

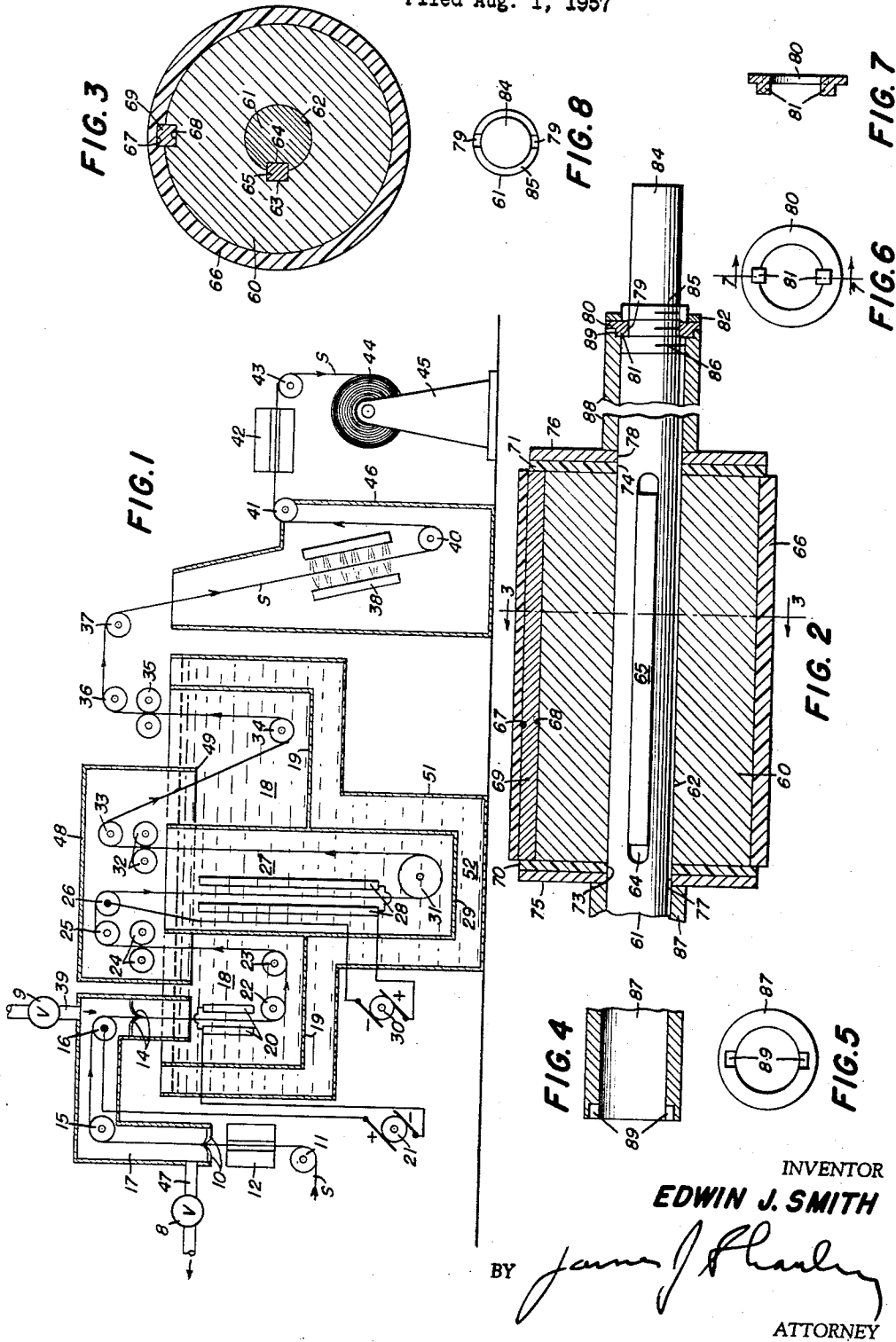
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ELECTROLYTIC APPARATUS INCLUDING AN IMPROVED ROLL

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ELECTROLYTIC APPARATUS INCLUDING AN IMPROVED ROLL

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This invention relates to improved electrolytic apparatus. In one of its more specific aspects, the present invention relates to an improvement in rolls serving to guide metal base, which may be in the form of strips, sheets or wire of extensive length, through electrolytic apparatus such as for example a continuous electroplating line.

