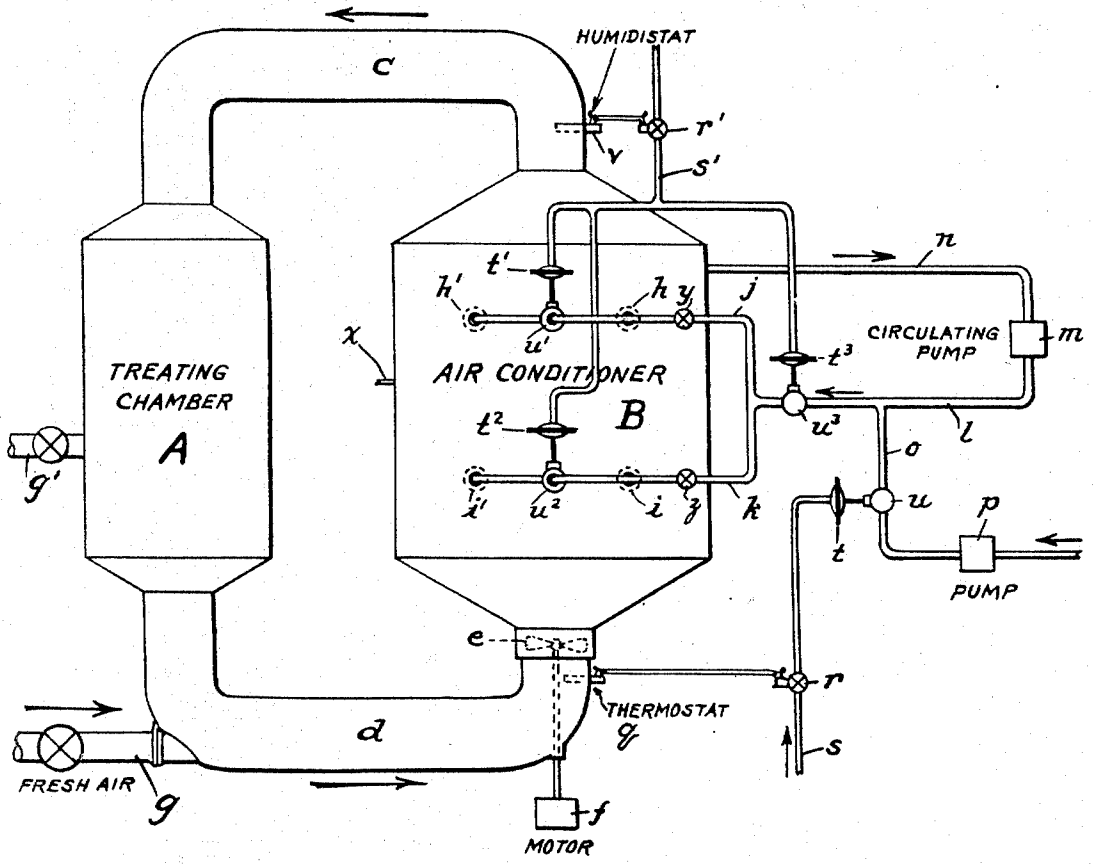
Jan. 28, 1941. R. D. TOUTON 2,229,943

METHOD FOR CONDITIONING AIR

Filed Nov. 22, 1938

Fig. 1.



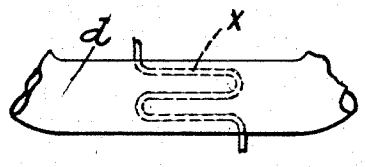


Fig. 2.

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Patented Jan. 28, 1941 2,229,943

UNITED STATES PATENT OFFICE

2,229,943

METHOD FOR CONDITIONING AIR

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Application November 22, 1938, Serial No. 241,763

8 Claims. (Cl. 131—140)

This invention relates to a method for conditioning air or other gas, more particularly with respect to temperature and moisture content.

As is well known variously in the commercial arts, a supply of air conditioned with respect to temperature and moisture content is required for the treatment of materials to condition them for processing. Thus, in the preparation of tobacco for fermentation, sorting, packing, etc., and in the manufacture of tobacco products, as cigars, air so conditioned is advantageously used in conditioning the tobacco by regulation of the moisture content of the tobacco by the removal of moisture from the tobacco or by the addition of moisture thereto.

