May 9, 1939. A. KOYEMANN 2,157,456

METHOD OF UNITING SPRAYED METAL TO WOOD

Filed Feb. 20, 1936

Fig.1

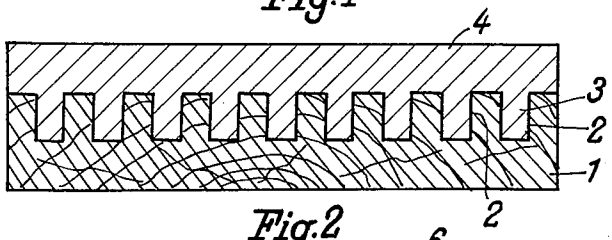


Fig.2

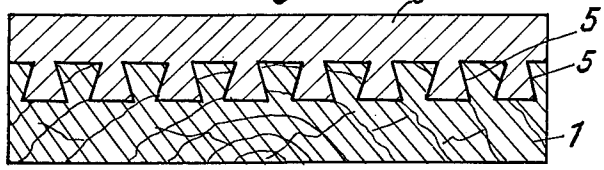


Fig.3

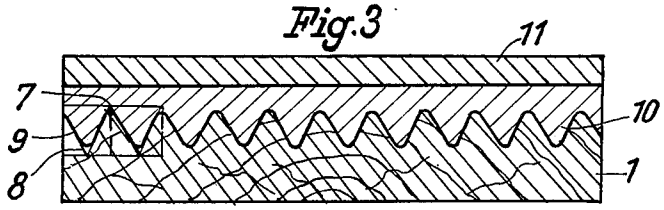


Fig.4

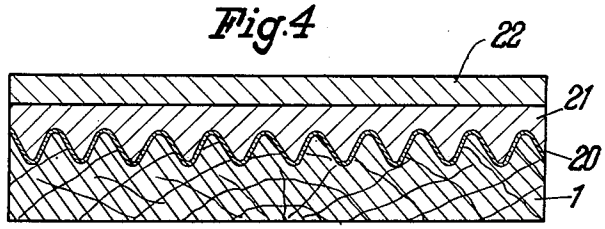


Fig.5 Fig.6 Fig.7

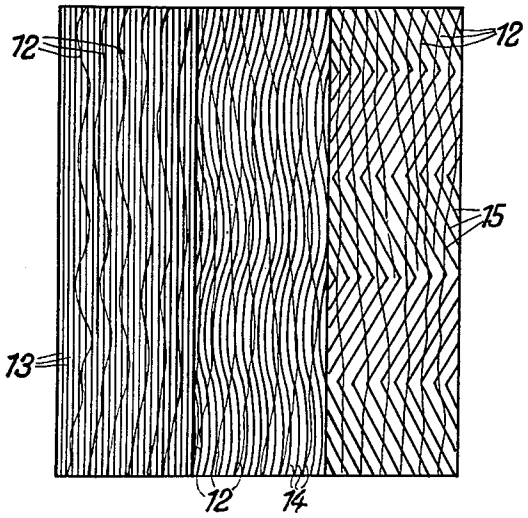
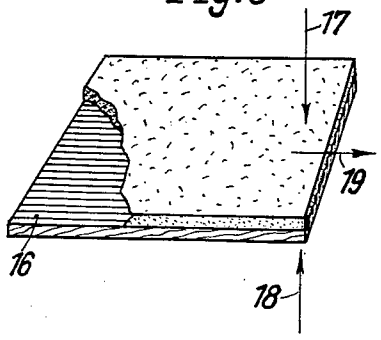


Fig.8



Inventor:

Alfred Koyemann,

By E. F. Wendroth

Atty.

