

Feb. 14, 1961

M. J. BERLYN

2,971,267

FLUID SUPPORTED WEB-DRYING DEVICE

Filed July 15, 1957

8 Sheets-Sheet 1

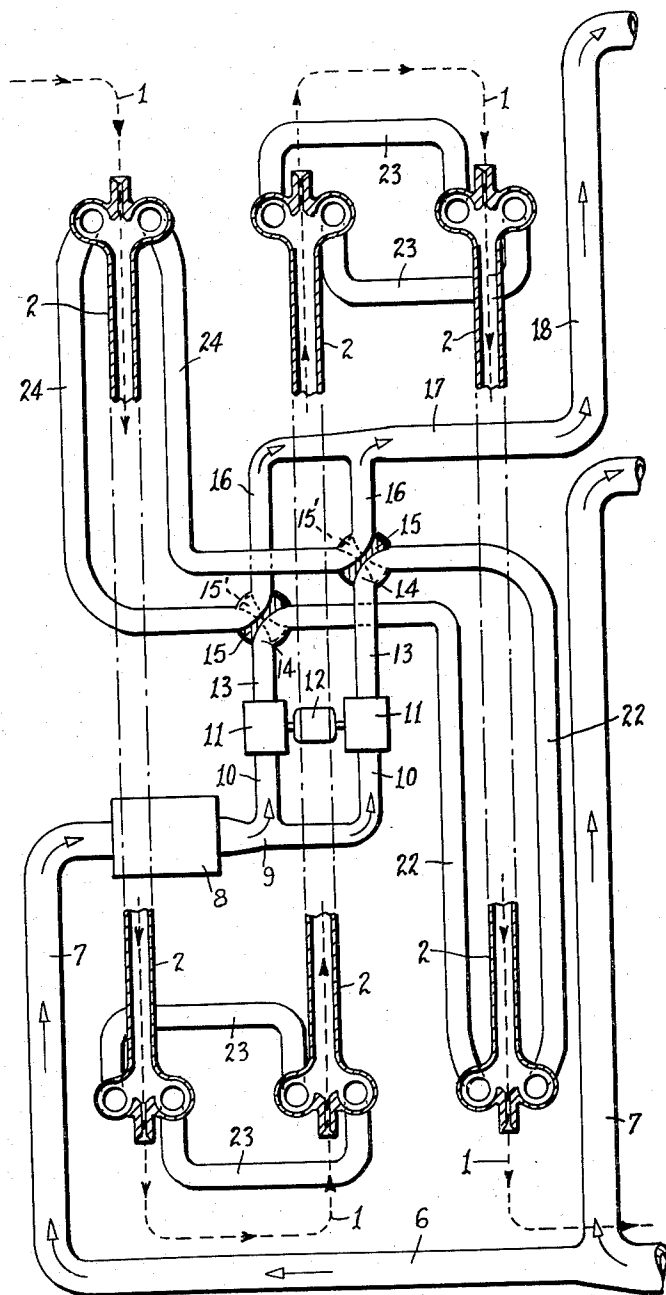


Fig. 1A

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8 Sheets-Sheet 2

