Aug. 10, 1926. 1,595,238

O. MINTON

VACUUM SEAL, METHOD AND APPARATUS

Filed Feb. 7, 1922 7 Sheets-Sheet 1

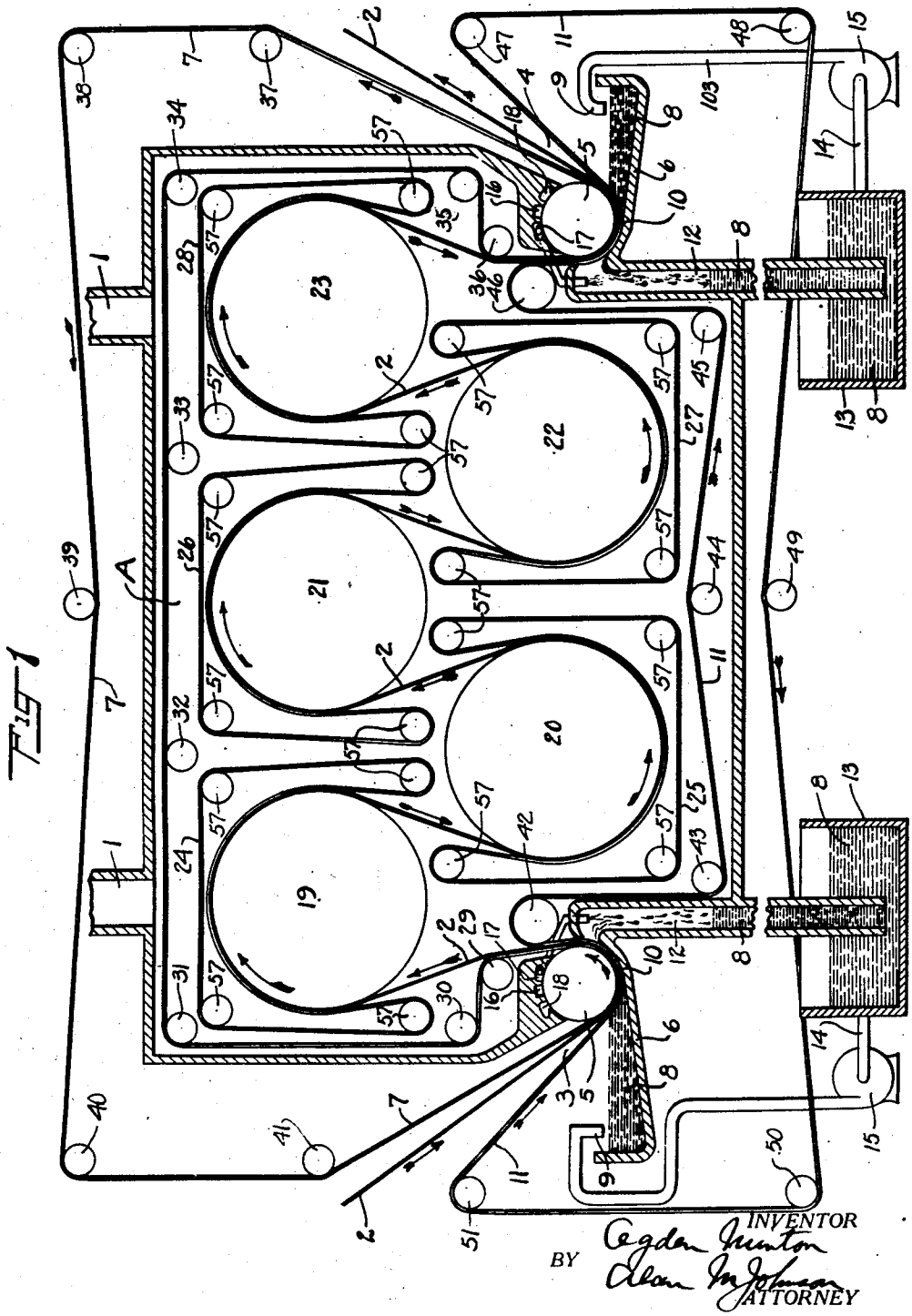


FIG 1

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VACUUM SEAL, METHOD AND APPARATUS

Filed Feb. 7, 1922 7 Sheets-Sheet 2

Fig 2

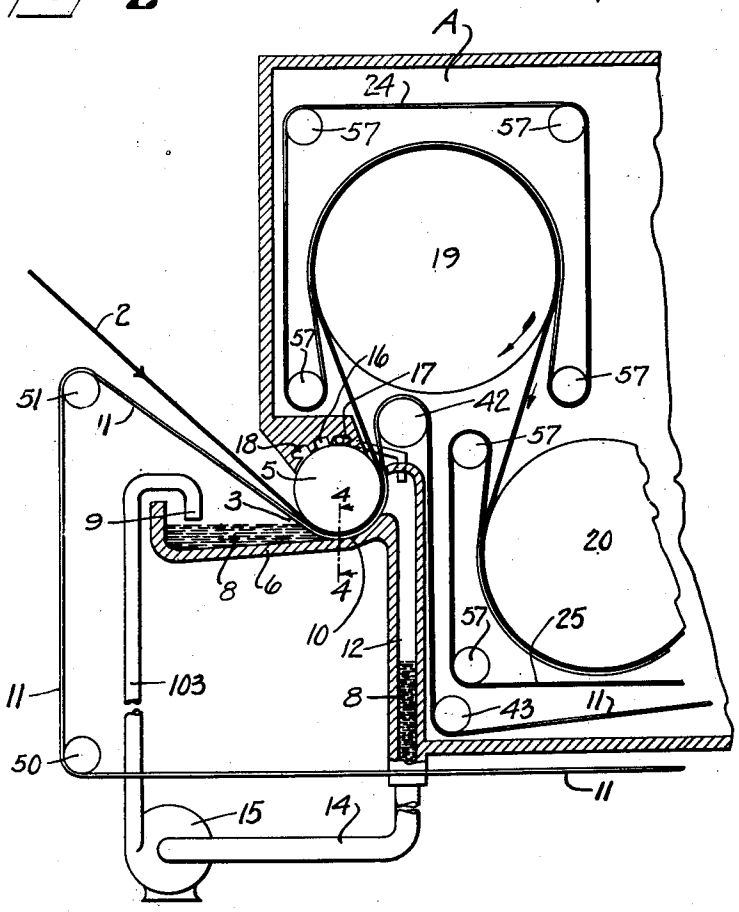


Fig 3

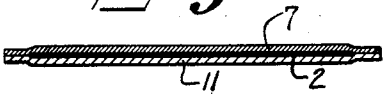


Fig 3A

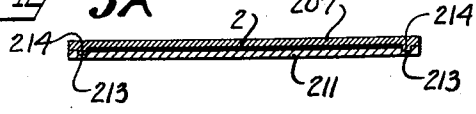
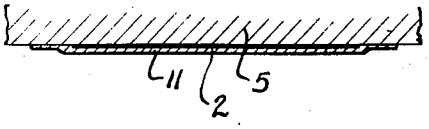


Fig 4



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VACUUM SEAL, METHOD AND APPARATUS