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METHOD OF UNITING SPRAYED METAL TO WOOD

Alfred Koyemann, Hamburg, Germany, assignor, by mesne assignments, to Naamlooze Vennootshap Derde Nederlandsche Patentenmaatschappij (D. N. P. M.) The Hague, Netherlands, a Dutch company

Application February 20, 1936, Serial No. 64,953
In Germany February 23, 1935

3 Claims. (Cl. 91—70.2)

The invention generally relates to a method of coating wood by spraying metal upon the surfaces of the wood. Its object is particularly to improve the method disclosed in my co-pending U. S. A. patent specification Ser. No. 38,668, filed August 30, 1935, in which a protective covering to the surfaces of wood is applied by spraying successively at least two layers of molten metal to the surfaces of the wood of which the metal nearest to the surface of the wood has a lower fusion point than the metal of the superposed layer and in which under certain circumstances an intermediate layer of an organic material glue is firstly applied to the surface of the wood before spraying the desired layers of metal to the surface of the wood. Said method also provides for roughening of the surfaces of the wood before coating it with layers of organic material and of metal.

The object of the invention is to improve the method above described and consequently to improve a structural material gained in this way which would give satisfaction to the highest static and dynamic requirements.

Further objects and advantages of the invention are to be gathered from the following description, the drawing and the claims appended.

Several embodiments of the invention are illustrated in the accompanying drawing.

Figs. 1 to 3 show cross sections of three metal-wood connections produced in different ways.

Fig. 4 shows a cross section of a metal-wood connection with an intermediary layer of an organic material.

Figs. 5 to 7 show in plan three ways in which the depressions or grooves or the like may extend in the wood.

Fig. 8 is a perspective view of a wood-metal plate according to the invention, part of the metal layer being omitted.

The invention starts from the following experiences which have originated with thorough practical tests with highly stressed structural material of wood covered with sprayed on metal layers in order to make the wood resistant against the high stresses which may be e. g. mechanical stresses and/or influences of the weather.

One has already sprayed metal having a low fusion point, e. g. tin, cadmium, zinc, with good success upon wood and one has obtained thereby a relatively good joint or connection with the wood if this was roughened because these metals have such a low fusion point that they do not burn the wood when being thrown on the metal by the spraying tool.

If it is intended to unite a harder metal, that is a metal having a higher fusion point, e. g. bronze, with wood, this is—especially also with a roughened wood surface—burnt, whereby the strength of the wood and also the adhesion between the metal and the wood is diminished. In order to avoid this disadvantage it has been proposed already first to spray to the wood a metal of a lower fusion point and then a layer of a metal having a higher fusion point. By this burning of the wood is prevented if the metal first sprayed on is so chosen that its fusion temperature lies below the limit suitable for the wood used.

Further it has been proposed to improve the adhesion between metal and wood by first applying to the wood organic substances such as masses having insulating and adhesive qualities.

None of these proposals, however, has led to a satisfying solution of the problem to obtain a thorough connection between wood and metal which is not loosened even if used perpetually if it is the question of wooden structural parts, e. g. air screws subjected to high stresses e. g. mechanical stresses and/or influences of weather.

In such cases it is necessary to spray on the wood hard metals having high fusion points, e. g. iron and steel, for building up an effective outer protective layer and that on account of the high stresses existing during operation. If the wood is only roughened e. g. by means of a sand blast apparatus and is then coated with the proposed adhesive or isolating mass, this mass and also the wood would be destroyed by burning when for instance iron and steel are sprayed on.

It is also not possible to use as inner layer next to the wood a metal fusible at a low temperature as e. g. tin, lead, or zinc when metal with very high fusion point is used for the outermost layer. When the liquid metal of the outer layer with the very high temperatures hits the layer of soft metal already sprayed on, this layer would become liquid at once and would lose any adhesion to the wood. In this case, therefore, the binding or intermediary layer would consist of a metal with a medium fusion point, e. g. bronze. When bronze is sprayed on directly to the wood, there is, however, danger of burning the wood on account of its high fusion point, lying between 700 and 1000° C.

