Aug. 10, 1965 E. C. BROWN 3,199,224

APPARATUS FOR TREATING CONTINUOUS LENGTH WEBS COMPRISING HIGH VELOCITY GAS JETS

Filed April 3, 1962 2 Sheets-Sheet 1

Fig. 1.

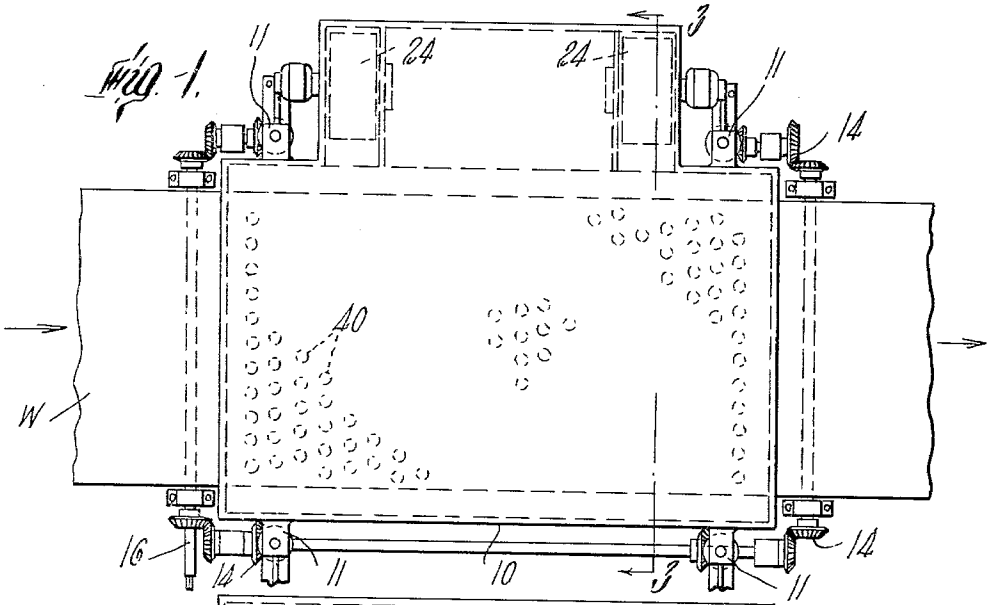


Fig. 2.

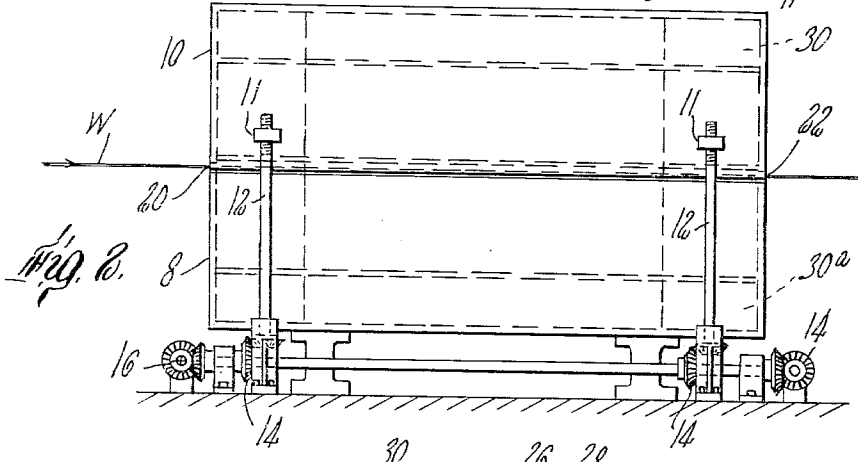


Fig. 3.

