

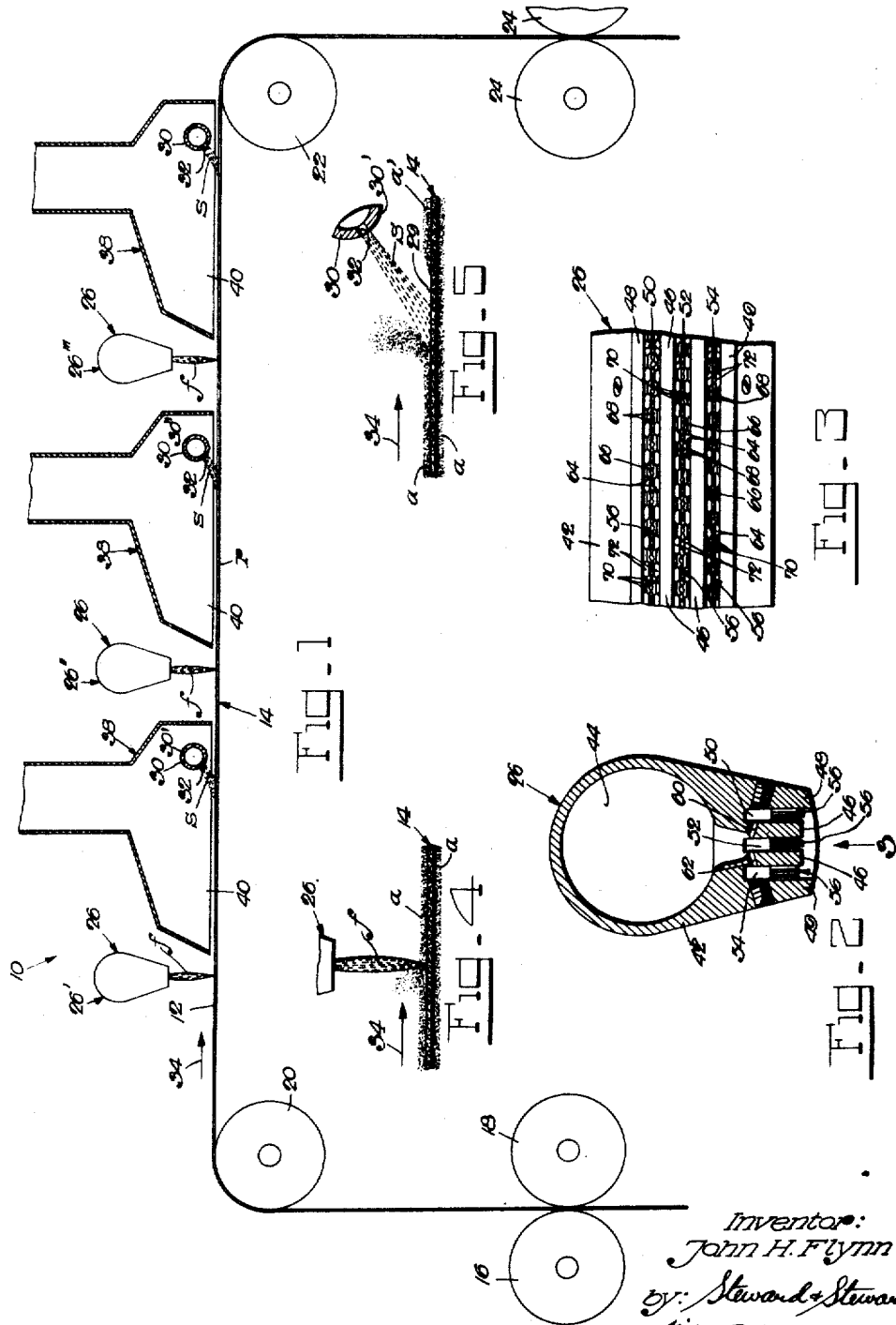
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METHOD OF DRYING COATED WEBS

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METHOD OF DRYING COATED WEBS

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This invention relates to a method of drying a freshly applied liquid or semi-liquid coating on the surface of sheet material of various kinds, particularly on the surface of a web of extended, continuous length. The invention pertains especially to drying such a coating while the sheet or web to which it is applied is traveling at high velocity.