In order to do away with these disadvantages according to the invention there is applied to the wood first an organic substance being of such a nature that it is not burnt at the higher temperatures of the metal binding layer, but protects the wood from being burnt by absorbing the heat

of the molten metal of medium fusion point, e. g. bronze, thereby becoming hard and tough thus forming a rigid connection between the metal particles on the one hand and the wood on the other hand. Upon this binding layer rigidly connected to the wood the covering layer proper is sprayed on consisting of very hard metal fusing only at highest temperatures, e. g. steel.

In case that even this connection does not give a sufficient adhesion adapted to withstand higher mechanical stresses, the invention further proposes to provide the wood with depressions or grooves before the organic substance and the metal layer or metal layers are applied. This is especially necessary with air screws on account of the large bending, tension, or centrifugal stresses which they are subjected to.

With these depressions or grooves the wood is provided in order to enlarge the effective area of adhesion. Preferably the depressions or grooves are milled into the surface and that parallelly to each other, because by this arrangement the highest area of adhesion is obtained and the depressions may be produced in an especially easy manner. Further it is rather of importance for the adhesion of the metal layers to the wood and for the strength of the metal-wood texture in which manner these depressions are cut. The depth of the depressions is of importance. This depth must suitably correspond to the thickness of the sprayed metal layers. The thicker these layers are, the deeper the depressions must be and vice versa. Further the shape of the impressions and their course of direction relatively to the fibres of the wood and relatively to the bending and tension stresses to which the wood-metal texture is subjected are of importance.

The effect contemplated may be realized by the provision of any suitable kind of depressions such as grooves, notches, incisions or the like.

In the embodiment illustrated in Fig. 1 the surface of the wood 1 is provided with parallelly extending groove-like depressions 2 of regular rectangular cross section. The metal 3 is sprayed into these depressions and the spraying operation is continued so far that there results a layer 4 covering the depressions, which layer is smoothed by grinding.

In the embodiment illustrated in Fig. 2 the surface of the wood is provided with longitudinally parallelly extending incisions 5 of dovetail section into and over which again the metal is sprayed. 6 denotes a metal layer covering the incisions.

In the embodiment shown in Fig. 3 the depressions in the surface of the wood, and the elevations between the depressions have a regular wave form in cross section. The individual waves may be produced in the manner represented in the left hand portion of Fig. 3. The surface of the wood 1 is in this case provided with parallel acute-angled cuts which are of uniform cross section and which are rounded on the top at 7 and on the bottom at 8.

These cuts do not need to be acute-angled but may have side walls 9 at right angles to one another or at an obtuse angle to one another. The side walls 9 of the cuts may be plane or curved and are preferably also roughened. The mode of production according to Fig. 3 has the special advantage that no dead angles and corners are left in the depressions. The individual fine metal drops therefore impinge at a favourable angle on the depressions and elevations so that the metal everywhere forms a firm union with the wood.

In this example two metal layers are applied by spraying in superposed relation. 11 denotes the outer metal layer. For the layers there may be used different metals, whether in pure form or in alloy form; or different alloys of the same metal may be used. The metals or metal alloys may differ from one another as regards melting point, hardness and ability to form a junction with the foundation, or may differ in other respects. Preferably the metal firstly sprayed to the surface of the wood has a considerably lower fusion point than the metal of its superposed layer.

Spraying in this manner will be chosen when there is danger that coating of the wood with a metal of a high fusion point would burn the surface of the wood when sprayed and consequently would not reliably adhere to the wood. In case of spraying a layer of iron or steel this manner is to be recommended.

Another way preferably to be used is to spray at first a layer of an organic material which is not liable to be burnt by the high melting metal when being sprayed on but which on the contrary becomes hard and tough when subjected to higher temperatures.

This organic material must further be chosen thus that it does not lose by the influence of the higher temperatures of the metal its adhesive and protective qualities by which it is able to unite rigidly the metal layer to the wood and to prevent the burning of the wood by the high temperatured metal.

