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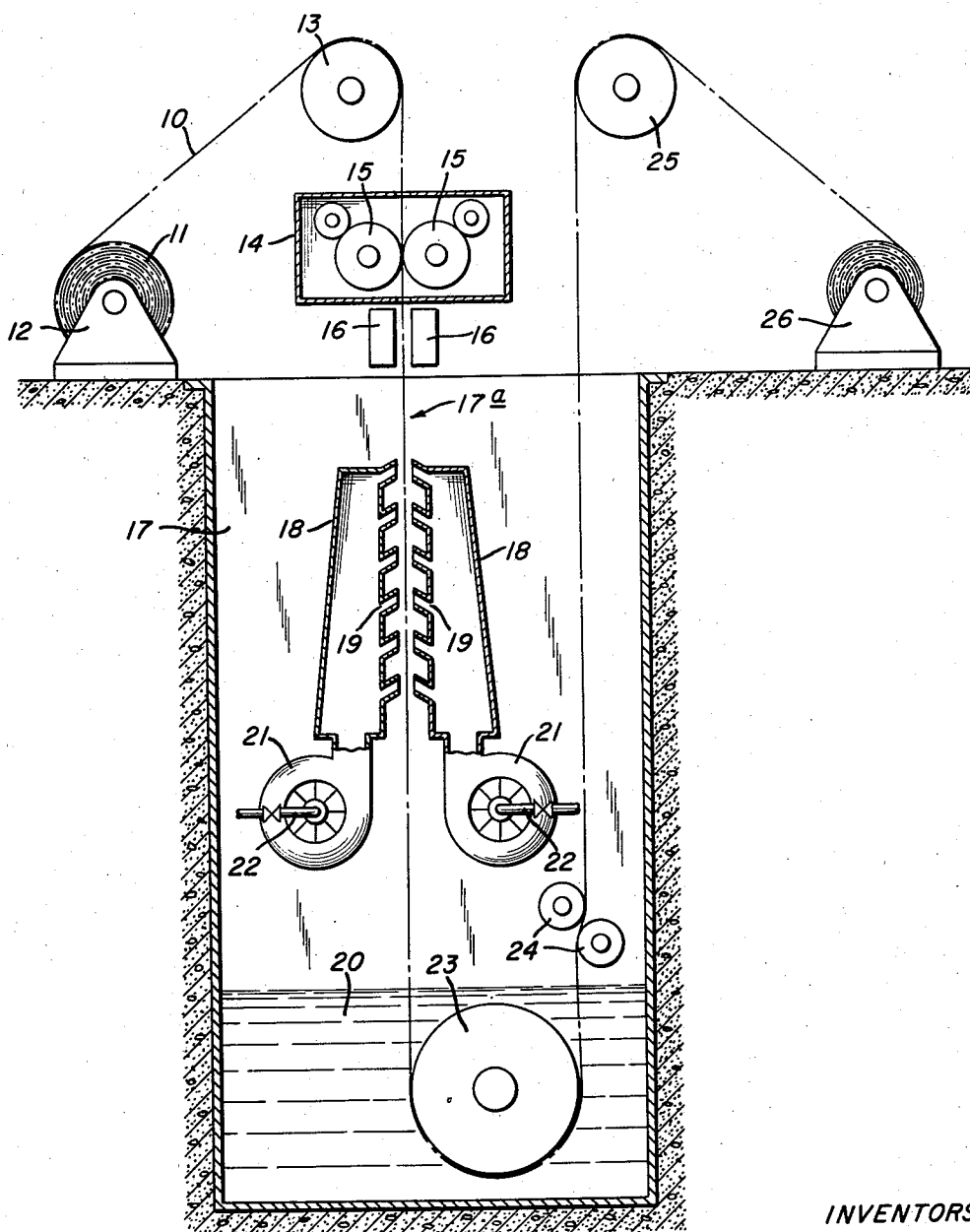
A. N. LAUBSCHER ET AL
METHOD AND APPARATUS FOR CONTINUOUSLY APPLYING
A PROTECTIVE FILM OF LACQUER TO STEEL STRIP

2,833,672

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3 Sheets-Sheet 1

FIG. 1.



