Oct. 9, 1923. 1,470,306

J. H. WALSH

ART OF AND APPARATUS FOR DRYING MATERIALS

Filed Oct. 15, 1919 4 Sheets-Sheet 1

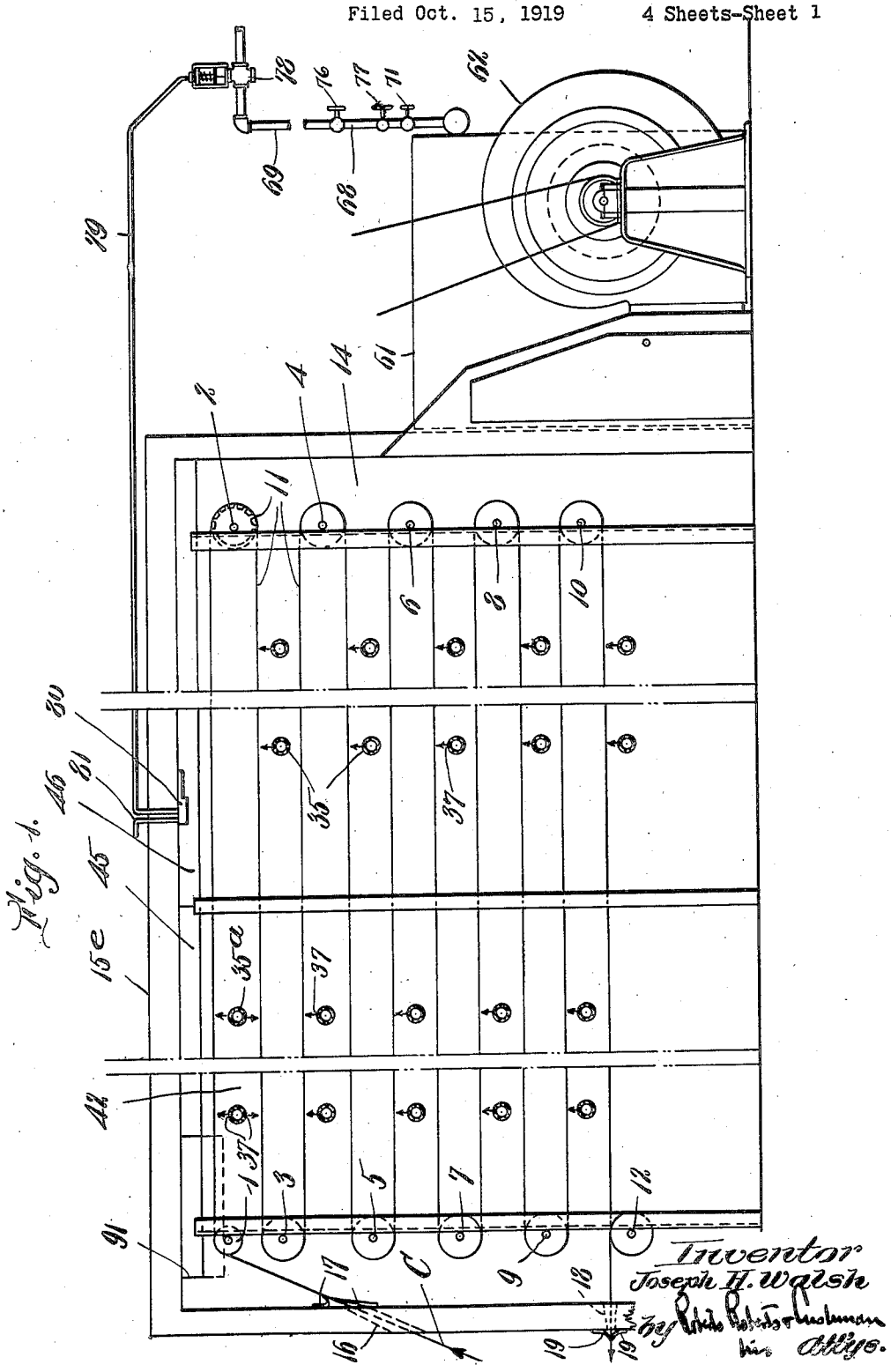

Fig. 1.

