March 1, 1938. F. B. MORRILL 2,109,704

TENTER DRIER

Filed Aug. 10, 1931 2 Sheets-Sheet 1

Fig. 1.

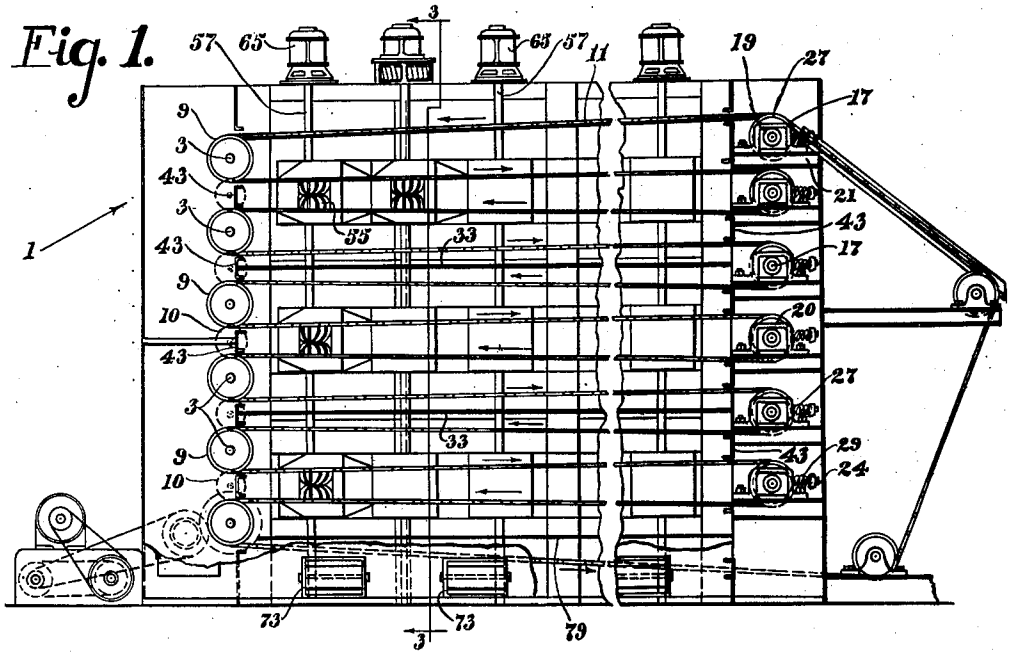

Fig. 2.

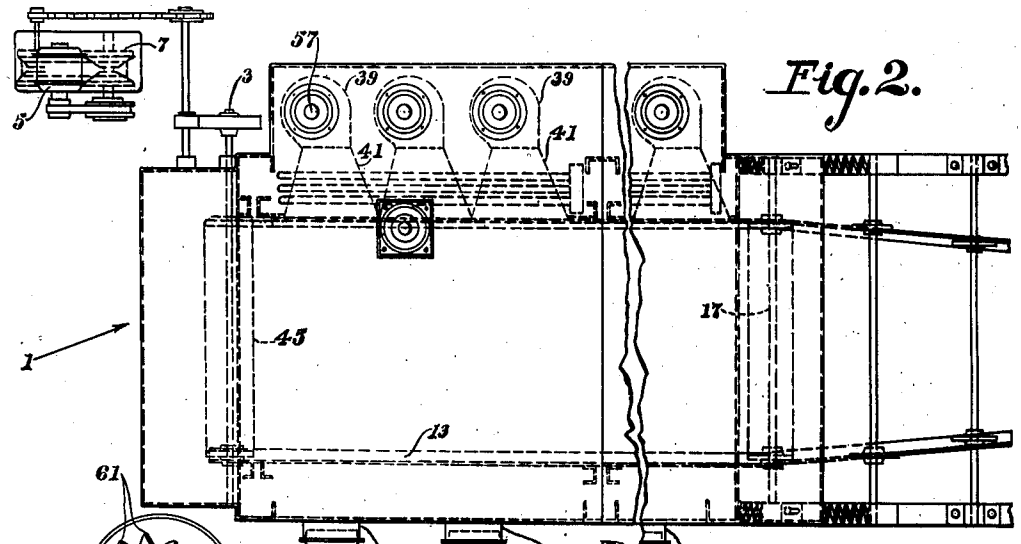

Fig. 4.

