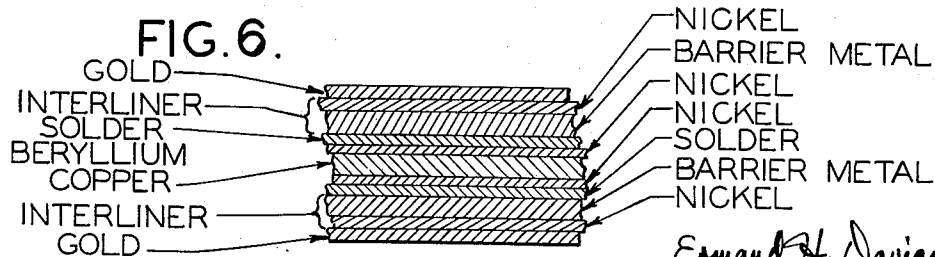
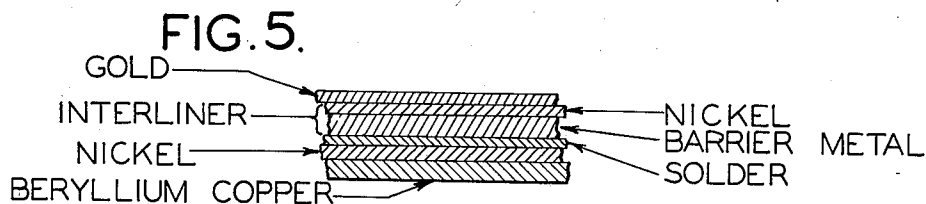
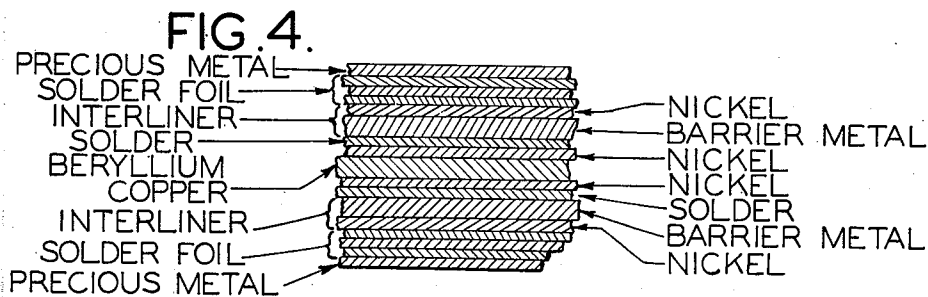
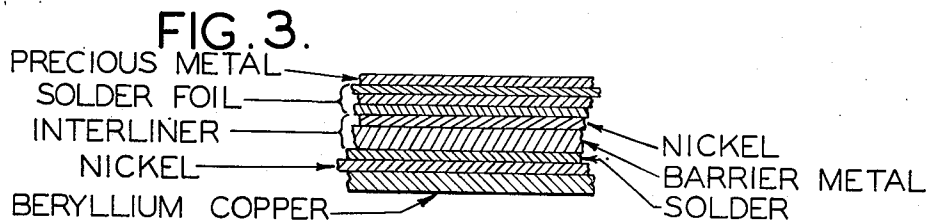
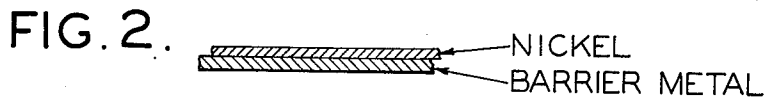
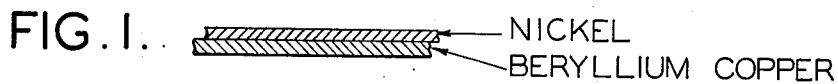


July 28, 1953

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COMPOSITE METAL HAVING PRECIOUS METAL
SURFACE AND BERYLLIUM-COPPER BASE
Filed Sept. 6, 1949

2,646,616



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2,646,616

COMPOSITE METAL HAVING PRECIOUS
METAL SURFACE AND BERYLLIUM-
COPPER BASEErmand H. Davignon, Attleboro, Mass., assignor
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Application September 6, 1949, Serial No. 114,266

12 Claims. (Cl. 29—199)

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This invention relates to composite metals and more particularly to composite metals having a precious metal surface and a beryllium-copper base.

