March 25, 1930. A. A. CRIQUI 1,751,472

DRYING PROCESS AND APPARATUS

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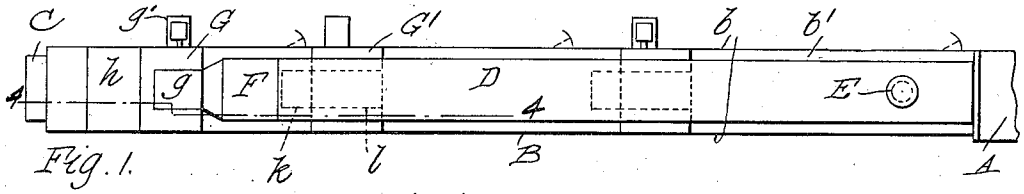


Fig. 1.

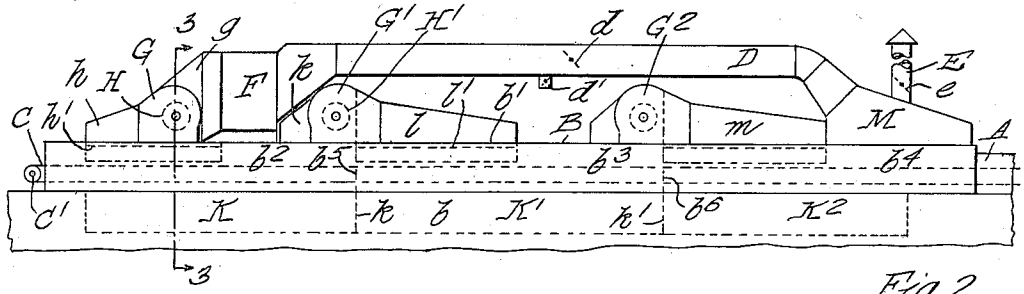


Fig. 2.

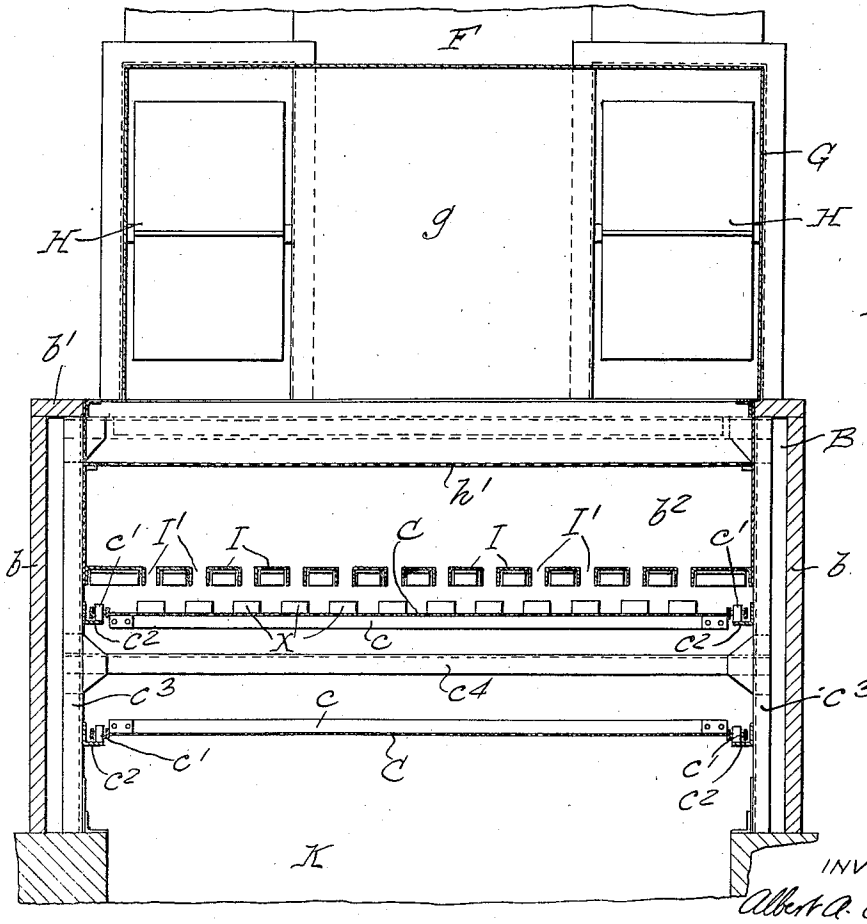


Fig. 3.

