Oct. 11, 1927. 1,645,366

J. E. ALEXANDER

METHOD OF DRYING MATERIAL

Filed Nov. 28, 1924 5 Sheets-Sheet 1

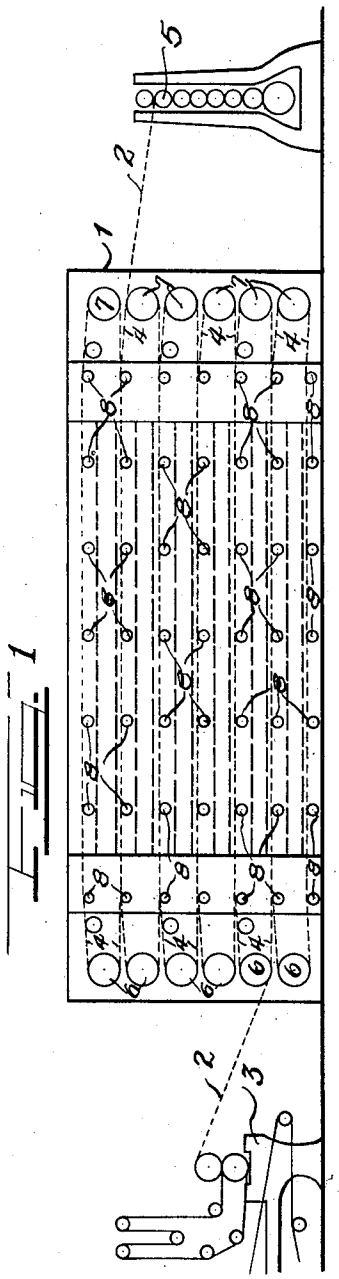


Fig. 1

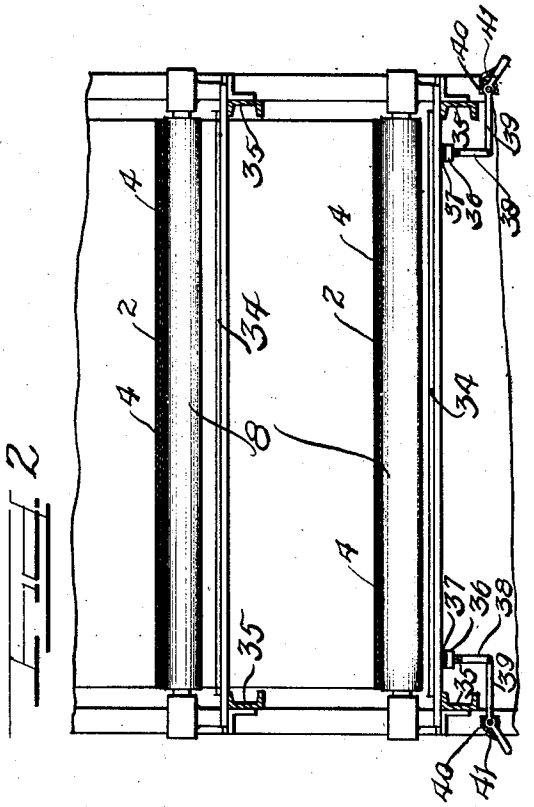


Fig. 2

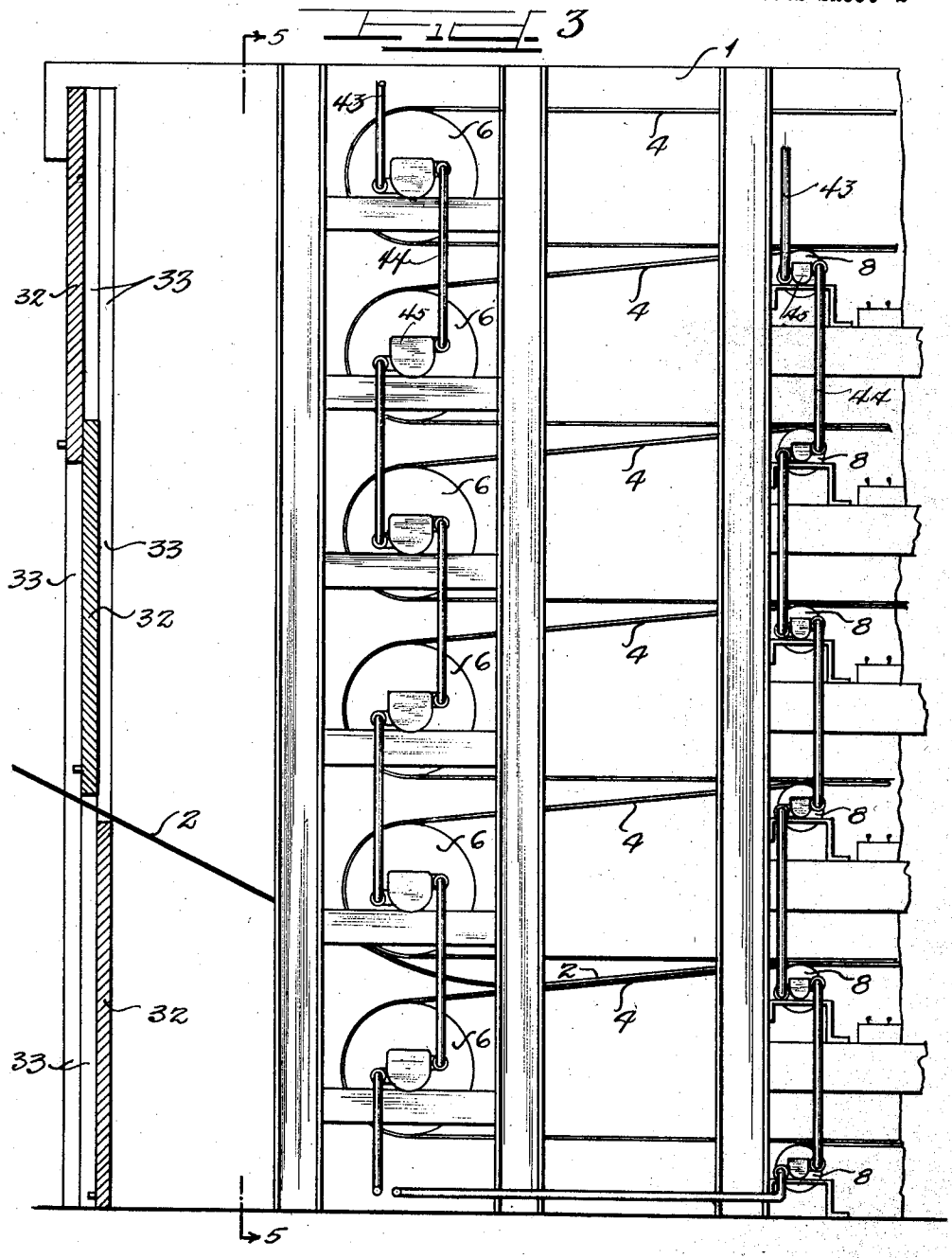
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Oct. 11, 1927. 1,645,366

