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(54) **Method for the manufacture of externally coated tube from steel strip and tube made by the method.**

(57) Externally coated steel tube is made from steel strip by longitudinally folding and welding the strip to form the tube (200), preheating (205) the tube and applying powder (206) to the exterior of the preheated tube. The tube is then baked at a higher temperature before cooling. In order to achieve an even and continuous coating when using thermosetting material as the coating powder, the temperature given to the tube by the preheating (205) is such as to cause the coating powder to melt and spread out immediately on application to form a substantially continuous coating, before substantial curing of the coating material occurs. Suitably, this is provided by passage of the tube through a box (207) which maintains the temperature of the tube.

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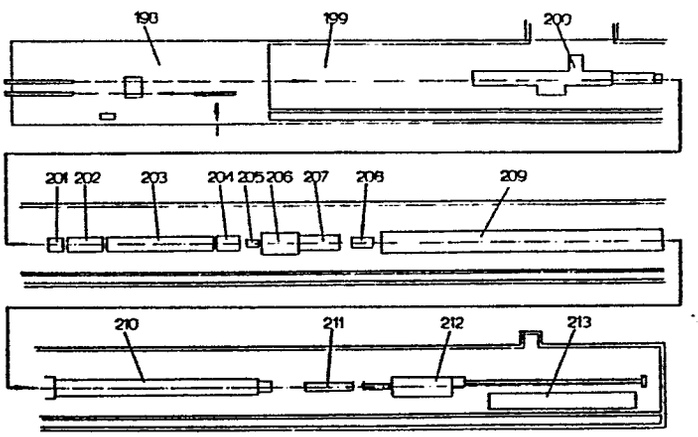
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METHOD FOR THE MANUFACTURE OF EXTERNALLY COATED TUBE FROM STEEL STRIP AND TUBE MADE BY THE METHOD

This invention relates to a method of making tube from steel strip and externally coating the tube with thermosetting material, including the steps of longitudinally folding and welding the strip to form the tube, preheating the tube, applying thermosettable material in powder form to the exterior of the preheated tube, inductively heating the tube so as to cause curing of the thermosettable material, and cooling the coated tube. The invention further relates to tube made by the method.

The thermosetting coating applied may be a lacquer, and we shall use this term frequently in the following discussion.

Many proposals have been made for processes involving the continuous lacquering of tube immediately after the welding of the tube following its shaping from steel strip.

For instance, United States patent specification 3,616,983 describes an apparatus for continuous formation of a metal tube which is internally and externally coated with artificial resin. The external coating step is performed by applying a powdered synthetic material after calibration (also called "sizing"), cleaning, liquid-priming and inductive heating of the previously welded and internally coated tube. It is followed by cooling sawing to length and storage. Although no kinds of artificial resin are specifically named, it may be concluded beyond all doubt from the statement that heating takes place "to a temperature above the melting point of the plastic material utilized", that the patentees are concerned with thermoplastic synthetic materials.

When applying thermoplastic powders it is possible to spray the powder directly onto a preheated surface, where it melts quickly

and forms a closed final layer, which cooling can follow immediately. Thermoplastic synthetic materials, however, have the disadvantage that they must be applied in a considerably thicker layer than thermosetting synthetic materials in order to achieve the same corrosion-resistance. Besides, when using thermoplastic synthetic materials, so-called "primers" must often be used to obtain proper adherence of the coating to the metal surface. Another disadvantage is that the standard thermoplastic synthetic materials such as polyvinyl-chloride, nylon etc. are a great deal more expensive that the usual thermosetting lacquer powders.

The use of thermosetting coating material for tubes has been proposed. See U.S.A. Patent No. 3,667,095 in which the application of resin with solvent prior to a two-stage heating process is proposed.

U.S.A. Patent No. 3,965,551 proposes a method as described at the outset in which after continuous forming, welding, and galvanising, the tube is covered with thermoplastic or thermosetting powder and then heated inductively to form the coating.

The purpose of the preheating before application of the powder is to dry a previously applied liquid coating, e.g. solvent-based primer coating. When a thermosetting powder material is used as the exterior coating, the controlled heating to effect melting and curing takes place entirely after the powder has been applied. This method is not fully satisfactory, and we have found it open to improvement, in particular to achieve a more rapid melting and flowing of the powder without the formation of bubbles or blisters in the coating due to entrapped air and chemical reaction products in the coating.

The object of this invention is to improve the known processes described above in order to provide a process suitable for use with thermosetting coating material, and in particular a process which will achieve a smooth and continuous layer of cured thermosetting material on the tube without formation of bubbles or blisters in the coating.

The method of the invention as claimed is intended to solve this problem.

The method preferably includes the steps of, after welding and before pre-heating the tube, cleaning its exterior surface and pre-treating its exterior surface to improve adherence of the thermosetting coating and to improve corrosion-resistance.

Heating of the tube both before and after the powder is applied is essential to the method according to the invention. The purpose of preheating is to cause melting of the thermosetting powder as soon as it is applied. It thus spreads out across the preheated surface, so that the entire process is speeded up. This preheating can also aid the formation of a proper smooth final layer.