Filed Feb. 7, 1922 7 Sheets-Sheet 3

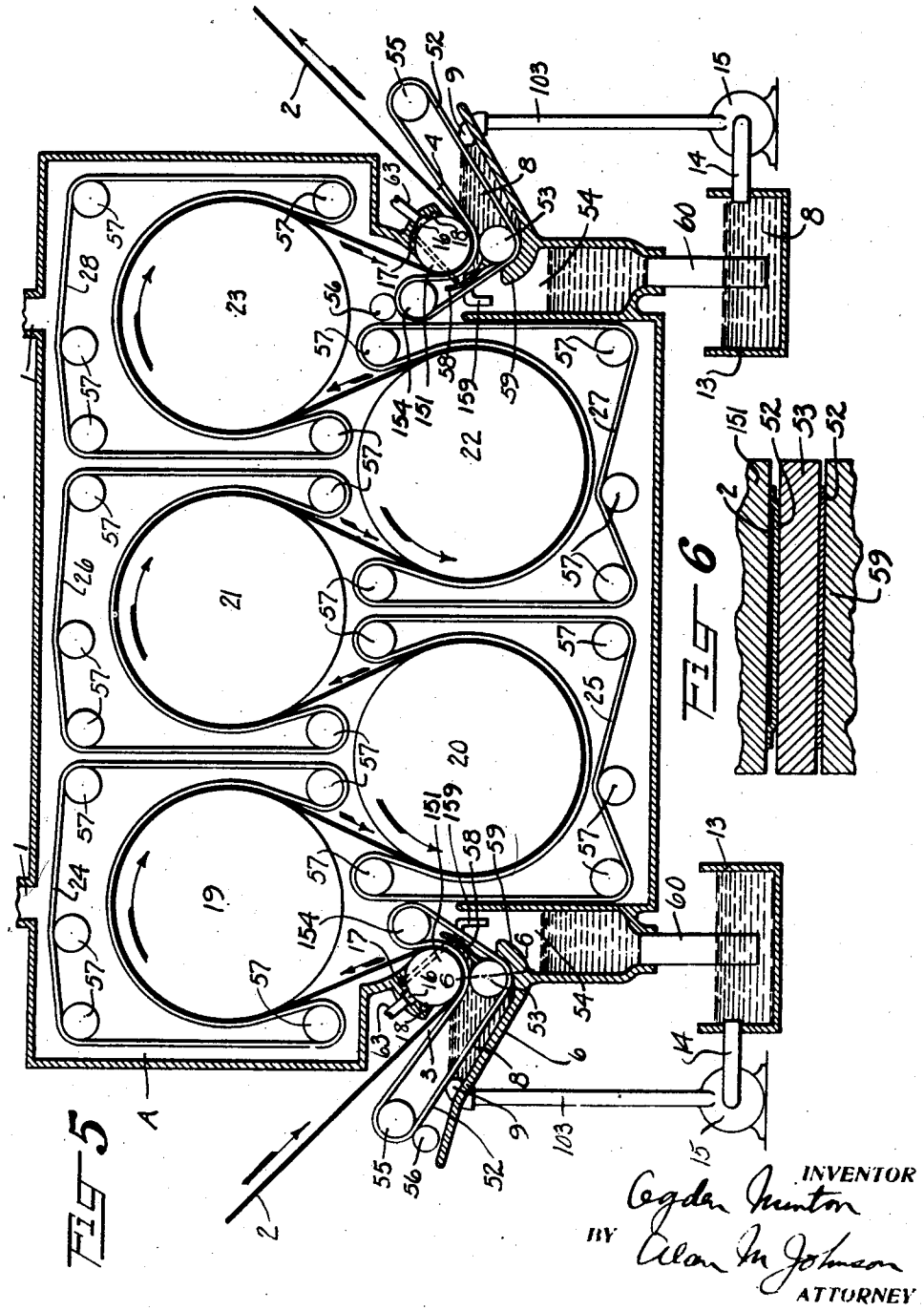


FIG 5

FIG 6

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VACUUM SEAL, METHOD AND APPARATUS

Filed Feb. 7, 1922 7 Sheets-Sheet 4

Fig 7a

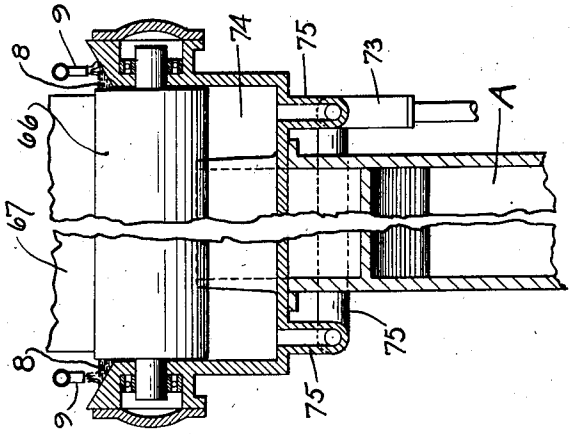
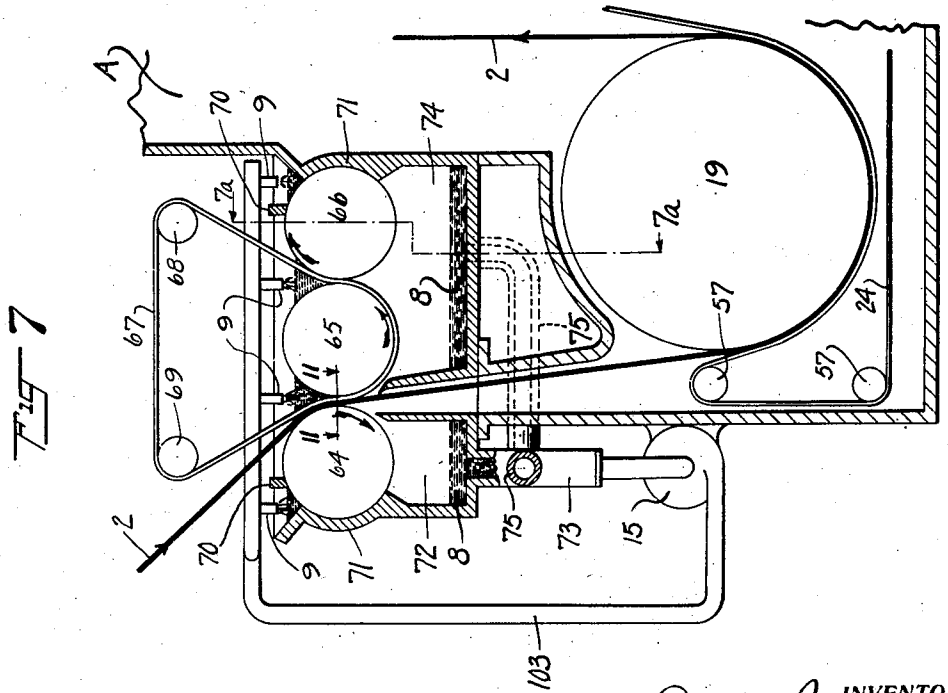


Fig 7



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VACUUM SEAL, METHOD AND APPARATUS

Filed Feb. 7, 1922 7 Sheets-Sheet 5

Fig 8.

