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WELDING ELECTRODE FOR HARD FACINGS

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Fig.1 Fig.2 Fig.3

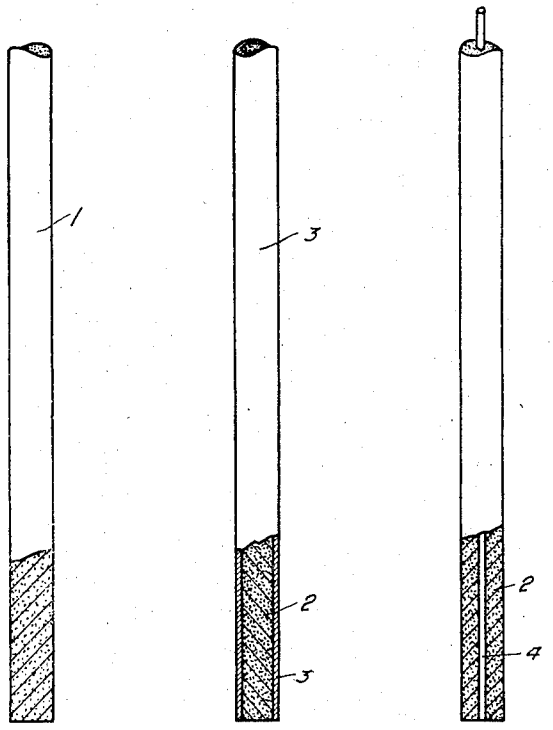
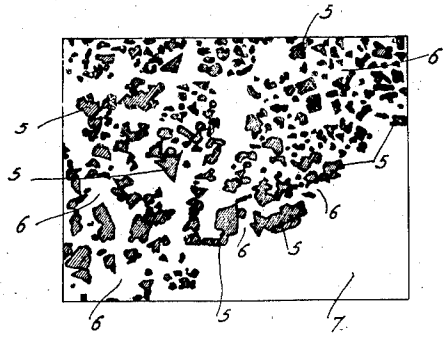


Fig.4



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WELDING ELECTRODE FOR HARD FACING

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Many methods have been proposed for forming, on the working surfaces of certain tools or of certain metallic pieces, a very hard superficial layer of metal withstanding wear and tear, the properties of such a layer resulting in certain of the said methods, from the presence of very hard infusible metallic carbides and more particularly of tungsten carbide.

The quality of thus deposited layers as to their properties with regard to their use as well as to the regularity of their obtention depends on two chief factors which are, on one hand, the dimension of the hard metallic elements and, on the other hand, the proportion of said elements with respect to the softer metallic binding agent in which they must be embedded. If one desires to obtain really commercial results in this respect, it is therefore necessary to make sure that, on one hand, all the hard metallic elements have dimensions of the same order and, on the other hand, that, whatever the form of the pieces on which the deposit will be effected, the deposited layer shows a constant predetermined and reproducible proportion of hard metallic elements with respect to the metallic embedding agent; this proportion must be able to vary according to the desired results and it must be controllable.

Among the methods which have been proposed one may discern those which concern hard metallic elements of macroscopic dimensions and those which concern hard metallic elements of microscopic dimensions.

One of the first methods consists in depositing by welding onto the surface of the piece a soft metallic layer embedding macroscopic particles of tungsten carbide. For this purpose supplying rods are used which are formed of a thin iron tube filled with particles of tungsten carbide which have previously been obtained by a fritting or smelting process, whereafter the substance of these rods is deposited on the surfaces to be recharged, for instance by means of an electric arc or a blowpipe. The iron tube of the rod melts and the molten iron is welded to the piece, thus embedding the particles of carbide. This method, while answering the above mentioned conditions for a commercial execution, offers however some serious drawbacks; it requires expensive materials, in this case tungsten carbide which has been prepared in advance and granulometrically selected, owing to the comparatively large distance between the macroscopic particles of carbide, the soft matrix in which they are embedded can be soon worn out comparatively, whereby the hard carbide particles can be prematurely

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loosened before they are worn out; finally, the macroscopic dimension of the carbide particles makes this method unusable for certain applications, such as for instance for lining valve seats of explosion engines.

The other methods which have been proposed, and which are used for depositing, on the piece, a layer containing hard metallic particles of microscopic dimensions, lead to the obtention of these particles by means of a reaction which takes place on the piece itself. One of these methods, described in the U. S. Patent to Davies Number 1,613,942, applied for on May 24, 1926, consists in incorporating into the surface of the pieces to be treated, a mixture of metallic tungsten and of carbon, by means of a heating instrument, this mixture being intended to cause directly the formation of a layer rich in tungsten carbide. The other method which is more economical than the former and is described in the U. S. Patent to Morgan Number 1,824,166 applied for on January 16, 1929, consists in applying a previously agglomerated and granulated mixture of tungsten ore and carbon onto the surface of the piece to be treated; the thus coated surface is then heated with an electric arc or an atomic hydrogen blowpipe so as to concurrently effect the superficial smelting of the piece and the reaction of reduction and carburization of the ore, thus leading to the formation of tungsten carbide.