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METHOD OF DRYING MATERIAL

Filed Nov. 28, 1924 5 Sheets-Sheet 2



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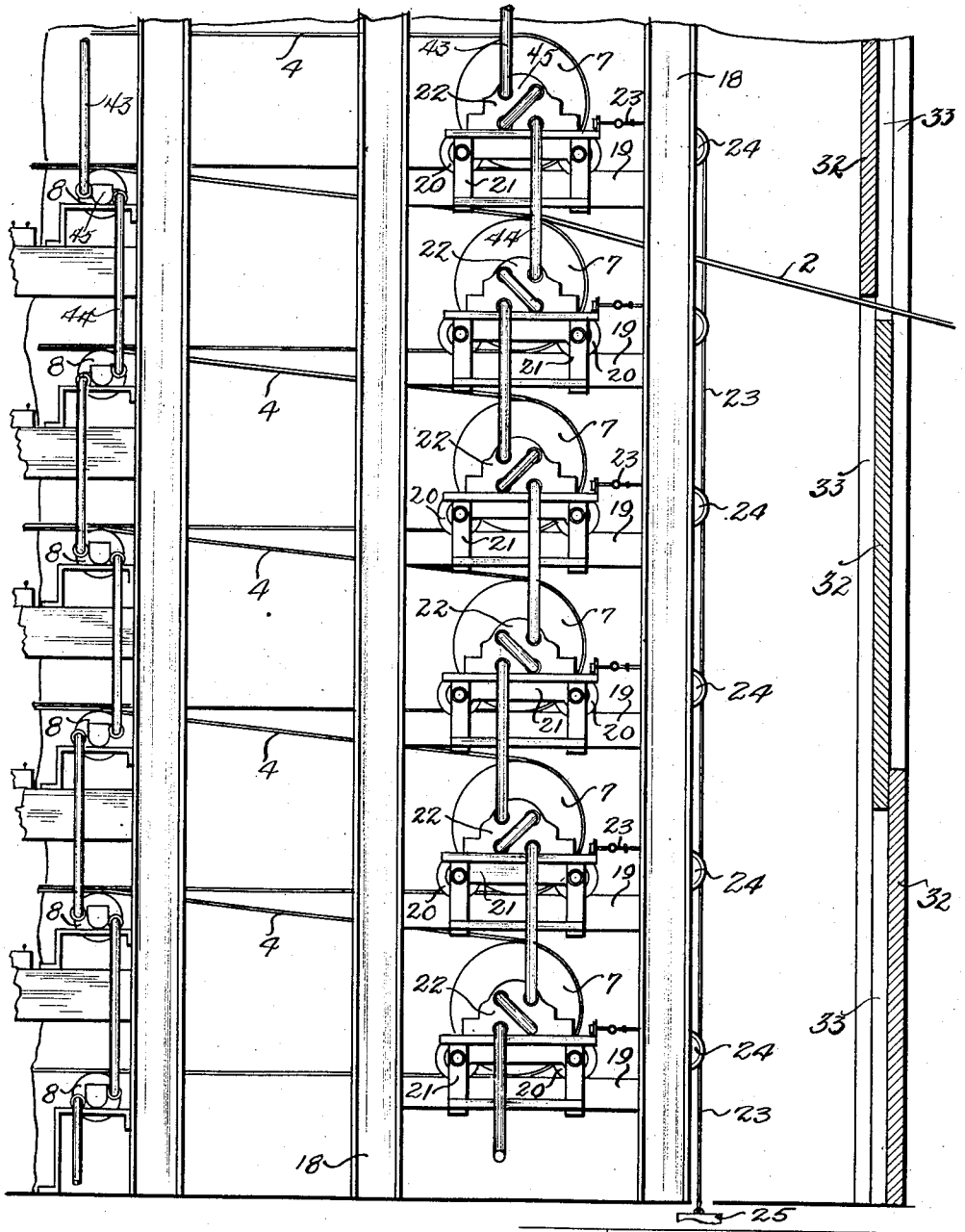
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J. E. ALEXANDER

METHOD OF DRYING MATERIAL