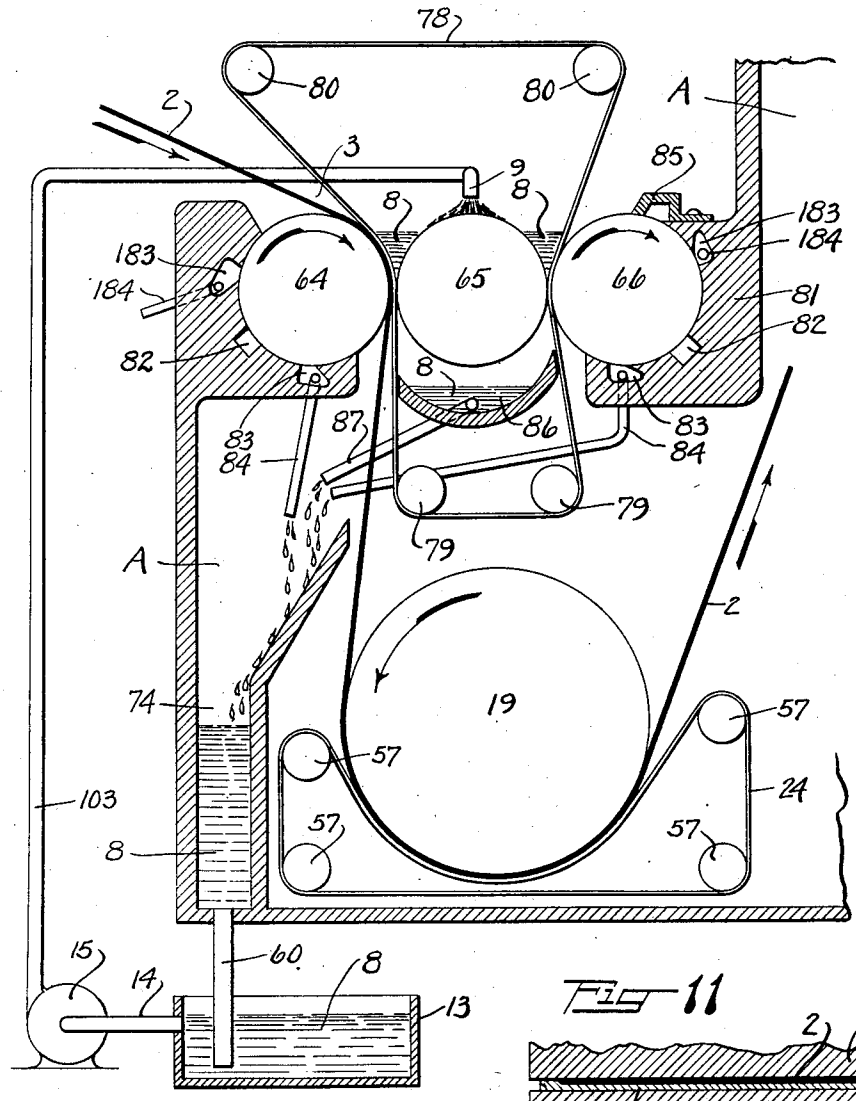
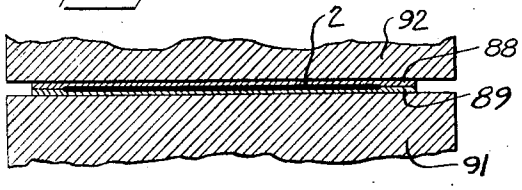


Fig 11

Fig 12



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VACUUM SEAL, METHOD AND APPARATUS

Filed Feb. 7, 1922 7 Sheets-Sheet 6

Fig. 10

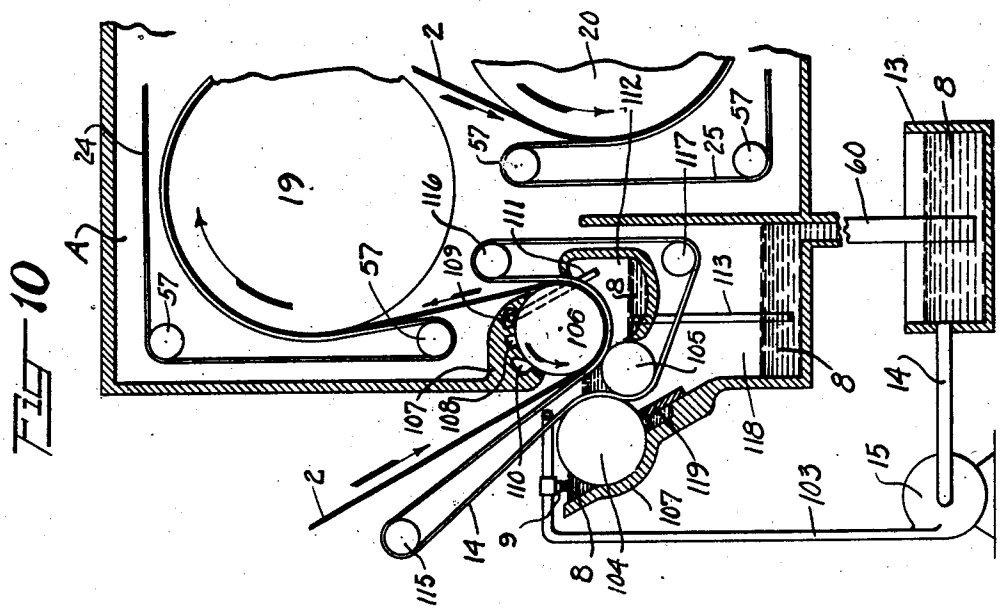
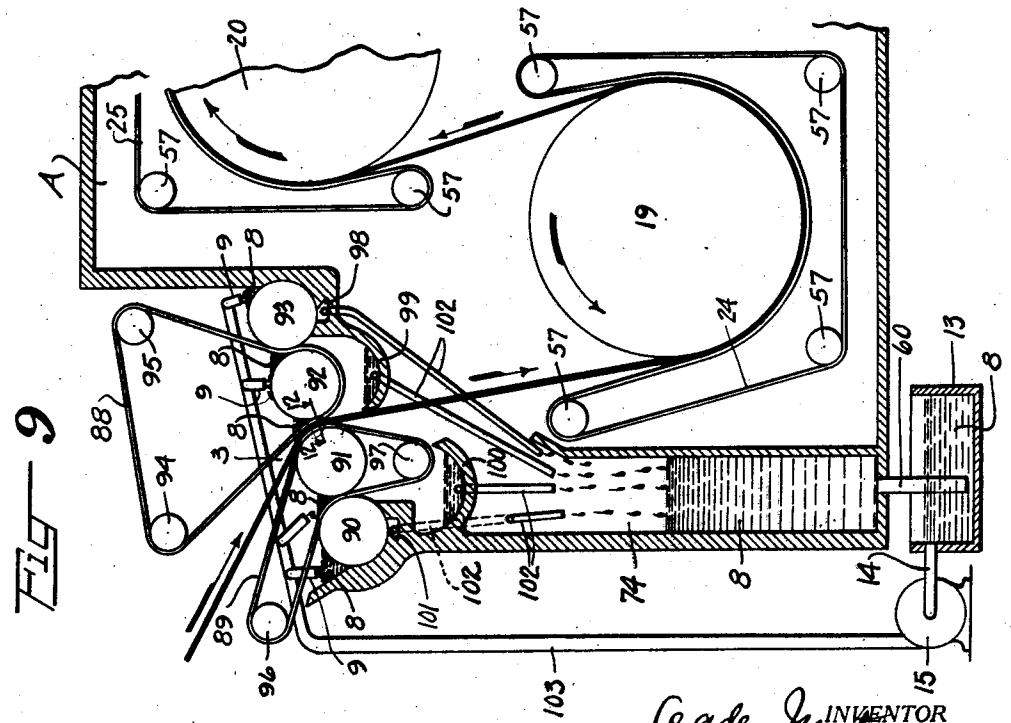


Fig. 9



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VACUUM SEAL, METHOD AND APPARATUS

