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METHOD OF COATING ALUMINUM

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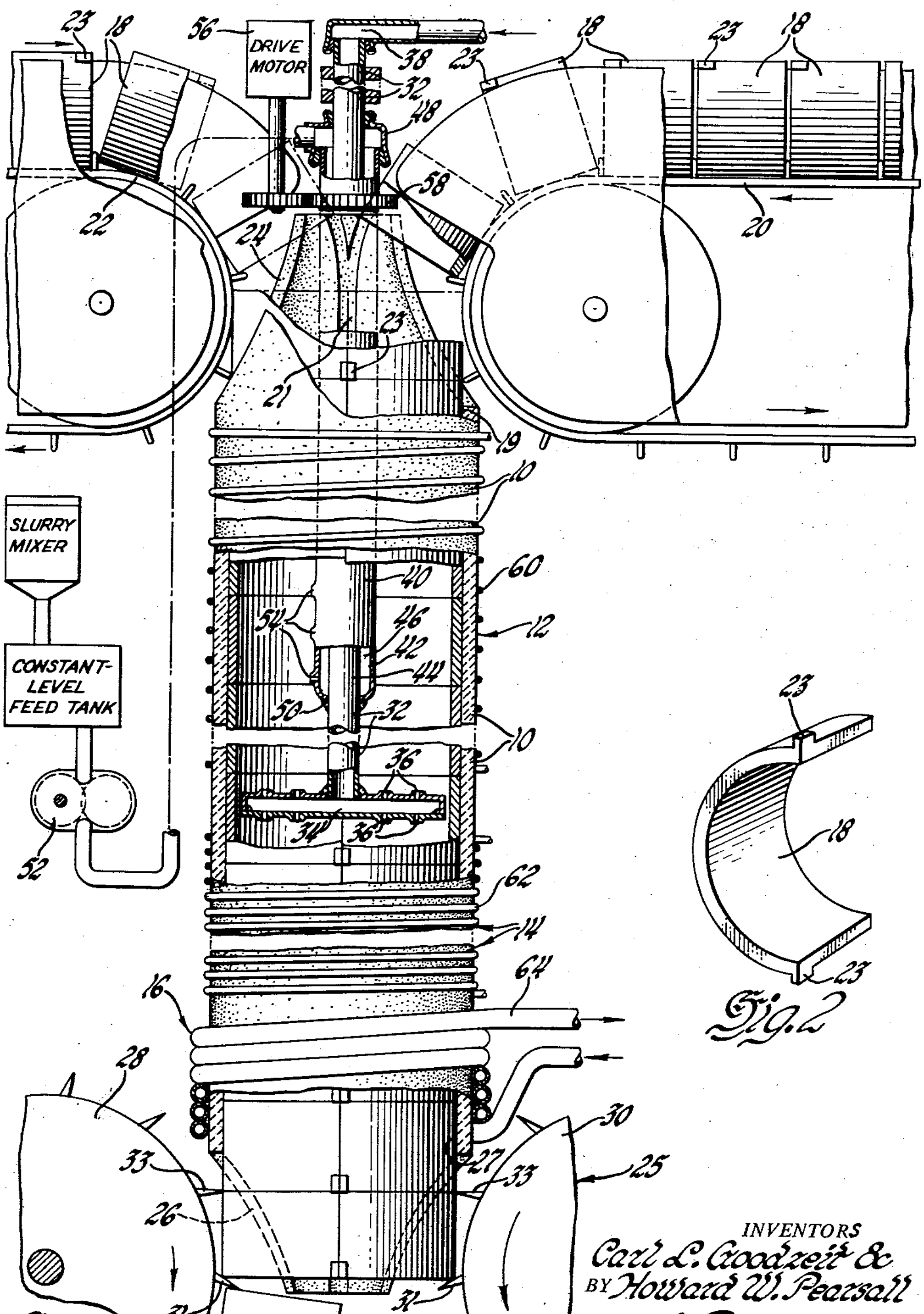

Fig. 1

Fig. 2

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METHOD OF COATING ALUMINUM

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This invention relates to the application of metal coatings to aluminum and aluminum alloy surfaces involving a method which more specifically is particularly suitable for the application of lead-base alloys to bearing surfaces of aluminum and aluminum-base alloys and an apparatus which can be utilized therewith.

