

July 28, 1959

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2,896,336

APPARATUS FOR DRYING WEB MATERIAL

Filed April 11, 1957

5 Sheets-Sheet 1

Fig. 1.

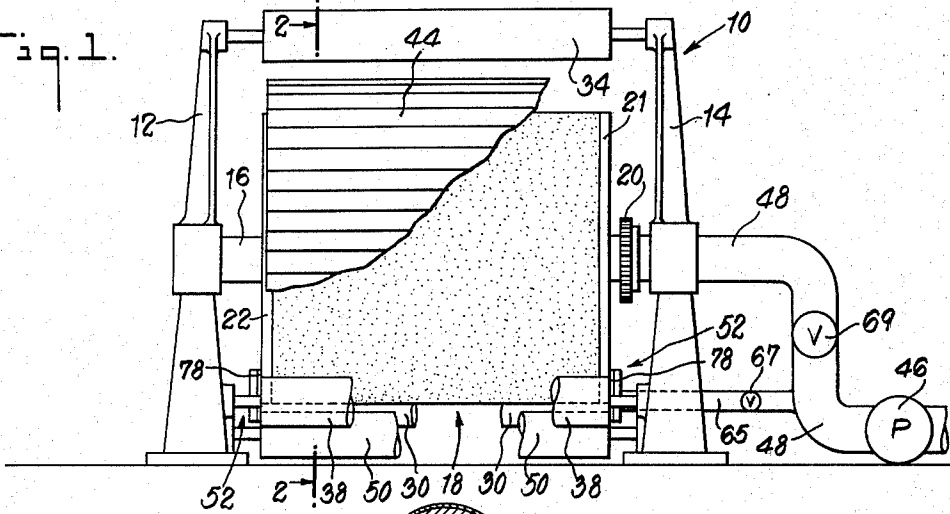
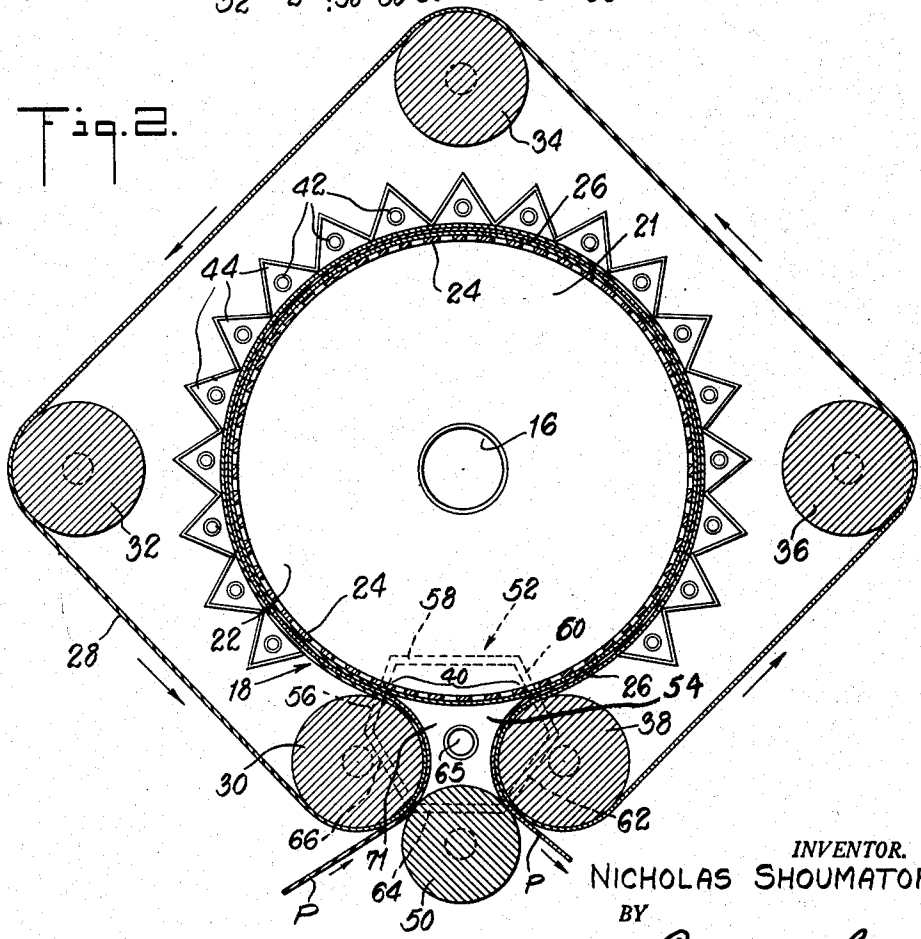


Fig. 2.