Filed Feb. 7, 1922 7 Sheets-Sheet 7

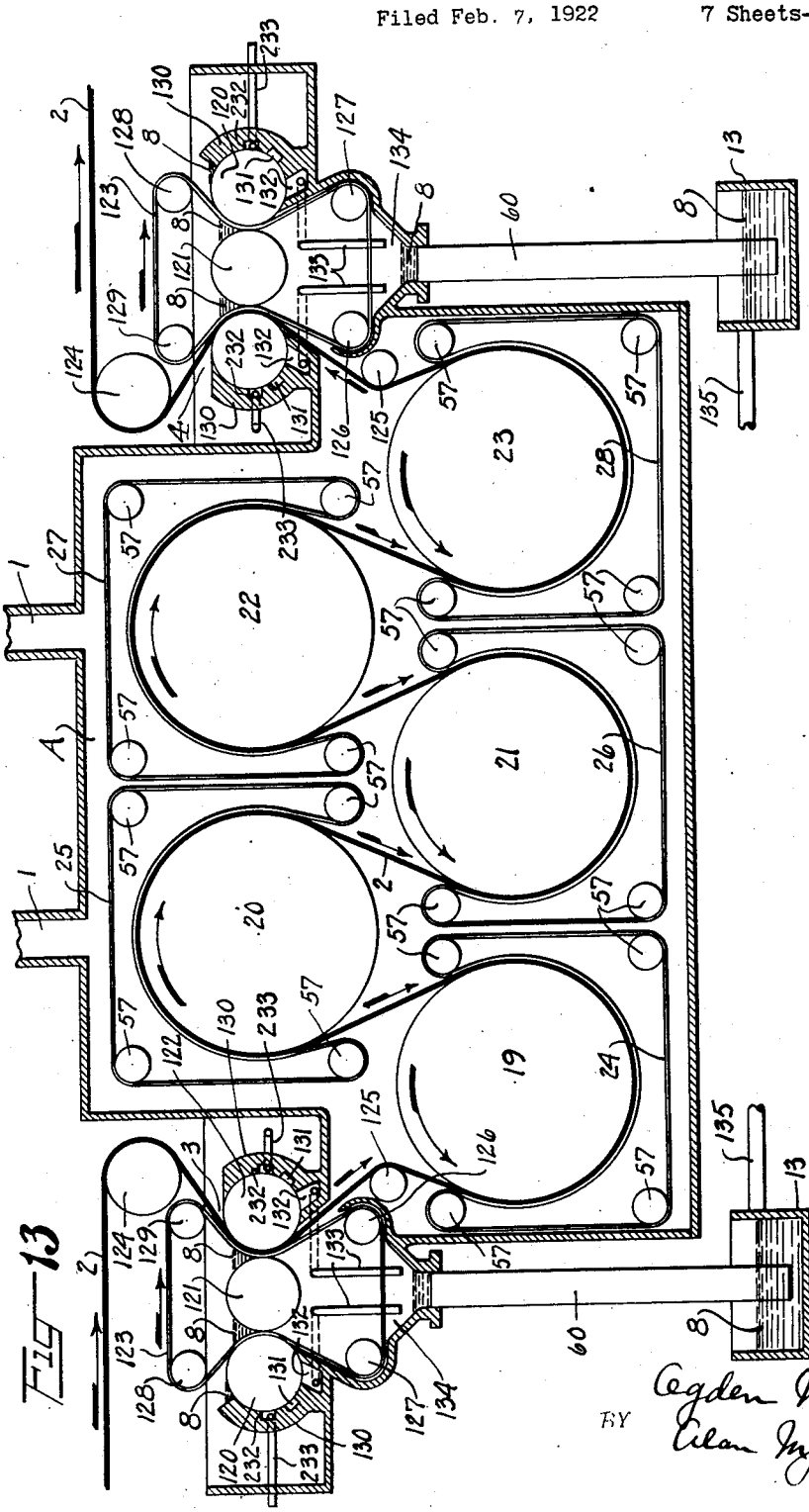


FIG 13

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Patented Aug. 10, 1926.

1,595,238

UNITED STATES PATENT OFFICE.

OGDEN MINTON, OF GREENWICH, CONNECTICUT.

VACUUM SEAL, METHOD AND APPARATUS.

Application filed February 7, 1922. Serial No. 534,812.

This application is for a species of my invention covered broadly in my copending application Ser. No. 427,436, filed November 30, 1920, and is also covered in the divisional application of said case filed Jan. 21, 1922, Ser. No. 530,990, case Q.

My invention relates to the method of treating materials in a vacuum, and more particularly to the method of protecting the opening or openings into the vacuum chamber, through which opening or openings the material to be treated is introduced and withdrawn from the chamber.

More particularly it relates to restricting the entrance and exit passages of the vacuum chamber by a moving member or members, as for example one or more rolls, mounted within the entrance and exit passages, making the roll or rolls substantially close the passage in which it, or they, are mounted leaving sufficient clearance to permit the free passage of a web of sheet material, and also the free passage of one or more carrier belts if these are used; and making the entrance and exit passages substantially air tight by employing any suitable fluid as a sealing medium. This sealing fluid has more or less flow, drip or seepage into the vacuum chamber depending principally upon the degree to which the entrance and exit passages are closed by the one or more rolls mounted in each passage. If the roll or rolls in the entrance and exit passages, together with the single or plural carrier belts and the web of paper or other sheet material substantially close the passage, the fluid will merely drip or seep through into the vacuum chamber. If, however the parts fit loosely more of the sealing fluid will work into the vacuum chamber and the fluid will have more or less flow. It is desirable to restrict the flow of the fluid as much as possible consistent with the successful operation of the method and apparatus as a whole.

The sealing fluid may be one which has an affinity or attraction for the paper, or other sheet material being treated, as for example water or similar liquid; or, the sealing fluid may be one which has no attraction or affinity for the web of paper or other sheet material to be treated in the vacuum chamber; such a liquid, for example, as mercury or an amalgam or other suitable material.

If the sealing fluid has an attraction for the web of paper, or other similar material, I guard and protect the web of paper or other similar material from contact with the liquid by one or more carrier belts as it passes through said sealing liquid.

My invention further relates to the method of drying any sheet material in a vacuum chamber, whether such material be woven fabric or not. It relates more particularly to drying a continuous web of paper either coming from the wet end of a paper machine, or from a sizing vat, or from a coloring apparatus, coating machine or printing machine or directly from a roll of wet paper.

My invention further relates to drying the fabric, paper or other sheet material, in the vacuum chamber by drying drums or cylinders, or any other suitable means mounted in the vacuum chamber.

When drying drums or cylinders are used my invention further relates to employing with each drying drum or cylinder a separate individual felt, so that drying rolls may be driven at different speeds to compensate for different shrinkage on the different drying drums or cylinders.

My invention further relates to certain steps and combinations of steps, also to certain elements and combinations of elements, whereby the method or processes herein described may be carried out, as well as to certain details of construction, all of which will be more fully hereinafter described in the specification and pointed out in the claims.

Various forms of apparatus may be employed to carry out my improved method. The number of the rolls and the number of the carrier belts may be varied; or the carrier belts may be omitted; the sealing liquid may be varied; different means may be used to retard or increase the flow of the sealing liquid into the vacuum chamber; different means may be used to withdraw the sealing fluid from the vacuum chamber; different drying elements may be used in the vacuum chamber; one sealing liquid may be used at the entrance to the vacuum chamber, and a different sealing liquid may be used at the exit passage as may be found convenient or expedient; and other various changes may be made without departing from the scope of my invention as described in the specification and claims.

I have shown in the accompanying draw-

ings various forms of apparatus, which may be used to carry out my improved method, but it is to be distinctly understood that these forms are simply shown by way of example and are diagrammatic, and that my invention is not to be confined to them.

In the accompanying drawings the same reference numerals refer to similar parts in the several figures.

Fig. 1 is a diagrammatic view showing one form of my invention in which two carrier or protecting belts are used to carry and protect the web while it passes through the liquid seal;

Fig. 2 is a diagrammatic sectional fragmentary view, of another form, similar to the first, except that only one carrier belt is employed to guard and protect the web in its passage through the liquid seal;

Fig. 3 is a detail cross section through the two protecting water-proof carrier belts and the web;

Fig. 3[a] is a detail cross section of a modification showing interlocking carrier belts;

Fig. 4 is a detail cross section on line 4—4 of Fig. 2, showing the use of one carrier belt or felt, the housing being omitted;

Fig. 5 is a vertical diagrammatic view of another form of apparatus shown by way of example;

Fig. 6 is a vertical section on line 6—6 of Fig. 5;

Fig. 7 is a diagrammatic vertical section of another and the preferred form of my apparatus, which may be used to carry out my method;

Fig. 7[a] is a vertical section of the preferred form shown in Fig. 7, showing particularly how the sealing fluid works around the ends of the sealing rolls and is taken substantially on the line 7[a]—7[a] of Fig. 7, looking in the direction of the arrows;

Fig. 8 is a fragmentary detail vertical section of another form of seal and carrier belt;

Fig. 9 is a diagrammatic fragmentary section showing still another arrangement of sealing rolls and carrier belts;

Fig. 10 is a diagrammatic fragmentary section showing still another arrangement of sealing rolls and carrier belts;

Fig. 11 is a detail section on line 11—11 of Fig. 7;

Fig. 12 is a detail section on line 12—12 of Fig. 9;

Fig. 13 is a diagrammatic vertical section of still another modification of my invention.