The present invention will be described and illustrated hereinafter with reference to the electrodeposition of aluminum on ferrous metal strip using a fused electrolyte containing aluminum chloride. However, it will be apparent to those skilled in the art that the principles of the present invention are applicable to other base metals, or forms of base metals, or coating metals, or similar electrolytes and liquids presenting the problems to be described hereinafter.

In copending application Serial No. 512,734, filed June 2, 1955, by Edwin J. Smith et al., for "Plating Apparatus and Method," now abandoned, a continuous electroplating line is disclosed which is suitable for electroplating aluminum on ferrous metal strip. In accordance with the teachings of this application, a fused plating electrolyte containing aluminum chloride within a preferred range produces objectionable fuming at the desired temperature of operation of the electroplating bath. This objectionable fuming is eliminated in the foregoing invention by sealing off the electroplating bath with a non-fuming fused sealing composition containing no essential component not present in the fuming fused electrolyte, thereby eliminating the fuming problem associated with the plating electrolyte and, in addition, it is possible to condition the strip prior to plating. Even more important, the entry of water into the fuming fused electrolyte in any of its various forms is entirely prevented, thus eliminating the gradual entry of water into the electroplating bath and the deleterious effects thereof.

When continuously electroplating ferrous metal strip with aluminum by means of the above mentioned plating apparatus and method, an additional problem is presented which is not solved by the subject matter disclosed therein. While a highly desirable product may be produced by the foregoing plating apparatus and method, salts removed from the non-fuming fused sealing composition and the fuming fused electrolyte were found to crystallize and gradually build up on certain rolls conveying ferrous metal strip through the electroplating line. Those rolls which are totally immersed offer no problem in this respect, but rolls which are above the surface of the non-fuming fused sealing composition and the fuming fused electrolyte, and contacted by salts removed therefrom during operation of the electroplating line, gradually build up a deposit of crystallized salts. This gradual build-up of crystallized salts on the rolls, as well as the corrosive nature of the non-fuming fused sealing composition and the fuming fused electrolyte, present problems of a practical nature which make continuous operation of the electroplating line over extended periods of time

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exceedingly difficult. For example, the gradual and uneven build-up of crystallized salts on the cylindrical surfaces of the rolls causes an undesirable, uneven or pitted surface to be formed on the ferrous metal strip as it passes through the electroplating line and in contact with the rolls. In addition, the rolls having such a build-up of crystallized salts on their cylindrical surfaces are not as effective in performing their function of guiding the metal strip through the electroplating line. Also, the aluminum chloride content of the various fused compositions, or other salts present therein, or reaction products thereof, and particularly within the area sealed off above the electroplating bath, are extremely corrosive and result in a relatively short roll life. The above problems are further complicated by the fact that the enclosed area above the electroplating bath is relatively inaccessible during operation of the electroplating line, and that every conventional roll material is either incompatible with the non-fuming fused sealing composition or fuming fused electrolyte, or will allow a build-up of salts.

In accordance with the present invention, the foregoing difficulties are eliminated by providing a roll which is entirely compatible with the various fused compositions and under the conditions of operation, and which will not allow salts removed from the various fused compositions to accumulate or to build up on the cylindrical surfaces of the roll body. It has been found that the only practical solution to this problem is by providing a roll having at least the major proportion of the cylindrical surface of the roll body normally contacted by the metal strip constructed of a suitable organic polymeric material which is non-wettable by the various fused compositions, and which is physically and chemically stable under the conditions of operation of the electroplating line. Preferably, all exposed metal surfaces of the roll structure are constructed of aluminum or other suitable metal compatible with the various fused compositions and under the conditions of operation of the electroplating line. A roll provided with a surface constructed of polytetrafluoroethylene is particularly desirable for guiding metal strip through a fused salt bath comprising predominant proportions of aluminum chloride. A roll surface so constructed is not wettable by such a fused salt bath and will readily shed off any salts, whether brought into contact with the roll surface by "dragout" or by condensation on the roll of aluminum chloride fumes or fumes of other salts present in the bath. Further, it has been found that both polytetrafluoroethylene and aluminum are entirely compatible with fused salt baths containing predominant proportions of aluminum chloride, and that a roll having exposed surfaces constructed of these materials has an extremely long life. The many advantages of the roll of the present invention, particularly when used in the environment described herein, will be readily apparent to those skilled in the art.