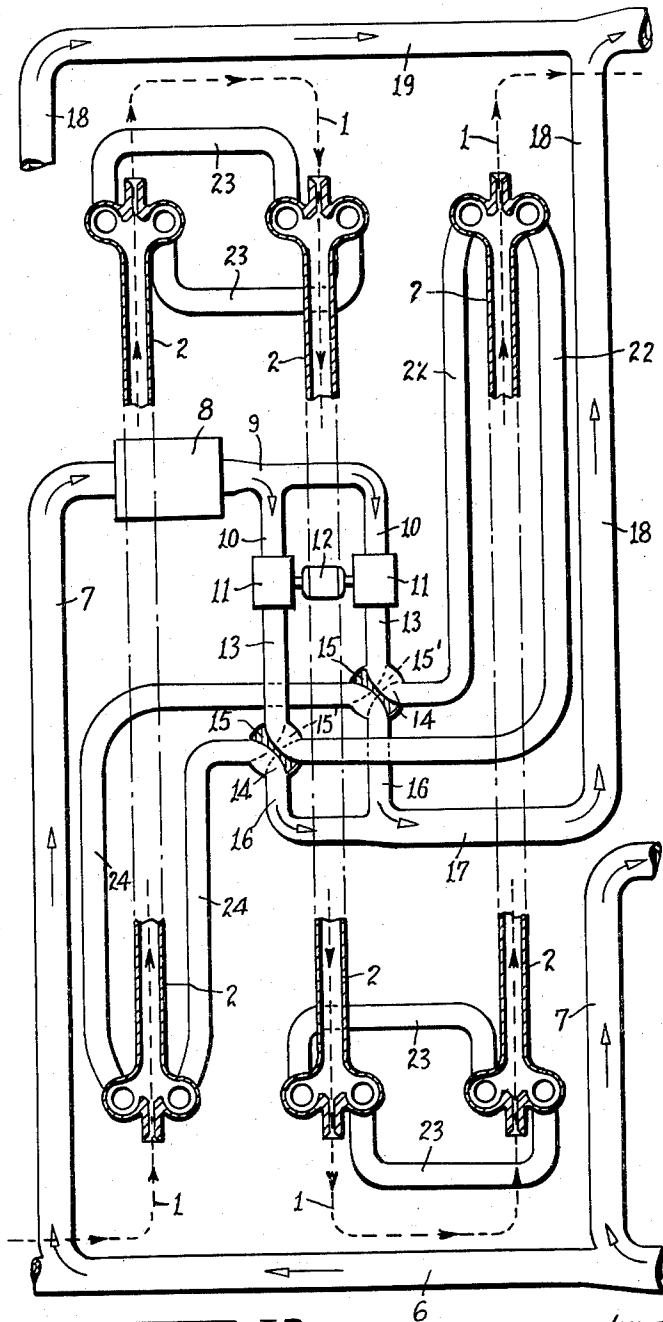


Fig. 1B

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8 Sheets-Sheet 3

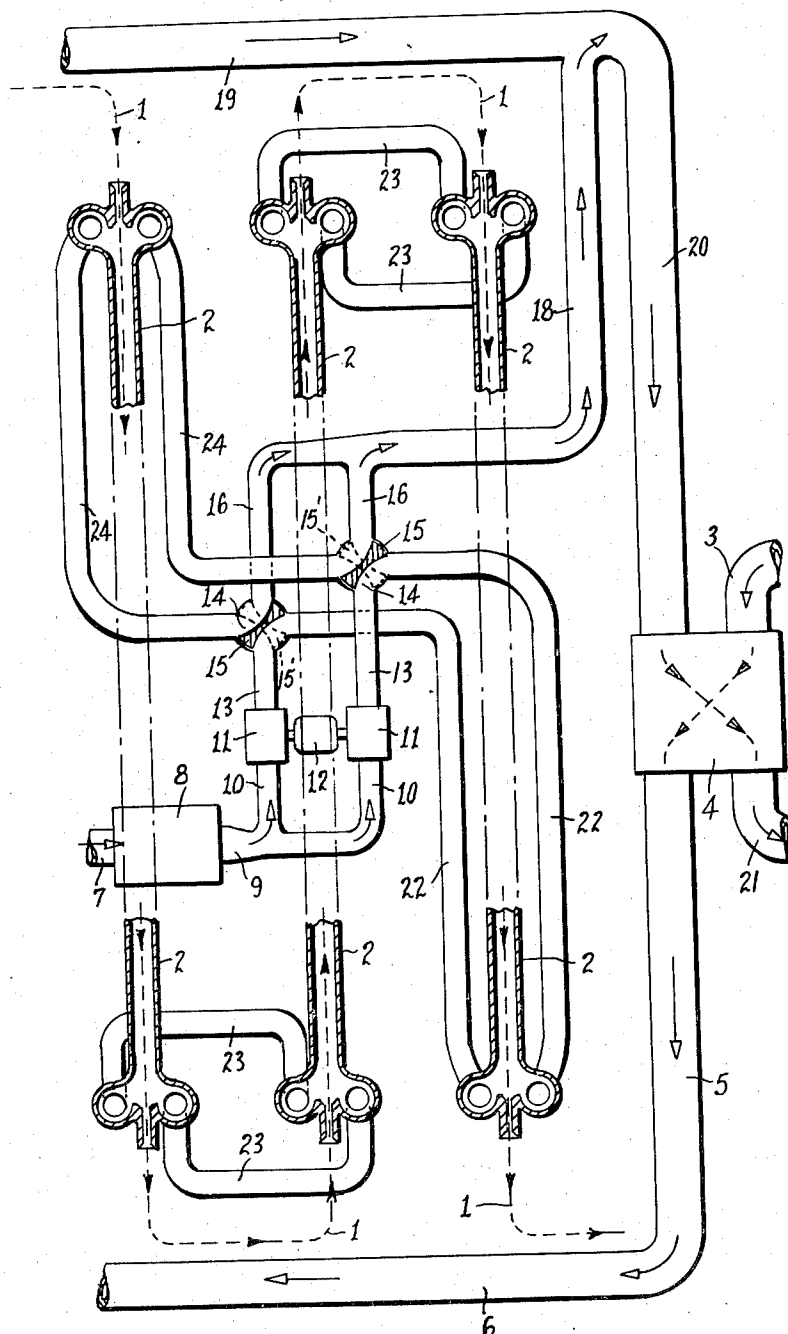


FIG. 1C

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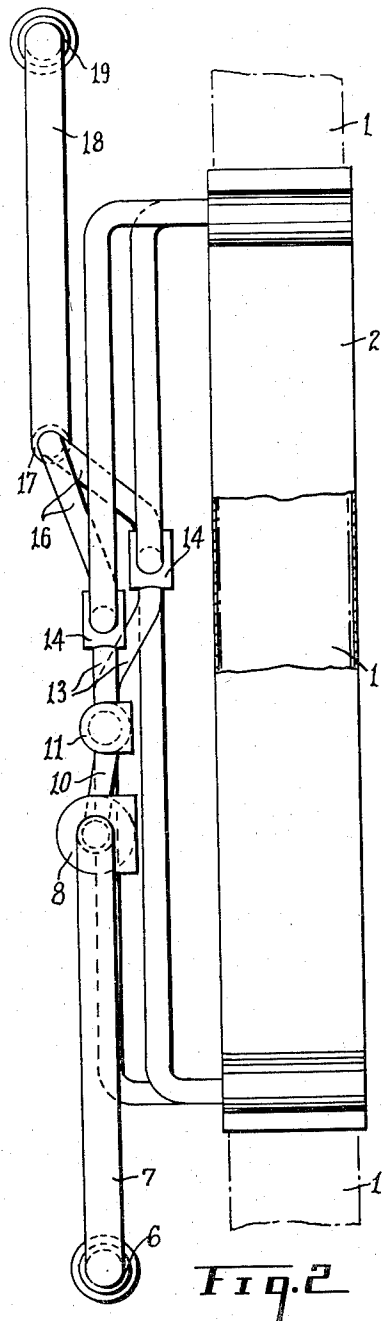