In the treatment of tobacco to effect regulation of its moisture content preparation or conditioning of the treating medium, as air or other gas, must be accomplished with unusual care and the large volumes of treating medium required for the treatment of tobacco must be conditioned uniformly and with economy, in view of the delicate nature of the tobacco and the economic limitations upon the cost of processing.

In order to bring the tobacco to a proper condition for fermentation, packing, etc., or fabrication, without injury to the tobacco from the standpoint of color, elasticity, flavor, etc., it is essential that a large volume of the conditioning medium, as air, be used and that the condition of the air adjacent to or operative on the tobacco under treatment be uniform. As a consequence economy in operation dictates that the treating medium, as air, be circulated and recirculated with relative rapidity about the tobacco under treatment and then, before any great change in its condition occurs, through a conditioning device by means of which its temperature and moisture content will be regulated to that desired for the treatment of the tobacco.

Now in accordance with this invention a method and apparatus are provided for the conditioning of air or other gas, with respect to its temperature and moisture content, more particularly for use in the treatment of tobacco, which will enable the production of large volumes of uniformly conditioned air or other gas with maximum efficiency and economy and enable control within close limits.

More particularly, the method and apparatus according to this invention will operate to effectively and uniformly condition air or other gas with respect to its temperature and moisture content by treatment of the air, or other gas, with water in amount and at a temperature with respect to the temperature and moisture content of the air to be treated such as to effect desired regulation of the moisture content and temperature of the air, or other gas, by a process of cooling, dehumidification and humidification with resultant regulation of moisture content and temperature of the air, or other gas, to that required.

Having now indicated in a general way the nature and purpose of this invention, I will proceed, with reference to the accompanying drawing, with a detailed description of apparatus in accordance therewith, and from which the method in accordance with this invention will become apparent.

Figure 1 is a diagrammatic view of a preferred form of apparatus for carrying out the method in accordance with this invention.

Figure 2 is a fragmentary view showing a detail of a modification of the apparatus shown in Figure 1.

In the drawing, A indicates a chamber for containing material, as tobacco, to be treated with conditioned air. The chamber A will be of any desired size and shape and will be effectively insulated. The chamber may contain any desired form of fixed or movable support for the material under treatment and may contain a duct system and nozzles for the distribution and direction of the conditioned air with respect to the material to be treated.

B indicates an air conditioning chamber. Conduits *c* and *d* connect the chamber B with the chamber A for the circulation of air therethrough, in the direction of the arrows, under the influence of a fan *e* located in the inlet to chamber B and driven by a motor *f*. A valved conduit *g* leads from the atmosphere into conduit *d* and a valved outlet conduit *g'* leads from chamber A.

Positioned within the air conditioning chamber B are spray heads *h*, *h'* and *i*, *i'* adapted to be supplied with water from pipes *j* and *k*, respectively, which in turn are supplied with water from a pipe *l* by means of a circulating pump *m* supplied through a pipe *n* which receives water discharged by the sprays. A pipe *x* leading from the conditioning chamber B permits excess water to be withdrawn. A make up line *o* leading from pump *p*, drawing from a water supply the temperature of which may be controlled, leads into pipe *l*.

A thermostat *q* is positioned in the inlet end of the conditioner B and is arranged to actuate a bleeder valve *r* in turn controlling the pressure

of air in a pipe s connected with a supply of air under pressure and with a diaphragm control t for valve u in the make up line o by which the supply of make up water is controlled.

A humidostat v is positioned adjacent the outlet end of the conditioner B and is arranged to actuate a bleeder valve r' in a pipe s' connected with a supply of air under pressure and with diaphragm controls t' and t^2 for valves u' and u^2 in the pipes j and k carrying spray heads h, h' and i, i', respectively, and with a diaphragm control t^3 for a valve u^3 in the pipe l.

In the operation of the apparatus described above air is circulated by the fan e through the treating chamber A and the conditioner B, air being withdrawn from the treating chamber, passed through the conditioner and returned to the treating chamber. The fan is essentially placed to draw air from the treating chamber A and discharge it into and through the conditioner B, as, for example, in the inlet to the conditioner. The fan e acts to put heat into the air in order that the air entering the conditioner will carry sufficient heat to evaporate water for humidification of the air after cooling.

The treating chamber contains, for example, hands of tobacco suitably supported on a fixed, or more desirably a movable, support, as an endless carrier, to which the hands are secured by their butts only. The air introduced into the treating chamber is generally circulated therein and desirably in part is introduced into the individual hands of tobacco by passage through suitable nozzles or jets (not shown) directed at the individual hands of tobacco.