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FIG. 4.



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METHOD OF DRYING MATERIAL

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FIG 5

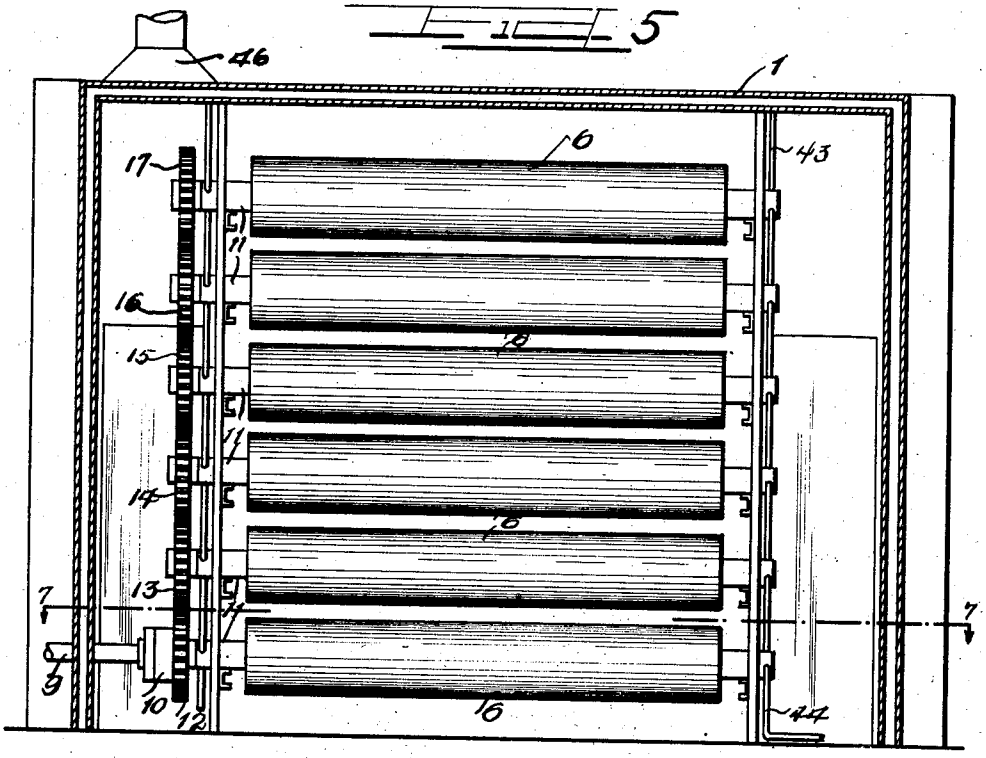
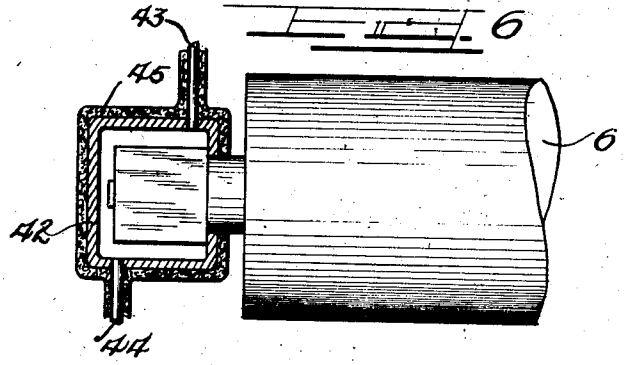