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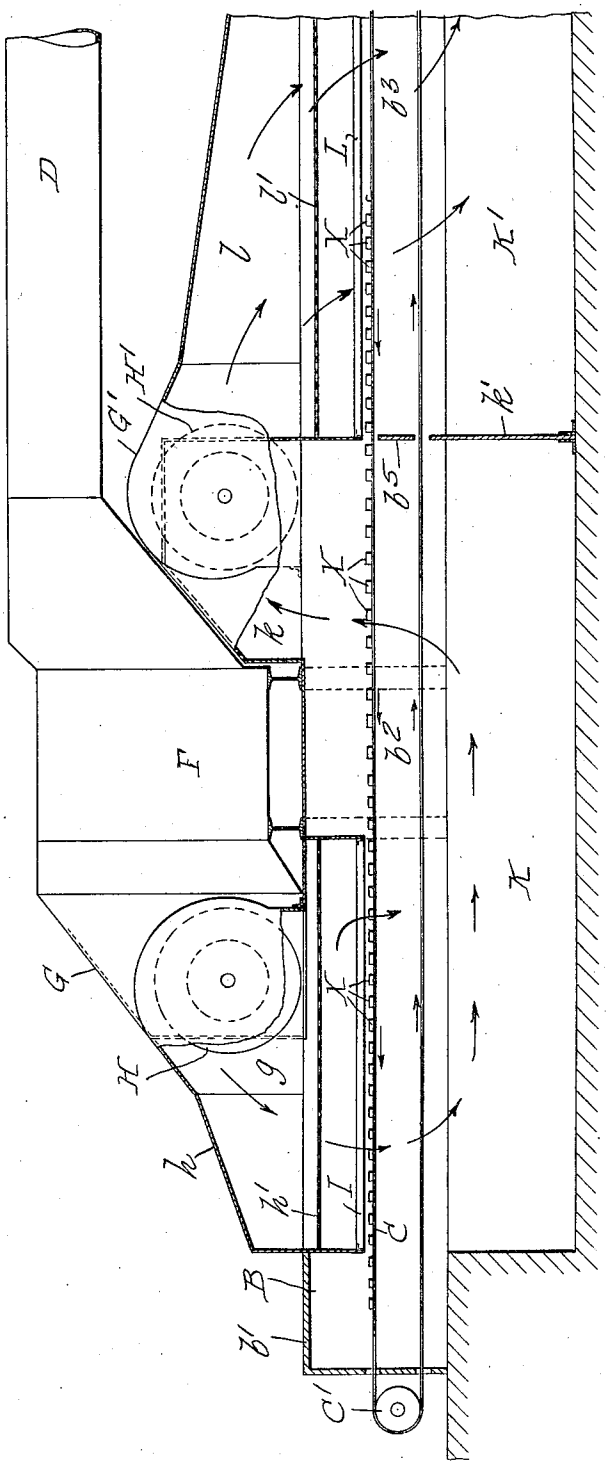



Fig. 4.

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# UNITED STATES PATENT OFFICE

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## DRYING PROCESS AND APPARATUS

Application filed May 1, 1926. Serial No. 105,975.

This invention relates to a process and apparatus for drying materials which are pervious to air or gases, and more particularly for drying material formed into cakes or shapes of considerable thickness and which must be dried uniformly throughout their interior and exterior portions.