Fig. 2

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8 Sheets-Sheet 5

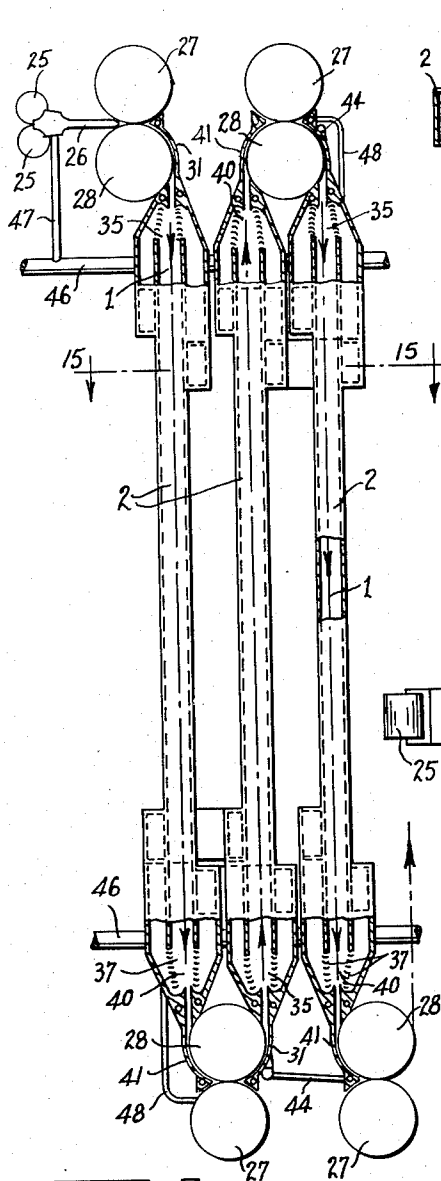


Fig. 3

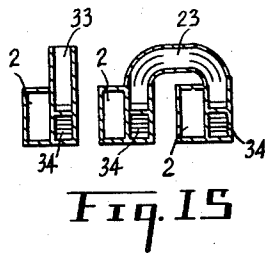


Fig. 15

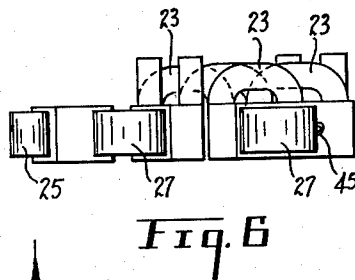


Fig. 6

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FLUID SUPPORTED WEB-DRYING DEVICE

Filed July 15, 1957

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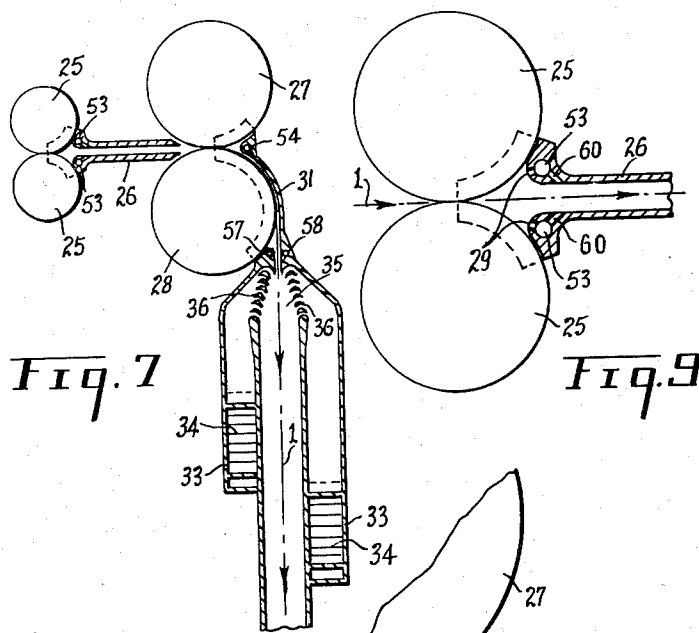


Fig. 7

Fig. 9

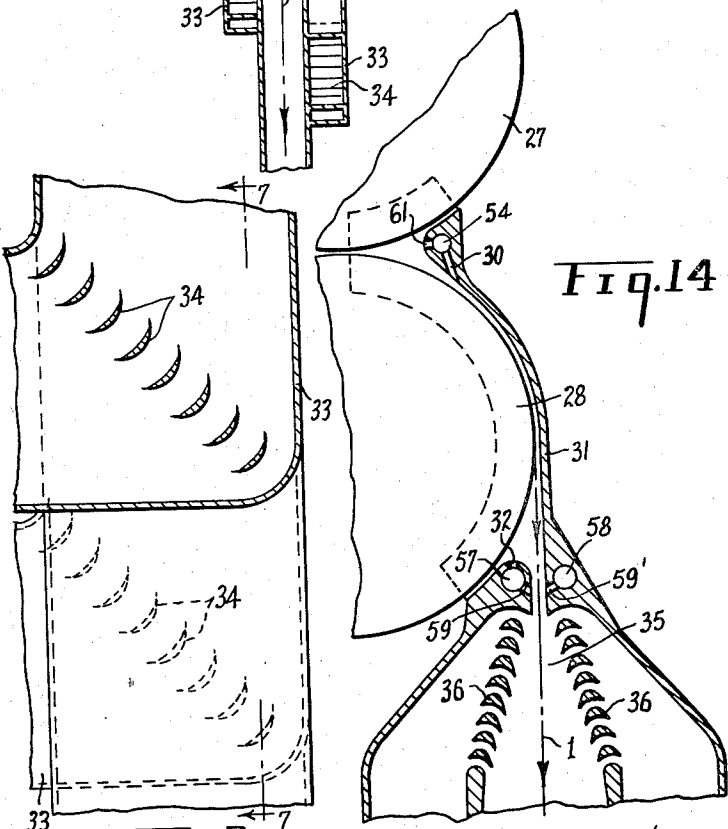


Fig. 8

Fig. 14

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FLUID SUPPORTED WEB-DRYING DEVICE

