

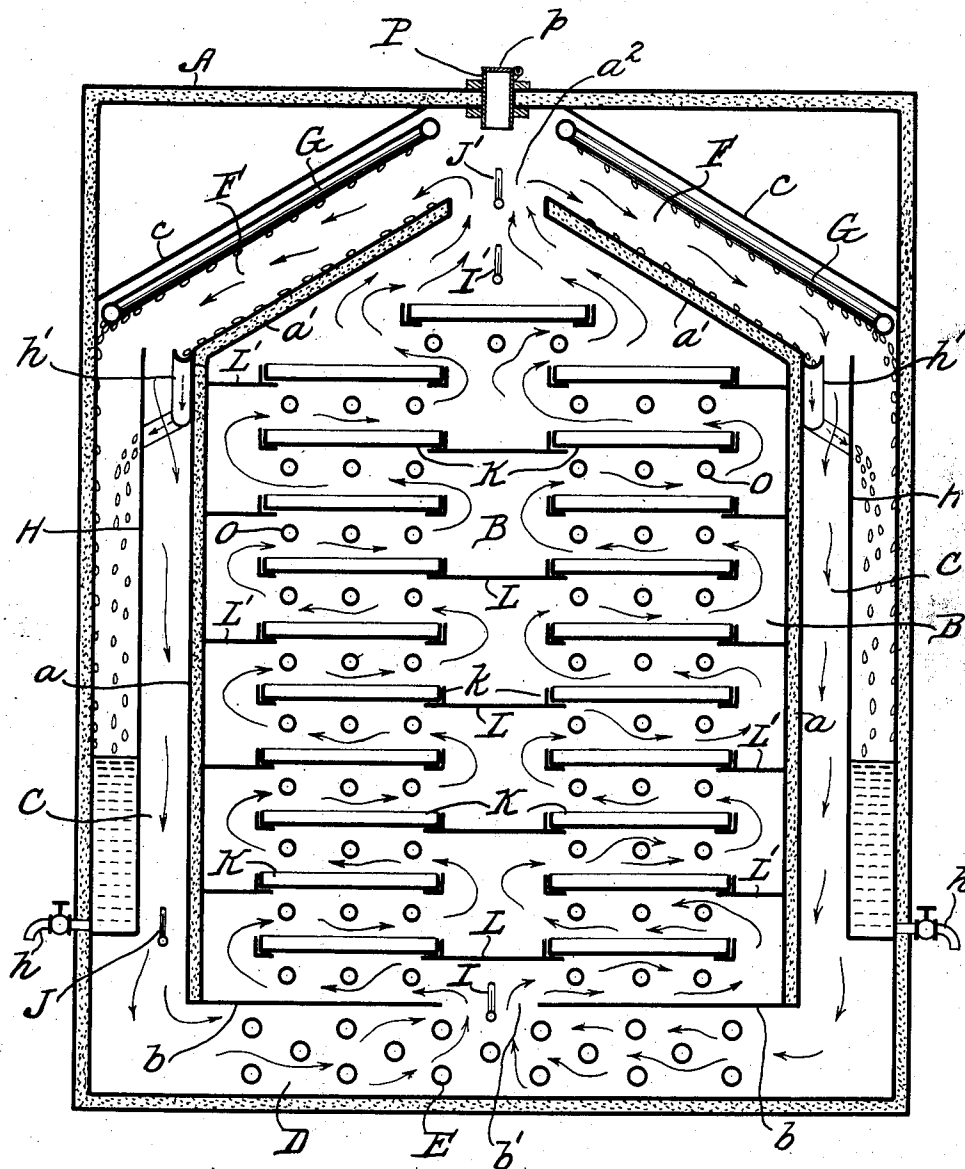
Dec. 8, 1925.

1,564,783

G. D. HARRIS

METHOD OF AND APPARATUS FOR DRYING INCLUDING SOLVENT RECOVERY

Filed May 6, 1921



BY *Gordon D. Harris*
H. J. Bernhard
Inventor.
Attorney.

UNITED STATES PATENT OFFICE.

GORDON DON HARRIS, OF ISLIP, NEW YORK, ASSIGNOR, BY MESNE ASSIGNMENTS, TO
THE INDUSTRIAL DRYER CORPORATION, OF STAMFORD, CONNECTICUT, A COR-
PORATION OF CONNECTICUT.