The objects of this invention are to provide a drying process and apparatus by means of which air is directed at the articles to be dried with sufficient force to pass through the articles; also to provide a process and apparatus of this kind in which the air is passed alternately downwardly through the articles and upwardly through the same; also to provide a process and apparatus of this kind in which the articles to be dried pass continuously on a conveyor through the various parts of the apparatus and in which the blast of air is so directed that the conveyor will tend to hold the articles in place while subjected to a blast of air or other drying medium; also to provide a process and apparatus of this kind in which a part of the air which has absorbed moisture from the articles to be dried is discharged and replaced by fresh air so that an efficient use is made of the air used for drying the articles; also to improve the construction of driers of this kind in other respects hereinafter specified.

In the accompanying drawings,

Fig. 1 is a top plan view of a drying apparatus embodying the invention.

Fig. 2 is a side elevation thereof.

Fig. 3 is a transverse, sectional elevation thereof on an enlarged scale on line 3—3, Fig. 2.

Fig. 4 is a longitudinal, sectional elevation thereof on line 4—4, Fig. 1.

The process and apparatus shown in the accompanying drawings is intended particularly for effecting the drying of cakes or biscuits of the kind made of a shredded grain or cereal in which the shreds or fibers are more or less loosely held together. Cakes or biscuits of this kind are generally first toasted while in wet condition to brown the opposite faces of the biscuits and are then dried, and it is important that both the exterior and interior of the biscuit be dried thoroughly to prevent molding or spoiling of the articles. It will be understood, of course, that the apparatus embodying this invention is usable for drying other materials which are pervious to air or other gas.

In accordance with my process the articles to be dried are passed through a drying chamber on a conveyor of screening or other perforate material, and a blast of air or other drying medium is directed downwardly by a fan against the articles while supported on the conveyor in such a manner that air will pass around and through the articles to be dried, the articles being supported in such a manner and the air being so directed at the articles that they will not be dislodged from their position on the conveyor by the air blast, and for this reason the air is preferably directed downwardly at the articles which are supported on a substantially horizontal conveyor. The direction of movement of the air after it has passed through the conveyor and through and around the articles thereon is changed so that the current of air then passes upwardly at a lower velocity through the screen and again passes through and around the articles, the decrease in velocity being sufficient so that the articles will not be dislodged from their positions on the conveyor. The same air is then preferably passed to another fan and again discharged at high velocity downwardly through and around other articles on the conveyor which contain a greater amount of moisture so that the same air can take up more moisture from wetter articles, the direction of the air after passing through the screens and articles being again changed so that the air at lower velocity again passes through and around wetter articles in an upward direction and at a reduced speed. As many fans may be employed as may be desired, three being shown in the drawings, the same air being successively used on articles containing greater amounts of moisture. When the air arrives at the end of the drier at which the moist articles enter, a part of the air may be discharged from the drier, and another part of the air mixed with fresh air or other drying medium passes through a heater and then to the first men-

tioned fan or blower, from which the warm and relatively dry air is discharged at high velocity to the comparatively dry articles near the discharge end of the conveyor, and the process is repeated.

The conveyor on which the wet articles are placed preferably passes first through a toasting chamber and then to the drier, communicating slots or openings being provided through which the conveyor and the articles thereon may pass from the toasting chamber to the drier, and the pressure of the air in the drier is so regulated as to be as nearly as possible equal to the pressure of the air in the toasting chamber so that there will be little or no circulation of air between the drier and toaster. This is preferably accomplished by regulating dampers or valves which control the discharge of air from the drier and the admission of fresh and recirculated air to the first fan. By means of this regulation of air pressure in the drier to prevent the flow of air through the passages connecting the toaster and the drier, the toasting of the articles can be carried on at the maximum efficiency and without interference by the flow of air in the toaster in either direction, and the moist air from the toasting chamber is kept out of the drier, so as not to interfere with the drying operation.