FIG 6



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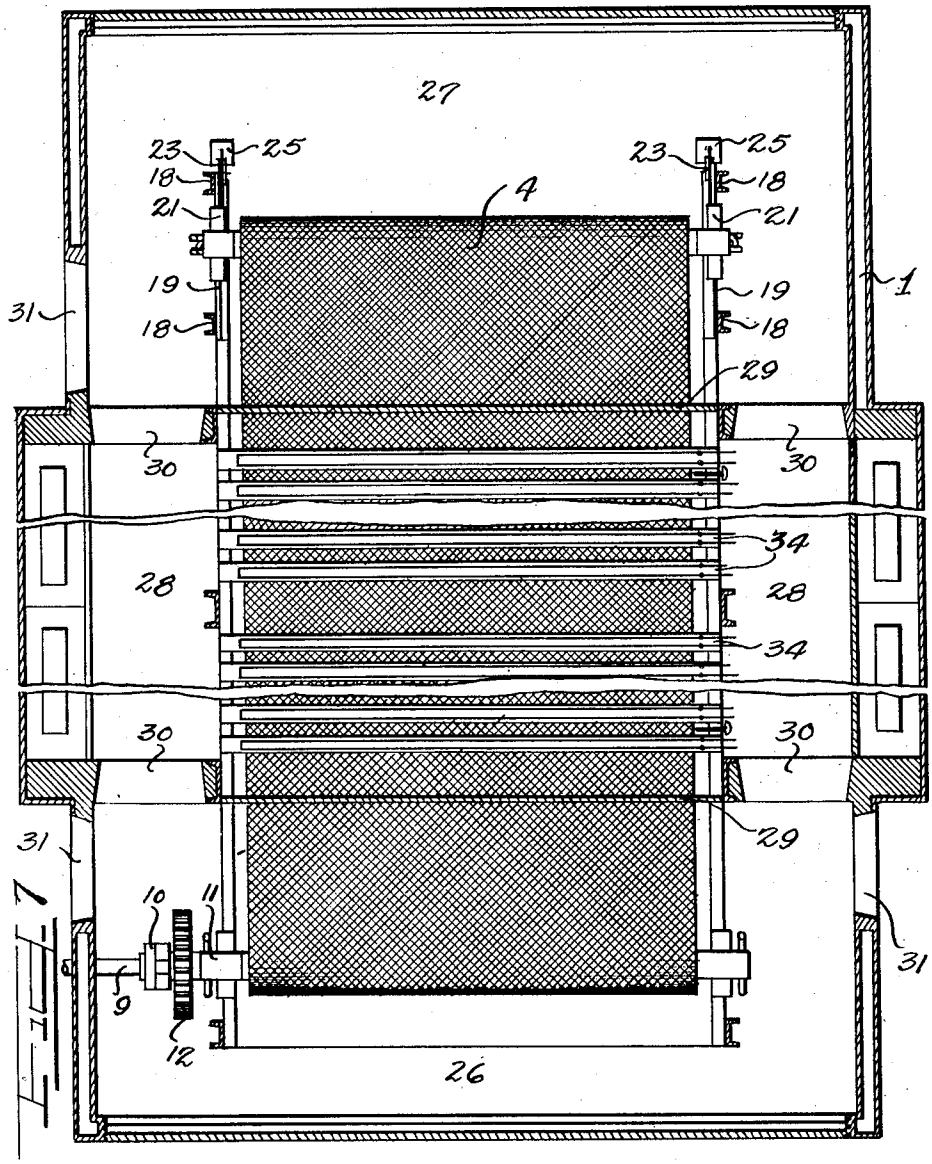
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Oct. 11, 1927. 1,645,366

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METHOD OF DRYING MATERIAL

Filed Nov. 28. 1924 5 Sheets-Sheet 5



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Patented Oct. 11, 1927. 1,645,366

UNITED STATES PATENT OFFICE.