Filed July 15, 1957

8 Sheets-Sheet 7

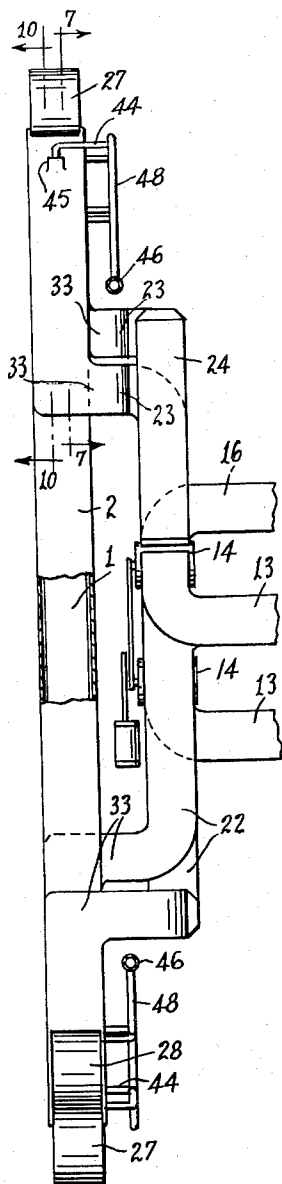


Fig 4

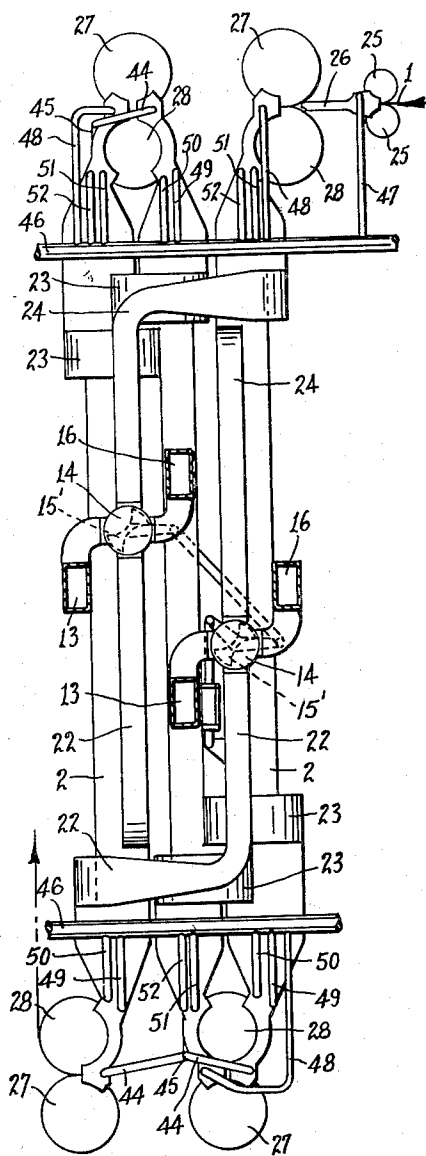


Fig 5

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Filed July 15, 1957

8 Sheets-Sheet 8

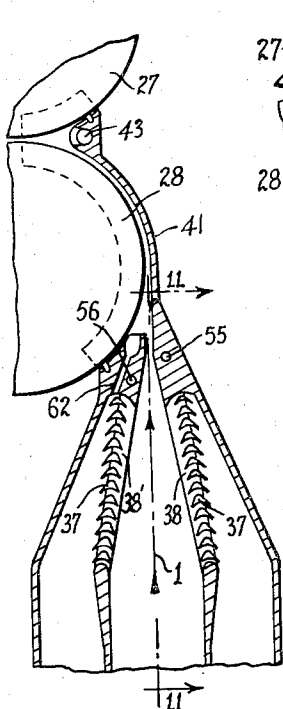


Fig. 10

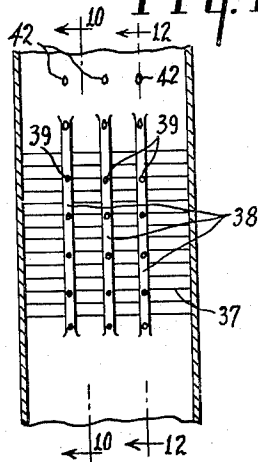


Fig. 11

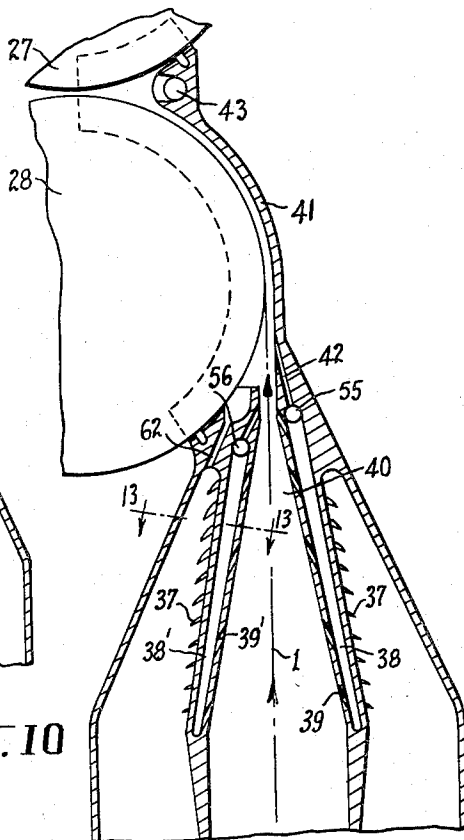


Fig. 12

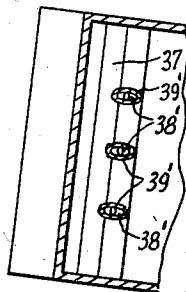


Fig. 13

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FLUID SUPPORTED WEB-DRYING DEVICE

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11 Claims. (Cl. 34—156)

This invention has reference to the drying of thin webs during the course of manufacture and is more particularly directed to the problem of drying a continuous web of paper, but it is by no means excluded from other applications.

In the dryer section of contemporary paper making machines, heat from steam is employed to evaporate water from the web of paper.

In dryers of the type in which the web is carried around the peripheries of a series of revolving steam-heated cylinders the web is pressed into contact with the cylinder surfaces by tensioned felts. The efficiency of heat transfer from steam to paper is low. The arrangement is also bulky and costly.

At lineal speeds considerably higher than those of contemporary high speed paper machines the conventional type of dryer would be even more costly and bulky than it is at present. Cylinder diameters would have to be increased in order to avoid dynamic malfunctioning at the higher lineal speed and, unless the diameter were to be increased substantially, a greater number of cylinders would have to be employed in order to satisfy the time function of the evaporating process.

The physical arrangement and the geometric configuration of contemporary dryers do not lend themselves well to provision of efficient means for removal from the neighbourhood of the web of the moisture released from it, and the hot and humid air surrounding such dryers constitutes an occupational hardship for the operating personnel.

In this invention, hot air is flowed over both sides of the web of paper simultaneously. The direction of air flow in normal operation is counter to the direction of motion of the web.

The moisture-laden air which has been passed over the web is rejected through heat-exchanging means in which incoming fresh air is preheated.

The stream of hot air for each side of the web is circulated by a separate blower. A pair of blowers, one handling the hot air for each side of the web, is driven from a common shaft; this provides that the two blowers of a pair are run at the same speed. The blowers are of a type having a head-quantity characteristic of steep pressure rise against throttled discharge whereby a pair of such blowers suitably ducted and driven at the same speed acts as a "flow divider." This device maintains the web central in its passage through the dryer casings while the streams of hot air pass on either side of the web in a direction counter to the motion of the web.

By flowing the streams of hot air counter to the direction of motion of the web two desirable objects are achieved; the hottest and driest air sweeps the hottest and driest part of the web while the cooler and moister air sweeps the cooler and wetter part of the web, thus providing the most uniform rate of drying, and the resultant high velocity of the hot air relative to the web is favourable to the removal from the web surfaces of the water vapour which has been released from them.

