Aug. 10, 1965 O. HULTGREEN 3,199,222

APPARATUS FOR DRYING MOVING WEBS

Filed Sept. 12, 1960 2 Sheets-Sheet 1

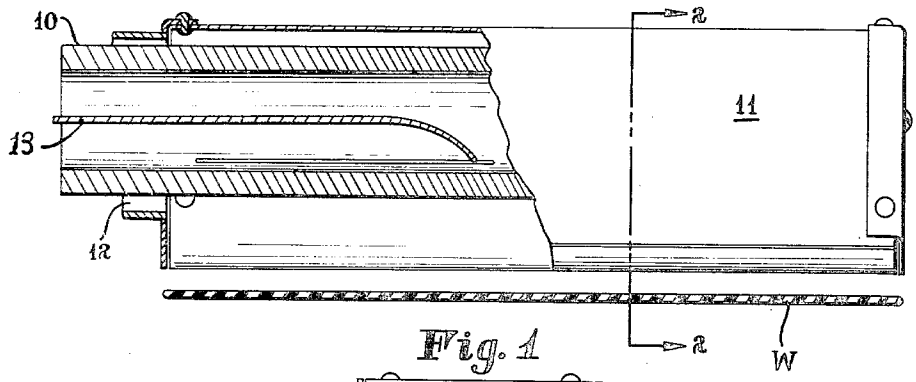


Fig. 1

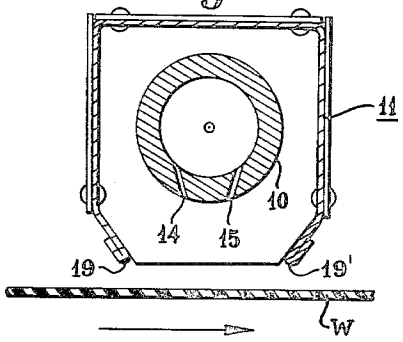


Fig. 2

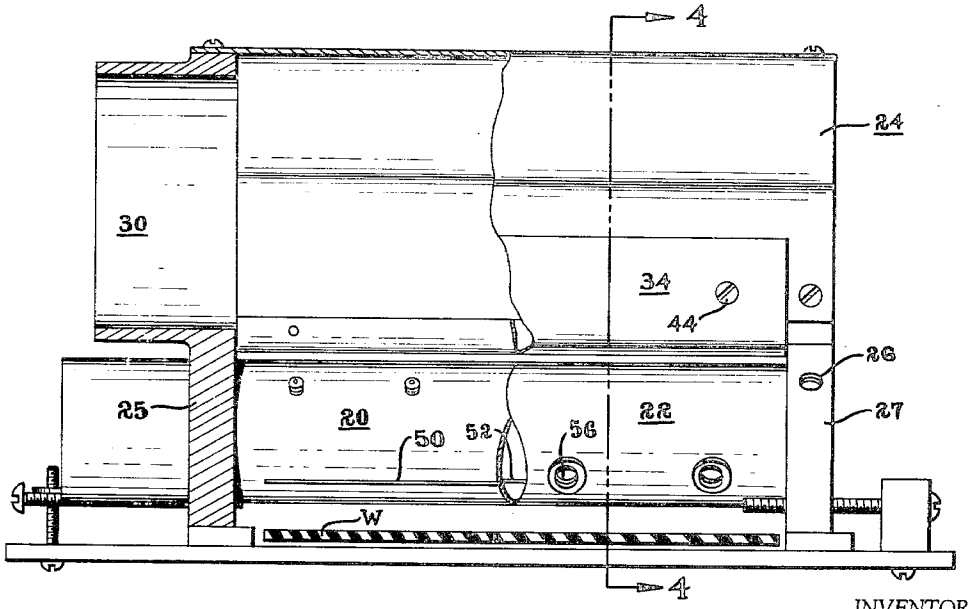


Fig. 3

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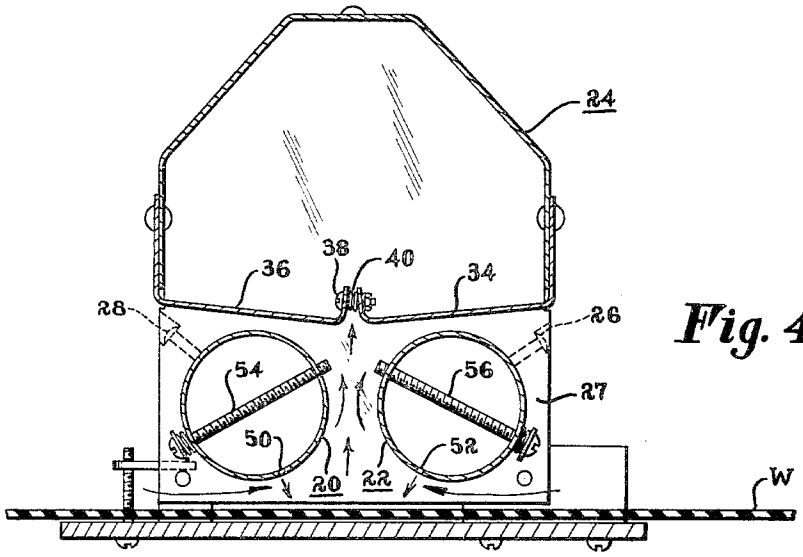


Fig. 4

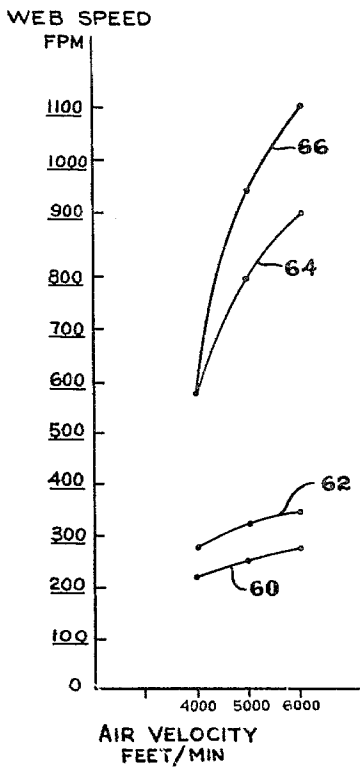


Fig. 5

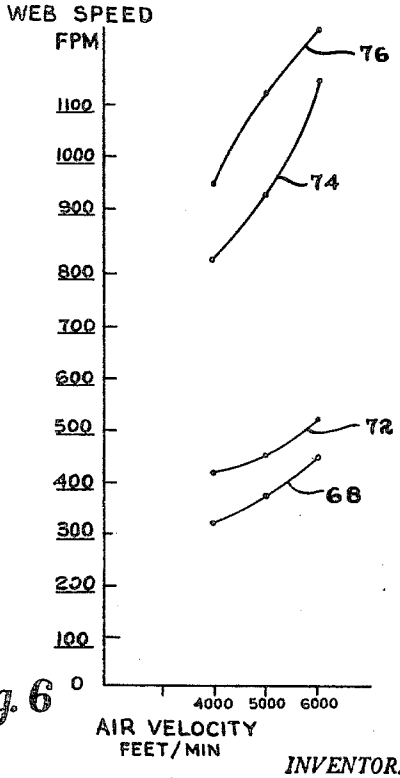


Fig. 6

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APPARATUS FOR DRYING MOVING WEBS

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This invention relates to apparatus for drying moving webs and more particularly to an apparatus adapted to remove moisture from traveling webs through the kinetic energy of a high velocity gaseous medium and the heat of the medium.

This apparatus represents an improvement on the apparatus described in my Patent No. 2,861,354, issued November 25, 1958. In the device disclosed in that patent, the combination of radiant energy and a high velocity gaseous medium is employed to achieve a drying action on a moving web. However, the use of radiant energy is not practical where electricity is not available at a reasonable price. Further, electricity cannot be employed where explosion-hazard solvents are used.