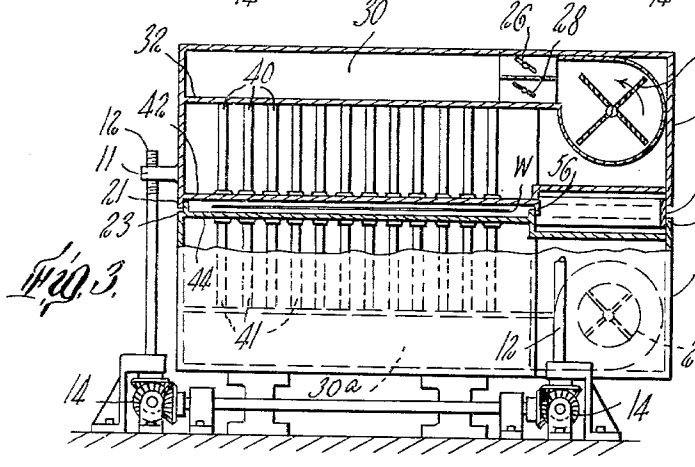
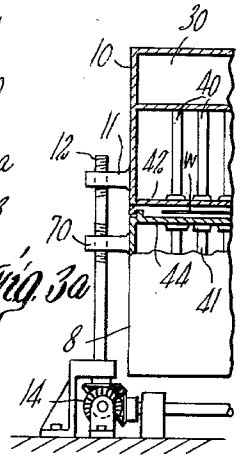


Fig. 3a



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APPARATUS FOR TREATING CONTINUOUS LENGTH WEBS COMPRISING HIGH VELOCITY GAS JETS

Filed April 3, 1962 2 Sheets-Sheet 2

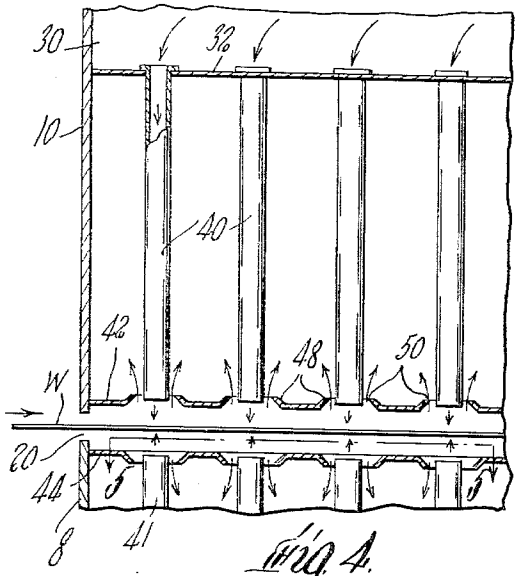

Fig. 4.

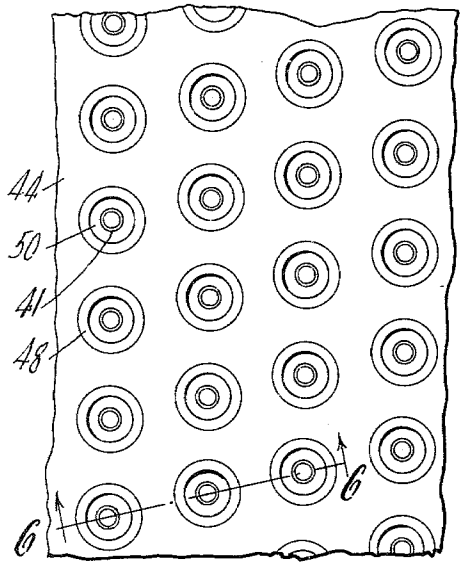

Fig. 5.

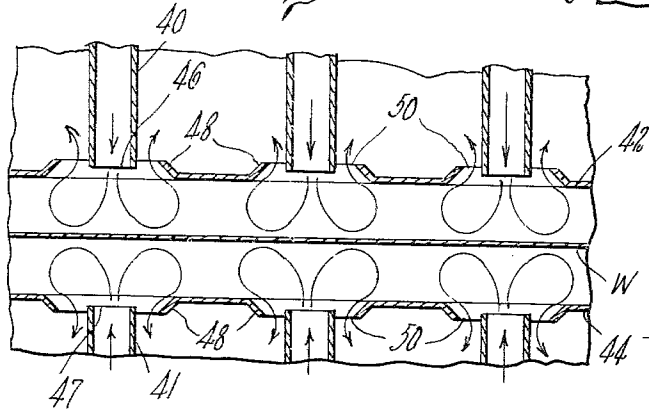

Fig. 6.