In the particular embodiment of the invention shown in the drawings, A, Figs. 1 and 2, represents the discharge end of a toaster or toasting oven through which the material to be dried passes before entering the drier. B represents the housing of the drier which is preferably connected with the toaster A by means of connecting passages or slits (not shown) through which the articles to be dried may pass from the toaster to the drier. This casing or housing B may be of any suitable or desired construction and is preferably in the form of a long channel or tunnel and includes side walls $b$ and a top wall $b'$. The drier housing is divided into a number of compartments arranged end to end lengthwise of the housing, three such compartments $b^2$, $b^3$ and $b^4$ being provided in the construction shown and being separated from each other by transverse walls or partitions $b^5$ and $b^6$. The materials or articles to be dried are placed on the upper run of a conveyor or belt C which is preferably made of screening or other perforate material and which extends lengthwise of the housing B and through the several compartments thereof. slits being provided in the partitions $b^5$ and $b^6$ and in the end walls of the housing B through which the conveyor and the articles supported thereon may pass. The upper run of the conveyor passes from the toasting chamber A to the left in Figs. 1, 2 and 4 through the drier housing and over a drum C′ which is arranged beyond the end of the drier housing and the dried articles are discharged at this end of the conveyor. The lower or return run of the conveyor may pass back through the drier housing and toaster in the reverse direction.

This conveyor may be of any suitable or desired construction, that shown including a series of transverse bars $c$ extending from side to side of the conveyor belt or screen C and secured thereto, Fig. 3, and the ends of these bars are preferably provided with suitable rollers $c'$ which operate on tracks or rails $c^2$. The rails in the particular construction shown are formed of angle iron bars, the lower or horizontal flanges of which form supports or guides for the rollers $c'$ and the upright flanges of which are secured to posts $c^3$ arranged within the housing B. $c^4$ represents braces extending transversely of the housing and secured at their ends to the posts $c^3$, these braces, in the construction shown, being arranged between the two runs of the conveyor belt C. X represents the articles which are being dried and which are preferably arranged in rows extending lengthwise of the conveyor. By means of the bars $c$ described, the parts of the belt are prevented from sagging and are maintained in their correct positions. A drier housing and a conveyor of any other suitable or desired construction may be provided, if desired.

D represents a return duct for conducting air from the compartment $b^4$ of the housing toward the article discharge end of the housing. This duct is provided with a valve or damper $d$ by means of which the amount of air passing through the return duct D may be regulated, the balance of the air being discharged from the article receiving end of the drier by means of an exhaust or discharge pipe or stack E, which preferably also has a valve or damper $e$ arranged therein so that by regulating the two valves or dampers $d$ and $e$, the amount of air recirculated through the duct D and discharged through the stack E may be controlled as desired. A fresh air inlet $d'$ is provided in the duct D beyond the damper or valve $d$, which may also, if desired, be provided with a damper for controlling the amount of fresh air admitted. The return duct D conducts the mixture of fresh and recirculated air to a heating chamber F, which may contain the usual steam coils or other heating devices (not shown), and the air is raised to the desired temperature while passing through the heating chamber F. The air is discharged from the heating chamber into a passage $g$ in a fan housing G, the passage $g$ being arranged between a pair of centrifugal fan wheels or rotors H, Fig. 4, preferably mounted on the same shaft and driven from the same motor, which may be mounted on a motor supporting platform $g'$ arranged at the side of the apparatus as shown in Fig. 1. The two fan wheels H discharge the air into a receiving chamber $h$ which extends in advance of and below the

fan or blower housing G, and contains near the upper portion of the chamber $h$ a substantially horizontally arranged distributor plate $h'$ which may be in the nature of a plate having a plurality of perforations therein through which the air may pass and which distributor plate serves to equalize the pressure and velocity of the air in the space below the plate. The air then passes through a series of openings or restrictions by means of which the air is directed at the articles which are being dried. These air guiding or directing openings may be of any suitable or desired form, being shown in the drawings as consisting of a series of channels or passages I' arranged lengthwise of the rows of articles to be dried. In the particular construction shown these channels are formed between the adjacent sides of a series of substantially inverted U-shaped grids or members I suitably supported in the lower end of the air chamber $h$ and directly above the articles X on the conveyor belt. It is to be understood, however, that these openings need not extend lengthwise of the rows of articles to be dried but may extend transversely of the direction of movement of the conveyor belt or they may be of other shapes adapted to direct the air in a series of jets downwardly upon the articles to be dried.

