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PROCESS AND APPARATUS FOR RAPIDLY ANODIZING ALUMINUM

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2 Sheets-Sheet 1

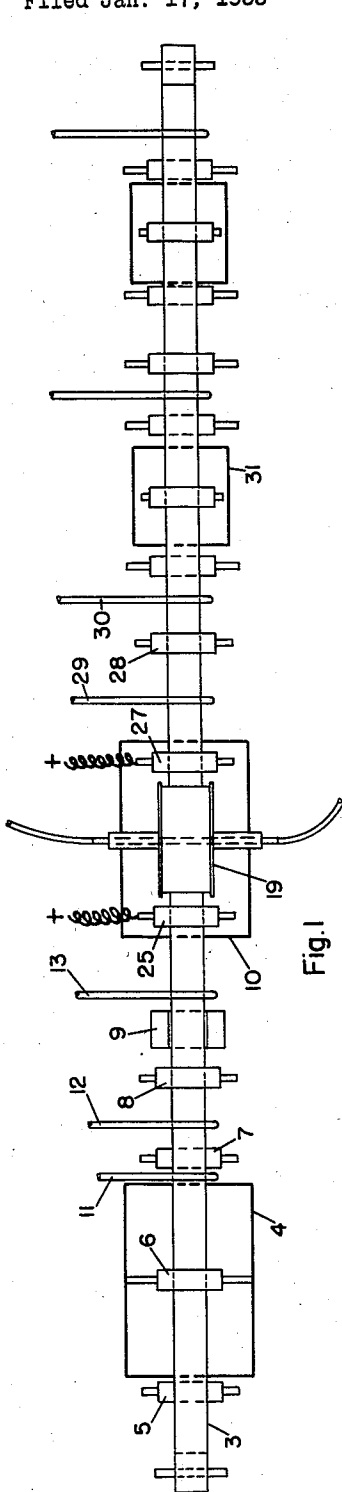


Fig. 1

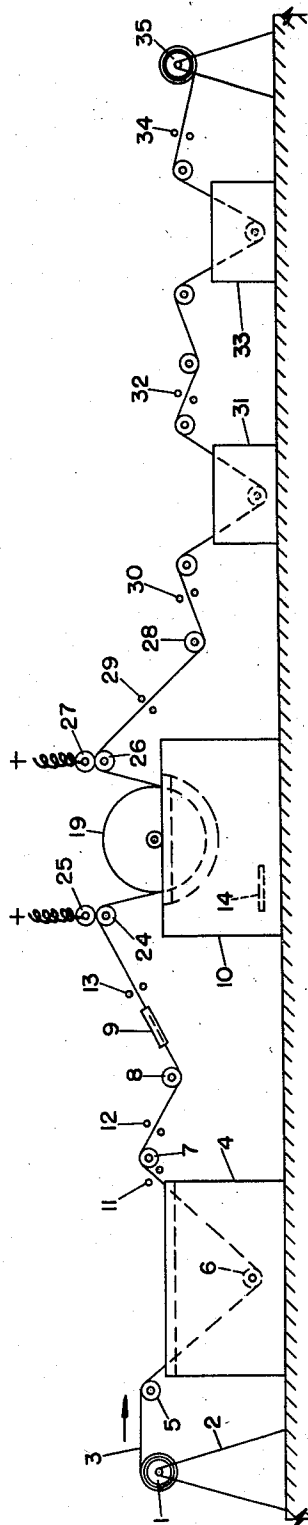


Fig. 2

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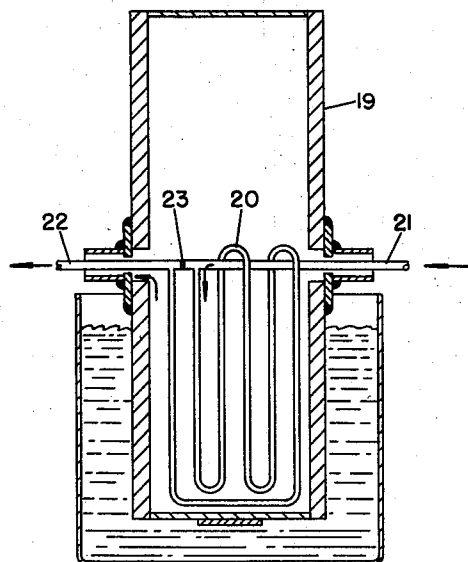
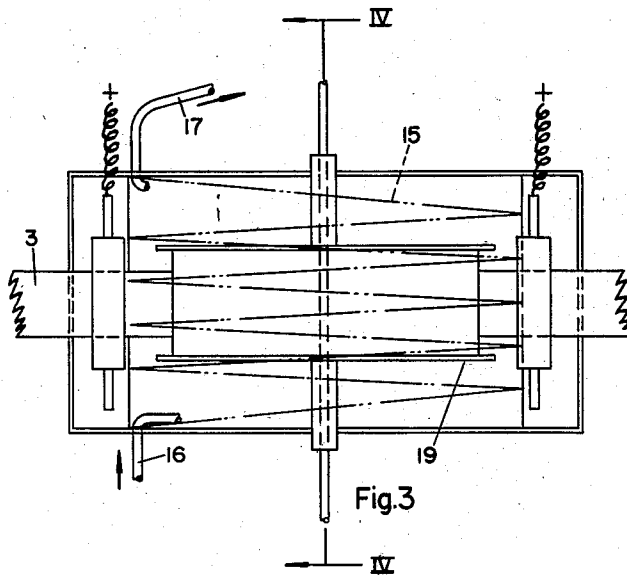


Fig. 4

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PROCESS AND APPARATUS FOR RAPIDLY ANODIZING ALUMINUM

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6 Claims. (Cl. 204—28)

This invention relates to an electrolytic method of producing oxide coatings on surfaces of aluminum and its alloys, and relates in particular to a method for increasing the rate of oxide formation.

There are several known methods for obtaining porous transparent oxide coatings on aluminum and its alloys by the aid of an electric current. In general these electrolytic processes involve passing an electric current through an aqueous bath of an acid with the aluminum surface as the anode, the current being continued until the desired depth of oxide coating has built up on the surface. Such methods are known as anodizing. The principal commercial electrolytic methods for producing porous oxide coats on aluminum and its alloys employ aqueous baths containing strongly ionized acids, such as, sulfuric acid or chromic acid, or dibasic organic acids, for example, oxalic acid, or mixtures of two of these acids, in which other compounds may be present. Variations in concentration of the bath may be made as desired, to vary the properties of the oxide coat. In this operation the aluminum oxide coat produced has electrical insulating properties, and the use of high voltages is not desirable, because of the possibility of perforating the oxide coat during the process. When perforation occurs the metal is attacked by the electrolyte to produce what is known as a "burn," so that blemishes occur in the finished product.

Each of these electrolytic process baths or processes has certain advantages and disadvantages which determine its suitability for a specific purpose. In each bath there is a safe upper limit for the current density that can be employed, and exceeding this upper current density limit may result in "burned" spots where the acid of the bath attacks the metal. Also, in each process, the amount or depth of oxide coat formed is a function of ampere minutes. For example, in a 15% sulfuric acid bath a current density of 12 amperes per square foot forms an oxide coating about .00001 inch thick per minute, so that it requires about ten to twenty minutes treatment to produce an oxide coat for most purposes. It has been proposed to chill the bath to enable the use of higher current densities, but this increases the resistivity of the bath, making necessary the employment of higher voltages with the attendant danger of breaking through the oxide coat and burning the surface, but even then, only a limited increase in coat forming rate is accomplished.