METHOD OF AND APPARATUS FOR DRYING INCLUDING SOLVENT RECOVERY.

Application filed May 6, 1921. Serial No. 467,493.

To all whom it may concern:

Be it known that I, GORDON DON HARRIS, a citizen of the United States, residing at Islip, county of Suffolk, and State of New York, have invented a certain new and useful Method of and Apparatus for Drying Including Solvent Recovery, of which the following is a specification.

This invention pertains to the art of oxidizing and drying, and more particularly to the recovery of solvents initially employed in the material under treatment and evaporated from such material by the oxidizing or drying thereof, whereby the solvents are condensed from the atmosphere and such solvents are collected for further use, thereby contributing to economy in the drying of materials.

It is well known that certain materials, or classes of materials, contain or carry solvents of one form or another, and that in oxidizing or drying such materials the solvents are volatilized and given off with or without aqueous vapors, from such materials.

One object of this invention is to recover all, or substantially all, the solvents present in or upon the surfaces of the material, and a further object is to conduct the oxidizing or drying of such material in a partial vacuum whereby the exchange of heat for the solvent and aqueous content is carried on rapidly, efficiently and economically.

The material is supported by any form of supporting means within a closed chamber which constitutes a part of a circulatory path from which outside atmospheric air is excluded during the drying and recovery periods. The circulation of an oxidizing atmosphere within this closed circulatory path is set up by a difference in temperature due to expanding such atmosphere by heating it within a definite zone of said circulatory path and to condensing such atmosphere by contact with relatively cold surfaces of a condenser or condensers positioned within another definite part of said circulatory path, as a result of which expanding and condensing operations the atmosphere flows within said circulatory path including the chamber, and into contact with the material. The flowing atmosphere carries heat to the material for driving off the solvent and aqueous content thereof, such solvent content

with or without moisture being given off as a volatile vapor or gas which is taken up by the drying atmosphere and is carried from the treating chamber into a certain cooling chamber or chambers constituting in part the circulatory path, said cooling chamber or chambers being equipped with a condenser or condensers to which a cooling medium of one character or another is supplied for cooling the surfaces of such condensers to a desired degree, such as to the dew point. The atmosphere carrying the volatile vapors, flows into contact with cold surfaces, and thus such vapors are condensed and the atmosphere is chilled, provision being made for collecting such condensate and for discharging the same from the circulatory path. The condensate may be distilled or otherwise treated for the purpose of making the solvent available for re-use.

Other functions and advantages of the invention will appear from the following description taken in connection with the drawing, wherein the figure is a vertical section through an apparatus for carrying out my invention.

The housing A is constructed with air tight walls, insulated in a well known manner, to the end that no outside atmospheric air may be admitted during the periods of conducting the drying or oxidizing operation and the recovery of the solvent, such operations involving the utilization of a drying or oxidizing atmosphere set into motion by a difference in temperature within a closed circulatory path and without resorting to means, such as blowers or exhausters, for mechanically circulating such atmosphere.

Within the housing are partitions *a*, insulated to arrest the transmission through the walls of heat and cold, said partitions being inclined to produce an interior roof *a'* in which is a centrally positioned opening or port *a''*. At the bottom of the walls or partitions *a* is a floor *b*, in which are provided one or more ports *b'*. The interior walls *a*, floor *b*, and roof *a'* constitute a material or treating chamber B within which is placed the material to be treated. Said walls or partitions *a* are parallel to the sides of the housing, and form therewith side chambers C C at opposite sides of the material chamber. The floor *b* is parallel to the bottom of the housing so as to form

therewith a chamber D below said material or treating chamber B, and within said chamber D is positioned a heater E, shown as coils to which a heating medium, such as steam or hot water, is adapted to be supplied, provision being made for controlling the flow of the heating medium to the coils for regulating the heating effect thereof upon the drying or oxidizing atmosphere.