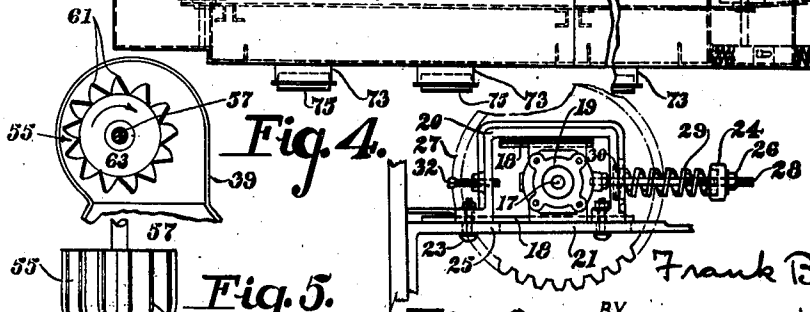

Fig. 5.

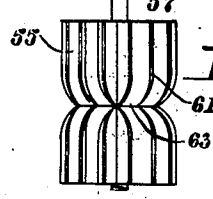

Fig. 6.

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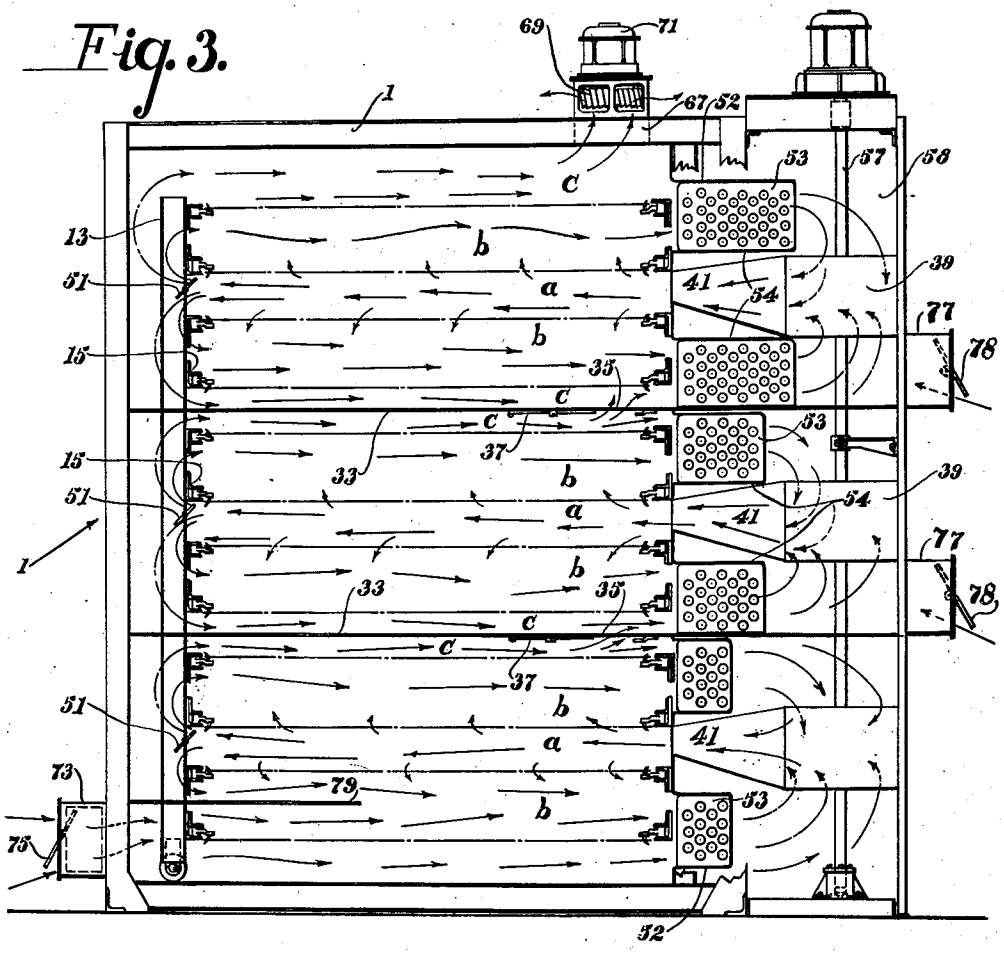
Fig. 3.