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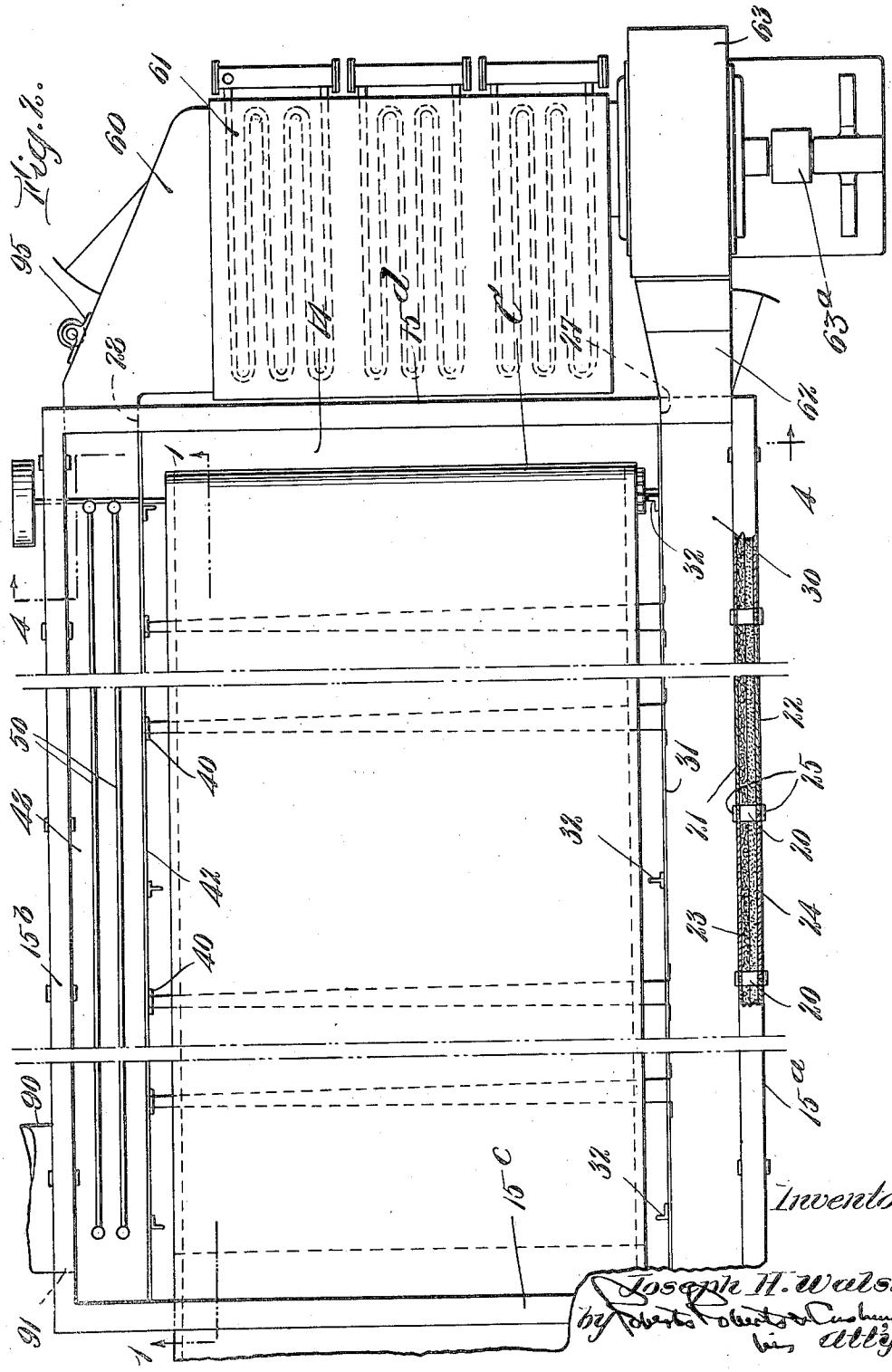
Filed Oct. 15, 1919 4 Sheets-Sheet 2



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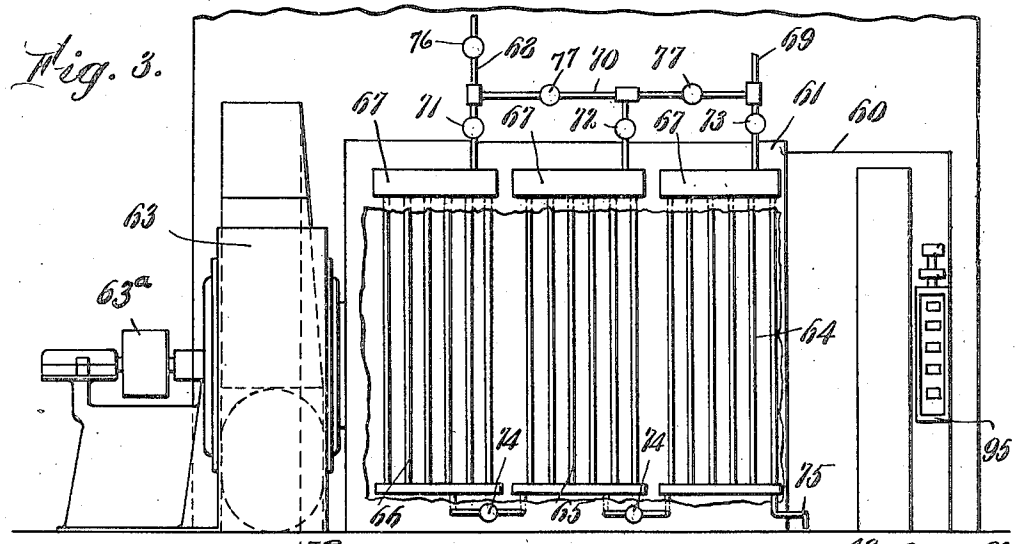
ART OF AND APPARATUS FOR DRYING MATERIALS

Filed Oct. 15, 1919 4 Sheets-Sheet 3

Fig. 3.