The vacuum chamber A has a vacuum maintained therein in any suitable manner by connecting the pipes 1, 1 with any suitable exhausting apparatus. This vacuum chamber has an entrance and an exit passage. Through these passages the material to be treated in the vacuum chamber A is introduced and withdrawn. Of course, if the passages were left unguarded too much air would leak into the chamber to feasibly maintain a vacuum.

My present invention broadly consists in restricting the entrance and exit passages by one or more movable members in connection with a liquid so that the movable member or members and the sealing liquid together make the passage substantially air tight and prevent air leaking into the vacuum chamber A. These members are preferably in the form of guide rolls so that in addition to their function of restricting the passages they also act as guides for the web to be treated.

The liquid employed may be one which has an affinity for the web to be treated, as for example water, or the liquid may have no affinity for the web, such for example as mercury, amalgam or similar liquid. When the liquid is one which has an affinity for the web it is protected in its passage through the liquid seal by one or more waterproof carrier belts.

In my invention any suitable material may be introduced into and withdrawn from the vacuum chamber A through my fluid seals. It may be paper, or a woven fabric, or any other suitable material to be dried or otherwise treated in the vacuum chamber. It may be fed through the vacuum chamber continuously or not. I have shown by way of example the material in the form of a continuous web 2 of paper, which passes continuously through the vacuum chamber A and the fluid seals. This web may be dried in the vacuum chamber, or coated, impregnated or treated in any other suitable manner.

The vacuum chamber A is provided with the entrance passage 3 and the exit passage 4. These passages are substantially the same so that the description of one will suffice for the other. In the entrance passage 3 of Fig. 1, is mounted a roll 5, its periphery being brought as close as possible to the roll chamber or housing 6, the clearance being just sufficient to permit the web 2, the lower carrier belt 11 and the upper carrier belt 7 to pass between it and the felt roll housing 6, together with such sealing liquid as will work through.

This liquid 8 is fed into the roll housing 6 in any suitable manner, such as through the nozzle 9, and seals the restricted passage 10 between the felt roll housing 6 and the felt roll 5 so that practically no air can work into the vacuum chamber A.

As the web 2 of wet paper, or other material, passes into the sealing liquid 8 it is, in the form shown in Fig. 1, protected by two waterproof carrier belts, the lower waterproof carrier belt 11 and the upper waterproof carrier belt 7. These waterproof car-

rier belts are wider than the web and completely enclose and protect it from contact with the liquid 8. As the web and carrier belts are fed continuously into the vacuum chamber A, a small amount of the sealing liquid 8 will work under the roll 5 and into the well 12. This liquid may be withdrawn from the vacuum chamber in any suitable manner. Preferably I permit it to flow into a barometric seal 13, which prevents any air working back into the vacuum chamber A. If desired the sealing liquid 8 may be permitted to run to waste, or it may be used over and over again as shown in Fig. 1, wherein the pipe 14 is connected to the pump 15, which pumps the liquid back to the nozzle 9 and into the roll housing 6. The restricted passage 10 is made as small as possible so that comparatively little of the sealing liquid will work into the well 12.

To insure that no air will work past the upper surface of the roll 5 and thence into the vacuum chamber A I may pack the roll in any suitable manner. This packing may be solid matter, or a series of dovetailed surfaces, or the packing may be liquid or any other form of packing may be used. I have shown in the drawings a liquid packing as for example water under pressure, which is fed into the liquid seal 16. Any water that may leak between the seal 16 and the roll 5 is caught by the wipers 17 and 18, and withdrawn in any suitable manner.

It has been found in practice that the shrinkage of the wet web of paper will vary on the different drying drums or cylinders 19, 20, 21, 22 and 23. While I have shown five drying drums or cylinders mounted in my vacuum chamber A, it is of course to be understood that any number of such drying drums or cylinders may be used as found convenient or expedient. To compensate for this unequal shrinkage of the wet web of paper, or other material, on the drying drums or cylinders, I revolve these cylinders at varying speeds and employ separate and individual felts 24, 25, 26, 27 and 28, one for each of the drying drums or cylinders, as shown in Fig. 1, the felts passing over the guide rolls 57, 57.

After the wet web of paper 2, protected by the water-proof carrier belts 7 and 11, has been fed into the vacuum chamber through the liquid seal 8 and through the restricted portion 10 of the entrance passage 3, these waterproof carrier belts are freed from the wet web of paper 2. This permits the separate individual drying felts 24, 25, 26, 27 and 28 to cooperate with the web while it is passing over and in contact with their particular drying drum or cylinder, which are driven in any well-known manner at varying speeds. In this way the different shrinkage of the web 2 on the different drying drums and cylinders is compensated for, which lessens the liability of breaking the web or causing what is known in the trade as "broke".

Any suitable arrangement of the two carrier belts 7 and 11 may be employed. I have shown for purposes of example, the upper carrier belt 7 after passing into the vacuum chamber A being led over the guide rolls 29, 30, 31, 32, 33, 34, 35 and 36. At the guide roll 36 the upper carrier belt 7 again meets the web 2, which is now dry, and protects it, with the aid of the lower carrier belt 11, as it passes out of the vacuum chamber around the second roll 5 and through the second or exit liquid seal 8. The upper carrier belt 7 is then passed over the guide rolls 37, 38, 39, 40 and 41 back to the entrance for the vacuum chamber, its movement being continuous.

The lower continuous carrier belt 11, after it passes into the vacuum chamber, passes over the guide roll 42 thence in contact with the guide rolls 43, 44, 45 and 46, where it again meets the now dry web 2 and protects it while it passes through the second or exit liquid seal 8, as previously described. It is then guided by the rolls 47, 48, 49, 50 and 51 back to the entrance of the vacuum chamber.

In some cases I may use interlocking carrier belts to prevent any of the sealing liquid contacting with the material being dried.

I have shown for example one form of such an interlocking carrier belt in Fig. 3[a] in which the upper carrier belt 207 and the lower carrier belt 211 are provided with interlocking surfaces. In the former shown by way of example the lower carrier belt 211 is provided with two continuous grooves 213, 213. The upper carrier belt 207 is provided with two continuous ribs 214, 214 to fit into the grooves 213, 213. Wherever I employ two carrier belts they may be formed with these or similar interlocking members.

I have shown in Fig. 2 a modification of my invention, which is substantially the same as that just described, except that the upper carrier belt 7 is omitted. In this form of my invention the lower waterproof carrier belt 11 will alone protect the web from the liquid 8 of the seal by pressing it against the roll 5 as shown in Figs. 2 and 4. In this form also I have shown the well 12 connected directly with a pump 15 instead of using a barometric seal.

It is to be understood that different sealing liquids may be used at the same time. For example, water may be used at the entrance to the vacuum chamber A, and mercury, amalgam or any other suitable fluid at the exit, or any other suitable liquids may be used.

I have shown a modification of my invention in Figs. 5 and 6. In this form of my invention I protect the entrance and exit

passages of the vacuum chamber by a plurality of rolls mounted in each passage.

The web 2 of paper is fed through the liquid 8 of the seal while in contact with the revolving roll 151 and pressed thereon and protected by means of the waterproof endless carrier belt 52. Beneath the roll 51, I mount the roll 53 so that these rolls together form a very restricted passage for the liquid 8 to work into the well 54 of the vacuum chamber A. The waterproof carrier belt 52 is wider than the web of paper 2 and is drawn taut over the roller 151 so that the web 2, including its edges, is completely protected from contact with the liquid, as is shown for example in Fig. 6. After the web 2 has been introduced into the vacuum chamber, the endless carrier belt 52 is immediately withdrawn and passed over the guide roll 154, back under the roll 53 and out through the liquid 8 to the guide roll 55. The wringer rolls 56, 56 serve to remove any liquid that may adhere to the waterproof carrier belts 52, 52.