In prior drying devices, the problem of handling toxic and explosive vapors has been dealt with by employing large hoods which enclose a number of fluid nozzles and a large portion of the web. These hoods are extremely bulky and cannot be employed within existing machinery, such as rotogravure presses. Further, these devices have a relatively low efficiency, thus requiring a large number of drying fluid nozzles and a low web speed.

Accordingly, it is an object of this invention to provide an improved apparatus for drying moving webs.

It is another object of this invention to provide an improved apparatus for drying moving webs which does not require or utilize electrical energy in the regions adjacent the web.

It is another object of this invention to provide a drying apparatus which is extremely compact, simple in construction, and efficient in operation.

It is a still further object of this invention to provide a drying apparatus for moving webs which eliminates the problem of the removal of fumes by exhausting the fumes between jets with high velocity gas evenly distributed over the web width.

It is another object of this invention to provide a drying apparatus which can be efficiently employed with a high speed web.

Briefly, I have discovered that the variable factors which are of importance in achieving a satisfactory drying operation are the velocity of the stream of drying fluid, the thickness of the stream of fluid, the distance from the jet opening to the web, the angle of the fluid stream with respect to the web, the temperature of the fluid stream, and an even exhaust of fumes over the width of the web.

In accordance with aspects of this invention, a simple and efficient drying apparatus is provided which utilizes one or more jets or elongated nozzles directed at angles with respect to the moving web. The exhaust gases are removed from the outer edges of the jets or they may be removed from between the jets. In the preferred embodiment, the nozzles are angularly disposed to direct fluid streams in converging directions. The resulting structure, which may be called a double-nozzle or double-jet assembly, may be inserted along the belt at any point at which drying is desired. Since these double-jet structures are relatively small, they may be inserted in existing machinery such as printing presses and rotogravure presses without modifying the existing structures.

In accordance with other aspects of this invention, the apparatus is provided with structure which permits the easy adjustment of the direction of the air jets with respect to the moving web.

In accordance with other aspects of this invention, the width of the elongated jet nozzles may be varied accurately to control the width of the fluid jet issuing from the nozzle.

In accordance with still other aspects of this invention, a double air jet or fluid jet device may be produced from a single pipe which is substantially enclosed within a structure which houses the exhaust ducts. With such an arrangement, the housing may be placed in close proximity with the moving web and the gases resulting from the drying operation will be removed rapidly without permitting any escape of these gases, thereby eliminating the hazards of the fumes, such as the possibility of explosion or contamination of the air. Advantageously, spaced slots may be formed in a single tube, which slots are parallel to the axis of the tube and may be angularly disposed relative to the radius of the tube such that the streams issuing from the two slots or orifices will converge at the surface of the web.

In accordance with still other aspects of this invention, the jets may be produced by individual slotted tubes which are rotatably mounted in a housing, which housing extends perpendicularly to the direction of the web travel. By rotation of the tubes relative to the housing, the angle of fluid flow incident to the belt can be accurately controlled. Further, the exhaust fumes may be removed from between the tubes by an exhaust system which is formed integrally with the housing. Also, the amount of surrounding air which is swept into the exhaust system can be accurately controlled by controlling the separation between the pair of pipes and the housing. Since the housing is integral with the pipes which produce the jet or fluid flow, these devices may be installed as serially positioned units without the use of a large hood to enclose the series of units. With such a simple arrangement, it is possible to remove, clean and adjust one of the units without terminating the movement of the belt and thus without stopping the drying process. By utilizing the novel structure of this invention, belt speeds can be increased greatly while achieving a satisfactory drying operation and while eliminating the hazards incident to some of the prior art devices. Further, by acting only on the surface of the web, it is not necessary to enclose a portion of the web within a hood. For industrial drying ovens, large rotogravure presses, coating and varnishing machines, a construction with a number, for example, 6 to 24, of adjustable jet tubes in a common housing will be the most economical and efficient installation.

Accordingly, it is a feature of this invention to provide a drying apparatus with one or more angularly disposed, elongated nozzles.