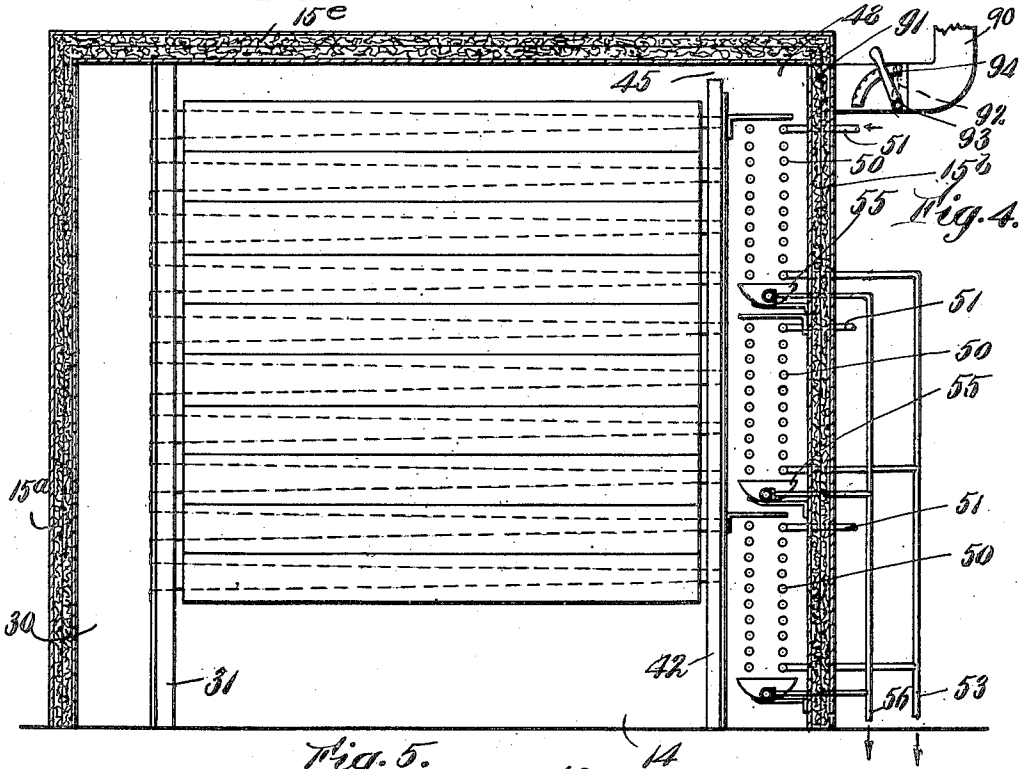


Fig. 4.

Fig. 5.

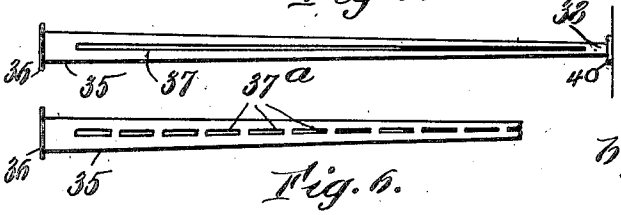


Fig. 6.

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ART OF AND APPARATUS FOR DRYING MATERIALS

Filed Oct. 15, 1919 4 Sheets-Sheet 4

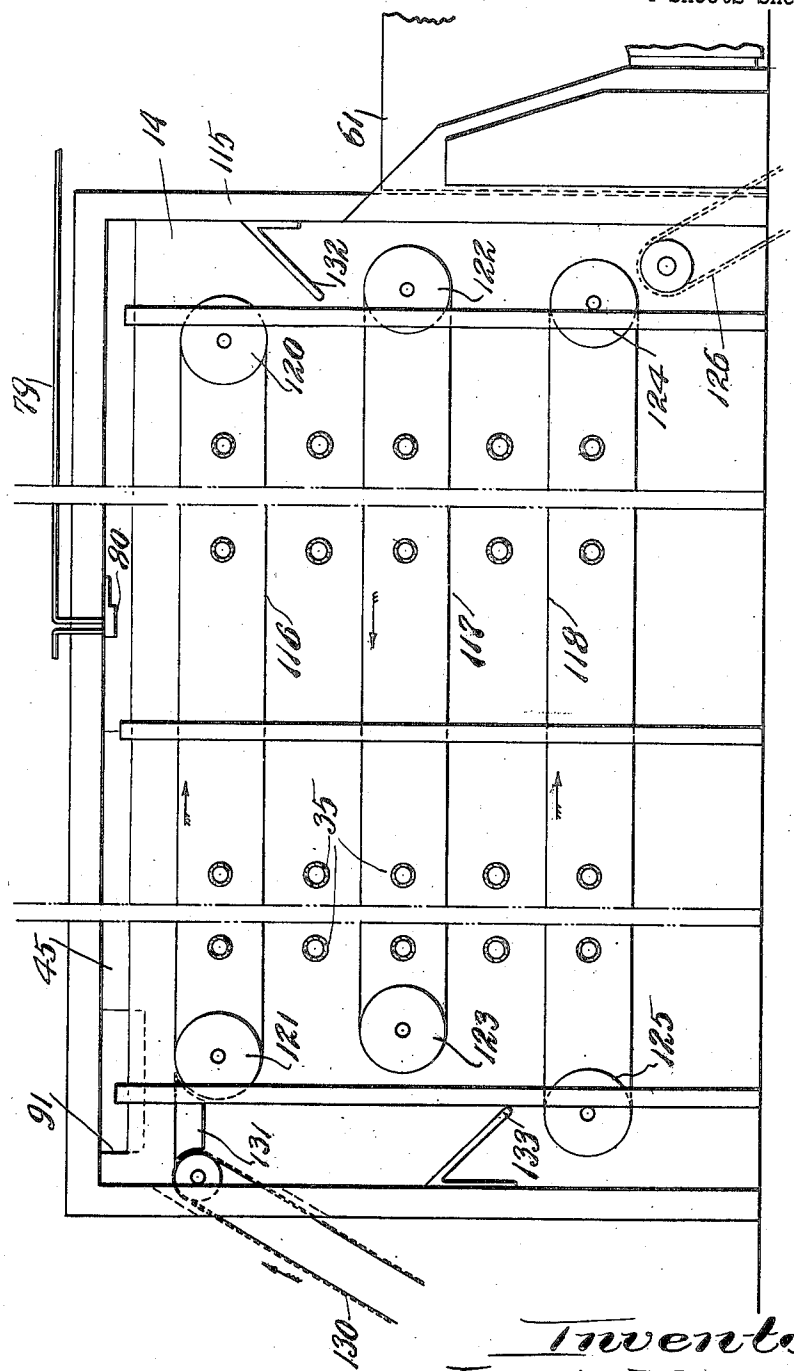

Fig. 1

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Patented Oct. 9, 1923. 1,470,306

UNITED STATES PATENT OFFICE.