There are many commercial processes involving the application of liquid or semi-liquid coatings to continuous webs to imprint on the surfaces thereof some wording, design or to apply thereto a protective finish. The webs are of paper, cloth, plastic or of thin sheet metal including foil, while any of various inks, enamels, lacquers or other protective finishes such as latex are the coatings applied. The application of the coating is commonly done while the web is caused to travel at high linear velocity through a printing or coating station. For economy of space, the web is fed to the printing station from a roll in which it is stored, and after the printing it is again rerolled. However, rerolling cannot be done until and unless the coating on the surface is completely dried, as smearing and sticking of the coating otherwise results. As a result, the drying rate has accordingly determined the speed of application for the coating, since modern printing presses or coating machines have speeds far in excess of that permitted by the normal drying rate of the inks, etc., applied. It has been conventional, therefore, to subject the coated web to an accelerated drying operation following the application of the coating thereto. Two principal methods of drying have been used, the first and heretofore generally more successful of these employing a radiant heat drying unit, in the nature of an oven, through which the web is passed to supply heat to the web while it is traveling. The other method of drying generally employed utilizes an open flame which is directed toward the coated surface of the web, the intention being to cause the flame to come into close or actual momentary contact with the web surface to dry the coating thereon, while moving the web through the flame sufficiently rapidly to avoid actual scorching. Still, these various prior attempts to accelerate drying of the printed web have not permitted utilization of the maximum speeds of which the printing presses, etc. are capable.

Some of the more serious disadvantages of radiant drying methods are the necessity for making provision for quick separation of the webs and burners or other sources of heat, in case the web is stopped or slowed, since the high residual heat stored in the burners will otherwise burn the webs, especially if they are paper. This requires considerable electrical and mechanical equipment to accomplish such quick separation of the burners and webs. The maximum web speed permissible with the radiant heat drying method, moreover, is limited in practice to not more than 350 to 400 feet per minute, whereas modern printing permits and calls for web speeds that reach 2,000 feet per minute. Even if radiant heat zones of greater heat intensity are provided, the hereto-

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fore maximum web speeds mentioned above cannot be appreciably increased, due to the formation of insulating air layers or barriers adjacent the traveling web, as will presently be more fully explained. Furthermore, in passing printed or coated webs of paper through radiant heat zones of high heat intensity, the paper stock of these webs is heated through and through, and absorbs and retains sufficient residual heat to suffer a loss of its natural moisture content which in some cases approaches one half of the initial normal moisture content. This is tantamount to a like reduction in the tensile strength of the paper and so reduces its strength as to cause frequent breaking of the web during printing. Shutdown of the printing machines in order to rewet the press is of course a very time consuming and expensive operation. Also, the intense radiant heat to which the ink or other coatings are subjected in this method for appreciable periods of time adversely affects the pigments in those coatings and perceptibly changes their true colors.

Prior to the present invention, attempts to use the direct or open flame method of drying the coating have left much to be desired in commercially practical operation. Several reasons for this appear: Because of the absolutely critical requirement for immediately removing the flame from the web should there be even a momentary stopping or slowing down of its travel, the dryer equipment necessary to protect the web from scorching, or complete destruction, presents numerous design problems. More importantly, however, prior attempts to use direct flames to dry the coatings on the webs have still proved ineffective at web speeds appreciably greater than the 350 to 400 feet per minute maximum possible with radiant heating discussed above. Although there has been some recognition that the rapidly moving web induces a layer of air to cling to the moving web surface, it has been assumed in the past that the flames employed for drying purposes penetrated or dissipated this layer so as to come into direct contact with the web surface. Contrary to the general belief, however, the layer of air is a much more effective barrier to the direct impingement of flame elements upon the surface of the web than was previously appreciated, more especially at the high web velocities of over 400 feet per minute with which this invention is primarily concerned. In fact this barrier becomes so pronounced at the higher web speeds contemplated in the method of this invention that ordinary flames from a gas burner, so directed as to impinge upon the surface of the web and effectively doing so under conditions existing at the conventionally used lower web speeds, are diverted by the layer moving with the web and thus do not actually or at least effectively contact the wet ink on the web surface at all.

The air layer is apparently produced by the friction between the air and the web at their interface, resulting in a thin envelope or sheath traveling with the web itself, although perhaps at a slightly lower speed, but nevertheless sufficiently rapidly to blunt and divert the flame elements of gas burners of conventional types heretofore employed under the conditions of use taught by the prior art.

It is accordingly an object of the present invention to provide a method of drying freshly coated sheets or webs which is far superior to the radiant heat and open flame methods previously employed, whereby to effect drying of freshly applied coatings on sheet or web surfaces up to and even exceeding web speeds of the presently contemplated maximum of 2,000 feet per minute. The novel method is, moreover, capable of effecting drying within a zone of much shorter extent than that required heretofore.

