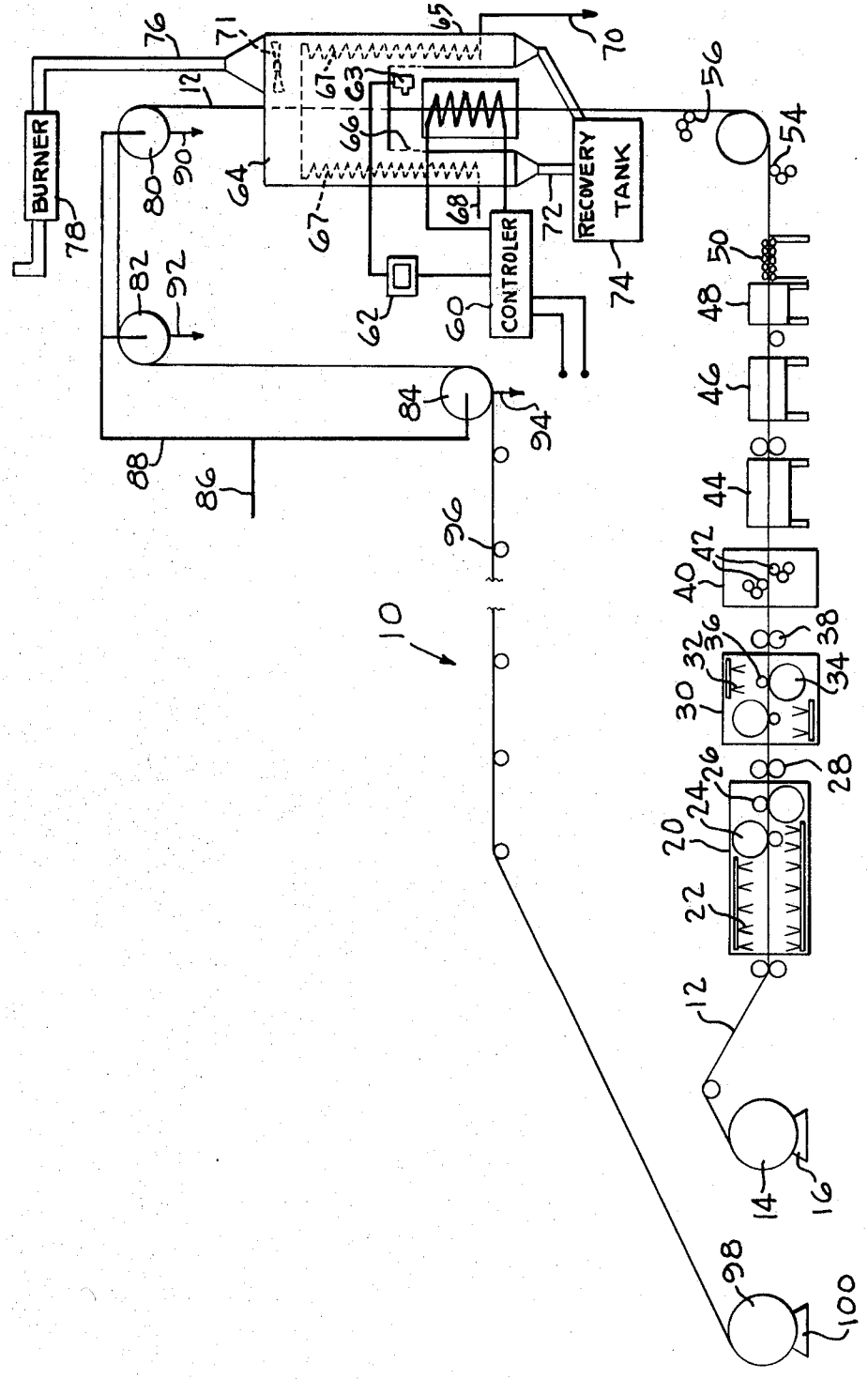
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METHOD AND APPARATUS FOR COATING METAL STRIPS