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2,109,704

UNITED STATES PATENT OFFICE

2,109,704

TENTER DRIER

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Application August 10, 1931, Serial No. 556,154

7 Claims. (Cl. 34—48)

The invention relates to tenter driers, and its general object is to increase the efficiency and structural and operative economy of such apparatus.

Especially the invention aims to expedite the drying operation, improve the condition or finish of the cloth as discharged from the drier and conserve heat-energy. Other aims of the invention are as will appear from the description which follows.

In the drier of the invention, the total drying space within the drier is divided into a plurality of compartments representing different drying stages, the cloth being traversed successively through the several stages, while air is passed progressively through the series of stages in a direction generally opposite to cloth travel and re-circulated in each stage, and heat is supplied in different amounts to the air in the different stages, usually in such manner that the highest temperature is maintained in the upper stage where the wet fabric enters and the lowest temperature in the bottom or dry stage, and a medium temperature in an intermediate stage. The cloth enters the top or wet stage and passes in a sinuous or zigzag course, traveling in a plurality of runs through it and thence to the intermediate and bottom stage, from which latter it issues in dry condition. In the present machine, the same air is passed from one stage to the next until its full absorptive powers have been utilized, the make-up air entering the bottom compartment, or dry stage, and being discharged from the top or wet stage, passing controllably from each stage to the next, in ascending order.

The air movement within the drier is independent of the rate of discharge of moist air therefrom, the provisions for re-circulating within each stage providing for getting the utmost drying action from the heated air in return for a given expenditure of energy in heating this air, with complete control of the rate and quantity of discharge and of admission of make-up air to take its place, whereby economy and efficiency are promoted. The heat supply, increasing from the bottom to the top stages, increases progressively the absorptive capacity of the air, and tends to produce the desired ascending air-movement. The cloth in its wettest condition is thus brought in contact with air at the highest temperature, in the top compartment or stage, wherein a large part of the moisture is removed; additional moisture is removed in an intermediate compartment or stage, and drying is completed in the moderately heated bottom compartment or stage.

The features of the present invention include the provision of a plurality of drying stages within the machine, defined by impervious division sheets of full width and length, which separate the various stages in a manner permitting positive control of the course of the air, so that different conditions of heat and moisture absorption in each stage may be definitely established at will.

The stages are interconnected by air communicating means, making it possible to control exactly the amount of air passed from one stage to the next. Likewise, means are provided for controlling exactly the rate, quantity and distribution of the make-up air, and hence for controlling the rate of discharge of the exhaust air.

Each stage is characterized by the provision of a pressure chamber therein, defined by the runs of the fabric, flanked above and below by suction chambers, so that a portion of the air in the pressure chamber passes through the fabric while the remainder passes along the surfaces of the cloth. Baffles at the side of these pressure chambers which are remote from the air circulating fans determine the relation between the quantity of air thus forced through the fabric and the quantity passing over the surface thereof, while the air escape from the pressure chambers into the suction chambers at the ends of the machine is prevented. The heaters installed in each stage are housed in a manner not only compelling the re-circulated air to pass completely through them, but also so as to form continuations of the said pressure and suction chambers, directing all the air discharged by the fans into the pressure chamber of each stage. Centrifugal fans of improved form are employed for re-circulating the air, making possible the use of multiple fans on the same shaft without having to deflect the blast in order to direct it transversely of the fabric, thereby imparting increased efficiency and operating economy.

The cloth is cooled just prior to its discharge from the machine through subjecting it to a controllable mixture of make-up air and moderately warmed air in the last or dry stage of the machine, and provision is made for modifying the quantity of make-up air and hence the temperature of the cloth in its last run in proportion to its proximity to the discharge point of the machine, so that the cloth may be brought to room temperature in the most gradual manner, avoiding harshness and other injurious effects of abrupt cooling.

Additional features of the invention are as will be pointed out hereinafter.

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

Fig. 1 is a vertical longitudinal section of the improved tenter drier.

Fig. 2 is a plan view of the same.

Fig. 3 is a vertical transverse section on line 3, 3, of Fig. 1.

Fig. 4 is a plan view of one of the centrifugal fans within its housing.

Fig. 5 is an elevation of the rotor of the centrifugal fan of Fig. 4. Fig. 6 is a detail showing the automatic chain adjusting means.