The wet web 2 is then passed over and in contact with the heated drying drums or cylinders 19, 20, 21, 22 and 23. After passing over the last drum 23, it is completely dried and is passed out of the vacuum chamber A through the exit passage 4, which is protected in the same manner as the entrance passage 3, so that the dry web of paper 2 does not come into contact with the liquid 8, whatever that liquid may be.

To allow for the separate shrinkage of the web upon the different drying drums or cylinders 19, 20, 21, 22 and 23, I preferably employ individual felts 24, 25, 26, 27 and 28, one for each of the drying drums or cylinders, as shown in Fig. 5, the felts being guided over the guides 57, 57. The advantage of this has been previously described in connection with the structure shown in Fig. 1.

As previously described, the liquid 8 may be a liquid which has an affinity for the material treated, or it may be a liquid such as mercury, amalgam, or any other suitable material, all as previously noted. This is true of all forms of my invention. This liquid will flow between the rolls 151 and 53 and between the roll 53 and the portion 58 of the roll housing 59. This flow will depend upon the degree of vacuum maintained within the vacuum chamber A and upon the area of the restricted passage formed by the rolls 151 and 53. With a very restricted passage, which is the preferred construction, a comparatively small amount of the liquid 8 will pass through the restricted passage and will be caught in the well 54. Some of the liquid will be caught by the catch basin 58 and permitted to run out through the pipe 159 around the carrier belt 52, and thence into the well 54. From this chamber it is withdrawn in any suitable manner; either being permitted to run to waste or to be used again as the liquid of the seal. For purposes of illustration, I have shown the well 54 connected by the pipe 60 with the barometric seal 13. From this barometric seal, the liquid may be permitted to run to waste, or it may be withdrawn by the pipe 14 and pump 15 and pumped back into the roll housing 59 to be again used as the liquid of the seal.

The dry web 2 of paper or similar material passes from the last drying drum or cylinder and out through the exit passage, and duplicate seals, rolls and carrier belts. It is to be understood, however, that different sealing liquids may be used in the entrance and exit passages, if desired.

To prevent air working around the upper periphery of the roller 151, I may pack this roller in any suitable manner, as the rollers 5, 5 are packed in Fig. 1. In the form shown the water under pressure is fed through the pipe 63 to the liquid seal 16. The wipers 17 and 18 remove any film of water that may adhere to the periphery of the rolls 151, 151.

I have shown another modification of my invention in Fig. 7. In this form the entrance and exit passages to the vacuum chamber A are substantially closed or restricted by three rollers 64, 65 and 66.

In this form I also use a single waterproof carrier belt 67 which guards and protects the web 2 of paper, or other material, by pressing it firmly against the periphery of the roll 64, see Fig. 7 and Fig. 11, and also prevents it from becoming wrinkled or crumpled. As soon as the web enters the vacuum chamber A, the carrier belt 67 is withdrawn from the web 2 and passed around the roll 65, thence out through the same seal in contact with the roll 66 and guide rolls 68 and 69 in a continuous movement.

On the rolls 64 and 66 I preferably employ wipers 70, 70, though these of course may be omitted without departing from my invention.

The rollers 64 and 66 fit the roll housing 71 so snugly that little water or other liquid 8, can work between these rollers and the housing 71. In this preferred construction whatever water or other liquid 8 works between the roll housing 71 and the roll 64 is caught in the catch basin 72 and flows from there into the well 73.

Whatever liquid 8 works between the roll housing 71 and the roll 66, as well as between the rolls 66 and 65, and between the rolls 65 and 64 is caught in the catch basin 74 and is led by pipe 75 to the well 73. From the well the liquid may be permitted

to run to waste or may be pumped back by the pump 15 and the pipe 103 to the rolls 64, 65 and 66 and again used.

The water or other sealing fluid works around the ends of the rolls or shown clearly in Fig. 7ª.

The drying of the web in this preferred form is the same as in those forms previously described.

In Fig. 8 I have illustrated another modification of my invention in which the waterproof carrier belt 78 protects the web 2 by covering and pressing it against the roll 64 in the same manner as in Fig. 7 and Fig. 7ª. In this form, however, the carrier belt is led around the guide rolls 79, 79 within the vacuum chamber A, thence out through the same liquid seal 8 between the rollers 65 and 66, and thence around the guides 80, 80 mounted on the exterior of the vacuum chamber.

In this form the sealing liquid 8 is located between the rolls 64 and 65 and between the rolls 65 and 66. To prevent air working past the rolls 64 and 66 and the roll housing 81, I use any suitable form of liquid, or solid packing. I have shown for example a liquid packing or seal, as for example, water or other suitable liquid, being fed to the liquid seals 82, 82 under pressure. To remove any thin film of water or other liquid which may adhere to the periphery of the roll 64, I mount a wiper box 83 on one side of the liquid seal 82, and another wiper box 183 on the other side of the liquid seal 82. The wiper 83 is connected by the pipe 84 so that any liquid which may be removed by the wiper 83 will drain into the well 74.

Any liquid 8 removed by the wiper 183 is permitted to drain into the room, as for example by permitting it to drain through the pipe 184, and catching it in any suitable manner (not shown).

The wiper boxes 83 and 183 cooperating with the rolls 64 and 66 are drained in the same manner, the wipers 83, 83 into the well 74 and the wipers 183, 183 through the pipes 184, 184 to the atmosphere where the liquid is caught and led away in any suitable manner (not shown).

I may use one or more wipers 85, though these may be dispensed with if desired. The catch basin 86 will catch any liquid 8 which may leak, drip, seep or flow into the vacuum chamber between the rolls 64, 65 and 66. Such liquid is led from the catch basin by the pipe 87 and permitted to flow into the well 74.

A similar seal may be used at the exit passage (not shown); or any other form of seal may be used, it of course being understood that the seals at the entrance and exit passages need not necessarily be duplicates, as previously pointed out.

In some cases I may use two carrier belts. I have shown such an arrangement in Fig. 9, where I employ an upper water proof carrier belt 88 and a lower waterproof carrier belt 89. In this form of my invention, I use four sealing rolls 90, 91, 92 and 93. The upper carrier belt 88 passes around the guide roll 94 and then through the bite between the rolls 91 and 92, protecting the upper portion of the web 2, and thence around the sealing roll 92 in contact with the sealing roll 93, around the guide roll 95 and back to the guide roll 94. The lower carrier belt 89 passes from the guide roll 96 in contact with the sealing roll 91, around the guide roll 97 and back between the rolls 90 and 91 to the guide roll 96. As the web 2 of paper, or similar material, passes through the sealing liquid and between the sealing rolls 91 and 92, it is protected by both the upper and lower waterproof carrier belts 88 and 89, see Fig. 12.

To catch any water or other sealing liquid 8, which may drip, seep or work through into the vacuum chamber A, I employ the water traps 98, 99, 100 and 101. Each of these traps has connected therewith a pipe 102 which permits any liquid collected by the traps to drip, seep or flow into the well 74, from which it is withdrawn by the pipe 60 and the barometric seal 13. The liquid may be permitted to run to waste, or be pumped back by the pump 15 and the pipe 103 to the rolls 90, 91, 92 and 93.

The web 2, after it enters the vacuum chamber A, is freed from the upper and lower carrier belts 88 and 89 and passes around one or more drying drums or cylinders 19, 20, 21, 22 and 23 in the same manner as previously described. The dry web is then passed out of the exit passages through a duplicate or other suitable seal in which the same sealing liquid, or any other suitable liquid may be employed.