Both these methods, while being more economical than the former above mentioned method, offer however very heavy drawbacks as to their commercial application because they do not make it possible to control the quality and regularity of the thus obtained products. Indeed, their carrying out implies the use of two metallurgical processes which are absolutely distinct from one another, viz., on one hand, the production of hard carbide and, on the other hand, the superficial smelting of the piece. These two processes, which may require for their achievement supplies of heat which may be quite different according to the nature of the chemical compounds leading to the formation of the hard carbides and according to the shape, nature and dimension of the pieces to be coated, are effected in both said methods at respective temperatures which it is not possible to vary with respect to one another; this can result either in an exaggerated heating of the piece or in a reduction or incomplete carburization of the mixture of oxides or elements. On the other hand, it is admitted, in the above mentioned patent to Morgan, that owing to the simultaneous heating of the piece and of the de-

posited substance the latter may be incorporated with variable quantities of underlying molten metal acting as a binding agent, which reduces the hardness of the layer and requires successive applications of substances in the same place to reach the maximum hardness; it is thus possible that this maximum hardness can be obtained only at the cost of increasing the thickness of the deposit. In addition to these drawbacks which considerably increase the cost of the practical production of layers with controlled properties and reduce their qualities, the carrying out of the said methods meets a great difficulty of application: for instance in the above mentioned patent to Morgan, the comparatively fine particles of the mixture are simply deposited on the surface of the pieces to be treated and adhere thereon thru their gravity; they are easily blown off this surface by the blast of the heating instrument, which makes it necessary to frequently interrupt the process for complementary supplies of substances. On the other hand, it is necessary, with this mode of application, to constantly keep the surfaces to be recharged in an horizontal position, which is a notable complication for pieces with a plurality of curves. Finally, it is known that with methods thru which a layer of substances which are to lead to the formation, on soft metallic pieces, of deposits which are rich in tungsten carbide, is spread on the surface of these pieces and heated concurrently with the said surface (as for instance the so-called swatting-on method), the heating operation proper is delicate and should be carried on by a tried specialist, because the smelting of two thick a layer of the piece causes a penetration through gravity down to the bottom of the molten layer, of particles of carbide having a very high specific weight, which results in the superficial layer losing much of its desired hardness.

According to a third method (French Patent Haynes Stellite Company, Number 799,040 of December 11, 1935) the surface of metal pieces may be hardened by means of rods formed of a ferrous core and a coating containing a reducing agent such as carbon, for instance, and components of a hard alloy, the latter being in the nature of elements or compounds such as oxides or carbides. When such a rod is used, the reducing agent reduces the oxide compounds and converts them into elements which then intervene as blending elements for forming a hard alloy which is deposited on the metal piece to be treated and welded with it. Such a method can yield only alloys having a hardness which is lower than those in which the hardness is given by the welding of infusible carbide particles on the metal piece to be treated.

Thus no method has hitherto been proposed for depositing a layer the hardness of which is due to the presence of microscopic particles of hard infusible metallic carbides of the kind of tungsten carbide, method which should simultaneously unite the qualities of economy due to the low cost of starting materials, with the qualities of easy application, owing to the use of a commercial welding method, and, finally, with the qualities of regularity, due to the control of the relative proportion of embedding agent with respect to the quantity of hard infusible metallic carbides which is used.

According to the present invention, the subject matter of which unites the above mentioned qualities, it has been found that when using a

welding rod formed of a conveniently dosed mixture of: (*a*) an oxidized compound of tungsten such as for instance a natural ore or a commercial oxidized compound, tungsten being, if desired partially or totally substituted by a metal giving similar hard infusible carbides such as, for instance, molybdenum, tantalum, titanium, vanadium, columbium, hafnium, zirconium, (*b*) a metal acting as a binding agent and liable to melt when heated, or a mixture of metallic oxides together with a reducing agent capable of freeing a metal having the same property (*c*) pulverulent carbon—the whole being bound by an organic or mineral agglomerating agent able to yield enough cohesion to the rod by drying or hardening—it may be seen that, if the proportion of carbon is high enough to give rise to formation of carbides under the conditions of the operation, the sufficiently high heating of the rod leads to direct formation of the substance for the supplied layer, which substance is composed of a mass of solid microscopic crystals of hard infusible carbides embedded in a fluid metallic bath supplied by the binding metal, as shown by microscopic examination of drops removed in a pasty condition from the extremity of the heated rod. It is then possible, by acting on the relative positions of the rod, the piece to be coated and the heating instrument, to provide the temperature conditions which permit, on one hand, to cause the formation of the desired substance at the extremity of the rod and, on the other hand, to heat the piece in a manner which is just sufficient for causing, at the surface of the piece, the melting of the metallic film which is necessary for insuring the welding of the supplied substance.

