Dec. 11, 1962 L. P. GOTSCH 3,068,119

METHOD OF HIGH SPEED COATING

Filed March 5, 1959

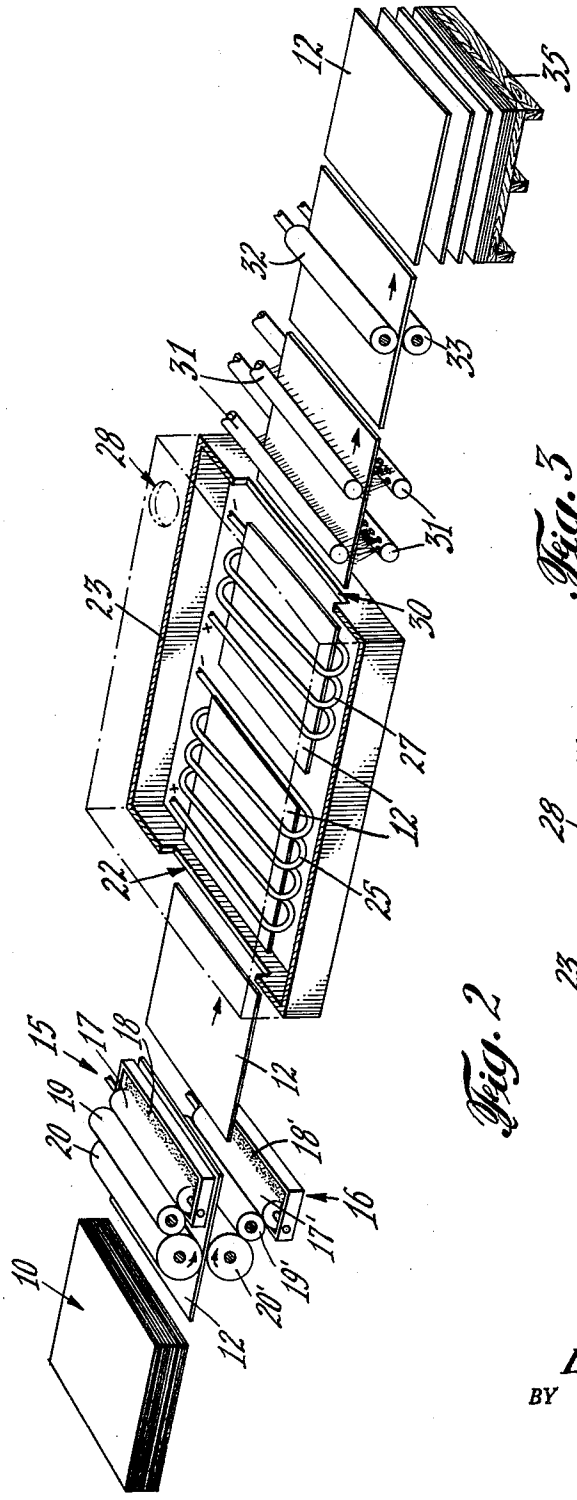


Fig. 1

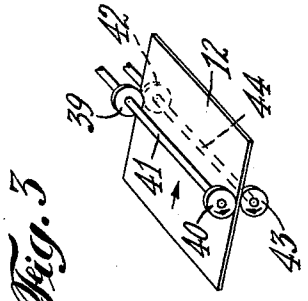


Fig. 3

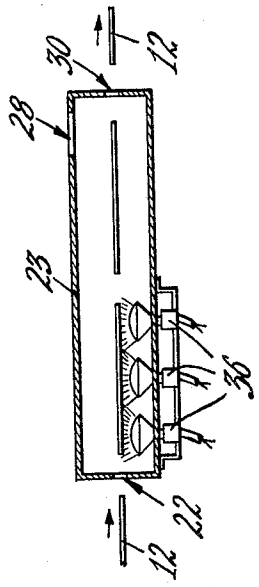


Fig. 2

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United States Patent Office 3,068,119 Patented Dec. 11, 1962

