Dec. 2, 1958 J. DUNGLER 2,862,305

APPARATUS FOR DRYING STRIP MATERIAL

Filed July 6, 1954 2 Sheets-Sheet 1

Fig.1

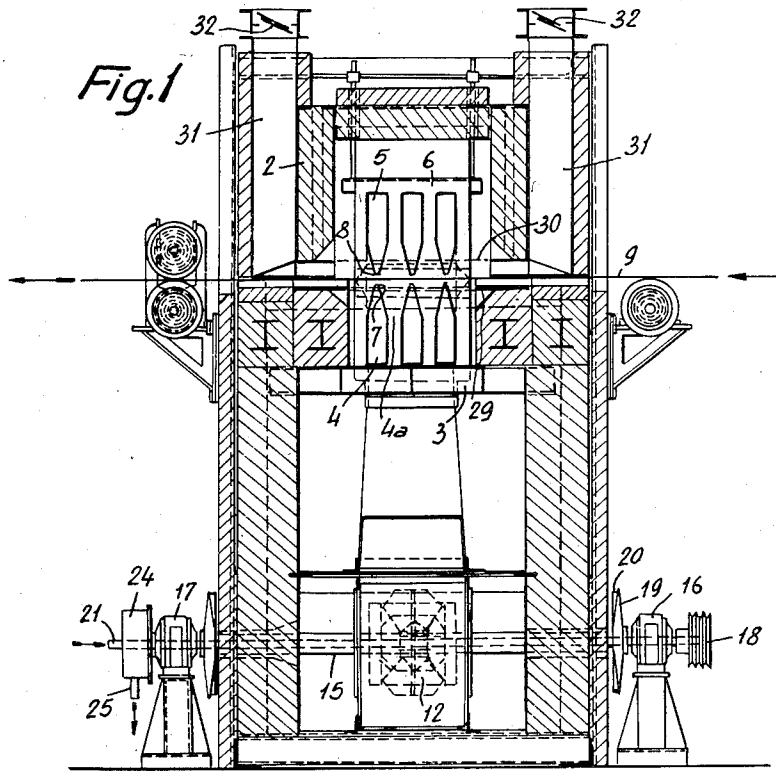


Fig.4

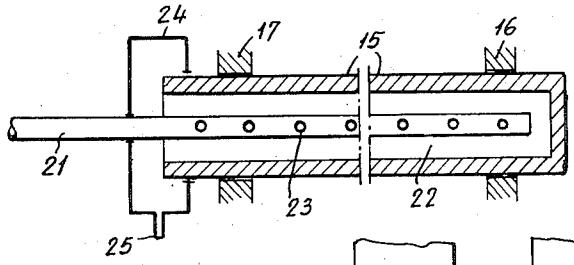
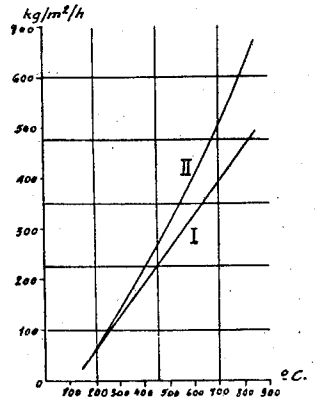


