March 31, 1931. J. P. BROWN 1,798,718

METHOD AND APPARATUS FOR DRYING MATERIALS

Filed July 9, 1926 4 Sheets-Sheet 1

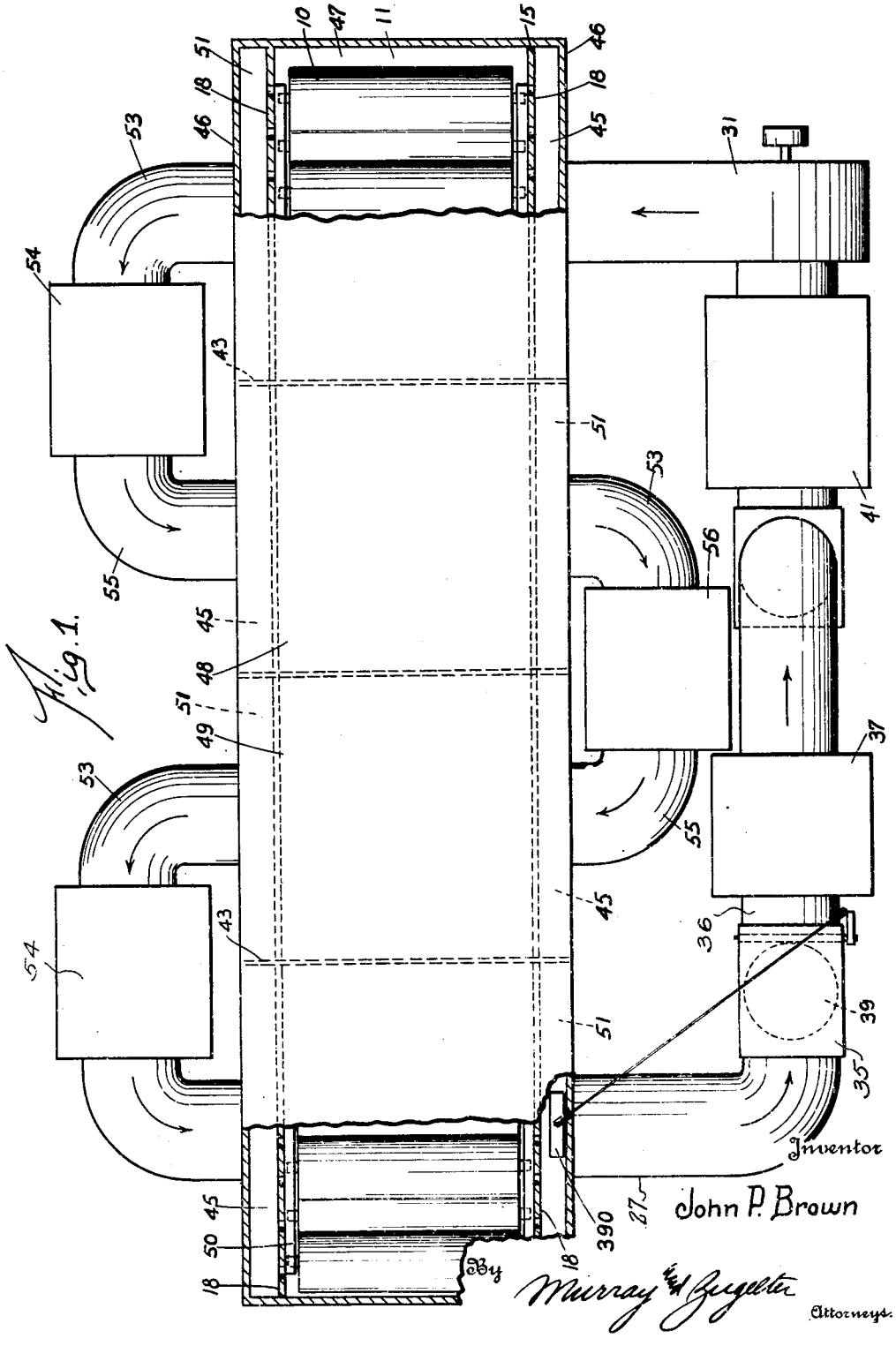


Fig. 1.

