

[54] CONNECTOR FOR USE WITH OXIDE COATED CONDUCTORS

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[58] Field of Search.....339/95, 97, 263

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[57] ABSTRACT

A method and apparatus are herein provided for making electrical connections using oxide coated conductors. A binding plate may be provided having an array of ridges formed thereon which ridges define at least one pocket. A binding device, e.g., a screw or the like,

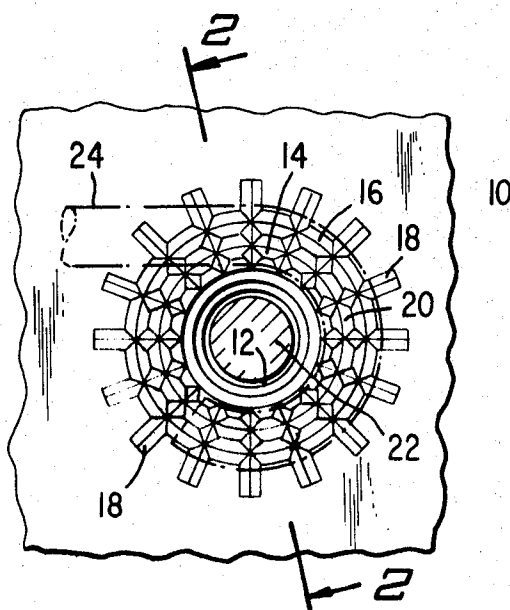
cooperates with the binding plate to urge a conductor against the binding plate until the ridges on the binding plate fracture the oxide coating on the conductor and penetrate the virgin metal thereof. The array of ridges is sized so that the ridges defining and completely surrounding at least one pocket will penetrate the virgin metal so as to form a gas-tight space between the binding plate and the conductor. The ridges may be formed as sharp cutting projections for fracturing the oxide and for facilitating the penetration of the virgin metal. Alternatively, the ridges may merely comprise the edges defining each pocket, which edges need not extend above the surface of the binding plate.

In one form of the invention, the array of ridges may define concentric circles disposed about a binding post and intersected by radially extending ridges. In another form of the invention, the array may comprise one or a plurality of indentations machined into the surface of the binding plate by a punch or the like.

In still another form of the invention, a washer may be provided having at least one pocket formed in a radial face thereof. The washer is disposed between the binding plate and a binding device which is then operable to urge the washer against the conductor to perform the functions of fracturing the oxide coating and of establishing an electrical connection with the virgin metal of the conductor.

In any form, however, each pocket is defined by a ridge which completely surrounds that pocket, and which is sized to define an opening which is completely covered by a conductor when urged there against.

