

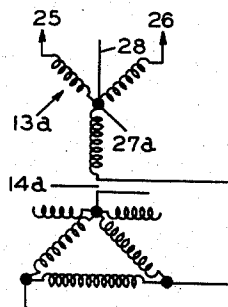
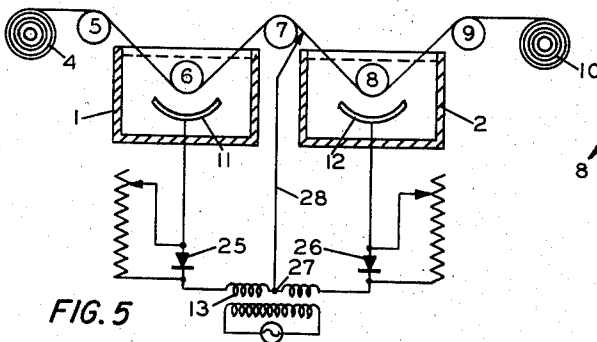
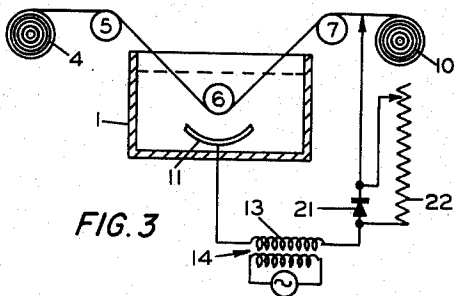
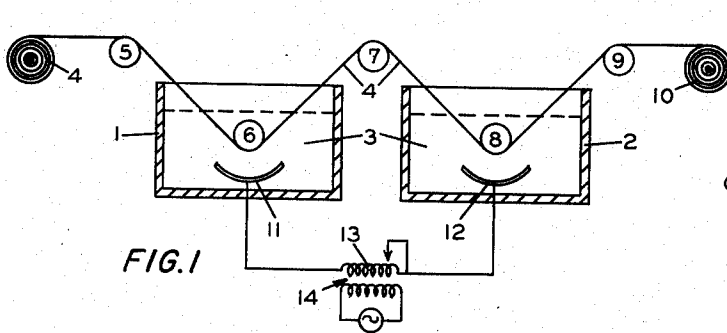
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APPARATUS FOR ANODIZING ALUMINUM SURFACES

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2,901,412

APPARATUS FOR ANODIZING ALUMINUM SURFACES

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1 Claim. (Cl. 204—211)

The present invention relates to a process and apparatus for anodizing the surfaces of aluminum or aluminum alloy bodies.

In commercial operations for anodizing aluminum surfaces for general use, direct current is passed through an electrolyte of the type which has a limited dissolving action on the oxide layer. Under the influence of the electric current, oxidation at the aluminum metal surface under the oxide coat is constantly occurring, while at the same time the electrolyte is dissolving oxide principally from the exterior surface of the oxide layer, so that the oxide layer produced is porous.

The thickness of the oxide layer thus produced is generally proportional to the quantity of electricity passed through the electrolyte from the cathode to the anode. Therefore, to produce a rapid or high rate of oxide formation, a high current density should be employed. Unfortunately, a high current density "burns" the anode surface; hence, to prevent burning, a relatively low current density normally must be used. Somewhat higher current densities can be employed in this operation if the electrolyte or the aluminum surface is cooled, but this involves the expense of cooling systems and consequent higher cost of equipment and operation.

It has been proposed to employ an alternating anodizing current by connecting an alternating current source across the anode and cathode but such method is not efficient. The anodized aluminum at the anode acts as an imperfect rectifier or asymmetrical conductor, allowing a relatively low current flow in one direction from cathode to anode and a relatively high current flow in the opposite direction. The low flow produces an oxide coating, the high inverse flow does not. A.C. current, therefore, is more expensive and less productive than D.C. current.

The principal objects of the present invention are: to provide a novel method of, and an apparatus for, anodizing aluminum which permits the use of current densities vastly higher than heretofore found possible; to provide a method and apparatus which makes possible the efficient use of alternating current, or its equivalent, for anodizing purposes; and to provide one which is simple, effective and relatively inexpensive.

All of the objectives of our invention can be achieved by electrically connecting a conventional anodizing tank to an alternating current source in series with an imperfect rectifier or asymmetrical conductor which permits the desired flow of an anodizing current of high current density in one direction and prevents the abnormal flow of current in the opposite direction. The imperfect rectifier may be in the form of a second anodizing tank serially connected in "back-to-back" relationship with the first tank so that all current flows in one direction operate as an anodizing current in the first tank and an inverse current in the second tank, while all current flows in the opposite direction operate as an inverse current in the first tank and an anodizing current in the second

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tank. Each tank thus serves, during its anodizing interval, to restrict the magnitude of the current flow through the circuit and thus prevents the flow of an abnormally high current density through the other tank during the non-anodizing or inverse current interval of the other tank.