It is another feature of this invention to provide a drying apparatus for a moving web with a pair of opposed elongated nozzles and a housing which encloses the nozzles and includes the exhaust system for the apparatus.

It is another feature of this invention to employ in a drying apparatus a housing, a pair of tubes in the housing, each having an elongated aperture therein and means for adjusting the tubes relative to the housing whereby the angle of incidence of the fluid streams issuing from the apertures in the tubes may accurately be controlled.

It is a still further feature of this invention to employ in a drying apparatus a housing, a pair of tubes rotatably mounted in the housing, an exhaust tube connected to said housing, and means for controlling the opening between the tubes and the housing, thereby controlling the exhaust fumes and scavenging air drawn from the region of the web.

It is another feature of this invention to employ in a drying apparatus for moving webs a housing, a pair of

tubes having their axes parallel to the axis of the housing and means for rotating the tubes relative to the housing, each of the tubes being provided with an elongated slot, means for adjusting the width of the slot, and exhaust passage means for exhausting the gases from between the tubes in which the aperture to the exhaust passage may accurately be controlled.

These various other objects and features of the invention will be more clearly understood from a reading of the detailed description of the invention in conjunction with the drawing, in which:

FIGURE 1 is a view in elevation, partly in section, of one illustrative embodiment of this invention;

FIGURE 2 is a view taken along the lines **2—2** of FIGURE 1;

FIGURE 3 is a view in elevation, partly in section, of a preferred embodiment of this invention;

FIGURE 4 is a view taken along the lines **4—4** of FIGURE 3; and

FIGURES 5 and 6 are graphical representations of web speed versus air velocity showing a comparison between the devices presently known in the art and the device which is the subject of this invention. For comparison, the gas is applied over the same drying area in each example.

Referring now to FIGURE 1, there is depicted a drying apparatus according to one embodiment of this invention in which a pipe **10** is positioned within a housing **11**. The housing **11** is provided with an exhaust tube **12**. A deflecting baffle **13** is provided to equalize the distribution of heating fluid from the tube **10**.

As best seen in FIGURE 2, the pipe has a pair of elongated slots extending parallel to the axis of the tube and angularly disposed relative to the diameter of the tube such that the slots **14** and **15** direct converging streams of fluid onto the belt or web W. Advantageously, the positioning of the housing **12** relative to the web W may accurately be controlled and is preferably limited to a distance such that the orifices **14** and **15** are within the range of ⅛ inch to ¾ inch from the web. With such an arrangement, the air volume required is of the order of 10 to 50 cubic feet per minute for a tube which is 10 feet long and in which the width of the slots is from .010 to .050 of an inch. Advantageously, with this arrangement, the exhaust is evenly obtained over the width of the web W and the required air velocity is much less than in high velocity air dryers. For example, the air velocity need be no greater than 7,000 to 8,000 linear feet per minute, whereas velocities of the order of 15,000 to 20,000 linear feet per minute are commonly used in high velocity air dryers. Also, advantageously, the entire assembly is very compact. For example, this embodiment may be made with the housing **12** which is of the order of 3 inches in width, measured in the web direction.

A device of this type is very light. It may be fabricated from aluminum or other light metals and in one illustrative embodiment weighs only two pounds for each 10 inches of web width. Devices of this type are easy to maintain. They can be removed individually, cleaned, adjusted and replaced in a matter of a very few minutes. Since they are often used in groups, the drying process need not be terminated while one of the devices is being serviced. These devices are economical with regard to blower energy consumption and volume of air required. The angle of incidence of the jet of fluid and the moving web can accurately be controlled merely by rotating the tube **10** relative to the housing **11**. There is no leakage of fumes from the unit since the housing accurately retains the fumes within the active field of the scavenging air which enters the housing **11** around the edges **19** adjacent the web W.