JOSEPH H. WALSH, OF READING, MASSACHUSETTS, ASSIGNOR TO JOHNS-MANVILLE INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

ART OF AND APPARATUS FOR DRYING MATERIALS.

Application filed October 15, 1919. Serial No. 330,813.

To all whom it may concern:

Be it known that I, JOSEPH H. WALSH, a citizen of the United States, and resident of Reading, in the county of Middlesex and State of Massachusetts, have invented new and useful Improvements in the Art of and Apparatus for Drying Materials, of which the following is a specification.

This invention relates to an art of and apparatus for treating material, and more particularly to the art of drying materials, and to apparatus applicable to this and other purposes. By drying, reference is made to removing from the materials [which may comprise cloth, fibrous stock of textile materials, or any raw or manufactured bulk capable of handling in a sheet or stream] by evaporation, vaporization or boiling either water or any vehicle or solvent in or upon the material; for instance, for removing mere dampness, or wash-water, or a volatile liquid, or the aqueous content of acid or alkaline solutions or chemical reagents employed in carbonizing treatments of textile fibre or cloth.

Referring now for an instance only to the treatment of cloth as heretofore practiced, so far as I am aware, the common drying step for merely removing moisture from cloth previously subjected to washing, fulling, soaping, bleaching, dyeing, tentering, rigging, straightening or steaming operations, has comprised subjecting the cloth to intense radiated heat from hot pipes, grids or plates, standing near runs of the cloth traveling on suitable carriers in a suitable serpentine path in some form of drying machine. The wet cloth entering the machine is thus subjected to a relatively high surface temperature, generally of the order of 235° F. or higher, the result being partly to evaporate and partly to boil the moisture in the cloth out of the cloth, and frequently being to damage the cloth either by the explosive action of steam from its contained moisture or by subjection of one or both faces to too-intense radiated heat. One consequence of treatment in this manner has been to subject the cloth in such a machine or during such a step in the process of treating it, to the wet steam or vapor-saturated air created by the boiling or rapid vaporization of the moisture in the cloth when it is subjected to radiant heat. Under these circumstances the moisture is removed by boiling rather than by absorbing it into the air, the air, if any, in contact with the cloth being saturated with steam. Another consequence of such treatment has been to fill the room in which the machines are installed with steam and moisture from the cloth under treatment, to the detriment of health and ruination of machinery. A frequent consequence has been the imperfect and irregular drying of the cloth because of operations attempted to be carried out in an atmosphere variably saturated with the expelled moisture from the cloth. Much the same difficulties have heretofore accrued when the treatment is of other materials than cloth, such as paper or textile fibrous stock, or when the drying is incident to carbonizing, or to other stage-products of chemical treatments, the acid- or alkaline-bearing material then delivering up destructive vapors, and being irregularly affected by the applied heat.

When, as in the case of some cloth driers, it has been sought to minimize these defects by enclosing the apparatus, a greater loss of efficiency followed because at no part of the fabric within the machine was it free from subjection to moisture-laden air or steam. This has led to the operation of such apparatus in the open air of the room in which it is installed, in order that the vapor may escape; and this in turn has led to excessive loss of heat, drying machines of the prior art requiring an excessive inflow of high-pressure steam to maintain the great heat required for the drying operation. The prior art, so far as I am aware, provides no compromise between imperfect and irregular drying in enclosed machines, and drying with heat-damage and great waste of heat in open machines.

This invention obviates the above-mentioned defects, one object being to provide steps for the treatment of the material in a moist state to dry it progressively and regularly at any desired rate. Other objects are to provide a step for the treatment of such material as cloth in such a manner as to preserve the surface qualities of the cloth; to provide for drying materials by absorption of vaporizable or volatile liquids or moisture into hot dry air in the absence of saturated vapor; to provide for the ac-

curate control of the temperatures to which the material is subjected, and so to avoid heat-damage to its surface or structure; to provide a cycle of steps for continuous operation gaining these results; and to provide apparatus suitable to carry out these operations in such a manner as greatly to increase the heat efficiency and reduce the cost of the whole operation, and at the same time to avoid filling the workroom with vapor and steam.

The invention is illustrated by specific drying machines typifying the genus of new apparatus suitable to carry out the new method or art, which will now be explained in connection with the apparatus, although it is obvious that other apparatus may be employed in the practice of the method, and that the apparatus is also suitable for operations not implicit in the method.

In the accompanying drawings,—

Fig. 1 is a side elevation partly in section on the line 1—1 of Fig. 2 of an evaporator employed in carrying out the process, and particularly adapted for materials in flexible lengths, such as cloth, or materials carried by endless webs;

Fig. 2 is a plan view with the cover removed of the apparatus shown in Fig. 1;

Fig. 3 is a right hand elevation;

Fig. 4 is a vertical section on the line 4—4 of Fig. 2;

Fig. 5 is a detail plan view of one of the air tubes;

Fig. 6 is a similar view showing a modification; and

Fig. 7 is an elevation partly in section of modified apparatus particularly adapted for handling materials in bulk.

