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Patented July 15, 1941

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UNITED STATES PATENT OFFICE

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COPPER CLAD STEEL

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No Drawing. Application July 18, 1938, Serial No. 219,837

6 Claims. (Cl. 148—31)

My invention relates generally to copper clad steel composite metal and it has particular relation to such composite metal the tensile strength of which is increased by precipitation hardening. This invention is a continuation in part of my copending application, Serial No. 64,280, filed February 17, 1936, now Patent No. 2,193,246.

There are many applications for a composite metal in which the corrosion resistance of copper and its alloys is combined with the strength of steel. Although there may be some cases in which such a composite metal is advantageous in itself, generally its advantage will be of an economic nature due to the relative cheapness of the steel. In order to bring out the above point the construction of water heater tanks may be considered in point. These tanks are subjected to a certain amount of corrosion and must also stand hydrostatic pressure. Therefore, in constructing such tanks both corrosion resistance and strength must be considered. Copper, bronze and other copper alloys have been used for the construction of such tanks, for these materials have high corrosion resistance. Steel of various grades has also been used for constructing such tanks, for it has great strength. Now, when copper and its alloys are used a considerably greater thickness than is necessary for corrosion resistance must be provided in order to secure sufficient structural strength, and, in contrast, when steel is used considerably greater thickness than is necessary for structural strength must be used in order to provide for corrosion resistance. Obviously, the problem could be solved by providing a composite metal in which a steel backing is clad with copper or a copper alloy facing. In this way advantage of the characteristics of each material can be most fully taken.

My above identified copending application discloses, in general, methods of and means for producing composite metal of the nature described above. However, by the incorporation and application of a phenomenon known in metallurgy as precipitation hardening together with the disclosure of the above identified copending application I have been able to develop a still better composite metal.

As is generally accepted, precipitation hardening is brought about by first obtaining a supersaturated solid solution by a cooling rate that will not permit the breakdown of the solution, and then allowing precipitation from the solution to take place at a temperature at which the precipitated particles will be very small. The resultant effect of this is an increase in the hardness and tensile strength of a metal so hardened.

Accordingly the object of my invention, generally stated, is to provide both a technique or method of producing composite metal comprising a steel backing and a copper facing the strength of which has been increased by precipitation hardening of the steel backing alone or of both the steel backing and the copper facing and also the product of such technique or method.

Another object of my invention is to provide composite metal comprising a low carbon steel backing and a copper facing in which the strength of the low carbon steel backing is increased to a value commensurate with that of a considerably higher carbon content steel.

Another object of my invention is to provide a composite metal comprising a low carbon steel backing and a copper facing bonded thereto in the production of which the superior bonding character of low carbon steel relative to that of high carbon steel is utilized and the strength of which is increased by precipitation hardening.

Other objects of my invention will, in part, be obvious and in part appear hereinafter.

In order that the nature of my invention may be more fully understood, the essential steps of a method of producing copper clad steel of the character set forth above will be outlined. A slab of steel approximately 6 inches thick has a liquid-tight mould space formed thereon by welding thin steel strips around a face thereof. The wall of this mould space may be about 1.2 inches high or about 20% of the thickness of the steel slab. The face or bonding surface of the steel slab is pickled, sand-blasted or otherwise cleaned to remove all oxides and scale therefrom, and the mould space is filled with a suitable powdered flux. The slab is then preheated to welding temperature, and the powdered flux becomes molten during preheating and covers the cleaned welding surface thereby preventing oxidation thereof. The preheated slab with the mold construction thereon is then removed to a leveling platform and the desired molten copper facing is poured into the mould space and it bonds to the welding surface of the steel slab. After cooling sufficiently the composite slab formed by the above procedure is rolled to the desired gauge or thickness. For instance it may be rolled to 12 gauge or approximately .1072 inch in thickness.

There are two cardinal points involved in the above procedure to which attention is directed.

Firstly, the weld or bond formed between the copper facing and steel slab must be so complete that the composite slab can be rolled and the composite metal sheet there formed can be worked without failure of the bond. And, secondly, there must be some range of temperature of the composite slab at which it may be hot rolled and at which the plasticity of the steel backing and copper facing are about equal. For otherwise, if the copper facing were too soft, which would be the usual tendency, it would squeeze out over the steel backing during rolling and the process would be inoperable or at least difficult to perform.