2

Although the hot air in normal operation passes through the casings counter to the direction of motion of the web, arrangements are provided, as will be explained hereinafter, to pass the hot air through the casings in the direction of motion of the web when starting a run, or when restarting after a break. This is to say that hot air in motion is employed as a vehicle to carry the web through the casings when starting up.

This hot air, to which motion has been imparted by blowers, is at substantially atmospheric pressure. It is employed as a vehicle only for the straight long vertical runs of the web, alternately downwards and upwards, through successive elements of the dryer assembly.

For changing the course of the web, as when transferring it from one casing element to the next in series, another air system is employed. This other system uses a relatively small amount of air which is fed from a source of compressed air at relatively high pressure and released through suitably located jets as will be hereinafter explained. The compressed air system is employed only when the hot air is being blown through the dryer casings in the direction of motion of the web, as when threading the web through the dryer at starting; it is shut off and inoperative when the hot air is being blown through the dryer casings counter to the direction of motion of the web, as in the steady-state drying operation. The compressed air system is also responsible for steering the web through certain restricted passages in the dryer casings and for directing it into the nips of pairs of rolls; in addition, it is employed for lifting the web from the surfaces of rolls to which it clings instead of peeling off tangentially as necessary for successful threading of the web through the dryer assembly.

In transfer from the outlet end of one dryer casing element to the inlet end of the next dryer casing element in series, the web is carried over the periphery of a cylindrical roll, which will be referred to as a turning roll. Associated with each turning roll is another roll which will be referred to hereinafter as a presser roll. While the web is changing its direction through 180°, between leaving one dryer casing element and entering the next in series, and is riding around the periphery of a turning roll, the associated presser roll rides firmly on the side of the web remote from the turning roll; at each transfer from one dryer casing element to the next in series, therefore, the web passes through the nip between a turning roll and its associated presser roll. The reason for provision of a presser roll for each turning roll is as follows: when moisture is removed from a wet web by sweeping its surfaces with hot air, the web becomes drier at its surfaces than at the middle of its thickness but, by squeezing the web in a roll nip the moisture from the middle of its thickness is forced towards the surfaces; this squeezing between rolls therefore, is a device for causing moisture to migrate from the inside of the web to its surfaces thereby giving hot air direct access to web moisture when the web passes through a dryer casing element immediately following its exit from a roll nip.