It is an object of the present invention to provide improved electrolytic apparatus.

It is a further object of the present invention to provide an improved roll for guiding metal strip and the like through a fused salt bath, and which is compatible with the bath and will not allow salts from the same to crystallize and accumulate to any appreciable extent on the roll surface.

Still other objects and advantages of the present invention will be apparent to those skilled in the art by reference to the following detailed description and the drawing, in which:

Fig. 1 is a diagrammatic side elevational view, partially in cross section, of a presently preferred embodiment of a continuous electroplating line constructed in accordance with the present invention;

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Fig. 2 is a longitudinal sectional view, with parts thereof broken away, of a presently preferred embodiment of the roll of the present invention;

Fig. 3 is a cross-sectional view taken along the line 3—3 of Fig. 2;

Fig. 4 is a fragmental longitudinal sectional view of the sleeves surrounding the shaft of the roll of Fig. 2;

Fig. 5 is an end view of Fig. 4;

Fig. 6 is a view in elevation of the washer used in construction of the roll of Fig. 2;

Fig. 7 is a cross-sectional view taken along the line 7—7 of Fig. 6; and

Fig. 8 is an end view of the shaft of the roll of Fig. 2.

Referring now to the drawing, Fig. 1 illustrates a continuous aluminum electroplating line with the novel roll of the present invention installed therein. The general construction and operation of the electroplating line of Fig. 1 is more particularly described in the above mentioned copending application Serial No. 512,734. Ferrous metal strip S is shown passing from a suitable conventional wet pre-treatment (not shown) under roll 11 and upward through heater 12 where it is heated sufficiently to evaporate water from the strip surface. The heated strip S is then passed over rolls 15 and 16, and through the strip conditioning unit 17 where the strip is thoroughly dried. If desired, the strip may be further treated within unit 17 at an elevated temperature and in a reducing atmosphere for the purpose of further conditioning the strip surface. Two pairs of suitable sealing flaps 10 and 14 are provided near the entrance and exit ends, respectively, of unit 17 for the purpose of preventing undue loss of gaseous treating agent which may be employed in unit 17. The gaseous treating agent is supplied to unit 17 by means of conduit 39, and is withdrawn from unit 17 by means of conduit 47. The flow rate of gaseous treating agent to unit 17 is controlled by valve 9, while the withdrawal rate is controlled by valve 8.

The ferrous metal strip S is passed downward from unit 17 into non-fuming fused sealing composition 18 contained in unit 19, between aluminum cathodes 20, under rolls 22 and 23, and then upward through the non-fuming fused sealing composition 18 between hood 48 and electroplating unit 29. The non-fuming fused sealing composition 18 contains critical proportions of aluminum chloride and one or more of the other constituents contained in the fuming fused electrolyte 27. For example, where the fuming fused electrolyte 27 is a binary plating electrolyte such as 80–85% aluminum chloride and 20–15% sodium chloride, by weight, the preferred non-fuming fused sealing composition 18 would consist of aluminum chloride and sodium chloride, with the aluminum content being less than 70% by weight. Where the fuming fused electrolyte 27 is a ternary plating electrolyte such as 80–85% aluminum chloride, by weight, with the balance being sodium chloride and potassium chloride, the preferred non-fuming fused sealing composition 18 would then consist of aluminum chloride, sodium chloride and potassium chloride, with the aluminum chloride content being less than 70% by weight. In all instances, the aluminum chloride content of the non-fuming fused sealing composition 18 preferably is less than 70% by weight aluminum chloride, since higher aluminum chloride contents may result in a fuming composition.

The ferrous metal strip S is given an anodic treatment while passing through the non-fuming fused sealing composition 18 for the purpose of further conditioning the surface of ferrous metal strip S prior to the electrodeposition of aluminum thereon. The current carrying characteristics of the non-fuming fused sealing composition 18, although not satisfactory as an electrolyte for aluminum plating, are such that it provides an excellent medium in which an electrolytic surface treatment of the ferrous metal strip can take place. It has been found

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that an anodic treatment eliminates objectionable dark undercoating in the finished plated product thereby resulting in a more desirable appearance. For the purpose of this anodic treatment, aluminum cathodes 20 are electrically connected to the negative side of generator 21, while the ferrous metal strip S is made electropositive between roll 16 and aluminum cathodes 20 by means comprising an electrical connection between roll 16 and the positive side of generator 21.