It is another object of the present invention to provide a method of drying freshly coated webs which is also

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far superior to the previous methods where the web is of paper or other absorbent material, by reducing very substantially the loss of moisture content in the body of the web, so that the webs retain their strength with little or no loss after subjection to the instant drying method. In the case of sheet metal webs, it is an object of the invention to reduce the time during which the web is held in a heated zone, whereby to reduce the penetration of heat into the body of the metal itself.

It is a further object of the present invention to provide a method of drying a freshly coated web by driving against the traveling web a flame of such high velocity as to penetrate the clinging air layer, and of such high local heat intensity as to drive the volatiles in the coating on the surface of the web into the air layer, then incinerating the volatiles to entrap the incinerated and any unburned products in the layer for removal thereby. In the preferred method of operation, a further step is incorporated wherein an air knife or high speed air jet is employed to separate the layer of air containing the incinerated products from the web.

Preferred forms of apparatus suitable for commercial practice of the novel method are described in my earlier Patents Nos. 2,797,074 and 2,803,446.

Further objects and advantages of the present invention will appear to those skilled in the art from the following more detailed discussion, considered in conjunction with the accompanying drawings wherein certain modes of carrying out the present invention are shown for illustrative purposes:

Fig. 1 is a diagrammatic view of a multiple station dryer installation for a freshly coated web, embodying the present invention;

Fig. 2 is a cross-section of a burner used in the drying installation of Fig. 1;

Fig. 3 is a fragmentary view of the same burner as viewed in the direction of the arrow 3 in Fig. 2;

Fig. 4 is a fragmentary sectional view of the freshly coated web as it is being subjected to a flame according to the present method; and

Fig. 5 is a fragmentary sectional view of the same web as it is being subjected to a stream of compressed air.

Referring to the drawing, and more particularly to Fig. 1 thereof, the reference numeral 10 designates an installation for drying a freshly applied coating, such as printing ink, for instance, on the face 12 of a continuous web 14 of paper or other suitable material. Web 14 passes between a printing or coat-applying roll 16 and a back-up roll 18 of which the former is supplied with ink or other coating material in conventional manner, not here shown. After emerging from the rolls 16 and 18, the web passes over spaced guide rolls 20 and 22 which may suitably be chilled for lowering the temperature of the web. The web thereupon passes between cooperating feed rolls 24 which draw it through the coat-applying and back-up rolls 16 and 18 and over the guide rolls 20 and 22 at a speed which is substantially constant in normal operation.

The drying installation 10 comprises, in the present instance, a plurality of spaced burners 26 which extend transversely of the web run *r* between the guide rolls 20 and 22. Each of the burners 26 is of a type capable of producing a flame of both high velocity and high heat output capacity, as hereinafter more fully defined. As shown in the diagrammatic representation in the drawing, the drying flame is produced by a high velocity ribbon burner and constitutes a substantially continuous sheet of flame *f* that extends across the width of the web 14. The flame produced has a knife edge, and each of burners 26 is so spaced from the web run *r* that it is just within flame reach thereof.

At the high web speeds contemplated in the present invention, i.e. web speeds within a range starting at the previous maximum practical web speed at 400 feet per

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minute for drying coated webs and extending to speeds of 2,000 feet per minute or more, a relatively heavy layer of air *a* is caused to adhere to the traveling web (Figs. 4 and 5). This air layer increases in thickness with increase in the web speed and acts as an effective heat insulator on the web and the printed ink or coating thereon, and must be penetrated by the flame before the latter reaches the web face and dries the ink or coating. Accordingly, the flame, in order to dry printed ink or a coating on a web traveling at high speed must have sufficient velocity to cut or drive through the air layer on the traveling web without being diverted by this air or giving up any substantial heat to it (Fig. 4).

The flame must at the same time be one of sufficient heat output capacity to drive the volatiles from the ink or coating during its very brief contact therewith. I have found that printed paper webs, for instance, traveling at the higher speeds here contemplated, can be contacted with a flame tip of such high heat capacity that it will effectively flash dry the ink thereon, yet will not produce burning or scorching of the web.