During my work and research in the development of this art I have found that the copper facing bonds more readily and better to low carbon steels than to high carbon steels, forming a soft ductile alloy at the union which will withstand heavy reductions in area by rolling. Furthermore, I have found that the range of plasticity of low carbon steels more closely coincides with a similar range of plasticity of copper facing metals, thus making the rolling operation easier and entirely satisfactory. However, these low carbon steels have low tensile strength and the composite metal having them for the steel backing is low in tensile strength and the intended purposes for which such composite metals are made are substantially defeated unless this condition is corrected. However, by the employment of the above mentioned phenomenon of precipitation hardening I can make use of low carbon steel backings in the production of composite metal and thereafter increase the strength of the composite metal.

The generally accepted explanation of precipitation hardening as given hereinbefore involved the formation of a supersaturated solid solution and then allowing precipitation to take place in the saturated solution. The ease of producing a supersaturated solid solution varies from one system to another. In copper irons or copper steels the copper is not precipitated on comparatively slow cooling, and instead of quenching in a liquid being necessary it suffices to cool in air in order to produce the required solution of copper in iron. By low carbon steels I refer to those steels containing not more than 0.2% carbon and more frequently they will have about 0.1% and under. Although not exact, the range of solubility of copper in low carbon steels is in the order of 0.4% at 750° F. and about 3.5% at 1530° F. In order to precipitation harden a steel of .08% carbon content and of 1.1% copper content it is necessary to heat such steel to around 1500° F. at which temperature there will be a complete solution of the copper in the steel. Then the steel is preferably air cooled to around room temperature and reheated to about 900° F. for four hours. When the copper-steel solution is cooled from 1500° F. it becomes supersaturated and on reheating to 900° F., precipitation of copper crystals takes place, thereby increasing the tensile strength and hardness of the steel. The steel may contain nickel up to 2% which prevents surface cracking in the steel during high temperature rolling around 2200° F. prior to the bonding with the copper facing alloy. The steel may also contain up to 1% manganese, small amounts of chromium, molybdenum and silicon, and traces of phosphorous and sulfur. The additional elements do not materially affect the precipitation hardening of the steel backing but may remain from the original production of the steel or may be added for various reasons.

Not only is the steel backing capable of precipitation hardening, but the copper facing may also be treated likewise. By copper facing I mean copper and copper alloys in which copper is the main constituent. It is possible to include an element or elements in copper which are more soluble at high temperatures than at low, and thereby permit the forming of a supersaturated solution from which precipitation may take place to cause precipitation hardening. For example, copper containing small amounts of iron is useful as a facing metal and since the solubility of iron in copper varies from 0.5% at 1000° F. to 4.0% at 2000° F. it is susceptible to precipitation hardening. The silicides of iron and such elements as cobalt, nickel and chromium are even more desirable, and the useful range of these elements would be 0.1% to 3.0% silicon and up to 5% of any of the silicide forming ingredients. For instance, the solubility of nickel silicides in copper varies from 0.7% at 570° F. to 8.2% at 1830° F. The copper facing material may also contain manganese, tin or zinc up to 2% in order to generally improve the alloy and make it more ductile.

It is seen then that although the analysis of the steel backing and copper facing may vary, the important and essential property that makes them useful in my invention is that they contain an element or elements the solubility of which is greater at high temperatures than at low temperatures. In other words, they are susceptible to precipitation hardening. A typical composite metal, according to my invention, would be one having a steel backing comprising 80% of its thickness and the copper facing comprising 20% or the remainder of its thickness. A typical backing might have an analysis of .08% carbon, 1.1% copper, .03% manganese and the balance iron, and a typical facing might have an analysis of 0.6% silicon, 1.3% iron, 0.2% manganese and the balance copper.