JOHN E. ALEXANDER, OF PORT EDWARDS, WISCONSIN.

METHOD OF DRYING MATERIAL.

Application filed November 28, 1924. Serial No. 752,574.

This invention relates to a method of drying material and particularly to a method wherein radiant heat is employed as the primary drying medium and wherein the drying is preferably effected in a chamber from which air is excluded by the higher pressure of a gaseous medium, generally superheated vapor removed from the material itself within the chamber.

Methods of drying heretofore employed have generally included an air circulatory system and in those cases wherein such a circulatory system has not been specifically provided there has been no provision for the exclusion of air except in vacuum type dryers which have not previously employed high temperature radiant heat as a primary drying medium.

Where radiant heat has been used heretofore the temperature thereof has been much lower than the temperature which I employ which often results in an operating temperature of from 1200° F. to 1400° F. although I do not purpose limiting myself herein to such exact temperature limit.

The present application is a continuation in part of my application for patent for high temperature radiant drying system, filed in the United States Patent Office on November 26, 1923, Serial No. 676,913, and patented December 1925, Patent No. 1,563,461.

This invention provides, and has for one of its important objects the provision of a method of drying material within an enclosed chamber by radiant heat of high temperature, air being excluded from the chamber during the drying operations.

Another object of the invention resides in the provision of a method of drying material wherein the percentage of moisture remaining in the material at the end of drying operation is readily controllable.

It is also an important object of this invention to provide a method of drying material by radiant heat wherein the material is enveloped by a superheated air excluding medium which of itself exerts a secondary drying effect.

It is a further object of this invention to provide a method of drying material by radiant heat within an enclosed chamber and enveloped solely by vapor emanating from said material wherein the temperature within the chamber is maintained at such a point that there is no condensation of said vapor therein.

It is another important object of this invention to provide a method of drying wherein a medium within a drying chamber is maintained at such a pressure that entrance of air into the chamber with the material to be dried is prevented.

It is finally an important object of this invention to provide a method of drying by radiant heat at very high temperatures which is effective, economical and readily controllable.

Other and further important objects of this invention will be apparent from the disclosures in the specification and the accompanying drawings.

The invention in a preferred form is shown in the drawings and hereinafter more fully described.

On the drawings:

Figure 1 is a diagrammatic side elevation illustrating a form of paper dryer adapted to effect the drying method of this invention.

Fig. 2 is an enlarged fragmentary sectional view showing the supporting rollers for the Fourdrinier wires and a mechanism for adjusting a section of the heating element.

Figure 3 is a fragmentary side elevation with parts in section showing the entrance end of a paper dryer adapted to effect the method of this invention.

Figure 4 is a view similar to Figure 3 showing the discharge end from which the dried web is taken.

Figure 5 is a section on the line 5—5 of Figure 3 with parts omitted and parts in elevation.

Figure 6 is an enlarged fragmentary detail view showing one arrangement of the water cooled bearings and the insulation which is provided therefor to prevent objectionable condensation.

Figure 7 is an enlarged section on the line 7—7 of Figure 5 with parts omitted and parts shown in elevation.

As shown on the drawings:

Referring to Fig. 1 which diagrammatically illustrates a paper dryer which is particularly adapted to effect the drying method of this invention, the reference numeral 1 indicates an outer enclosing housing which preferably comprises walls, floor and ceiling of heat insulating material, these enclosing

portions being made of any desirable material and construction to afford a low degree of heat conduction. A web 2 of material to be dried, such, for example, as paper, is taken from a forming machine, such as a Fourdrinier paper machine 3 and introduced into the enclosing housing 1 through a suitable opening to be described hereinafter, thence it is threaded back and forth through a plurality of passes of the dryer between transferring means, preferably Fourdrinier wires 4 and after being conducted through said passes of the dryer, said web 2 passes outwardly from the housing through a restricted opening therein to a calender stack 5, or other suitable receiving apparatus. Each of the Fourdrinier wires 4 is made in a continuous loop in a well known manner and the ends of said loop are respectively supported upon breast rolls 6 at the entrance end and breast rolls 7 at the discharge end, said breast rolls 7 being adjustably mounted to maintain a proper tension on the wire to compensate for expansion and contraction thereof in a manner to be described hereinafter. The Fourdrinier wires 4 are supported intermediate their ends inside the casing 1 by suitable rollers 8 which are similar in construction to table rolls of a paper making machine and which are spaced sufficiently close to afford a proper support for said wires.