I have shown another modification of my invention in Fig. 10, in which the sealing rolls 104, 105 and 106 are formed of different diameters, 105 being smaller than the others. In this form, the sealing fluid 8 of water or other liquid is located between the sealing rolls 104 and 106 and above the intermediate sealing roll 105. To prevent any air working around the sealing roll 104, I locate some of the sealing liquid 8 above that roll and between it and the roll housing 107. To protect the other roll 106 I provide the housing 107 with a water seal 108. Water under pressure, depending upon the degree of vacuum in the vacuum chamber A, is forced into this water seal 108. I also mount wipers 109 and 110 in the housing. The wiper 109 is connected by the pipe 111 with the water trap 112. The wiper 110 may be drained in any suitable manner. These wipers will remove any thin film of water which may adhere to the

periphery of the sealing roll 106. That removed by the wiper 109 drips into the water trap 112 from which it is removed by the pipe 113.

In this form of my invention, I use a single carrier belt 114, which passes over the guide roll 115 and protects the web 2 of paper, or other similar material, by pressing it tightly against the periphery of the sealing roll 106. The carrier belt is then passed over the guide rolls 116, 117 sealing roll 105 back to the guide roll 115. To catch any water or other sealing liquid 8, which may be employed, I use the water trap 112, which may be emptied in any suitable manner, as by a pipe 113, which drains into the well 118. I may also employ a wiper 119 bearing upon the sealing roll 104. Any liquid that this wiper may remove from the sealing roll 104 will also fall into the well 118, from which it is drawn off in any suitable manner as, for example, by the pipe 60 connecting with the barometric seal 13. The liquid 8 may be permitted to run to waste, or if desired for any reason it may be withdrawn from the barometric seal 13 by the pipe 14 and pumped by the pump 15 and pipe 103 back to the roll housing to be again used, as shown in Fig. 10.

I have shown another modification of my invention in Fig. 13. In this figure I use three sealing rolls 120, 121 and 122 and one waterproof carrier belt 123. The web 2 of paper, or other suitable material, is fed over the guide roll 124 and thence in contact with the sealing roll 122 through the sealing liquid 8. Before the web 2 passes through the sealing liquid 8 of water, or other suitable liquid, it is protected by the waterproof carrier belt 123, which presses it against the periphery of the sealing roll 122.

After the web 2 has passed from the sealing rolls 121 and 122, it is withdrawn from the protecting waterproof carrier belt 123 and passed around the guide roll 125 and thence around the drying drums or cylinders 19, 20, 21, 22 and 23.

After the endless waterproof carrier belt 123 has protected the web of paper 2, while it passed through the liquid seal 8, the carrier belt is then passed over the guide rolls 126, 127, through the bite between the sealing rolls 120 and 121, to the guide rolls 128 and 129, its movement being continuous.

In this form of my invention, I provide the roll housing 130 with two liquid seals 131, 131. The pressure of the water or other liquid in these seals 131, 131 will depend upon the degree of vacuum maintained in the vacuum chamber A as previously described. In the housing 130, I also provide two wipers 132 and 232. The wipers 132, 132 are connected with their respective drain pipes 133, 133 and drain into the well 134. The wipers 232, 232 are connected with their respective drain pipes 233, 233 and drain into the room where the liquid 8 is collected and removed in any suitable manner (not shown).

The liquid 8 in this form of my invention, as well as in the other forms, is not meant to flow between the sealing rolls 120, 121, 122. However, some of the water or other similar liquid will drip, seep or work into the chamber or well 134. I withdraw this liquid in any suitable manner from this chamber and permit it to run to waste through the pipe 135 or again use it, as may be found the most economical practice.

In this form of my invention I have shown the exit passage 4 of the vacuum chamber A equipped with the same form of seal as the entrance passage 3, though, of course, it is to be understood that any suitable seal and sealing liquid may be used at the exit, and that such seal does not necessarily have to be identical with that at the entrance passage to the vacuum chamber, all as previously explained in connection with other forms of my invention.

My invention is particularly adapted to be used in connection with drying sheet materials in the form of paper, though it is to be distinctly understood that it is equally applicable to and covers drying sheet material in the form of textile fabrics, as for example, drying such fabrics after they have been washed or bleached or dyed, or otherwise treated by a liquid of some description.

My method possesses many advantages not present in processes heretofore used for many years in the drying of paper.

The evaporation process, which is characteristic of the so-called loft drying of paper, has many fully recognized disadvantages, and yet it is used today and has been in use for many years. In this method the wet paper is taken from the paper machine, cut into sheets, hung on poles, carried to the drying room where it is subjected to hot air at about 130° F. for about 48 hours, and when dry, each sheet is separately calendered. Although possessing the advantage of drying at a comparatively low temperature, whereby the moisture is slowly evaporated, loft drying is obviously very inefficient and costly, because it requires many separate manipulations, is extremely slow, uses extensive floor space and wastes heat.

The process which is employed in the ordinary paper machine in common use, is likewise subject to many disadvantages. In such machine, the wet paper as it comes from the paper machine, is passed over many revolving cylinders, heated internally by steam to sufficiently high degree of heat, to raise the temperature of the water in the paper to 212° F., the atmospheric boiling point of water. It is customary to supply

the drying cylinders with steam at approximately 5.3 pounds gauge pressure, at which the steam has a temperature of 228° F., giving a difference of temperature (228°–212°) of only 16° F. With this slight difference of temperature the transfer of heat is extremely slow, and hence it is necessary to employ many drying cylinders, in board machines often one hundred, and in news print machines, forty or more.

Also due to convection and conduction losses, as well as those incident to leaks in the piping system and other inefficiencies, the heat actually required for atmospheric drying of a ton of wet paper, is very much in excess of the theoretical requirement. The thermal efficiency of atmospheric drying by steam heated cylinders is therefore very low. Furthermore, the steam produced from boiling the water out of the paper, is driven off into the operating room, and although fans and exhausters are employed, at large expense for power and maintenance, the room atmosphere is so constantly saturated with moisture as to rust and ultimately destroy all iron and steel materials, and produces an exceedingly disagreeable and unhealthy atmosphere in which to work. It is well known that the minimum temperature 212°, the atmospheric boiling point of water, is positively injurious to, and results in oxidizing, the fibres of the paper, the strength of which is vastly improved when the paper is dried at lower temperatures, as in loft drying. This atmospheric drying process requires large initial cost for cylinders, felts, and other necessary equipment, and extensive floor space, and results in the consumption of large amounts of power, and great cost for operation, maintenance and repairs.

Some of the modern open air dryers are equipped with a blower system by which air, either heated or not, is blown through the dryer section, which will lower the temperature at which the water is evaporated from the paper much below 212° F., and may, in some cases, reduce the temperature of evaporation as low as 180° F. of lower.

In my improved vacuum drying method I contemplate maintaining within the chamber a vacuum of about 28″ of mercury, in which water boils at 100° F., and supplying the drying cylinders with steam at 5.3 pounds gauge pressure, producing a temperature of 228° F. The temperature difference between the temperature of the steam in the cylinders and that of the paper, is therefore, 128° F. in my vacuum method, or 8 times greater (16° F.×8=128° F.) than the temperature difference in atmospheric drying. In my improved method the paper dries approximately 8 times faster than in atmospheric drying, and I require only about one-eighth the number of drying cylinders to dry paper at the same rate of speed. I am able to dry paper with 5 cylinders in the same time required of 40 cylinders drying at atmospheric pressure, resulting in great economies in cost of the machine, floor space and of necessary piping, felts, auxiliary equipment, and particularly in power and maintenance charges.

The thermal efficiency of my vacuum method is very much greater than that of the atmospheric cylinder drying heretofore in universal use for drying paper. Theoretically, it requires about 4287 pounds of steam to dry one ton of paper at atmospheric pressure, but to compensate for convection and conduction losses, and those due to leaks in the piping system, and other inefficiencies, it has been shown in practice that about 10,600 pounds are required.

