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FLAME TREATMENT OF ALUMINUM

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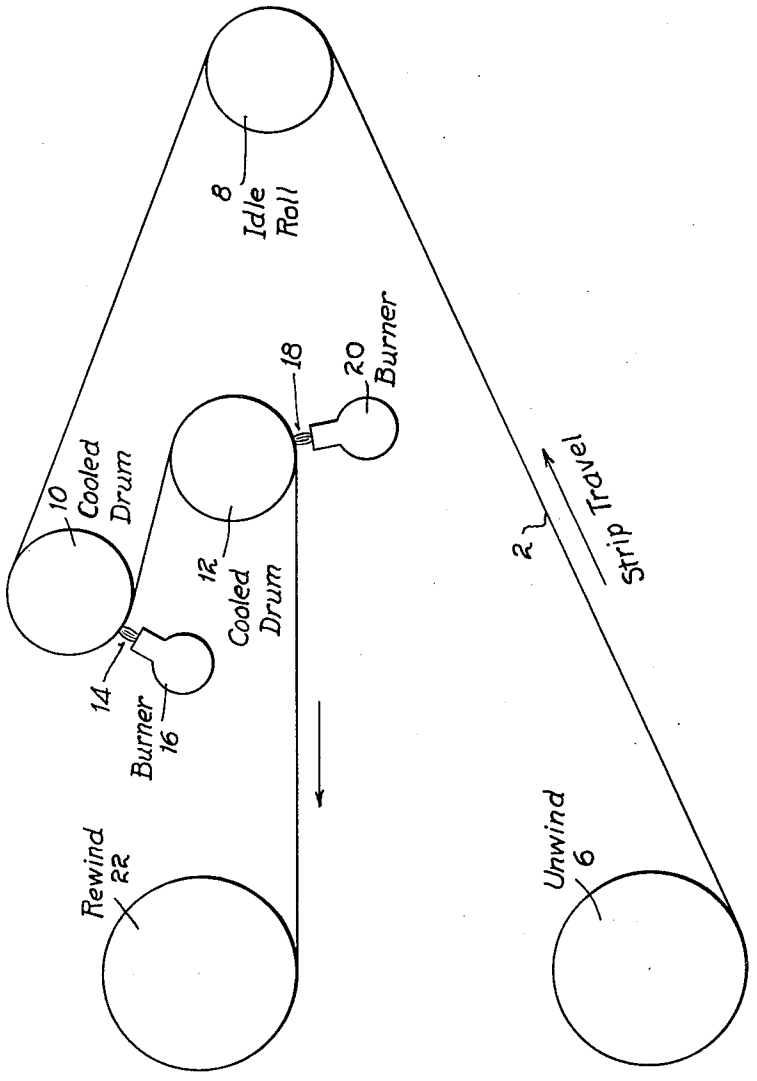

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FLAME TREATMENT OF ALUMINUM

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This invention relates to the flame treatment of aluminum surfaces, and more particularly to the flame treatment of thin aluminum strip surfaces, especially foil surfaces in strip form, i.e. in continuous lengths. Aluminum, as generally used herein, embraces both aluminum of various commercial grades and aluminum base alloys. Thin aluminum strip, as used herein, means aluminum of sheet-like section less than .015 inch thick and of continuous or indeterminate length. Aluminum foil, as used herein, means aluminum in sheet or strip form less than .006 inch thick.

The commercial applications of thin aluminum sheet and foil have been continually increasing, and there is a growing market for aluminum in thin strip form, for example in labeling and packaging. Consequently, it has become necessary to economically render the surfaces of thin aluminum sheet and foil, particularly in as-rolled tempers, as free as possible of surface contaminants. Such surfaces are thereby made water wettable, and conventional printing inks, adhesives, plastic films and other coatings will readily adhere thereto.