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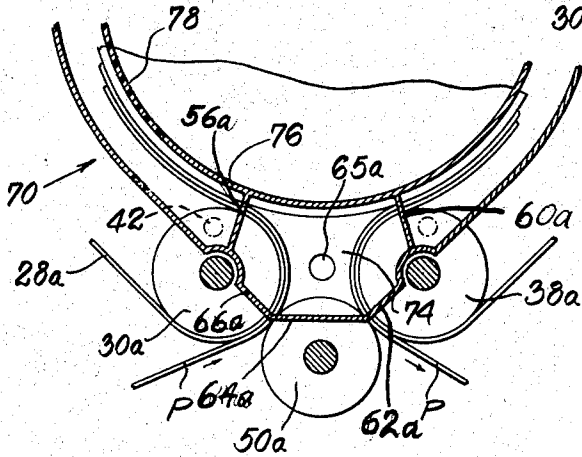
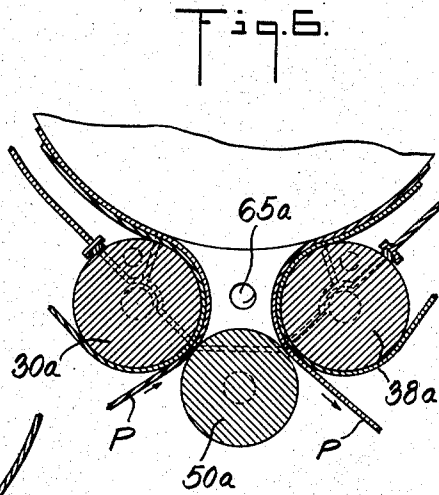
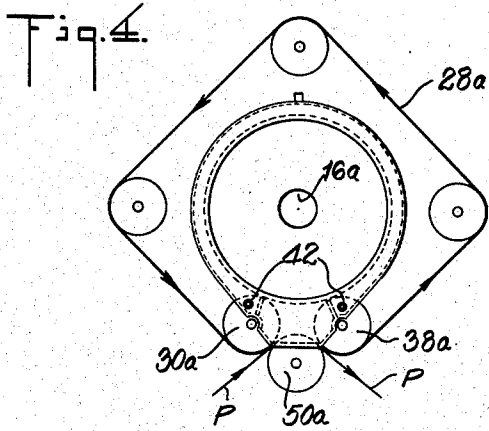
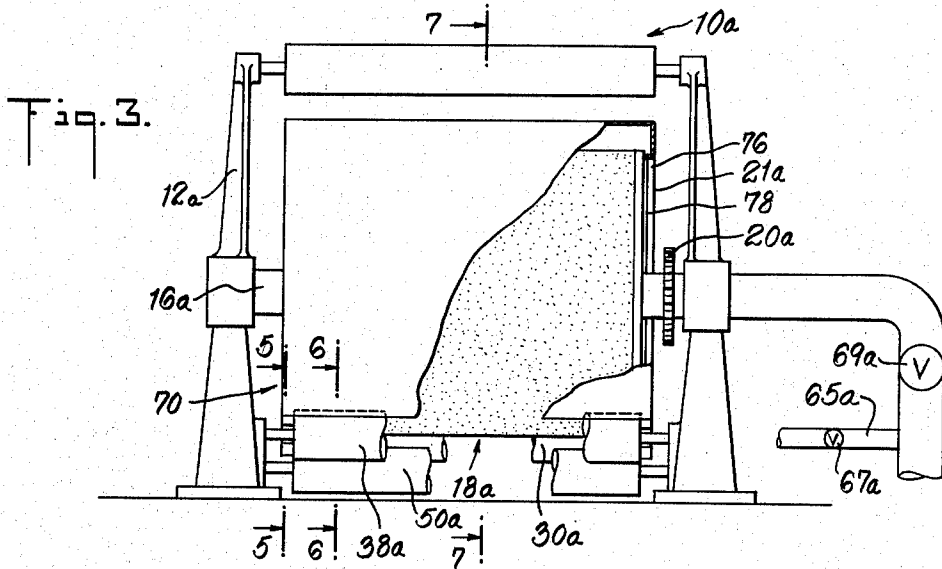
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APPARATUS FOR DRYING WEB MATERIAL

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5 Sheets-Sheet 2



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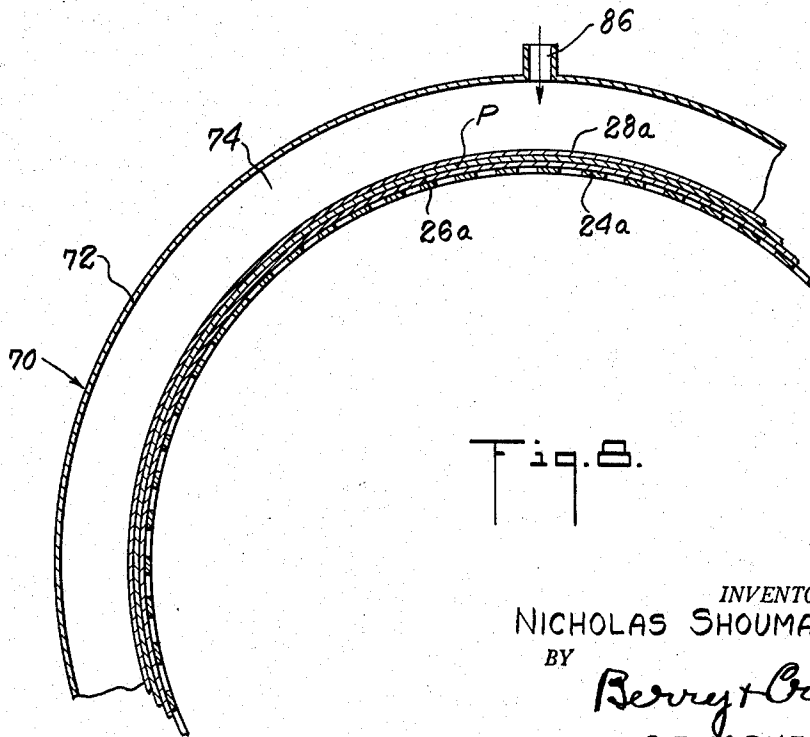
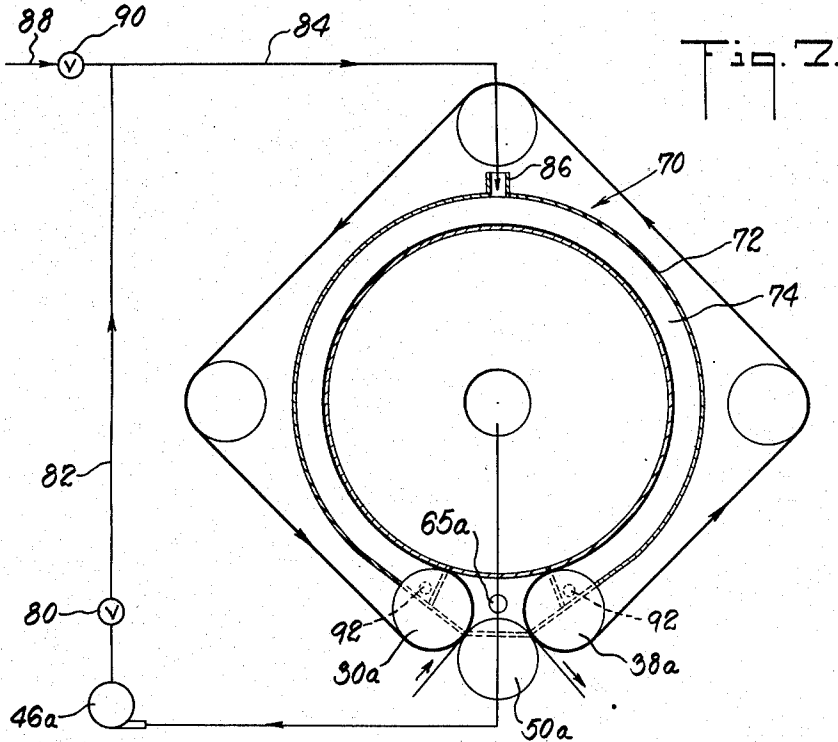
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APPARATUS FOR DRYING WEB MATERIAL

Filed April 11, 1957

5 Sheets-Sheet 3



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2,896,336

APPARATUS FOR DRYING WEB MATERIAL

Filed April 11, 1957

5 Sheets-Sheet 4

Fig. 9.