I have found furthermore that there is a definite critical relationship between the minimum flame velocity and heat capacity thereof for various ranges of web velocity that must be observed in order to effect penetration of the air layer and successful flash evaporation of the volatiles in the coating material. In general, at a web velocity of around 400 feet per minute, which is representative of maximum web velocities heretofore commercially achieved for satisfactory drying of links and similar coatings, I have found that the flame should have a minimum propagation rate or velocity of 1,500 feet per minute. Preferably it should be on the order of 2,000 feet per minute. While burner flames have been available heretofore in which such velocity may be attained, those flames have not had the heat capacity required to effect adequate drying in the short interval of time during which the flame contacts each successive point on the surface of a web traveling at the rates of speed mentioned. Equally important with the requirement for flame velocity, therefore, is the requirement for heat output or capacity of the flame. Again speaking generally, since the figure will of course vary with the nature of the coating applied to the web, the minimum heat capacity per inch of burner length should be about 5,000 B.t.u.'s. As the web speeds increase the flame velocity and heat capacity must also be increased. For coatings in which the ratio of volatile to solid components is high, still higher burner capacities and more burners are needed as the web speed increases, in order to handle the higher evaporation requirements.

As an illustration, for the more readily dried aniline printing inks commonly used today, the following conditions are necessary in order to obtain effective drying at the several web speeds indicated:

Table I

Web Velocity, Ft./min.	Number of Burners	B.t.u. per inch of Burner Length	Flame Velocity, Ft./min. (Approx. Aver.)
400-600	1	5,000-6,000	2,880-3,500
600-1,200	1-2	6,000-7,500	3,500-4,300
1,200-1,600	2-3	7,500-10,000	4,300-5,750
1,600-2,000	3-4	10,000-15,000	5,750-8,700
2,000	4	15,000	8,700

These figures are based on producing a flame tip temperature of about 2,500° F. contacting the web surface itself in order to obtain effective volatilization of the solvents in the ink. While it is difficult to determine actual surface temperatures of the web itself as a practical matter, it in general will be on the order of 280° F., with a maximum of 380°-400° F. under the conditions specified. Because the web travels at such high rate, direct physical

contact of a temperature measuring element gives inconclusive indications due to frictional effects. Readings obtained by reflectometer and similar temperature indicating means are also subject to error due to color changes in the printed surface itself.

For the heat-setting inks, which are somewhat more difficult to dry, a higher instantaneous flame tip temperature is desirable. Generally this temperature is on the order of 2,500° to 3,000° F. and the web surface temperature approaches the upper limit mentioned above. For this, the following approximate flame requirements are needed at the various indicated web speeds:

Table II

Web Velocity, Ft./min.	Number of Burners	B.t.u. per inch of Burner Length	Flame Velocity, Ft./min. (Approx. Aver.)
400-600.....	1	6,000-7,500	8,500-4,300
600-1,200.....	1-2	7,500-10,000	4,300-5,750
1,200-1,600.....	2-3	10,000-15,000	5,750-8,700
1,600-2,000.....	3-4	15,000-20,000	8,700-11,600
2,000.....	4	20,000	11,500

In order to obtain the flames of high velocity and high heat capacity which, as indicated above, are imperative in drying freshly applied ink or a coating on a web in accordance with the present method, burners of suitable characteristics must be employed. An example of a burner having these flame characteristics is indicated in Figs. 2 and 3 and is shown and described in full detail in my Patent No. 2,647,569, dated August 4, 1953. This burner comprises a casing 42 having a longitudinal gas passage 44 which is in communication with any suitable source of a combustible gas, usually a mixture of a hydrocarbon gas and air. The casing 42 is provided with a burner face 46 which is flanked by opposite shoulders 48 and 49 that project somewhat beyond the burner face 46 to protect the combustible gases or flames thereat against dilution, deflection and undercutting by surrounding air currents. The burner surface 46 is provided with a plurality, in this instance three, longitudinal burner grooves 50, 52 and 54 which extend parallel to each other (Fig. 3), each burner groove holding burner ribbons 56, respectively, which may suitably be secured therein as by cross-pins, for instance. Each of the longitudinal burner grooves 50, 52 and 54 is open to the atmosphere. The center groove 52 throughout its width is in full communication with the main gas supply passage 44 in the burner casing 42 and is supplied with gas therefrom at high velocity. The outer burner grooves 50 and 54 are not in direct communication with the gas supply passage 44, but indirectly communicate therewith through gas ducts 60 and 62 (Fig. 2) which allow for gas flow between the center groove 52 and the outer grooves 50 and 54, respectively. These gas ducts 60 and 62 occur in pairs which are disposed at spaced intervals longitudinally along the burner casing 42. Since the gas ducts 60 and 62 are of relatively small diameter and are relatively few in number, the amount of gas per time unit flowing from the center groove 52 to each of the outer grooves 50 and 54 is naturally less than that in the center groove, and the flame emerging from the outer grooves is of lower velocity than that at the center.