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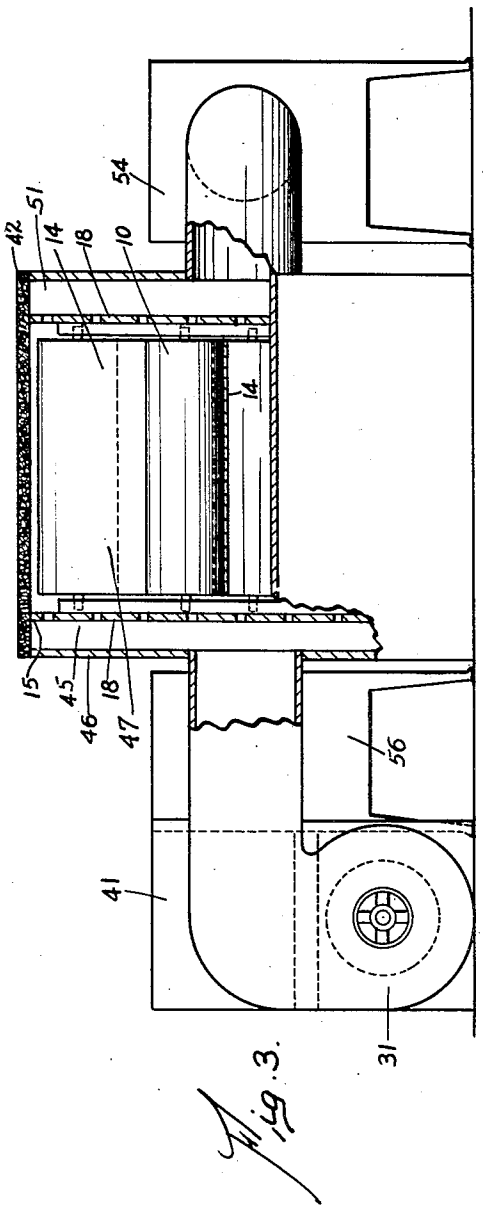


Fig. 3.

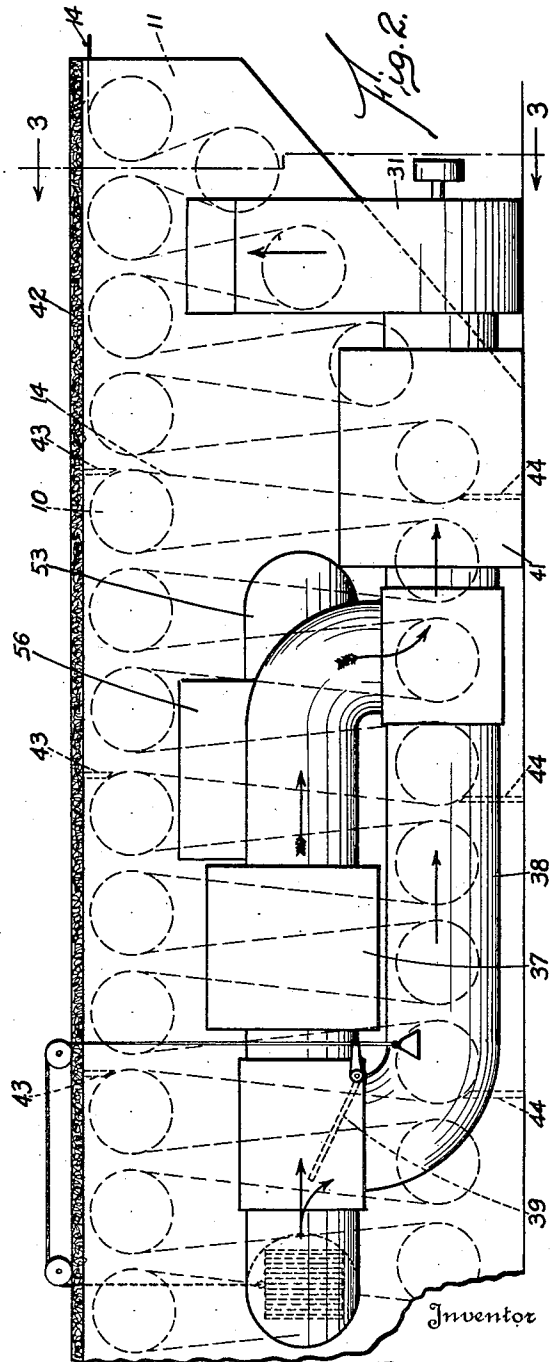


Fig. 2.