An object of this invention is to provide a highspeed web-drying device for operation at web speeds in excess of contemporary practice.

Another object is to provide a web-drying device which is smaller and less costly than those commonly in use.

Another object is to provide a web-drying device having a higher thermal efficiency than those commonly employed in the industry.

Another object is to provide a web-drying device requiring a lower power input than that demanded by present-day dryers.

Another object is to provide a web-drying device which does not employ felts.

Another object is to provide a web-drying device which

will not release excessive heat into the machine-room in which it is housed.

Another object is to provide a web-drying device which does not employ rotary steam joints.

Another object is to provide a web-dryer in which the rolls contain no moisture.

Another object is to provide a web-drying device in which the rolls are not subjected to internal fluid pressure.

Another object is to provide improved means for leading a web initially through all the elements of a web-drying device, for starting a run, or for restarting following a break in the web.

Figs. 1A, 1B and 1C conjointly show a longitudinal vertical median section through a series of nine typical elements of the dryer. All elements are similar but, throughout the length of the dryer, alternate casing elements are inverted to accommodate the reversal of direction of motion of the web in successive elements.

Fig. 2 shows a partial end elevation of the group of dryer elements.

Fig. 3 is a front elevation of the group of three dryer casing elements at the wet end of the dryer, showing more detail of construction than is disclosed in Fig. 1A.

Fig. 4 is an end elevation of Fig. 3 and shows the external ducting and piping associated with a group of three dryer casing elements.

Fig. 5 is a rear elevation of the group of three dryer casing elements at the wet end of the dryer and shows the external ducting, valving, and piping associated with a group of three dryer casing elements.

Fig. 6 is a top plan view of Fig. 3.

Fig. 7 is a partial section, on an enlarged scale, through the upper end of the first, and any odd-numbered, dryer casing element; it is in a plane normal to the web, as indicated by 7-7 on Fig. 8. This is the web-entry end of a dryer casing element.

Fig. 8 is a partial section of what is shown in Fig. 7 but is a plane parallel with the plane of the web.

Fig. 9 is an enlarged section of the upper left hand portion of Fig. 7.

Fig. 10 is a partial section, on an enlarged scale, through the upper end of the second, or any even-numbered, dryer casing element; it is in a plane normal to the web, as indicated at 10-10 on Fig. 11. This is the web-exit end of a dryer casing element.

Fig. 11 is a partial vertical median section, in the plane of the web, through the portion of a dryer casing element shown in Fig. 10, as indicated at 11-11 in Fig. 10.

Fig. 12 is, on an enlarged scale, a partial section in a plane normal to the web, through a portion of the dryer casing shown in Fig. 10.

Fig. 13 is a section through 13-13 of Fig. 12.

Fig. 14 is an enlarged section through the same portion of a dryer casing as shown in the upper right-hand part of Fig. 7.

Fig. 15 is a section through 15-15 of Fig. 3.

Referring now more particularly to Figs. 1A, 1B and 1C, it will be seen that all casing elements are similar but, throughout the length of the dryer, alternate elements are inverted to accommodate the reversal of web direction in successive elements.

As shown, the nine dryer elements are, insofar as their associated ducting is concerned, subdivided into groups of three.

The web 1 is passed successively through the entire series of dryer casings 2. Atmospheric air entering at duct 3 (Fig. 1C) passes through economizer 4 which it leaves by way of duct 5. Duct 5 is connected with manifold 6 from which branch ducts 7 (Fig. 1B) lead to air heaters 8. From air heaters 8 hot air leaves by way of ducts 9 from which branch ducts 10 convey air to blowers 11. As shown, each group of three dryer elements 2 is provided with a pair of blowers 11 driven by a common motor 12. From blowers 11 hot air passes through ducts 13 to four-way valves 14.

In Figs. 1A, 1B and 1C the four-way valves 14 are all shown with movable valve members 15 in the position in which they are held during the operation of drying web 1; in steady-state drying of web 1 the hot air leaving blowers 11 by way of ducts 13 is directed by four-way valves 14 to dryer casings 2 in such a manner that the direction of the hot air through dryer casings 2 is counter to the direction of motion of web 1. Considering the steady-state web-drying operation, with movable valve members 15 oriented as shown solid in Fig. 1, hot air passes from valves 14 through ducts 22 to the ends of casings 2 from which web 1 is leaving. The hot air passes through casing 2 in a direction counter to web 1 and leaves the first casing of a group of three by way of jumper ducts 23. Hot air from jumper ducts 23 enters the next element of the group of three dryer casings 2 and passes through this dryer casing 2 in a direction counter to the motion of web 1. Leaving this second casing element 2 of the group of three the hot air passes through another pair of jumper ducts 23 and enters the third element of the group of three dryer casings 2. Passing through this third element of dryer casing 2, again in a direction counter to the motion of web 1, the hot air leaves this third element of dryer casing 2 by way of ducts 24 which lead to four-way valves 14. The hot air leaves four-way valves 14 by way of branch ducts 16 which lead it to duct 17 and thence it flows by way of duct 18 to manifold 19. From manifold 19 it passes through duct 20 to economizer 4. On leaving economizer 4 the air is rejected to waste through outlet duct 21.

Hot air leaving the dryer assembly by way of manifold 19 is not only loaded with moisture but it is hotter than the atmospheric air entering economizer 4 by way of duct 3. In economizer 4, therefore, the air and water vapour from manifold 19 give up heat to the fresh air entering the system through duct 3 and this air, which leaves economizer 4 by way of duct 5 and enters the dryer system by way of manifold 6, is preheated by waste heat from the spent air and water vapour from manifold 19.