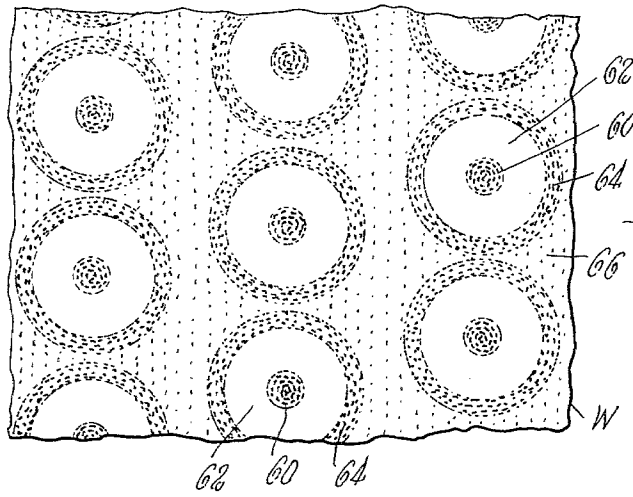

Fig. 7.

United States Patent Office 3,199,224 Patented Aug. 10, 1965

3,199,224

APPARATUS FOR TREATING CONTINUOUS LENGTH WEBS COMPRISING HIGH VELOCITY GAS JETS

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3 Claims. (Cl. 34—156)

This invention relates to apparatus for treating webs for heat transfer purposes or for causing chemical reactions therein, as in treating webs coated or impregnated with thermosetting or polymerizable plastic or resinous compounds, for example, in the manufacture of battery separator webs or the preheating of resin-impregnated papers in preparation for pleating, as in the manufacture of filters, and to the method of handling such webs exemplified in the use of such apparatus.

The drying or setting-up treatment of webs which have coating or impregnating materials applied to both sides thereof presents certain problems with respect to uniformity of treatment. If one side is first coated and treated, and then the other side, the first coating tends to be overtreated during exposure of the coating on the second side in the subsequent treatment. If both sides are treated simultaneously, handling problems arise. If conveyors are utilized, even of the open-mesh type, the conveyor tends to mar the coating or to shield the supporting surface of the web from direct and equal treatment with other portions of the web, or both. Where continuous processing of such webs is desired, it has hence been necessary to resort to the use of costly apparatus adjuncts, for example, tenters or other tensioning devices, to hold both surfaces of the web out of contact with the elements of the drying or treating apparatus. As the width of the material increases and its tensile strength decreases, such tenters and the like have a tendency to cause ruptures or tears if sufficient tension is applied to prevent the wide webs from contacting portions of the treating apparatus.

It is a primary object of this invention, therefore, to provide an apparatus for treating relatively wide webs for heat transfer or impregnant polymerization or the like with the length of the material being treated being unsupported at its sides and under only sufficient tension to move it forwardly as by pulling one end of the web with feeder rolls or the like, while providing means for constraining the unsupported length of web being treated to move in a substantially single horizontal plane despite the fact that the pulling tension would be insufficient in and of itself to prevent the moving web from drooping out of a single plane. In this manner, the disadvantages and dangers present with the use of cross-tensioning devices, such as tenter frames, and the like are completely avoided.

The objects of the invention are accomplished by utilizing as the heat transfer medium hot air jets which are directed perpendicularly towards the web, both from below and from above, and so controlling the geometry, including the spacing, and the path of flow and the velocity of the air streams that the web floats in a plane substantially midway between the orifices from which the opposed jets originate.