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METHOD AND APPARATUS FOR DRYING MATERIALS

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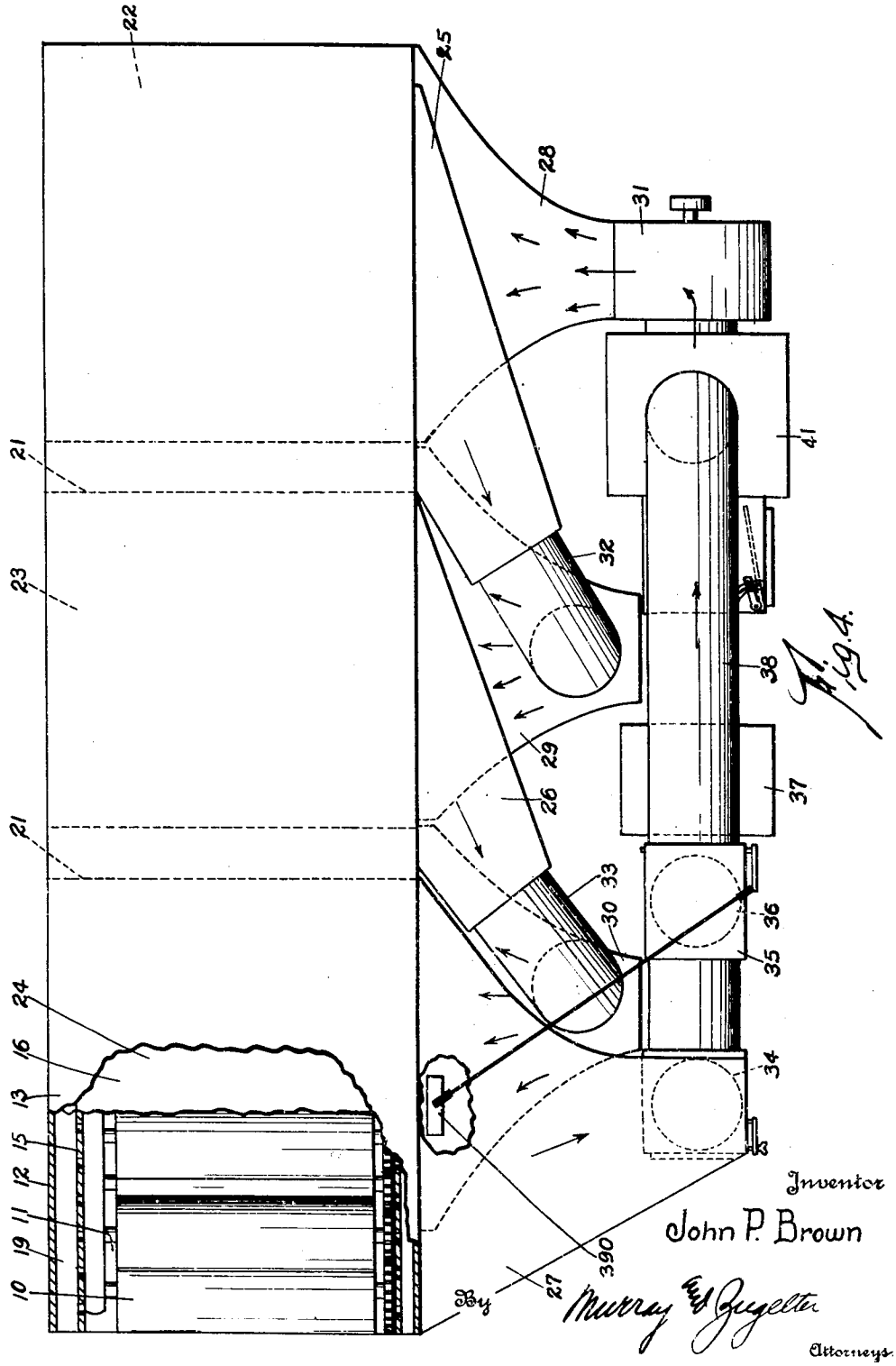


Fig. 4.

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METHOD AND APPARATUS FOR DRYING MATERIALS

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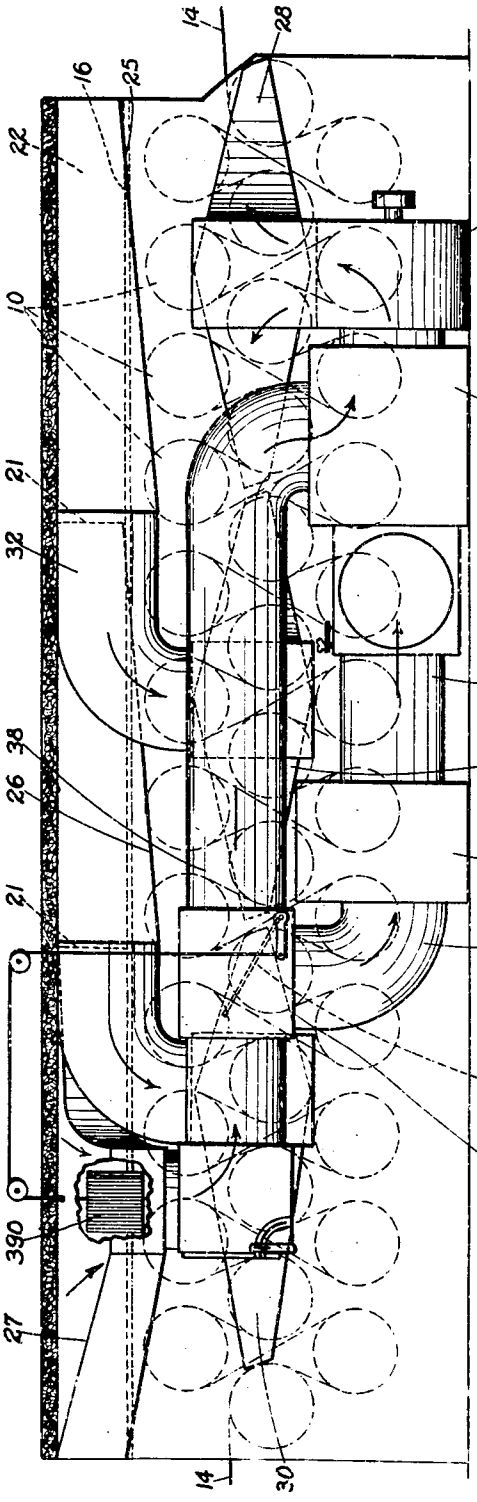


Fig. 5.