The air in its passage through the treating chamber in contact with and in proximity to the tobacco therein gains or loses moisture depending upon whether the condition of the tobacco and of the air entering the heating chamber is such that the tobacco is dried or moistened by the air. Further, the air after leaving the conditioner B is subjected to an increase in temperature due to heat emanating from operators in the treating chamber and from lights, motors, etc., and from the action of the fan e by which the air is circulated. The temperature of the air is further increased by the heat of absorption where the tobacco is moistened and some cooling effect is exerted by the evaporation of moisture from the tobacco when the tobacco is dried.

As a consequence, whatever be the condition of the air leaving the conditioner, its condition with respect to moisture content and temperature is different when it is returned to the conditioner.

Assuming now that it is desired to deliver from the conditioner air capable of performing the desired work on the tobacco, the volume and temperature of the water to which the air is subjected in the conditioner B will be regulated so that it will cool the air entering the conditioner to a point such that it will lose sensible heat and moisture or be dehumidified to a degree and will, by the heat extracted from the air, be caused to evaporate water to a degree such that the air will be rehumidified to the desired degree. In other words, the volume and temperature of the water will be such as to effect desired cooling of the air, dehumidification and humidification to the desired degree.

Thus, control of the temperature of the water to give air at a desired temperature and/or dew point at the outlet of the conditioner B, and consequently about the tobacco, will be effected with respect to the temperature of the air on entering the conditioner by operation of the valve u in the make up line o through the medium of the thermostat q, which through operation of bleeder valve r will effect operation of valve u by causing a greater or less air pressure to act on the diaphragm control with consequent opening or closing of valve u. The water supplied through the make up line o will be maintained at a constant temperature and will act to maintain or vary the temperature of the water discharged through the spray heads by pump m.

The valve u will be normally partially opened and it will be obvious that opening or closing it from its normal condition will result in a change in the temperature of the water circulated through the spray heads.

The volume of water to which the air will be subjected in the conditioner in order to give air at a desired moisture content or relative humidity will be controlled, with respect to the moisture content or humidity of the air leaving the conditioner, by operation of one, two or three of the valves u', u^2, or u^3 through the medium of the humidostat v, which through the operation of bleeder valve r' will control the air pressure on the diaphragm controls t', t^2, and t^3. The several diaphragm controls will be so adjusted that the several valves will be actuated at different pressures or variously the separate units may be closed off by manual operation of valves y and/or z to enable initial control of water volume to which the air is subjected to be exercised through operation of valve u^3 in the line l and secondary control to be exercised, to meet more severe conditions, through operation of the valves u' and u^2 controlling the flow through spray heads h' and i', respectively.

As will now be observed, the air circulated through the treating chamber A is reconditioned to a predetermined constant condition in the conditioner B by water at a temperature and in volume with respect to the condition of the air entering the conditioner with respect to its temperature and moisture content so that cooling to a desired temperature, dehumidification and humidification to a desired moisture content is accomplished through automatic control of the temperature and volume of water to which the air is subjected. As will now be obvious, the temperature of the water will be regulated by the regulation of the admission of make-up water by control of valve u by the thermostat q and the volume of water will be controlled by regulation of the amount of water admitted to the spray heads h, h' and i, i', or by the cutting out of spray heads h' and i', either or both, by control of valves u', u^2 and u^3 by the humidostat v, or manually by manual operation of valve y and/or valve z.

Where necessary or desirable, fresh air may be admitted to the system through valved pipe g and, as will be obvious, various cooling and heating devices may be included in the system where necessary or desirable.

As more specifically illustrative of the carrying out of the method in accordance with this invention with the use of the apparatus described in connection, for example, with the moistening of tobacco in preparation of the tobacco, for example, for fabrication, as in the making of cigars, the tobacco to be moistened, in the form of hands comprising a plurality of relatively dry tobacco leaves, is suitably supported in the treating chamber A. The tobacco, as has been indicated,

will desirably be supported by securing the butts of the hands to a suitable support which, desirably, will comprise an endless carrier, which may move through a circuitous course in order that the tobacco will be subjected to some mechanical manipulation, as, for example, inversion.