10 Claims, 7 Drawing Figures



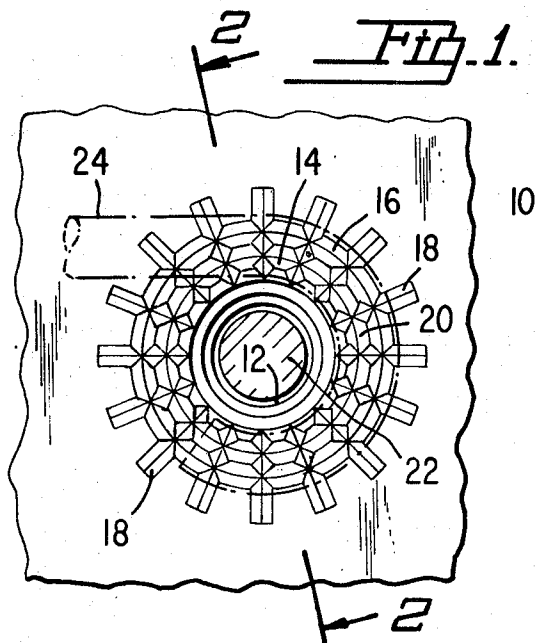
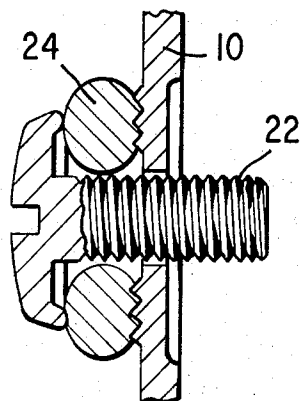
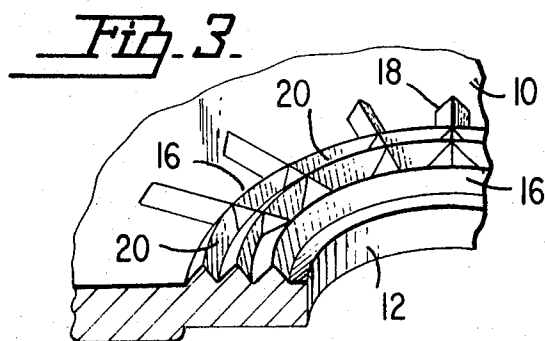
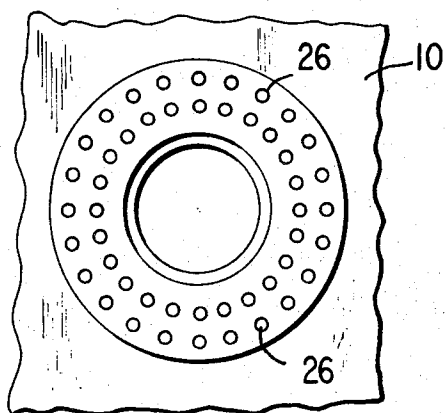
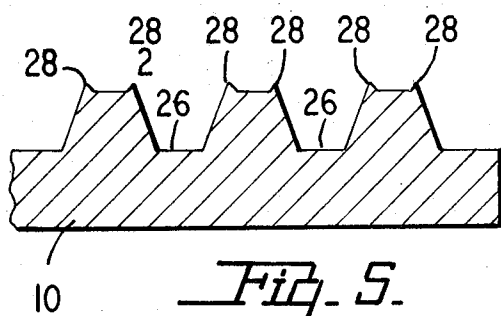
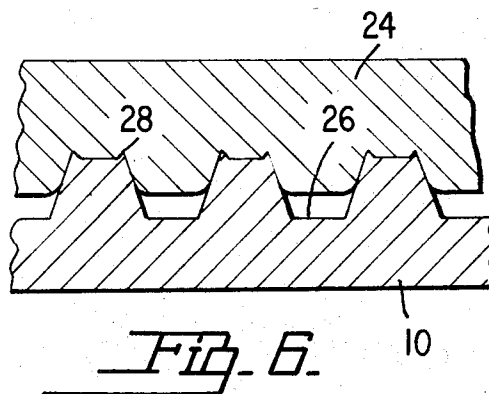
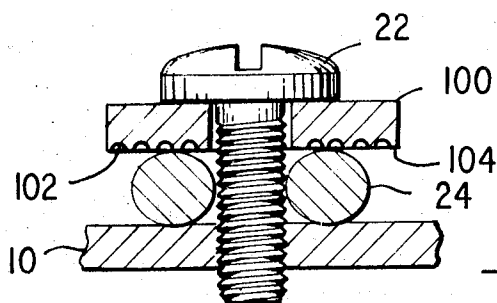


Fig. 7.

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BACKGROUND OF THE INVENTION

Due to the instability of the copper market, as well as the high cost of copper, industry is considering the use of small gauge aluminum wire in the place of copper wiring for domestic homebuilding and the like.

Aluminum is a low density metal with good electrical properties. Indeed, the mass conductivity of pure aluminum is over twice that of copper, and the volume conductivity is about sixty-five percent that of copper. Therefore, although an aluminum conductor of a given current-carrying capacity is somewhat larger than an equivalent copper conductor, it weighs only half as much.

For most small gauge wiring applications, however, the slightly larger size of aluminum conductors is not the feature which has prevented the wide spread use of aluminum. The most serious problem resides in the difficulty of connecting or terminating the aluminum conductors. The physical and chemical properties of aluminum differ substantially from those of copper and, unfortunately, make termination problems exceedingly acute.

In wiring connections, the virgin metal surface of a conductor is always covered with a layer of oxide film. On copper, this oxide is a discoloration which turns progressively darker. The oxide may be invisible as is the transparent oxide on aluminum. The nature of the oxide surface on an electrical conductor is critical to the quality of the connection or termination of that conductor. Since oxide layers of these metals have a higher resistivity than the associated base virgin metal, conduction paths must be created through the oxide.