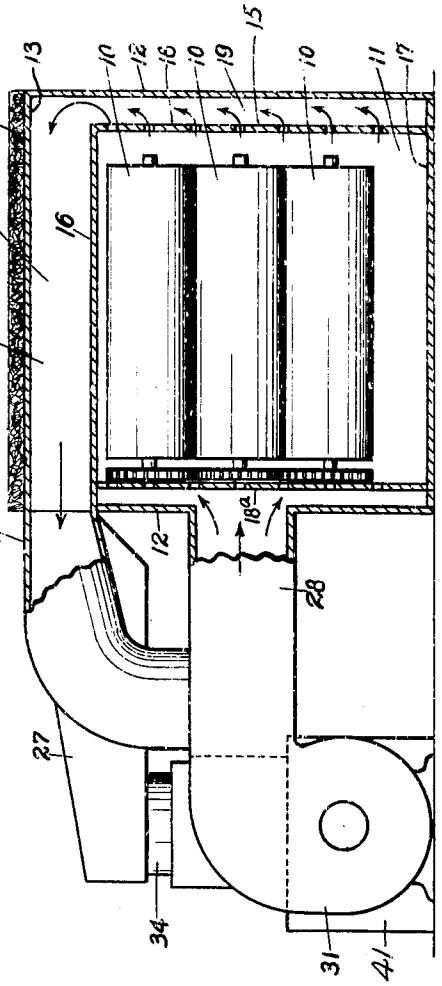


Fig. 6.

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UNITED STATES PATENT OFFICE

JOHN P. BROWN, OF CINCINNATI, OHIO

METHOD AND APPARATUS FOR DRYING MATERIALS

Application filed July 9, 1926. Serial No. 121,476.

This invention relates to a process and apparatus for drying various kinds of material and is especially adapted to use in rapidly drying continuous sheet or strip material.

An object of my invention is to provide a method and means whereby a maximum of moisture may be removed from a quantity of material in a given time.

Another object is to provide such method and means whereby a minimum of heat is utilized for rapidly removing a maximum moisture content from a quantity of material to be dried.

Another object is to provide a means for the purposes stated whereby a volume of heated air is used for continuous circulation over a quantity of moving material and is intermittently changed in temperature to the end that the air circulating about a portion of the material is always of a proper temperature for permitting a maximum moisture absorption per unit volume of air which the material acted upon will yield when in a given state of moistness.

Another object is to provide means for automatically removing moisture from the air and to automatically by-pass the air about such means when the moisture content in the air is below a safe minimum to the end that substantially no heat is wasted.

These and other objects are attained by the method described herein and by the means disclosed in the accompanying drawings, in which:

Fig. 1 is a top plan view of a device of my invention, part being broken away.

Fig. 2 is a side elevational view of the device shown in Fig. 1.

Fig. 3 is a cross sectional view taken on line 3—3 of Fig. 2.

Fig. 4 is a plan view of a commonly used type of drying apparatus to which has been added the necessary parts to provide a modified form of my invention.

Fig. 5 is a side elevational view of the device shown in Fig. 4.

Fig. 6 is an end elevation, partly in cross section, of the device shown in Figs. 4 and 5.

The method of my invention comprises utilizing a confined body of heated air and subjecting it to continuous circulation over a body of moist material and through heating chambers separated from the moist material by suitable walls. Each movement of the air through and about the moist material causes it to lose some of its heat and to absorb a quantity of moisture which is carried away with it into a heating chamber where the air is heated sufficiently not only to replace the lost heat but to raise its temperature somewhat. The air is thus caused to intermittently lose a few degrees of temperature and gain a greater number of degrees than is lost. These steps are repeated a number of times until the gradually rising mean temperature reaches a desired maximum. The material as it loses more of its moisture is subjected to a correspondingly higher temperature of air which is then passed through a suitable condenser where it is freed of its moisture. The comparatively dry air is then heated to a relatively low initial temperature and is again circulated over and about the moist material and again performs the series of operations just described.

The invention is herein described as embodied in an apparatus for drying a continuous sheet or strip of paper as it leaves a paper making machine.

In explaining the method of my invention I have disclosed two different installations of apparatus. The first installation is as shown in Figs. 1, 2 and 3, and constitutes an entire apparatus of a preferred form. The second installation comprises modifications of and additions to previously installed dryers of a type heretofore used and is shown in Figs. 4, 5 and 6.

In the old form of drying apparatus a plurality of heated rolls 10 are generally mounted in staggered relation in an open room. In applying my invention to such installations I enclose the rolls 10 in an elongated chamber 11, comprising a floor 17, side walls 12, and a top 13. A sheet of wet or moisture laden material 14, such as paper, is carried by the rolls in a circuitous path through the chamber. The rolls 10 are usually internally steam heated and various means have been provided for effecting movement of

the air which becomes saturated with moisture evaporated from the paper or material as it moves through the chamber.