Ferrous metal strip S, after emergence from non-fuming fused sealing composition 18, has its dragout losses reduced by the action of squeegee rolls 24 and passes upward over rolls 25 and 26, and then downward into the fuming fused electrolyte 27 contained in electroplating unit 29. The fuming fused electrolyte 27 has a high aluminum chloride content such as, for example, 82% aluminum chloride, 9% sodium chloride, and 9% potassium chloride, by weight, and fumes in the presence of water or water vapor under operating conditions. A hood 48 is positioned above electroplating unit 29. It will be noted that the unit 19 containing non-fuming fused sealing composition 18 is so constructed as to completely surround electroplating unit 29, while the hood 48 is so constructed and arranged as to completely surround the upper portion of electroplating unit 29 with the lower edge 49 of hood 48 positioned below the surface of the non-fuming fused sealing composition 18. Thus, the electroplating unit 29 is completely sealed off from the atmosphere, with the fumes from fuming fused electrolyte 27 being retained under hood 48. This arrangement completely eliminates the gradual entry of water into the fuming fused electrolyte 27, as well as the deleterious effects thereof.

Electroplating unit 29 is provided with anodes 28 of high purity aluminum. The ferrous metal strip S passes from roll 26 downward through fuming fused electrolyte 27, between anodes 28, around roll 31, and then passes upwardly through fuming fused electrolyte 27. The anodes 28 are electrically connected to the positive side of generator 30, while the ferrous metal strip S is made electro-negative between roll 26 and anodes 28 by means comprising an electrical connection between roll 26 and the negative side of generator 30. The ferrous metal strip S is electroplated with a coating of aluminum of desired thickness while within electroplating unit 29.

The ferrous metal strip S, after emerging from fuming fused electrolyte 27, passes between squeegee rolls 32, which tend to reduce the dragout of the electrolyte. The ferrous metal strip S then passes upward over roll 33, downward between electroplating unit 29 and hood 48 into non-fuming fused sealing composition 18, under roll 34, and upward through non-fuming fused sealing composition 18. Upon emerging from non-fuming fused sealing composition 18, the ferrous metal strip S passes between squeegee rolls 35, and is then guided by rolls 36, 37, 40 and 41 through washing unit 46, where washing and spraying apparatus 38 serves to remove any excess material carried on the strip surface. The ferrous metal strip S subsequently passes from over roll 41 through heater 42 where it is dried, and over roll 43 onto coiling unit 44, which is supported by pedestal 45.

For the purpose of minimizing the loss of heat, unit 19 and electroplating unit 29 are positioned within unit 51, which contains an insulating material or a heated medium such as oil in the space 52. Additionally, and in order to maintain the non-fuming fused sealing composition 18 and the fuming fused electrolyte 27 at the proper temperature, immersion heating (not shown) may be employed as is conventional in the art.

In operating the electroplating line described above and with conventional rolls installed therein, it was found that salts from the non-fuming fused sealing composition 18 and the fuming fused electrolyte 27 crystallize on rolls guiding the ferrous metal strip through the electroplating zone. With continuous oper-

ation of the electroplating line over a period of time, the salts gradually build up a layer of sufficient thickness to offer many practical difficulties. Those rolls not contacted by the salts or rolls totally immersed in the fused compositions offer no problems from this standpoint, but those rolls which are contacted by the various fused compositions, and particularly rolls which are under hood 48 and thus in contact with aluminum chloride fumes, in addition to the normal amount of dragout, gradually build up a layer of crystallized salts which adversely affect operation of the electroplating line. For example, the gradual and uneven build-up of crystallized salts on the cylindrical surfaces of the rolls causes an undesirable uneven or pitted surface to be formed on the ferrous metal strip as it passes through the electroplating line and in contact with the rolls. In addition, the rolls are not as effective in performing their function of guiding the ferrous metal strip. The above problems are further complicated by the fact that the more troublesome rolls, i.e., rolls 24, 25, 32 and 33, are located above the fuming fused electrolyte 27 and under hood 48, and are thus relatively inaccessible due to the highly corrosive aluminum chloride vapors filling the space under hood 48 and the high operating temperature, e.g., 250–400° F. Experience in the operation of the above described continuous electroplating line has shown that it is necessary that rolls 24, 25, 32 and 33 be constructed in accordance with the roll of the present invention in order to produce a high-quality plated product and to enable continuous trouble-free operation of the electroplating line over extended periods of time and without costly loss of time for cleaning and replacement of the rolls. It is also desirable that at least rolls 22, 23, 34 and 35 be constructed in accordance with the roll of the present invention, in addition to the foregoing rolls, due to the corrosive nature of the non-fuming fused sealing composition 18 and the fuming fused electrolyte 27.