The tenter drier comprises the usual housing 1, of air-tight and heat-insulating construction, and includes any desired number of similar units or sections arranged end to end to give the desired length. In this housing are journalled at the rear end of the machine the shafts 3 driven in usual manner by motor 5 through variable speed devices 7 and appropriate driving connections, the shafts having fixed thereon driving sprockets 9 around which pass the tenter chains 11 at one end of the machine, all geared together by gears on the shafts 3 and intermediate gears 10, or by sprocket-chains, if preferred. As usual, certain of the sprockets are splined to their shafts and movable inward or outward within the housing 1 along with the movable side 13 and the chain tracks 15 thereon, to accommodate different widths of fabric. Other shafts 17 at the front end of the machine are carried in bearings in journal-boxes 19, each slidably mounted between guide-plates 18 of an open-sided frame 20 applied to portions 21 on the housing 1 with capacity for adjustment of its lengthwise position, as by bolts 23 through slots 25 in the portion 21, and are urged by expansion springs 29 engaging the spring-collars 24 fixed by nut 26 on the end of rod 28 which is screwed into the journal-box side, the springs also engaging within a socket 30 in the end of the frame 20, in a direction causing their sprocket wheels 27 to take up any slack developing in the several runs of the chain through wear or expansion. Stop-screws 32 limit the movement of the journal-boxes in the opposite direction under chain-contraction, and adjustment of the chain-tension may be varied by nut 26. The sprocket wheels and their yielding supports 19 obviously move under tension of the chain to permit contraction and expansion of the latter, and save a great deal of wear on the joints of the chain. This is especially important when all of the chain driving shafts 3 are positively driven by gear or sprocket-chain connections, which would tend to cause certain stretches of the chain to be excessively tensioned, or other stretches to run slack, in absence of the described or equivalent tensioning means.

The interior of the housing is divided into a plurality of drying stages, herein, three distinct stages, by impervious division sheets 33 which extend horizontally substantially the full length of the runs of the chain and the full width of the housing, appropriate shielded apertures being made for the uprights of the movable side 13 to permit their necessary inward and outward movement in accommodating varying widths of fabric. These division sheets are equipped at intervals in their length with apertures 35 provided with sliding dampers 37, so that any desired or requisite degree of intercommunication between one stage and the next may be secured.

In each stage the runs of the tenter chains are arranged so as to cooperate with the fan within its housing 39 in a manner defining a pressure chamber and a suction chamber defined and separated from each other by a run of the cloth. The purpose of this arrangement is to cause a certain proportion of the air circulated by the fan to pass through the cloth itself, while the rest of the air passes along and across the surface of the cloth, whereby the drying of the fabric is greatly expedited through extracting the moisture from within the thickness of the fabric as well as evaporating the same from the surface thereof, as distinguished from prior arrangements in which the surface moisture alone has been removed by air passing only over the surface, with accompanying slow drying action in the case of relatively thick fabrics resulting from the slow movement of internal moisture to the surface of the fabric whence it could be removed by the passing air currents.

In the preferred embodiment, four runs of the tenter chains and of the fabric are included in each stage, combined with the fan housing 39 so that the latter discharges through its leader 41 into the chamber *a* defined by the two middle runs of the fabric. The two intakes of the fan communicate with the chambers *b* immediately above and below the pressure chamber *a*, while provision is made for additional return of air over and under the top and bottom runs of the fabric respectively, through the chambers *c* which also are in communication with the intakes of the fan.

Each chamber is closed at both ends of the machine, at one end by the usual telescoping drum 45 combined with the sprockets 9, 27, to support the fabric at the end of a run, and at the other by a baffle 43, so that the air will go where intended, and also so it will not pass from one stage to the next beyond the ends of the division sheets 33.

The chain guides 15 are especially arranged so as to leave all possible space between vertically adjacent runs of the chain (and corresponding stretches of the cloth) so as to provide the freest possible circulation of air. Thus, the chain guides are each made of two angle irons with the vertical flanges thereof overlapped to reduce their vertical height and diminish their obstruction to the laterally directed air current, and the alternate guides are inverted. Dampers 51 are mounted on horizontal pivots on the movable side 13 across the end of the pressure chamber *a* in each stage, these dampers being adjustable either from within or without the housing to close more or less completely the space between the adjacent chain guides 15 at the end of each pressure chamber which is away from the fan, so that the ratio between the quantity of air forced through the cloth and that allowed to pass across the surface of the cloth, and thence out around its selvage, may be varied as desired. These dampers 51 may extend the full length of the runs of the cloth, or may comprise a series of dampers arranged end to end throughout the length of the runs of the chain, in which latter arrangement a varying ratio between the air forced through and the air traveling over the cloth may be had within the length of a single run, a feature which may be of particular value in the cool or dry stage in improving the feel of the cloth.