In my method, using a vacuum of about 28″, the convection, conduction and piping losses are exceedingly small and the total steam required to dry a ton of paper by my method is approximately 5200 pounds.

It is an established fact that paper dried at low temperatures is much stronger than when it is dried at the high temperatures used in paper machine atmospheric drying. Paper dried in a vacuum of 28″, or at a temperature of about 100° F. as in my method, is very much stronger than paper dried at atmospheric pressure, when the steam in the driers is at 228° F. When paper is dried by my method, therefore, a cheaper furnish or stock can be used and still produce a paper equal in strength to atmospheric dried paper, in which a higher grade furnish or stock is used. In making newsprint paper, I am able to dispense with a considerable portion of the more expensive sulphite pulp, as this can be replaced with the cheaper ground wood pulp. By my method I also reduce the number of breaks in the web as it passes over the cylinders.

Furthermore, in my method there is a great saving of heat (or steam) because the process is carried on in a vacuum chamber which acts on the principle of a thermos bottle, and the steam and vapors driven out of the wet paper are caught in the closed vacuum chamber, and conducted away to the condenser. The operating room is free from steam, humidity and neat, and fans, and exhausters are dispensed with. In the use of my method the apparatus is at all times operating under definite humidity, the control of the drying can be closely standardized, and the moisture content in the paper carefully regulated.

Having pointed out the many advantages of my method and apparatus over those heretofore used, it will be apparent that the use of my invention results in great economy in the initial cost of apparatus and in large savings in cost of operation, maintenance and repairs.

Having thus described this invention in connection with different illustrative embodiments thereof, to the details of which I do not desire to be limited, what is claimed as new and what is desired to secure by Letters Patent is set forth in the appended claims.

What I claim is:—

1. The method of sealing a vacuum chamber having openings for the passage of material to be treated, consisting in partially closing each opening against the admission of air by means of one or more rotating members mounted in each opening, and substantially sealing by means of a liquid said openings against the admission of air.

2. The method of sealing a vacuum chamber having openings for the passage of materials to be treated, consisting in partially closing each opening with one or more rotating members and rendering each opening substantially air tight by means of a moving dripping or seeping liquid.

3. The method of sealing a vacuum chamber having openings for the passage of material to be treated, consisting in partially closing each opening with one or more rotating members and rendering each opening substantially air tight by means of a liquid working into the vacuum chamber, and withdrawing any liquid that may work into the vacuum chamber.

4. The method of sealing a vacuum chamber having openings for the passage of material to be treated, consisting in partially closing each opening with one or more rotating members and rendering each opening substantially air tight by means of a liquid working into the vacuum chamber and circulating the liquid so that the same liquid can again seal the opening in the vacuum chamber.

5. The method of sealing a vacuum chamber having openings for the passage of material to be treated, consisting in partially closing each opening each against the admission of air by means of one or more rotating members mounted in each opening, and substantially sealing by means of water said openings against the admission of air.

6. The method of sealing a vacuum chamber having openings for the passage of material to be treated, consisting in partially closing each opening with one or more rotating members mounted in the openings and rendering each opening air tight by means of moving dripping or seeping water.

7. The method of continuously drying any material, consisting in continuously feeding the material into and out of a vacuum chamber through restricted passages the walls of each of which are formed in part by one or more rotating members, and passing a liquid through the restricted passages, the liquid forming a seal and substantially preventing the admission of air into the vacuum chamber, and drying the material in the vacuum chamber.

8. The method of continuously drying sheet material consisting in continuously feeding the sheet into and out of a vacuum chamber through restricted passages the walls of each of which are formed in part by one or more rotating members, and passing a liquid through the restricted passages, the liquid forming a seal and substantially preventing the admission of air into the vacuum chamber, protecting the sheet from contact with the liquid as it passes through it, and drying the sheet material in the vacuum chamber.

9. The method of continuously drying sheet material consisting in continuously feeding the sheet into and out of a vacuum chamber through restricted passages the walls of which are formed in part by one or more rotating members, passing a liquid and the sheet through the restricted passages, the liquid forming a seal and substantially preventing the admission of air into the vacuum chamber, guiding the sheet material over one of the rotating members and drying the sheet material in the vacuum chamber.

10. The method of continuously drying a web of sheet material consisting in continuously feeding the sheet into and out of a vacuum chamber through restricted passages the walls of each of which are formed by one or more rotating members and non-rotating members, passing the sheet around one of the rotating members and permitting liquid to work through said restricted passages to seal said passages and substantially preventing the admission of air into the vacuum chamber, and drying the web in the vacuum chamber.

11. The method of continuously drying sheet material consisting in continuously feeding the sheet into and out of a vacuum chamber through a restricted passage the walls of each of which are formed in part by one or more rotating members and at the same time feeding a protecting carrier belt through said restricted passage and out again through the same restricted passage, feeding a sealing liquid through said restricted passage to render the same substantially air tight, and drying the web in the vacuum chamber.

12. The method of drying sheet material consisting in passing it through a liquid partially contained in the bite of two rotating rollers partially closing the entrance into a vacuum chamber and drying the sheet material in the vacuum chamber.

13. In a vacuum drying apparatus the combination in a vacuum chamber having an entrance passage of movable means mounted in said entrance passage and sub-

stantially closing said passage, and a fluid to seal said passage against the entrance of air into the vacuum chamber.

14. In a vacuum drying apparatus the combination in a vacuum chamber having an entrance passage of movable means mounted in said entrance passage and substantially closing said passage, and a fluid to seal said passage against the entrance of air into the vacuum chamber and drying means mounted in the vacuum chamber.

15. In a vacuum drying apparatus the combination of a vacuum chamber having an entrance passage for the admission of material to be treated in the vacuum chamber, one or more rotating members mounted in the passage and tending to prevent a sealing liquid working into the vacuum chamber, and a sealing liquid to prevent air working around the rotating members into the vacuum chamber.

16. In a vacuum drying apparatus the combination of a vacuum chamber having entrance and exit passages one or more rolls in each passage, a liquid to substantially close each passage against the admission of air into the chamber, drying means mounted in the vacuum chamber and one or more carrier belts adapted to pass through the liquid and protect the material to be dried from contacting with said sealing liquid.

17. In a vacuum drying apparatus the combination of a vacuum chamber having entrance and exit passages to permit the continuous passage of sheet material to be treated into and out of the vacuum chamber, one or more rolls mounted in each entrance and exit passage to partially close said passage, a liquid in the said passage which, with the roll or rolls, renders the said passage substantially air tight, and means mounted in the vacuum chamber to dry the sheet material as it passes through the said chamber.

18. In a vacuum drying apparatus the combination of a vacuum chamber, one or more drying drums or cylinders in the chamber, moving dripping or seeping fluid seals to seal the entrance and exit passages of said chamber, means to cause the fluid to move drip or seep one or more carrier belts to protect the material treated while passing through said fluid seals, and a separate felt and guiding means therefor for each drying drum or cylinder to compensate for the different shrinkage on each drying drum or cylinder.

19. In a vacuum drying apparatus the combination of a vacuum chamber having entrance and exit passages, means to dry the material treated in the vacuum chamber, fluid seals rendering the passages substantially air tight, and a plurality of interlocking carrier belts to receive between them the material to be dried and protect said material from coming in contact with the fluid of the fluid seals and guiding means for the belts.

20. In a paper drying machine the combination with a web feed roll, of a doctor coacting therewith, and a liquid supply means connected with the doctor to supply liquid thereto to afford a liquid seal between the doctor and said roll.

21. In combination with a vacuum web drier machine comprising a drier housing having openings therein, a plurality of rolls and doctors closing said openings, and liquid sealing means connected with said doctors.

22. In combination with a vacuum web drier machine comprising a drier housing having openings therein, a plurality of contacting rolls in said openings, and liquid sealing means supported from said housing and contacting two of said rolls to afford a non-leaking seal.

ODGEN MINTON.