It has heretofore been proposed in Dungler Patent No. 2,682,116 to provide apparatus wherein side gripping devices convey a tensioned web through a dryer having a succession of parallel slits extending transversely of the path of the web disposed in alignment above and below the web, and between which guide and supporting rollers for the web are provided. The contact of the latter rollers with the web, in particular, is detrimental to the most efficient drying operation, and may be unusable in the case

of certain tacky surfaces where the rollers would tend to remove portions of the impregnant or coating.

The same patentee proposed staggering the slits above and below the pathway so that cloth fed therebetween could assume a wavy appearance with the air passing directly through a cloth web into a vacuum area located opposite the transverse slit. Such an operation is exceedingly difficult to control, and of course, should not be utilized in any case where such distortion of the web would be harmful to the quality of the product. For example, certain material, such as battery separator plate material, has a stiffness which would prevent its assuming such a wavy appearance without cracking or breaking the brittle material and such undue flexing and disruption of the impregnant surface coating is obviously undesirable in many other cases.

In accordance with this invention, I produce a floating feed of untensioned web through an air dryer, not by staggering parallel full width air streams longitudinally above and below the pathway to create vacuum areas between the orifices, but by directing air towards the web both from above and below only in discrete areas spaced both longitudinally and transversely of the pathway with the air streams in opposed aligned relation. The web is constrained along its length to move along a substantially plane path because the surfaces of the web as it moves are contacted along selected equal and opposite areas of both sides thereof with substantially equal volumes of air having little or no velocity but elevated pressure, and along intervening equal and opposite discrete areas segregated both longitudinally and transversely of the path of movement of said length of material, with substantially equal volumes of lower pressure air moving at high velocity normally into, along, and substantially normally out of contact with the surfaces of the web between said selected areas.

The building up of a static pressure which is equal on both sides of the web throughout a matrix is accomplished by providing two opposed apertured plates which lie in planes spaced slightly closer together than the planes of jet nozzles extending into the apertures, and by locating and shaping exhaust ports in such manner that certain air between the exhaust ports remains substantially undisturbed. For this purpose the exhaust ports surround the individual nozzles and are so proportioned with respect to the orifices of the nozzles as to exhaust the gases at approximately the same cubic foot per minute rate as their rate of issue from the orifices.

Such a construction may be better understood by reference to the accompanying drawings, illustrating a form of apparatus useful in practising the method of the invention and in which:

FIG. 1 is a plan view of such an apparatus;

FIG. 2 is a side elevational view thereof;

FIG. 3 is a cross-sectional view taken along the line 3—3 of FIG. 1;

FIG. 3*a* is a cross-sectional detail of a modified form of apparatus;

FIG. 4 is an enlarged cross-sectional detail of a certain part of the apparatus;

FIG. 5 is a representation of the nozzle pattern of the apparatus;

FIG. 6 is still a larger scale depiction of certain portions of the apparatus taken along the line 6—6 of FIG. 5; and

FIG. 7 is an illustrative plan view of a sheet of web material which has been subjected to the operation of the apparatus without being moved in order to depict the character of the operation as shown by a test to be hereinafter described.

The apparatus comprises a lower casing 8 over which is superimposed an upper hood casing 10 which is mounted for restricted movement up and down towards

and away from the lower casing. For this purpose the upper casing **10** has four threaded brackets **11** which receive supporting shafts **12**, all of the shafts **12** being mechanically connected by sets of miter gears **14** to a common adjusting shaft **16** located at the input end of the apparatus.

Upper edges of lower casing **8** and lower edges of upper casing **10** are so proportioned that in the position shown there is provided at the left-hand side of the apparatus an inlet opening **20**, and at the right-hand side of the apparatus an outlet opening **22** through which openings the web material may be horizontally passed in flat-wise condition, but the side edges **21**, **21***a* of the upper casing and **23** of the lower casing are so designed as to overlap in telescoping relation to form barriers and substantially seal the two casings together along the sides.

As shown in FIG. 3 the upper casing **10** encloses a fan **24** which leads through controlling dampers **26** and **28** into a plenum **30**, and the lower casing **8** duplicates this construction.