By means of the arrangement described a strong blast of air is produced since the total area through which the air is forced to pass is greatly restricted by the grids or deflectors I. Furthermore by means of the grids or deflectors, the air is accurately directed downwardly upon the articles since the channels I' for directing the air from the air chamber $h$ guide the air currents so that the air passes directly downwardly against the articles, thus eliminating any tendency of the air to blow the articles from the screen, and causing the air pressure merely to force the articles against the screen itself. The air blast can, therefore, pass completely through the articles and carry off moisture contained within the articles.

The air, after having passed through the articles to be dried and through the two runs of the conveyor screens, enters into a passage K arranged below the housing of the drier and then passes upwardly at a considerably reduced velocity through the conveyor as indicated by the arrows in Fig. 4. The air may then again pass through and around the articles in the compartment $b^2$ of the drier housing and finally enters into a passage $k$ arranged between the air inlets of a second pair of fan wheels H', Fig. 4, arranged in a second fan housing G'. These two fan wheels discharge the air into a housing $l$ containing a distributor plate $l'$ similar to the distributor plate $h'$ and the air then again passes through a series of channels or discharge openings formed between adjacent grids or plates L arranged above the conveyor belt, from which the air passes through and around the articles to be dried in the second compartment $b^3$ of the drier housing. It must be borne in mind that the upper run of the belt carrying the articles to be dried moves in a direction indicated by the arrow in Fig. 4, so that the air discharged between the grids L contains some moisture and is blown through and around articles containing more moisture than those in the compartment $b^2$. Consequently the air will pick up considerable additional moisture in passing through and around the articles in the compartment $b^3$.

After the air has passed downwardly through the articles and the screens in the compartment $b^2$, it collects in a second passage or tunnel K' below the conveyor, which may be a continuation of the tunnel K and separated therefrom by means of a wall $k'$, which may be a continuation of the wall $b^5$. From the passage K' the air is again supplied to a fan contained in a third fan housing $G^2$ from where it is again directed from an air chamber $m$ through and around the articles in the third compartment $b^4$ of the drier housing. The air then enters the third passage or tunnel $K^2$ below the conveyor belt and from this passage $K^2$ the air again passes upwardly through the conveyor screen and the moist articles which have just entered the compartment $b^4$ at the article receiving end of the drier. The air then enters a hood M arranged over the air discharge end of the compartment $b^4$, from which hood part of the air is discharged through the stack E and the remainder of the air enters the return duct D.

By means of the construction disclosed the warmest and driest air is forced through and around the driest articles in the compartment $b^2$. The air then passes upwardly from the channel or duct K through and around the articles on the upper run of the conveyor belt, the velocity of the air being greatly reduced so that the air will not tend to blow the articles upwardly or laterally from the conveyor belt or screen. This air is then slightly cooler and has taken up a small amount of moisture from the relatively dry articles and is then again blown downwardly through and around the somewhat more moist articles in the compartment $b^3$ by the second fan, and a part of the moisture of the articles is absorbed by the air. From this second air duct or channel K' the air passes again upwardly through the articles in the compartment $b^3$, drying the lower faces thereof, and the operation is again repeated by the third fan, which forces the air through and around the wet articles which have just entered the drying chamber from the toaster.

By regulating the dampers $d$ and $e$ and the damper in the fresh air inlet $d'$, if the articles are comparatively hard to dry, a larger

amount of fresh air is admitted into the return duct D and more heat is supplied to the air by the heater F. If the articles are comparatively easy to dry, a larger amount of warm moist air may be recirculated so that more of the heat contained in the air under the hood M may be conserved and less heat is supplied to the air by the heater F.

By means of a proper regulation of the dampers, the pressure of air within the housing B of the drier can be regulated in such a manner that there is little or no flow of air from the toasting chamber or tunnel A to or from the drying chamber, which insures the efficient action of the toaster since air flowing through the toaster in either direction interferes with the proper toasting of the articles, and air flowing from the toaster into the drier may also interfere with the drying operation because of the comparatively large amount of moisture contained in such air.