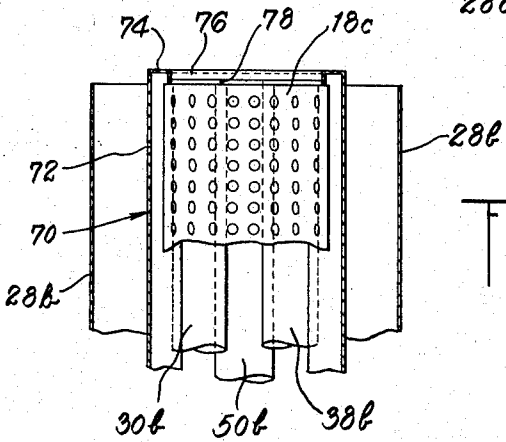
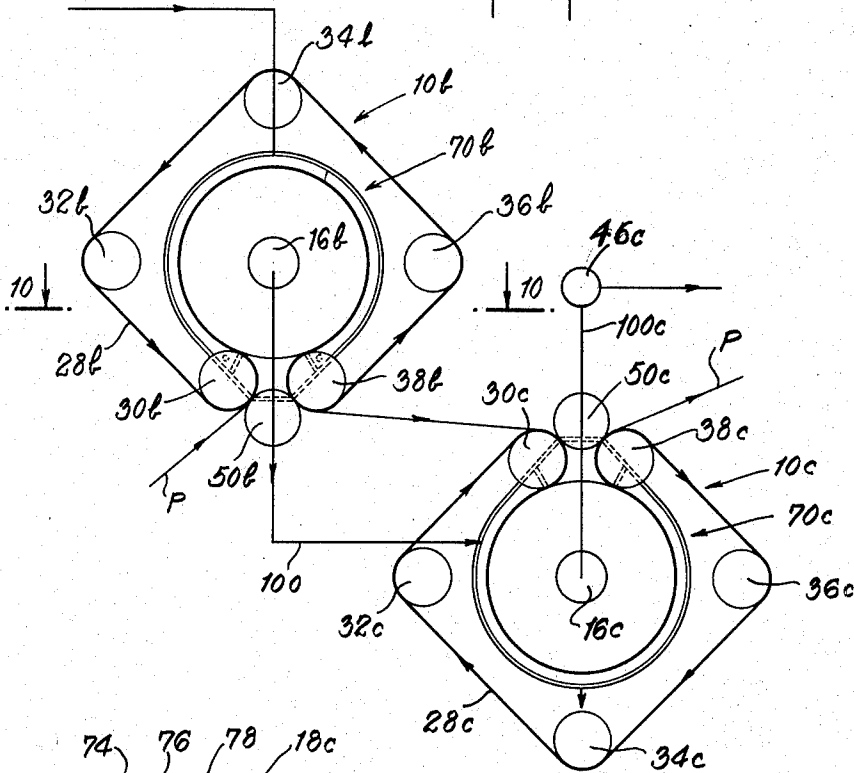


Fig. 10

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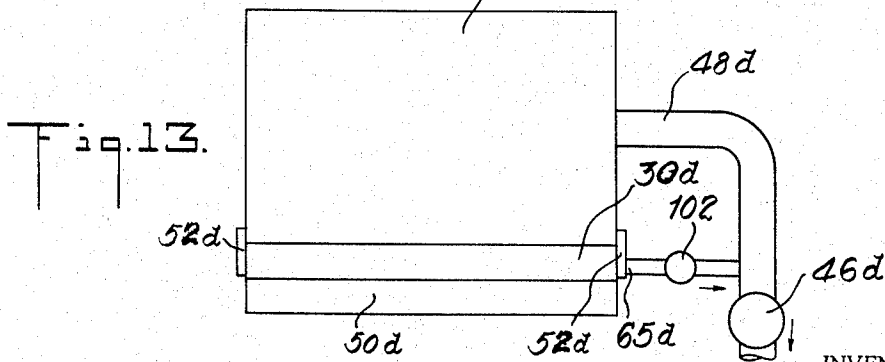
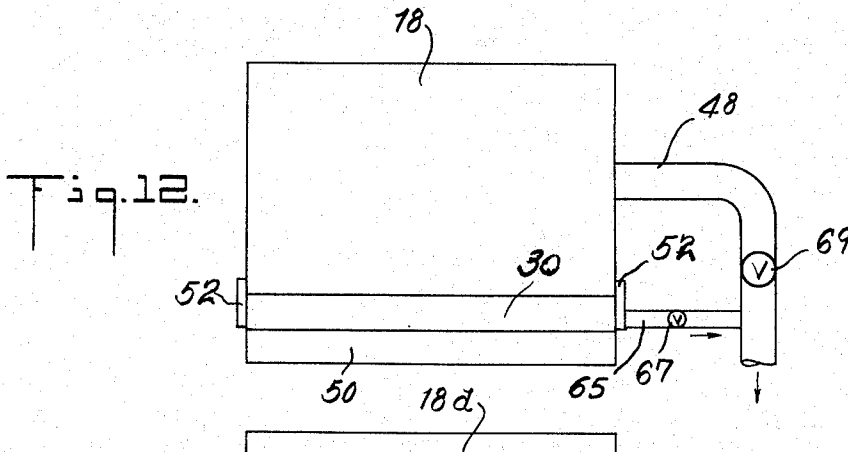
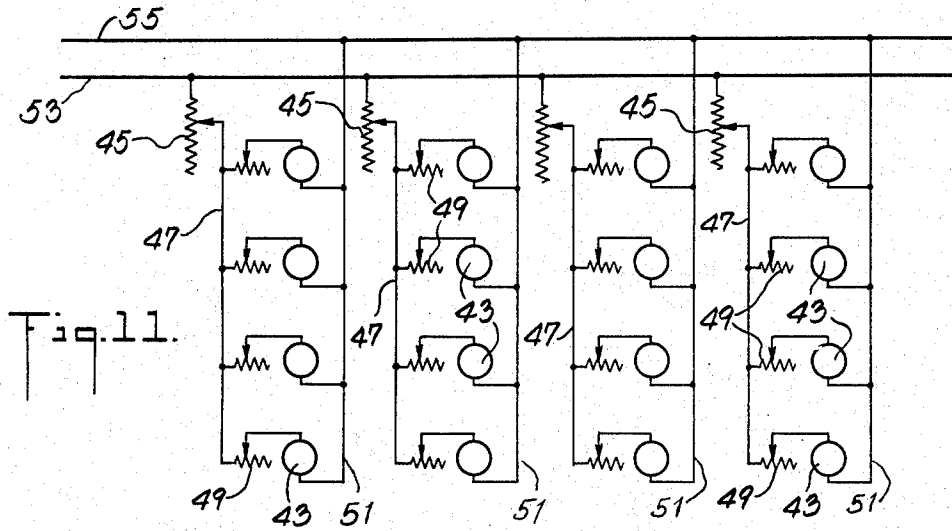
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2,896,336