With two tanks connected in series, and with an alternating current of extremely high current density flowing through both tanks, a considerable amount of power is wasted in each tank during each of its inverse current alternations or intervals. This can be substantially reduced, in accordance with our invention, by substituting, for the second tank, an imperfect rectifier of the shunt resistance type which permits the unrestricted flow of anodizing current through the rectifier proper at little power loss, but restricts the flow of inverse current to the shunt resistor which can be designed or adjusted to reduce the current flow to a relatively small value. This flow of inverse current is important. We have found that, to permit the use of an extremely high anodizing current density over substantial periods of time, it is necessary to have an inverse current flow apparently to cause depolarization. We have also found, however, that the magnitude of the inverse current is not important; hence, it may be restricted to a low value as above indicated.

It will be appreciated that the use of an imperfect rectifier in series with an alternating current source is a simple and effective way of producing an anodizing alternation of high current density and an inverse alternation of low current density and that this form of A.C. reduces the waste of power to a minimum. The use of commercially available A.C. is preferred in the practice of this invention because of its ready availability but, obviously, we may obtain the same end result with another type of alternating current such as results when A.C. is superimposed upon D.C. with the A.C. and D.C. magnitudes being such as to produce a large anodizing current amplitude and a relatively small inverse current amplitude.

The method of and the apparatus for practicing the present invention is explained hereinafter in connection with the accompanying drawing wherein:

Figure 1 schematically illustrates a pair of anodizing tanks connected in series with each other across an A.C. source;

Figure 2 illustrates the balanced current flow obtained in the arrangement of Figure 1 and also indicates the unbalanced current flow heretofore obtained;

Figure 3 schematically illustrates a single anodizing tank connected across an A.C. source in series with an imperfect rectifier of the shunt resistance type;

Figure 4 illustrates the current flow obtainable in the arrangement of Figure 3; and

Figures 5 and 6 schematically indicate how the Figure 3 arrangement can be employed with 2-phase and 3-phase sources of A.C.

The arrangement illustrated in Figure 1 includes a pair of anodizing tanks 1 and 2, each of which contains an electrolyte 3 composed of dilute sulfuric acid or other suitable oxide-dissolving type of electrolyte. A strip 4 of aluminum to be anodized extends from a supply coil, also designated 4, respectively over and under guide and submerged rollers 5 through 9 to a wind-up roll 10, which preferably is power driven by suitable means, not shown, in order to unwind the coil and move the strip. The tanks 1 and 2 are respectively provided with cathodes 11 and 12. These cathodes are connected to opposite terminals of the adjustable secondary winding 13 of a conventional transformer 14 or to any other suitable source of A.C. power.

In operation, we assume that, when the voltage is ap-

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plied, each of the current alternations designated 16, in Figure 2, will flow from secondary 13 to cathode 11 of tank 1, thence through electrolyte 3 therein to anodic strip 4 and along strip 4 to tank 2, thence through electrolyte 3 therein to cathode 12 and finally back to secondary 13. In other words, each alternation 16 flows as an anodizing current in tank 1 and as an inverse current in tank 2. The latter tank does not offer any appreciable resistance to this flow of current because it is in the inverse direction.

In tank 1, however, the voltage must build up to a value high enough to overcome the insulating or dielectric effect of the oxide barrier coat on its anode. Once this voltage is reached, the anodizing current will start to flow and it will continue to flow until the voltage falls below the value required to overcome the oxide barrier coat.

The reverse of the foregoing operation is true for all current alternations 17, since these flow in a direction opposite to that of alternations 16; hence, function as an anodizing current in tank 2 and as an inverse current in tank 1. As a practical matter, a small leakage current flows between alternations 16 and 17; hence, these alternations are shown as connected to each other.

Before passing from Figure 2, it may be noted that alternation 17, being an inverse current in tank 1, causes a power loss in that tank equal to the square of the current represented by alternation 17 multiplied by the relatively low resistance of tank 1 to an inverse current flow. Now, if tank 2 were omitted in Figure 1, an abnormal alternation 18 would flow in place of normal alternation 17, as an inverse current in tank 1, causing a substantially larger waste of power. The extent of the current abnormality is graphically indicated in Figure 2 by the shaded portion of the alternation 18. Accordingly, our invention, as illustrated in Figure 1 in addition to its simplicity and effectiveness, has the further advantage of reducing the power loss as above explained.