In laboratory tests on layers of oxide film with an average thickness of 100 angstroms, the voltage necessary to achieve proper current conduction through copper oxide was found to be less than one volt. However, the voltage necessary for proper current conduction through an equivalent layer of aluminum oxide was 40 volts. Therefore, the industry has generally conceded that conduction across an aluminum wire termination can be only achieved by utilizing extremely high voltages or by mechanically breaking the aluminum oxide layer.

Even though the industry has long recognized that proper conduction may be achieved through an aluminum conductor by fracturing the aluminum oxide layer, it has also been found that the oxide may reform on the surface of the aluminum conductor within a matter of seconds after the bare metal has been exposed to the atmosphere. This layer may attain a thickness of from 60 to 100 angstroms during this short period of time. Furthermore, the thickness of this oxide film may increase to magnitudes of thousands of angstroms under normal ambient conditions associated with changes in temperature and humidity.

Therefore, a significant problem which must be overcome to achieve a good aluminum wire termination is the prevention of re-oxidation of the virgin metal which has been exposed after breaking through the oxide layer.

Another problem encountered in binding aluminum wiring to a connection is the problem of cold flow or "creep." This problem is much more severe with alu-

minum than it is with copper. When aluminum is subjected to stress, it has a strong tendency to flow away from the stressed area. Such a cold flow ultimately stops in copper but, when stress is applied to aluminum wire, the wire yields almost indefinitely.

The rate of "creep" increases with increasing temperature because the yield strength decreases. This property of aluminum causes problems in any pressure connection as the aluminum flows away from the stressed area and exposes the virgin metal to the atmosphere. The movement also results in a higher resistance joint which, in turn, causes further heating. This sequence of internal heating causing additional creep which, in turn, causes more heating, has a cascading effect which ultimately results in failure of the connection.

Another problem which has been confronting the industry in its attempts to provide a satisfactory electrical connector for aluminum wiring is caused by the differences in the thermal expansion rates of other metals used with aluminum with respect to aluminum. When aluminum is heated in close conjunction with copper, for example, the aluminum expands more than the copper. This differential expansion can cause a permanent set to be induced in the aluminum. When the joint cools, the cross-sectional area of the aluminum is effectively reduced which results in a poor contact and a re-oxidation of the exposed virgin metal.

Still another problem associated with the use of aluminum wiring is corrosion. If an aluminum wire is terminated at a copper base connector and exposed to humidity, galvanic corrosion will probably occur. The amount of water vapor, industrial wastes and salt present in the atmosphere will play a significant role in the degree of corrosion. Currently, the industry is recommending that the copper material be plated with tin or that grease compounds be used to protect the exposed surfaces. Such measures have been found to be undesirable when dealing with small gauge wiring for household use and the like.

Some of the approaches advanced by industry for solving the problems associated with terminating aluminum conductors include the use of very high pressure contacts and the use of copper clad aluminum wiring. Other approaches include soldering, brazing, welding, cold-welding, and the use of certain aluminum alloys.

All of the above mentioned approaches to solving the difficult problems attending the termination of aluminum wiring present the disadvantage of a high manufacturing and installation cost.

It would, therefore, be advantageous if a method and apparatus were provided which would insure low-resistance terminations for aluminum wiring without requiring an additional significant increase in the cost over the cost of conventional copper connections.

SUMMARY AND OBJECTS OF THE INVENTION

It is, therefore, an object of the present invention to provide a method and apparatus for forming low-resistance electrical terminations using oxide coated conductors.

It is another object of the present invention to provide a method and apparatus for forming such electrical terminations without significantly increasing the

cost of the connector members comprising the termination.

It is still another object of the present invention to provide an electrical termination for oxide coated conductors which inhibits the re-oxidation of the electrical contact area after the oxide has been fractured.

It is yet another object of the present invention to provide a method and apparatus for electrically terminating aluminum wire by pressure contact without inducing an undesirable degree of cold flow in the aluminum conductor.

It is a further object of the present invention to provide a method and apparatus for reducing any galvanic corrosion between dissimilar metals of an electrical conductor and an electrical connector combination.