I claim as my invention:—

1. The process of drying articles which are pervious to air, including directing a blast of air at high velocity at close range through and around an article in a direction to hold the articles against displacement on their support and enable their penetration by the blast, changing the direction of the blast of air and decreasing the velocity thereof, and directing the same in said changed direction and at said decreased velocity through and around the article so as to avoid displacing said articles from their support.

2. The process of drying articles which are pervious to air, including carrying the articles on a perforate conveyor, directing a blast of air at high velocity at close range downwardly into the path of movement of the articles to cause the air to pass downwardly through and around the articles in a direction to prevent displacement of the articles on their support and enable their penetration by said blast, changing the direction and decreasing the velocity of the blast of air after the same has passed through said articles and perforate conveyor and directing the air at said decreased velocity upwardly through the conveyor and through and around the articles supported thereon also to avoid displacing the articles on their support.

3. The process of drying articles which are pervious to air, including carrying the articles on a perforate conveyor, directing a blast of dry heated air at high velocity downwardly into the path of movement of partly dried articles to cause the air to blow through and around the articles and through said perforate conveyor, changing the direction and decreasing the velocity of the air after the same has passed through said conveyor and directing the air in said changed direction through said conveyor and through and around the articles supported thereon, again imparting velocity to the air, and directing the same at high velocity on articles supported on said conveyor and containing more moisture than the articles acted upon by said first mentioned blast.

4. A drying apparatus including a drying chamber, a perforate conveyor passing through said chamber and adapted to support the articles to be dried, a blower, a restricted passage for directing a current of air at high velocity in one direction through and around the articles to be dried, said restricted passage being in such close proximity to said articles that said articles are exposed to the air at the increased velocity caused by said restricted passage and a passage of larger cross sectional area for reversing the current of air after the same has passed through and around said articles to cause the air to blow at a reduced velocity through and around said articles in said reverse direction.

5. A drier including a housing, a perforate conveyor passing through said housing and on which the articles to be dried are supported, a blower, a restricted passage having its discharge arranged in immediate proximity to the articles for directing a blast of drying medium at high velocity through and around the articles in a direction substantially perpendicular to the article supporting surface of said conveyor, and a passage of greater cross sectional area than said restricted passage for reversing the direction of flow of air after the same has passed through said perforate conveyor to cause the same to pass at a reduced velocity and in said reversed direction through and around said articles.

6. In a drying apparatus, the combination of a housing, a perforate conveyor for carrying the articles to be dried through said housing, a plurality of blowers arranged above said housing means for directing currents of air downwardly at increased velocity through said conveyor and through and around the articles supported thereon, and means below said conveyor for changing the direction of air and reducing the velocity thereof to supply the same from one blower to another and to pass the air upwardly through and around the articles on the conveyor.

7. In a drier, the combination of a housing, a perforate conveyor passing through said housing and on which the articles to be dried are supported, a blower arranged above said conveyor for directing a blast of air through said conveyor and through and around the articles supported thereon, and a series of restricted passages terminating immediately above said conveyor and which guide currents of air substantially perpendicularly to the supporting surface of said conveyor and at an increased velocity to hold the articles against displacement on the conveyor while drying the same.

8. In a drier, the combination of a housing,

a perforate conveyor passing through said housing and on which the articles to be dried are supported, a blower, an air chamber into which air is directed by said blower, a perforated plate arranged at a distance above the lower end of said air chamber and which distributes the air uniformly throughout the lower portion of said chamber, and a structure provided with a series of channel-shaped slots at the lower end of said air chamber through which the air is discharged at high velocity at the articles carried by said conveyor.

9. In a drier, the combination of a housing, a perforate conveyor passing through said housing and on which the articles to be dried are supported, a blower, an air chamber into which air is directed by said blower, a perforated plate arranged at a distance above the lower end of said air chamber and which distributes the air uniformly throughout the lower portion of said air chamber, a structure provided with a series of channel-shaped slots at the lower end of said air chamber through which the air is discharged at high velocity at the articles carried by said conveyor, an air passage below said conveyor into which the air passes after being discharged through said conveyor and from which the air again passes through said conveyor in the opposite direction and through and around the articles supported thereon.