Power is applied to the breast rolls 6 through a drive shaft 9 which is connected with an electric motor or other suitable source of power and which projects through the wall of the housing 1 in the manner shown in Figure 5. Said drive shaft 9 is connected through a suitable connection 10 to an axial shaft 11 upon which the lower breast roll 6 is mounted and secured to said shaft 11 adjacent the connection 10 is a suitable gear 12 which drives a train of similar gears 13, 14, 15, 16 and 17 which successively mesh with each other and which are secured to the ends of shafts like the shaft 11 on which the breast rolls 6 are mounted.

In order to provide automatic compensation for expansion and contraction of the Fourdrinier wires 4 the breast rolls 7 at the discharge end of the dryer unit are adjustably mounted in the manner which will now be described, reference being had particularly to Fig. 4 of the drawings. Supported between vertical frame members 18 adjacent either end of said breast rolls 7 are horizontal track members 19, one of said track members being mounted adjacent each end of each of said breast rolls. A pair of rollers 20 which are rotatably mounted on carriage members 21 and which roll on the track members 19, afford suitable support for bearings 22 in which the axial shaft projecting from the ends of the breast roll 7 is journalled. Secured to each of the carriage members 21 at the outside end thereof is a flexible member such as a cable 23 and such cables 23 pass over pulleys 24 which are rotatably supported on the outside frame members 18 and extend downwardly from said pulleys having weights 25 secured to the lower end thereof. For purposes of convenience said cables 23 may extend through an opening in the floor of the housing 1 and have the weights 25 attached thereto below said floor. It will be apparent that by the provision of said movable carriage members 21 to which the weights 25 are attached by the cables 23 I have provided means whereby a definite tension is always maintained on the Fourdrinier wires 4 and compensation is made for adjustment or contraction of said wires which is caused by the rising or lowering of the temperature within the casing 1.

As will be seen from an examination of Fig. 7 the interior of the housing 1 is divided into end chambers 26 and 27 and an intermediate chamber 28, said intermediate chamber 28 being a high temperature drying chamber in which the radiant heating elements are mounted. Division of the interior of the housing 1 into said chambers or compartments 26, 27 and 28 is effected by means of a plurality of baffle plates 29 which extend transversely of the interior of the housing between the various passes of the dryer composed of the Fourdrinier wires 4 and said baffle plates are preferably positioned so that the upper and lower edges thereof are in close proximity to said Fourdrinier wires to afford as complete a division between the chambers or compartments as possible. Mounted between the ends of said baffle plates 29 and the inside walls of the housing 1 are suitable doors 30 which may be closed to isolate the compartment or chamber 28 from the compartments or chambers 26 and 27 which at the same time may be opened if desired to afford the operator access to said chamber or compartment 28. Suitable doors 31 are also provided in the walls of the housing 1 preferably adjacent the ends of said walls to provide access to the interior of the chambers or compartments 26 and 27. These doors are preferably constructed of suitable insulating materials to prevent the conduction of an objectionable amount of heat therethrough when the dryer unit is in operation.

As will be clearly seen from an examination of Figs. 3 and 4 means are afforded for providing ready access to the entering and discharge end of the housing 1 to permit of readily threading the web unto and between the Fourdrinier wires 4 when the unit is being started in operation. Said means comprise a plurality of vertically slidable door members 32 which are preferably constructed of heat insulating material and which may

be slid upwardly or downwardly in guideways or vertical tracks 33 to afford access to the upper or lower passes of the dryer unit as desired. As will be noted from Figs. 3 and 4 said doors 32 are so positioned as to allow narrow openings between the edges thereof and the web 2, which is to be dried, enters the housing 1 through said opening in the entering end of the housing and leaves the housing through the opening which is similarly formed at the discharge end preferably at the upper portion thereof. It will, of course, be apparent that the web might be introduced at the entering end at the top of the housing and threaded through between the various Fourdrinier wires and discharged from the lower pass at the lower part of the discharge end of the housing.