In modifying a previously installed dryer I utilize the old structure and provide means for effecting a continuous circulation of a given volume of warm air transversely of the material and first utilize the air to take up its full capacity of moisture at a relatively low initial temperature, then pass the saturated air through a heating chamber for raising the temperature thereof above its initial temperature after which it is again passed over and about the material for taking up additional moisture.

In modifying a previously installed drying system the heated rolls 10 are housed in a smaller inner casing 15 within chamber 11. The inner casing 15 has a top wall 16 spaced below the top 13 of chamber 11, and a bottom wall 17. The wall 16 is connected to one of the side walls 12 and terminates at a distance from the opposed side wall 12. A perforated wall 18 forms a vertical passage 19 in the chamber 11 through which air may rise into heating space 20 above casing 15. (See Fig. 6). Transverse partitions 21, shown in dotted lines in Fig. 4, provide a plurality of non-communicating heating chambers 22, 23, and 24 in the heating space 20. Funnels 25, 26 and 27 are connected to heating chambers 22, 23, and 24 respectively, and extend from the top portion of the first mentioned side wall 12 of chamber 11. A lower series of funnels communicate with the interior of inner casing 15 through the side wall 12 and adjacent perforated wall 18^a of the inner casing 15 and serve to direct air transversely through the casing across the material 14 carried by rolls 10. It will be noted that the material 14 extending over rolls 10 serves to substantially divide the interior of casing 15 into three sections comprising practically separate chambers which receive air or any suitable drying medium, which is directed thereinto by a lower series of funnels 28, 29 and 30 respectively. An air moving device, such as a fan 31, causes air to move through funnel 28, registering opening in wall 12 to which it is attached, through perforated side wall 18^a and to sweep through the end of casing 15 and across the material extending therein, whereupon it may leave through perforate wall 18 and pass into passage 19. As previously explained, the sheet material to be dried forms dividing walls so that funnel 28 directs air through and across the material carried by a given end group of rolls, the space between which comprises the first drying chamber in casing 15 and this air which has been heated to an initial and relatively low temperature absorbs the moisture liberated by the material 14 and carries it through perforated wall 18 into passage 19 from which it moves into and through heating chamber 22 directly above it and outwardly into funnel 25. The air passing across the material in the first section or drying chamber carries the moisture with it and thus overcomes the tendency of the moisture to hang close to the material so that the heat from rolls 10 may rise to the top of casing 15. In this way the top wall 16 of casing 15 becomes hot and radiates its heat into heating chamber 22. It will be apparent therefore as the moisture bearing air rises from passage 19 and passes through chamber 22 its temperature will be raised by the radiating heat from the top wall 16 which also forms the bottom wall of chamber 22. After passing through heating chamber 22 the air has reached a temperature above its initial temperature and passes from funnel 25 into the second lower funnel 29 through elbow conduit 32. The air or drying medium of a higher temperature has now a capacity to absorb more moisture and is forced or drawn through the substantially separate intermediate section or chamber in casing 15. The portion of material 14 which has yielded some of its moisture in the first operation has now been moved by revolving rolls 10 to this intermediate portion of the casing and is subjected to a second moisture removing operation by the heat of the intermediate group of rolls 10 and by the air from funnel 29. The operation in the second or intermediate drying chamber is the same as that which previously took place in the first drying chamber with the exception that the material acted upon contains less moisture and that the air acting upon it is of a higher temperature. After passing through the second or intermediate drying chamber the air has absorbed additional moisture and passes through passage 19 into a second heating chamber 23 where it is again heated through the agency previously explained and passes through the second upper funnel 26, elbow conduit 33 and into the third lower funnel 30, from whence it is carried through the remaining end portion of casing 15 and removes the remaining moisture from the material which has twice been similarly acted upon. The air or drying medium has been intermittently raised to a constantly increasing temperature and at the end of its third operation has absorbed a maximum of moisture. The speed of rotation of the heat of rolls 10 may be regulated by any approved means and the rate of movement of the air may also be regulated by regulating the speed of fan 31. The air or drying medium must now be taken from the last top funnel, relieved of its moisture and prepared to be again circulated through the apparatus by the fan 31. For the purpose of most efficiently effecting these results moisture laden air from funnel 27 is carried by pipe 34 into a coupling 35 which is connected by pipe 36 to any approved

type of condenser 37. A by-pass conduit 38 is also connected with coupling 35 and valve 39 is adapted to completely close pipe 36 leading to the condenser or by-pass pipe 38 and is automatically controlled by a humidostat 390 operatively connected thereto, so that pipe 36 is open and by-pass 38 is closed when an appreciable quantity of moisture is carried by the drying medium. At this time all of the drying medium or air passes through condenser 37 wherein the moisture is condensed to liquid form and may be carried away for any desired use or purpose. The drying medium then moves through pipe 40 to a heater 41 which may be thermostatically controlled if desired in order to heat the air to an initial comparatively low temperature prior to again performing its circuit of operations. If the air or drying medium passing from the endmost upper funnel 27 contains very little moisture so that it may be considered dry for all practical purposes, the humidostat automatically closes valve 39 over pipe 36 so that the drying medium travels directly through by-pass conduit 38 into a heater 41. In this way an appreciable amount of heat may be conserved since the drying medium loses heat in passing through the condenser 37. Suitable means may be provided for releasing some of the heating medium, and for admitting fresh atmosphere to the device at such times as may be deemed advisable. In order to prevent radiation of heat from the top wall 13 of chamber 11, I prefer to provide a heavy heat insulating layer on the top surface of said wall 13. This may take the form of an asbestos insulating cover which may be made up of a plurality of single sheets or of a number of thick blocks.