When starting a run, or when restarting after a break, the movable valve members 15 are turned through 90° and assume the orientation as shown dotted at 15' in Fig. 1. With the movable valve members 15 oriented as shown at 15' the hot air leaving blowers 11 by way of ducts 13 is directed into ducts 24 which now feed air to the ends of dryer casings 2 at which web 1 enters dryer casings 2. The heated air is then driven through dryer casings 2 in the direction of motion of web 1 and, after passing through jumper ducts 23 in the opposite direction to that in which it flowed during steady state drying, the air leaves the third element of each group of three dryer casings 2 by way of ducts 22 and leaves four-way valves 14 by way of ducts 16 and 17 and thence by way of branch ducts 18, manifold 19 and duct 20 to economizer 4 from which it is rejected to waste via duct 21.

The arrangement of four-way valves 14, as shown in Figs. 1A, 1B and 1C, is a convenient device for reversing the direction of the air flow through dryer casings 2. Flowing the air through dryer casings 2 in the direction of motion of web 1 makes possible the threading of web 1 through the dryer casings 2, and flowing the air through dryer casings 2 in the direction counter to the motion of the web provides the condition required for efficient heat exchange between the hot air and the web 1 and for effective removal of the moisture released from the surfaces of the web.

With reference now to Figs. 3 to 15, consider conditions when the web is being led into and through the dryer at the start of a run.

As indicated in Fig. 5 the movable valve members 15' of four-way valves 14 are so oriented that the hot air from ducts 13 will be driven through casings 2 in the direction of motion of web 1.

Air at relatively high pressure from a source of compressed air is fed by manifolds 46 to branch pipes 47,

48, 49, 50, 51 and 52 (best shown in Fig. 5) which lead to ports 53 (Figs. 7 and 9), 54 (Figs. 7 and 14), 55 and 56 (Figs. 10 and 12), 57 and 58 (Figs. 7 and 14) respectively.

Ports 53 feed air jets 29 and 60 (Fig. 9). Ports 54 feed jets 30 and 61 (Fig. 14). Ports 55 feed jets 42 and manifolds 38; manifolds 38 feed jets 39 (Figs. 10, 11 and 12). Ports 56 feed manifolds 38' which in turn feed jets 39' (Fig. 12). Ports 57 feed jets 32 and 59; ports 58 feed jets 59' (Figs. 7 and 14).

Web 1 entering the dryer by way of guide rolls 25 is passed by air guide 26 into the nip between presser roll 27 and turning roll 28 (Figs. 3, 7 and 9).

On leaving the nip between guide rolls 25 the web 1 may cling to the surface of one or other of these rolls but high pressure air issuing from jets 29 (Fig. 9) lifts web 1 off the roll surface and momentum carries it into the throat of air guide 26 through which it is propelled by air jets 60 until it is caught in the nip between presser roll 27 and turning roll 28 (Figs. 3, 7 and 9).

On leaving the nip between presser roll 27 and turning roll 28, if web 1 should cling to the surface of presser roll 27 it is lifted off by jets 61 (Fig. 14) and momentum carries it into the gap between the periphery of turning roll 28 and air guide 31. Air from jets 30 deflects web 1 towards the periphery of turning roll 28 and prevents contact of web 1 with the surface of air guide 31; it also drives web 1 towards the entrance to casing 2.

If web 1 clings to the surface of turning roll 28 it is lifted off by jets 32 and momentum, aided by air from jets 30, carries it into the entry-throat of casing 2 where it is caught by jets 59 and 59' which then steer and propel it into the portion of casing 2 generally indicated by 35 (Figs. 7 and 14).

Two streams of hot air are directed by movable valve members 15' of four-way valves 14 along ducts 24 (Figs. 4 and 5) to casing elbows 33 in which turning vanes 34 (Figs. 7 and 8) steer them to turning vanes 36 (Figs. 7 and 14) which direct them through the long vertical run of the first of a group of three casings 2.

The leading end of web 1, having been propelled by jets 59 and 59' into the portion of casing 2 generally indicated by 35 (Figs. 7 and 14) is caught in the two streams of hot air from turning vanes 36 (Figs. 7 and 14) and is carried through the long vertical run of the first of a group of three casings 2.

At the web-exit end of casing 2 in the region generally indicated by 40 the two streams of hot air leave the long vertical run of casing 2 by way of turning vanes 37 (Figs. 3, 10, 11, 12 and 13) thence the two streams of air pass through casing elbows 33 at the web-exit end of the first of a group of three casings 2 into jumper ducts 23 (Figs. 4, 5, 6 and 15).

Web 1 entering the web-exit zone of casing 2 as generally indicated by 40 is deprived of the driving force of the two streams of hot air as they leave casing 2 by way of turning vanes 37 but now web 1 is caught by the streams of high-pressure air issuing from jets 39 and 39' in manifolds 38 and 38' respectively and driven to and through the web exit throat of casing 2 (Figs. 10, 11, 12 and 13). Air from jets 42 deflects web 1 from contact with air guide 41 (Figs. 3, 10 and 12) and towards the surface of turning roll 28.

Air from the jets 39 and 42 escapes by way of ports 43 (Figs. 10 and 12) and pipes 44 (Figs. 3, 4 and 5) and is returned to casing 2 via bosses 45 (Figs. 4 and 5). Air from jets 39' escapes by way of ports 62 (Figs. 10 and 12) and returns to casing 2 which is at a lower pressure.

