cross-section of the refrigerator casing is desirably greater than the cross-section of the pipe 46, I may use any desired arrangements of baffles such as those shown at 48 and 49 to distribute the air and entrained meal over the refrigerating coils. These coils comprise pipes 50 for the refrigerant, the pipes desirably being somewhat streamlined as shown in Fig. 5 and desirably having fins at 52 which may be interleaved in the manner shown in Figs. 5 and 6. The refrigerating mechanism is desirably so designed that these pipes and attached fins are maintained at or near 32 degrees F. Due to the scouring action, and the fact that the meal is considerably warmer than the fins, it is possible to operate the finned coils at temperatures materially below 32 degrees F. without any moisture or frost or dust accumulating on the coils. As aforesaid, the amount of the dry material is so extremely large with respect to the amount of condensation that the removal of condensate from the finned coils does not appreciably wet the material, nor does the material adhere to the coils, contrary to what has heretofore been supposed.

From the refrigerating casing 47, the gases and entrained meal pass tangentially into the cyclone separator 55, where the gases and solids are separated, the solids issuing through a trap 66 to the discharge point 67. As indicated in dotted lines in Fig. 1, the trap 66 comprises a generally horizontal sleeve 68 in which a power driven screw 69 is in operation. Beyond the end of the screw is a gate valve 70 biased toward a closed position by the weighted arm 71. The gate will be lifted only when the screw 69 operates on solids in the pipe 68 which have sufficient volume to be forced beyond the screw to lift the valve. When the pipe 68 is empty, or contains a small volume of solids, the gate 70 will remain closed, the object being to isolate the circulatory system from exchange of air with the atmosphere.

From the top of the cyclone separator 55 leads the return pipe 75, from which the pipes 41, 42, and 44' branch. If desired, the relative flow through the various pipes may be controlled by valves 76 and 77 having external handles 78, 79, respectively.

While the gases in the closed circulatory system have sometimes been referred to as air, this expression is used generically, since the composition of air varies in nature, and it is immaterial to the invention whether such gases contain oxygen or comprise carbon dioxide relatively free of oxygen. By way of indicating the desirable use of carbon dioxide to exclude oxygen in such a circulating system, we have shown in Fig. 1 a CO₂ cylinder having connection at 81 with pipe 42 so that gaseous losses throughout the various traps of the circulatory system may be made up by the admission of additional CO₂ gas.

It will be understood that the system is as nearly com-

pletely closed against atmospheric communication as it is practicable to make it. The convection and refrigeration current in which the material is entrained during its cooling is continually recirculated throughout blower 45, refrigerator 47, separator 55, and the return pipes leading back to the blower. The purpose of the separator 16 and trap 26 is to deliver the material into this closed recirculatory system as free as possible of the air or other gases in which the material was originally entrained. The purpose of the separator 55 and the trap 66 is to release the material while preserving the convection and refrigerating gases as nearly as possible entirely in the closed system.

Such dust as may remain in the circulating gases after the discharge of the chilled material from separator 55 is delivered directly into material newly entering the system. There being no venting of gases to the atmosphere, there is no way in which this dust can escape from the closed system except through the trap 66 with the particles of larger size. Consequently there are no losses such as occur in other systems handling fine materials.

Moreover, the dust ceases to be a problem so far as the refrigeration coils are concerned. It has heretofore been supposed that the way to keep the refrigeration coils free of dust was to remove all solids, including dust, as completely as possible from the air before passing the air over the coils. The present invention is based upon the discovery that just the contrary is true; that the coils can be kept free of accumulations by passing the coarse with the fine material simultaneously over the coils prior to attempting any separation. The material which is coarse enough so that it has little or no tendency to cling to the coils is given velocity enough to scour from the coils any of the finer material which might otherwise adhere, minute droplets of condensate being removed at the same time.

While the invention is by no means limited to the chilling of meal immediately following dehydration and grinding, the treatment of such meal is of particular advantage because the heat used in the dehydrator will destroy the vitamin content of the product unless the product is promptly cooled. The cooling also minimizes fire hazard. Accordingly, we have shown in Fig. 7 a dehydrating apparatus which may, for example, be of the type shown in Patent 2,076,873. The hot gases from the furnace 82 pass into the rotating drying drum 83. Admitted to the gases in the entrance pipe 84 is the produce which has been dumped on to receiving conveyor 85 to be carried by the delivery conveyor 86 to the machine.