Because of the limitations imposed by the maximum usable current density the coating of a continuous web or sheet is slow, and the area of the web that can be treated in a given time period is limited by the size of the tank necessary to be employed, and by the technical difficulties of securing uniformity of current density over large areas. Also, a relatively large capital investment is involved in the use of large tanks and in the large volume of electrolyte required for such tanks.

It is an object of this invention to reduce the time

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required to produce an oxidized or anodized layer on aluminum.

A further object is the provision of a continuous anodizing process applicable to the treatment of long webs of aluminum by reducing the time required for treating a unit area.

Another object is the provision of a continuous process of anodizing webs of aluminum which may be employed for anodizing one or both sides of the web.

The present invention is based upon our discovery that the allowable maximum current density that may be employed in a given composition bath in the electrolytic anodizing of aluminum surfaces may be increased by maintaining a differential between the temperature of the aluminum surface to be anodized and the temperature of the body of electrolyte in the bath. Thus, as the practice of this invention permits the employment of greatly increased current densities, the time required to produce an oxide layer on the anode of a predetermined thickness is greatly reduced.

The aluminum surface to be anodized may be maintained at a lower temperature than the bath, or at a higher temperature. By maintaining the aluminum surface at a lower temperature the current density may be increased to correspondingly decrease the time required for effecting a desired thickness of coat, and the coat in general is comparable in properties to that produced by the conventional anodizing methods. If the temperature of the aluminum surface is maintained higher than the bath temperature a higher current density may be employed with a corresponding decrease in time, and the film or coat of oxide produced is superior in smoothness, toughness and flexibility, is of fine grain texture, and of improved resistance to corrosion compared to the oxide coat obtained in the conventional low current density anodizing operation. The bath itself may be maintained at any suitable temperature, in accordance with prior practice, and using various known formulations of acid in the electrolytic bath, the properties of the oxide layer produced may be varied within limits.

The invention is applicable to the various acid electrolyte types of baths of the prior art known to be operative to produce, with an electric current, porous, generally transparent oxide coats, such as, for example, aqueous sulfuric acid, chromic acid or oxalic acid baths, and particularly in all cases, enables the use of current densities substantially higher than the maximum allowable limits heretofore usable, to rapidly produce oxide coatings, so that the time required to produce a predetermined coating is reduced, without requiring the use of high voltages.

The present invention is to be distinguished from the known process for electrolytically polishing aluminum which employ high current densities. In the polishing operation a different electrolyte usually is employed, and the anode surface goes into solution—a condition inimical to the production of an anodized or oxide coat on the metal.

In operating with a dilute sulfuric acid bath the temperature and concentration are selected to avoid easy attack on the aluminum and enable the use of low voltage to minimize the possibility of break-through. For example, a concentration of 15% sulfuric acid at room temperature, is suitable for many applications. Generally in using chromic acid or a mixture of chromic and sulfuric acids, higher bath temperatures are employed. The invention is not restricted with respect to the temperature of the bath, which in any case will be selected to prevent excessive attack of the aluminum, nor is the invention limited with respect to the amount of temperature differential between the electrolyte and anode sur-

face to be coated. A substantial decrease in time required to produce a given thickness of oxide layer is brought about by a 10° F. temperature differential, but generally we prefer to operate at greater temperature differentials. Where cooling of the anode is employed, a temperature difference on the order of about 20–25° F. is preferred, whereas, where the anode is heated a temperature difference as high as about 140° F. may be used. It should be pointed out that the oxide coat, which rapidly forms on the anode surface, is a good heat insulator, and thus facilitates maintaining the desired temperature difference between the anode and the electrolyte.

In some cases, as for example, when operating with an electrolyte at room temperature and a cooled anode, heat transfer from the electrolyte may be low enough to balance heat absorption from the atmosphere, so that heating of the electrolyte becomes unnecessary. Or, when operating with a heated anode, some cooling of the electrolyte may be desirable, especially if the electrolyte is to be maintained at room temperature, while in other cases, heat losses to the electrolyte may be sufficient to maintain the electrolyte at a desired elevated temperature.