The treating chamber A will desirably be equipped with a duct system adapted to receive conditioned air from the conduits *c* and equipped with discharge openings arranged to promote general circulation of conditioned air within the chamber and also will desirably be provided with discharge openings in the form of nozzles arranged with respect to the line of travel of the hands of tobacco, so that forceful jets or streams of conditioned air discharged through the nozzles will be directed variously into the hands of tobacco from the tip ends and/or from the butt ends of the hands.

In the operation of moistening, the air supplied through conduit *c* to the treating chamber will generally be at a lower temperature than that to which the tobacco is subjected in subsequent treatment, as fabrication, in packing and the like, and will generally be less than about 80° F. and the air will contain desired moisture content.

The air withdrawn from the treating chamber will have an increased temperature and lowered moisture content due to loss of moisture to the tobacco. The air passing from the chamber A through the conduit *d* will pass through the fan *e* into the conditioner B. The temperature of the air entering the conditioner will be increased by the heat dissipated by the fan *e*.

The air entering the conditioner B will contact with a spray of water from the spray heads *h*, *h'* and *i*, *i'*, the temperature of which will be slightly cooler, say not more than 5° F., than the wet bulb temperature of the entering air. The air will first be cooled by the water to somewhat below its dew point, with the result that it will be partially dried, or dehumidified, by condensation.

The volume of water to the volume of air and the relative temperature of the water and the air will, however, be such that excessive condensation or drying will not be set up, but, rather, where the air, as in the case of moistening tobacco, is deficient in moisture, removal of excess heat with only slight dehumidification will be effected.

The heat removed from the entering air by the water with which it initially contacts, will be absorbed by the water, some of which will be immediately warmed to the evaporating point thereby and the air having been cooled and slightly dehumidified will, by virtue of the evaporation of some of the water, be provided with the requisite moisture to bring it to the desired moisture content or relative humidity.

The thermostat *q* and the humidostat *v* will effectuate necessary adjustment or regulation of the temperature and volume of the water to which the air from chamber A is subjected in conditioner B to insure that the air leaving conditioner B for return to chamber A will be at desired temperature and moisture content or relative humidity.

It will be appreciated that a large volume of air will be circulated with substantial rapidity through the treating chamber and conditioner to the end that the work of the conditioner will be reduced to a minimum and the maintenance of substantially constant conditions of temperature and relative humidity in chamber A will be facilitated.

As a specific example in connection with the moistening of tobacco, for example, assume that 85,000 c. f. m. of air is circulated through the chamber A and conditioner B, that the heat put into the air in B and A is 4,000 B. t. u. per minute and that 1.25 pounds of water or 8,750 grains of water per minute are lost in A from the air.

In such a system the heat increase will amount to .65 B. t. u. per pound of air and there will be a loss of 1.43 grains of moisture per pound of air in A.

Assuming that the air is released from the conditioner at 75° F. dry bulb, 72° F. wet bulb, the air will have a dew point of 70.8° F. and the wet bulb depression will be 3° F.; and assuming further that the air delivered from the conditioner B contains 35 B. t. u. per pound and 114 grains of moisture per pound, the net change in the condition of the air will be as shown in the following table:

	In *c* original	After *e* return	Change
	° F.	° F.	° F.
Dry bulb	75	77	2
Wet bulb	72	72.5	0.5
Depression	3	4.5	1.5

The temperature and water volume to which the air from treating chamber A will be subjected in the conditioner B will be so regulated as to recondition the air by cooling, dehumidification and humidification, the latter being effected by evaporation of water by the heat extracted from the air by the water in cooling, so that air will be discharged from the conditioner into the conduit *c* in its original condition. The air will be humidified in the conditioner B by evaporation of water caused by heat extracted from the air to an absolute moisture content very substantially higher than that of the air entering the conditioner.

Assuming that tobacco in chamber A is to be dried, a somewhat higher temperature, say about 80° F. to about 90° F. will be used. Under such conditions there will usually be some heat lost through the walls of the chamber A and also a heat loss due to the evaporation of moisture from the tobacco. In such case, if the heat input to the air from the fan *e*, is insufficient to somewhat increase the temperature of the air as returned to the conditioner, heat may be supplied to the air by means of any suitable heating means *x* placed, for example, in conduit *d* to correct the heat losses, as shown in Figure 2.