As is obvious from Fig. 3, the air that is forced into the pressure chambers *a* from the fans

through their leaders 41 passes partly through the two runs of cloth stretched on the two runs of chain immediately above and below the outlet ends of the leaders 41, and such part as is permitted to pass the dampers 51 enters the flanking suction chambers *b* directly above and below the pressure chamber and defined between the named two runs of cloth and the run of cloth respectively above and below the two named runs, and also passes respectively above and below these two outer runs of cloth and travels through the chambers *c*, because these chambers *b* and *c* are in communication with the suction or intake ports of the fans. The air drawn into the intakes of the fans located within housings 39 thus comes entirely from between the runs of cloth, (with the exception of the make-up air entering beneath the bottom run in the lowest stage). In its passage to the fan it is forced to pass through banks 53 of steam pipes, which are housed by sheets 52 and 54 and the division sheets 33 to continue the suction chambers, thus heating the air to the requisite degree, the temperature being increased progressively in the successive stages from the bottom or coolest stage to the top or hottest stage, in suitable manner, as by increasing the radiating surface through an increase in the number of steam pipes, as shown.

As is apparent, the main part of the air movement employed to effect the drying, consists of recirculation of the air within its own separate stage, as defined by the division sheets 33.

The air-circulating means comprises one or more air-impelling instrumentalities in each of the stages; and while in the broader aspect of the invention, any known or suitable impelling device may be used, including fans of the propeller type, it is preferred to employ centrifugal blowers, constructed and arranged to deliver air radially and tangentially at considerable velocity and with substantial pressure-effect, practically directly into the pressure-chambers *a*.

As shown in detail in Figs. 4 and 5, a blower of a type preferred in some cases, and of simple and inexpensive construction, includes a rotor 55 on a shaft 57, and a jacket or casing 39, which is open at top and bottom. The rotor is eccentrically located in the casing, which is connected with the discharge leader 41. The rotor has impelling blades 61 extending axially in both directions from a central supporting or septum plate fixed on the shaft. The blades are set angularly to axial planes, to exert an angular reaction and centrifugal discharge effect on air entering the casing ends and flowing inward along the shaft, as well understood by skilled persons.

In the particular arrangement shown herein, a plurality of blowers (specifically, three) is placed in each housing section, although the number and arrangement may be varied, as before indicated. The arrangement is also preferably such that a plurality of blowers, including one in each stage, may be driven by a single shaft. Thus, as shown, each blower rotor is axially aligned with others in lower or upper stages, and all of these are fixed on a common driving shaft 57 which extends vertically through the top wall of the upper compartment, and is there connected to any suitable driving means. Preferably, to avoid mechanical complications or other disadvantages involved in driving the various vertical blower shafts at the necessary high speed by belt or gear connections, each shaft is driven by an individual electric motor 65. An advantage of the particular type of rotor adopted herein, is, that it is capable of efficient action at the relatively high speed of rotation of the average electric motor, enabling it to be direct-connected, with obvious advantages. Further, the thrust-bearing of the electric motor serves in certain instances to support the load of the shaft and its multiple rotors, enabling a simple sleeve-bearing to be applied to the lower end of the shaft, avoiding the need for a thrust-bearing at this point with the troublesome problems its use would entail in view of the expansion and contraction of this shaft under varying running temperatures.

A particular advantage gained through the use of centrifugal blowers instead of the propeller and other type fans in prior use is that in the nature of such devices the air-current at high velocity is bent at right angles, the intake air entering along the axis of rotation and the discharge leaving at right angles thereto, without the loss of efficiency involved in effecting this deflection in other types of fans. Another advantage is that the blast is distributed substantially uniformly throughout the full width and height of its leader, and when the flaring leaders are placed side by side in continuous relation throughout a section as shown in Fig. 2, there is a practically uniform distribution of the combined blasts of air in a sheet extending substantially the full length of each section, and without the need for baffles and vanes which have had to be used hitherto when multiple fans have been mounted on a common shaft in order to direct, turn, and distribute the blast across the width of the fabric, with resulting loss of efficiency through the retarding action of such diverting and directing means.