APPARATUS FOR DRYING WEB MATERIAL

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5 Sheets-Sheet 5



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1

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**APPARATUS FOR DRYING WEB MATERIAL**

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Application April 11, 1957, Serial No. 652,302

15 Claims. (Cl. 34-86)

This invention relates to apparatus for drying paper or other web material.

The invention includes among its objects, either separately or in combination:

- (1) Increased uniformity of drying;
- (2) Economy of heat and power consumption in effecting drying; and
- (3) Low capital cost of drying equipment.

When evaporation is effected by the supplying of steam to the interior of a hollow heating drum, according to the practice most commonly followed at the present time in the paper making industry, the drum is provided with a solid circumferential wall of substantial thickness and rigidity. The wall must be especially thick and rigid in the larger paper making machines in which paper webs up to twenty feet in width are handled, because the drum must be correspondingly long. The mere fact of providing walls thick enough to have the desired rigidity introduces a substantial impediment to the transfer of heat into the paper web and results in a very substantial thermal inertia of the structure. The rate of heat transfer may be increased by supplying steam at a temperature far above the atmospheric boiling temperature of water, but then the generation and accumulation of steam between the drum and the web tends to cause the web to be blown off the drum; i.e., to be so spaced out from the drum that efficient conduction of heat into the web is impossible.

In the Minton dryer the boiling point of the web-contained water is lowered, and thereby the rate of heating is increased at the same time that the total amount of heat required is diminished. When this is done, however, the effective transfer of heat into the web is still limited by the inadequate pressure of the web against the heating drum, and the danger of blowing off is not avoided. The complete enclosure, moreover, represents a bulky and expensive structure, and renders the web and the web handling equipment inaccessible.

It is characteristic of the present invention that the web of paper is heated from without while being fed around a permeable hollow drum, and while covered and held to the drum by a very thin, flexible, impermeable, overlying, metallic or semi-metallic band, which runs in unison with the drum and with the paper web. Because of its thinness, the band interposes little resistance to the transmission of heat.

With such an arrangement, an increased rate of heat transfer from the band to the paper may be realized for a given temperature difference, even when the exterior of the band is exposed to atmospheric pressure, by pro-

2

viding a partial vacuum within the cylinder. This secures the advantages of the Minton dryer while avoiding the disadvantages thereof.

Providing a substantial partial vacuum causes the band to be drawn against the paper web with a pressure far in excess of that which could be made available by the mere tensioning of the band. Intimacy of contact of the paper and the heating surface is a factor of primary importance in bringing about rapid transference of heat to the paper web and to the moisture contained in the web. The partial vacuum serves also to withdraw the steam from the web as fast as the steam is formed, so that intimacy of belt and web contact is not impaired by any accumulation of steam between them. The partial vacuum serves also to lower the boiling temperature of the water in the web, thereby facilitating the removal of the water and keeping down the temperature of the paper.

The difference of pressure may be further increased by using jacketed steam, in direct contact with the band, as the heating medium for the band. Since the band is exposed exteriorly to the steam pressure, this serves both to increase the force with which the band is pressed against the web and the force with which the band and web are pressed against the drum.

It is an important feature of this invention that the web of paper is dried in an atmosphere of almost pure steam, thereby eliminating the heating of surrounding air. The almost pure steam drying atmosphere is obtained by the evaporation of the moisture in the web of paper while it is traveling between the overlying heated metallic band and the porous surface of the drum. Another important feature of the invention is that the almost pure steam, which is continuously evaporated from the moist web and continuously sucked through the porous surface of the drum and withdrawn from the drum, can be recovered and reused.

The availability for use of the steam driven out of the web depends upon the purity of the steam; i.e., freedom from contamination by air. Admixture of air can result from either of two causes: (1) the presence of air in the web, and (2) the leakage of atmospheric air into the drum. The web-contained air is known to be sufficiently small in quantity to assure that it will not be a serious contaminant. The flexible band, together with auxiliary sealing fixtures, can be depended upon to exclude all but a negligible quantity of atmospheric air from the drum. Because the generated steam is thus kept substantially air-free, it is available for use as a heating medium, and the important quantity of latent heat which it contains can be recovered to a large extent.

It therefore becomes feasible when steam is used as the heating medium to provide a succession of evaporating units, operated on the principle of multiple effect evaporation. In each unit the jacket steam may be maintained at pressure and temperature moderately higher than the pressure and temperature within the associated drum, and the steam generated in communication with each drum, other than the last, may be delivered from the drum to the heating jacket of the next unit. The steam generated in the last unit can be utilized in any one of a variety of ways for recovering the heat contained in it. The recovered steam can also be piped through a thermal compression cycle to raise the temperature of the steam for reuse in the same drying unit.

The order in which the units are combined as successive units of a multiple effect group is not necessarily the order in which the paper web passes the units.