Fig.5



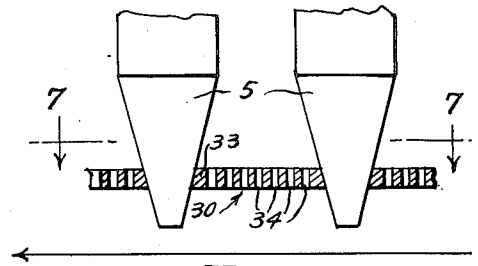


Fig.6

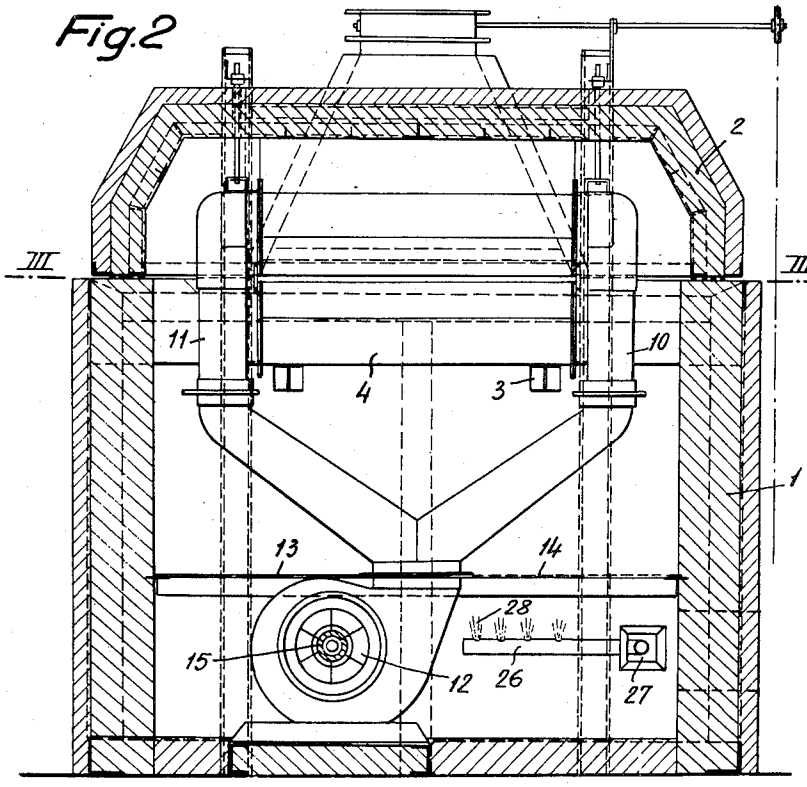
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Fig. 2



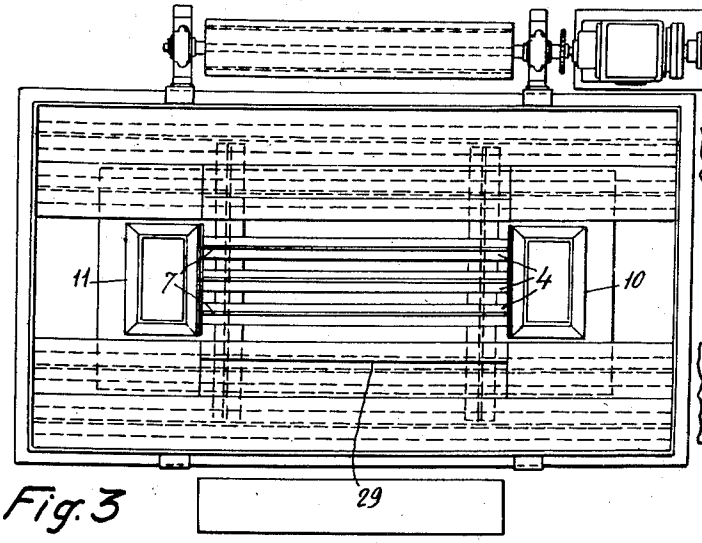


Fig. 3

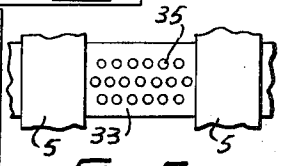


Fig. 7

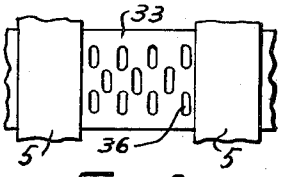


Fig. 8

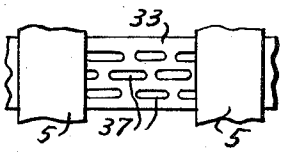


Fig. 9

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2,862,305

APPARATUS FOR DRYING STRIP MATERIAL

Julien Dungler, Basel, Switzerland

Application July 6, 1954, Serial No. 441,337
Claims priority, application France July 29, 1953
2 Claims. (Cl. 34—68)

The present invention relates to means for drying strip or web material, such as fabrics, papers, pulp, sugar and other permeable or liquid containing materials by means of a treatment fluid, in particular a gaseous fluid.