This application is a continuation-in-part of my copending application Serial No. 768,365, filed August 13, 1947, now abandoned, which in turn is a continuation-in-part of my copending application Serial No. 750,534, filed May 26, 1947, now abandoned.

Briefly the present invention relates to composite metals in which a precious metal surface is bonded to a beryllium-copper base through an intermediate layer of nickel and a barrier metal.

Among the objects of this invention are the provision of a composite metal having a precious metal surface and a beryllium-copper base; the provision of a composite metal of the class indicated which may be solution annealed without blistering so that the composite metal may be easily formed, and yet may be subsequently treated to spring temper it. Other objects will be part apparent and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, steps and sequence of steps, features of construction and manipulation, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing, in which several of various possible embodiments of the invention are illustrated,

Fig. 1 is a fragmentary section through an intermediate for the production of the composite metal of the present invention;

Fig. 2 is a fragmentary section through another intermediate;

Fig. 3 is a fragmentary section through the composite metal prior to bonding;

Fig. 4 is a fragmentary section through an alternative embodiment of the composite metal prior to bonding;

Fig. 5 is a fragmentary section through still another embodiment of the composite metal prior to bonding; and,

Fig. 6 is a fragmentary section through another embodiment of the composite metal prior to bonding.

Similar reference characters indicate corresponding parts throughout the several views of the drawing.

Beryllium-copper alloy has been used as a base for a plate of silver, gold or other precious metals.

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However, such composite metals could not be solution annealed because when such a treatment was attempted the composite metal blistered and the precious metal layer peeled.

Precious metal plates on a beryllium-copper base have been utilized in the past but these have been in the cold-roll-hardened state. A cold rolled beryllium-copper is not as hard nor springy as one which is first solution annealed and then tempered. Such cold rolled plated beryllium-copper composite metal was accepted heretofore, since it was the only alternative available to a blistering and peeling composite metal.

According to the present invention, a beryllium-copper alloy base metal and a precious metal surface layer are combined to form a composite metal which may be solution annealed, and which may therefore be tempered to a desired hardness and springiness. In the composite metal of the present invention the beryllium-copper alloy base and the precious metal layer are bonded together through a separating layer which is bimetal in arrangement. This bimetal separator has for one side a layer of nickel and for the other side a layer of barrier metal. The barrier metal is a substantially non-ferrous alloy containing predominantly nickel or copper and it is solder-diffusible and of sufficient strength to withstand the layer separating forces at the solution annealing temperature of beryllium-copper. This barrier metal may be a brass such as one containing 92% copper, 7% zinc and 1% tin, although this may be varied provided the copper is not reduced substantially below 85% and the tin is not substantially more than 5%. Alternatively this barrier metal may be a nickel-silver, a bronze, a cupro-nickel or a Monel. The nickel-silver may contain from 50 to 70% copper, 15-30% zinc and 5-30% nickel. A suitable composition would contain copper, 64%, zinc 18% and nickel 18%, or copper 65%, zinc 25% and nickel 10%. The bronze may contain 60-98.75% copper, 0-32% zinc, 0-4% tin, 0-2% nickel and 0-0.25% phosphorus. A typical specific composition from among the bronzes is copper 95.75%, tin 4% and phosphorus 0.25%. The cupro-nickels may contain 55-70% copper and 30-45% nickel. A suitable Monel is copper 30%, nickel 67%, iron 1.4%, manganese 1%, impurities 0.6%. All percentages are by weight.

This interliner composition may be formed prior to assembly with the precious metal and the beryllium-copper base or it may be formed in place by assembling the components as part of the assembly for forming the final composite

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metal ingot. The nickel and barrier metal layers are each preferably approximately 0.01 inch thick. The beryllium-copper base is protected prior to assembly by a layer of an antioxidant metal such as nickel.

Referring now to the drawing, Fig. 1 illustrates a beryllium-copper base which has been coated with a protecting layer of nickel. This coating may be applied in any desired manner, as by dipping, electroplating, spraying, etc. The nickel coating protects the beryllium-copper surface from oxidation.

Fig. 2 illustrates the intermediate bimetal separator layer one side of which is nickel and the other side is a barrier metal of the composition referred to above. These layers may be bonded in any desired fashion.