The composition and the manufacture of the rod may be defined as follows: the hardness and the total resistance to wear of the desired supplied layer being a function of the proportion of metallic binding agent with respect to the proportion of hard infusible metallic carbides formed in the course of the operation, a comparatively large proportion of metallic binding agent should be chosen if one desires to obtain layers showing a comparatively low hardness for certain applications. Under these conditions, one should use, for instance, a tungsten ore such as wolframite containing, in addition to tungsten, proportions of iron and magnesium oxides which are capable to yield thru reduction a comparatively high quantity of binding metal. On the contrary, when one desires to obtain very hard layers, i. e. layers which are very rich in hard infusible carbides, one should then use commercial tungstic acid to which one will add a quantity of binding metal which will just be sufficient (of the order of 5%) to embed the carbide particles which have been formed in the course of the operation and to allow the welding to the superficial molten film of the piece. In any case the quantity of carbon which is added should be sufficiently large not only to insure the reduction of the oxidized compounds and the formation of microscopic particles of carbide but also to balance the losses thru combustion and to provide the reducing atmosphere necessary for avoiding the oxidation of the metallic substances. It will thus be possible between these extremes to regulate and control the hardness of the resulting layer by dosing, according to above specified rule, the substances which lead on one hand to formation of hard infusible carbides and, on the other hand, to formation of the embedding metallic binding agent. The latter can advantageously be formed

of iron or of a more or less carburized iron alloy associated or not with a metal or alloy able to act as a deoxidizing agent such as, for instance, aluminum.

All these starting materials should be pulverized and preferably have rather small particle dimensions; for instance, they must pass through a sieve of 40 meshes per linear centimetre. However, one may depart widely enough from such dimensions without any inconvenience. It is remarkable to note that, while the particles of which the rod is formed have rather large dimensions, the deposited particles of carbide have microscopic dimensions.

The various materials which are used should be bound together by means of an organic or mineral agglomerating agent and preferably one which leaves no fixed residue; "Bakelite" varnish has yielded very good results. The proportion of agglomerating agent to be used should be just high enough to form a paste of a suitable consistency for being moulded, compressed or extruded in the shape of rods. A round section 6 millimetres in diameter, for instance, will be suitable for a larger number of applications. It is also possible to compress the mixture into a thin metallic tube or to coat a wire with it; however, this latter mode of operation is much less expedient, because the cost is thus increased and it is also possible, in this case, that the proportion of binding metal, which it is desired to bring into the supplied layer is exceeded. After its manufacture, the rod should be dried or hardened.

The appended drawing shows by way of example in its Figures 1 to 3 elevational views with partial sectional views of three forms of execution of rods according to the invention.

Figure 4 is a micrographic view of the section of a hard layer supplied according to the invention.

In the form of execution according to Figure 1, the rod is formed of a stem 1 composed of agglomerated mixture of oxidized compounds of the metal intended to form the particles of carbide, carbon for reducing the said oxides and for forming the carbides in question and a binding agent agglomerating these materials.

In the modification according to Figure 2 the agglomerated mixture 2 is contained in a metal tube 3 made of the metal intended to bind the microscopic carbide particles formed by the reduction of the oxide or oxides contained in the mixture and the metal piece upon which the carbide particles are to be fixed.

Figure 3 shows another modification in which the mixture is agglomerated around a metal stem the function of which is to weld the carbide particles onto the metal piece.

For the supply operation itself one works as follows:

One begins by slightly heating the surface to be treated; then one brings an extremity of the rod just above this surface and heats it strongly by means of a blowpipe or any other similar means while melting a thin layer of metal of the piece itself immediately under the rod. The material forming the rod, which is further strongly heated, is then spread over the superficial molten film of the piece in the form of a layer of pasty consistency which adheres to it. Once this application is obtained, the supply operation is over in the considered place. It is possible to renew the same operation in the same place, and thus effect a plurality of supplies, but it is to be noted that the desired hardness is obtained immediately with the first supply, since the metal of the piece does not contribute in this case to appreciably increase the proportion of binding agent around the carbides in the deposited layer. When observed under the microscope the treated surface of the piece shows an appearance corresponding to Figure 4 of the appended drawing; it is remarkable to note that the oxide of the rod has practically disappeared and that only particles of carbide 5 remain, embedded in a metallic matrix 6. Said particles are moreover very fine, their dimensions being of the order of 3 to 30μ, and they are regularly distributed thru the whole mass with a practically constant density; the layer forming the transition with the underlaying metal 7 has a very small thickness, the absence of dilution of the supplied binding agent by the metal of the piece being thus confirmed. This micrographic texture gives to the supply a perfectly regular hardness in the whole of its thickness. Finally, folding tests made with the deposited layer have shown that this layer is very little brittle.