The backing and facing metals can be bonded by any method resulting in a diffused and inseparable bond which will withstand rolling stresses during conversion, and bending and forming on a completed product. Methods described in my copending applications, Serial No. 118,812, filed January 2, 1937, now Patent No. 2,190,310, and Serial No. 158,656, filed August 12, 1937, now Patent No. 2,211,922, can be used, but preferably the method described in my copending application, Serial No. 6,497, filed February 14, 1935, now Patent No. 2,145,248. The last step, previously described, for working the composite metal slab was the rolling thereof to the desired gauge or thickness. It is after this rolling step that I prefer to precipitation harden the composite metal. The hot rolling should be performed above the lower limit of the solid solubility temperature involved and below the upper limit at which the copper facing can be rolled. These temperature limits would be 1250° F. to 1700° F. for a composite slab having the typical analysis given above. As both metals remain soft and reduce readily within this temperature range, one heating is usually sufficient for rolling to finished gauge, but if the composite metal cools during rolling to below the solid solubility temperature, i. e. 1250° F., it should be reheated for further hot rolling. After the rolling operation the sheets are heated to about 1500° F. and air cooled, which results in the formation of a

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supersaturated and unstable solid solution. Precipitation hardening is induced in both the backing and facing layers by reheating to about 900° F. for about four hours. The resulting tensile strength and yield point of the composite metal product is about 87,000 #/in.² and 69,000 #/in.² respectively, as compared with a tensile strength of 50,000 #/in.² and yield point of 38,000 #/in.² of a similar composite metal not subjected to the precipitation hardening process.

Since certain further changes may be made in the above described methods and compositions of the invention without departing from the scope thereof, it is intended that all matter contained in the above description shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. A precipitation hardened composite body of metal comprising a steel backing and a copper facing integrally bonded together, said steel backing and said copper facing containing, respectively, sufficient copper and iron prior to hardening as will subsequently effect the simultaneous precipitation hardening thereof when subjected to the same temperature cycle.

2. A precipitation hardened composite body of metal comprising a backing comprising from a small but effective amount up to 0.2% carbon, from 0.4% to 3.5% copper, and the balance substantially all iron; and a facing integrally bonded to said backing comprising from 0.5% to 4.0% iron and the balance substantially all copper; said integrally bonded backing and facing having been heated to about 1500° F. and air cooled and then heated to about 900° F.

3. A precipitation hardened composite body of metal comprising a backing comprising from a small but effective amount up to 0.2% carbon, from 0.4% to 3.5% copper, from a small but effective amount up to 5.0% nickel, and the balance substantially all iron; and a facing integrally bonded to said backing comprising from 0.5% to 4.0% iron and the balance substantially all copper; said integrally bonded backing and facing having been heated to about 1500° F. and air cooled and then heated to about 900° F.

4. A precipitation hardened composite body of metal comprising a backing comprising from a small but effective amount up to 0.2% carbon, from 0.4% to 3.5% copper, and the balance substantially all iron; and a facing integrally bonded to said backing comprising from 0.1% to 3.0% silicon, from a small but effective amount up to 5.0% of a silicide selected from the group consisting of cobalt, nickel, iron and chromium, and the balance substantially all copper; said integrally bonded backing and facing having been heated to about 1500° F. and air cooled and then heated to about 900° F.

5. A precipitation hardened composite body of metal comprising a backing comprising from a small but effective amount up to 0.2% carbon, from 0.4% to 3.5% copper, from a small but effective amount up to 5.0% nickel, and the balance substantially all iron; and a facing integrally bonded to said backing comprising from 0.1% to 3.0% silicon, from a small but effective amount up to 5.0% of a silicide selected from the group consisting of cobalt, nickel, iron and chromium, and the balance substantially all copper; said integrally bonded backing and facing having been heated to about 1500° F. and air cooled and then heated to about 900° F.

6. A precipitation hardened composite body of metal comprising a metal backing and a metal facing integrally bonded thereto; said metal backing forming about 80% of the thickness of the composite body and comprising about 0.08% carbon, 1.1% copper, 0.03% manganese, and the balance substantially all iron; said metal facing forming about 20% of the thickness of the composite body and comprising about 0.6% silicon, 1.3% iron, 0.2% manganese, and the balance substantially all copper; said integrally bonded metal backing and facing having been heated to about 1500° F. and air cooled and then heated to about 900° F.

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