Fig. 3 illustrates, with the layers in their relative positions, the composite metal ready for bonding.

It will be noted that a surface layer of a precious metal and a beryllium-copper base are joined together preferably through a layer of a solder foil consisting of three layers, the outer being layers of a silver alloy consisting of 76% silver and 24% copper, while the center is a brass composed of 92% copper, 7% zinc and 1% tin (a conventional silver solder may be substituted for this tri-layer); an interliner consisting of a layer of nickel bonded to a layer of barrier metal; a solder layer which is an alloy of 70% copper and 30% silver; and a layer of nickel.

The layer assembly may be bonded together in any of the usual ways. For most purposes, it is preferred that the assembly be clamped together and then heated. This is conveniently done by sandwiching the assembly between two sheets of iron which have been coated on the contacting sides with layers of lamp black. The two sheet iron layers are held in position by clamps which also serve to retain the layers of composite metal in juxtaposition. The assembly is then heated at about 1580° F., taken out of the oven and the clamps tightened. This bonds together the layers of the composite metal to form the desired product.

The resulting composite metal ingot has a beryllium-copper base and a precious metal surface layer. It may be solution annealed without danger of the layers separating or blistering or other damaging effects, and may be formed as desired by rolling operations, etc. For example, it may be rolled to a desired final thickness with as many anneals in between rolling operations as are necessary, and after a final solution anneal may be sold either in the soft form or heat treated to spring temper, as preferred.

Fig. 4 illustrates an alternative embodiment of the composite metal in which a beryllium-copper base is plated on both sides with a precious metal. In this instance the beryllium-copper base is initially plated on both sides with a protecting layer of nickel, and two intermediate layers and two precious metal layers are utilized, one on each side of the beryllium-copper base.

Fig. 5 illustrates an alternative embodiment of the composite metal in which a beryllium-copper base is plated with gold without the use of a solder foil, such as described above. It has been found that the yellow golds running from approximately 10 karat to 14 karat may be satisfactorily plated in this way upon a beryllium-

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copper base without the solder foil layer. The red and white golds, however, while they will generally bond even though the solder foil layer is not used, will not roll satisfactorily after the bonding. Apparently the bonding operation under these circumstances so changes the characteristics of red or white gold that it becomes relatively non-malleable.

The embodiment of Fig. 6 is similar to that of Fig. 4 in that both sides of the beryllium-copper base are plated with a precious metal. However, the precious metal utilized in this embodiment is one of the yellow golds and, as in the Fig. 5 embodiment, the solder foil is omitted.

The solder layers may instead be one of the other customary types used for such purposes and, if desired, a flux may also be used. The coatings referred to above may be put on electrolytically to a desired thickness or may be put on by lamination, by dipping, etc. and then rolled down to desired thickness.

As specific examples of the formation of the composite metal of the present invention, the following are given:

Example 1

A sheet of gold at least .010" thick is used as a precious metal layer. It may be thicker, if preferred, and may be as thick as the beryllium-copper on which it is to be plated. In the present example the gold is .035" thick. A beryllium-copper layer .750" thick and consisting, in the present example, of an alloy containing 2.25% beryllium by weight and the remainder copper is electroplated with pure nickel to a thickness of approximately .00025". A sheet of nickel .010" thick is bonded to a sheet of brass approximately .010" thick consisting in this example of 92% copper, 7% zinc and 1% tin. The elements are now assembled with the gold on top, next preferably a solder foil which consists in the present example of three layers, the outside layers of which are each composed of 76% silver and 24% copper and the center is composed of 92% copper, 7% zinc and 1% tin, next the intermediate consisting of the layer of nickel bonded to the layer of brass, then a layer of solder and then the final layer of the plated beryllium-copper. A flux may or may not be used depending on the type of atmosphere in which the bonding is done. On top of the gold is placed a sheet of 1/8" iron covered with lamp black. A similar sheet is placed outside the beryllium-copper. The lamp black provides a reducing atmosphere and also prevents the gold and beryllium-copper from sticking to the iron. The assembly is then clamped to hold the pack together and heated at 1580° F. for a time depending upon its volume, e. g. a 3" wide by 14" long ingot would take about 35 minutes. The assembly is then taken out of the oven, the clamps tightened before cooling, and the whole is then permitted to cool.