The moving tube product is preferably preheated, suitably by middle-frequency induction heating, to a maximum temperature of 200°C, or any other suitable temperature at which the hardening reaction of the thermosetting material does not progress very quickly. However, the powder will start to melt and flow together and as a result of the very slow progress of hardening at the temperature chosen will have the opportunity to work itself into a smooth film across the tube surface. In this way it is possible to achieve a satisfactory closed final layer.

Since the powder is heated from inside by the heat of the tube and thus melts from the inside outwardly, entrapped air and any gases produced on melting can escape outwardly as melting progresses. It is additionally helpful that melting begins even while the powder is being applied.

In the succeeding stage a higher temperature is produced, again preferably in the tube material by means of middle-frequency induction heating, so that hardening of the thermosetting layer is initiated. A third important step is to maintain a suitable higher temperature (e.g. 400° C maximum) of the tube for a certain periode sufficient to produce hardening or curing of the layer.

An embodiment of the invention will now be described with reference to the accompanying drawing, the single figure of which is an outline top view of a production line for steel tube, the line is being drawn in three sections one below the other. The arrows show the path of the tube material.

In the strip preparation device 198, each coil of steel strip is welded to the previous coil to form an endless strip which is continuously fed through the plant. In the strip-cleaning device 199, the strip is cleaned. In the shaping, welding and calibrating machine 200, a tube is shaped out of the strip, is welded and next sized or calibrated to the proper desired end size. If necessary a straightening unit 201 follows. Optionally, pre-heating of the tube can take place in a gas furnace 202.

In a degreasing and phosphating section 203 the tube is cleaned on the outside and provided with a priming coat e.g. iron phosphate to enhance lacquer adherence. There follows a rinsing bath 204, in which the tube is rinsed clean. So far, the process is conventional, and need not be described in more detail.

A first middle-frequency induction heating furnace 205, encircling the tube path in the manner of a coil (its frequency is approx. 3000 Hz) serves to dry the tube and to heat it to a temperature of approx. 50 to 150 degrees C (maximum 200 degrees C), the exact temperature being chosen according to the melting temperature of the lacquer powder to be applied next. By a known electrostatic technique, thermosetting powder is then applied to the tube in the powder cabin 206, as a starting material for the desired lacquer coating. Epoxy resins, polyester resins such as polyurethanes, polyacrylate resins or combinations of these may serve as suitable thermosetting synthetic materials in powder form.

As a result of the internal heat contained in the tube, the powder melts when applied. In the subsequent enclosure 207, which may simply be a box, the powder has the oppertunity to spread

out and to form a closed smooth layer all round the tube. This melting and spreading out, initiated while the powder is being applied, has a beneficial effect on the quality of the coating produced; in particular it causes air bubbles in the lacquer film to be removed. By supplying heat from the inside, any porosities in the lacquer film are moved outwards, in contrast to the case where heat is supplied only from the outside when porosities can be trapped in the lacquer film.

Thus it is a special feature of the invention that a smooth closed film of thermosetting synthetic material can be obtained starting from powder. This powder is given the opportunity to flow and spread out at comparatively low temperatures at which polymerisation of the synthetic material still progresses very slowly.

The use of thermosetting synthetic powder is advantageous because dispersion lacquers which can be diluted with water, and so-called two-component lacquers which must be sprayed on as a liquid with 10 to 20 percent solvent, have known disadvantages. Also, the solvent in each case has drawbacks of an environmental nature.

Next, a second middle-frequency induction heating

furnace 208 (frequency approximately 3000 Hz) causes a rapid rise in temperature of the tube (up to a maximum of 400 degrees C) so that hardening of the already molten and spread out lacquer film is speeded up substantially. In the subsequent hardening film is brought about. The temperature in this furnace 209 is also 400 degrees C maximum. In the so-called addition reaction of the thermosetting synthetic material about 1 percent of secondary products are formed. These can be removed by suction. Since here the heat for hardening originates from the tube material itself, the hardening process starts from the inside. This too contributes to the fact that practically no air bubbles can arise in the lacquer film (it should be borne in mind that the layer thickness of a thermosetting synthetic material is frequently less than 0.060 mm, in contrast with the layer thickness of a thermoplastic synthetic material, which frequently exceeds 0.1 mm). The hardening lacquer film should be kept at the chosen temperature for the time required for adequate hardening of the thermosetting material selected, which is the reason why the hardening furnace 209 is comparatively long.

In the cooling section 210, the lacquered tube is cooled down to room temperature. A drawing or pulling caterpillar 211 draws the tube from the point 205 in a flattened catenary curve.

In the cutting device 212, the endless tube is cut into manageable final pieces, which are caught in a collecting station 213 and prepared for further transport.