Each of the aforementioned burner ribbons 56 comprises in this instance two major ribbons 64 and a minor ribbon 66 (Fig. 3). This arrangement of the major and minor ribbons results in the formation in the minor ribbon 66 of a plurality of relatively small and, hence, low velocity gas ports 68, and in the formation in the major ribbons 64 of a plurality of medium or intermediate velocity gas ports 70 and a plurality of high velocity gas ports 72, the latter extending along the opposite side walls of the respective burner groove, while

the low velocity and intermediate velocity gas ports 68 and 70 are disposed between the outer high velocity gas ports 72. In explanation of the velocity characteristics of the aforesaid gas ports, it may be stated that the small cross-sectional area of each of the low velocity gas ports 68 has a relatively high skin friction effect on gas passing therethrough, with the result that the gas issuing therefrom has relatively low velocity and does not reach any appreciable distance beyond the burner ribbons. On the other hand, the cross-sectional area of each of the intermediate gas ports 70 is somewhat larger than that of each of the low velocity gas ports 68, with the result that there is less skin friction and the gas issues therefrom at high velocity. In like manner, each of the high velocity gas ports 72 has a larger cross-sectional area than any of the intermediate or low velocity gas ports 70 and 68, with the result that there will be even less skin friction, and gas issuing from these high velocity gas ports 72 will project the largest distance beyond the burner ribbons. Each of the burner ribbons 56 produces flames of three different heights, the long flames emanating from the high velocity gas ports 72 and being maintained by the flames emanating from both the low velocity gas ports 68 and intermediate gas ports 70, while the flames emanating from the latter are, in turn, sustained by the flames emanating from the low velocity gas ports 68. This burner construction has been found to produce a driving flame of high velocity and high heat intensity, due to the fact that the long center flame portion from the center groove 52 in the burner casing is sustained and maintained by the shorter flames from the burner grooves 50 and 54, by which arrangement relatively high gas pressures may be used with a consequent increase in the heat output capacity of the burner to enable the latter to meet the requirements of the drying method herein disclosed.

As hereinbefore explained, printed paper webs which for ink-drying purposes were subjected to the previous radiant heat method, suffered a loss of moisture amounting to as much as 40% and, hence, suffered a proportional reduction in tensile strength. The high velocity flame or flames, which in accordance with the present method have very brief flash contact with the printed web face, despite their high heat intensity, momentarily heat the exposed printed web face to a permissible extent and the rest of the web only to a negligible extent, because the brief interval during which the printed web face is contacted by a flame is far too short to permit the latter to drive its heat into the interior or main body of the web. Once the printed face of the web has passed a flame, the heat transferred from the flame-struck printed face into the interior of the web is insufficient to heat the latter to an extent where appreciable moisture loss can result.

In order to reduce moisture loss in a paper web even further, in fact to the extent where the same is negligible and the tensile strength of the web is substantially unaffected, or in order to preclude all possibility that webs of steel or other metals, as well as other materials, become scorched, the present method further contemplates directing against the printed or coated web face, after it has passed a flame, a stream of high velocity air counter to the feeding direction of the web. This air stream lifts the adhering air layer and the entrapped volatiles of the ink or coating from the web face and thus accelerates evaporation of any remaining volatiles in the ink or coating, and effects cooling of the printed or coated web face before most of the residual heat thereon has any substantial opportunity to be transferred to the interior of the web. To this end, the ink-drying installation 10 of Fig. 1 includes, after the first burner 26' and preferably after the second burner 26'', and also after the last burner 26''' if desired, a conduit 30 which is in communication with any suitable supply of compressed air, and is provided with perforations 32, or a continuous slot, through which the compressed air is directed in a continuous stream against

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the web face 12 counter to the feeding direction of the web indicated by the arrow 34. In thus subjecting webs to a stream or streams of compressed air, moisture loss from paper webs has actually been reduced to a negligible 1% or less, leaving these paper webs substantially unchanged in respect to their original tensile strength.

The velocity of the air used in producing the aforesaid air knife must also, of course, be sufficient to cut through the barrier of air clinging to the traveling web. At a web velocity of 400 feet per minute, the air knife velocity should be about 5,000 feet per minute. This should be increased to a minimum of 6,000 feet per minute as the web speeds are increased within the range of 600 to 1,200 feet per minute. At web velocities of 1,200 to 1,600 feet per minute, the minimum air knife velocity should range upwards from about 8,000 feet per minute, while at web speeds of 1,600 to 2,000 feet per minute, the minimum air velocity should be 15,000 feet per minute.