3,068,119

METHOD OF HIGH SPEED COATING

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Filed Mar. 5, 1959, Ser. No. 797,533
8 Claims. (Cl. 117—93)

The present invention pertains to a method of and apparatus for providing a metal surface with a protective coating at a high rate of speed. More particularly it pertains to a method of and apparatus for applying a liquid coating to a metal surface, heating and hardening this coating, all at high speed, to provide the metal surface with a protective covering. The instant invention is similar to but an improvement upon that set forth in U.S. Patent 2,833,672.

The term "metal sheet material" as used hereinafter is meant to include both individual sheets of metal passed along a predetermined path in processional order and a continuous, long length of sheet metal usually referred to as metal strip.

It is an object of the instant invention to provide a method for the high speed production of metal sheet material having a smooth, uniform, inert, protective coating thereon.

It is also an object to provide a method of high speed coating and heat curing a protective coating on the surface of metal sheet material.

It is a further object to provide a method of high speed coating and heat curing a protective film on a metal surface wherein the coating is heated from the metal surface outwardly to insure rapid and efficient heat transfer and solvent removal.

Another object is to provide a method of the character described wherein any solvent in the liquid coating is removed from the base of the coating outwardly towards its surface to prevent skinning-over of the coating surface and to promote rapid and efficient solvent removal.

Yet another object is to provide a method of applying and heat curing a synthetic resin coating on a metal surface having provision for the recovery of volatile constituents in the coating.

Still another object is to provide a method of the character described wherein the liquid coating is raised to a temperature above the decomposition temperature of one or more of its ingredients to effect very rapid cure of the coating but without thermally damaging the coating.

A further object is to provide an apparatus whereby the method of the instant invention may be accomplished.

Numerous other objects and advantages of the invention will be apparent as it is better understood from the following description, which, taken in connection with the accompanying drawings, discloses a preferred embodiment thereof.

In general the above objects are accomplished by performing the following steps in rapid sequence: passing metal sheet material along a predetermined path of travel; applying a liquid coating to at least one surface of the sheet; heating the liquid coating to a temperature of at least 500° F. from the substrate metal outwardly toward the surface of the coating; passing the heated sheet material and hot coating thereon into a temperature holding zone to permit continuation of the heat-curing or baking cycle for a brief time interval; rapidly cooling the hot coating and substrate metal to terminate the heat-curing or baking of the coating; and thereafter collecting in a compact load the coated sheet material for any desired subsequent operation.

Referring to the drawings:

FIG. 1 is a schematic perspective view illustrating an apparatus for high speed continuous coating of sheet material; FIG. 2 is a schematic side elevational view of a modification of the apparatus shown in FIG. 1 for heating sheet material; and FIG. 3 is a perspective view of a sheet conveyor means.

The metal sheet material used in the present invention has substantial width relative to its thickness. In passing through the various steps of the instant invention, the operations are performed on the relatively wide, flat portion of the sheet material. The sheet material is fed into its predetermined path from a supply thereof such as a coil, in the case of continuous strip, or from a stack of individual sheets. The liquid coating is then applied to the moving sheet material by any suitable means such as forward roller coating, reverse roller coating, doctor knife, dipping, spraying, etc., situated contiguous the path of travel of the sheet material. In the instant invention, the coating is preferably applied by forward roller coating, i.e. the applicator roller of the coater and the surface being coated both are moving in the same direction at their point or line of contact, because of the ease and speed of this form of coating application.

The liquid coatings useful in the instant invention are those which harden by non-oxidative curing. These compositions are well known in the art as protective coatings for metal sheet material and include synthetic resins such as vinyl resins, phenolic resins, epoxy resins, polyamide resins, etc. Most usually these resin compositions are applied as a solution of resinous components in a suitable volatile organic solvent. However, it is considered within the purview of the instant invention to apply resinous coatings consisting of 100% non-volatile resin, free of any volatile solvent therefor. Such 100% resinous coatings would be applied either as molten liquids or as combinations of interreactive liquid ingredients which upon intermixing and heating react to form a solid coating.