Copious amounts of oil are commonly employed in the rolling of aluminum sheet and foil, and the aluminum surfaces retain substantial amounts of residual rolling oil on and in the natural films of oxide present on each surface. Consequently, the as-rolled surfaces exhibit poor water wettability. Many commonly used printing inks, wash coats and adhesives, for example, exhibit little or no adhesion to an oily aluminum surface and may be easily stripped or lifted from the surface. In fact, by far the most objectionable contaminants preventing surface adhesion are the lubricants used in the strip rolling of thin aluminum sheet and foil. Consequently, it is generally necessary to remove residual rolling lubricant from the aluminum surface prior to a coating step.

It is well known that rolling oil is volatilized or "burned off" during the process of annealing aluminum sheet or foil. However, annealing is costly and time consuming, and may not sufficiently remove the rolling lubricant from the metal surface to allow the most satisfactory adherence of coatings. Furthermore, annealing not only alters the mechanical properties of the metal, but also may adversely affect the surface appearance of thin aluminum strip. That is to say, annealing reduces the tensile strength and yield strength of the metal as compared to metal in the as-rolled temper, and also may dull the metal surface. Annealing may even result in staining of sheet and foil surfaces when lubricant is retained on the foil in coil convolutions, for example.

In view of the objections and disadvantages of annealing thin aluminum sheet and foil to remove residual lubricant, it is an object of the invention to remove such lubricant without subjecting the aluminum to annealing.

It is a general object of this invention to provide a process for treating thin aluminum strip surfaces, particularly surfaces of aluminum foil in continuous strip form, to render such surfaces substantially free of contaminants and thereby improve the receptivity of such surfaces to various coatings, including plastic films, adhesives, inks or other protective or decorative matter.

It is a further object to provide a process for treating thin aluminum sheet or foil to remove rolling lubricant from the surface without affecting the mechanical properties of the sheet or foil.

It is still a further object to provide a process for flame treating a surface of as-rolled aluminum in thin strip form, particularly foil strip, to remove substantially all of the rolling lubricant without affecting the mechanical properties thereof.

Other objects and advantages of the invention will become evident in the following description thereof.

According to the present invention, a thin aluminum strip surface may be moved through at least one gas flame so as to volatilize residual rolling lubricant from such surface. Heretofore, it has been though that such a treatment would be impractical or would require, or result in, annealing and/or excessive wrinkling of the thin strip, especially foil. However, it has been found that such a flame treatment may be employed to render the aluminum surface water wettable, and is particularly effective in the treatment of foil strip. Such treatment thereby improves the receptivity of the aluminum surface to various coatings, including adhesives, inks, plastic films or other protective or decorative matter, without annealing or excessive wrinkling.

In the preferred practice of the invention, a thin aluminum strip, preferably aluminum foil in continuous length, is surface treated by impinging a gas flame on the surface thereof while subjecting the opposite surface of the moving strip to cooling, for example, by passing the strip over a relatively cool heat conducting surface. By this procedure, substantially all of the residual rolling lubricant is volatilized from the flame treated surface of the foil strip, and that surface is characterized by having water-wettability at least substantially equal to that of a corresponding annealed strip. The thin strip may be any as-rolled temper, whether full hard or intermediate. Yet when it is flame treated as described herein, there is no substantial loss in mechanical properties resulting from the flame treatment. This has been established by substantially identical tensile strengths, yield strengths and percent elongations obtained on samples of foil, before and after such flame treatment. In addition, it is also possible to flame treat the foil side of a foil-paper laminate without damagnig the paper laminate. The flame treated foil surface, being water wettable, is highly receptive to such conventional printing inks as gravure, offset and water base inks, as well as to emulsion type adhesives, and to nitrocellulose and dewaxed shellac wash coatings. In fact, the flame treated foil retains good receptivity to a variety of coatings even after storage.

The drawing diagrammatically illustrates apparatus suitable for carrying out the invention in the treatment of a continuous strip of thin aluminum sheet or foil.

