The present invention relates to improved armored metal articles with a thin hard film made in situ and conforming to the exact contour of the underlying surface. The hard film may deteriorate on the underside, i.e., the base metal. When the wear continues practically to completion, then practically no base remains on which a hard surface can be restored. This is much less likely to be true where it is used as a bearing surface or of an abrasion producing surface. While results heretofore attained in actual practice in the art have been an improvement over tools without such surfaces, these prior results have not been all which could be desired. For example, it has been very difficult and impossible for practical purposes to apply a uniform thin layer of hard metal to the surface which receives the wear and still obtain a uniform and adequate bond through the interface. As a result, it has been customary to apply a relatively thick layer having a thickness of about 3/8 of an inch or more and constituted of hard metal to the tool surface and grind off the excess of hard metal. Inasmuch as the surface to be ground is very hard, this grinding operation is difficult and expensive. When it is necessary to produce a thin layer, especially of hard material, very painstaking precision in the making and fixturing of the base of the metal article is required. It is necessary to rework the surface to permit grinding just close to the thin layer and not to grind through the layer. The harder the overlay, the harder it is to maintain the abrasive wheel and its relation to the thinness of the layer. Some distortion occurs during grinding but probably much more during brazing and heat treatment, which would make it practically impossible to maintain the correct relation between the base surface and the grinding wheel and to grind a thin, even layer, thus necessitating the use of a thicker layer. Due to the use of a thicker layer, there is a tendency to become spherical and much more material must be used to produce a coated article with square corners after grinding and still have an overlay on them. A thin layer is desired because a thick layer on a cutting tool causes a heel to form whereas a thin layer allows the clearance to be maintained. Due to the interfacial alloying, the as-produced overlay would be hardest on the surface. When it becomes necessary to grind the surface, the part of the overlay is destroyed. The extent of interfacial alloying depends on the heating time or time at or above melting. Moreover, the bond attained between the hard surface layer and the main body of the tool often has not been strong enough or has not been uniform with the result that there have been certain instances of the hard coating chipping off or being sheared away during use. Furthermore, the hard layer as applied was bumpy and for this reason also had to be ground down to a smooth surface. Although attempts were made to overcome the foregoing difficulties and other disadvantages, none, as far as I am aware, was entirely successful when carried into practice commercially on an industrial scale.

It is an object of the present invention to provide a metal article having a hard wearing layer applied to a selected surface to provide a thin hard armor. Another object of the invention is to provide improved armored metal articles with a thin hard film made in situ and conforming to the exact contour of the underlying surface. The invention also contemplates providing an improved armored metal article having a selected surface coated with a thin hard wearing surface of smooth and uniform character containing hard spots of particles of a diamond substitute and conforming to the exact contour of the selected surface.

It is a further object of the invention to provide an improved tool made of a ferrous metal and having a hard wearing surface applied in situ thereto. The invention further contemplates providing an improved armored metal article having a hard wearing surface applied in situ to a selected area which requires no subsequent grinding and which can be used in the as-produced condition.

It is another object of the invention to provide an improved armored metal article having a hard wearing coating produced in situ which is relatively free from tendency to chip off or shear off during use and which can be applied to an internal surface, even one having a small opening.

Still another object of the invention is to provide an improved armored tool having a hard wearing layer applied in situ to a selected area which is self-sharpening during use in service operation.

It is likewise within the contemplation of the invention to provide improved armored metal articles having a hard wearing coating produced in situ which is thin, which has a relatively smooth, hard surface when initially applied and which preserves and conforms to square corners of internal and external types.

It is also the purpose of the invention to provide an improved armored ferrous tool having a hard wearing coating which can be removed quickly, easily and inexpensively applied in situ than by prior methods. Among the further objects of the present invention is the provision of an improved armored metal article having a hard wearing coating, layer, film, skin, glaze or enamel applied in situ which results in a substantial saving of materials over prior methods, which is particularly valuable for armored tools, which involves an exact control of metal to be applied, which obtains a firm controlled penetration forming a tenacious bond between the face of the article and the hard coating, which permits the retention by diamond substitutes of their effectiveness even through and after heat treatment, which enables coated tools to be heat treated without substantial loss of hardness of the hard bonded coating, and which maintains the hardness of the armor even in service and even when heated in use up to red heat.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a schematic cross section, greatly enlarged and exaggerated, of the point or cutting edge of an insert saw tooth made in accordance with the present invention, using a combination of Stellite and Haystellite in the powdered mixture;