While the drum 83 is rotated by motor 87, the material and gases pass to and fro between the inner, intermediate, and outer shells as shown in the above patent, finally issuing at 88 to pass into the blower 89. The discharge pipe 90 of this blower communicates with the pipe 15 of the separator 16 as shown in Fig. 1. At this point, either in this device or the device of Fig. 1, we may use a trap 660 like the trap shown at 66 in Fig. 1, the trap 660 discharging into the hammer mill 400 driven by motor 91.

In this construction the hammer mill base 430 has a baffle 92 above which there is an air passage 420 and below which there is an air passage 460, these passages performing the functions of the pipe 42 and 44' in the Fig. 1 construction. This feature may also be used in the Fig. 1 organization.

In this device, the material passes through the pipe 140 to a cooling cylinder 94 which, like the dehydrating cylinder, may be of the general construction shown in Patent 2,076,873, a cross-section of this cylinder being illustrated in Fig. 10. It will be observed that there is an outer shell 95, an intermediate shell 96, and an inner shell 97 into which the material is directly delivered from the pipe 140. The material flows in sequence through the passages between these shells, being lifted by the flights 98 and caused to drop through the current of moving gas over and over again, advanced by the gas flow through the cylinder in

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the course of each dropping movement. The cross-section of the cylinder is, of course, so great as to reduce the gas velocity below the speed at which the material will be entrained to move at the same velocity at which the gas is moving.

The fan responsible for the movement of all of the gases and material in the closed system is the fan 45, this device differing from that of Figures 1 to 3 principally in the inclusion of the cooling cylinder 94 between the hammer mill and the fan. Beyond the fan the gas velocity increases in pipe 141, and the material is again entrained and moved through pipe 141 to the refrigerator 47 which removes some heat directly from the material and takes from the gases such heat as they have picked up from the material, as in the Fig. 1 device. The discharge from the refrigerator 47 leads, as in Fig. 1, to the separator 55, from which the refrigerated gases return to the hammer mill through pipe 750 and branch 410, the chilled meal being discharged through the trap 661.

In both of the embodiments above described, a hammer mill has been included in the closed circulatory system. However, it is not at all essential to the invention that the material be ground while in the system, or even that it be ground at all. In the embodiment shown in Fig. 11, the material, whether ground or unground, is admitted through the pipe 152 to a trap 662 which may be like the trap 66 shown in Fig. 1. This trap discharges at 672 directly into the pipe 442 which is a part of the closed system in which the refrigeration gases are in circulation. This pipe constitutes an admission pipe for the fan 45, the delivery pipe 142, leading from the fan directly to the refrigerator 472 where the gases are chilled in the presence of all the entrained material. Beyond the refrigerator, the gases pass into the separator 55 from which the entrained material is delivered through the trap 66 while the gases return through pipe 442 to the blower 45.

In any of these embodiments, the dwell of the material to be cooled in the circulatory system may be prolonged by incorporating in the system at any desired point a rotary cylinder like that shown at 94 in Figs. 7, 9, and 10. Such a cylinder has further advantage in that it very thoroughly mixes various materials which may be entrained in the circulatory gases.

In the event that the relatively coarse and fine materials discharged by the hammer mill become separated in the system, the rotating cylinder will tend to recombine them.

Fig. 13 shows an arrangement for intentionally separating fines from coarser materials to avoid over-grinding the fines in an effort to reduce coarser components. The utility of the suggested arrangement is not limited to the embodiment of Fig. 13.

In Fig. 13, the material, which may, for example, be alfalfa, passes from the dehydrator 833 into blower 893 which delivers the alfalfa and moisture saturated air through pipe 99 to separator 163. From the top of separator 163, the hot wet air is discharged. The dehydrated alfalfa passes through trap 663 into hopper 100, which is open to the atmosphere. Below this hopper is an inclined pipe 101 to which the alfalfa moves with entrained relatively cool and dry atmospheric air into blower 894. Nails, stones, and the like are discharged by gravity through the opening 102 at the lower end of pipe 101.