Referring to the drawing, a strip **2** of aluminum foil is shown being continuously drawn in the direction indicated by the arrows from an unwind reel **6**, over an idler roll **8**, and around a relatively cool drum **10**, exposing one surface of strip **2** to a flame **14** to be further discussed. The opposite surface of strip **2** is preferably exposed to a second flame **18** as it is drawn around a second cool drum **12**. The flame treated strip is finally taken up on rewind reel **22** and stored for subsequent use. However, instead of being rewound on reel **22**, the strip **2** may be drawn directly into another apparatus, not shown in the drawing, for a coating or other operation.

As the continuously drawn strip **22** moves arcuately in contact with the cool drum **10**, gas flame **14** from a burner **16** is impinged on the surface of the foil. In like manner, as illustrated in the drawing, the reverse side of the strip is simultaneously treated by flame **18** from a burner **20** as it moves arcuately in contact with cool drum **12**, so that both sides of the strip are treated. Generally, as when the aluminum foil is supplied from a coil and rewound into a coil, it will be desirable to

flame treat both surfaces of the metal, to avoid re-contamination of the treated surface by contact with the untreated surface. On the other hand, it may be quite satisfactory to flame treat only one side of the strip, as in the case when the metal is fed directly to a coating apparatus. In such case the second cool drum **12** and burner **20** may be omitted.

During operation, the gas flame **14** or **18** would contact the strip. The burner **16** or **20** may be located quite close to the strip, say about ⅛ to 1¼ inches. The flame may be generated by burning a gas, such as natural gas or propane, mixed with air in a burner suitable for the same. Each burner is preferably a low pressure burner, and is preferably in the form of an elongated manifold substantially the width of the metal strip to be treated. In this manner, the flame treatment is made uniformly effective over the strip width. In some cases, more than one such burner may be employed around each cool drum, so that only one pass through the flame treating apparatus need be made.

The drum **10** or **12** may be cooled by any suitable means, for instance, by continuously passing water therethrough. Each drum preferably is maintained at a temperature below about 212° F. By properly adjusting the drum temperature, the burner spacing between the burner face and the surface of the foil, the burner location relative to the point where the strip leaves the cool drum, and the strip speed and tension, wrinkling may be substantially avoided and moisture condensation may be minimized while concurrently obtaining the high efficiency in oil removal. Despite the direct impingement of a flame upon such thin aluminum strip as conventional packaging foils, wrinkling is best avoided when the cool drum is employed and maintained at a temperature below about 165° F., although higher temperatures may be employed where thicker strip is treated or when some wrinkling can be tolerated. The flame may be applied near the point at which the strip leaves the drum, as this also appears to minimize wrinkling in the case of foil strip.

The duration of the flame treatment, necessary for obtaining a surface compatible with inks and other coatings, is dependent upon the temperature of the flame, variations in the oil film, the linear speed of the strip and its thickness. Therefore, it may be desirable under some conditions, to prolong the flame treatment or to provide for a plurality of gas burners around the cool drums. In each case, optimum conditions for yielding a surface highly receptive to printable matter and other coatings may be readily determined through simple experimentation.

The following example is given by way of illustration. As-rolled aluminum foil of 99.45% purity and .00035 inch thick was flame treated in strip form on each side with a propane-air flame. Two adjacent elongated manifold type burners were provided for each surface of the foil, and the distance from each burner face to the foil surface was ⅛ of an inch. The cool drum temperature did not exceed approximately 190° F. The linear speed of the foil was 250 feet per minute. The treated foil surface exhibited good water wettability even when treated with flame from only one burner per surface. Foil treated with two burners per surface retained good water wettability after several weeks of aging at room temperature. In intermediate tests such foil had retained good adhesion with ink after two months of aging at room temperature, and after two weeks of aging at 140° F. had retained good adhesion with nitrocellulose adhesive. There was substantially no change in tensile strength, yield strength, and percent elongation between a treated and untreated sample. Similar flame treatments have been effectively carried out with thin aluminum strips of various other gauges and with various operating conditions.