10. In a drier, the combination of a housing, a perforate conveyor passing through said housing and on which the articles to be dried are supported, a blower, an air chamber into which the air is directed by said blower, a perforated plate arranged at a distance above the lower end of said air chamber and which distributes the air uniformly throughout the lower portion of said air chamber, a structure provided with a series of channel-shaped slots at the lower end of said air chamber through which the air is discharged at a high velocity at the articles carried by said conveyor, an air passage below said conveyor into which the air passes after being discharged through said conveyor and from which the air again passes through said conveyor in the opposite direction and through and around the articles supported thereon, and a second fan which receives the air after the same has passed through said conveyor in a reverse direction and from which the air is again discharged at high velocity through and around other articles on said conveyor.

11. A drier for articles pervious to air including an elongated housing divided into a plurality of compartments, a perforate conveyor adapted to support the articles to be dried and to pass said articles successively through the several compartments of said conveyor, a blower for blowing a blast of relatively dry warm air downwardly through and around the articles on said conveyor in the compartment nearest to the discharge end of said conveyor, an additional blower for each additional compartment adapted to receive air from one compartment and direct the air at a high velocity into another compartment further removed from the discharge end of the conveyor, means for discharging to the atmosphere some of the air discharged from the compartment furthest removed from the discharge end of the conveyor, and a return duct for conducting another part of the air from said farthest removed compartment to said first mentioned blower, and means for heating the air delivered by said first mentioned blower to the compartment nearest to the discharge end of the conveyor.

12. In a drying apparatus including housing, a perforate conveyor passing through said housing and on which articles to be dried are supported in rows extending lengthwise of the conveyor, a blower, and a series of channel shaped passages extending lengthwise of said rows and above the same for directing blasts of drying medium at high velocity, through and around said articles in a direction substantially perpendicular to the article supporting surface of said conveyor.

13. A process of drying articles which are pervious to air, which comprises supporting the articles on an approximately horizontal pervious grid, directing high velocity jets of drying gas downwardly against the tops of said articles in a direction substantially normally thereto and at close range, and conducting away the gas from below said grid to obtain movement of the gas downwardly only, whereby the drying gas will penetrate and thoroughly dry the articles and hold them against displacement on said grid.

14. A process of drying articles which are pervious to air, which comprises supporting the articles on an approximately horizontal pervious grid, directing high velocity jets of drying gas downwardly against the tops of said articles in a direction substantially normally thereto and at close range, and from one side only of the conveyor, whereby the jets of drying gas will penetrate and dry the interior of the articles and hold the articles against displacement on the grid during treatment thereon.

15. A process of drying articles which are pervious to air, which comprises carrying the articles in rows on a conveyor that moves in a direction parallel to said rows, and directing downwardly against said articles in each row, approximately normal to the upper faces thereof, a jet of drying air extending substantially continuously along the row for a considerable distance, whereby the articles in each row will be subjetced to said jet of air substantially continuously for a considerable

portion of their travel, and dried interiorly by the penetrating jet of air.

16. Apparatus for drying articles which are pervious to air, which comprises a pervious conveyor movable in a prescribed path, a jet device arranged above, and at relatively close range to, said conveyor for directing downwardly against said conveyor in a direction approximately normal thereto, a jet of drying air which penetrates and dries articles arranged upon and carried by the conveyor beneath the jet device, and holds the articles against displacement on the conveyor during treatment thereof.

17. Apparatus for drying articles which are pervious to air, which comprises a pervious conveyor movable in a prescribed path, a jet device arranged above, and at relatively close range to, said conveyor for directing downwardly against said conveyor in a direction approximately normal thereto, a jet of drying air elongated in a direction along the path travelled by any articles arranged on said conveyor beneath the jet, whereby the articles will be subjected for a considerable extent of their travel with the conveyor, to a substantially continuous jet of drying air which penetrates and dries the articles and holds the articles against displacement on the conveyor during treatment thereof.

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