It is an important point that the paper web, although

continuously gripped under high pressure between the traveling drum surface and the traveling band, and firmly supported by the drum surface, is maintained free of substantial tension. The pressure applied to the web is not due to any unusual tensioning of the band itself, nor to the application of localized pressure, as through pressure rollers, but rather to the difference of fluid pressures existing at opposite sides of the band and web, in conjunction with the firmness of the continuous support afforded by the drum. The loss of web width caused by web tension in conventional dryers is therefore eliminated.

Various forms of external heaters may be utilized. Heaters which discharge hot vapor or gas against the band, such as gas burners; radiant heaters such as infra-red burners and infra red lamps; heaters of the jacket type to which steam or other hot gas or liquid is supplied, and high frequency electrical heaters of the inductive or dielectric type, as well as electrical conductivity heating, are all available and are all susceptible of practical utilization. Except in the case of heaters of the jacket and electrical conductivity types, heating elements are provided, desirably arranged in rows both axially and circumferentially of the drum, and are individually controlled to bring about uniformity of moisture content across the web, and any desired variation of temperature gradient circumferentially of the drum.

Because of the high pressure per unit area which is exerted by the band and drum upon the web a very substantial quantity of water may, in some installations, be expressed mechanically from the web, over and above that which is removed by evaporation.

By combining an external source of evaporating heat with the heat conductive band and the suction drum, it is possible to realize simultaneously a lowering of the boiling point of the web contained liquid so that less heat is required to effect evaporation, and an increased pressure of the band against the web. The lowered boiling point limits the temperature of the web and protects it against damage from the heat source. A higher temperature heat source may therefore be utilized than would otherwise be feasible. The increased pressure serves both to press liquid from the web and to promote the conductance of heat from the band into the web. The increased conductance serves both to increase the rate of evaporation and, through lowering the viscosity of the remaining liquid, to enhance the pressing action. The lowered viscosity of the liquid also facilitates the withdrawal of steam from the web. The high rate of evaporation, combined with the lowered viscosity of the liquid, further promotes the removal of liquid by entrainment of liquid in the steam.

In whatever form the invention is embodied, a very substantial reduction of mechanical power consumption may be realized because of the fact that with a higher unit capacity, as compared with conventional dryers, fewer dryer units are required.

The invention affords increased flexibility in the rate at which heat is supplied to the sheet and the possibility of making more rapid adjustments in the application of heat to produce paper of superior moisture uniformity, both in the machine direction and in the cross-direction.

The invention eliminates dryer ventilating equipment as a factor of cost, and as a factor producing cross-direction non-uniformity of moisture content.

The invention makes available the opportunity to produce a sheet which is machine glazed on both sides in a single drying stage. Other objects and advantages will hereinafter appear.

In the drawing forming part of this specification,

Fig. 1 is a fragmentary view in side elevation, partly broken away, showing one practical and advantageous form of drying unit which embodies features of the invention;

Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1, looking in the direction of the arrows;

Fig. 3 is a view similar to Fig. 1, showing a second form of mechanism which embodies features of the invention;

Fig. 4 is a view in front elevation, on a smaller scale than Fig. 3, showing the structure of Fig. 3;

Fig. 5 is a fragmentary sectional view taken on the line 5—5 of Fig. 3, looking in the direction of the arrows, and showing particularly the sealing arrangement provided in the mechanism of Figs. 3 and 4;

Fig. 6 is a fragmentary sectional view taken on the line 6—6 of Fig. 3, looking in the direction of the arrows;

Fig. 7 is a sectional view taken on the line 7—7 of Fig. 3, looking in the direction of the arrows;

Fig. 8 is a fragmentary sectional view taken on the line 7—7 of Fig. 3, looking in the direction of the arrows, but on a larger scale than Fig. 7, and showing certain details not susceptible of clear illustration on the scale of Fig. 7;

Fig. 9 is a view generally similar to Fig. 5, but partly broken away, showing two of the units connected in a plural effect arrangement;

Fig. 10 is a sectional view taken on the line 10—10 of Fig. 9, looking in the direction of the arrows;

Fig. 11 is an electrical diagram showing how heating lamps may be controlled individually and by circumferential rows;

Fig. 12 is a fragmentary detail view showing a blow-back scheme for clearing the drum shell of lint; and

Fig. 13 is a view similar to Fig. 12 showing an alternative scheme for clearing the drum shell of lint.

The illustrative drying unit 10 of Figs. 1 and 2 may be included in the dry end of a paper making machine, either following the usual steam heated dryer rollers or, in combination with other like units, as a substitute for the usual steam heated dryer rollers.

The unit 10 includes upright frame members 12 and 14, a hollow shaft 16 mounted therein, and a hollow drum 18 fast on the shaft and through which the shaft extends from end to end. The shaft 16 is driven at uniform rotary speed through a suitable driving gear 20 which is fast on the shaft. The drum 10 includes solid ends 21 and 22, a hollow, metallic, perforated sleeve or body 24, and a porous cover 26.

An endless, impervious, flexible, heat inductive, metallic band 28 is guided on a series of guide rollers 30, 32, 34, 36 and 38, being directed by the rollers 30 and 38 to have a wrap extending all the way around the drum with the exception of a small arc designated 40 in Fig. 2. The perforations of the drum, and the porous cover 26 are confined to a zone which extends throughout nearly the full length of the drum periphery, but which leaves imperforate margins at both ends of the drum. The imperforate margins stand flush with the outer face of the porous cover 26. The band 28 extends beyond the perforated zone at both ends of the drum to seal the drum against ingress of air.