The flame treating process should have extensive use in the packaging trade where it is necessary to print or otherwise decorate an aluminum foil overwrap. Removing the rolling lubricant by annealing dulls the foil surface. On the other hand, flame treating as-rolled foil to improve its ink adhesion will not materially alter its metallic luster. Therefore, a package, carton, or wrapper made from as-rolled foil which has been flame treated for ink receptivity will be more attractive because of its bright surface.

The dead fold characteristics of annealed foil result in a marked tendency for such foil to retain the convolutions imparted to it. This may cause problems in feeding sheeted foil or foil laminate to sheet fed printing presses with resulting excess downtime of the press and slow operating speeds. These problems are obviated with the use of aluminum foil in an as-rolled temper having snap-back characteristics. Thus, it is possible to print directly onto a flame treated hard foil surface with no paper backing or with merely a laminate of a light paper stock.

As-rolled foil which has been surface conditioned may be used as a lithoplate in lithographic printing. Such as-rolled foil also may be used in honeycomb panel assemblies, such as are employed in airplanes, and which must be free from the rolling lubricant before adjoining the various parts with organic adhesives. Other uses for flame treated foil in as-rolled tempers will, of course, be obvious to those skilled in the art.

Having thus described my invention, what I claim is:

1. A method for removing residual rolling lubricant from a thin aluminum strip surface which comprises moving a surface of an aluminum strip less than .015 inch thick and in an as-rolled temper through at least one gas flame, while subjecting the surface opposite the flame to cooling, and thereby volatilizing residual rolling lubricant from said flame treated surface, whereby said flame treated surface is rendered water wettable without substantially affecting the mechanical properties of said aluminum strip.

2. A method according to claim 1 wherein the gas flame impinges on said first surface as the opposite surface of said strip passes over a relatively cool heat conducting surface.

3. A method according to claim 2 wherein the heat conducting surface is maintained at a temperature below about 212° F.

4. An aluminum strip less than .015 inch thick and in substantially an as-rolled temper, having at least one surface from which substantially all of the residual rolling lubricant has been removed by the flame treatment method of claim 1, and characterized by having freedom from residual rolling lubricant and water-wettability of the flame treated surface at least substantially equal to that of a corresponding annealed strip surface, but with mechanical properties of the flame treated strip at least substantially equal to those of the as-rolled strip before being so treated.

5. A method for treating a bright surface of aluminum foil strip in an as-rolled temper and retaining residual rolling lubricant, which comprises impinging a gas flame on said surface as the surface of said foil strip opposite the flame passes continuously and arcuately in contact with a relatively cool heat conducting surface, and thereby volatilizing substantially all of the residual rolling lubricant from said flame treated surface, whereby said flame treated surface remains bright and is rendered water wettable without substantial wrinkling of said foil strip and without substantially affecting the mechanical properties of said foil strip.

6. A substantially unwrinkled aluminum foil strip in substantially an as-rolled temper, having at least one bright surface from which substantially all of the residual rolling lubricant has been removed by the flame treatment method of claim 5, and characterized by having freedom from residual rolling lubricant, water-wettability

and bright appearance of the flame treated surface at least substantially equal to that of a corresponding annealed foil strip surface, but with mechanical properties and freedom from wrinkling of the flame treated foil strip at least substantially equal to that of the as-rolled foil strip before being so treated.

7. A method for removing residual rolling lubricant from an aluminum foil strip surface which comprises moving a first surface of said foil strip in an as-rolled temper through at least one gas flame which impinges on said first surface, while subjecting the surface opposite the flame to cooling, as it moves arcuately in contact with a heat conducting surface which is maintained at temperature below about 165° F., and thereby volatilizing residual rolling lubricant from said first, flame treated surface, whereby said first, flame treated surface is rendered water wettable without substantially affecting the mechanical properties of said aluminum foil strip.

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