Referring now to Figs. 1 to 4, the apparatus comprises a drying machine (or a stretching-and-drying machine) which so far as means for supporting and conducting the web or cloth through the machine, for driving the supporting and conducting means at a desired predetermined speed, and so far as the construction and operation of the mechanical or operative parts is concerned, may be any desired machine, such as those common to the prior art. As illustrated, the machine comprises any suitable machine frame having therein bearings for an idler roll 1 (Fig. 1), for suitable transverse shaft having sprockets 2, 3, 4, 5, 6, 7, 8, 9 and 10, for endless carrier chains 11 traveling with the margins of the web or cloth, and an idler roll 12. Any one of the sprocket shafts, for instance shaft 2, may be driven to drive all of the others and the carrier chains 11. These chains 11, Fig. 1, may be of any type known in the art, comprising grippers, clamps, or tenter-pins or hooks to take into the selvages or the cloth (or the material-carrying web) and hold it laterally open or stretched during progress through the machine. The cloth indicated at C moves in the direction of the arrowhead at a speed predetermined for the state of saturation of the cloth when it enters the machine and the desired state of dryness when it leaves the machine.

The machine comprising the sprockets 1 to 10 over which the chains 11 pass is housed in a treating chamber 14 enclosed by a relatively tight heating-insulating casing having an entrance passage 16 (Fig. 1) for the web or cloth, which passage may if desired be protected by leather or rubber flaps 17, and having an exit passage 18 which may if desired be protected by similar flaps 19.

The insulating casing comprises side walls 15^a and 15^b respectively spaced away from the machine frame by a substantial distance as best shown in Fig. 2. These walls may comprise uprights 20 of wood or metal, an inner sheathing 21, preferably of asbestos wood or other heat-insulating and moisture-resisting material, an exterior sheathing 22 of the same or any preferred material, and if desired a heat-insulating packing 23 in the spaces between the uprights 20 and adjacent to the inner wall 21, and preferably consisting of a number of layers of asbestos paper or other laminated material. If desired, the space between the packing 23 and the outer wall 22 may also be packed with any desired fibrous or heat-insulating material, as indicated at 24. The asbestos wood sheathing 21, 22, may be nailed on the uprights 20 and the joints covered with sealing strips 25. Any other construction which will provide a heat insulating wall of high resistance to conduction and substantially air-tight quality may be employed.

The end wall 15^c at which the web enters and leaves the machine may be of the same construction as the walls 15^a and 15^b; the other end wall 15^d may be of the same construction but extends less than the entire width between the walls 15^a and 15^b, leaving vertical openings 27 and 28 at either side of the machine. The opening 27, leads into a chamber 30 set off within the casing 15 by a vertical partition 31 preferably erected on vertical angle-irons 32, 32, extending from the floor to the top 15^e of the outer casing.

The chamber 30 is an entrance or plenum chamber for circulated air currents presently to be explained. The partition 31 may be of asbestos wood, or metallic, or of indurated fibre or a metal protected by a heat insulating paint or layer, and is utilized as the support for a number of hot-air distributing ducts 35 communicating with holes in the partition 31. These ducts are arranged in substantially horizontal rows which are vertically spaced to lie respectively between the several runs of the chain 11. In the drawings but two ducts of each row

are shown to avoid confusion of illustration. Preferably as shown, these are conical tubes (see Figs. 2, 5 and 6) having flanges 36 at their larger ends and having therein in an axial direction an educt port 37. This port may be a tapered slot 37 wider toward the wider end of the tube 35, so that a blast entering the inner cavity through the open end, and increasing in pressure toward the closed further end 38 of the tube, will be delivered at a uniform rate through all parts of the port 37. The port 37 may be of any preferred form effecting this result; for instance, as shown in Fig. 6, it may comprise separate aligned openings 37^a separated by portions of the wall of the tube. The distributing conduits or tubes 35 are preferably made of indurated fibre, of asbestos wood, or of any suitable heat and moisture-resisting composition or metal, preferably adapted to be molded to shape. The smaller ends of the tube 35 may if desired be integrally closed or open, closure if open being effected by mounting the ends as in sockets 40 attached to a vertical partition 42 like the partition 31, and extending from the wall 15^d of the casing to the wall 15^c and extending from the floor above the position of the topmost run of cloth carried by the chains 11, leaving a narrow space 45 between the top of the partition 42 and the top 15^e of the heat-insulating casing through which space air taken into the cloth-treating chamber 14 defined by the partitions 31 and 42 can make its exit.

Any desired part of the space 45 toward the right hand side of Fig. 1 may be closed by a stop 46. The space 48 between the partition 42 and the wall 15^b of the casing is an educt chamber through and from which moisture-laden air making its exit through the space 45 is removed by suction or pressure from the casing. Pressures in chamber 48 are preferably arranged to vary from plenum at and near the opening 45 to less than atmospheric pressure at and near the educt opening 28, but it will be understood that the pressures mentioned are relative only, and may be of any value suitable to cause the desired circulation of the air in the apparatus. This chamber 48 may and preferably does contain condensation or other drying means for the extraction from the air of its contained moisture or vapors.

Referring to Figs. 2 and 4, any desired condensing means may be employed, but I prefer a large surface of cold metal against which the vapor- or moisture-laden air pours and through which it is caused to flow. Preferably these surfaces are in the form of pipe coils 50 having cold water inlets at 51 from a suitable cold water source [such as a city water supply] and having outlets into a common outlet 53. The outlet 53 may deliver to the wet room or to the boiler feed of the plant in order to conserve the heat transferred to the water in the coils 50 from the air moving in the chamber 48. The condensate liquid taken out of the air in the chamber 48 collects in suitable troughs 55 and drains off through pipe connections to a common drain 56. This condensation liquid may be treated to recover contained acid when the apparatus is used for carbonizing purposes, or to recover volatile solvents.