Outside the active length of the band 28, a multiplicity of infra-red heat lamps 42 is arranged in rows and columns which extend axially and circumferentially of the drum. A simplified arrangement showing four columns of four lamps each is illustrated in Fig. 11. The lamps 43 of each circumferential column are connected in parallel in a common circuit, distinct from the circuits of all the other circumferential columns, and a rheostat 45 is provided in one conductor 47 of each of such circuits for simultaneously adjusting the intensity of all the lamps of the circuit. Each circuit consists primarily of conductors 47 and 51, connected respectively to mains 53 and 55. By this arrangement a desired distribution of heat cross-wise of the web may be obtained in accordance with observed requirements for securing a more uniform cross-direction drying. Each lamp also desirably has a rheo-

stat 49 disposed in series with it, but not in series with any other lamp, the rheostat being adapted for manual adjustment to secure a desired temperature gradient circumferentially of the drum. Reflector means 44 is provided for the lamps 42 for concentrating the heat of the lamps on the band 28 as the band runs on the drum. The hollow shaft 16 is formed with openings inside the drum so that the interior of the shaft is in free communication with the interior of the drum. A vacuum pump 46 which, through a conduit 48, has sealed communication with the interior of the shaft 16 at one end of the shaft, maintains a uniform, desirably high vacuum inside the drum, and delivers steam withdrawn from the drum to any desired destination for use or disposal.

Ingress of air to the drum through the arc 40 is prevented by the guide rollers 30 and 38, an intervening sealing roller 50 which bears against both the rollers 30 and 38, and end seals 52 which are desirably identical one with another. Each end seal 52 includes an end wall 54 and, as illustrated, six side walls 56, 58, 60, 62, 64 and 66. The rollers 30, 38 and 50 extend the full length of the drum 18, and are formed with solid end walls which are desirably coplanar with the end walls of the drum. The side wall 56 of each end seal bears against end faces of the roller 30 and the drum 18. Similarly, each wall 58 bears against an end face of the drum 18, each wall 60 bears against the drum and the roller 38, each wall 62 bears against the roller 38, each wall 64 bears against the roller 50, and each wall 66 bears against the roller 30. By the arrangement described, the drum 18, the guide rollers 30 and 38, the sealing roller 50, and the seals 52 are caused to form a complete, substantially sealed enclosure. This enclosure communicates freely with the interior of the drum, but does not communicate with the atmosphere.

In normal operation the steam is drawn from the drum through the shaft 16. A pipe 65 (Figs. 1, 2, and 12), which connects one of the seals 52 with the pipe 48 may normally be closed off by a manually operable valve 67. There is a tendency for lint to collect in, and to clog, the pores of the drum shell. It is desirable to be able to drive steam forcibly outward through the drum shell 24 from time to time in order to clear the shell pores of lint.

The structure of Figures 1, 2 and 12 is constructed to enable a blow-back to be effected as desired, and this while continuing the dryer in operation. To this end, the pipe 48 is provided with a manually adjustable throttle valve 69 in advance of the point at which the pipe 65 communicates with the pipe 48. When it is desired to blow-back the pores of the drum shell the valve 67 is first adjusted to open position and the valve 69 is closed. This seals off exit of steam from the drum through the shaft 16, and forces the steam to pass from the drum through the shell into the space 71 bounded by the rollers 30, 38, 50 and the seals 52. From that space the steam passes through the pipes 65 and 48 to the pump 46. In passing from the drum into the space 71, the steam travels counter to the direction in which it enters the drum from the web. When the blow-back has been satisfactorily effected the valve 69 is opened and the valve 67 is closed. This restores the parts to the normal condition.

The roller 50 does not, of course, run in direct engagement with the rollers 30 and 38, since the band 28 runs between the rollers 50 and 30 when approaching the drum and between the rollers 50 and 38 when traveling away from the drum. The paper web P travels between the band 18 and the roller 50 when approaching the drum and also when traveling away from the drum. The band 18 and the web P therefore form part of the sealing means.

With the arrangement shown and described, the traveling band 28, which is desirably a very thin, flexible, heat conductive, non-corrosive, metallic or semi-metallic band, is pressed forcibly toward the drum by atmospheric pressure in response to the partial vacuum maintained in the drum. If, by way of example, it be assumed that the

interior of the drum is maintained at an absolute pressure which is twelve pounds per square inch below atmospheric pressure, substantially this full pressure will be applied directly to every square inch of the band 28 which bears against the drum, and will be applied by the band to the paper web. This pressure is of an entirely different order from that which could be realized merely by tensioning of the band. The pressure applied, moreover, does not put the paper web under tension, except to the extent that surface friction may restrict the tendency of the web to shrink. The maintenance of a uniform high pressure between the heating surface and the paper web is probably the most important single factor in bringing about the rapid and evenly controlled transfer of heat into the web.

The use of electrical heating lamps is to be regarded as merely illustrative of a wide variety of heating means which may be employed, as has already been pointed out. Whenever individual heating elements, such as lamps or burners, are employed, they are to be arranged in rows and columns and controlled both by columns and individually as outlined above.

The unit shown and described can be used as a press for physically squeezing liquid from the web, with or without the utilization of heating means. When used solely as a press, however, the unit would ordinarily be used in a location in the paper making machine ahead of the evaporating dryers.

In Figs. 3 to 8, disclosure is made of a second heating unit 10a, generally similar to the unit of Figs. 1 and 2, but employing a different form of heating means and a feature of heat conservation not employed in the unit of Figs. 1 and 2. In view of the fact that many structural features of Figs. 3 to 8 are the same as those of Figs. 1 and 2, corresponding reference characters have been applied to corresponding parts of Figs. 3 to 8 with the subscript "a" added in each instance, and the description will be confined to those features which differentiate the structure of Figs. 3 to 8 from that of Figs. 1 and 2.

The drum, the drums supporting and driving means, the heating and pressing band, and the guiding and sealing rollers may all be identical with the corresponding parts of Figs. 1 and 2. The heating and sealing means are different, however, and the disposition made of the steam withdrawn from the drum is specifically important.

The drum 18a is surrounded by a steam casing 70 which is complete except for the space occupied by the drum and the spaces in which the rollers 30a, 50a, and 38a are received. The casing 70, which may serve as a steam jacket, includes a peripheral wall 72 spaced outward from the circumference of the drum 18a. The casing also includes end walls 74 which are located short distances outward beyond the ends of the drum, and interned annular flanges 76 which bear continuously against marginal areas of the end faces of the drum 18a. The terminal faces of the flanges 76 are desirably faced with Teflon 78 (Fig. 5) for sealing the joint between the drum 18a and the casing 70 against the escape of steam.