The resulting ingot of a gold plated beryllium-copper base is then ready for desired forming operations, which may include solution annealing.

Example 2

An ingot is formed as described in Example 1 except that the beryllium-copper base is plated on both sides with nickel and two sheets of gold, one on each side of the beryllium-copper base, are bonded thereto through the intermediate layers described in Example 1. Thus the elements are assembled with a layer of gold on top, next a solder foil which consists of three layers, as de-

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scribed in Example 1, next the intermediate as described in Example 1, then a layer of solder, next the plated beryllium-copper, next a layer of solder, then another intermediate layer, then another layer of solder foil and then the other layer of gold. The assembly is then bonded, as described in Example 1.

The resulting ingot of beryllium-copper plated on both sides with gold is then ready for desired forming operation which may include solution annealing.

If desired, a composite metal having a center layer of gold and a beryllium-copper layer on each side may be formed by reversing the order of arrangement of the elements so that a gold layer forms the center of a sandwich, as the beryllium-copper does in Example 2. Other methods customarily employed in plating may be used. For example sheet iron around the pack and a salt bath for heating may be used, or an open box fire using clamps.

Example 3

A sheet of silver at least .010" thick is used as the precious metal layer. It may be thicker, if preferred, and may be as thick as the beryllium-copper on which it is to be plated. In the present example the silver is .035" thick. A beryllium-copper layer .750" thick and consisting, in the present example, of an alloy containing 2.25% beryllium by weight and the remainder copper is electroplated with pure nickel to a thickness of approximately .00025". A sheet of nickel .010" thick is bonded to a sheet of brass approximately .010" thick consisting in this example of 92% copper, 7% zinc and 1% tin. The elements are now assembled with the silver on top, next preferably a solder foil which consists in the present example of three layers, the outside layers of which are each composed of 76% silver and 24% copper and the center is composed of 92% copper, 7% zinc and 1% tin, next the intermediate consisting of the layer of nickel bonded to the layer of brass, then a layer of solder and then the final layer of the plated beryllium-copper. A flux may or may not be used depending on the type of atmosphere in which the bonding is done. On top of the silver is placed a sheet of $\frac{1}{8}$ " iron covered with lamp black. A similar sheet is placed outside the beryllium-copper. The lamp black provides a reducing atmosphere and also prevents the silver and beryllium-copper from sticking to the iron. The assembly is then clamped to hold the pack together and heated at 1580° F. for a time depending upon its volume, e. g. a 3" wide by 14" long ingot would take about 35 minutes. The assembly is then taken out of the oven, the clamps tightened before cooling, and the whole is then permitted to cool.

The resulting ingot of a silver plated beryllium-copper base is then ready for desired forming operations, which may include solution annealing.

Example 4

An ingot is formed as described in Example 3 except that the beryllium-copper base is plated on both sides with nickel and two sheets of silver, one on each side of the beryllium-copper base, are bonded thereto through the intermediate layers described in Example 3. Thus the elements are assembled with a layer of silver on top, next a solder foil which consists of three layers, as described in Example 3, next the intermediate as described in Example 1, then a layer of solder, next the plated beryllium-copper, next a layer of solder, then another inter-

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mediate layer, then another layer of solder foil and then the other layer of silver. The assembly is then bonded, as described in Example 3.

The resulting ingot of beryllium-copper plated on both sides with silver is then ready for desired forming operations which may include solution annealing.

If desired, a composite metal having a center layer of silver and a beryllium-copper layer on each side may be formed by reversing the order of arrangement of the elements so that a silver layer forms the center of a sandwich, as the beryllium-copper does in Example 4. Other methods customarily employed in plating may be used. For example sheet iron around the pack and a salt bath for heating may be used, or an open box fire using clamps.