Referring now to FIGURES 3 and 4, there is depicted the preferred embodiment of this invention in which a pair of tubes **20** and **22** is employed to supply the fluid to the web. These tubes are mounted in a housing **24** which includes end members **25** and **27** and are retained by individual set screws, such as **26** and **28**, such that the set screws may be released, the tubes **20** and **22** are rotated and the set screws rotated to secure the pipes in their rotated position. Conduit **30** is the exhaust conduit which terminates in end member **25** of housing **24** above the pipes **20** and **23**. A pair of plates **34** and **36** is positioned within the housing **24** above the tubes **20** and **22** and have their edges spaced by means of nut and bolt assemblies, such as **38**, with springs **40** retained between the plates **34** and **36** and encircling the bolt of the assembly **38**. With such an arrangement, accurate adjustment of the exhaust opening of the plates **34** and **36** may be achieved by adjusting the assemblies **38**.

As best seen in FIGURE 4, plate **34** is connected to the housing **24** by means of screws, such as **44**. These screws **44** may be removed and the plates, such as **34**, lowered into contact with the tubes **22** to make a closed-in assembly, which enables re-circulation to reach higher economy when gases which are not explosion hazardous are evaporated. If these plates **34** and **36** are retained in the position shown in FIGURES 3 and 4, scavenging air will be drawn in between the tubes **20** and **22** and the plates **34** and **36**, enabling surplus air to be sucked in and mixed with these gases before the gases enter the exhaust system. The jet streams of gas are produced through slots, such as **50** and **52**, in tubes **20** and **22**, respectively, which slots extend axially the length of the tube. Advantageously, the aperture defined by these slots may accurately be controlled by means of screws, such as **54** and **56**, respectively. The apertures employed are of the order of .010 to .050 of an inch.

It is preferable that the housing **24** be mounted adjacent the web such that the space between the slots **50** and **52** and the web W is of the order of ⅛ inch to ¾ inch. With this preferred embodiment, it is possible completely to regulate the air or fluid to form the thinnest usable stream. It is further possible to adjust this stream to have the same velocity over the entire width of the web by adjusting the width of the slots. For example, the slots may taper in width, being widest at the end remote from the intake end of the tube. It is also possible to adjust the angle of each of the jets of fluid to the most suitable angle for the particular materials involved. It is further possible to regulate the exhaust slot to obtain an even exhaust over the width of the web by providing a small separation between the plates **34** and **36** and the tubes **20** and **22**, respectively. It is possible to draw in secondary air from around the apparatus, thus extracting dangerous fumes to prevent explosion or contamination of the air without cooling the web surface.

Referring now to FIGURES 5 and 6, there are depicted graphical representations of the comparative operating characteristics of the devices according to this invention and the device of the prior art in which identical belt lengths are acted on. As seen in FIGURE 5, which is a plot of air velocity in feet-per-minute as the abscissa, and web speed in feet-per-minute as the ordinate, the curve **60** represents a prior art device operating with an air jet at 70° F. With such an arrangement, web speeds of from 250 to 300 feet-per-minute constitute the usable range. If the temperature of the fluid used with this prior art device is elevated to 150° F., curve **62** indicates usable range of web speeds. If, however, apparatus of the type depicted in FIGURES 3 and 4 is employed with a fluid of 70° F., the range of web speeds may be in accordance with curve **64**. If the temperature of the drying fluid is elevated to 150° F., the curve of **66** will indicate the range of web speeds. For the purpose of this comparison, the novel structure in accordance with this invention occupies the same lateral space along the web as does the prior art devices. From a comparison of the curves **60** and **64**, it is apparent that for a given velocity of air of the order of 4,000 feet-per-minute, the maximum

attainable belt speed with the prior art device is of the order of 250 feet-per-minute compared to 600 feet-per-minute in the illustrative embodiment of this invention. If the air velocities were increased to 6,000 feet-per-minute, the prior art device could operate with a belt speed of 300 feet-per-minute as opposed to a belt speed in excess of 900 feet-per-minute with this novel apparatus. If the temperatures of the operating fluid were elevated, even greater disproportionate results were achieved. For example, at 6,000 feet-per-minute and a 150° F. temperature, the prior art device could operate with a belt or web speed at slightly less than 400 feet-per-minute, whereas in the illustrative embodiment depicted in FIGURES 3 and 4, belt speeds in excess of 1100 feet-per-minute are possible. These results are at least partly attributable to the co-operating pairs of tubes which issue angularly converging jets which "shear" the fluid from the web or utilize the kinetic energy of the drying fluid to decrease or destroy the surface tension of the fluid in the web.