In orderly practice of the new process, the air from the chamber 48, dried by condensation, is removed from the chamber 48 through the opening 28, is reheated to the desired predetermined temperature, and is then delivered to the plenum or blast chamber 30 through the opening 27. For this purpose the apparatus comprises a connector casing 60, a heating casing 61, a delivery casing 62 and a blast-fan 63 of any desired type, adapted to be driven, as by a belt on pulley 63^a, and which is so connected as to exhaust the heated air from the heater 61 and deliver it at the desired plenum or pressure through the casing 62. The casings 60, 61, 62, and the fan 63 are all preferably of heat-insulating material, or of metal covered by an insulating layer, lagging or plastic of any desired kind.

The heater 61 may contain any desired plurality of steam coils 64, 65, 66, preferably connected to steam drums or headers 67 outside of the heater 61 through separate supply pipes 68 and 69 connected by cross-over 70 and individual valves 71, 72, 73, to the respective headers. The discharge side of the steam coils 64, 65, 66, may be provided with valves 74 outside of the heater 61, in the arrangement as shown, the coil 64 being directly connected to the return pipe 75. Preferably the pipe 68 is controlled by a hand valve 76 and the cross-over 70 is controlled by hand valves 77; the pipe 69 is controlled by an automatically, preferably pneumatically actuated valve 78 connected by air pipe 79 to a thermostat 80 of any suitable or known air-pressure-control type supplied from a constant source of air pressure through the pipe 81. The thermostat 80 is mounted on any convenient place in the casing for instance on the under side of the cover 15^e. The thermostat and the connections for controlling by it the valve 78 may if desired be any other type, such as any of the well-known electrical circuit-controlling types.

When the cloth is excessively wet, or the available condenser-water relatively warm, it may be expedient to sacrifice a portion of the heat carried by the air in passing from the heater 61 in order to make sure of sufficient drying effect upon the cloth, the condensers 50 under these circumstances failing to remove as much of the moisture as desired

from the air circulated. One way of doing this is to provide for the escape of a regulated portion of the air from the casing, after it has taken up the moisture in the cloth, and to permit the introduction into the system of a corresponding quantity of dry air, as from the room in which the machine is installed.

Devices for effecting such regulated escape from and entrance to the circulatory system of moist and dry air may comprise a moist-air educt pipe 90 leading out of doors. A port 91 leads from a part of the chamber 48 in which the air-pressure is a plenum or positive, in respect to the outer air, for instance, as shown, at a part of the wall 15[b] near the cover 15[c] and opposite the opening 45. Port 91 is effectively adjustable by means of a valve 92, Fig. 4, on a stem 93 fast to a handle adjustable in any position on a sector 94.

Entrance of air to the system is controlled by a damper or valve 95 placed at any point where the pressure is less than atmospheric or negative; as shown, to control openings in the casing 60. Valve 95 may be adjusted in any convenient manner. Normally, the valves 92 and 95 remain closed.

The method or art and operation of the apparatus will now be clear. To explain the drying of cloth C [for an instance of the operation applicable to materials of any nature held on or between an endless web or webs traveling in the path of the chains] the wet cloth, held upon the chains 11 as usual by impaling the selvages upon the tenter-pins (or catching the selvages within the clamps) on the chains 11 enters the opening 16 and passes to the top of the treating chamber 14. Here it comes into contact with the heated and dried air supply maintained within the chamber 14 by the operation of the heater 61 and the fan 63, the supply in the device shown being delivered in the form of uniform flat blasts through the ports in the conical pipes 35. The distribution of the ports 37 in the pipes 35[a] of the first row is such as to deliver a blast upwardly and near which the entering cloth passes, and downwardly against the adjacent face of the cloth supported by gravity on the chain-clamps or pins. The blast delivered upwardly against the bottom face of the cloth by the remaining pipes 35 is of aid in maintaining the cloth on the carrier chains when the chains are above the cloth. The lateral distribution of the blast through the slots 37 [or equivalent openings] in the tubes 35[a] and 35 is uniform and the drying effect upon the cloth is consequently uniform. Drying is by evaporation, not by boiling under radiant heat.

The cloth continues to pass additional pipes 35 delivering blasts of dry warm air until it finally leaves the machine over the idle roller 12 and through the opening 18 in the desired uniformly dried state.

Whatever the specific form of the apparatus, the air employed to remove the moisture from the cloth in the preferred practice is caused to travel in a closed air circuit, which in the apparatus illustrated is made up of treating chamber 14, chamber 48, opening 28, connection 60, heater 61, fan 63, connection 62, chamber 30, blast pipes 35. In traveling in this circuit the air takes up the moisture in the cloth in the outer casing, delivers this moisture to the condensers 50, is sucked away from the condensers 50 through the connections 60, is reheated to a predetermined temperature in the heater 61, and is then delivered at the desired pressure in the plenum chamber 30. The cycle employed saturates the air in chamber 14, dries it in chamber 48, reheats it in heater 61 into a moisture-absorbing condition, and recovers all except the used heat in the condenser-water without substantial loss, owing to the heat-retaining casing. Large economies flow from this cycle of treatment; the amount of heat required in the heater is much smaller than that required to continuously heat a fresh supply of air, or to supply the great losses by convection and radiation characteristic of the practice heretofore followed. An even more important result is the automatic and accurate control of the temperature and hygrometric condition of the treating air, by which the conditioning of the material treated is made certain and uniform, instead of the variable and often damaging results of the prior practice.