It is one of the objects of the present invention to provide means affording marked improvements in drying of materials of the aforesaid character, including extreme rapidity of drying performance, economy and reduction in the overall dimensions of the equipment thereby used, as the treatment fluid may now be used at increased temperatures materially far above any temperatures heretofore or usually applied.

It was up till now possible to expose during drying a product impregnated with a liquid to a temperature higher than the temperature which such product ordinarily would withstand in a dry condition. Such an increased or higher temperature ranges between 100° C. and 200° C. Furthermore, it is common practice to dry a product by directing upon the latter infra-red radiations or other rays emitted by special radiation sources to reach required temperatures.

Drying according to this invention is carried out by a treatment fluid which is circulated, and of which at least some components are brought up to a temperature so that the fluid itself and any metal or like elements located in the treatment chamber, such as fluid guiding means, which direct the treatment fluid for contact with the product to be dried, emit radiations which efficaciously contribute to considerably increased drying effect of the product under treatment, in addition to usual convection heat.

According to another feature of this invention, the treating fluid is heated to a temperature above at least 200° to 250° C.

It is still another object of this invention to provide means affording heating of the treatment fluid to its required temperature by the combustion of a fuel carried out in a treatment chamber or in a separate enclosure which is in communication with said chamber, so that the treatment fluid resulting therefrom consists partly at least of burnt fuel gases produced in this combustion.

It is a further object of this invention to provide means performing the combustion for heating the treatment fluid under admission of air, in such manner which ensures complete combustion without leaving any excess of air in the treatment chamber.

It is still another object of this invention to provide means ensuring promotion of irradiations from the circulating treament fluid, which is heated to a temperature sufficiently high enough to inherently produce heat by convection and radiation, particular radiant elements being preferably disposed along the path of the treatment fluid, which impart to the product under treatment radiation effect without disturbing the circulation of the fluid.

Yet another feature of this invention is to provide

means imparting a relatively high radiation emitting power to the surface of at least some of the radiant elements which are devoid of any special heating source and are located in the treatment chamber, such as guiding or nozzle elements for said treatment fluid.

Still another feature of this invention resides in drying the material by the simultaneous application thereto of heat by convection and radiant heat.

According to this invention, the introducion of the product to be treated into the treatment chamber is effected by means of a substantially inert strip of a material, which is usually not affected by the condition or conditions prevailing in the treatment chamber, such as asbestos or the like, whereby such asbestos strip is advanced ahead of the product under treatment, said strip having a length so that the drying or like treatment machine may be initiated and its output rate properly adjusted, prior to the admission of the product proper into the treatment chamber.

Still another object of this invention is to provide means conducive to a highly economical treatment plant of the type hereinabove stated, in which excess fluid built up in one treatment chamber, i. e., essentially by virtue of the evaporation of the liquid with which the treated product is impregnated, is used for the further supply of treatment fluid in another treatment chamber without the necessity of any special heat exchanger.

It is still a further object of the invention to provide means rendering the possibility of discharging the treated product from the treatment chamber substantially before the dryness degree requisite for the respective product is obtained, the drying operation being automatically completed outside the treatment machine or plant, owing to the heat stored within the treated product at the moment when the latter leaves the treatment chamber.

It is still another object of the invention to provide means facilitating the disposition of the nozzle means so as to form a vertical, inclined or horizontal treatment path, whereby in the case of a vertical passageway or path obtained by the nozzles, the material (pulp, for example) to be treated may be introduced into the dryer by gravitation, rather than by pulling forces.