The ink-drying installation of Fig. 1 preferably further includes after each burner 26 an exhaust hood 38 which extends with its opening 40 into close proximity to the web face 12 and preferably encloses the adjacent air-blast conduit 30, so that the air layer and the volatiles of the ink or coating lifted by the air stream *s* from the web face 12 will be carried off through the hood 38. Of course, while the air stream *s* from the first blast conduit 30' lifts the air layer from the oncoming web face 12, a new air layer *a'* will form on and cling to the same web face almost immediately after the latter passes the air stream from the conduit 30' (Fig. 5), and this newly formed air layer will again be lifted from the web face 12 by the air stream from the next following blast tube 30". Thus, a new air layer will form on and cling to the web face 12 after each previous air layer has been lifted therefrom by an air stream *s*.

The penetration by the high velocity flame of the burner or burners, as well as the heat capacity thereof, effectively drives the volatiles in the ink or other coating material from the pigment or other material in the coating composition, and these volatiles are caught up in the air layer traveling with the web. If the volatiles are inflammable, they are immediately incinerated by the flame and the incinerated products are carried off by the layer to be separated, along with the layer, from the web by the air knife. If the vehicle in the coating is water, this is rapidly converted by the flame from a liquid to vaporous state and the vapor is entrapped in the air layer for separation therewith. In order to avoid redeposition of the incinerated products (or water vapor) on the face of the web, after passing the drying flame, it is desirable that the distance between the flame and the air knife be kept at a minimum. At the same time, the air knife must be so positioned as to avoid disturbance of the drying flame. The spacing is, accordingly, somewhat critical. In practice under the operating conditions disclosed hereinabove, a distance of about 12 to 24 inches has proved generally optimum. At this spacing, the removal of the products entrapped in the air layer is accomplished before any re-deposit of them (and resulting smudging) on the web occurs, yet the air knife does not interfere with the drying flame.

By way of example, the following illustrations of actual commercial operations will indicate the remarkable improvement achieved in the use of the drying method of the invention as compared with the best available drying methods previously known.

A large printing installation employing a high capacity multiple color magazine printing press was used in conjunction with a commercial drier of the radiant heating type in order to dry the ink on the paper stock or web as it came from the printing press. The drier used was approximately seven feet long, and radiant burners were provided at the upper printed surface of the web only. In order to get adequate drying, the maximum web speed which could be attained with this installation was 350 feet

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per minute. Tests made on the paper stock of which the web was formed, made before and after the drying operation, showed a loss of 40% in the natural moisture content of the stock. This is indicative of a similar loss in the tensile strength of the stock and is above tolerable limits for most purposes. While drying speed might be increased by employing radiant burners on both sides of the web in the drier, there would result a still greater concomitant loss of moisture from the stock.

Using the same printing press, web stock and ink, but substituting a drier employing the method of this invention, the same or greater amount of drying of the ink on the web was accomplished at web speeds of 1,400 feet per minute, while the loss of natural moisture content in the web stock was cut to less than 5%, in fact in some tests it got as low as 1%.

A reduction of from 40 to 20% in the loss of moisture content would be considered, for practical purposes, a highly significant improvement. Thus, the significance of a reduction in this loss to less than 5% can readily be appreciated.

In another instance, the problem involved was the drying of a latex coating on cardboard used in the production of milk cartons. To render the cardboard impervious to liquids, it is coated with an aqueous solution which typically comprises about 28% by weight of a suitable elastomer, the balance being water. In the original installation, the drier employed for drying the latex coating was 200 feet in length, and the maximum web speed attainable consistent with satisfactory drying results was 200 feet per minute. In other words, under those conditions, any given point on the web remained in the drier for a period of sixty seconds. In this time an appreciable amount of heat is driven into the body of the web itself, so that there is a material loss of natural moisture content from the web stock, resulting in brittleness and loss of tensile strength.

The foregoing installation was replaced by a unit employing the drying method herein disclosed. The drier in this instance was only 20 feet long. The latex coating on the web was dried quite as fully in this instance as in the foregoing example at a web speed of 400 feet per minute. It will be seen, therefore, that in this case the maximum length of time that any given portion of the web stock is in the drier is only 3 seconds. In that short interval of time the web itself cannot pick up any substantial amount of heat, and for this reason the loss of natural moisture content is practically eliminated.

Similarly startling results have been obtained in drying lithographed sheet metal used in the production of tin cans.