FIG. 2 is a schematic cross section, greatly enlarged and exaggerated, of the point or cutting edge of a saw
tooth armored in accordance with the present invention, using Stellite alone;

FIG. 3 is a schematic representation, greatly enlarged and exaggerated, of a half-millimeter section of the edge of a saw tooth armored in accordance with the present invention;

FIG. 4 illustrates a perspective view of an improved armored insert saw tooth embodying the present invention; FIG. 5 is a view similar to FIG. 4, with parts broken away for clarity and for showing the coating of armor and the underlying base metal;

FIG. 6 is a representation of a photomicrograph at 50 magnifications of a cross section of an armored saw tooth point which had been in service; and

FIGS. 7 and 8 are reproductions of photomicrographs of cross section of a portion of the surface of an armored metal article showing fusion bonds at the interface between the armor coating and the base metal taken at 200 and 250 magnifications, respectively.

In accordance with the present invention an improved armored article is provided with a hard refractory surface applied in situ and containing diamond substitutes, and, more particularly, an improved tool having a hard surface produced in situ comprising a ferrous base and a heavy metal carbide-containing hard surface layer conforming to the shape of said tool and firmly bonded to said base by said hard surface layer in a single thin smooth and fused to said base. The hard refractory surface is thin and when applied in accordance with the principles of the present invention, it conforms almost exactly to the shape of a metal article, such as a tool. It is also a sufficiently smooth surface so that for many purposes no smoothing operation is necessary. Generally, no grinding of the article is required to reshape the metal article, such as a tool. Moreover, the hard refractory surface material and base metal are bonded together by the matrix or brazing alloy which fuses, melts, softens, plasticises, and/or sinters at the interface but not to an objectionable degree, thereby giving an excellent bond and obviating most of the danger of chipping and shearing while at the same time retaining the hard surface containing the diamond substitute. When hard or diamond substitute particles are of the carbide type, for example, the carbide particles of the ferrous type, for example, the constituents are soluble in the matrix alloy and thus provide an excellent bond at the interface. An armored tool, for instance, having an applied hard refractory surface, after subsequent normal heat treatment for the tool as if unarmored, has an finished surface apparently unaffected by the heat treatment.

Generally speaking, the present invention contemplates an improved armored metal article and particularly an improved ferrous article, made of steel, semi-steel, cast steel, iron, cast iron and the like. The metal article is first cleaned to produce a metallic surface to which the armor will adhere tenaciously. After cleaning, the article or a selected surface or surfaces thereof has a film of liquid adhesive applied thereto. Such an adhesive film is then coated with a thin layer or coating of metal powder ground or granulated through a wide range of mesh, such as 5, 10, 20, 30, 40 or 50 down to 100, 200, 300 or 325 mesh. Powders of this kind can be obtained on the market or can be milled as those skilled in the art know. Metal powder for this invention must soften or become plastic over a wide range of temperatures as in the illustrative examples disclosed herein and must not melt quickly or burn from the surface, which are sloped, inclined, vertical, irregular, internal, external, etc. As mentioned hereinafter, any excess is removed from the article or the surface being armored. After the removal of the excess, the remaining powder is held in place by the adhesive. The adhesive remaining powder constitutes a thin film which represents a single layer. The coated article is preferably dried in any appropriate manner well known to those skilled in the art.

When the article is dried, it is then ready to be heated in order to produce the permanent armor on the surface under treatment. During such heating, the dried adhesive is volatilized and the article is coated with the matrix constituent of the powder constituting a coating alloy which forms a permanent fusion bond between the armor and the surface of the article.

The temporary adhesive or binder has a volatile liquid vehicle, such as water, alcohol, mixtures thereof, or the like which can be volatilized and dried readily. Such an adhesive or binder can contain suitable ingredients like shellac and borax. As those skilled in the art know, borax is a non-volatile, non-metallic, inorganic adhesive material which has plastic holding properties at the fusion bonding temperature of the matrix.