The plenum **30** has as a lower wall a partition plate **32** which is apertured to receive a series of spaced nozzles **40** which extend downwardly from the plenum **30** in the upper casing and another series **41** which extend upwardly from the corresponding plenum **30***a* in the lower casing towards apertures located in opposed parallel plates **42** and **44** which define the pathway therebetween for the web material W, which may be fed from a source of supply such as a braked roll (not shown) through any desired treating station, e.g., a coating operation on both sides into inlet **20**.

As indicated in FIG. 1 and FIG. 5, all the nozzles are in rows extending transversely of the apparatus, but they are slightly offset from one another longitudinally of the apparatus for well-known purposes of increasing the uniformity of treatment by assuring that every surface area of the length of material being treated is subjected to a substantially equal volume of high velocity air.

As shown more particularly in FIG. 6, it will be noted that the nozzles **40** terminate in orifices **46** which lie in a single plane, and the nozzles **41** in orifices **47**, which lie in a spaced single plane; and both plates **42** and **44** have portions thereof **48** bent upwardly or dished out of the planes of the plates to form apertures or exhaust ports **50** of annular shape surrounding each nozzle. The dishing aids in establishing the proper path of air stream flow between the plates. It is further noted that the orifice planes lie between the planes of the bent-up edges **48** forming the exhaust ports **50** and the planes of the plates **42** and **44**, respectively.

Moreover the area of the exhaust ports **50** is such that while the velocity of the air passing therethrough is less than the velocity of the air as it emanates from the orifices **46** and **47**, substantially the same volume of air per unit of time passes through the exhaust ports as issues from the orifices so that all the air issuing from the orfices is exhausted through the exhaust ports.

This results in the building up of more or less dead spaces or non-turbulent zones between the plates **42**, **44** in the areas between the bent portions **48**, and, as a consequence of the velocity of the air streams curling around therebetween, as shown by the arrows in FIG. 6, a static pressure is built up in these areas which, because the areas are equal and opposed on each side of the sheet, tend to stabilize the sheet, despite the impact on and motion of the air streams relative to the web W in the discrete areas lying directly opposite the nozzles and their surrounding exhaust ports. The two plates **40** and **42** can have their inner side edges (FIG. 3) flanged over in telescoping relationship at **56** forming barriers to minimize lateral air flow outwardly of that edge of the web W, though such inner closure has not been found to be essential.

In any event, it has been found by demonstration that in an apparatus of the above character, when the plate **42** is moved to a proper distance from the plate **44** for a given type of web material, the web material will be constrained against draping or drooping or touching either of the plates **42** or **44** throughout the length of the dryer, being constrained in a substantially single horizontal path of movement by the air stream operation in and of itself and without requiring any support at the edges and without fluttering at the edges.

The existence of a pressure build-up between the two plates has been demonstrated by treating a web without moving it and inserting cinnamon in the air stream. When the material was not moved, it was found that a pattern of light and dark areas developed, as shown in FIG. 7. Thus directly beneath ach nozzle there is a separate darkened circular portion **60** where cinnamon was deposited. Surrounding this was a ring **62** of very much lighter color, a narrower ring **64** of darker color, and therebeyond a matrix **66** of intermediate dark color. From this operation it is apparent that drying had advanced in the ring portion **62** to a much higher degree than either directly beneath the nozzles in areas **60** or in the matrix portions **66** surrounding the ring portion. This is explainable on the ground, as shown in FIG. 6, that the air stream moving with great velocity along the surfaces of the web in areas **62** prevents the deposit of cinnamon and develops the greatest drying power outwardly from the center of the nozzle, and then reversing and withdrawing upwardly through the exhaust ports leaves the matrix area substantially untreated, because of little or no velocity of the air relative to the surface of the paper in these areas, as in the area directly beneath the nozzles where there is a downward impact but no relative motion along the surface of high velocity air. The ring **64** represents an area of cinnamon deposit as the air velocity across the surface of the sheet decelerates.