Thus, the method and the supply rods to which the invention relates offer the following advantages:

(*a*) a control of the desired hardness and resistance thru the previous adjustment of the proportions of hard infusible carbide and embedding metal, thus making it possible to reproduce easily the thus obtained industrial results;

(*b*) a hardness of the supply layers independent of their thickness, thus insuring a great regularity of the quality of the resulting layers; this thickness can vary by one to several millimetres and it can be obtained in one or more operations;

(*c*) a control of the distinct working temperatures which are necessary for conveniently effecting both metallurgical operations, i. e. formation of the substance of the layer and its application to the surface of the pieces, thus bringing a great adaptability of the method which is made independent of the form, dimension and nature of the pieces to be treated;

(*d*) ease of use thru a typical mode of welding, without it being necessary to claim the services of a specialist and

(*e*) finally, a very low cost, because of the low cost of starting materials and of the ease of manufacturing the rods.

The following is an example of execution of the invention.

A rod was prepared by mixing 75% tungstic acid, 18% pulverized graphite, 6% ferro-manganese (6% C and and 70% Mn) and 1% aluminum filings, the whole being agglomerated with 5% fluid Bakelite with respect to the weight of the above mentioned mixture. The thus obtained pasty mixture was then extruded by a press into rods 6 mm. in diameter and finally hardened at 100° C. The application was made on a half hard chromium-nickel steel by means of an oxy-acetylene blowpipe. A layer 2 millimetres thick and of a hardness of 70–72 Rockwell C units was obtained.

The method and the rods to which the present invention relates are particularly suitable for recharging metallic pieces such as, for instance, raking nozzles, rolling mill guides, aircraft tail-skids, dies and punches for stamping and cutting out operations, valves, valve seats, shearing machine blades, gauges, drawing-plates, extruding dies and nozzles, appliances for mines, appliances

for boring and sinking, and in a general manner every appliance which should resist abrasion.

What we claim is:

1. A supply rod composition comprising an intimate mixture of an oxidised compound of a metal selected from the group consisting of tungsten, molybdenum, tantalum, titanium, vanadium, columbium, hafnium and zirconium, an iron alloy adapted to form a metallic binding medium for the carbide of the selected metal, a proportion of carbon large enough to reduce the oxidised compound and to form a carbide with the reduced metal, and an agglomerating binder adapted to form no residuum when heated to the melting temperature of the metallic binding medium.

2. A supply rod composition comprising an intimate mixture of tungsten oxide, an iron alloy adapted to form a metallic binding medium for tungsten carbide, a proportion of carbon large enough to reduce the tungsten oxide and to form a carbide with the reduced metal, and an agglomerating binder adapted to form no residuum when heated to the melting temperature of the metallic binding medium.

3. A supply rod composition comprising an intimate mixture of an oxidised compound of a metal selected from the group consisting of tungsten, molybdenum, tantalum, titanium, vanadium, columbium, hafnium and zirconium, a metallic binder selected from the group consisting of oxidised compounds of a metal melting at medium high temperature and said metal, a proportion of carbon large enough to reduce the oxidised compound and to form a carbide with the reduced metal, and an agglomerating binder adapted to form no residuum when heated to the melting temperature of the metallic binder.

4. A supply rod composition comprising an intimate mixture of an oxidised compound of a metal selected from the group consisting of tungsten, molybdenum, tantalum, titanium, vanadium, columbium, hafnium and zirconium, an oxidised iron alloy adapted to form a metallic binding medium for the carbide of the selected metal, a proportion of carbon large enough to reduce the oxidized compound and to form a carbide with the reduced metal and also to reduce at least partly the oxidised iron alloy, and an agglomerating binder adapted to form no residuum when heated to the melting temperature of the metallic binding medium.

5. A supply rod composition comprising an intimate mixture of pulverulent tungsten oxide, a pulverulent iron alloy adapted to form a metallic binding medium for tungsten carbide, a proportion of pulverulent carbon large enough to reduce the tungsten oxide and to form a carbide with the reduced metal, and an agglomerating binder adapted to form no residuum when heated to the melting temperature of the metallic binding medium.

6. A supply rod composition comprising an intimate mixture of an oxidised compound of a metal selected from the group consisting of tungsten, molybdenum, tantalum, titanium, vanadium, columbium, hafnium and zirconium, an oxide of a binding metal melting at medium high temperature, a small amount of aluminum powder for reducing the binding metal oxide, a proportion of carbon large enough to reduce the oxidized compound and to form a carbide with the reduced metal, and an agglomerating binder adapted to form no residuum when heated to the melting temperature of the binding metal.

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