Thus, the use of centrifugal fans makes possible the use of multiple fans on the same shaft without having to resort to special directing means in order to direct the blast transversely of the fabric. Rotors of different sizes and air propelling capacities may be mounted on the same shaft to work in the different stages, if it is desired to create different conditions or rates of air movement in the several stages.

It is also contemplated within the scope of the present invention to run the fan shaft 57 horizontally through the fan-chamber 58 of each stage, as an alternative construction to the vertical fan shaft arrangement shown in the drawings.

In this alternative arrangement, certain advantages are had, notably, that the respective shafts in the different stages can all be driven through beveled gears in obvious manner from a common vertical drive shaft located at one corner of the housing. In this form, the type of centrifugal blowers shown and described is preferably used, each blower having the same sort of double intake, and the air entering axially of the shaft at each side of the fan casing, the fans being arranged in simple and obvious manner to force air into the pressure chambers *a* alone through coupling the exhaust port of the fan casing properly to the leader 41, and allowing the intakes of the fan to be in communication with the suction chambers *b* as before. Another advantage of this arrangement is that it permits different rates of air circulation to be established in the different drying stages.

As usual, provision is made for discharging the air from the top or wet stage as it becomes substantially completely saturated, and hence no longer capable of absorbing moisture from the cloth; correspondingly, the usual provision is

made for admitting the requisite quantity of make-up air into the drier to replace that which it is desired to discharge from the wet stage.

Herein, the discharge from the wet stage is effected through a vent 67 in each vertical section, whence the desired amount of hot, humid air is removed by a suitable exhausting means, such as the centrifugal fan 69, driven by its own electric motor 71.

The make-up air enters the bottom or dry stage at the side of the drier remote from the circulating fans, through a port extending the full length of the chain runs, or through a series of ports 73, extending throughout the length of the chain runs. The vertical height of the port or ports 73 is such that air will be admitted substantially equally above and below the final, bottom or exit run of the cloth, as shown in Fig. 3. The ports 73, or the single port, if such is employed, are equipped with dampers 75, which may be set to control the quantity of make-up air admitted, or to shut it off entirely, and also to distribute the amount of make-up air in proportion to the proximity of any given point in the final or exit run of the cloth to the point of issuance of the cloth from the drier. Thus, the make-up air is introduced in such manner that it serves to cool the final run of the fabric to the degree necessary to prevent a sudden temperature change as the cloth emerges into the air surrounding the drier, with the avoidance of objectionable effects upon the sensible finish or texture of the fabric which result from sudden chilling, as is well known in the art. The air entering ports 73 is of course at the temperature of the air outside the housing 1, and this air is mixed with the warmed air of the dry or cool stage immediately upon entering. To provide for this tempering of the cool air from outside through a mixture of warm air therewith, while at the same time insuring that the final or lowest run of the fabric shall be properly cooled without lowering the temperature throughout the whole volume of the bottom stage, an airflow controlling septum or baffle 79 is provided, extending substantially the full length of the chain runs, between the two lowermost runs of the cloth, attached to the wall of the housing 1 that is away from the fans, and extending inwardly horizontally from such wall (with proper provision in the way of slots for the necessary movement of the movable side 13) to a distance greater than the inward movement of the side wall 13 in accommodating the narrowest fabrics for which the machine is designed. This baffle thus permits the make-up air to travel across the fabric to the fans on both sides of the lowermost run of the cloth, and by opening the dampers 75 progressively wider in the direction of travel of this lowermost run of the cloth so that more and more fresh air is admitted as the cloth approaches the exit point the cloth can be brought in the most gradual manner to substantially the same temperature as that existing outside the drier, with great advantage in avoiding the harshness and stiffness which result from sudden cooling. In certain instances, additional fresh-air inlets 77 with dampers 78 may be used adjacent the fan-intakes in the other stages, to help control the humidity.