Other objects and advantages of this invention will appear from the following specification and claims, reference being had to the accompanying drawings in which:

Fig. 1 is a sectional view of a machine according to the present invention,

Fig. 2 is a cross section of the machine of Fig. 1,

Fig. 3 is a section taken on line III—III of Fig. 2,

Fig. 4 is a section of detail employed in the invention and drawn to an enlarged scale,

Fig. 5 is a diagram aiding in the explanation of the invention,

Fig. 6 is a fragmentary and enlarged vertical sectional view through an upper screen with blowing nozzles employable in the invention,

Fig. 7 is a horizontal sectional view taken along lines 7—7 of Fig. 6,

Figs. 8 and 9 are similar horizontal sectional views as seen in Fig. 7, but showing screens with modified shapes of perforations.

Referring now more particularly to Fig. 2, there is disclosed a treatment chamber forming a highly heat-insulated enclosure with a lower portion 1 and a removable upper portion 2.

Within this treatment chamber are accommodated a plurality of blowing nozzles 4 (in the example three nozzles are shown) resting upon cross-members 3 and separated from one another by adjacent discharge or evacuation ducts 4a having any suitable shape, such as

described in my U. S. patent application Serial No. 382,221, filed October 9, 1953.

To the lower blowing nozzles 4 are coordinated upper blowing nozzles 5 suspended from a bracket 6 in the upper portion of the treatment chamber. The fluid discharge slots 7 and 8 of the nozzles 4 and 5, respectively, form a boundary for the path of travel of the product 9 to be treated in the treatment chamber 1. It should be pointed out that this product is not supported by any supporting member whatever during its traversal of the treatment chamber, it is rather maintained along its path by the action of the discharged drying fluid, and possibly by the longitudinal traction or pulling force exerted on the product by external drawing means. In fact, any supporting member whatever during its traversal of the reach too high a temperature liable to cause the treated product to be damaged when getting into direct engagement with such heated supporting means.

The supply of treatment fluid to the nozzles 4 and 5 is performed through lateral collectors 10 and 11, supplied by a blower 12 arranged in the lower portion of the treatment chamber under a metal sheet partition 13 extending about half the cross section of the treatment chamber, the other half of the chamber being separated from the enclosure which covers the blower 12 by a wire screen 14.

Due to the high temperature conditions of operation, means for driving the blower 12 should be arranged outside the treatment chamber and the shaft 15 of the blower is to be efficiently cooled. The shaft 15 which is supported in two bearings 16, 17 (Fig. 4) placed outside the treatment chamber carries at one of its ends a pulley 18 for a V-shaped belt transmission and adjacent the bearings 16 and 17, discs 19 having ventilation ribs 20 for air-cooling the bearings.

The shaft 15 is hollow and contains in its bore 22 a stationary and perforated pipe 21 which may be provided inside its bore with holes 23. This pipe 21 passes through a stationary drum 24, into which extends the open end of the shaft 15 and which is fitted at its lower part with a drain conduit 25. The pipe 21 is supplied with a cooling fluid, such as, compressed air or water, which gathers within the drum 24 and flows out through the conduit 25 after having cooled the shaft 15 while circulating in the bore 22.

Heating of the treatment fluid may be effected, according to a feature of this invention, by the combustion of gas, fuel, the fuel and the air being directly and simultaneously supplied to the treatment chamber. To this end, a gas or fuel-oil pipe 26 enters through an opening 27 the treatment chamber 1 below the wire screen 14. Said pipe is fitted with burners 28 supplied with fuel and air in such proportion as to secure a complete combustion without any excess of air.

According to another feature of this invention, wire screens 29, 30 made from perforated sheet metal 33 and pervious to the treatment fluid, the end and function thereof will be explained hereinafter, are arranged along the travel path of the treatment fluid in a direction substantially parallel to the treated product 9 and spaced therefrom a relatively short distance.

The fluid in excess is discharged from the treatment chamber through flues or stacks 31 the cross section of which is controlled by valves or flap means 32 manually or automatically operated in any desired manner.