The drying of the wet web inside the housing 1 is effected by means of a plurality of electric heating elements 34 (Figs. 2 and 7) which are supported on suitable longitudinal bars 35 and which are positioned beneath each path of the Fourdrinier wires 4 between which the web to be dried is carried. The radiant heating elements preferably extend substantially the width of the Fourdrinier wires and are also so spaced longitudinally thereof that their effect upon said wires or section thereof is uniform both longitudinally and laterally. It may sometimes be desirable to move certain sections of said heating elements 34 into closer proximity to the Fourdrinier wires in which the web 2 is carried to increase the rate of heat transference to said web and for this purpose I have provided an arrangement which is shown in Fig. 2, it being understood that other suitable arrangements for suitably positioning individual elements or sections thereof might be provided. This arrangement consists of longitudinal bars 36 which may be mounted underneath any desired section or sections or heating elements 34 and which are preferably insulated on their upper faces as shown at 37. Pivotally connected to the under side of said bars 36 near each end thereof is a link 38 which in turn is pivotally connected to one arm of a crank member 39 pivoted on one of the supporting posts of the housing 1. Said crank 39 is provided with a ratchet 40 which is adapted to be engaged by a pawl 41 to lock the crank in a desired adjusted position. With this construction it is possible by rotating the cranks 39 about their pivotal mountings to raise the heating elements 34 into a position closer to the Fourdrinier wires 4 between which the web 2 is carried. When said cranks 39 have been actuated to raise said section of heating elements which rests on the bars 36 to a desired position the pawls 41 are allowed to engage the ratchet 40 whereby said heating elements are held in the position to which they have been raised. By thus adjusting the position of various sections of the heating elements 34 relative to the Fourdrinier wires 4 and the web 2 passing through the dryer housing, it is possible to control the rate of heat transference to the web, it being understood that this transference is mainly effected by radiant heat from the high temperature radiant heating element 34.

On account of the high temperature inside the housing 1 it is desirable that some means be provided for cooling the bearings in which the shafts of the breast rolls 6 and the cable rolls 8 are journalled. For that purpose I have provided each of said bearings with a water cooling arrangement whereby a circulation of cooling water is maintained through cooling jackets surrounding the bearings at all times. A detail of one of said water cooled bearings is shown in Figure 6 wherein the reference numeral 42 represents a jacket or housing surrounding the bearings to which water is supplied by means of a pipe 43 and from which water is discharged by means of a pipe 44. All of the bearings for the various rolls 6, 7 and 8 are provided with similar water cooling arrangements the cooling water for each vertical row of bearings preferably entering the housing through the top thereof and being discharged at the bottom into a suitable discharge conduit.

In order to eliminate objectionable condensation which might be caused by the flow of cooling water through the pipes 43 and 44 and the jacket 42, I have covered said pipes and said jacket entirely with a suitable sheathing of insulating material such as an asbestos composition or the like which I have indicated in Figure 6 by the reference numeral 45. By thus insulating said pipes and jacket and also by providing the walls of the housing 1 of material which is a poor conductor of heat it is possible to maintain an extremely high drying temperature within the interior of the housing 1 and to eliminate dripping or condensation which might otherwise be caused by the superheated steam within the housing coming in contact with a cool surface.

In order to provide for the removal of the superheated steam from the housing the ceiling or upper wall of said housing is provided with openings which communicate with suitable discharge passages ordinarily consisting of pipes or conduits such as I have shown at 46 in Figure 5. These pipes or conduits may be connected to a suitable fan arrangement to facilitate the removal of this superheated steam as excess quantities thereof are formed from the web of material which is being dried.

The method of drying.

Since the method of this invention is particularly applicable to the drying of a con-

tinuous web of paper as it leaves the press rolls of a paper making machine, the following description of the application of my method will be made as applied to such a drying operation. It is apparent, of course, that the method described might be applied to the drying of a wide variety of materials without departing from the principles or teachings of this invention.

The wet sheet of paper or other material is conducted into the end chamber of the dryer housing where it is threaded in such manner as desired between the Fourdrinier wires 4 or other conducting and transferring members which are designed to conduct heat thereto and transfer the same through both end chambers and the intermediate heated chamber of said housing.

The heating elements 34 are put in operation by connection with a suitable source of electrical energy, the Fourdrinier wires 4 or other transferring mechanism having been previously started to conduct the web through the housing. The housing 1 is now closed with the exception of narrow openings between the doors 32 in the ends thereof which permit the sheet or web to pass into and out of the same and the transference of radiant heat from the heating elements to said web or sheet causes an immediate evaporation of moisture therefrom. The vapor thus formed is rapidly changed to superheated steam driving the air from the housing and building up a pressure which prevents the entrance of additional air through the small openings in the ends of the housing surrounding the sheet.