The casing 70 embodies in its structure a substitute for the end seals 52 of Figs. 1 and 2. At each end the wall 74 takes the place of the wall 54, and a segment of the annular flange 76 takes the place of the wall 58. Inwardly extending flanges 56a, 60a, 62a, 64a and 66a serve to perform the sealing function of the flanges 56, 60, 62, 64 and 66, respectively, of Figs. 1 and 2. The terminal faces of these flanges are also desirably faced with the Teflon 78.

A compressor 46a withdraws steam from the interior of the drum 18a through the hollow shaft 16a, and increases the pressure of the steam to that maintained in the casing 70. The compressed steam is delivered past a check valve 80 and through a conduit 82, to a line 84 which conducts steam to the casing 70 through a nipple 86. A line 88, connected with an independent, higher



pressure source of steam, delivers steam through a pressure reducing valve 90 for initially supplying all the steam required to the casing 70, and for thereafter automatically supplying any deficiency in the quantity of steam furnished from the interior of the drum 18a. Condensate outlets 92 are provided at the lower ends of the casing, these outlets being connected to conventional means (not shown) for eliminating condensate from the casing while preventing any substantial loss of steam.

A steam pressure considerably above atmospheric can be maintained in the casing 70 without involving a temperature high enough to be detrimental to the paper web, and this pressure is applied directly to the metallic band 28a. The result is that the band can be pressed against the paper web and through the web against the drum, with a substantially greater pressure per square inch than when the atmosphere alone is relied upon for furnishing the external pressure. The increase of the pressure further reduces the resistance to heat transfer from the band to the web, still without putting the band or the paper web under any substantial tension. Since the higher pressure steam is necessarily maintained at a temperature considerably above the boiling point of water at atmospheric pressure, an increased temperature difference between the steam and the web is maintained.

The putting of the steam evaporated from the web through a thermo-compression treatment for use as heating medium in the unit 10a represents a very substantial saving of thermal energy. This is made possible by reason of the fact that the web is dried in an atmosphere of almost pure steam. The air which is carried in the pores of the paper web is very small in mass compared to the vaporizable moisture carried in the web. The resulting steam therefore is nearly pure, being very little contaminated with air.

To conserve heat the casing 70 may be enlarged to enclose the return run of the impervious belt, with appropriate seals provided between the casing and the guide roller hubs or shafts.

In Figs. 9 and 10, two units 10b and 10c are illustrated, each being desirably a duplicate of the unit of Figs. 3 to 8 with the exception that the steam delivered from within the drums is handled differently. Since the previously described structure is largely duplicated in Figs. 9 and 10, corresponding reference characters have been applied to corresponding parts in Figs. 9 and 10, with the subscripts "b" and "c" added, respectively, in connection with the unit 10b and the unit 10c, and the description will be confined to those features which are specifically different from the showing of the preceding figures. The unit 10b is followed in the machine by a similar but inverted unit 10c. The paper web P passes first around the drum of unit 10b and then around the drum of unit 10c.

The units 10b and 10c are combined according to the principle of multiple effect evaporation. Comparatively high pressure steam is supplied to the casing 70b of the unit 10b and the steam evaporated from the web in the unit 10b is collected in the drum 18b at a pressure which may desirably be slightly below atmospheric. The hollow shaft 16b is connected to deliver the steam from the drum 18b as heating medium through a conduit 100 to the casing 70c of the unit 10c. The interior of the drum 18c is evacuated by a vacuum pump 46c, the low pressure steam being discarded or re-used, as dictated by the economic factors affecting the particular mill. It is practical and advantageous to extend the principle of multiple effects to more than the two units illustrated, so that the steam developed in the second unit may be used as heating medium in a third unit, and so on. Here again, the availability of steam developed in a unit as heating medium in a subsequent unit results from the fact that the developed steam is almost completely free of air. The sequence of descending pressure in the re-

use of vapor need not be the same as the sequence of web travel.

In every instance the band may be formed with a highly polished surface for contact with the web. The drum may also be formed with a highly polished surface for contact with the web. When this kind of surface is provided on the drum, however, the drum perforations are made numerous but very fine. By this arrangement both faces of a web may be machine glazed at a single passage of the web through a single drying unit.

In Fig. 13 disclosure is made of a modified form of blow-back mechanism, applicable as a substitute in any of the embodiments for the blow-back means shown in Figs. 1, 2 and 12. The arrangement may be the same as that of Figs. 1, 2, and 12 except that the valve 69 is omitted and a small booster pump 102 is substituted for valve 67. Normally the pump 102 is idle, and the steam passes through the hollow shaft of drum 18d to the pipe 43d and thence to the pump 46d. When blow-back is desired the pump 102 is set into operation, causing all, or nearly all the steam to pass from the drum through the pump 102.

While certain preferred embodiments of the invention have been illustrated and described in detail, it is to be understood that changes may be made therein and the invention embodied in other structures. It is not therefore the intention to limit the patent to the specific constructions illustrated, but to cover the invention broadly in whatever form its principles may be utilized.

I claim:

1. Apparatus for drying web material by evaporation comprising, in combination, a hollow rotary drum having a steam permeable circumferential zone, a uniformly thin, impermeable, endless heat conducting band running on the drum in unison therewith for conducting a web to be dried part-way around the drum between itself and the drum, the band being wide enough to cover the permeable zone of the drum and prevent access of air to the band covered area of the web and the passage of air into the drum, external heating means located outside the drum and band and furnishing moisture evaporating heat to the web through the band, means for sealing against ingress of air the arc of the drum which is not covered and sealed by the band, and means for conducting away from the drum the substantially pure steam delivered to the interior of the drum from the web.

2. Apparatus as set forth in claim 1, in which means is provided for maintaining a substantial vacuum within the paper web and the drum.

3. Apparatus as set forth in claim 1, in which means is provided for maintaining a substantial vacuum within the paper web and the drum and the external heating means consists of a multiplicity of heating units arranged in rows axially and circumferentially of the drum, together with means for individually adjusting the heating effect of each unit.

4. Apparatus as set forth in claim 1, in which the external heating means comprises a steam jacket formed jointly by the band and an overlying casing, so that the heating steam is caused to come into direct contact with the band and to apply its pressure directly to the band and through the band to the web material.