The speed with which an oxide coat is formed on the surface renders the invention especially suitable for anodizing continuous sheets or strips of aluminum, as the processing time can be controlled by the speed of movement of the web through the electrolyte, and uniformity in treatment is easily maintained.

In a preferred embodiment the desired temperature differential is maintained by moving the anode web through the electrolyte with one face in heat transfer contact with a continuously moving conditioning surface which may be heated or chilled as desired. In this way only one face is exposed to the electrolyte and is anodized, and the other face then may be anodized, if desired, in a second operation in which the uncoated surface contacts the electrolyte while the previously coated surface is in contact with a continuously traveling heat exchange surface. In using a cylindrical drum as the heat exchange surface, the tank containing the electrolyte may be of generally semi-cylindrical shape to reduce the volume of electrolyte required.

In the accompanying drawing there is shown one form of apparatus, by way of example, for carrying out the invention, and the invention will be described in greater detail in connection therewith. In the drawing,

Figure 1 is a plan view diagrammatically illustrating the apparatus;

Figure 2 is a side elevation of Figure 1;

Figure 3 is a plan view of the anodizing tank; and

Figure 4 is a sectional view taken on line IV—IV of Figure 3.

Referring to the drawing, a roll of sheet aluminum to be anodized is carried on a suitable reel 1 rotatably mounted on a support 2. The web 3 from the reel passes through a cleaning and brightening tank 4 which may contain suitable brightening chemicals. As examples of such chemicals are known in the art, it is not necessary to state the composition of the brightening bath. In its passage through the bath the web is supported by rollers 5, 6 and 7, and the web then passes under a roller 8 at a lower level than roller 7, and upward through a guide 9 to the anodizing tank 10. Rearwardly of roller 7 is a drying apparatus 11 for applying streams of air to the web to evaporate any liquid carried up with the web from tank 4, and washing apparatus 12 and 13 fore and aft of roller 8 apply wash water to the web. Because of the slope of the web, the wash water does not flow into the brightening or anodizing tanks, but is discharged at the sides of the web.

The anodizing tank 10 may be lead lined, and contains a suitable anodizing electrolyte, for example, a quantity of 15% aqueous sulfuric acid solution. The lead lined tank may serve as the cathode, or a separate lead cathode

14 may be located at a suitable position in the tank, preferably along the web and at a uniform distance from the web. The tank may contain suitable coils 15, adjacent the bottom or sides of the tank, having an inlet 16 and an outlet 17. Coils 15 may carry a heating or cooling medium as required.

A drum 19, of suitable resistant material mounted on suitable bearings (not shown) at the top of the tank carries a coil 20 for the circulation of hot or cold water, as desired, the water entering at 21 and discharging at 22. Any suitable construction of coil may be employed, the one illustrated being nonrotatable and having a plug 23 therein to divide the inlet and outlet. Thus, while the drum rotates the coil remains always in the lower half. If desired, the drum may be half filled with a fluid to conduct the heat from the coil to the wall of the drum, or the drum wall may be heated by radiation from the coil.

The web 3 passes between the rolls 24, 25 under drum 19 and between rolls 26, 27, the rolls 24 and 26 being located preferably so that one face of the web first engages the drum surface at or above the level of electrolyte in the tank. Of the pairs of rolls, 25 and 27 serve as electrical contacts with the web so the web serves as the anode. Electrical contact with these rolls may be made in known manner, as by a slip ring, and the lower rolls 24, 26 may be of electrical insulation material or covered with a coat of such material. Because of the high current density applied to the web, it is desirable to employ two anode contacts 25, 27 on the web, so that the current through the web will be split. Thus, the heating effect of the current in the web is reduced. The drum is rotated by engagement with the moving web, but if desired, the drum may be power driven.