When web 1 leaves the nip of presser roll 27 and turning roll 28 it progresses through subsequent casings 2 in exactly the manner described above with reference to its passage into, through, and out of the first casing 2 of the series. As mentioned earlier, the web passes

vertically downwards in the odd-numbered casings 2 and vertically upwards in the even-numbered casings 2. In principle it could be vice-versa but the odd-down even-up arrangement is preferred as being more convenient.

Hot air passes from the web-exit end of the first of three casings 2 to the web-entry end of the second of three casings 2 by way of jumper ducts 23 (Figs. 4, 5 and 15). In the same manner the hot air passes from the web-exit end of the second of three casings 2 to the web-entry end of the third of three casings 2.

On leaving the web-exit end of the third of three casings 2 the hot air passes through ducts 22 (Figs. 4 and 5) by way of four-way valves 14 to ducts 16 and, via ducts 17, branch ducts 18, manifold 19, and duct 20 to economizer 4.

When the web has been threaded through the entire dryer assembly, which may consist of, say, forty-five dryer casings 2 in fifteen groups of three, the direction of flow of the hot air through the casings 2 is reversed, preferably in one three-casing group at a time, by turning the movable valve members 15' of four-way valves 14, a coupled pair at a time, through 90° so that they assume the positions which direct the hot air through casings 2 in the direction counter to the motion of web 1.

Also, as soon as the web has been threaded through the entire dryer assembly, the compressed air supply to manifolds 46 (Figs. 3, 4 and 5) is turned off.

The turning rolls 28 constitute mechanical web propelling means for moving the web through the various elements of the dryer during the web drying operation. These rolls are driven, by any suitable drive means, at speeds controlled to maintain proper tension in the web and to pass it through the dryer at the desired rate. The presser rolls 27 are freely journaled rolls whose sole function is to exert pressure on the web to force moisture from the interior to the surfaces of the web. These turning and presser rolls contain no moisture and are free of internal pressure.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Web drying apparatus adapted to thread the web therethrough before subjecting it to counter-current air drying, comprising means defining an elongated drying chamber having an opening at each end for the passage of a vertically aligned web, means for guiding the vertically aligned web through each of the end openings, and means for selectively admitting two streams of air at alternate ends of the chamber to flow longitudinal thereof in contact with opposite sides of the web, said last-named means comprising duct means for supplying the air streams and communicating with the chamber at oppositely disposed ports adjacent each end opening in the chamber, means associated with the duct means for dividing the air supply into two equal streams and selectively introducing the equal streams through the ports at alternate ends of the chamber, and means associated with the ports for directing the equal air streams into engagement with opposite sides of the web in a direction inclined toward the opposite end of the chamber.

2. Web drying apparatus according to claim 1 wherein the air supply dividing and introducing means associated with the duct means comprises a pair of blowers connected with common driving means and valve means disposed in the duct means intermediate the pair of blowers and the ports.

3. Web drying apparatus according to claim 2 wherein the duct means includes a pair of ducts each of which communicates with one of the ports at each end of the chamber and each of the blowers is associated with one of the pair of ducts, and the valve means includes a valve disposed in each duct intermediate the blower associated therewith and the ports with which it communicates.

4. Web drying apparatus according to claim 3 further

comprising heat transfer means associated with the duct means and with which each of the pair of ducts communicates, each of the valves being adapted to divert effluent air from the chamber to the heat transfer means to pre-heat the air supply to the blowers.

5. Web drying apparatus according to claim 1 wherein the air stream directing means associated with the ports comprises a series of vanes so disposed in each port as to direct the air stream introduced therethrough in a direction inclined towards the opposite end of the chamber.

6. Web drying apparatus according to claim 1 wherein the web guiding means comprises air jets disposed adjacent the inside peripheral portion of each end opening to operatively engage the web at its sides.

7. Web drying apparatus according to claim 6 wherein the air jets are mounted in manifold extending transverse the mouth of the ports adjacent the end opening.

8. Web drying apparatus according to claim 1 wherein the web guiding means comprises a pair of rollers so disposed adjacent each end opening as to form a nip for the web and means disposed between the nip of the rollers and the adjacent end opening for guiding the web therebetween.

9. Web drying apparatus according to claim 8 wherein the means for guiding the web between the nip of the rollers and the adjacent end opening includes air jets disposed to operatively engage the web at its sides.

10. Web drying apparatus adapted to thread the web therethrough before subjecting it to counter-current air drying, comprising means defining a plurality of parallel, elongated drying chambers each having an opening at each end for the passage of a vertically aligned web, means for guiding the web through each of the end openings, means for guiding the web between adjacent

end openings of a pair of the chambers, and means for selectively admitting two streams of air at alternate ends of each chamber to flow longitudinal thereof in contact with opposite sides of the web, said last-named means comprising duct means for supplying the air streams and communicating with the chamber at oppositely disposed ports adjacent each end opening in the chamber, means associated with the duct means for dividing the air supply into two equal streams and selectively introducing the equal streams through the ports at alternate ends of the chamber, and means associated with the ports for directing the equal air streams into engagement with opposite sides of the web in a direction inclined toward the opposite end of the chamber.

11. Web drying apparatus according to claim 10 wherein the means for guiding the web between the adjacent end openings of the pair of chambers includes a pair of rollers so disposed between the adjacent end openings as to form a nip for the web, means defining a curvilinear passage for the web with the cylindrical surface of one of the rollers between each of the adjacent end openings and the nip of the rollers, and air jets disposed to operatively engage the web at its sides and urge it through the passage between each of the adjacent end openings and the nip of the rollers.

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