Thick layers of Babbitt linings on bearings have proved to have comparatively poor resistance to fatigue. However, the fatigue strength of the Babbitt lining increases as the thickness of the layer decreases. A Babbitt lining of approximately 0.0007 inch has adequate strength for bearing use. Such a thin Babbitt layer must be supported by a backing material which is particularly strong and resistant to fatigue and seizure.

Aluminum and aluminum alloys, hereinafter referred to as "aluminum," which are in turn supported on a steel backing material, are well suited as backing materials for Babbitt linings. Backing members formed of such metals are light in weight, yet have adequate strength and sufficient resistance to fatigue and seizure. The use of aluminum-base backing materials is particularly advantageous due to the good bearing properties of aluminum itself. Thin linings of the Babbitt metal alloy with the aluminum surface to provide a bearing of superior quality. Aluminum-base alloys which possess particularly good bearing qualities include an alloy consisting essentially of 0.3% to 11.0% silicon, 0.05% to 5% cadmium and the balance aluminum, and an alloy consisting essentially of 0.05% to 3% magnesium, 0.3% to 11% silicon, 0.05% to 5.0% cadmium, 0.1% to 2.25% chromium and the balance aluminum.

In the past smooth, adherent coatings of Babbitt metal on steel backing members have been obtained by electrodepositing Babbitt metal directly onto the steel backing. Electrodeposition has heretofore been the most satisfactory commercial method of applying Babbitt to an aluminum backing material. Unfortunately, due to the rapid formation of an oxide coating on aluminum surfaces, it is exceedingly difficult to obtain electrodeposition of Babbitt metal directly onto aluminum. Therefore, the aluminum surface requires extensive pre-treatment before receiving the babbitt. The backing member normally is first immersion-coated with zinc, and then given a flash coating of copper, the Babbitt metal being electrodeposited onto the flash copper layer. A thin layer of tin is then usually electrodeposited onto all the surfaces of the bearing. This method of applying Babbitt to an aluminum backing material is relatively costly. In addition, the presence of zinc and copper in the overlay of the aluminum surface, although necessary for adherence of the electroplated Babbitt, has proved in some instances to be detrimental to bearing performance.

It is, therefore, a principal object of this invention to provide a method for directly coating aluminum by means of a fused chloride or bromide of a metal below aluminum in the electromotive series. Another object of this invention is to provide a method of joining aluminum parts using such a coating. More specifically, another object comprehended by this invention is to provide an apparatus and process whereby aluminum bearing backing members may be directly coated with a thin layer of Babbitt metal.

Other objects, advantages and features of the present invention will appear more clearly from the following description of preferred embodiments thereof and from the drawing which shows a schematic vertical view in partial section of an apparatus which can be used to practice the process described herein.

In accordance with the invention, the aluminum surface is covered with a layer of a powdered chloride or bromide of a metal below aluminum in the electromotive series, and the composite article is thereafter heated to the fusion temperature of the salt. More particularly, we have employed chlorides and bromides of lead and tin to provide satisfactory results in an expeditious manner. At the temperature required to fuse the salt, a displacement reaction occurs wherein the metal of the salt is reduced to the pure metal and deposited on the aluminum surface. The chlorine or bromine of the salt combines with the aluminum to form a volatile aluminum halide which escapes by vaporization. The fusion temperature of some otherwise satisfactory salts is often undesirably high, such as that of lead chloride which is about 934° F. However, the temperature required to fuse this salt may be reduced to about 750° F. by employing an approximately eutectic mixture of the desired metal salt and other suitable salts, such as potassium chloride and sodium chloride. An example of such a mixture is one consisting of about 68% plumbous chloride, 18% potassium chloride and 14% sodium chloride.