5. Apparatus as set forth in claim 4, in which provision is made for causing the pressure and temperature in the heating jacket to be substantially higher than the pressure and temperature within the drum, and which further includes means for withdrawing steam from the interior of the drum, for increasing the pressure and temperature of such steam to the pressure and temperature maintained in the jacket, and for delivering such steam to the jacket as heating medium therefor.

6. Apparatus as set forth in claim 4, in which a series of units as described is provided and in which the principle of multiple effect evaporation is employed, and in

which means is provided for delivering steam issuing from the drum of one unit as heating medium to the heating jacket of another unit and so on, and means is provided for maintaining progressively lower pressures and temperatures in the jackets of successive effects and progressively lower pressures and temperatures in the drums of successive effects.

7. Apparatus as set forth in claim 4, in which band guiding rollers serve as sealing members for the jacket at the ends of the casing.

8. Apparatus as set forth in claim 4, in which band guiding rollers serve as sealing members for the jacket at the ends of the casing, and the same band guiding rollers together with an intervening contiguous roller serve as sealing members for the drum segment which is not covered by the band.

9. Apparatus as set forth in claim 1, in which the drum includes a perforated metallic shell and a covering of porous material therefor.

10. Apparatus for drying web material, in part by evaporation and in part by mechanically expressing web contained moisture comprising, in combination, a hollow rotary drum having a permeable circumferential zone, a uniformly thin, impermeable, endless heat and pressure transmitting band running on the drum in unison therewith for conducting a web to be dried part-way around the drum between itself and the drum, the band being wide enough to cover the permeable zone of the drum and to seal said zone against the passage of atmospheric air, a casing forming with the band a steam jacket for applying to the web through the band a super-atmospheric pressure which is substantially uniform throughout the area of the web covered by the band, means for supplying steam under pressure to the jacket, means for sealing against ingress of atmospheric air the arc of the drum which is not covered and sealed by the band, the construction and arrangement being such that the pressure exerted by the steam through the band serves both to squeeze water from the web, and to promote the conductance of the latent heat of the heating steam into the web, and means for conducting vapor from the interior of the drum.

11. Apparatus for drying web material, in part by evaporation and in part by expressing web-contained moisture comprising, in combination, a hollow rotary drum having a permeable circumferential zone, an endless impermeable band running on the drum in unison therewith for conducting a web part-way around the drum between itself and the drum, the band being wide enough to cover the permeable zone of the drum, external heating means maintained at an evaporating temperature for applying evaporating heat to the web through the band, means for maintaining a partial vacuum in the drum to increase the heat conductive relation of the band to the web and the pressing action of the band, while lowering the boiling point of the web-contained liquid, and means, including the band, for sealing the drum against ingress of atmospheric air.

12. Apparatus for drying paper by evaporation comprising, in combination, a hollow rotary drum having a steam permeable circumferential zone, a supporting shaft for the drum, a uniformly thin, endless, heat conductive, impermeable band running on a substantial arc of the drum in unison therewith for conducting a web to be dried part-way around the drum between itself and the drum, the band being wide enough to cover the permeable zone of the drum, external heating means located outside the drum and band and heating the web through the band, means sealing against ingress of air the arc of the drum which is not covered by the band, said sealing means forming an external chamber which communicates through the permeable circumferential zone of the drum with the interior of the drum, and means for withdrawing from the drum through said

chamber steam delivered to the interior of the drum from the web.

13. Apparatus for drying paper by evaporation comprising, in combination, a hollow rotary drum having a steam permeable circumferential zone, a supporting shaft for the drum, a uniformly thin, endless, heat conductive band running on a substantial arc of the drum in unison therewith for conducting a web to be dried part-way around the drum between itself and the drum, the band being wide enough to cover the permeable zone of the drum, external heating means located outside the drum and band and heating the web through the band, means sealing against ingress of air the arc of the drum which is not covered by the band, said sealing means forming an external chamber which communicates through the permeable circumferential zone of the drum with the interior of the drum, means including vacuum pumping mechanism for normally withdrawing steam from the interior of the drum through the drum shaft, and adjustable means for causing the steam to be alternatively withdrawn from the interior of the drum through said external chamber when blow-back of steam through the steam permeable zone of the drum is desired for clearing said zone of lint.

14. Apparatus for drying paper by evaporation, comprising, in combination, a hollow rotary drum having a steam permeable circumferential zone, a supporting shaft for the drum, a uniformly thin, endless, heat conductive band running on a substantial arc of the drum in unison therewith for conducting a web to be dried part-way around the drum between itself and the drum, the band being wide enough to cover the permeable zone of the drum, external heating means located outside the drum and band and heating the web through the band, means sealing against ingress of air the arc of the drum which is not covered by the band, said sealing means forming an external chamber which communicates through the permeable circumferential zone of the drum with the interior of the drum, means including vacuum pumping mechanism and a connecting conduit normally in communication with the interior of the drum through the drum shaft for withdrawing steam from the interior of the drum through said shaft, a second conduit connecting said external chamber with the pumping mechanism, and valve means settable to shut off communication between the shaft and the pumping mechanism and to establish communication between the external chamber and the pumping mechanism, so that the steam will be caused to travel from the drum through said external chamber to effect blow-back of steam through the steam permeable zone of the drum for clearing said zone of lint.

15. Apparatus for drying paper by evaporation, comprising, in combination, a hollow rotary drum having a steam permeable circumferential zone, a supporting shaft for the drum, a uniformly thin, endless, heat conductive band running on a substantial arc of the drum in unison therewith for conducting a web to be dried part-way around the drum between itself and the drum, the band being wide enough to cover the permeable zone of the drum, external heating means located outside the drum and band and heating the web through the band, means sealing against ingress of air the arc of the drum which is not covered by the band, said sealing means forming an external chamber which communicates through the permeable circumferential zone of the drum with the interior of the drum, means including vacuum pumping mechanism and a connecting conduit normally in communication with the interior of the drum through the drum shaft for withdrawing steam from the interior of the drum through said shaft, a second conduit connecting the external chamber with the first conduit, and a booster pump in the second conduit, the construction and arrangement being such that the steam is withdrawn from

the drum, in major part at least, through the shaft when the booster pump is idle but is withdrawn from the drum, in major part at least, through the external chamber when the booster pump is in operation, thereby to effect blow-back of the steam through the permeable zone of the drum for clearing said zone of lint. 5

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