Within the housing and above the roof a' to the material chamber are inclined partitions c which extend across the side chambers C, said partitions c and roof a' producing certain chambers F which communicate with material chamber B by way of port a^2 and which chambers F have free communication with the side chambers C. Positioned within the chambers F are condensers G, herein shown as coils to which there is supplied an appropriate cooling medium, such as cold water or the usual refrigerating agent, provision being made for controlling at will the feed of the cooling medium to said condensers with a view to keeping the surfaces thereof at a low temperature, such as at the dew point. The condensers are inclined downwardly toward the sides of the housing and the chambers C, and in the service of the apparatus such condensers perform the twofold function of condensing the volatile vapors and aqueous vapors present in the drying atmosphere flowing within the chambers F and of chilling such atmosphere so that its temperature is materially reduced, to the end that the atmosphere flowing out of chamber B and within the chambers F will become chilled and descend within the chambers F and C, and thence pass into expanding chamber D for contact with the heater E. Chambers F constitute cooling chambers for the drying atmosphere, whereas chamber D is a heating chamber.

The chambers B, F, C, D constitute the closed circulatory path for the flow of the drying or oxidizing atmosphere, whereof the material chamber B is intermediate the heating chamber D and the cooling chambers F, so that the drying or oxidizing atmosphere, carrying the volatilized solvent vapors and aqueous vapors out of material chamber B, flows into contact with the cold surfaces of condensers G, thus chilling the atmosphere and condensing its volatilized solvent and aqueous content.

Provision is made for collecting the condensate which drips from the cold surfaces of the condenser. Below the inclined condensers are tanks H positioned within chambers C, each tank having a draw-off cock h extending through the housing for discharging the condensate from the circulatory path. The condensate may be distilled or otherwise treated by a subsequent operation for the separation of the water of condensation

from the solvent and the latter rendered available for re-use. The condensate may drip from the surfaces of the condenser and lodge upon the sloping roof a' of chamber B, wherefrom the liquor is free to gravitate into collecting gutters h' leading to the tanks H, as shown.

Thermometers I I' are positioned in the ports b' a^2 for indicating the temperatures of the heated atmosphere flowing into and out of chamber B.

A thermometer I is positioned in the space b' at the bottom of the chamber and in the path of the atmosphere flowing from heating chamber D into the material-containing chamber. Other wet-bulb thermometers (two or more as at I', J') are positioned at the upper part of the material-containing chamber and within the space a^2 said wet bulb thermometers I', J', being in the line of flow of the atmosphere flowing out of the material-containing chamber. Said thermometers I', J', may be of any desired character known to the art for indicating the humidity of the atmosphere flowing out of the material chamber, but as such wet bulb thermometers are well known in the art, I have not considered it necessary to further illustrate or describe the same.

The material is supported by suitable means within the treating chamber B, but in the form shown, said supporting means consists of trays K arranged in two vertical series within said chamber, each tray resting upon appropriate slides, k , whereby the trays may be removed and replaced as required. Co-operating with said trays are baffles L L' positioned for the middle baffles L to be in staggered or alternate relation to the side baffles L', said baffles and trays being so related as to produce a continuous flow passage ascending in a tortuous direction or path from the lower part of the chamber to the upper part thereof.

The drying atmosphere is heated and expanded primarily by heat units from the heater E below material chamber B, but the aqueous and volatile vapors emanating from the material in the trays results in a decrease of the temperature of the drying or oxidizing atmosphere, to compensate for which drop in temperature the atmosphere is reheated as it flows within the tortuous flow passage within said chamber B. Said reheaters O are shown as coils each positioned intermediate two adjacent trays, or between the top of one tray and the bottom of the next tray, and not at the ends of the trays, whereby the atmosphere flowing within the tortuous passage has repeated contacts with the material and with the reheaters for the purpose of heating the flowing atmosphere to a desired temperature, either to keep said atmosphere at a constant temperature, but preferably to heat it increasingly during its

flow from the bottom to the top of chamber B.

P is a vent in the top of the housing, said vent having communication with the closed circulatory path adjacent the port a^2 through which the drying or oxidizing atmosphere flows from chamber B into condensing flues or chambers F. This vent in the normal operation of the apparatus is closed by a valve p exposed to and closed by the pressure of external atmospheric air, but said vent tube is open at the lower part thereof for the free ingress of the atmosphere internally of the housing, so that the valve is exposed to the pressure of both the internal atmosphere and of the external atmospheric air, the preponderance of the latter normally tending to close the valve.