The apparatus of my invention as preferably embodied in a complete new installation is shown in Figs. 1, 2, and 3. In this form (see Fig. 3) the casing 15 is provided within a chamber 11 by extending spaced perforated side walls 18 from the top to the bottom of chamber 11. The rolls 10 may be fewer in number and are preferably spaced in opposed upper and lower rows, the rolls in opposed rows being disposed in staggered relation so that the material 14 extends over and between rolls in practically perpendicular relation to the insulating top wall 42 of chamber 11. The drying chambers are provided by extending spaced depending partitions 43 transversely of the lower face of the insulating top wall 42 and permitting them to extend downwardly and substantially tangentially of given ones of the rolls 10 of the top row. Similar upstanding spaced partitions 44 extend transversely across the bottom of the device and are positioned substantially opposite the upper partitions 43 and are adapted to close the space beneath the circumference of given rolls 10 of the lower row. The free edges of partitions 43 and 44 extend in close proximity to the circumference of their respective rolls 10 so as to permit the material 14 to pass therebetween, and at the same time to cause the sheet of material 14 to serve substantially as a connecting wall between opposed partitions 43 and 44. In this embodiment, as heretofore explained, the drying chambers are more completely defined and extend from top to bottom of the chamber 11 between the perforate side walls 18. On one side of each drying chamber is provided a pressure chamber 45 which is bounded by one of the longitudinal outer walls 46 of chamber 11 and one of the perforate walls 18 which open into the drying chambers 47, 48, 49, and 50 respectively. On the opposite side of each drying chamber is provided a receiving chamber 51 similar to the pressure chambers 45. The pressure chamber 45 shown at the right-hand end in Fig. 1 receives air under pressure taken from first heater 41 by fan 31 and distributes it through the perforations in wall 18 so that it passes transversely across the sheet of material 14 for the purpose of carrying off moisture therefrom. The moisture laden air then passes through the perforations in opposed perforate wall 18 into receiving chamber 51 from whence it passes through an exhaust conduit 53 into the first heater 54. Here the air, which has lost some of its heat in absorbing moisture in the first drying chamber, is heated to a temperature above that at which it entered pressure chamber 45, so that the air or heating medium not only retains the moisture which it absorbed in the first drying chamber 47 but has also acquired an added capacity for absorption of moisture. The air is then carried from the second heater 54 through conduit 55 to second pressure chamber 45, from whence it passes to the second drying chamber 48 where an additional quantity of moisture is absorbed and from whence it passes to the second receiving chamber 51 and passes through a second conduit 53 to a third heater 56. In the third heater the air again has replaced the heat which it lost in drying chamber 48 and also an additional amount of heat, so that the air entering drying chamber 49 from the third pressure chamber 45 is of a higher temperature than that which left the second heater 54. In the same manner, the drying medium or air takes a quantity of moisture from drying chamber 49 and carries it through a fourth heater where the temperature is again raised above that in the third heater. After air from the fourth heater has performed its work upon the material 14 extending in the drying chamber 50, the air has reached the desired maximum temperature and has absorbed a maximum of moisture. The humidostat 390 is disposed in the last receiving chamber 51 and operates in substantially the manner heretofore de-

scribed in operating the directing valve 39 for directing the moisture laden drying medium through condenser 37 or through bypass conduit 38, depending upon the quantity of moisture in the air. In this embodiment the rolls 10 may be smaller than those ordinarily used, and need not be internally heated.

By carefully regulating the series of heaters so that each one will add the proper amount of heat to the drying medium as it passes therethrough, there is made possible a very efficient drying apparatus which consumes a minimum of heat. The drying process furthermore takes place very rapidly when the volume of drying medium enters each consecutive drying chamber at a temperature above that at which it entered the preceding drying chamber. From this it will be apparent that the drying medium need not be initially heated to a very high temperature in order to become saturated in passing through the first drying chamber where the very moist material will readily yield a large percentage of its moisture. In the second drying chamber the material is less moist and requires a higher temperature to cause it to yield more moisture. The heating of the air intermediate the first and second chambers increases its capacity so that under the proper conditions the capacity of the air or drying medium for absorbing moisture may be doubled when its mean temperature is increased about 25 degrees at each heater. The temperatures and the rate of movement of the drying medium may be varied to suit the particular requirements of a given material and the rate of movement of the material may also be adjusted so that practically any given material may be entered at one end of the apparatus in a wet or moisture saturated condition and will leave the apparatus in a dry condition.