Example 5

A sheet of 14 karat yellow gold at least .010" thick is used as the precious metal layer. It may be thicker, if preferred, and may be as thick as the beryllium-copper on which it is to be plated. In the present example the gold is .035" thick. A beryllium-copper layer .750" thick and consisting, in the present example, of an alloy containing 2.25% beryllium by weight and the remainder copper is electroplated with pure nickel to a thickness of approximately .00025". A sheet of nickel .010" thick is bonded to a sheet of brass approximately .010" thick consisting in this example of 92% copper, 7% zinc and 1% tin. The elements are now assembled with the gold on top, next the intermediate consisting of the layer of nickel bonded to the layer of brass, then a layer of solder and then the final layer of the plated beryllium-copper. A flux may or may not be used depending on the type of atmosphere in which the bonding is done. On top of the gold is placed a sheet of $\frac{1}{8}$ " iron covered with lamp black. A similar sheet is placed outside the beryllium-copper. The lamp black provides a reducing atmosphere and also prevents the gold and beryllium-copper from sticking to the iron. The assembly is then clamped to hold the pack together and heated at 1580° F. for a time depending upon its volume, e. g. a 3" wide by 14" long ingot would take about 35 minutes. The assembly is then taken out of the oven, the clamps tightened before cooling, and the whole is then permitted to cool.

The resulting ingot of a gold plated beryllium-copper base is then ready for desired forming operations, which may include solution annealing.

Example 6

An ingot is formed as described in Example 5 except that the gold is 18 karat yellow gold instead of 14 karat yellow gold. The resulting ingot may then be subjected to desired forming operations which may include solution annealing.

Example 7

An ingot is formed as described in Example 5 except that the beryllium-copper base is plated on both sides with nickel and two sheets of 14 karat yellow gold, one on each side of the beryllium-copper base, are bonded thereto through the intermediate layers described in Example 5. Thus the elements are assembled with a layer of gold on top, next the intermediate as described in Example 5, then a layer of solder, next the plated beryllium-copper, next a layer of solder, then another intermediate layer and

then the other layer of gold. The assembly is then bonded as described in Example 5.

The resulting ingot of beryllium-copper plated on both sides with gold is then ready for desired forming operations which may include solution annealing.

If desired, a composite metal having a center layer of gold and a beryllium-copper layer on each side may be formed by reversing the order of arrangement of the elements so that a gold layer forms the center of a sandwich, as the beryllium-copper does in Example 7. Other methods customarily employed in plating may be used. For example sheet iron around the pack and a salt bath for heating may be used, or an open box fire using clamps.

In attempting to solution anneal a precious metal-to-beryllium-copper plate without an interliner such as, for example, the intermediate described above, diffusion of the bonding medium, if one is used, will result in alloying of the precious metal, loss of color and general deterioration, in addition to loss of karat value, especially of the precious metal surface. The present invention avoids these difficulties and not only is the bond formed not brittle, so that the ingot is suitable for subsequent cold working, but it is also suitable for solution annealing. The relative and absolute thickness of the layers may be varied in accordance with requirements of the trade, as with respect to the required karat value of the resulting plate and other customary plating specifications.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A composite corrosion-resistant laminated metal comprising a beryllium-copper base layer, an anti-oxidant protective metal layer bonded to said base layer, a solder layer bonded to said protective layer, a barrier metal layer bonded to said solder layer, a nickel layer bonded to said barrier metal layer, and a precious metal layer bonded to said nickel layer, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent layers remaining intact at the solution annealing temperature of beryllium-copper, said barrier metal being a substantially non-ferrous alloy containing predominantly one of the group consisting of nickel and copper, said barrier metal being solder-diffusible and of sufficient strength to withstand the layer separating forces at the solution annealing temperature of beryllium-copper.

2. A composite corrosion-resistant laminated metal comprising a beryllium-copper base layer, an anti-oxidant protective metal layer bonded to said base layer, a solder layer bonded to said protective layer, a brass layer bonded to said solder layer, a nickel layer bonded to said brass layer, and a precious metal layer bonded to said nickel layer, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent layers remaining intact at the solution annealing temperature of beryllium-copper.

3. A composite corrosion-resistant laminated

metal comprising a beryllium-copper base layer, an anti-oxidant protective metal layer bonded in said base layer, a solder layer bonded to said protective layer, a nickel-silver layer bonded to said solder layer, a nickel layer bonded to said nickel-silver layer, and a precious metal layer bonded to said nickel layer, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent layers remaining intact at the solution annealing temperature of beryllium-copper.