It is preferred to regulate the temperature of the air automatically. The thermostat 80 accomplishes this by determining at the valve 78 the flow of steam into one or more of the steam coils 64, 65, 66. If desired the coil 66 or the coils 66 and 65 may be isolated from the regulating means by turning valve 77 [or the valve 77 and valve 72] and thus supplying the coil 66 or the coil 65 or both directly with live steam through the pipes 68 as regulated by the hand valve 76, or cutting them out of the system, as required by the variations in heat replenishment needed by the system for any particular class of work. Whether the thermostat controls the steam supply for all three coils or for two of them or for one only, the apparatus when adjusted to the particular work to be done operates automatically by increase and decrease of the effective heat to maintain the desired degree of temperature in the circulating air at a substantially constant figure. Since the temperature at the thermostat is affected by variable mosture content in the material, the apparatus automatically provides more or less heat for the absorption of more or less moisture. Conditions within the ma-

chine may be observed by any suitable thermometers and hygrometers conveniently placed, not shown, if so desired.

The art or method and the generic class of apparatus are equally applicable to treating materials in the bulk, either as suggested above by placing such material on an endless web running through the apparatus of Fig. 1 on the course of the chains 11, or by including the material between perforated belts or carrier webs in the same course. The kind of carrier, in other words, by which the material to be treated is circulated in the treating chamber 14 may be varied to suit the particular work in hand.

For instance, as shown in Fig. 7, the treatment chamber 14 may be defined by insulating walls 115, of the same construction as above described for the walls of the outer case and within the chamber so formed and in the same relation to partitions 31 and 42 as described in connection with Fig. 1 separate endless carrier belts 116, 117, 118, may be arranged for rotation on pulleys or rolls 120, 121, 122, 123, 124, 125, one roll of each pair being driven by suitable means not shown. To cooperate with carrier belts 116, 117, 118, a feed lattice 130 may enter the treatment chamber 14, delivering onto a guide plate 131 and thence onto the belt 116, loose material placed on the belt 116 falling at the right side of the figure upon an inclined baffle 132 guiding the material to the belt 117, which in turn delivers to an inclined baffle 133. The material passes from the baffle 133 to the belt 118. Any suitable number of such carrier belts may be arranged. The lowermost carrier belt as shown, the belt 118, will deliver to a suitable delivery conveyor such as the lattice 126.

The circulation of air through the chamber 14 is the same as before, the pipes 35 securing within the chamber the proper distribution of warmed and dried air circulated through the heater 61 and the air-drying means, the temperature being controlled by the thermostat 80 as above explained.

A practical advantage of the apparatus and method flows from the lower temperature effective to do the work of drying by the use of regenerated air. This not only avoids heat-damage to the cloth, but is also a great economy. The degree of heat required in the heater 61 is easily maintained by exhaust or low-pressure steam or hot water from the engine room of the plant under all conditions of usual employment of the apparatus.

When reference is made herein to drying the material, it is not to be understood that all of the moisture or wetness, as of water, a solvent or any applied liquid, is necessarily removed. The method described permits the removal of any predetermined fraction only of the volatile or absorbable liquid contents, according to the adjustment of the condenser, the heater, and the rate of the blower 63.

I claim:

1. The art of drying materials which comprises exposing the material in a heat insulated chamber devoid of other heating means while subjecting it to the action of a plurality of blasts of preheated dried air severally impinging upon the material, the air moving in a substantially closed air circuit, forcibly causing circulation of the air contained in said air circuit, treating the air in the circuit after contact with the material to remove absorbed moisture therefrom, and again warming the air before delivery against the material.

2. In material treating apparatus, the combination of a casing comprising therein an air-circuit including a treating chamber, means for supporting the material in said chamber, means for circulating air through said circuit, means for causing a plurality of blasts of the circulating air to impinge upon the material within said chamber, and means for removing moisture from the air operating between exit of the air from said chamber and return of the air to said chamber.

3. Drying apparatus having therein a drying chamber comprising heat-insulating walls, ingress and egress gates therein for the material to be dried, means for supporting and moving the material through the chamber, a plenum entrance chamber divided from the treating chamber, and means for heating and blowing through said chambers in contact with the material a stream of warm dry air comprising jet tubes communicating with the plenum chamber and having orifices for directing a plurality of blasts upon the material.

4. Material treating apparatus having therein a treating chamber, a plenum entrance chamber, means for maintaining air in said entrance chamber at a predetermined temperature and pressure, means for supporting the material in the treating chamber, means for heating air delivered to said entrance chamber, and a plurality of separate blast orifices delivering toward the material within the treating chamber and communicating with the entrance chamber for blowing into the treating chamber and against the material currents of the heated air.

5. Material treating apparatus having therein a treating chamber means for supporting the material in the chamber, and means for heating and blowing through said chamber in contact with the material a current of warm dry air, said blowing means including a plurality of separate blast-devices delivering air-blasts laterally uniform in

volume and temperature against the material.

6. Drying apparatus having therein a casing providing a substantially closed air-circuit including a drying chamber, means for supporting material in said chamber, means for circulating air through said circuit, and means for first drying and then heating the air moving in said circuit between exit of the air from said chamber and return of the air to said chamber and means for protecting the material from heat radiated by the heating means.

7. Drying apparatus having therein an air-circuit including a drying chamber having heat-insulating walls, means for supporting the material in the chamber, and means for heating and blowing into said chamber and into contact with the material a plurality of blasts of warm dry air, and means for regulating the temperature of the air blasts, operating as a consequence of the temperature in the treating chamber.

8. Material-treating apparatus having therein a casing comprising therein a treating chamber, means for supporting material in said chamber, a series of air-ducts delivering air into said chamber and upon the material therein, means for removing moist air from the chamber, and delivering the air to said air-ducts, and drying means for the air operating between exit of the air from said chamber and return of the air to said chamber.

9. Material treating apparatus having therein a substantially closed casing enclosing an entrance chamber, a treating chamber, and an educt chamber; a series of ducts delivering air from the entrance chamber against material in the treating chamber, means for drying the air, and means for moving the air past said drying means, from the educt chamber, and into the entrance chamber at a predetermined rate independent of the convection currents due to heating.