In Fig. 4 this embodiment of the invention is illustrated. Fig. 4 shows depressions in the surface of the wood similar to those illustrated in Fig. 3. 20 designates a layer of an organic material of the qualities described above. 21 and 22 are layers of different metals of which the metal nearest to the surface of the organic layer 20 has a lower fusion point than the metal of the superposed layer. For instance layer 21 may consist of bronze and the outer layer 22 may consist of steel.

Figs. 5 to 7 show in plan depressions which extend substantially in the direction of the wood fibres 12. In Fig. 5 the depressions 13 are shown as being straight and parallel to one another. In Fig. 6 they form parallel waves 14. The depressions 15 in Fig. 7 are disposed zig-zag and comprise parallel groups.

With the arrangement of the depressions 13, 14, 15 according to Figs. 5 to 7 in the direction of the wood fibres destruction of the fibres is substantially avoided, so that the wood body, including the depressions, is not weakened but is reinforced. By this means also the strength of the wood-metal structure is increased.

In the embodiments according to Figs. 5 to 7 the individual depressions may be of any suitable section; for example, they may be formed as in the embodiments illustrated in Figs. 1 to 3, i. e., they may have a rectangular, dovetailed or waved cross-section.

In the plate illustrated in Fig. 8 in the part from which the metal coating has been removed, the disposition of the depressions 16 is as in Fig. 3. This disposition is such that the depressions are at right angles to the direction of the bending stresses or extend in the direction of tensional forces to which the plate is subjected. The bending forces are indicated by arrows 17, 18 at right angles to the plate and the tension stress

is indicated by the arrow 19 extending in the direction of the depressions. With this arrangement the capacity of the plate to withstand the forces acting thereon is the maximum.

A structural material according to the invention can be used wherever metal-wood combinations produced by a metal spraying process are to be subjected to mechanical stresses. It is particularly adapted for highly stressed light structures such as are met with in the construction of aircraft. It can withstand severe thrust, bending, compression, and torsional stresses as well as tension and centrifugal stresses and stresses due to changes in temperature and weather conditions without the connection between the metal and the wood being loosened or destroyed.

I claim:

1. A process for the production of a multi-layer protective metal coating on a wooden constructional element which is subject to severe stresses, the exterior layer of said coating being of a hard metal of high melting point, said process comprising first providing the surface of the wood with spaced parallel grooves extending substantially in the direction of the grain and at right angles to the direction of said stresses, the depth of said grooves corresponding to the thickness of the metal coating, then applying to the resultant grooved surface a thin layer of a heat hardenable organic adhesive material which insulates the wood against the heat of subsequently applied layers, then spraying on said organic layer an intermediate layer of a metal of a melting point substantially lower than that of said hard metal, and finally spraying on said intermediate layer a layer of hard metal of high melting point.

2. An air propeller coated with a plurality of metallic protective layers, comprising a wooden body, the surface of said body being provided with a plurality of spaced parallel grooves corresponding in depth to the thickness of the metal layers, said grooves extending substantially in the direction of the grain and at right angles to the direction of stresses to which said propeller is subjected in use, a first layer of an organic heat hardenable adhesive and heat insulating material on said grooved surface, an intermediate layer of metal on said first layer, an outer layer of hard metal of high melting point on said intermediate layer, the metal of the intermediate layer being of a melting point appreciably lower than that of the outer layer.

3. An air propeller coated with a plurality of metallic protective layers, comprising a wooden body, the surface of said body being provided with a plurality of spaced parallel grooves corresponding in depth to the thickness of the metal layers, said grooves extending substantially in the direction of the grain and at right angles to the direction of stresses to which said propeller is subjected in use, a first layer of an organic heat hardenable adhesive and heat insulating material on said grooved surface, an intermediate layer of bronze on said first layer, and an outer layer of steel on said intermediate layer.

ALFRED KOYEMANN.