The plot of FIGURE 5 was made with regard to a particular solvent which was being dried from the web. In this instance, the solvent was xylol. If a different solvent, for example, toluol, is employed, different results are achieved. In the instance of toluol, FIGURE 6 is a graphical representation of the results achieved. Curve **68** represents the results achieved in the prior art devices at 70° F., while curve **72** illustrates the operation at 150° F. Curve **74** represents the operation of the illustrative device of FIGURES 3 and 4 at 70° F., while curve **76** illustrates the operation of the preferred embodiment at 150° F. It is to be noted that belt speeds in excess of 1100 feet-per-minute are possible even at 70° F. if the air velocity is of the order of 6,000 feet-per-minute in the preferred embodiment of this invention. In contrast, the prior art devices employing the same air velocity are restricted to a belt speed of only 450 feet-per-minute.

Since these devices operate only on the surfaces of the web, it is not necessary that the web be transported through a hood as is employed in the prior art types of devices.

While I have described and discussed the device as using pre-heated fluid, such as air, it is understood that precooled fluid may be employed.

As a still further advantage of this structure the temperature of the fluid is maintained substantially constant at each point on the orifice, whereas in the prior art types of devices which employ heaters in the tubes, temperature ranges as extreme as 50° F. have been measured along the orifice, which variation causes a highly irregular or uneven drying operation. In the illustrative embodiments of this invention, a high degree of uniformity of drying is achieved. As previously mentioned, it is also possible to adjust the exhaust slot to compensate for differences in velocity in exhaust gases such that the volume of exhaust gases will be substantially uniform throughout the length of the apparatus.

While I have shown and described various embodiments of my invention, it is understood that the principles thereof may be extended to many and varied types of apparatus. The invention, therefore, is not to be limited to the details illustrated and described herein.

What is claimed is:

1. Apparatus for drying a moving web comprising in combination, an exhaust housing compartment extending across the width of the moving web and having an elongated exhaust opening positioned to receive fluids from the surface of the web and extending across the width of the moving web, end members extending from said housing on either side of said moving web and terminating in mounting means over which the web moves to space the exhaust housing away from the web to define an open treating zone on the surface of the web as it moves through open sides disposed between said end members, two inlet tubes for receiving drying fluid flow therethrough and mounted between the end members in a position between the housing and moving web on opposite sides of the elongated exhaust opening and each having a single slit extending across the width of the moving web to direct the fluid with the two slits being disposed to converge two thin streams of fluid across the width of the web intermediate the two inlet tubes, one said slit directing fluid in the direction of web travel and the other said slit directing fluid opposite the direction of web travel to scavenge the surface of the web, and suction means for exhausting from said housing through the elongated exhaust opening intermediate said tubes the scavenging air flow from said tubes mixed with surplus air entering from the sides of said open treating zone.

2. Apparatus for drying a moving web according to claim 1 further including means for rotatively mounting said tubes relative to said housing whereby the angular direction of said aperture is controlled relative to said web.

References Cited by the Examiner

UNITED STATES PATENTS

1,590,417	6/26	Brunk	34—160 X
1,595,478	8/26	Minton	34—16
2,349,558	5/44	Offen	34—122
2,370,811	3/45	Osgood	34—23 X
2,402,545	6/46	Frum	34—160
2,464,119	3/49	Dawson	34—155
2,499,572	3/50	Dunakin et al.	34—156 X
2,558,097	6/51	Maurer et al.	34—155
2,691,225	10/54	Kamprath	34—18
2,804,693	9/57	Brodie	34—18
2,828,552	4/58	Brendel	34—122 X
2,941,062	6/60	Halley	34—160 X

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