The air returned to the conditioner B from the treating chamber A will have an excess moisture content and a somewhat increased temperature. On entering the conditioner B, the air will be first dehumidified by a portion of the water to which it is subjected and by increase in the temperature of the water by heat extracted from the air, the required evaporation and humidification of the air will be accomplished. In the case of drying, the cooling and dehumidification will be effected on a relatively smaller portion of the air than in the case of moistening and a relatively lessened amount of subsequent evaporation and rehumidification of the air will be effected. Such will be accomplished by using water of a lower temperature than that used for the reconditioning of air used for moistening, and by reducing the volume of water, the temperature of the water and its volume being controlled by opera-

tion of the temperature and/or humidity responsive controls as described above.

As a specific example of procedure for the drying of, for example, tobacco, assume a system in which 85,000 c. m. f. of air is circulated, which on discharge from the treating chamber A shows a net heat gain of 2,000 B t. u. per minute or .33 B. t. u. per pound of air after the air leaves fan *e* and a net moisture gain of 1.25 pounds of water per minute or 1.45 grains per pound of air. Assuming that the air discharged from the conditioner B into the treating chamber A has a dry bulb temperaure of 85° F. and a wet bulb temperature of 77° F. the net changes will be as shown in the following table:

	In *c* original	After *e* return	Change
Dry bulb.....° F..	85	85.8	+.8
Wet bulb.....° F..	77	77.3	+.3
B. t. u./lb.....	39.67	40	+.33
Dew point.....° F..	74.2	74.5	+.3
Grains/lb.....	127.80	129.25	+1.45
Depression.....° F..	8	8.5	+.5

As indicated, the temperature and volume and an area of water to which air is subjected in the conditioner B will be regulated to recondition the air from chamber A to its original condition. It will be noted that to accomplish reconditioning of the air used for drying, some condensation or drying is required, as opposed to the case of the reconditioning of air used for moistening.

From the above examples with reference to moistening and drying tobacco, it will be noted that the heat input into the circulated air from the work done in circulating it, as by the fan and friction in the ducts, etc., exceeds the gain or loss of heat by the air by transfer from or to the tobacco. Thus, in moistening, as given above, 4000 B. t. u. per minute are put into the circulating air with a loss of 1.25 pounds of water per minute. The heat input per minute by transfer from the tobacco, as indicated by the loss from the air of 1.25 pounds of water per minute, on the basis of about 1050 B. t. u. per pound, is about 1313 B. t. u. per minute. Hence, the heat input from the work of circulation is about 2687 B. t. u., an amount in excess of the input by transfer from the tobacco. In drying, as given above, a net of 2000 B. t. u. are put into the circulating air with a gain to the air of 1.25 pounds of water per minute, indicating a loss of about 1313 B. t. u. from the circulating air by transfer to the tobacco.

The heat input in excess of that from heat transfer is best accomplished substantially in whole by the frictional effect of a fan, rather than by a heating unit, since the fan will insure against stratification and unever temperatures or humidities and will insure uniformity.

Again, from the above examples it will be noted that the circulating air, subjected to cooling and dehumidification in the conditioner, is humidified in the conditioner, through the evaporation of water by heat extracted from the air, to a moisture content above that of the return air entering the conditioner from the treating chamber.

It will be noted that the circulation of air through the treating chamber and air conditioner is accomplished by the fan *e* and that the air is delivered from the conditioner directly to the treating chamber through duct *c*, which is free from fans, or the like. The work done in circulating the air is primarily done by the fan *e* and the heat input into the air due to the work required for its circulation results from the effect of the fan and the movement of the air in its circulation.

In proceeding for either moistening or drying, controlled quantities of fresh air having a lower absolute moisture content than that of the air in circulation from the conditioner and chamber may be admitted through the valved pipe *g* in order to assist in maintaining desired constant temperature and humidity of the air circulating through chamber A and also as a practical means of enabling air to be discharged from the system for humidifying adjacent areas.

It will be appreciated that with a constant heat and moisture load upon the conditioner B, the effect of raising of the water temperature will be to increase the relative and/or absolute humidity due to lessened condensation.

On the other hand, with decrease in the water temperature, both the temperature and moisture content of the air will be lowered. It will be further appreciated that with a constant ratio of heat in the water to that in the air the humidity of the air may be decreased by spraying more water into the same area in the conditioner; i. e., using all of the spray heads *h*, *h'* and *i*, *i'* with control of the water volume by means of valve v^3. Again, the humidity of the air may be decreased by lowering the temperature of the circulating water by the admission of an increased quantity of cold make-up water.

Variously under certain conditions of air and water volume and temperature where a relatively small amount of dehumidification is required less than all the spray heads will be used.