After application of the liquid coating, the coated substrate is carried along its predetermined path toward the heat curing or baking operation. Certain coating operations, such as forward roller coating, produce ridges on the coating surface which must be removed prior to heat curing. This is accomplished by maintaining the coating as a mobile liquid for a time interval of from 2 to 10 seconds and preferably about 6 seconds between coating and baking, to permit it to flow out into a smooth, even and continuous film over the substrate metal surface. Other means of coating application, such as reverse roller coating or doctor blade, do not produce an uneven or ridged surface, thus obviating the necessity for a flow-out time interval between coating and baking.

The sheet material with the smooth, level but still liquid coating thereon then passes into the heat curing or baking zone to be given a high temperature-short time bake. To transfer heat to the coating adequately and rapidly, the heat for this operation must be supplied from the metal of the sheet material outwardly towards the surface of the coating. This particular type of heating may be accomplished in a number of ways. Where the coating is applied to one surface only of the sheet material, the heat may be supplied to the coated surface by imparting heat to the uncoated surface of sheet material such as by moving the uncoated surface of the sheet material past but in proximity to a battery of infrared heaters. However, by far the most readily controllable and rapid means of heating the coating from the metal outwardly is by electromagnetic induction. This may be accomplished by passing the coated strip adjacent an electromagnetic induction coil so as to produce eddy currents, and thereby heat, in the metal of the sheet material at an extremely rapid rate. By this means sheet material coated on one or both sides may be raised to

the desired high temperatures in a very brief time interval. The hot sheet metal transmits its heat to the coating from the surface of the sheet material outwardly, thereby heat-curing the coating in the same direction and driving out solvents, if any, present in the coating and preventing any skinning effect on the surface of the coating.

In the heating step of the present invention, the temperature of the coating must be raised at least 200° F. per second to a temperature of from 500° F. to 800° F. Based on these requirements, the coated sheet material will spend a minimum of about 2 and a maximum of about 5 seconds within the heating zone.

After emergence from the heating zone, the hot sheet metal and coating thereon pass into a temperature holding zone which may be open or enclosed, and wherein the coating loses heat principally by radiation. In this zone, either the supply of heat energy to the sheet material and its coating is discontinued, thereby permitting the coating to cool at a relatively slow rate; or heat is supplied at substantially the same rate as it is lost so as to maintain the coating at substantially the same temperature as in the heating zone. Since the temperature of the coating as it emerges from the heating zone is 500° F. or above, heat curing of the coating continues as the sheet material passes through the temperature holding zone. Also during this time any residual solvent remaining in the coating volatilizes.

Since the coating is actually raised above its decomposition temperature in the heating zone, prolonged heating above the decomposition temperature leads to heat degradation or charring of the coating, which heat degradation would destroy the effectiveness of the coating. To prevent such degradation or charring, the heating of the coating and its passage through the temperature holding zone must be performed within a brief time interval. This time interval that the coating may remain at the elevated temperature set forth above of course will vary inversely with the temperature to which it is heated. However, for the purposes of the present invention the maximum time interval the coating may remain in the heating and temperature holding zones is about 20 seconds.

To terminate the baking or heat curing of the coating, the hot, coated sheet material is then rapidly cooled to a temperature well below its heat degradation or charring temperature, principally by conduction. This cooling may be accomplished in a number of ways, such as by cold water spraying, immersion in cold water, blowing cold air onto the coating, or, in the case of sheet material coated on one side only, by passing the sheet over and in contact with a chilled surface. This quenching or chilling operation terminates all heat reaction of the coating and sets the coating to its final solid, inert condition. Thereafter, the coated sheet material may be compacted such as by stacking in the case of individual sheets or coiling in the case of continuous strip. The compacted coated sheet material is then ready for any desired subsequent operation.