As illustrated in the examples, Stellite constitutes the matrix of the armor which is fusion bonded to the article. When a diamond substitute is included in the armor, a carbide or carbides of refractory metals can be used such as one sold under the trade name Haystellite. For special purposes, cutting diamonds or the like may be used as those skilled in the art appreciate.

It will be obvious to those skilled in the art that the operations, adhesives or binders, metal powders, etc., can be varied. For instance, the liquid adhesive which is first applied as a film to the article may comprise a volatile liquid such as water or other suitable liquid that can be volatilized and dried readily. The metal powder can be composed of a great variety of metallic materials as noted hereinafter. Borax or a similar ingredient can be applied as a solution in water in the form of a film over the coating of metal powder after the removal of the excess. Before heating, it is preferred to dry the coated article. If the main heating is performed in such a manner as to include appropriate drying, then a separate drying operation is not needed. Instead of applying a separate film of borax powder or of a boron-containing solution, such as, boric acid and/or borax flux, the borax, boric acid or mixtures thereof can be incorporated in the metal powder. Naturally, such a powder should be mixed very thoroughly before applying in order to obtain best results. Borax or other appropriate flux can be applied as a powder over the coating before heating. In other words, it can be applied as an overcoat.

The heating may be conducted in any suitable manner. A welding torch is a very convenient way but is only suitable for small production. When larger production is desired, suitable furnaces with appropriate atmospheres can be used. For instance, oil or gas fired furnaces of the muffle type, muffle furnaces or electrically heated furnaces can perform satisfactorily. Under such conditions of heating, protective atmospheres, such as a reducing one, must be employed. For fast production, induction heating has been found to be satisfactory, even without a protective atmosphere.

In carrying the invention into practice, it is preferred to provide an improved armored metal article, like a ferrous tool, which is made by sprinkling metal powder onto the article coated with a film of adhesive or binder. Such sprinkling can be done manually and/or automatically with the aid of mechanical and/or electrical devices. For instance, a curtain of falling metal powder being quite uniform and controllable can be supplied by an electromagnetic vibratory feeder. The speed at which the article or piece is passed through the curtain would also tend to allow a controlled amount of the material to fall on the surface and the article. Moreover, the amount retained is also controlled by the thickness of the adhesive film and the size of the metal particles. In order to get a substantially uniform thickness, the surface can be held in a horizontal plane and passed under a thin curtain of powder falling from an electromagnetic vibratory feeder. Any surface is suitably held in a horizontal plane and only the parts that have been wetted will pick up the falling powder. In this manner, I have
coated the teeth of a ferrous tool, like a file, the points of the teeth on the file being the only parts that were wetted when the file was blotted on a blotter soaked with adhesive. The file was held at such an angle that the clearance side of the teeth were tipped point down a little past the horizontal so that the metal powder or grinders would not get lodged at the base of the teeth or on the forward side of the teeth. A chain saw guide plate was arced around the edge having no unwanted armor in the milled slot. The edge of the guide was rolled against a blotter soaked with an alcoholic solution of shellac and then rolled over the plane containing the powder. Instead of a blotter, any suitable porous material can be used, such as a sponge, impregnated sheet, rubber, cellular plastic, and the like. The metal article or piece can be pressed or rolled against the porous material carrying the adhesive or binder. By using a roll made of rubber, metal, sponge and the like and cut out so as to contact the metal article only at selected spots or areas, a desired or selected pattern can be applied to the surface. This operation might be termed printing adhesive on the metal article. In both of these cases, an overcoat of flux was added.

The present invention provides a simple way of applying a uniform layer of approximately the thickness of the desired article or piece to the powder used. How large or to how many larger grains present to be distributed over the surface sufficiently to allow the smaller grains to fall into place between them. The article is held at such an angle that the first grains falling get stuck to the adhesive while the rest of the powder falls off with the exception of the smaller particles which fall in between the larger particles. Many articles can be armored with powders having about 100 to about 200 mesh. For smoother coats, finer powders are included. In effect, when the proportion of the sizes of the particles is selected approximately, a very thin, flat, uniform surface is formed. When the particle sizes come as crushed, ground, and sieved metal powder from the largest size desired down to the finest size desired, one has a natural piling of the grains for falling compactly and for keeping the mixture uniform for handling. Of course, the excess powder is removed before heating.