It has been found that the addition of the potassium chloride and sodium chloride not only reduces the temperature required to melt the desired salt but also promotes wetting of the aluminum surface, thereby assisting in the formation of a more adherent coating of the desired metal. In connection with this latter function, it is often desirable to add a small amount of these salts in excess of that required to form a eutectic mixture. For example, in coating aluminum with a mixture of metals, as noted hereinafter, small excess amounts of sodium and potassium chlorides do not significantly increase the fusion temperature yet provide desirable additional wetting action. The potassium and sodium chlorides, which do not form part of the coating, rise to the surface of the coating during fusion, and subsequently can be washed therefrom with water after cooling of the coated article.

If it is desired to coat an aluminum surface with a combination of metals, this end may be accomplished by employing a mixture of the appropriate metal chlorides or bromides, e.g., $PbCl_2$ and $SnCl_2$. Coatings composed of two or more metals also can be applied by employing a mixture of a powdered pure metal and a metal chloride or bromide. The mixtures tin powder and $PbCl_2$ as well as lead powder and $SnCl_2$ have efficaciously been employed to practice this modification of the invention. The hereinbefore mentioned eutectic forming salts can also be employed in the mixture to apply these coatings when it is desirable to utilize the lower melting point and the wetting effect produced by the potassium and sodium chlorides.

It has been found that such a powdered mixture as described above cannot be conveniently applied to an inclined surface. However, if a small amount of an organic polymer with "adhesive" properties, such as nitrocellulose or acrylic resin, is incorporated in the powdered mixture, the resulting mixture will adhere to an inclined surface as firmly as to a horizontal surface.

The present invention also comprehends coating aluminum by immersing it into a bath of the molten metal on which the molten chloride or bromide salt of that metal is floating (e.g., lead and $PbCl_2$). The aluminum is preferably preheated and dipped into this bath, whereupon the metal (e.g., lead) deposits onto the aluminum. The melting point of the halide salt can be suitably lowered, as previously indicated, by employing a eutectic mixture of potassium and sodium chlorides. The coating of aluminum with an alloy can be accomplished employing a bath of this type simply by incorporating in the bath the appropriate metals with their corresponding chloride or bromide salts in the supernatant molten salt layer.

A further modification of the present invention is the coating of Babbitt metal directly onto aluminum bearings. A powdered mixture such as hereinbefore described is suspended in a highly volatile liquid, forming a slurry, and sprayed onto a heated aluminum surface. The volatile liquid rapidly evaporates from such a surface depositing thereon a film of the powdered mixture which is so adherent that it will even cling to vertical surfaces without the use of an adhesive.

The slurry is generally comprised of a metal halide and a powdered metal suspended in a highly volatile organic liquid. One such mixture which has been used to coat babbitt on the aluminum bearing is as follows:

56.5% lead chloride
11.8% sodium chloride
15.0% potassium chloride
12.5% cuprous chloride
4.5% tin powder

The above dry ingredients are passed preferably through a 200 mesh screen, mixed together in a ball mill with a suitable volatile liquid, such as lacquer thinner, in a proportion of one part by weight of dry solids to one and one-half parts of lacquer thinner. The slurry formed thereby is sprayed onto the surface of the bearings and, as the volatile liquid evaporates, the solids of the slurry are deposited on the bearing surface. This layer of solids can be built up to a substantial thickness through successive sprayings of slurry on warm bearings, each layer being permitted to dry before the succeeding layer is applied. Thus, it is possible to obtain correspondingly thicker metallic coatings after fusion of the mixture.