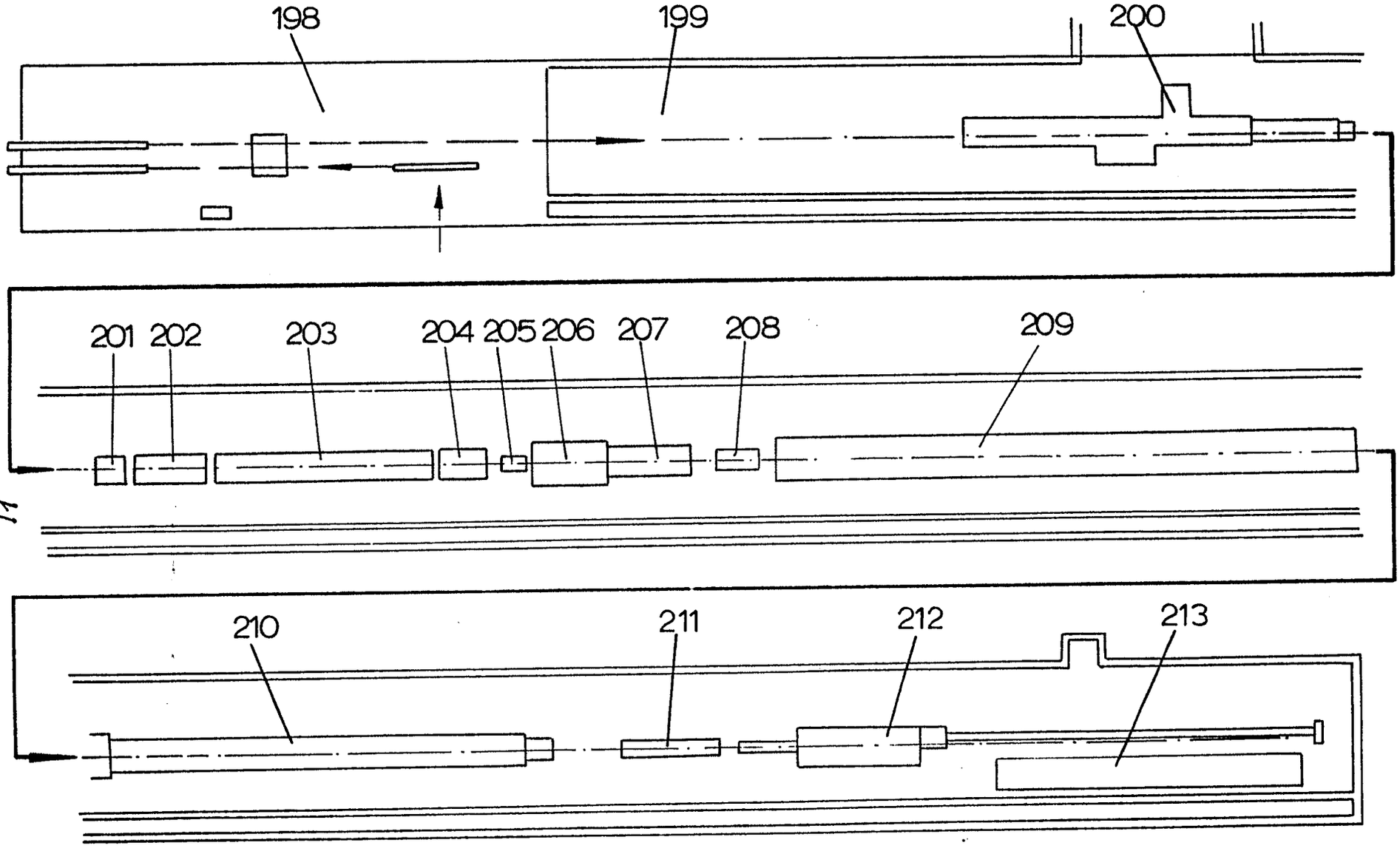
CLAIMS:

1. A method of making tube from steel strip and externally coating the tube with thermosetting material, including the steps of longitudinally folding and welding the strip to form the tube, preheating the tube, applying thermosettable material in powder form to the exterior of the preheated tube, inductively heating the tube so as to cause curing of the thermosettable material, and cooling the coated tube, characterized in that the temperature given to the tube by the preheating is such that, immediately upon application the powder material begins to melt and spread out on the tube so as to form a complete covering of the tube exterior surface while substantially no curing of the material occurs.

2. A method according to claim, characterized by the steps, known per se of, after welding and before preheating the tube, calibrating the tube, cleaning its exterior surface and pre-treating its exterior surface to improve adherence of the thermosetting coating and to improve corrosion-resistance.

3. A method according to claim 1 or claim 2, characterized in that, after application of the powder, the tube passes through an enclosure (207) which helps to maintain the temperature of the tube required to cause the powder material to melt and spread out.

4. Externally coated steel tube made by the method of any one of claim 1 to 3.



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EUROPEAN SEARCH REPORT

Application number

EP 79 20 0005

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
DX	US - A - 3 965 551 (A.E. OSTROWSKI) * The complete document *	1,2,4
	FR - A - 2 278 503 (URALSKY N.I.I. TRUBNOI PROMYSHLENNOSTI) * Page 4, lines 15-39 *	3

CLASSIFICATION OF THE APPLICATION (Int. Cl.²)

B 05 D 7/14
B 05 D 1/38
B 21 C 37/08

TECHNICAL FIELDS SEARCHED (Int.Cl.²)

B 05 D 7/14
B 05 D 1/38

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20-04-1979	VAN THIELEN