The temperature and the volume and/or area of water in the conditioner are, as explained above, controlled or regulated with respect to the requirements of the air discharged from the treating chamber A, with respect to the condition required for the air delivered to the treated air, by the thermostat *q* and the humidostat *v*. It will be appreciated that the thermostat and humidostat may be placed in positions other than those shown in the accompanying drawing, and other forms of control instruments, as, for instance, wet bulb thermostats, may be used. Thus, both the thermostat and humidostat may be placed adjacent the point of inlet of the air to the conditioner or both may be placed in the outlet conduit and, if desired, may be arranged in the treating chamber A to compensate one another to exercise control usually under small change in condition of the air.

This application is a continuation-in-part of application filed by me Serial No. 122,729, filed January 28, 1937.

What I claim and desire to protect by Letters Patent is.

1. The method of treating tobacco with air for effecting a transference of heat and of moisture between the tobacco and the air, which comprises circulating about hands of tobacco in a chamber and through a conditioner air, without the air being substantially recirculated within the chamber prior to discharge therefrom, in such volume and at such velocity as to increase, by the work required for its circulation, its heat content by an amount greater than that involved in the heat transfer between the air and the tobacco.

2. The method of treating tobacco with air for effecting a transference of heat and of moisture between the tobacco and the air, which comprises circulating about hands of tobacco in a chamber and through a conditioner air in such volume and

at such velocity as to increase, by the work required for its circulation, its heat content by an amount greater than that involved in the heat transfer between the air and the tobacco, and subjecting air leaving the chamber to water at a temperature and in an amount with respect to the temperature and volume of the air such that the air will be first cooled and dehumidified and then humidified to a desired moisture content by evaporation of water by heat extracted from the air.

3. The method of treating tobacco with air for effecting a transference of heat and of moisture between the tobacco and the air, which comprises circulating about hands of tobacco in a chamber and through a conditioner air in such volume and at such velocity as to increase, by the work required for its circulation, its heat content by an amount greater than that involved in the heat transfer between the air and the tobacco, and subjecting air leaving the chamber to water at a temperature and in an amount with respect to the temperature and volume of the air such that the air will be first cooled and dehumidified and then humidified to a moisture content above that of the air leaving the chamber.

4. The method of treating tobacco with air for effecting a transference of heat and of moisture between the tobacco and the air, which comprises circulating about hands of tobacco in a chamber and through a conditioner air, without the air being substantially recirculated within the chamber prior to discharge therefrom, in such volume and at such velocity as to increase, by the work required for its circulation, its heat content by an amount greater than that involved in the heat transfer between the air and the tobacco and introducing into the circulating air controlled quantities of fresh air having a lower temperature and a lower moisture content than the circulating air.

5. The method of treating tobacco with air for effecting a transference of heat and of moisture between the tobacco and the air, which comprises circulating about hands of tobacco in a chamber and through a conditioner air in such volume and at such velocity as to increase, by the work required for its circulation, its heat content by and amount greater than that involved in the heat transfer between the air and the tobacco, the air in the conditioner being first cooled to the desired temperature and dehumidified and then humidified to an absolute moisture content above that of the air as it enters the conditioner by evaporation of water by heat extracted from the air.

6. The method for moistening tobacco with air which comprises circulating air about tobacco to be moistened and in contact with water at a temperature and in an amount with respect to the temperature and volume of air such that the air will be first cooled to the desired temperature and dehumidified and then rehumidified to an absolute moisture content above that of the air after it leaves the tobacco and before contact with the water by heat extracted from the air.

7. The method of treating tobacco with air for effecting a transference of heat and of moisture between the tobacco and the air, which comprises circulating about hands of tobacco in a chamber and through a conditioner air, without the air being substantially recirculated within the chamber prior to discharge therefrom, in such volume and at such velocity as to increase, by the work required for its circulation, its heat content by an amount greater than that involved in the heat transfer between the air and the tobacco, the air being heated substantially only by the work required for its circulation.

8. The method of treating tobacco with air for effecting a transference of heat and of moisture between the tobacco and the air, which comprises circulating about hands of tobacco in a chamber and through a conditioner air in such volume and at such velocity as to increase, by the work required for its circulation, its heat content by an amount greater than that involved in the heat transfer between the air and the tobacco, the air being introduced into the chamber directly toward the tobacco in the chamber and passing through the chamber without any substantial deflection therein except by the tobacco and its supports within the chamber.

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