As a preferred or exemplary embodiment of the instant invention, the drawing illustrates a stack **10** of individual metal sheets **12**. The lowermost sheet **12** is fed from the stack **10** to a coating apparatus comprising an upper and lower forward roller coater **15**, **16**, respectively, of conventional, well-known construction. In general, each roller coater **15**, **16** includes a pick-up roller **17**, **17'**, rotating in a reservoir of liquid coating material **18**, **18'**, which liquid coating is transferred thence by roller **17**, **17'**, to transfer rollers **19**, **19'**, and thence to the applicator rollers **20**, **20'**. Although the coating apparatus shown in FIG. 1 applies coating to the upper and lower surface of the sheet **12** simultaneously, it is to be understood that either coater **15** or **16** may be disengaged or entirely eliminated so that the coating is applied to one side only of the moving sheet **12**.

As mentioned previously, forward roller coating applies a coating having a ridged surface. Therefore, after the sheet **12** leaves the roller coaters **15**, **16**, sufficient time is provided during its travel along its predetermined path to permit flow-out and leveling of the applied coating. However, this step may be eliminated if the coating is applied by other conventional means which produce no ridging, such as reverse roller coating or doctor knife application.

After leaving the flow-out zone, if any, the sheet then passes through a restricted opening **22** into an enclosed chamber **23**. Immediately upon entering the chamber **23**, the sheet **12** passes through an induction coil **25** connected to a suitable source of power (not shown). As the sheet **12** passes through the induction coil **25**, eddy currents are produced within the metal of sheet **12**, thereby heating it at an extremely rapid rate. The heat from the metal of the sheet **12** is transferred to the coating thereon, progressing from the metal outwardly towards the surface of the coating, to heat the coating to the desired temperature, i.e. 500 to 800° F. thereby heat curing the coating and volatilizing any solvents therein. The hot sheet and coating then pass into a temperature holding zone, also within the chamber **23**, wherein the coating is maintained at a curing temperature, thereby continuing its cure. Also within the temperature holding zone, the last remnants of any solvent are driven off.

As mentioned previously, no additional heat energy need be supplied to the hot sheet and coating in the temperature holding zone whereby the coating cools slowly, principally by radiation loss of heat. However, also as mentioned hereinbefore, heat energy may be supplied to the hot sheet and coating in the temperature holding zone to balance heat loss from the coating in this zone, thereby maintaining the coating at substantially the same temperature as it had upon emergence from the heating zone. It is also within the purview of the instant invention that the heat supplied in the temperature holding zone is somewhat less than the heat loss whereby the temperature of the coating decreases but at a slower rate than if no additional heating were provided. As shown in FIG. 1, heat energy is supplied to the sheet and its coating in the temperature holding zone by means of an electromagnetic induction coil **27** connected with a suitable source of energy not shown. Induction coil **27** has fewer windings than induction coil **25**, whereby less energy is supplied to and less heat produced in the sheet **12**.

The chamber **23** enclosing the heating and temperature holding zones is provided adjacent its exit end with an outlet aperture or pipe **28** through which solvent vapors are drawn. To permit efficient collection of the solvent vapors, the chamber **23** is maintained at a negative pressure. The solvent vapors drawn through aperture **28** are passed by means of suitable piping to a collecting tank where they may be condensed, concentrated and reused or disposed of by other desired means. The continued and controlled removel of solvent vapors reduces any explosion hazard from inflammable vapors and by the reuse thereof greatly reduces the material cost of the coating and thereby of the overall operation.