By operating the machine which has just been described, the invention may be put into practice as follows:

When the operation is initiated, the drying chamber is filled with air. After the burners 28 have been lit up, the blower 12 is started and the temperature progressively increases in the treatment chamber. As soon as the desired temperature is reached, the air contained in the chamber may be, if desired, expelled by means of a direct steam jet introduced through discharge means (not shown). Such an operation is however not necessary since the steam produced by the evaporation of the liquid with which the treated product is impregnated is soon substituted for the air. It should be noted that this operation takes place in a very short time owing to the small capacity of the treatment chamber (note the small number of blowing nozzles as compared with that in similar treating machines of known construction) and the short time required for the drying operation.

Since the machine is to be operated at a very high temperature, namely, above 250° C., the treated product, for instance, fabric, should not be introduced into the treatment chamber until accurately determined operating conditions are secured, so as to prevent any damage to the fabric. To this end, a strip of an incombustible material, such as asbestos or the like, is attached to one end portion of the fabric.

This strip is then introduced into the machine and the length of this strip of asbestos is predetermined in a manner, such as to afford enough time for the necessary adjustments, particularly the adjustment of the temperature and/or the rate of feed, to be carried out before the fabric proper enters the treatment chamber. Preferably, the operation is initiated with a rate of feed above that necessary for normal operation, such rate of feed being then progressively reduced until the desired degree of dryness is reached.

According to an essential feature of this invention, the circulating treating fluid is heated above a temperature, for instance, 250° C., so that the drying effect is not only obtained by direct transmission of heat through contact between the treating fluid and the material, but also by irradiation effect of at least some components of the fluid and by additional heat radiating elements which are located in the treatment chamber and consist mainly of elements for guiding the treating fluid, whereby through emission of radiations the drying effect is favorably increased and becomes highly economical. In fact, if the treatment fluid has a temperature of about 250° C., any elements which come into contact with the circulating fluid, particularly the walls of the nozzles 4 and 5 as well as the surfaces of the wire screens or perforated means 29 and 30 provided for this purpose (having variously shaped perforations 34, 35, 36, 37 according to Figs. 6 to 9), are heated to the same temperature which promotes the emission of radiations, thus effectively contributing to rapid drying of the material by supplying also heat in the form of radiations. It should be noted that in contradistinction to known machines provided with special radiation emitting elements heated to the required temperature by a special heat source, radiations according to the invention are automatically obtained and without involving any additional consumption of energy or power.

It will be noted that with the process of the invention the lengthy, liquid-impregnated material is moved continuously through the enclosure means, while the treating fluid is heated within the enclosure means by a single source of heat to a temperature sufficiently high to deleteriously affect the material when in dry condition.

Separate streams of the heated fluid are oriented for impingement of these streams against spaced apart areas on opposite surfaces of the material moving through the enclosure means.

Simultaneously with the impingement of the streams of heated fluid on the material, radiant heat is directed uninterruptedly onto the entire surface areas of the material, this radiant heat emanating from the heated fluid via radiant heating means and in close proximity to the opposed surfaces of the material, so that the material is dried in the enclosure means by heat convection and radiation. In this way areas of the liquid-impregnated material which are treated by the fluid streams are also exposed to radiant heat.

Furthermore, it should be noted that the circulating fluid is constituted in the example contemplated, apart from the steam produced by the evaporation of the liquid with which the material or fabric is impregnated, by combustion gases emanating from the burners **28**. The treatment fluid thus contains H_2O and CO_2, namely gases with a high absorption and emitting power. Such gases thus absorb radiations coming from the aforesaid walls, which radiations are otherwise unable to directly reach the material or fabric and will now become useful in the treatment process.

To increase the radiating effect, the surfaces of the elements which are located in the treatment chamber may be shaped, coated and otherwise prepared to promote radiation, for instance, by surface strata of black-lead or graphite.