From blower 894 the material moves with cool air through pipe 101 into separator 164, being cooled by the air in which it is entrained. Such air is delivered off at the top of separator 164 and the material is discharged into the coarse-cut mill 403. The leaves and stems are not finely powdered in such a mill and are delivered together by blower 895 through pipe 102 to separator 165. The entraining air is again discharged at the top. The coarse ground alfalfa passes through hopper 103 onto a vibrating screen 104 which may be reciprocated by a connecting rod 105 from crank shaft 106. The fines passing through the screen (mostly leaf

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material) go through trap 664 and pipe 107. The coarser stock (mostly stem material) is picked up in hopper 108 and passes through trap 665 in the fine-cut hammer mill 404 where the coarse material is reduced to fineness and passes into the refrigerated air supplied through pipe 753 and branch pipes 413 and 423 and 463. Pipe 463 leads into pipe 144 into which the pipe 107 discharges the separated leafy material so that this may enter the cooling cylinder 94 along with the refrigerating air and ground stems to be simultaneously cooled and recombined with the separately ground stems. Otherwise the circuit of Fig. 13 corresponds to that of Fig. 12.

It is contemplated that a device of the character described can be used in a manner such that the freshly dehydrated alfalfa will be only coarse ground in the first instance and thereafter immediately cooled and stored without sifting or regrinding at the time. For this operation there is no substantial dust loss in an ordinary cyclone, because virtually no dust is formed in the coarse grinding of freshly dried products.

At the time of use or sale, the stored coarse ground material may be taken out of storage and sifted to segregate the coarse stems from the relatively finer leaf material. Only the coarse or stem portion will then be re-ground and remixed with the fines as above described.

In such remixture, it is desirable to use closed circuit convection current cooling, as described above, to eliminate the heat developed in the regrinding operation and to preclude dust loss.

The resulting product is rather granular than dusty, considered in its entirety, and is made up of particles relatively uniform in size. Handled in this way, there is little heat generated in grinding, and little power consumed, and negligible loss in dust. In operations conducted by conventional methods preceding this invention, dust losses have averaged about 6% of the total of the material handled. Almost all such losses are saved by the present invention.

Alternatively, materials of different origin or different type may be fed separately into the circulatory system to be mixed in the cooling cylinder 94 concurrently with their chilling by refrigerated gases circulating in the closed circuit. Thus, in Fig. 12, we have shown two separates traps 666 and 667, each provided with its own admission pipes 109 and 110 respectively and each discharging into the pipe 144 of the circulatory system which leads into the cooling cylinder 94. From the rotatable cooling cylinder, wherein the different materials are thoroughly mixed with each other while being chilled by the circulatory gases, all of such materials are entrained in the gases in the blower 45 and delivered through pipe 144 to the refrigerator 474 and then to the separator 55. From the top of this separator leads the pipe 144 to return the gases to the cylinder 94. From the bottom of separator 55 the mixed materials are discharged through the trap 665. In this device, as in all other embodiments of our invention, all of the materials entrained in the circulatory gases pass with the gases over the refrigerating coils where the materials are directly cooled by contact with the coils and serve to keep the coils clean while the gases are being cooled.

The embodiment shown in Fig. 14 contains two additional suggestions for modification, these being applicable independently or concurrently to any other of the embodiments herein disclosed and particularly any other embodiment using a dehydrator in conjunction with the cooling circuit.

In Fig. 14, the dehydrator 946 has its burner 109 supplied with gaseous fuel from a storage tank 110 wherein such fuel is kept under high pressure. The expansion of the fuel, following its passage through the pressure reducing valve 111, results in a considerable temperature drop which may be used by passing the expanded fuel through the coil 112 in brine storage tank 113 to reduce

the temperature of the brine 114 circulated by pump 115 through the refrigerating chamber 476, which corresponds to that shown at 47 in Fig. 1, and is disposed in the pneumatic cooling circuit so that the material to be chilled will pass with the pneumatic convection currents over the cooling coils as above described, it being deemed unnecessary to repeat the disclosure of such circuit or the coils.