After the predetermined time lapse in passing through the temperature holding zone, the sheet **12** pases shrough a restricted opening **30** out of the enclosed chamber **23**. Immediately upon emergence from the chamber **23** the temperature of the coating is rapidly reduced, principally by conduction, using a cold water spray emanating from a plurality of spray heads **31**. It will be readily apparent to one skilled in the art that cold air could be fed through the piping that supplies the water to spray heads **31** whereby a cold air blast would be impinged against the surface of the hot coating on sheet **12**; or the hot coated sheets may be quenched by completely immersing them in a water bath. The chilling or quenching operation performed by the spray heads **31** or their equivalent sets the coating to its final hardened state.

The excess water remaining on the surface of the sheets **12** due to the quenching operation is removed by passing the sheets between a pair of opposed squeegee rollers **32, 33**. Other suitable means of water removal such as an air knife will be readily apparent to those skilled in the art. Thereafter the sheets **12** having the hardened coating thereon are stacked in a compact bundle such as on a pallet **35**, ready to be transferred to a subsequent operation.

FIG. 2 illustrates a modified form of high temperature-short time heating of the sheets **12**. In this modified form the sheets are coated on their upper side by means of a forward roller coating apparatus similar in construction and operation to the coating apparatus **15** described in relation to FIG. 1. After coating and flow-out of the coating, if necessary, the sheets pass into the enclosed chamber **23** past a battery of electric infra-red heaters **36**, the heat from which is directed against the uncoated side of the sheet **12**. The heat energy imparted to the sheet **12** is transferred to the coating on its upper surface, thereby heating and curing the coating from the metal outwardly. Thereafter, the hot, coated sheet **12** passes through the temperature holding zone, the quenching zone, water removal and stacking operation in the same manner as described in relation to FIG. 1.

FIG. 3 illustrates a means by which the sheets **12** are conveyed along the predetermined path. This means comprises a multiplicity of upper rollers **39, 40**, connected by a common shaft **41** and opposed lower rollers **42, 43**, also connected by a common shaft **44**. These rollers, driven by any suitable means (not shown), engage the side margins of the sheet **12** so as not to interfere with the various operations performed upon the sheet and to have little or no effect on the coating applied to the sheet.

Although the drawings and description thereof are limited to treatment of individual sheets moving along a predetermined path in processional order, it is to be understood that the instant invention has equal application both in method and in apparatus to a continuous web of metal sheet material often referred to as metal strip. It will be readily apparent to one skilled in the art that to adapt the apparatus illustrated in FIG. 1 for the handling of metal strip it is necessary only to substitute a pay-off reel or coil for the stack of sheets at the left-hand side of the drawing and a wind-up reed or coil for the stacked sheets on pallet **35**.

I claim:

1. In a method of providing a metal surface with a protective coating comprising the steps of: moving said surface along a predetermined path, applying to said surface by means of forward roller coating a liquid coating comprising a film forming synthetic resin, passing the thus coated surface into a heating zone and progressively heating said coating from the metal surface outwardly to a temperature between 500 and 800° F. at a rate of at least 200° F. per second to at least initiate solidification of said resin, passing the heated coating into a temperature holding zone wherein heating of said coating continues at a rate not in excess of the rate of heat loss from said coating to continue the heat treating of said resin at a temperature not higher than that attained in said heating zone, and subjecting said resin to the operation of a cooling medium to rapidly terminate the heat treating thereof; the improvement comprising maintaining said coating in a mobile liquid state for from 2 to 10 seconds prior to heating to permit said coating to flow out into a smooth even film on said surface.

2. The method set forth in claim 1 wherein said metal is a ferrous metal.

3. The method set forth in claim 1 wherein said cooling medium is a water quench.

4. The method set forth in claim 1 wherein said cooling medium is a cool air blast.

5. The method set forth in claim 1 wherein said surface is that of a metal sheet.

6. The method set forth in claim 5 wherein the liquid coating is applied to one surface only of said metal sheet.

7. The method set forth in claim 6 wherein said coated surface is heated in said heating zone by passing the uncoated surface of said sheet contiguous a high temperature heating means.

8. The method set forth in claim 7 wherein the uncoated surface of said sheet passes contiguous infra-red radiation means.

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