It will thus be seen that the drying is effected in a chamber from which air is excluded and where the air originally in the housing is replaced by superheated steam emanating from the web or sheet and immediately superheated by the heat within the chamber from the radiating elements.

Thus it will be apparent that the radiant heat from the heating elements forms the primary means whereby the moisture is driven from the sheet or web first in the form of steam at 212° F. which becomes superheated while in close proximity to the sheet and forms a superheated medium filling the dryer housing and acting as a secondary drying medium. The action of this high temperature heat might be further described as causing the temperature of the water contained in the initially wet material to be raised to 212° F. The water is then changed from water at 212° to steam at 212° F. after which the temperature of this steam is raised to such an extent that it becomes a dry superheated steam, which expands in volume in the substantially enclosed casing and thus causes a pressure therein. This transformation or change of the greater part of the water contained in the initially wet material is effected, even in the early stages of the movement of the web through the casing, that is, the hereinbefore described change in the water is effected immediately after the web enters the casing, as well as during the rest of its path of movement through the casing.

As the material is supported by and located between foraminous metal supporting means a certain amount of heat will be absorbed initially by the Fourdrinier wires and will then be conducted to the web of material. The dry superheated steam caused by the radiant heating elements, whose temperature is greatly in excess of that of the web of material and of the superheated steam caused thereby, results in maintaining the superheated steam in a substantially dry condition, that is very effective in assisting in the drying operation.

The discharge passages or conduits afford means whereby the superheated steam may be removed from the housing and, if desired, transferred to an economizer, condenser, turbine or steam dryers of the drum type or other types, for further utilization of the heat units therein. The superheated steam that is thus discharged is of course replaced within the housing by newly formed steam from the web or sheet which prevents the entrance of air into said housing. The temperature of this superheated steam and interior of the housing is preferably maintained sufficiently high so that there is no condensation and consequent objectionable dripping within the housing.

As long as there is moisture in the web or sheet of material no injury can be done thereto, even though the temperature of the heat produced by the radiant heating elements is very greatly in excess of that of the sheet, because of the absorption of heat by the sheet and the formation of steam at 212° F.

It is only necessary to so limit the rate of transference of radiant heat to the sheet that violent ebullitions within the sheet are not effected with a resulting possible injury to the fibers.

It is, of course, apparent that the rate of heat transference may be controlled by varying the position, effective number and (or) temperature of the heating elements, and in the same manner the moisture content of the material leaving the dryer housing may be governed and controlled.

A substantially uniform temperature of the superheated steam within the casing may be maintained by the use of thermostatic controls for the heating element circuits. Such controls are shown and described in the copending application of myself and Stephen A. Staege, Serial No. 713,637, filed May 15, 1924.

The sheet or web after leaving the dryer may of course be subjected to any desired

additional operations such as calendering, reeling and the like. If desired the web may be subjected to the action of drum or other type steam dryers both or either before and after entering the electric dryer. Due to the fact that the drying of the material by this method does not involve placing the material in direct contact with a heated surface of a character adapted to conduct heat rapidly thereto, as has been the case with many previous drying methods, the danger of injury thereto during the drying operation under high temperatures is minimized.

I am aware that various forms of apparatus of the general character disclosed herein may be employed in carrying out the method of drying of my invention and I therefore do not purpose limiting the method to details of the particular apparatus or otherwise than necessitated by the prior art.

I claim as my invention:

1. That method of drying comprising the application to material to be dried within a drying chamber of variable degrees of concentration of heat and at the same time maintaining a substantially uniform temperature of the superheated steam in the chamber surrounding the material.

2. The method of drying material which comprises subjecting the same to the action of relatively high temperature radiant heat in a substantially enclosed casing, preventing the admission of appreciable quantities of air to said web by maintaining a pressure slightly greater than atmospheric within said casing, superheating the steam formed by said radiant heat, and employing superheated steam to aid in drying said web.

3. The method of drying a web of paper which comprises passing said web continuously through a substantially closed area heated to a temperature sufficiently elevated to cause the moisture in the web to form superheated steam, said steam thereby being under sufficient pressure to substantially exclude air from said area.

In testimony whereof I have hereunto subscribed my name.

JOHN E. ALEXANDER.