While in the foregoing discussion it has been assumed that a continuous web is treated, it is fully within the scope of this invention to handle separate sheets or webs which may be carried successively past the flame or flames of the burners by a conveyor.

In the appended claims, the expressions "freshly applied coating" is meant to denote ink or any other coating material, while "coated web face" refers to a printed or coated web face on which such coating has been printed or otherwise applied. It will also be understood that the term "web" as used in the claims comprehends both continuous and discontinuous sheets, as mentioned above.

The method may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the embodiments are, therefore, to be considered as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

This application is a continuation-in-part of my copending application Ser. No. 388,541, filed October 27, 1953.

What is claimed is:

1. The method of drying a freshly applied coating on a face of web material wherein said web is fed past a

drying station at such high linear velocity, on the order of at least 400 feet per minute, that a substantial layer of air is caused to cling to and travel with the surface of said web, which comprises feeding a combustible fuel mixture to a high capacity burner, at said drying station to produce a knife-edge type of flame, directing said flame into contact with said coated web face transversely of the feed direction of the latter, said flame having a minimum heat capacity of 5000 B.t.u.'s per inch of burner length and a velocity of at least 1,500 feet per minute whereby to effect penetration of said clinging air layer, flash drying the coating on said web by direct contact of said flame therewith to evaporate and incinerate volatile products in said coating and to drive such products rapidly into said air layer for entrapment therein and subsequent removal therewith.

2. The method of drying a freshly applied coating on a face of web material as defined in claim 1, which includes the further step of directing a jet of high speed air against the coated face of the traveling web, after it passes said drying station, in a direction transversely of and at an angle counter to its line of travel, to lift the air layer containing said volatiles and incinerated products from said web face, and drawing off said air and products entrapped therein.

3. The method of drying a freshly applied coating on a face of web material wherein said web is fed past a drying station at a linear velocity of approximately 400 to 600 feet per minute, whereby a substantial layer of air is caused to cling to and travel with the surface of said web, which method comprises feeding a combustible fuel mixture to a single high capacity burner at said drying station to produce a knife-edge type of flame, directing said flame into contact with said coated web face transversely of the feed direction of the latter, said flame having a heat capacity of from 5,000 to 7,500 B.t.u.'s per inch of burner length and an average velocity of approximately 2,880 to 4,300 feet per minute whereby to effect penetration of said clinging air layer, flash drying the coating on said web by direct contact of said flame therewith to evaporate and incinerate volatile products in said coating and to drive such products rapidly into said air layer for entrapment therein and subsequent removal therewith.

4. The method of drying defined in claim 3, which includes the further step of directing a jet of air against the coated face of the traveling web, after it passes said burner flame, in a direction transversely of and counter to the direction of web feed, said air jet having a minimum velocity of at least 5,000 feet per minute.

5. The method of drying defined in claim 4, wherein the distance, in the direction of web travel, between the point of contact of said knife-edge flame on the web and the impingement thereon of said air jet is on the order of 12 to 24 inches.

6. The method of drying a freshly applied coating on a face of web material wherein said web is fed past a drying station at a linear velocity of approximately 600 to 1200 feet per minute, whereby a substantial layer of air is caused to cling to and travel with the surface of said web, which method comprises feeding a combustible mixture to a pair of high capacity burners disposed across said web and spaced longitudinally of its direction of feed, each of said burners producing a knife-edge type of flame, directing the flame of each burner into contact with said coated web face transversely of the feed direction, each flame having a heat capacity of from 6,000 to 10,000 B.t.u.'s per inch of burner length and an average flame velocity of approximately 3,500 to 5,750 feet per minute whereby to effect penetration of said clinging air layer, flash drying the coating on said web by direct contact of said flames therewith to evaporate and incinerate volatile products in said coating and to drive such products rapidly into said air layer for entrapment therein and subsequent removal therewith.

7. The method of drying defined in claim 6, which includes the further step of directing a jet of air against the coated face of the traveling web, after it passes each burner flame, in a direction transversely of and counter to the direction of web feed, said air jets each having a minimum velocity of at least 6,000 feet per minute.

8. The method of drying defined in claim 7, wherein the distance, in the direction of web travel, between each point of contact of a knife-edge flame on said web and the impingement thereon of the following air jet is on the order of 12 to 24 inches.