Referring now to Fig. 2 of the drawing, the novel roll of the present invention comprises a cylindrical aluminum roll body 60 provided with a centrally located and longitudinally extending bore 62. The roll body 60 is mounted on shaft 61, which is constructed of corrosion-resistant steel, or other suitable material. The shaft 61 is provided with a keyway 64 in the surface thereof which extends substantially the length of roll body 60. Bore 62 in roll body 60 is likewise provided with a similar keyway 63, as best seen in Fig. 3. A key 65 is inserted in keyways 63 and 64 for the purpose of locking roll body 60 on shaft 61 and thus preventing rotation thereof when in use.

A sleeve 66 of polytetrafluoroethylene, i.e., Teflon, or other suitable organic polymeric material which is non-wettable by the non-fuming fused sealing composition 18 or fuming fused electrolyte 27, and which is physically and chemically stable under the conditions of operation of the electroplating line, is fitted on the cylindrical surface of roll body 60. As best seen in Fig. 3, the internal surface of sleeve 66 is provided with a keyway 67, and the outer surface of roll body 60 is likewise provided with a similar keyway 68. A key 69 is inserted into keyways 67 and 68 for the purpose of preventing rotation of sleeve 66 on roll body 60 during use.

Circular flanges 70 and 71 constructed of polytetrafluoroethylene, i.e., Teflon, having a diameter substantially that of roll 60 and provided with centrally located openings 73 and 74, respectively, are inserted on shaft 61 and in abutting relationship with the ends of roll 60. Similar flanges 75 and 76 constructed of aluminum or other suitable corrosion-resistant material and provided with centrally located openings 77 and 78, respectively, are likewise inserted on shaft 61 and in abutting relationship with flanges 70 and 71, respectively.

Similar sleeves 87 and 88, which are constructed of aluminum or other suitable corrosion-resistant material, 75

are inserted over the ends of shaft 61 and in abutting relationship with flanges 75 and 76, respectively. As best seen in Figs. 4 and 5, the outer ends of sleeves 87 and 88 are each provided with a pair of oppositely disposed keyways 89; and, as best seen in Fig. 8, the ends of shaft 61 are provided with a similar pair of oppositely disposed keyways 79. As best seen in Figs. 6 and 7, the washer 80 is provided with a pair of oppositely disposed keys 81. The washer 80 is inserted on the ends of shaft 61, with the keys 81 being inserted into keyways 79 and 89, for the purpose of preventing rotation of aluminum sleeves 87 and 88 on shaft 61. It will be noted that the outermost ends 84 of shaft 61 are of a reduced diameter forming annular shoulders 85. Also, the portions of shaft 61 immediately inward of shoulders 85 are provided with threaded portions 86. Nuts 82 are inserted on the threaded portions 86 of shaft 61 and tightened into place to prevent any possibility of longitudinal slippage of the assembly along shaft 61.

The above described embodiment of the roll of the invention has been found to be particularly well adapted for the purpose of guiding ferrous metal strip through the continuous electroplating line described herein. The roll of the invention is entirely compatible with both the non-fuming fused sealing composition 18 and the fuming fused electrolyte 27 used therein, when constructed in accordance with the foregoing description. However, it is essential that all exposed metallic portions thereof be constructed of a material which is compatible with the various fused baths, aluminum being preferred for this purpose. Further, the cylindrical roll surface must be constructed of an organic polymeric material, such as polytetrafluoroethylene, which is both compatible with the various fused baths and not wetted thereby, and which is physically and chemically stable under the operating conditions. The roll of the invention overcomes the many disadvantages of conventional prior art rolls used for this purpose, and has an extremely long and useful life. Even more important, due to its inability to be wetted by the various fused baths described herein, salts from the bath are not crystallized on the roll in tightly adhering relation. Where salts crystallized on the strip collect on the roll, a simple scraper may be arranged in a conventional manner to scrape the roll surface and thus remove the loosely adhered crystals from the roll surface.