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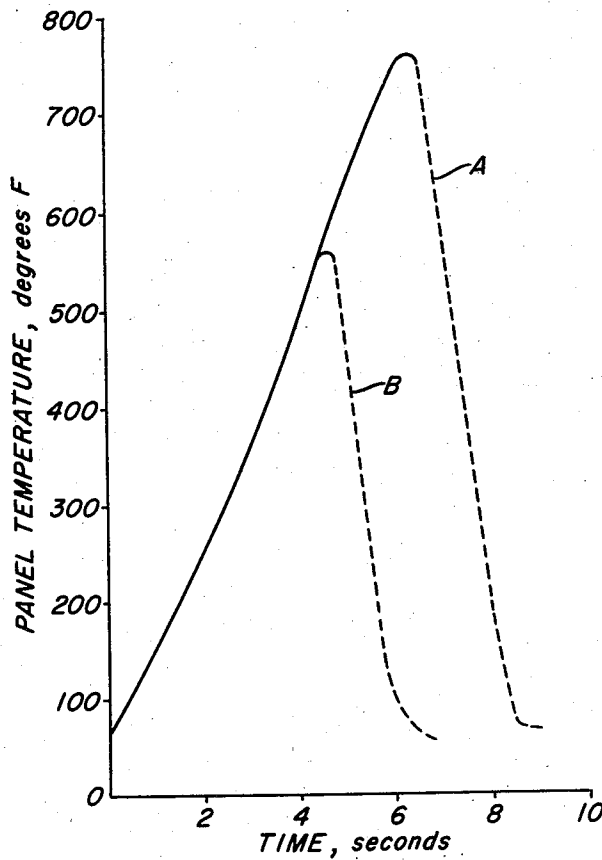
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FIG. 2.



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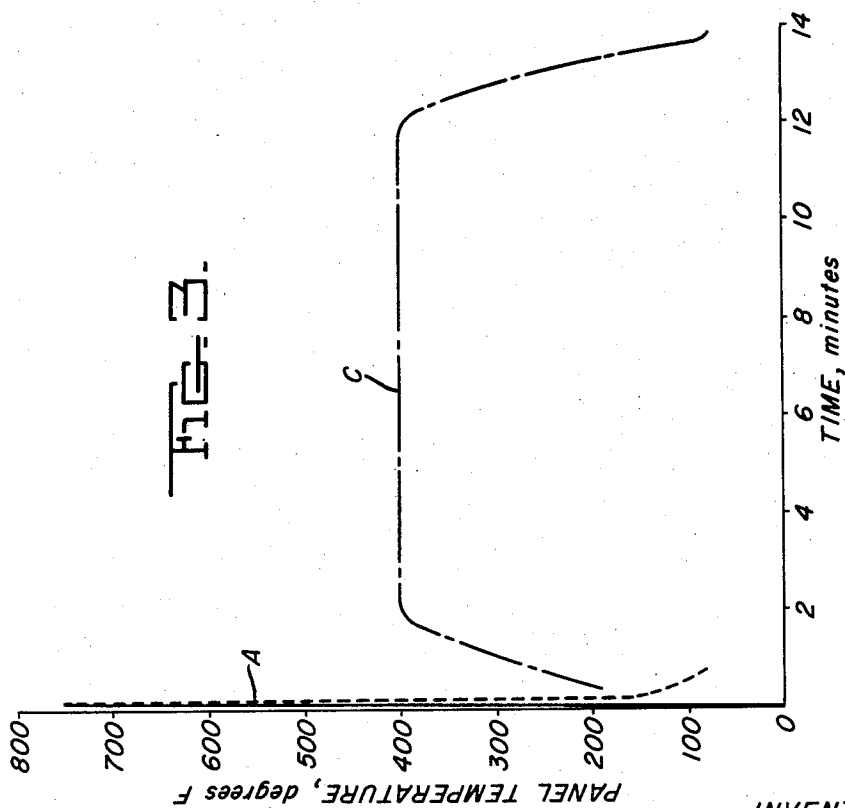
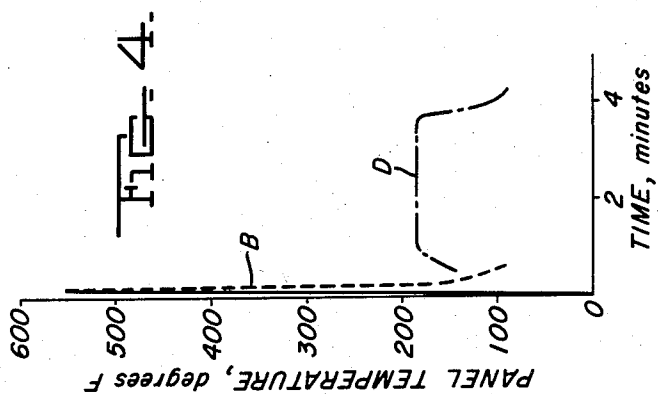
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1

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METHOD AND APPARATUS FOR CONTINUOUSLY APPLYING A PROTECTIVE FILM OF LACQUER TO STEEL STRIP

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Application May 17, 1955, Serial No. 508,891

6 Claims. (Cl. 117—103)

This invention relates to the coating of sheet metal, such as low-carbon sheet steel, with a heat-curable organic coating, such as a commercial lacquer, and the curing thereof in a continuous operation, at high speed.