10. Material treating apparatus having therein a substantially closed casing enclosing an entrance chamber, a treating chamber, and an educt chamber; a series of ducts delivering air from the entrance chamber against material in the treating chamber, means in the educt chamber for drying the air, and means adapted to maintain a predetermined plenum pressure in said entrance chamber for moving the air past said drying means, from the educt chamber, and into the entrance chamber.

11. Material treating apparatus having therein means for drying the material comprising a treating chamber, means for moving the material in a constant serpentine path in said chamber, air-ducts near the path taken by the material, and means for blowing from each of said ducts upon the material a flat stream of warm dry air, said stream in a direction lateral of the path taken by the material being uniform in respect to the quantity of air delivered at any part of the stream in a given time.

12. Apparatus for treating webs of material comprising a heat insulated enclosure having therein means for drying a web of material comprising means for moving the web while supporting it out of substantial contact with heat radiating solids, series of air ducts near the path taken by the web, and means for blowing from each of said ducts upon the cloth a flat stream of warm dry air, said stream in a direction lateral of the path taken by the web being substantially uniform in respect to the quantity of air delivered at any part of the stream in a given time.

13. In drying apparatus, means for blowing a uniform stream of air onto the material to be dried comprising an air-duct having therein a lengthwise air delivery port of varying width, wider at parts of the duct subject to lesser air-pressure, and narrower at parts subject to greater air-pressure, and means for supplying air under pressure to that end of said duct at which said port is widest.

14. In drying apparatus, means for blowing a uniform stream of air on to the material to be dried comprising an air-duct subject to air pressure at one end, and having a longitudinal air delivery port varying inversely in width in substantial accordance with the rise of air-pressure in the tube toward its other closed end.

15. In drying apparatus, means for blowing a uniform stream of air on to the material to be dried comprising a conical air-duct subject to air pressure at its larger open end, and having a longitudinal air delivery port varying inversely in width in substantial accordance with the rise of air-pressure in the tube toward its smaller closed end.

16. Drying apparatus having therein, in combination, mechanism adapted to support and move the material to be dried in a series of parallel runs, a heat insulating casing surrounding said mechanism, and means for projecting a plurality of flat jets of heated air against the several runs of material within the casing, said jets being uniform in respect to the quantity of air delivered at any part of the stream in a given time, and being directed substantially perpendicularly against the face of the material.

17. Driving apparatus having therein, in combination, mechanism adapted to support and move a web of material to be dried in a plurality of parallel runs, a heat-insulating casing surrounding said mechanism, means for delivering blasts of heated air of substantially uniform temperature against the several runs of the web within the cas-

ing, and means for automatically controlling the temperature of such blasts in response to the temperature within the casing.

18. Drying apparatus having therein, in combination, mechanism adapted to support and move a web of material to be dried in a series of parallel horizontal runs, a heat-insulating casing surrounding said mechanism, nozzles disposed between the several runs of material for delivering successive blasts of heated air against the web at spaced points in the length thereof, a heater for the air, and thermostatic means having a sensitive element within the casing for controlling the heater.

19. Drying apparatus having therein, in combination, mechanism adapted to support a web of material to be dried in a plurality of horizontal runs, means to subject the several runs of material to the successive action of currents of heated fluid of substantially uniform temperature whereby to dry the material, and an insulating casing surrounding the mechanism and adapted to conserve the heat of its contents, including the material under treatment.

20. In cloth drying apparatus, a heat-insulating casing adapted to surround mechanism for moving and supporting the drying cloth, and means dividing the casing into a centrally disposed cloth-treating chamber containing the mechanism, an entrance chamber to one side of the cloth-treating chamber, and an educt chamber on the other side thereof, the structure comprising means for discharging air from the entrance chamber in a series of blasts against the cloth, and means for causing air to flow from the treating chamber to the educt chamber and thence to the entrance chamber.

21. A cloth drying apparatus comprising spaced walls of asbestos wood sheets assembled in substantially air-tight relation, means for supporting said walls in surrounding relationship to mechanism for supporting and moving the cloth under treatment, and means within said apparatus for continuously circulating air, for drying air at one point in its path, for heating it at another point in its path, and thereafter delivering such air against the material to be dried in the form of thin jets.

22. A cloth-treating apparatus comprising spaced walls of asbestos wood sheets assembled in substantially air-tight relation, an intervening packing adapted to resist loss of heat, means for supporting said walls in surrounding relationship to mechanisms for supporting and moving the cloth under treatment, means within said walls for continuously circulating the air, for heating such air, and for delivering such air in the form of heated blasts perpendicularly against the surface of the cloth to be treated.

23. Apparatus for drying materials comprising a heat insulating housing having therein means for subjecting the material to be dried to the absorbent action of successively acting blasts of gaseous fluid of substantially uniform temperature adapted to evaporate the moisture from the material, and means for continuously circulating the fluid within the housing and for treating the fluid before its access to the material whereby to remove contained moisture from such fluid, the chamber being devoid of other heating means than the blasts.

24. Apparatus for drying comprising a heat insulated housing having a material treating chamber and an air circuit through such chamber, means within the chamber for supporting material out of contact with heat radiating solids while being dried, said circuit comprising a series of uniformly treated air blasts, a cold condenser in said circuit, and a heater in said circuit, said heat insulating housing substantially enclosing said air circuit, condenser and heater, whereby otherwise wasted heat is conserved and usefully employed in raising the temperature of the condenser water.

Signed by me at Boston, Massachusetts, this third day of October, 1919.

JOSEPH H. WALSH.