Occasionally, a particular coating mixture does not produce a satisfactory metal deposit when the coating mixture has been built up to a substantial thickness. It was found that incorporation of an organic adhesive, for example nitro cellulose lacquer, in such coating mixtures permitted thicker deposits of the metallic coating to be prepared which were suitable for bearing use. When an adhesive was included in the following composition, it permitted a substantial increase in the thickness of the coating mixture which could be applied to produce a satisfactory thicker metallic coating:

10% sodium chloride
10% potassium chloride
70% plumbous chloride
8% tin (powder)
2% copper (powder)

This mixture is passed preferably through a 200 mesh screen and combined with approximately 12 parts adhesive to 100 parts of the above mixture by weight. Sufficient lacquer thinner is then added to comprise a final slurry of about 5% to 10% lacquer thinner.

Referring more particularly to the drawing, the apparatus shown can be used to coat bearings in accordance with the invention. The apparatus comprises a cylindrical vertical column **10** of any suitable refractory material. This column includes a bearing spray section **12**, bearing firing section **14**, and a bearing cooling section **16**. Semi-cylindrical bearing sleeves **18** are introduced in pairs in the column through the upper opening **19**.

Two conveyors **20** and **22**, arranged generally opposite one another at the upper opening **19** of the column **10**, carry the bearing sleeves to the top of the column. The semi-cylindrical bearing sleeves are placed in the top of the column with their inner cylindrical surfaces facing one another, their ends being in general abutment, thereby forming a generally cylindrical inner bearing surface. The positioning of the bearing sleeves at the top of the column is aided by a frusto-conical skirt **24** projecting upwardly from the opening **19** of the column **10**. The alignment and positioning of the bearing sleeves within the column may be assisted, by indentations **21** on the inner surface of the column and suitably positioned tangs **23** as shown in FIGURE 2 on the outer surface of the sleeves which engage the indentations **21** of the column.

The bearings progress downwardly through the column under force of gravity, the rate of such progression being determined by the speed of an automatic bearing support and take-off or removal device **25** located at the bottom of the column. A downwardly depending second frusto-conical skirt **26** also can be employed at the bottom of the column to assist in the proper positioning of the bearing as it emerges from the lower opening **27**. The bearings can be supported at the lower end of the vertical column by any suitable device which will also permit the lowering of the bearings in the column and a removal therefrom. A preferred form for such a device is the toothed wheels **28** and **30** located at the lower end of the vertical column as shown. The semi-cylindrical bearing sleeves are supported by teeth **31** on the outer periphery of the wheels and automatically lowered as the wheels revolve. An adjacent tooth **33** on the wheel then engages the next bearing sleeve to separate it from the one above it and in doing so projects under the lower edge of the bearing thereby supporting it.

A rotatably mounted air tube **32** for introducing dry air into the interior of the column is positioned within the upper part of the column coincidentally with the axis of same. Connected to the lower extremity of the tube **32** is a hollow metal disk **34** which has an outer diameter slightly smaller than the inner diameter of the bearings, thereby permitting free passage of the bearings down the column. The interior of the hollow metal disk communicates with the interior of the tube **32**. The upper and lower walls of the disk **34** are provided with apertures **36**, forming inlet openings, through which dry air, introduced into the tube **32** at its upper extremity **38**, passes and enters the interior of the column.

Surrounding an upper portion of the air tube is a second tube **40** of larger diameter rotatably mounted at its upper end and having its side wall **42** spaced from the wall **44** of the air tube **32**, thereby forming an annular space **46** therebetween. A non-rotatable cover **48** is positioned over the upper open end of the outer tube **40** surrounding the inner tube **32** and is suitably sealed, forming an upper wall for the annular space **46** defined by the tubular members. A lower wall for the annular space **46** is formed by sealing the lower end **50** of the outer tube to the wall **44** of the air tube **32**. The lower end of the outer tube **40** can be sealed in any suitable manner capable of withstanding the heat of the column and the detrimental effect of vapors present in the column, a preferred seal being obtained by welding. Its ends being thus sealed, the annular space **46** defined by the tubular members forms an annular chamber.