The passages 35 in the division sheets 33 provide the means of communication through which the air that has completed its usefulness in the previous stage is passed on to the next wetter stage, where it is heated to a higher temperature, and thus becomes capable of absorbing more moisture from the wetter fabric. Thus, while the impervious and continuous division sheets 33 make it possible to establish entirely different conditions of heat and moisture in each stage, yet the characteristic heat-economy of all machines in which the air is thus passed in series from one stage to the next, to be heated successively to higher degrees is maintained, and the full benefit of the energy put into heating the air obtained, while the disposition of these passages 35 at intervals throughout the length of the division sheets 33 enables them to be opened or closed, by means of their sliding dampers 37, to a greater or less extent at varying points throughout the length of the machine, thereby making possible a complete control of the make-up air entering each stage, whereby the temperature throughout the full length of each stage may be made uniform or progressively varied, as desired.

A feature to be noted is that the pressure chambers *a* and suction chambers *b* are so disposed with respect to the successive runs of the chain, that there are no air currents tending to lift the fabric off of the tenter pins. As shown in Fig. 3, wherever the air currents tend to pass through the cloth, the tenter pins point in the opposite direction to these air currents. This is a feature of great importance, because when, as has frequently happened, the cloth comes off of the tenter pins, through air pressure or for other reasons, when a length of cloth is in passage through the drier, and sags onto the tenter pins of chain-runs moving in the opposite direction, the cloth becomes badly torn, and since there is no way of knowing that this is occurring until after the fact, or of gaining access and remedying the situation, but the piece must continue to be run through the drier until it emerges at the exit point, whole lengths of valuable fabric are frequently ruined in this way.

While I have illustrated and described certain forms in which the invention may be embodied, I am aware that many modifications may be made therein by any person skilled in the art, without departing from the scope of the invention as expressed in the claims. Therefore, I do not wish to be limited to the particular forms shown, or to the details of construction thereof, but what I do claim is:—

1. In a tenter drier, the combination with opposed tenter-chains and means for producing air-circulation in a closed path transversely of the material being dried, of pressure and suction chambers defined by runs of the material carried by the tenter-chains, and means controlling the pressure difference between such chambers to control the amount of air passing through such runs of the material.

2. In a tenter drier, in combination, a housing, means for carrying the material to be dried through the interior thereof in a plurality of runs, a partition extending partway only across the width of the material between the final run and the rest of the runs, and means for entering cool air along such partition transversely of the material.

3. In a tenter drier, in combination, a housing, tenter chains, means guiding the chains to dispose the fabric in a plurality of spaced runs in stretched relation, a plurality of drying stages defined by impervious division sheets, air-circulating devices maintaining an independent air circulation in each stage in a closed path defined by the runs of fabric, and passages

through such sheets admitting air from one stage to the next, whereby such air transfer is effected wholly within the outlines of the housing.

4. In a tenter drier, in combination, a housing, air-treating means therein, tenter chains carrying the material to be dried through the housing in a plurality of runs, and a plurality of damper-controlled air-inlet ports along the length of the final run of the fabric for passing progressively increased amounts of cool air from outside the housing onto the final run of the material as the latter approaches its point of issuance from the drier.

5. In a tenter drier, in combination, a housing, tenter chains having tenter pins carrying the material to be dried and traversing the housing in a plurality of runs, adjacent pressure and suction chambers defined by the material to be dried as carried by the chains, and air-impelling means circulating the air transversely of the chains in a closed path and creating pressure and suction in the said chambers, with the runs of the chains arranged with the tenter pins which carry the material defining the pressure chambers pointing inwardly into such chambers so that the air under pressure from the air-impelling means where directed against the material tends to force the material onto the tenter pins.

6. In a tenter drier, a housing, means for carrying web material through the housing in a sinuous course including parallel horizontal runs of length greater than the width of the web, said means comprising tenter chains having thereon tenter pins which protrude through the web, means on a longitudinal side of the runs for circulating air in a closed path transversely of, and in opposite directions over and under some of the runs, adjustable means on the other longitudinal side of each of such runs in said path between those parts of said path which lie above and below such runs of the web and extending along the length of those runs for creating a resistance to the flow of air in said path to create a greater pressure on that side of the web through which the free ends of the tenter pins protrude than on the opposite side so that this air pressure will tend to hold the web on the tenter pins.

7. In a tenter drier, in combination, a housing, opposed tenter chains disposing the fabric in stretched relation in a plurality of parallel runs, means within the housing for producing air-recirculation in a closed path transversely of the fabric through adjacent pressure and suction chambers defined by the runs of fabric, and adjustable means variably obstructing the free egress of the air entering the pressure chamber as such air passes out from between the runs of fabric defining such chamber, whereby a variable part of the air is forced through the fabric.

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