This pattern, of course, would not be observable were the material moved continuously through the apparatus, because with such continuous motion, each unit area of the product receives equal treatment, and therefore, the entire sheet, as it leaves the apparatus, would be covered uniformly with cinnamon indicative or uniform treatment throughout both its surfaces.

As an example, the preheating of phenolformaldehyde resin impregnated paper for pleating in the manufacture of automotive oil filters, is best accomplished by treating the web on both sides simultaneously with gases heated to a temperature between 140° F. and 250° F. adjusted according to the speed of motion of the web. This speed will be between the limits of 600 ft./min. and 1000 ft./min. according to the amount of impregnation of the paper and the production required.

In this process the paper must become uniformly plastic and malleable so that it may be formed into pleats in the subsequent pleating apparatus. For this purpose the two plates in the jet preheater are adjusted to a distance of one inch apart. The plates have exhaust ports one and one-quarter inches in diameter, surrounding nozzle orifices five-eighths inch in diameter, arranged on two and one-half inch centers transversely and in row three inches apart longitudinally.

The treating gas in the nozzles has a velocity of 6000 linear ft./min. and the gas passing outward through the exhaust ports has a velocity of 2000 linear ft./min. Under the above described conditions the web of paper will be properly softened while it is moving along a substantially plane path parallel to and substantially equidistant from the planes of the faces of the upper and lower surface plates.

While the apparatus shown in FIGS. 1–3 has a stationary lower casing **8** and an upper casing **10** movable relative thereto, in some cases it may be desirable to make provision for simultaneous equal movement of the upper and lower casings toward and away from each other. This may be done in a variety of manners, including, for example, the construction shown in FIG. 3*a*, wherein the lower casing **8**, instead of being fixedly supported, is

provided with a series of threaded brackets 70, one of which is shown in FIG. 3, and all of which are in alignment with the upper casing brackets 11. The brackets 70 are screw threaded with an opposite thread from the thread of brackets 11 so that the shafts 12, when rotated, move the lower casing 8 up or down in counter motion with respect to the motion of the upper casing 10. In this structure the plates 42 and 44 will always be equidistant above and below, respectively, the plane of a web W being fed into opening 20 at a fixed level.

What is claimed is:

1. Apparatus for treating a flexible continuous web comprising a casing forming a treating chamber and defining an inlet leading into and a discharge opening leading out of said chamber, two opposed parallel spaced plates extending longitudinally within said casing and forming therebetween a passageway for advance of a web fed into said inlet through said passageway and out of said discharge opening, said plates having opposed aligned apertures dished out of the planes of said plates spaced both longitudinally and transversely of said plates and having portions between said aligned apertures forming opposed flat continuous matrices, opposed aligned nozzles extending into each opposed pair of apertures leaving annular openings between the nozzles and the aperture edges, through which said annular openings gas emanating from said nozzles may be exhausted, and the nozzles extending into the apertures of each plate having orifices lying in a single plane, the distance between said orifice planes being at least as great as the minimum distance between said opposed plates whereby upon discharge of gas at high velocity through said nozzles, a web advancing through said apparatus will be contacted along selected equal and opposite areas on both its sides between said matrices with substantially equal volumes of gas having little or no velocity but elevated pressure and will be contacted along intervening equal and opposite discrete areas segregated both longitudinally and transversely of the path of movement of said web with substantially equal volumes of lower pressure gas moving at high velocity normally into contact with, along, and substantially normally out of contact with intervening surfaces of said web lying between said selected areas to float said advancing web in said passageway free from contact with said opposed plates and nozzles.

2. Apparatus as claimed in claim 1, wherein portions of said plates leading to said apertures are bent away from said passageway, and the remainder of said plates forming said matrices lie in parallel planes.

3. Apparatus as claimed in claim 2, wherein the planes if said orifices lie between said parallel plate planes and the edges of said apertures.

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NORMAN YUDKOFF, *Primary Examiner.*