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METHOD AND APPARATUS FOR COATING METAL STRIPS

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ABSTRACT OF THE DISCLOSURE

An apparatus for applying a coating to a metal strip whereby the metal strip is first pretreated to condition it for application of the coating, after which the coating is applied to either one or both sides of the strip. Thereafter, the coated strip passes through a heating station where it is heated by means of electromagnetic induction. A hood surrounds the induction heating means so that the vaporized solvents and other fumes are prevented from passing into the atmosphere and over the coated metal strip downstream of the heating station. A hood is provided with condensing means to condense the vaporized solvents and to permit recovery of the condensed solvents, and is also provided with an afterburner to burn up any uncondensed vapors or gases to prevent contamination of the atmosphere. A series of cooled rollers are provided downstream of the heating means to not only act as conveyors for the strip, but also as progressive cooling means to complete the cure of the coating.

This invention relates to coating of metal strips with heat-curable paint, and its particularly relates to an apparatus for applying such coating in a continuous process.

It has heretofore been the general practice in the coating of metal strips, constructed of such materials as low carbon steel and the like, to apply the coating to the strip and then pass the strip through a curing oven where heat is applied to effect curing of the strip. Since a temperature higher than a predetermined temperature would cause deterioration of the coating and melting of the strip itself, it was necessary to use a temperature substantially lower than the deterioration or decomposition point of the coating and the melting point of the strip in the curing process. This resulted in the necessity of applying the heat over an extended period of time, which, in turn, necessitated the use of very elongated ovens to permit the continuously travelling strip to remain in the heated environment for a sufficient time to effect the required cure of the coating.

There were various disadvantages inherent in the above-described process. One disadvantage resided in the fact that the time involved was unduly extended because of the necessity for the strip to travel the great distance through the elongated oven. Another disadvantage was that the elongated oven required a great deal of space which could otherwise be more efficiently used. A third disadvantage was that if a breakdown occurred, or if it were necessary to stop the machine for any other reason, the portion of the strip then passing through the oven would remain stationary and would be subject to such an accumulation of heat, that the strip might melt or the coating might decompose or be otherwise deteriorated. Even if the oven were immediately deactivated, the accumulated heat therein would still have this effect since the oven could not be cooled with sufficient rapidity to dissipate such heat.

The substitution of an induction heating means for the elongated oven overcomes the problem of heat accumulation since, as soon as the induction heater is deactivated, the heat stops flowing and there is no accumulated heat because the induction heater is open to atmosphere. Such induction heating means also obviates the necessity of having an elongated heating area and, therefore, saves considerable space.

A further advantage of the use of induction heating means is that a very high temperature can be instantaneously induced. Such temperature may be considerably higher than either the deterioration temperature of the coating or the melting point of the strip, but as long as the coated strip is thereafter immediately cooled below such temperature, there is little likelihood of damage. However, this cooling must be effected before the accumulation of heat causes deterioration and melting. Furthermore, if the heat is permitted to flow into the surrounding area downstream of the heating means, it might still be sufficient to cause deterioration and melting of the coated strip. One manner of avoiding this is to provide a cooling means close to the heating means and to cool the coated strip at the same rate at which it was heated. However, such rapid cooling is disadvantageous because the rapid heating and cooling cycles tend to warp and weaken the coated strip, and breakage often occurs as the strip continues along its treating path. The resultant product is also often warped and weakened.

It is an object of the present invention to provide an apparatus for applying a cured coating on a metal strip in a continuous production line wherein an induction heating means with all its advantages is utilized but wherein the coating is effectively cured without any warpage or weakening thereof.

Another object of the present invention is to provide an apparatus of the aforesaid type wherein the cooling means is an integral part of the strip moving means.

Another object of the present invention is to provide a product of the aforesaid type wherein the solvents in the coating material are substantially recovered.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following description when read in conjunction with the accompanying drawings wherein:

The single figure in the drawing is a schematic view of a system embodying the present invention.