We have shown at 116 a stand-by mechanical refrigeration unit which has its evaporator coil 117 in the brine for the further refrigeration thereof in the event that the refrigeration received by coil 112 is inadequate to effect desired cooling in chamber 476. Thus, this embodiment suggests that, instead of having the refrigerant evaporating in the coils of the cooling chambers, we may use an interposed circulatory medium such as the brine 114 for absorbing heat from such coils, this being a well known equivalent to the direct chilling of such coils. Also suggested in this embodiment is the use of the expansion of a gaseous fuel as a means of refrigerating, or contributing to the refrigeration of, the coils which actually cool the convection current and product to be chilled.

We claim:

1. A method of refrigerating solids in a stream of gas containing moisture, said method comprising circulating gases in a closed circuit, delivering the solids to be cooled into said circuit at one point for advance therein by the circulating gases, separating the solids from the circulating gases and discharging the solids from another point in the circuit, and passing both the gases and solids over refrigerating heat exchange surfaces at a point intermediate the point of admission and the point of discharge of the solids at scouring speeds whereby the impact of said solids against said surfaces scours said surface and prevents accumulation of liquids or solids thereon, said refrigerating heat exchange surfaces being cooled to the point where condensation of the moisture in said gas would otherwise hold and accumulate solids on said surfaces.

2. The method of refrigerating solids susceptible of pneumatic convection, said method consisting in the circulation of cooling gases in a closed circuit at speeds sufficient to entrain said solids, said gases containing moisture, exposing said gases to refrigerating heat exchange surfaces in the course of their circulation to normally condense said moisture on said surfaces, introducing the solids to be cooled into the circulating gases before such gases reach said refrigerating surface, the velocity of the gases and entrained solids being such that the solids traverse such surfaces with the gases to scour from said surfaces such moisture and solids trapped thereby, and discharging such solids from said gases after the solids and the gases have traversed said surfaces.

3. The method of cooling small particles of solids, said method comprising circulating cooling gas in a closed circuit, exposing said gas to refrigerating heat exchange surfaces in the course of its circulation, introducing into said gas in advance of said surfaces the solid particles to be cooled, passing such particles with the gas across said surfaces, retarding the rate of gas flow during the movement of the particles with the gas below the speed at which the particles will be entrained in the gas, repeatedly raising the particles and dropping the particles across the path of gas movement to give the particles prolonged exposure to the gas for the delivery of their heat to the gas, centrifugally separating the particles from the gas after the particles and the gas have traversed such surfaces, and discharging the particles from the closed circuit while returning the gas for recirculation therein.

4. Apparatus of the character described comprising the combination with conduit means providing a closed circulatory system and including therein a blower, a refrigerator, a separator, and connecting conduit means, the blower being adapted to circulate gas through said closed system, said refrigerator comprising heat exchange

surfaces exposed to the gas in the course of its circulation in said system, means for the admission of solids to the gas before the gas reaches said surfaces, and means for operating the blower at speeds which will impact said solids against said surfaces to scour said surfaces and keep them free from accumulation of liquids or solids therein, said separator being located beyond said heat exchange surfaces in the direction of gas circulation and constituting means for the discharge of cooled solids from said system after said solids have passed with the gas over said surfaces.

5. In a device of the character described, the combination with a refrigerator casing, a blower casing, and a cyclone separator casing, of piping connecting said casings in series in a closed circuit, refrigerator coils in the refrigerator casing, a blower fan in the blower casing, a discharge trap opening from the cyclone casing, means for admitting material to be cooled to said piping in advance of the refrigerator casing, and means for operating the blower fan at speeds to scour entrained material against said refrigerator coils, whereby such material will pass through said refrigerator casing with the gas in said system without deposit on said coils and will be separated from said gas in said cyclone casing after traversing said coils, the refrigerator casing being located between said admission means and said cyclone casing.