It has been the practice heretofore, in the metal-container industry, to coat sheets of tin-plate or black-plate with lacquer and cure the resulting film by baking it with heat applied externally. Pfeffer Patent No. 2,529,414 deals with this practice. The curing requires heating to a definite temperature characteristic of the coating medium employed and holding the sheets at such temperature for a predetermined time. The practice is usually carried out by using a roller coater to apply the lacquer and standing the sheets on edge on a chain conveyor traversing a curing oven. The maximum temperature at which the curing is accomplished usually ranges from 400 to 425° F., in order to avoid melting the metal coating in the case of tin plate. For many coatings cured in that range, a curing time of about ten minutes is required.

For many applications, it would be advantageous for the steel industry to be able to supply users of sheet steel such as tin-plate, black-plate or drawing sheets, with a product having a lacquer film already applied to one or both surfaces thereof. It is the object of our invention to provide a method whereby this result may be achieved. A further object is to provide a method of coating sheet steel with lacquer, which can readily be integrated with other processes involved in making steel strip, and can operate at a speed which is customary in such processes.

Our invention is based on the fact that there is an inverse relation between curing time and curing temperature for many organic coating compositions now in use. We have discovered that this relation extends over a much broader range than has previously been realized. More particularly, we have found that a film of organic material such as a commercial lacquer, can be cured rapidly and without over-curing or charring, by suddenly raising its temperature along a steeply ascending gradient, to a value much higher than the top of the range for curing as practiced heretofore, provided only that the coated material is cooled substantially immediately with approximately equal rapidity, to a temperature below the normal curing range. More particularly, our invention involves heating a lacquer-coated steel strip to a temperature two or three times that of normal curing, in degrees Fahrenheit, and then immediately reducing the temperature below normal curing values, all within a time of from 2 to 5% of that required for the customary baking at such normal curing temperatures.

A novel condition present in our high-temperature, short time curing is that the coatings are subjected to temperatures substantially in excess of that normally considered the decomposition point of the organic coating material (about 500° F.). We have found, however, that the decomposition can be avoided and the desired degree of cure can be obtained by careful control and limitation of the time at the high temperature. Thus,

2

advantage can be taken of the rapid curing afforded by very high temperatures, without the occurrence of the deterioration usually occurring when organic materials are subjected to these temperatures. By this method, an operating speed may be attained comparable to those ordinarily used in lines of equipment for processing steel strip from the final rolling in the temper mill to the finished product.

A complete understanding of the invention may be obtained from the following detailed explanation which refers to the accompanying drawings illustrating a suitable form of apparatus for carrying out the method. In the drawings:

Figure 1 is a section, largely diagrammatic, taken along the central vertical plane through the apparatus;

Figure 2 shows heating and cooling curves for two coatings, A and B, as cured by our invention; and

Figures 3 and 4 are the curves A and B of Figure 2, drawn to a different scale for comparison with the heating and cooling curves used in the baking cure practiced heretofore.

Referring now in detail to the drawings, and, for the present, to Figure 1, low-carbon steel strip 10 of tin-plate gage, for example, which has been thoroughly cleaned by any known process, is unwound from a coil 11 mounted on an uncoiler 12 of known construction, trained over a guide sheave 13 and drawn downwardly through a coating tank 14. The tank has contact rolls 15 between which the strip passes, and contains a coating material such as the organic lacquer which has been used heretofore for coating can stock, e. g., a synthetic resin dissolved in a suitable solvent.

Immediately after passing through the coating tank, the strip is heated almost instantaneously to a temperature much higher than that conventionally used in curing a lacquer coated steel sheet, thus flashing the lacquer solvent into vapor. The heating is preferably accomplished by high-frequency induction units 16 which induce eddy currents in the strip. As shown, the strip passes between two of the units spaced slightly apart. They should be of sufficient capacity to heat the strip at rates as high as 500° F. per second, so as to reach a temperature of 500° to 800° F. at high speeds of travel, e. g., 600 F. P. M., without requiring units of too great length, i. e., over 8' or 10'. The details of such heating units are known and require no further explanation. Figure 2 shows the heating curves found suitable for curing two commercially available sheet lacquers.