It is yet a further object of the present invention to provide a method and apparatus for electrically terminating small gauge aluminum wiring more easily than has been heretofore possible.

It is yet still a further object of the present invention to provide a method and apparatus for electrically terminating oxide coated wiring which method and apparatus solves many of the problems confronting the electrical industry today.

At least some of the above stated objects are achieved by the provision of an electrically conductive binding member and a means for urging a conductor forcibly against the binding member. An array of edges is formed on the binding member to define at least one pocket having an opening which is completely covered by the surface of the aluminum conductor when the conductor is forcibly urged against the binding member. As the conductor is forced against the ridges, a gas-tight space is formed between the conductor and the binding member so that, when an oxide layer on the conductor is fractured, any reoxidation or galvanic corrosion of exposed virgin metal is substantially reduced. The matrix of edges biting into the conductor is further operable to inhibit a directional cold flow which may result in the failure of the connection. The operation of the ridges is also effective to minimize the effect of differential thermoexpansion of the elements comprising the electrical termination.

BRIEF DESCRIPTION OF THE DRAWINGS

While the invention is particularly pointed out and distinctly claimed in a concluding portion of the specification, several embodiments are set forth in the following detailed description which may be best understood when read in connection with the accompanying drawings, in which:

FIG. 1 is a plan view of a binding plate according to the preferred embodiment of the present invention;

FIG. 2 is a cross-sectional view of the binding plate shown in FIG. 1, taken along line 2—2;

FIG. 3 is a partial cross-sectional view of the binding plate shown in FIG. 1;

FIG. 4 is a plan view of an alternative binding plate arrangement according to the present invention;

FIG. 5 is a partial cross-sectional view showing a detail of the ridges and pockets which may be formed on the surface of the binding plates shown in FIGS. 1 and 4;

FIG. 6 is a partial cross sectional view showing an aluminum conductor urged into pressure contact with a binding plate according to FIG. 5; and

FIG. 7 is a cross-sectional view of another alternative arrangement of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to the drawings in which like numerals are used to indicate like parts, throughout the various views thereof, FIG. 1 shows a plan view of a binding plate according to the preferred embodiment of the present invention.

A generally planar surface 10 may be formed to define a threaded aperture 12 having circular ridges 14 and 16 formed concentrically thereabout. Radially extending ridges 18 are formed to radiate outwardly from the threaded aperture 12 and intersect the concentric ridges 14 and 16.

Due to this arrangement, a multiplicity of relatively small pockets 20 are defined by the intersecting concentric and radial ridges.

FIG. 2 shows a conventional binding screw 22 threadedly engaged within the aperture 12 to urge an oxide coated aluminum conductor 24 forcibly into engagement with the binding plate 10. It will be noted that the circular array of ridges defines a path generally followed by the aluminum conductor 24 as shown in phantom lines in FIG. 1.

As the binding screw 22 is forcibly urged against the aluminum conductor 24, the metal mass of the conductor 24 flows into the pockets 20 defined by the ridges presented on the binding plate 10. As the ridges, defining the pockets 20 penetrate through the oxide layer on the aluminum conductor, the dual functions of fracturing the oxide and of sealing off the electrical contact portion of the conductor from the ambient are accomplished.

FIG. 4 shows an alternative arrangement for defining pockets in a binding plate 10 by a machine punch, or the like. FIG. 5 shows the result of such a machine punch operation wherein sharp ridge-like projections extend upwardly from the plate 10 for engagement with the oxide layer of an aluminum conductor.

FIG. 6 shows the result of urging the ridges shown in FIG. 5 forcibly against an electrical connector 24. It will be noted that the conductor 24 cold flows into the pockets 26. Then, the combination of binding plate, pocket and conductor defines an airtight space which is effective to inhibit re-oxidation of any exposed virgin metal as well as to reduce galvanic corrosion due to the existence of dissimilar metals in an electrolytic ambient. If sufficient force should be applied to the conductor 24 to move the conductor 24, even slightly, with respect to the binding plate 10 to expose the virgin metal, any re-oxidation of that metal will be held to a minimum so as to maintain a low-resistance contact between the binding plate and the aluminum conductor.

FIG. 7 sets forth another alternative embodiment wherein an electrically conductive washer 100 is provided as a binding member having pockets 102 formed in one radially extending surface 104 thereof.