6. In a device of the character described, the combination with a refrigerator casing, a blower casing, and a cyclone separator casing, of piping connecting said casings in series in a closed circuit, refrigerator coils in the refrigerator casing, a blower fan in the blower casing, a discharge trap opening from the cyclone casing, and means for admitting material to be cooled to said piping in advance of the refrigerator casing, whereby such material will pass through said refrigerator casing with the gas in said system, and will be separated from said gas in said cyclone casing after traversing said coils, the refrigerator casing being located between said admission means and said cyclone casing, and a rotary drum of materially greater cross-section than said piping intervening between the point of material admission and the point of material discharge and being provided with flights for the elevation of material and its discharge across the circulating gases in the course of drum rotation, the cross-section of the drum being sufficiently large to retard gas flow so that the material will be advanced by such flow but not entrained therein during its traverse of the drum.

7. In a device for refrigerating solid particles, the combination in closed circuit of a fan casing, a refrigerator casing, and a cyclone separator casing and connecting piping from each casing to the next, an admission trap opening into said piping in advance of the refrigerator casing, and a discharge trap opening from the cyclone separator casing, the solids to be cooled being admitted through the admission trap into such circuit to move with the gases therein through the refrigerator casing and discharged from such gases in the cyclone separator casing for delivery through the discharge trap, the fan casing being provided with a fan and the refrigerator casing with refrigerated heat exchange surfaces, in further combination with a second admission trap opening into said circuit, said circuit further including a rotatable drum having driving connections for its rotation and being of such large cross-section as to reduce below entrainment velocity the gases circulating in the system, the said drum being located beyond both of said admission traps and having internal flights adapted in the course of drum rotation to elevate materials received through the respective traps and to drop such materials across the path of gases circulating in said system to mix and to cool such materials.

8. The method of grinding the stems and leaves of produce, which includes coarse-grinding the stem and leaf material together, screening such material to separate

the finer ground product from the coarser ground product, regrounding the coarser product to fineness independently of the product initially finer ground, recombining the re-ground product with the product initially finer ground by establishing an air current to which both of said products are delivered by dropping them transversely of said current, and refrigerating the current of air across which said products are dropped, whereby exposure to the refrigerated air will effect the cooling of said products concurrently with the mixing thereof.

9. A method of comminuting, dehydrating, and chilling produce comprising leaf and stem material, which method comprises dehydrating all of such material together, coarse-grinding all of such material together, screening the coarse ground material to separate the finer component, mostly leafy material, from the coarser component, mostly stem material, re-grinding said coarser component to a degree of fineness comparable to that of the initially finer component, establishing a current of cooling air in a substantially closed circuit, refrigerating at a certain point the air of such circuit, delivering into such air the material initially finely ground and that re-ground for pneumatic convection and cooling in the air of such circuits, and discharging the material from the air of such circuit.

10. The method recited in claim 9 in which the material is caused to flow with the air of said circuit past the point at which such air is refrigerated whereby said material scours the refrigerator before such material is discharged from the circuit.

11. The method recited in claim 10 in which the initially finely ground material and the re-ground material, while in said current of air, are rapidly elevated transversely of said current and dropped by gravity transversely of said current, while the air in such current is retarded in velocity to an extent such as to advance the material without entrainment thereof, whereby the said material is remixed and simultaneously cooled.

12. Apparatus comprising in combination a dehydrator, a first blower, a first separator having separate air and

material discharge openings, a second blower having a collective opening for receiving such material from the first separator, a second separator connected to receive the material with atmospheric air from the second blower and provided with separate air and material discharge openings, a coarse mill having inlet means arranged to receive the material discharged from the second separator, said inlet means being open to receive atmospheric air, a third blower having its inlet connected with said coarse mill to receive the product ground therein, a third separator connected to the third blower to receive such material along with atmospheric air and provided with separate air and material discharge openings, a mechanical screening device positioned in the path of material discharged from the third separator and having separate outlets for coarse and fine material, a fine grinding mill connected to the coarse material outlet of said screening device to receive the coarser material discharged from said device, a pneumatic conveyor system substantially closed against atmospheric communication, and into it the finer material is directly delivered from said screening device and the reground material is delivered from said fine grinding mill and means for refrigerating the air circulating in said system and for discharging from such air the cooled material aforesaid.

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