It should further be noted that heating of the treatment fluid may also be carried out in a different manner, e. g. by means of electric resistors or through indirect heating means by burning a liquid or gaseous fuel within a tubular element placed inside the suction channel of the blower **12** and wherein the treatment fluid is separated from the combustion gases which are discharged to the atmosphere. In this case, the treatment and radiant fluid is constituted essentially by H_2O.

Fig. 5 demonstrates for a particular machine of the kind above described, the increase of efficiency obtained by using the method according to the invention. The diagram of Fig. 5 shows plotted against the temperature of the circulating treatment fluid, the quantity of water evaporated in kg./m.^{2} per hour. While curve I indicates the evaporation due only to the amount of heat transferred by convection to the treated product, i. e. by direct contact between the treatment fluid and the treated product, curve II shows the complete result obtained by the heat delivered by convection, as well as radiation to the product under treatment, whereby the difference between curve II and curve I demonstrates the gain obtained by the process according to the invention.

It appears from this diagram that the gain obtained by radiation heat reaches a substantial value at temperatures above 200° C. Thus this gain is about 8% at a temperature of 300° C. and 26% at a temperature of 500° C. Obviously, such efficiency becomes greater with the increase of the temperature and it should be noted that it is within the scope of this invention to also use temperatures of the order say, of 800° C. up to 1500° C. and more. The use of such temperatures is made possible because as long as any liquid or impregnant remains in the product the boiling temperature of the impregnant cannot be surpassed and because of the very short time the liquid-impregnated product under treatment is subjected to such very high temperature (only seconds according to the quantity of the liquid impregnant contained in the product before treatment). There are further no elements present in the treatment chamber, such as supporting rollers and the like, which heated up to such high temperature would engage said product. In this respect, it should also be noted that it is also the purpose of the invention that the time during which the gaseous blowing fluid and the product under treatment are in contact with each other, be reduced as much as possible (less than one minute).

The fluid in excess originated in the treatment chamber by the active evaporation is discharged through the stacks **31**. It should be observed that the fluid is discharged at a still high temperature, a condition which makes it possible, according to a feature of this invention, to use it for supplying another treatment chamber or machine of any type operated at lower temperature.

The treated fabric may not necessarily leave the treatment chamber with the final degree of dryness. In fact, it is possible to subject the fabric only to a preliminary or incomplete drying operation and to effect the final drying performance in a further machine, for instance, a

machine which is supplied with the fluid of treatment discharged from stacks **31** or the predrying chamber.

According to another modification, the final drying operation may be automatically achieved outside the machine by the heat stored within the fabric at the moment the fabric leaves the treatment chamber.

The invention has among others the following advantages heretofore not yet stated:

An extremely intense and quick drying effect is obtained by the combined action of convection and radiation heat at a temperature which would be deleterious if it would act on the dry product even at a reduced time limit of the order of one minute. It should be noted that such radiations are not emitted by a particular emitting element wasting energy, but by elements located in the treatment chamber and heated to the required temperature by the treating fluid itself without necessitating any further source of heat or consumption of energy.

Owing to the intensity and the quickness of the operation, the overall dimensions of the treating machine are extremely reduced as compared with those of known treating machines. Since high temperatures are used, the specific weight of the treatment fluid is reduced to such an extent that the power absorbed for driving the blower or fan which circulates the treating fluid is but a small fraction (for instance ⅕ or less) of that necessary in known machines.

The following examples show comparative production obtainable by a dryer arrangement according to the invention and at different temperatures. For this production a dryer or predryer is used having a length of 1 metre and a width of 1 metre.

Let it be assumed that cotton material is to be subjected to treatment in accordance with the present invention weighing 100 grams/m.^{2} and containing about 90% water. The temperature of the treatment fluid is approximately 140° C. An evaporation of 50 kg./h. will take place at a transit speed of the material passing through the dryer at approximately 10 m./min.

If the temperature is increased to approximately 300° C., the evaporation will increase to 140 kg./h. at a transit speed of approximately 29 m./min.