The organic polymeric materials which are useful in practicing the present invention must be substantially non-wettable by the particular liquid or electrolyte through which the metal strip is being guided. In addition, the organic polymeric material must be substantially chemically inert to the particular environment in which the roll is to be used and capable of withstanding the forces normally required of a roll surface when in use in the environment. In other words, the polymeric material must be chemically and physically stable in its environment and under the conditions of operation. For example, in the specific environment illustrated herein, the organic polymeric material must be chemically and physically stable at temperatures of 250–400° F. or at the particular temperature of operation, and in the presence of the various fused salt baths which comprise predominant proportions of aluminum chloride and minor proportions of sodium and/or potassium chloride. Examples of suitable organic polymeric materials include polytetrafluoroethylene and polytrifluorochloroethylene. Of these materials, polytetrafluoroethylene is preferred in most instances due, in part, to the fact that it is chemically and physically stable at temperatures up to about 500° F. However, polytrifluorochloroethylene may be used at lower temperatures of operation, such as 250–350° F.

Polytetrafluoroethylene and polytrifluorochloroethylene are sold under the trade-marks "Teflon" and "Kel F," respectively. These materials are available in commercial

quantities as granular powders which may be molded or extruded into desired shapes and cured by processes well known to the art to thereby provide a shape, e.g., a sleeve for use in the present invention, having high impact strength, high compressive strength and high temperature resistance.

The foregoing detailed description and the drawing are for the purpose of illustrating a presently preferred embodiment of the invention, and are not to be taken as limiting the scope or spirit of the appended claims.

What is claimed is:

1. In electrolytic apparatus of the class wherein metal strip is guided through a body of liquid containing at least one salt by a series of suitably arranged rolls, the improvement which comprises a sleeve covering at least the major proportion of a roll normally contacted by the metal strip during operation of the electrolytic apparatus, the sleeve comprising an organic polymeric material that is non-wettable by the liquid.

2. In electrolytic apparatus of the class wherein metal strip is guided through a body of liquid containing at least one salt by a series of suitably arranged rolls, the improvement which comprises a sleeve covering at least the major proportion of a roll normally contacted by the metal strip during operation of the electrolytic apparatus, the sleeve comprising polytetrafluoroethylene and being non-wettable by the liquid.

3. In electrolytic apparatus of the class wherein metal strip is guided through a body of liquid containing at least one salt by a series of suitably arranged rolls, the improvement which comprises a sleeve covering at least the major proportion of a roll normally contacted by the metal strip during operation of the electrolytic apparatus, the sleeve comprising polytrifluorochloroethylene and being non-wettable by the liquid.

4. In electrolytic apparatus of the class wherein metal

strip is guided through a body of fused electrolyte containing aluminum chloride by a series of suitably arranged rolls, the improvement which comprises a sleeve covering at least the major proportion of a roll normally contacted by the metal strip during operation of the electrolytic apparatus, the sleeve comprising an organic polymeric material that is non-wettable by the electrolyte.

5. In electrolytic apparatus of the class wherein metal strip is guided through a body of fused electrolyte containing aluminum chloride by a series of suitably arranged rolls, the improvement which comprises a sleeve covering at least the major proportion of a roll normally contacted by the metal strip during operation of the electrolytic apparatus, the sleeve comprising polytetrafluoroethylene and being non-wettable by the electrolyte.

6. In electrolytic apparatus of the class wherein metal strip is guided through a body of fused electrolyte containing aluminum chloride by a series of suitably arranged rolls, the improvement which comprises a sleeve covering at least the major proportion of a roll normally contacted by the metal strip during operation of the electrolytic apparatus, the sleeve comprising polytrifluorochloroethylene and being non-wettable by the electrolyte.

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