4. A composite corrosion-resistant laminated metal comprising a beryllium-copper base layer, an anti-oxidant protective metal layer bonded to said base layer, a solder layer bonded to said protective layer, a bronze layer bonded to said solder layer, a nickel layer bonded to said bronze layer, and a precious metal layer bonded to said nickel layer, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent layers remaining intact at the solution annealing temperature of beryllium-copper.

5. A composite corrosion-resistant laminated metal comprising a beryllium-copper base layer, an anti-oxidant protective metal layer bonded to said base layer, a solder layer bonded to said protective layer, a cupro-nickel layer bonded to said solder layer, a nickel layer bonded to said cupro-nickel layer, and a precious metal layer bonded to said nickel layer, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent layers remaining intact at the solution annealing temperature of beryllium-copper.

6. A composite corrosion-resistant laminated metal comprising a beryllium-copper base layer, an anti-oxidant protective metal layer bonded to said base layer, a solder layer bonded to said protective layer, a Monel layer bonded to said solder layer, a nickel layer bonded to said Monel layer, and a precious metal layer bonded to said nickel layer, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent layers remaining intact at the solution annealing temperature of beryllium-copper.

7. A composite corrosion-resistant metal comprising a beryllium-copper base layer, a first anti-oxidant protective metal layer bonded to said base layer, a solder layer bonded to said first protective layer, a barrier metal layer bonded to said solder layer, a nickel layer bonded to said barrier metal layer, and a silver layer bonded to said nickel layer, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent layers remaining intact at the solution annealing temperature of beryllium-copper, said barrier metal being a substantially non-ferrous alloy containing predominantly one of the group consisting of nickel and copper, said barrier metal being solder-diffusible and of sufficient strength to withstand the layer separating forces at the solution annealing temperature of beryllium-copper.

8. A composite corrosion-resistant laminated metal comprising a beryllium-copper base layer, a first anti-oxidant protective metal layer bonded to said base layer, a solder layer bonded to said first protective layer, a barrier metal layer bonded to said solder layer, a nickel layer bonded to said barrier metal layer, and a gold layer directly

bonded to said nickel layer, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent layers remaining intact at the solution annealing temperature of beryllium-copper, said barrier metal being a substantially non-ferrous alloy containing predominantly one of the group consisting of nickel and copper, said barrier metal being solder-diffusible and of sufficient strength to withstand the layer separating forces at the solution annealing temperature of beryllium-copper.

9. A composite corrosion-resistant laminated metal comprising a beryllium-copper base layer, an anti-oxidant protective metal layer of nickel bonded to said base layer, a solder layer bonded to said protective metal layer, an interliner layer bonded to said solder layer, a solder foil layer bonded to said interliner layer, and a silver layer bonded to said solder foil layer, said interliner layer having a brass surface layer adjacent said protective metal layer and a nickel surface layer adjacent said solder foil layer, said solder foil layer having surface layer of silver alloy and a center layer of brass, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent layers remaining intact at the solution annealing temperature of beryllium-copper.

10. A composite corrosion-resistant laminated metal comprising a beryllium-copper base layer, a first anti-oxidant protective metal layer bonded to said base layer, a solder layer bonded to said first protective layer, a brass layer bonded to said solder layer, a nickel layer bonded to said brass layer, and a gold layer bonded to said nickel layer, said solder layer having a melting point

exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent bonds remaining intact at the solution annealing temperature of beryllium-copper.

11. A composite corrosion-resistant laminated metal comprising a beryllium-copper base layer, a layer of nickel on the beryllium-copper layer, a solder layer bonded to the nickel layer, a brass layer bonded to the solder layer, a second nickel layer bonded to the brass layer, a solder foil layer bonded to the second nickel layer and a gold layer bonded to the solder foil layer, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent bonds remaining intact at the solution annealing temperature of beryllium-copper.

12. A composite corrosion-resistant laminated metal comprising a beryllium-copper base layer, a layer of nickel on the beryllium-copper layer, a solder layer bonded to the nickel layer, a brass layer bonded to the solder layer, a second nickel layer bonded to the brass layer, a solder foil layer bonded to the second nickel layer and a gold layer bonded to the solder foil layer with a silver alloy layer on each side, said solder layer having a melting point exceeding the solution annealing temperature of beryllium-copper, the bonds between adjacent bonds remaining intact at the solution annealing temperature of beryllium-copper.

ERMAND H. DAVIGNON.

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