If the temperature however is increased to about 800° C., the evaporation will be effectuated at a rate of 600 kg./h. while the material passes through the enclosure at a transit speed of 125 m./min. In such latter case the evaporation will be effectuated at a rate of 460 kg./h. by convection and at a rate of about 140 kg./h. by radiation.

It will further be noted that the moisture content of the material leaving a dryer in which a treatment fluid is used at a temperature of about 800° C. will be somewhat above 15% of the normal moisture content which is approximately 6 to 8% for cotton and about 17% for wool.

The aforesaid examples may further elucidate the treatment of material first in a predryer of about 2 meter length in which the treatment fluid (superheated steam, carbon dioxide etc.) is heated up to about 800° C. Thereafter the material is passed through an adjacent second dryer section in which part of the treatment fluid of the first or predryer may be employed at a temperature of about 300° C. This second dryer may have a length of about 3 metres. Following said second dryer section, the material may be finally passed through a third dryer section of approximately 3 metre length, in which the material is exposed to a treatment fluid of a temperature of 140° to 150° C. and derived from treatment fluid of the first and/or second dryer sections.

Thus, the transit speed of the product under treatment would be about 370 m./min. It is to be noted that air is generally not suitable as a fluid as same at extremely high temperatures contemplated by the invention, does not produce heat effects through convection and radiation, but only through convection.

The velocity of fluid jets emanating from the nozzles or like blowing elements which may be arranged in vertical, horizontal or inclined rows, may range from 2 to 50 m./sec. or may be considerably higher, for example, 150 to 200 m./sec.

It can thus be seen that there has been provided according to the invention means for treating liquid-impregnated material as hereinabove mentioned by a fluid in enclosure means to thereby obtain therein a temperature of above 200° C., said material being treated by impinging onto the latter within said enclosure means fluid, which is at least partially condensable, having a temperature above 200° C. at which said fluid inherently emits heat by convection and radiation and which would be deleterious to the material when in dry condition, and passing said material continuously at a rate of speed and within less than one minute through said enclosure means, so that said treated material leaves the latter still with a predetermined moisture content approximately above normal.

Of course, the treatment according to the invention as well as means or apparatus to carry same into effect and hereinabove given are merely illustrative; the features and the shape, nature, assembly and arrangement of the parts and elements of the dryer may be modified in any suitable manner (Figs. 7 to 9) without departing from the scope of the invention.

Thus, the temperature of the treating fluid may be substantially increased above 300° C. Furthermore, heating of the fluid may be carried out by any suitable means.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. Apparatus for drying strip-like material in a continuous manner, comprising a treatment chamber through which said material is to be continuously passed, a plurality of nozzle members positioned within said chamber at spaced locations along and on opposite sides of the path of movement of said material through said chamber, a source of heated, air-free gaseous medium disposed in said chamber, means for feeding some of said medium to said nozzle members for discharge therethrough against the opposite surfaces of said material as

the latter is moved along said path, the remainder of said heated gaseous medium flowing freely throughout said treatment chamber, and respective perforated means arranged substantially parallel to and spaced a small distance from said path on said opposite sides thereof between the respective nozzle members and in position to be contacted by said gaseous medium flowing within said chamber about said material, whereby both said nozzle members and said perforated means are heated to a temperature at which they radiate heat, to thereby ensure that drying heat is applied to said material both by direct contact thereof by said gaseous medium and by heat radiation emanating from said nozzle members and said perforated means due to contact thereof with said gaseous medium.

2. In apparatus for drying moving strip-like material in a continuous manner by the simultaneous effect of heat of a circulating gaseous medium and radiant heat; a plurality of radiating elements positioned along the path of movement of said material and oriented substantially parallel to said path and transversely to the direction of circulation of said gaseous medium about said material, said radiating elements being pervious to said medium and spaced a short distance away from said path and adapted to be brought into heat-radiating condition by said gaseous medium whereby one and the same gaseous medium serves to apply drying heat directly to said material by contact therewith and to initiate radiation of heat by said radiating elements for applying additional drying heat indirectly to said material.

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