In operation, the material is introduced by trays or otherwise into chamber B, and the latter thereupon is closed for excluding outside atmospheric air during the drying or oxidizing period. Steam is admitted to heater E and reheaters O, whereas a cooling medium is supplied to condensers G G, the inflow of the heating medium and of the cooling medium being regulated as required by the working conditions within the circulatory path constituted by chambers B, F, C, D. The contact of the atmosphere with the cold surfaces of the condensers chills said atmosphere within chambers F and results in the descent within chambers C, whereas the heat units given off by heaters E expands the atmosphere for effecting its ascent within chamber B, the atmosphere being thus set into motion by the difference in temperature given to it at distinctly different zones in the circulatory path and the flow of such drying or oxidizing atmosphere being established without resorting to mechanical means for effecting such circulation. The direction of flow of the atmosphere within chamber B is in tortuous paths directed by the trays and the baffles, at which period the atmosphere exchanges heat for the aqueous and solvent content of the material, said atmosphere being boosted by the action of the reheaters positioned in the line of flow within the chamber, and the temperature and humid condition of such atmosphere at different stages of its flow being indicated by the thermometers. As the atmosphere emerges from the top of chamber B carries the volatilized solvent and aqueous vapors given off by the material into contact with the cold surfaces of the condensers, the effect of which is twofold, to condense the volatilized vapors and the aqueous vapors so that the condensate is collected by the gutters h' and the tanks H, and to chill the atmosphere, insuring the downward flow within chambers F C, and thence to the primary heater.

It will be understood that a higher tem-

perature within the apparatus is established at the beginning of the operation than is employed in the subsequent normal operation, such initial higher temperature tending to expand the atmosphere and to increase the pressure therein for initially opening the vent valve. Thereupon a reduction in temperature takes place and the pressure within the apparatus is less than the outside atmospheric air, and thereafter the condensers chill some of the air present in the apparatus and such chilling with the reduction in temperature sets up a flow of the atmosphere the pressure of which is normally less than that of the outside atmospheric air until in the cycle of repeated operations the internal pressure exceeds that of the outside atmospheric air, the result of which is that the internal pressure opens the vent valve although at infrequent or irregular intervals.

The flow of the drying or oxidizing atmosphere within the circulatory path takes place at a pressure less than external atmospheric pressure (14.7), resulting in vent valve p being kept in a closed condition; but in continued operation the heat units given off to the atmosphere by the heaters and reheaters so increases the volume of the oxidizing atmosphere that the pressure internally of the housing exceeds the external atmospheric pressure, whereupon the vent valve p is opened for such a length of time that some of the atmosphere escapes through the vent or until its pressure is reduced below the outside atmospheric pressure, the vent valve p being thereupon closed. The automatic opening of the vent valve occurs intermittently for the exit of a limited volume of the drying atmosphere, attended by a consequent rarification of such atmosphere, the effect of which is to conduct the drying or oxidizing operation and the recovery of solvents in a partial vacuum and under conditions insuring the recovery of practically all the solvent material present in or upon the surfaces of the material under treatment.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. In the art of drying, the process which consists in placing the material to be treated within a closed circulatory path from which outside atmospheric air is excluded and within which circulatory path is established an attenuated oxidizing atmosphere, the pressure of which is less than that of the outside atmospheric air, heating and so expanding the attenuated oxidizing atmosphere within a definite zone of the circulatory path to establish an upward flow of such atmosphere within a part of said circulatory path, dividing the ascending attenuated oxidizing atmosphere at an upper

part of the circulatory path, and chilling and condensing the divided currents of the attenuated atmosphere within different parts of said circulatory path and remote from the heating zone aforesaid.

2. In the art of drying, the process which consists in setting up an attenuated oxidizing atmosphere within a closed circulatory path from which outside atmospheric air is excluded, and the pressure of which attenuated oxidizing atmosphere within the circulatory path is less than that of the outside atmospheric air, heating and so expanding the attenuated oxidizing atmosphere at a definite zone within the circulatory path to establish an upward flow within a part of said path of the attenuated atmosphere, dividing the upflowing attenuated atmosphere at an upper part of said circulatory path and within the same, and chilling the divided currents of the attenuated atmosphere by conducting said currents into contact separately with condensers positioned within the circulatory path at points remote from the heating zone and acting individually to condense the aqueous and volatile solvent vapors carried by said attenuated atmosphere.