Referring now in greater detail to the drawing wherein similar reference characters refer to similar parts there is shown a continuous treating system, generally designated **10**, comprising a low carbon steel strip **12** passing from a coil **14** mounted on an uncoiler **16** of standard construction. The strip **12** passes between a pair of pinch rolls **18** and then through a series of pretreating operations prior to the coating operation.

The first of these pretreating operations is performed by the apparatus **20** where sprays **22** of alkali solution are projected against both sides of the strip **12** and the strip is then scrubbed and cleaned by scrubbing rollers **24** while the strip is supported by back-up rollers **26**. The strip is then guided by pinch rollers **28** into an apparatus **30** where the strip is rinsed by sprays **32** and smoothed by abrasive wheels **34** while being supported by back-up rollers **36**. The cleaned and smoothed strip **12** is then guided by pinch rollers **38** into an apparatus **40** where the strip is provided with a chemical coating to condition the strip for the application of the paint, this coating, which is of standard formulation, being applied by means of rollers **42**. The strip **12** then passes successively through a rinsing apparatus designated generally as **44**, a drying means **46** and an auxiliary drying and leveling means generally designated **48** and **50**. The strip **12** then passes around a roller **52** before and

after which it is provided with a coating of paint by means of rollers **54** and **56** in the standard manner.

It is to be understood that the above-described pretreating operations are standard operations which, by themselves, form no part of the present invention, although they are part of the total processing system. Furthermore, other pre-treating operations may be substituted without affecting the actual inventive process and apparatus of the present invention.

After the paint has been applied as a coating to both sides of the strip **12** by the rollers **54** and **56**, the strip passes through an induction heating coil **58**. The coil **58** is connected to a source of electrical energy (not shown) which supplies the coil with high frequency electrical oscillations, to created a field of force surrounding the strip and, thereby, induce heat producing eddy currents in the strip. A control unit **60**, of standard design is imposed in the circuit to vary the current, and therefore the temperature, as desired. A recorder **62** is also provided in the circuit to record the temperature at any particular instant in response to a sensing device **63**.

The heat produced by the induction coil **58** not only acts to heat each segment of the strip to the desired curing temperature as such segments pass through the coil, but also acts to vaporize the solvent which forms a component of all standard paint compositions. This vaporized solvent would ordinarily then flow downstream of the path of travel of the strip **12**, during which time it would begin to condense in the atmosphere. This condensation, being an exothermic process, would give off the heat of vaporization to the coated strip. Such additional heat would not only prevent immediate cooling of the coated strip but would often actually build up the temperature to a point where it would be sufficient to cause deterioration of the coating material or melting of the strip itself. Furthermore, the solvent would tend to contaminate not only the atmosphere but the coated strip itself which, by this time, should desirably be free of solvent. In addition, the solvent, itself, is a useful product and, when it is permitted to dissipate into the atmosphere, it becomes an economic loss.

In order to overcome the above-described problems relating to the vaporized solvent, there is provided a hood **64** which overlies the coil **58** and which is provided with a slot through which the strip **12** passes in its course through the system. This hood **64** is provided with depending box-like portions **65** having openings **66** adjacent the upper end of the coil **58**. Condensing coils **67** extending down into the portions **65** and are cooled by cold water flowing thereinto from a source (not shown) through line **68**. The water passes from the condensing coils to a sump (not shown) through line **70**.

As the vapors are formed, they pass through the openings **66** into the hood **64**, a blower **71** drawing the vapors therethrough.

The solvent is condensed by the coils **66** and flows down through the depending portions **65** and through conduits **72** to a recovery tank **74**. Any vapors or fumes that are not condensed are drawn up through an exhaust duct **76** by the blower **71** to an afterburner **78** where they are burnt up to prevent any contamination of the atmosphere.

The strip **12** thereafter passes around an internally water-cooled roller **80** provided closely adjacent the hood **64**, and then successively around rollers **82** and **84** which are also internally water-cooled. Cold water is supplied to all three rollers **80**, **82** and **84** from a source (not shown) through a line **86** and a manifold water supply line **88**. Each roller **80**, **82** and **84** have water outlets, as indicated at **90**, **92** and **94** respectively, which lead to a sump or the like (not shown). The coated strip finally passes over guide rollers **96** to a coil **98** mounted on a standard recoiler **100**. The recoiler **100** is powered by a motor (not shown), in the standard manner, to draw the strip from the coil **14** in a continuous manner.