9. The method of drying a freshly applied coating on a face of web material wherein said web is fed past a drying station at a linear velocity of approximately 1,200 to 1,600 feet per minute, whereby a substantial layer of air is caused to cling to and travel with the surface of said web, which method comprises feeding a combustible mixture to three high capacity burners disposed across said web and spaced longitudinally of its direction of feed, each of said burners producing a knife-edge type of flame, directing the flame of each burner into contact with said coated web face transversely of the feed direction, each flame having a heat capacity of from 7,500 to 15,000 B.t.u.'s per inch of burner length and an average flame velocity of approximately 4,300 to 8,700 feet per minute whereby to effect penetration of said clinging air layer, flash drying the coating on said web by direct contact of said flames therewith to evaporate and incinerate volatile products in said coating and to drive such products rapidly into said air layer for entrapment therein and subsequent removal therewith.

10. The method of drying defined in claim 9, which includes the further step of directing a jet of air against the coated face of the traveling web, after it passes each burner flame, in a direction transversely of and counter to the direction of web feed, said air jets each having a minimum velocity of at least 8,000 feet per minute.

11. The method of drying defined in claim 10, wherein the distance, in the direction of web travel, between each point of contact of a knife-edge flame on said web and the impingement thereon of the following air jet is on the order of 12 to 24 inches.

12. The method of drying a freshly applied coating on a face of web material wherein said web is fed past a drying station at a linear velocity of approximately 1,600 to 2,000 feet per minute, whereby a substantial layer of air is caused to cling to and travel with the surface of said web, which method comprises feeding a combustible mixture to four high capacity burners disposed across said web and spaced longitudinally of its direction of feed, each of said burners producing a knife-edge type of flame having a heat capacity of from 10,000 to 20,000 B.t.u.'s per inch of burner length and an average flame velocity of approximately 5,750 to 11,500 feet per minute whereby to effect penetration of said clinging air layer, flash drying the coating on said web by direct contact of said flames therewith to evaporate and incinerate volatile products in said coating and to drive such products rapidly into said air layer for entrapment therein and subsequent removal therewith.

13. The method of drying defined in claim 12, which includes the further step of directing a jet of air against the coated face of the traveling web, after it passes each burner flame, in a direction transversely of and counter to the direction of web feed, said air jets each having a minimum velocity of at least 15,000 feet per minute.

14. The method of drying defined in claim 13, wherein the distance, in the direction of web travel, between each point of contact of a knife-edge flame on said web and the impingement thereon of the following air jet is on the order of 12 to 24 inches.

15. The method of drying a freshly applied coating on a face of web material wherein said web is fed past a drying station at such high linear velocity, on the order of at least 400 feet per minute, that a substantial layer

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of air is caused to cling to and travel with the surface of said web, which method comprises feeding a combustible fuel gas mixture to a high capacity ribbon burner disposed transversely of the web feed direction at said station, producing at said burner a knife-edge type of flame 5 composed of a high velocity central flame portion disposed between and in contact with lateral flame portions of lower velocity, said flame having a minimum heat capacity of 5,000 B.t.u.'s per inch of burner length and a velocity of at least 1,500 feet per minute in said central flame portion, and flash drying the coating on said web 10 by direct contact of said flame therewith to evaporate and incinerate volatile products in said coating and to drive such products rapidly into said air layer for entrapment therein and subsequent removal therewith.

16. The method of drying defined in claim 15, wherein each of the said central and lateral flame portions produced at said burner is composed of high velocity flame jets interspersed with flame jets of intermediate and low velocity.

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17. The method of drying defined in claim 15, wherein each of said central and lateral flame portions produced at said burner is composed of a series of high velocity flame jets separated longitudinally of the burner by flame jets of lower velocity, and flame jets of still lower velocity are produced along said burner adjacent said high and lower velocity flame jets.

18. The method of drying defined in claim 15, which includes the further step of directing a jet of air against the coated face of the traveling web, after it passes the burner flame, at a distance of from about 12 to 24 inches therefrom in the direction of web travel, said air jet having a minimum velocity of 5,000 feet per minute.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,884,705

May 5, 1959

John H. Flynn

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 45, after "B.t.u.'s" and before the period insert -- per hour --; line 59, Table I, third column thereof, in the heading after "B.t.u." insert -- per hour --; column 5, line 16, Table II, third column thereof, in the heading after "B.t.u." insert -- per hour --; column 9, line 9, claim 1, line 36, claim 3, line 67, claim 6, column 10, line 24, claim 9, line 53, claim 12, and column 11, line 9, claim 15, after "B.t.u.'s", each occurrence, insert -- per hour --.

Signed and sealed this 2nd day of August 1960.

(SEAL)

Attest:

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Commissioner of Patents