It will, of course, be understood that each alternation 16 produces a power loss in tank 2 of Figure 1, while each alternation 17 produces a corresponding power loss in tank 1. In accordance with our invention, these power losses may be drastically reduced by substituting for, say, tank 2, an imperfect rectifier of the shunted resistor type which is illustrated in Figure 3 and which reduces the inverse power-wasting current as indicated in Fig. 4.

In Figures 3 and 4, an anodizing current alternation 16 again flows from secondary 13 through tank 1 to and along strip 4 and thence through rectifier 21 back to the current source. The inverse current alternation 19 flows in the reverse direction but, since it cannot flow through rectifier 21, it must flow through the shunt resistor 22 which can be adjusted to reduce the inverse current to a value which, in relation to alternation 16, is relatively small.

The modification shown in Fig. 5 is identical to Fig. 1 except that a rectifier 25 of the shunt resistor type is introduced between cathode 11 of tank 1 and the corresponding terminal of the secondary 13, another similar rectifier 26 is similarly introduced between cathode 12 and its terminal of secondary 13 and the mid point 27 of secondary 13 is connected through line 28 to strip 4. With this arrangement, an anodizing current, such as alternation 16 flowing through tank 1, will automatically divide itself between mid point line 28 and tank 2 so that only a small portion of the current will flow through tank 2 as an inverse current, most of the current flowing directly through line 28 to the secondary 13. During a reverse alternation, say 17, causing an anodizing current to flow through tank 2, the current will again divide so that most of it returns through line 28, only a small inverse current passing through tank 1. The arrangement shown in Figure 5 is the equivalent of a 2-phase arrangement.

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Figure 6 indicates how Figure 5 can be converted into a 3-phase arrangement. This conversion simply involves: substituting, for transformer 14, a 3-phase transformer 14a having a secondary 13a, which is shown as a Y-type but may be of any other equivalent type; extending the aluminum strip 4 through another anodizing tank 30; and connecting its cathode 31 through an imperfect rectifier 32, of the shunted resistor type, to one lead terminal of the 3-phase secondary 13a. The other lead terminals of the secondary 13a and its common point 27a are connected in Fig. 6 in the same manner as the corresponding lead terminals and the common point 27 of secondary 13 are connected in Fig. 5.

The operation of the embodiment shown in Figure 1 is illustrated by the following specific examples:

Example 1

Temperature of bath 70° F.
Electrolyte—sulfuric acid 15 to 20%.
Transformer primary voltage, 110 v.
Current in each bath, 40 amp.
Immersed area in each bath, 40 sq. in.
Voltage drop between cathode 11 and strip 4:
(a) In tank 1, 14 v., and
(b) In tank 2, 14 v.

The aluminum strip treated was 3SO alloy, and its speed at the beginning of treatment was 4¾ lineal inches per minute. Due to the manner of winding the strip on a roll of gradually increasing diameter, the speed of the strip at the end of the treatment was 5½ lineal inches per minute. The connections of the cathodes to the transformer were adjusted as required to maintain the current at 40 amp.

The calculated current density in each tank was 144 amp. per square foot of anode surface. The anodized film produced showed no evidence of burning or other defects. Its average thickness was about .00018 inch.

Example 2

In a second example, conditions employed were the same as in Example 1, except as here indicated:

Immersed area was 12 square inches. Speed of strip varied from 6¼ inches per minute at beginning to 6¾ inches per minute at end. Current applied varied from about 42.5 amp. at the beginning to about 30 amp. at the end. The voltage drop in tank 1 between strip and cathode was 16 v., and in tank 2 was 22 v. The current density employed varied from about 510 amp. per sq. foot of anode at the beginning to 360 amp. per sq. foot at the end. The anodized film is opaque, greenish grey in color, and showed no evidence of burning. Its average thickness was about .00030 inch.

Having described our invention, we claim:

An anodizing apparatus comprising: a first unit including a first shunt-resistor rectifier and a first tank for containing an electrolyte for anodizing an aluminum surface immersed in said electrolyte, said tank having cathode and anode terminals; a second unit substantially similar to said first unit, said second unit including a second shunt-resistor rectifier and a second anodizing tank having cathode and anode terminals; an alternating current source having first and second power terminals and a common terminal; means electrically connecting both anode terminals to said common terminal; and means electrically connecting said first power terminal serially through the first rectifier to the cathode terminal of the first tank and said second power terminal serially through the second rectifier to the cathode terminal of the second tank, each rectifier constituting a means for restricting the inverse current flowing through it to a value substantially less than that of the anodizing current flowing therethrough.

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