As the web passes through the electrolyte in contact with the drum the web is heated or cooled by conduction to the desired temperature and is maintained at such temperature during its passage through the bath. If the web is heated, some heat, of course, will be lost to the bath, and the cooling coils 15 serve to remove the heat to keep the bath at the desired temperature limits. After leaving the electrolyte bath the web passes under a roller 28, and is washed or rinsed by water from the washers 29, 30.

If the anodized surface is to be dyed, the web continues into the tank 31 containing a suitable organic or inorganic dye, and then, after being washed at 32, continues to a tank 33 containing a suitable sealing solution, and is then air dried at 34, and is wound upon a reel 35, which may be power driven, so the drive of the web is from the rewind reel.

Example 1.—Hot process

The following example illustrates the treatment of the web in the electrolytic tank. Assuming the web is four feet wide, and the drum has a diameter of ten feet, half its circumference will be approximately 15 feet. Thus a web four feet wide and about 15 feet long is being treated at all times in the bath. The electrolyte preferably comprises 15% by weight sulfuric acid in water, and the cooling coil maintains the bath temperature at about 68–74° F. The heating coil in the drum maintains the drum at about 140° F. and a current at about 20 to 22 volts is impressed on the bath. By using a current density of 120 amperes per square foot of anode area and a treating time of one minute, the web speed can be 15 feet per minute, and the production rate will be 60 square feet per minute. With this arrangement one side only of the web is anodized. The oxide layer film produced is uniform, fine grained, microscopically smooth, highly flexible and provides good protection against corrosion of the metal. In general, the coat produced is superior to that obtained in the conventional sulfuric acid anodizing operation.

In the above example, time, current density, and other details are merely illustrative of the invention. Usually, an oxide coating about .00012 inch in thickness is desired,

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and the operation will be carried out under conditions to produce such a film.

Example 2.—Cold process

The above apparatus is adapted to carry out the cold process, by circulating a coolant through coil 20 in the drum, and if desired, circulating a heating medium through coil 15 in the tank. The temperature of the sulfuric acid electrolyte is maintained at about 68–74° F. and the surface of the drum is kept at about 35–40° F. The current density is about 120 amperes per square foot at a potential of about 25 to 27 volts, and the speed of the drum may be fifteen feet per minute.

The film produced is non uniform in thickness, microscopically rough, hard and brittle and has good resistance to abrasion, and is comparable in properties to the coating produced in the conventional sulfuric acid anodizing operation.

In comparison, it should be pointed out that if a current density of about 12 amperes per square foot is employed, as in the conventional anodizing process, the time of treatment would have to be about ten minutes to provide a sufficient period in the bath to produce the same thickness of coat as in the above examples. That is, the production rate would be only 6 square feet per minute.

We claim as our invention:

1. A method of anodizing a surface of an anode composed of aluminum which comprises: introducing said anode into an acidic electrolytic anodizing liquid bath in a manner maintaining a predetermined surface area of said anode in active contact with said bath; passing an electric current from said anode through the bath at a predetermined rate to maintain a high anodizing current density over said active surface area; conditioning the bath to maintain its temperature below a value at which substantial dissolution of aluminum from said active surface area occurs; and maintaining a temperature dif-

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ferential of at least 10° F. between said anode and said bath by continuously engaging another surface of said anode in heat exchange relationship with a conditioning surface while said predetermined anode surface is subjected to said anodizing current.

2. The method as specified in claim 1 wherein: said aluminum anode is a continuous web which is advanced continuously into and through said bath while engaged with said conditioning surface; and said web is continuously withdrawn from the bath to arrest oxide formation.

3. The method as specified in claim 2 wherein: said conditioning surface comprises a moving surface.

4. The method as specified in claim 1 wherein: said bath comprises aqueous sulfuric acid maintained substantially at room temperature; and said anode is maintained at a temperature lower than the temperature of the bath.

5. The method as specified in claim 1 wherein said bath is maintained substantially at room temperature; and said anode is maintained at a temperature higher than the temperature of the bath.

6. The method as specified in claim 1 wherein said bath comprises aqueous sulfuric acid.

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