The coating slurry, a suspension of metal chlorides or bromides and a powdered metal in a highly volatile liquid, is introduced under pressure by a suitable pump **52** into the annular chamber **46** through the cover **48**. Several small vertically aligned orifices **54** in the outer tubes are located adjacent its lower end **50**. The slurry of the coating mixture is sprayed under pressure through these orifices onto the inner vertical surfaces of the bearings.

The outer tube **48** and the air tube **32** are rotated by means of a motor **56** communicating with a spur gear **58** secured to the outer periphery of an upper part of the outer tube. As the slurry mixture is pumped into the slurry chamber, the tubes are rotated and the slurry is sprayed under pressure from the orifices **54** while the tubes are rotating. The bearing sleeves **18** progressing down the tube are therefore coated with the slurry by means of the rotating spray.

Surrounding the bearing spray section **12** of the column **10** is a suitable heating device, preferably a spiral electric resistance heater **60**. The resistance heater **60** is connected to an appropriate source of electrical current (not shown) so that the upper portion **12** of the chamber may be warmed to approximately 300° to 400° F. Around the bearing firing section **14** of the column **10** beneath the upper warming heater **60** is another heater, preferably spiral electric resistance heater **62** which when connected to a suitable source of electrical current (not shown) is capable of raising the interior temperature of the encircled portion **14** of the column to approximately 725° to 825° F. Immediately below the bearing firing section is the bearing cooling section **16** of the column. Surrounding this portion of the column is a cooling coil **64** which is connected to a source of coolant (not shown), preferably water. It is desirable that the cooling section of the column reduce the temperature of the bearing to approximately 400° F. or less before it emerges from the column.

The bearing sleeves **18**, prior to coating with the Babbitt metal, are degreased and cleaned in a conventional manner and thereafter dried. The bearings are then placed on the conveyers **20** and **22** which introduce the semi-cylindrical bearing sleeve halves **18** into the top of the column where they are warmed to about 350° F., preferably in the presence of dry air, although either nitrogen or incompletely dried air is also fairly suitable.

The inlets **36** for admission of the dry air into the chamber are located between the spray section **12** and the firing section **14** so that the combustible volatile liquid vapors are blown upwardly out of the column and the corrosive aluminum chloride vapors formed in the firing section are carried out the lower opening **27**.

As the bearings progress down the column, they are warmed by the heating coil **60** around the outside of the column. The warmed bearings are then coated with a suitable slurry mixture by means of the rotating spray. During the progression down the column, the caking and building up of the coating mixture correspondingly progresses due to the action of the rotating spray.

The bearings are then subjected to the heat of the firing section **14** wherein the temperature is raised to approximately 800° F. The exact temperature preferred for the firing section will depend upon the melting point of the coating mixture employed. It is advantageous to have the temperature slightly above the melting point of the salt mixture but not high enough to cause any damage to the aluminum. Generally, the mixtures employed for coating lead-base alloys will have a melting point between approximately 725° F. and 825° F. After the bearing has been fired for a sufficient length of time to complete reduction of the Babbitt metal, the bearing progresses to the cooling section **16** of the column which reduces the temperature of the bearing to generally 400° F. or less. Cooling of the bearings in dry air prevents corrosion, which would occur if the hot bearings were introduced into moist air. The cooled bearing is removed from the column and preferably washed in a suitable soap solution. Simultaneous scrubbing with a fiber brush also aids in removing any excess metal salts still remaining in the Babbitt coating.

The present method of bonding a metal to an aluminum surface may also be employed as a means to join aluminum surfaces to each other. Coating mixtures, such as those previously described, may be placed between two aluminum parts, the parts secured together and the assembly heated to fuse the coating mixture. Particularly adaptable to the joining of aluminum parts is a coating mixture comprising plumbous chloride and a sufficient quantity of powdered zinc to produce an alloy bonding material having generally equal parts by weight of lead and zinc.