In order to condense the moisture carried by the drying medium but a small drop in temperature is required, and this drop in temperature may be so controlled that the medium on leaving the condenser may be conditioned for passage through the first drying chambers. Further, the products of condensation would carry a considerable number of heat units wherefore these products of condensation may be utilized in the plant and will require less heat to bring same to a working temperature than would be required to raise an equivalent quantity of water at normal temperature to a working temperature. The savings in water, therefore, reach appreciable amounts.

My invention is not limited to the drying or treating of moving strips of material, but is also adapted to use upon many kinds of materials in different forms. For example, hides may be dried by suspending them in chambers through which the drying medium, conditioned and directed as heretofore explained, may be passed. In handling and operating upon such materials it is feasible to employ a drying medium of a practically uniform temperature in given chambers, while each of a series of chambers may be of different temperatures. The general operation of the medium conveying and conditioning means is the same and provides the advantages heretofore enumerated.

What I claim is:

1. The method of drying moist material comprising moving said material successively through a series of substantially separated drying chambers, directing a confined body of drying medium, such as air, through each of the drying chambers consecutively and adding heat in such degree to the drying medium prior to its entry into each succeeding drying chamber that the medium has a greater than previous temperature as it enters each succeeding drying chamber, the air being first passed through the chamber in which the material is first introduced.

2. The method of drying moist material comprising progressively moving said material through a series of substantially separated drying chambers, directing a heated drying medium consecutively through each of the drying chambers, increasing the temperature of the drying medium prior to its entry into each succeeding drying chamber to a degree in excess of that at which it entered the preceding chamber, removing the moisture from the drying medium after it leaves the last of the series of drying chambers, then heating the drying medium to an initial given temperature and again directing it through the series of drying chambers, the drying medium at said initial temperature being introduced into the chamber in which the material is first introduced.

3. The method of drying moist material comprising moving said material successively through a series of substantially separated drying chambers, circulating a confined body of drying medium through the first of the series of drying chambers at an initial relatively low temperature for permitting the heating medium to become saturated with moisture from the material which is introduced first into said first chamber, whereby the drying medium loses some of its heat, directing the moisture bearing drying medium from the first drying chamber to a heater wherein the lost temperature is replaced and the drying medium is heated to a temperature exceeding its initial temperature at which it was introduced into the preceding chamber, directing the drying medium, thus heated, through the second of the series of drying chambers, wherein said drying medium absorbs more moisture from the material in said drying chamber and wherein it also loses some of its increased heat, then

again heating the drying medium to a temperature exceeding its temperature prior to entry into the second of said drying chambers, progressively passing the drying medium through succeeding drying chambers and progressively raising the temperature prior to entry of the drying medium into said chambers to a higher degree than that at which it was introduced into the preceding chambers whereby all of the moisture is removed from the material and finally removing the moisture from the drying medium and directing it through the series of drying chambers in the order and in the manner named.

4. The method of drying moist material comprising progressively moving a moist material through a series of substantially separated drying chambers, progressively and consecutively directing a given controlled body of drying medium through said chambers and over the material therein, intermittently and progressively raising the temperature of a drying medium so that it enters each succeeding chamber at an increased temperature over that at which it enters the preceding chamber, removing the moisture from the drying medium after it leaves the last of the series of drying chambers, then heating the drying medium to its initial temperature and repeating the operations in the order and manner named whereby new material entering the chambers may be dried, the material to be dried being introduced first through the first of a series of chambers.

5. In a drying apparatus the combination of means for directing material to be dried through a circuitous path, means for substantially enclosing the material whereby to provide a confining casing having opposed perforate walls, means including the material acted upon for providing a series of drying chambers within the casing and through which series of drying chambers the material moves, means for consecutively directing a body of drying medium transversely through the series of drying chambers and for returning said body of drying medium externally of the drying chambers to an initial starting point and individual heating means through which the drying medium must pass prior to entry into each consecutive drying chamber, said individual heating means being adapted to replace and add an excess of heat to the medium over the temperature at which the medium enters a preceding chamber, the material to be dried being introduced first into the chamber in which the drying medium is entered at its initial low temperature.

6. In a device of the class described the combination of a series of drying chambers through which moist material may be consecutively passed, and means associated with the chambers and serially connecting them for directing a drying medium through consecutive chambers and for increasing the temperature of said medium prior to its entry into each succeeding chamber to a higher degree than that at which it was introduced into the preceding chamber, the drying medium being first introduced into the first of a series of chambers to receive the material to be dried.

7. In a device of the class described the combination of a series of drying chambers through which moist material may be successively passed, means associated with the chambers and serially connecting them for directing a drying medium through consecutive chambers and for increasing the temperature of said medium prior to its entry into each succeeding chamber above that at which it entered the preceding chamber, and means including a condenser for returning the drying medium to the first drying chamber, the material to be dried being first introduced into the first chamber in which the drying medium is also first entered.

8. In a device of the class described the combination of a series of drying chambers within which moist material may be disposed, means associated with the chambers and serially connecting them for directing a drying medium through consecutive chambers and for increasing the temperature of said medium prior to its entry into each succeeding chamber, means for returning the drying medium to the first drying chamber, means interposed in the circuit of the drying medium between the last and first drying chambers for removing moisture from the drying medium, a by-pass in the circuit adjacent the last mentioned means, a directing valve controlling the by-pass and said last mentioned means, and a humidostat associated with the last of the series of drying chambers and controlling the directing valve.