After being heated to the desired temperature by the heating units 16, the strip enters a curing zone 17a at the top of a quenching chamber 17 in which the film becomes fully cured. The strip loses only a small amount of heat in the curing zone but this loss may be made up and additional heat supplied, if desired, by supplemental heating means in zone 17a. The strip then passes between spaced cooling manifolds 18 having nozzles 19 for discharging air jets thereon, and then into a final quenching bath 20 of water at the bottom of the chamber. Blowers 21 deliver air to manifolds 18, if desired, and any suitable sprays or atomizers 22 connected to a water supply, may be used to cause entrainment of water droplets in the air streams. The quenching effected by manifolds 18 and pool 20 causes the temperature of the strip to drop at a rate even greater than that at which it was heated. The curves of Figure 2 show the extremely high rate of cooling produced by the quenching operation. The strip travels around a guide sheave 23 immersed in the quenching bath and then passes upwardly between wringer rolls 24 to a guide sheave 25 above the top of chamber 17. The strip dries as it ascends by virtue of its residual heat and is drawn around sheave 25 to a recoiler 26.

It it should prove desirable to prolong the curing time, some of the nozzles at the top of the manifolds may be closed or the blowers 21 shut down, leaving bath 20 as the sole quenching means. Any suitable or necessary provision may be made for cooling the water of the bath, though it will continue to be effective even though it reaches the boiling point. When manifolds 18 are not used, the strip temperature falls only about 50° or 100° F. until it becomes immersed in the quenching bath.

As already stated, the heating and cooling curves of Figure 2 show curing cycles suitable for two commercial lacquers. Curve A represents that used for the aluminum-pigmented enamel #114-C of Interchemical Corporation. Curve B is for "Vinsynite" AU-1 of Thompson and Company. In both cases the quench was effected solely by bath 20, manifolds 18 not being used. The heating rate was about 100 or 120° F. per second and the cooling rate even greater, i. e., about 350° F. per second.

Figure 3 shows curve A to a different scale from that of Figure 2, for comparison with curve C which is the normal baking treatment recommended for curing the coating used. Figure 4 similarly shows curve B to the same scale as curve D which is the cycle ordinarily used for the coating material involved. It will be noted that curves A and B run up two or three times as high as curves C and D. The total times, i. e., heating plus cooling, however, are only 1 to 5% of those required by the cycles represented in curves C and D.

Coating compositions other than those mentioned above are susceptible to similar short-time, high-temperature curing treatment, as follows:

Manufacturer	Manufacturer's Designation	Max. Temp. Attained, °F.	Total Heating and Quenching Time, sec.
Thompson & Co.	PV678	625	5.0
Do.	FS-2	635	5.2
Do.	AS-4	625	5.0
Do.	13670	800	7.0
Pgh. Plate Glass	VD4084	840	7.6
Interchemical Corp.	3476B	560	4.6
Do.	1457	825	7.5
Do.	3396	640	5.4
du Pont.	U43970	815	6.5

The chief advantage of our invention is that it provides a method of curing lacquer coating films at speeds comparable to those at which lines for cleaning and tinning steel strip are now being operated, without extending the heating apparatus to unacceptable length. While the high temperature employed would ordinarily be expected to over-cure or char the film, the rapid quench following so quickly after attainment of the

maximum temperature effectively prevents this. A further advantage flowing from the use of induction heating units is that they cause heat to be generated internally of the strip, quickly evaporating the coating solvent and curing the solute left adhering to the strip, from the inside outwardly.

Although we have disclosed herein the preferred embodiment of our invention, we intend to cover as well any change or modification therein which may be made without departing from the spirit and scope of the invention.

We claim:

1. In a method of coating ferrous-metal strip, the steps comprising drawing the strip along a predetermined path at a speed of several hundred F. P. M.; applying a continuous film of liquid containing a volatile solvent to at least one surface thereof, at one point in said path, progressively heating the strip immediately thereafter to a temperature between 500 and 800° F. substantially instantaneously and before substantial evaporation of the solvent from the film, by electro-magnetic induction, thereby flashing the solvent into vapor, and immediately thereafter bringing the heated strip into contact with cooling fluid in a region closely adjacent said point of heating, thereby cooling the strip at a rate at least equal to that at which it was heated.

2. A method as defined by claim 1, characterized by said cooling fluid being an air blast impinging on the heated strip.

3. A method as defined by claim 1, characterized by said cooling fluid being a water quench.

4. A method as defined by claim 1, characterized by effecting said heating at a rate of about 115° F. per second.

5. Apparatus for coating strip comprising a quenching chamber, a coating mechanism disposed above said chamber, induction-heating means mounted immediately below said mechanism, strip-cooling means in said chamber, and means for passing strip successively through said mechanism and said heating means and downwardly into said chamber through said cooling means.

6. Apparatus as described in claim 5, characterized by said cooling means being an air-blast manifold mounted in said chamber.

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