The binding screw 22 cooperates with the binding plate 10 to forcibly urge the topography of surface 104 into engagement with the oxide coated conductor 24.

Once again, the pockets 102 may be defined by ridges extending above the surface 104 to present sharp projections for piercing oxide coatings or may be formed by edges which are co-extensive with surface 104 so as to be flush therewith.

It should be noted that the concentric and radial ridges shown in FIG. 1 may be formed with the same cross-sectional profile as the ridges shown in FIG. 5 in that they may, instead of being triangular in cross-sectional area, be trapezoidal with cutting edges 28 extending from the upper corners thereof in the manner set forth in FIG. 5.

It can thus be seen that an improved method and apparatus is herein provided for electrically terminating aluminum conductors of the small gauge wiring category. Of course, the invention is applicable to the termination of any conductor, but is especially useful in connection with aluminum conductors. The arrangement according to the present invention forms a gas-tight space between the conductor and an associated binding member to seal out the ambient so as to inhibit re-oxidation of exposed virgin aluminum and to reduce the galvanic corrosion thereof. Furthermore, the matrix of gripping surfaces provided by the multiplicity of specially arranged edges provides a multiplicity of stress areas so that one portion of the conductor is forced to flow against an opposing flow from another stressed portion to reduce any large scale directional cold flow which may result in a termination failure.

The method and apparatus according to the present invention is less expensive in both manufacturing and installation than currently proposed approaches, and is particularly adaptable for use with small gauge aluminum wiring for use in household applications and the like.

SCOPE OF THE INVENTION

While what has been described herein is a preferred and an alternative embodiment of the present invention, it is of course understood that various modifications and changes may be made therein without departing from the invention. It is, therefore, intended to include in the following claims all such modifications and changes as may fall within the true spirit and scope of the present invention.

I claim:

1. An electrical connector comprising:

a. A binding plate;

b. Means for urging an elongated conductor against said binding plate;

c. An array of edges formed on said binding plate to define at least one pocket, the edges defining said pocket lying wholly in a single plane and extending in a continuous, unbroken line through the full periphery of the pocket;

d. Said pocket presenting an opening sized to be completely covered by the surface of the conductor when the conductor is forcibly urged against said binding plate; and

e. Whereby said binding plate and said conductor define a gas-tight pocket upon the forcible engagement of the conductor with said binding plate.

2. An apparatus according to claim 1 wherein said array of edges includes intersecting circumferentially and radially extending ridges.

3. An apparatus according to claim 1 wherein a conductor engaging portion of each of said edges includes at least one metallic oxide-cutting ridge;

each of said ridges extending upwardly from the surface of said binding plate and completely surrounding an associated pocket.

4. An apparatus according to claim 1 wherein said array of edges defines a plurality of depressions formed in said binding plate with each depression being surrounded by at least one oxide cutting portion.

5. An electrical connector according to claim 1 wherein said binding plate comprises a washer.

6. An apparatus according to claim 1 wherein said binding plate is held stationary while said means for urging the conductor thereagainst is movable.

7. An apparatus as described in claim 6 wherein said means for urging the conductor against said binding plate comprises threaded fastening means.

8. An apparatus according to claim 7 wherein said array of edges is formed about a threaded aperture formed in said binding plate; and

said array generally follows a path described by the conductor when the conductor is properly held against said binding plate to form a termination.

9. An electrical connector comprising:

a. A binding plate;

b. Means for urging a conductor against said binding plate;

c. At least a portion of the surface of said binding plate being formed with pockets;

d. Said pockets being defined by ridges extending upwardly from said surface of said binding plate;

e. Said ridges being formed with a cutting portion for piercing an oxide coating formed on the conductor and for penetrating into virgin metal of the conductor;

f. Said ridges being disposed to extend continuously and without interruption therein about the full periphery of each pocket in a common plane; and

g. Said pockets being sized to form gas-tight spaces between said binding plate and the conductor when said ridges are forcibly urged into the virgin metal of said conductor.

10. An apparatus according to claim 9 wherein said ridges are formed circumferentially and radially about a threaded aperture; and

said means for urging a conductor against said binding plate comprises a binding screw.

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