9. In a device of the class described the combination with means for supporting a moist material, of opposed perforate walls disposed on opposite sides of the supporting means, outer walls spaced at a distance from each of the perforate walls for providing confined pressure chambers and receiving chambers on opposite sides of the pair of perforate walls, means for directing a drying medium into one of the pressure chambers and through the perforations in one of the perforate walls transversely of the supporting means and the material carried thereby and permitting passage of the drying medium into an opposed receiving chamber, a heating chamber for receiving the drying medium from the receiving chamber and adding heat thereto, means for directing the drying medium at increased temperature through a second pressure chamber, over the carrying means and the material to be dried and into a succeeding receiving chamber, a humido-

stat in said receiving chamber, means for directing the drying medium from the last mentioned receiving chamber, a two way valve associated with the last mentioned means and operated by the humidostat, a condenser, a by-pass adjacent the condenser, said condenser and by-pass being controlled by the two way valve, and means for moving the drying medium from the condenser and by-pass to the first mentioned pressure chamber.

10. In a device of the class described the combination of a series of chambers through which material to be treated may be consecutively passed, and means associated with the chambers and serially connecting them for directing the treating medium transversely through consecutive chambers and for conditioning the medium prior to its entry into each succeeding chamber so that the medium before being introduced into each successive chamber is heated to a temperature higher than that at which it was introduced into the preceding chamber, the drying medium being first passed through the chamber in which the material is first introduced.

11. The method of drying moist material comprising progressively moving said material through a series of substantially separated chambers, directing a drying medium consecutively through each of the chambers, increasing the temperature of the drying medium prior to its entry into each succeeding chamber to a temperature higher than that at which it was introduced in the preceding chamber, and removing the moisture from the medium after it leaves the last of the series of chambers the drying medium being first introduced in the chamber in which the material is first introduced.

12. In an apparatus for treating materials, the combination of means for directing material to be treated through a circuitous path, means for substantially enclosing the material whereby to provide a confining casing, means including the material acted upon for providing a series of chambers within the casing and through which series of chambers the material moves, means for directing a fluid treating medium through the series of chambers and independent conditioning means through which the medium must pass prior to entry into each chamber, the material traveling from one chamber into the succeeding ones and the drying medium being first passed through the chamber in which the material is first introduced and then passed successively through the succeeding chamber and heated to a higher temperature than that at which it was when passed through the preceding chamber.

13. In a device of the class described, the combination with means for carrying material to be treated, of opposed perforate walls disposed on opposite sides of the carrying means, outer walls spaced at a distance from each of the perforate walls for providing confined pressure chambers and receiving chambers on opposite sides of the pair of perforate walls, means for directing a treating medium into one of the pressure chambers and through the perforations in one of the perforate walls transversely of the carrying means and the material carried thereby and permitting passage of the treating medium into an opposed receiving chamber, a conditioning chamber for receiving the medium from the receiving chamber and altering the temperature thereof, means for directing the medium at altered temperature through a second pressure chamber, over the carrying means and the material to be treated and into a succeeding receiving chamber, means responsive to the condition of the medium disposed in the last mentioned receiving chamber, means for directing the medium from the last mentioned receiving chamber, a two way valve associated with the last mentioned means and operated by said responsive means, converting means for the medium, a by-pass adjacent said converting means, said converting means and by-pass being controlled by the two way valve, and means for imparting movement to the treating medium.

14. The method of drying moist material comprising distributing said material within a series of substantially separated chambers, moving the material successively into said separated chambers, transversely directing a drying medium consecutively through each of the chambers, increasing the temperature of the drying medium prior to its entry into each succeeding chamber to a degree above that at which it entered the preceding chamber, then removing the moisture from the medium after it leaves the last of the series of chambers and again passing said medium through the chambers as aforesaid, the drying medium being first passed into the chamber in which the material is first introduced.

15. In a device of the class described the combination of a series of inclosing means within which material to be dried may be disposed, means for directing a treating medium transversely through each of the individual inclosing means and a conditioning means for receiving the treating medium from each of the inclosing means and acting upon said treating medium prior to its entry into the next succeeding inclosing means, the material to be dried being advanced consecutively through the series of enclosing means, the treating medium being introduced first into the enclosing means within which the material is first introduced and then passed successively through succeeding enclosing means and heated to a higher temperature than that at which it was when passed through the preceding enclosing means.

16. In a drying structure for paper the combination of a series of inclosing means, means for directing material to be dried in a circuitous path successively through the inclosing means and means for providing a continuous flow of heated air transversely through each of the individual inclosing means and including heaters for receiving air from each of the inclosing means and for raising the temperature thereof above its temperature at entry to a given preceding inclosing means, air being first passed through the chamber in which the material is first introduced.

In testimony whereof, I have hereunto subscribed my name this 28th day of June, 1926.

JOHN P. BROWN.