As hereinbefore indicated, it is not always convenient to employ a dry powdered mixture for the bonding, for example, when coating an inclined aluminum surface. In such instances, it is advantageous to apply the coating mixture as a paste or slurry which is formed by adding to the powdered mixture a suitable amount of a volatile liquid such as water, alcohol, lacquer thinner, etc. Suitable salts of other metals below aluminum in the electromotive series can also be included in the mixture if it is desirable to employ a solder of a different composition than specified above. It is understood that eutectic mixtures, such as hereinbefore described, can also effectively be employed in joining aluminum parts by this method.

Although the present invention has been described in conjunction with preferred embodiments thereof, it is understood that variations and modifications may be found which are obvious to those skilled in the art. It is not intended that these preferred embodiments be a limitation of the scope of the invention except as limited by the appended claims.

We claim:

1. The method of making an aluminum backed multilayer bearing which comprises heating an aluminum bearing member while progressively lowering said bearing member within a vertical column, providing a dry air atmosphere within said column, successively spraying a slurry onto said heated bearing member as said bearing member progresses downwardly through said column, said slurry containing a volatile carrier and a eutectic mixture of potassium chloride, sodium chloride and at least one metal salt from the group consisting of metal chlorides and metal bromides and said slurry further containing at least one powdered metal wherein said metal in said metal salt and said powdered metal are each below aluminum in the electromotive series, evaporating the carrier in said slurry and depositing contents thereof on said heated aluminum surface, further lowering said bearing members in said column into a region of high temperature sufficient to fuse said metal and said metal salt to form a metal coating on said bearing member, subsequently lowering said bearing member in said column to a region having a temperature below approximately 400° F., removing said coated bearing member from an opening in the lower end of said column, and washing said metal coated bearing member to remove residual surface salts.

2. The method of making an aluminum backed multilayer bearing which comprises heating an aluminum bearing member while progressively lowering said bearing member within a vertical column, providing a selected atmosphere within said column, successively applying a fluid onto said heated bearing member as said bearing member progresses downwardly through said column, said fluid containing a volatile carrier and at least one metal salt from the group consisting of metal chlorides and metal bromides, said metal in said metal salt being below aluminum in the electromotive series, evaporating the carrier in the fluid applied to said aluminum surface and depositing said salt in a solid coating thereon, further lowering said bearing member in said column into a region of high temperature sufficient to fuse said metal salt to form a metal coating on said bearing member, subsequently lowering said bearing member in said column to a region having a temperature below approximately 400° F., removing said coated bearing member from an opening in the lower end of said column and washing said metal coated member to remove residual salts.

3. The method of coating an aluminum member which comprises heating an aluminum member while progressively lowering said member within a vertical column, providing a selected atmosphere within said column, successively applying a fluid onto said heated member as said member progresses downwardly through said column, said fluid containing a volatile carrier and at least one metal salt from the group consisting of metal chlorides and metal bromides, said metal in said metal salt being

below aluminum in the electromotive series, evaporating the carrier in the fluid applied to said aluminum surface and depositing said salt in a solid coating thereon, further lowering said member in said column into a region of high temperature sufficient to fuse said metal salt to form a metal coating on said member, subsequently lowering said member in said column to a region having a temperature below approximately 400° F., removing said coated member from an opening in the lower end of said column and washing said metal coated member to remove residual salts.

4. The method of coating an aluminum member which comprises heating an aluminum member while progressively moving said member within a substantially closed housing, providing a selected atmosphere within said housing, successively applying a fluid onto said heated member as said member progresses through said housing, said fluid containing a volatile carrier and at least one metal salt from the group consisting of metal chlorides and metal bromides, said metal in said metal salt being below aluminum in the electromotive series, evaporating the carrier in the fluid applied to said aluminum surface and depositing said salt in a solid coating thereon, further moving said member in said housing into a region of hgh temperature sufficient to fuse said metal salt to form a metal coating on said member, subsequently moving said member in said column to a region having a temperature below approximately 400° F., removing said coated member from an opening in the housing and washing said metal coated member to remove residual salts.

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