The use of the water-cooled rollers **80**, **82** and **84** is important in this invention because they provide a means for gradually cooling the coated strip during the curing stage in a manner to lower the temperature sufficiently to prevent deterioration or melting while not cooling the strip so rapidly as to initiate stresses and strains therein and consequent warpage and weakness. This is, of course, aided by the provision of the hood **64** which prevents much of the residual heat built up by the induction coil **58** from passing over the coated strip in the areas of cooling.

It is to be understood that water used to cool the rollers **80**, **82** and **84** may, instead of being passed to a sump, be passed through a heat exchanger of any ordinary design and, thereby, be recycled for repeated use in a closed system. It is also within the scope of the present invention to utilize any other feasible type of cooling means such as air or other cooled gases, vapors or liquids.

The strip **12** may be any feasible material which lends itself to the described process. Low carbon sheet steel has been utilized in the description herein, but other types of material may be used if they possess the desired characteristics and if they can be coated with the desired paint or the like by the use of this process. The coating is usually an organic paint composition including an organic solvent, but any solvent which will volatilize under these conditions without contamination of the coating may be used.

The thickness of the strip and coating material as well as the type of metal of the strip and the chemical formulation and characteristics of the coating are factors in the heating and cooling cycles and these must be carefully controlled in accordance with such conditions. Generally, the temperature, when using standard type paints, is about from 350° F. to about 1000° F. The thickness of the strip used in the above described process is about 16 gage and the coating speed is preferably about 300 f.p.m. The thickness of the coating may vary within desirable and feasible limits depending on the type of coating substance used, the speed of movement of the strip and the heat generated by coil **58**. The speed may, however, vary from about 250 to about 800 f.p.m., depending to a great extent on the amount of cooling rollers used, their cooling effect and their spacing. In this respect, although three such cooling rollers **80**, **82** and **84** are used, the number may decrease or increase in accordance with conditions. Furthermore, these rollers may be made adjustable to vary their positions with respect to the heating means as well as with respect to each other. In such case, if a water-cooling system such as shown in the drawing is used, the line **84** may be made flexible or telescopic or may be made adjustable in any other manner that would be within the skill of the art.

It is also to be understood that although the invention has been described as relating to coatings having solvents therein, it is equally well adapted to the evaporation of any liquid vehicle or diluent of which solvents are only one example.

Obviously, many modifications of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

The invention claimed is:

1. In a coating system for coating a metal strip with a heat-curable coating, an induction heating means, a hood enclosing said heating means, said hood being substantially closed to ambient atmosphere, said hood having means to permit movement of the coated strip therethrough, and conveying means for continuously moving said strip, with a heat-curable coating thereon, from a coil through said heating means and to a recoiler, said heating means being constructed and arranged to induce a curing temperature throughout both the strip and coating thereon, and a cooling means situated downstream from the heating means and constructed and arranged to cool the coated strip in at least one area downstream from said heating means.

2. The system of claim 1 wherein said cooling means comprises at least one cooling roller provided with cooling fluid for reducing the temperature of the coated strip as it passes thereover.

3. The coating system of claim 1 wherein the hood is provided with condensing coils for condensing vapors resulting from the heating of the coating, and means for removing the condensed vapors from the system.

4. The coating system of claim 1 wherein the hood is provided with an exhaust duct for uncondensed vapors and gases, and burner means for burning said uncondensed vapors and gases.

5. The coating system of claim 2 wherein there are a plurality of cooling rollers positioned in spaced relation to each other downstream of the heating means.

6. The coating system of claim 1 wherein a control

means is operatively connected to the induction heating means to control the amount of electrical energy passing thereto.

7. The coating system of claim 2 wherein the cooling roller is adjustable relative to the path of movement of the strip.

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