3. In the art of drying, the process which consists in setting up an attenuated atmosphere within a closed circulatory path from which outside atmospheric air is excluded and the pressure of which attenuated atmosphere is less than that of outside atmospheric air, heating at a definite point within said circulatory path the attenuated atmosphere and so expanding the same to create an upward flow within a part of said circulatory path, dividing the upflowing attenuated atmosphere at an upper portion of said circulatory path to establish separate currents in said flowing attenuated atmosphere, chilling the separate currents of said atmosphere by contact with condensers situated within the circulatory path at points remote from the heating zone and condensing the aqueous and volatile content in said divided currents of said attenuated atmosphere, and collecting the condensate so as to discharge the same from the circulatory path.

4. In the art of drying, the process which consists in setting up an attenuated atmosphere within a closed circulatory path from which outside atmospheric air is excluded and the pressure of which attenuated atmosphere is less than that of said outside atmospheric air, alternately heating and chilling the attenuated atmosphere at definite zones within the circulatory path and so expanding and contracting the said attenuated atmosphere so as to create an upflow and a downflow within distinct areas of the circulatory path, dividing the upwardly flowing attenuated atmosphere at the top of the circulatory path to create individual cur-

rents of said atmosphere, conducting the attenuated atmosphere during the upflow thereof into contact with material to be dried, and reheating said upflowing attenuated atmosphere in the periods between the initial heating and the division thereof.

5. In the art of drying, the process which consists in placing the material to be treated within a closed circulatory path from which outside atmospheric air is excluded during the drying period, heating and so expanding and chilling an oxidizing atmosphere by heating and condensing the same at different zones within said circulatory path and setting the same into motion within said path by a difference in temperature, condensing the volatile vapor content of said atmosphere by flowing the same into contact with cold surfaces of a condenser positioned within said circulatory path, and venting said circulatory path at intervals by utilizing the pressure of the oxidizing atmosphere to open a valve normally closed by external atmospheric pressure.

6. In a drier, a housing provided with a material containing chamber forming part of a circulatory path within which is established an attenuated atmosphere and from which path outside atmospheric air is excluded, said chamber being provided in the top thereof with a substantially central outlet, a plurality of flues leading from said outlet and establishing paths for the downflow of separate currents of the attenuated atmosphere flowing through said outlet from said chamber, a plurality of condensers positioned within said flues and adjacent to said outlet from the chamber, and heating means adjacent an inlet to the bottom portion of said chamber.

7. In a drier, a housing provided with a material containing chamber forming part of a circulatory path within which is established an attenuated atmosphere and from which path outside atmospheric air is excluded, said chamber being provided in the top thereof with a substantially central outlet, a plurality of flues leading from said central outlet and establishing paths for the downflow of separate currents of the attenuated atmosphere flowing through said outlet from said chamber, a plurality of condensers positioned within said flues and adjacent to said outlet from the chamber, means adjacent the condensers and within said flues for oscillating the condensate produced by contact of the downflowing currents of the attenuated atmosphere with said condensers, and heating means within the circulatory path and adjacent an inlet to the bottom portion of said chamber.

8. In a drier, a housing provided with a material containing chamber forming part of a circulatory path within which is es-

established an attenuated atmosphere and from which path outside atmospheric air is excluded, said chamber being provided in the top thereof with a substantially central outlet, a plurality of flues leading from said outlet and establishing paths for the down-flow of separate currents of the attenuated atmosphere flowing through said outlet from said chamber, a plurality of condensers positioned within said flues and adjacent to said outlet from the chamber, heating means positioned within the circulatory path adjacent to the inlet at the bottom portion of the chamber, and boosters positioned within the chamber intermediate the inlet at the bottom and the outlet at the top of said chamber.

9. In a drier, a housing provided with a circulatory path including a material chamber and from which outside atmospheric air is excluded during the drying period, condensing means positioned within the

circulatory path adjacent the exit from said chamber, heating means positioned within the circulatory path for warming an atmosphere adapted to flow within said path and for expanding the said atmosphere to a point at which the pressure within the housing is in excess of the external atmospheric pressure, means at the top portion of said material chamber for dividing the upflowing atmosphere into separate currents emerging from the top portion of the chamber, and a valved exit to said circulatory path, the valve of said exit being normally closed by external atmospheric pressure and said valve being exposed to the pressure of the atmosphere within the housing and adapted to be opened when the pressure therein is in excess of the atmospheric pressure.

In testimony whereof I have hereto signed my name this 29th day of April, 1921.

GORDON DON HARRIS.