In practical operations, the article is held in such a way that the surfaces to be coated are held preferably at an angle so that when the falling powder hits the surface, only a part adheres to the adhesive and the rest just slides over the surface and falls down. Instead of powdering all at one time, several layers can be used to prevent any flow of the powder. A single layer of powder, however, is the best. The powder may be small enough to be blown with a blast of air, and the part to be coated is then held in the air stream. Then the powder is blown to its place and the part to be coated is held in the air stream. Then the powder is blown to its place and the part to be coated is held in the air stream and the leaf spring returns it up and forward to its original position, although not as sharply as the down-pull. The amount of grinding may be necessary, though this is much less than required on hard layers applied by previous methods. For instance, no grinding or a negligible amount thereof is required whereas previously it was necessary to grind about 50% to about 75% on metal applied. The present method can be used to produce a great variety of metal articles, especially iron and steel tools, used in many industries including metal-working, mining and wood-working industries and including automotive, agriculture, brick, cement, coke and gas, excavating, glass, iron and steel, lumber and paper, machinery, mining, oil and gas, power, sugar, etc., as those skilled in the art will fully appreciate. In these industries, various parts are armored including wear and heat resistant parts, abrasion and corrosion resistant parts, percussion and impact parts, etc.

In utilizing the present invention for the production of an improved armored insert saw tooth, an insert saw tooth is first treated with an alcoholic solution of shellac, the solution being applied in a roller, the insert saw tooth or a selected area or portion of the surface on which the hard layer is desired. As those skilled in the art know, a shellac solution is well known in the paint art. The solution may be applied in any desired manner, as by dipping, brushing, spraying or the like as is well known to those skilled in the art. After the piece coated with the alcoholic solution of shellac in place is then treated with a powdered mixture containing the components for the hard surface; namely, a matrix, brazing or bonding alloy, or more of the diamond substitutes, and borax. The use of carbonate is optional and may be used, if desired. The coated surfaces of the tooth are then heated as by an oxyacetylene torch using a carburizing flame until the "sweating point" of the base metal as coated is reached, whereupon the matrix or brazing alloy becomes soft, plastic and/or fluid but not so fluid as to run off or away from the surface being coated and whereupon there is a bonding or fusion of the surface layer and the ferrous base of the tool by melting or fusing or softening or plasticizing at the interface. The heating is continued until the matrix or brazing alloy starts to melt, at which temperature, the matrix dissolves both the iron of the ferrous base and the carbide of the hard refractory particles. When a good bond is insured at the interface, the heating is discontinued. By "sweating point," I mean the point at which the metal becomes plastic but not so plastic as to run off or away from the surface being coated and whereupon there is a bonding or fusion of the surface layer and the ferrous base is fused, melted and/or otherwise bonded. In this manner, the surface layer becomes in situ a coating, skin, glaze or enamel tenaciously bonded to a metal article such as a ferrous tool made of a steel, semi-steel, cast steel, iron, cast iron or the like. In practical operations, the armored metal article can be used in the as-produced condition with no subsequent grinding or only a negligible or small amount thereof. As those skilled in the art will know, articles such as ferrous tools require heat treatment under certain circumstances and the new armored metal articles can be heat treated.

A convenient way of applying the powder mixture to the surface is to pass the tooth through a curtain of the powdered material which is falling from one elevation to another, as by use of a Syntron magnetic feeder. As those skilled in the art know, a Syntron vibratory feeder or electromagnetically vibrated feeder operates by vibrating a trough carrying the material and, by adjusting the vibrations, the flow of powdered material in the form of a falling curtain of powder can be varied from a trickle to a heavy flow. The trough is mounted on flexible leaf springs and is vibrated at high speed by an electric engine. The magnet, energized by pulsating currents, pulls the trough sharply down so that the leaf springs return it up and forward to its original position, although not as sharply as the down-pull. The
powdered material in the trough falls perpendicularly as the trough is pulled sharply backwards out from under it, to a new position forward in the trough. The same action is repeated at high speed. This vibrating action causes the material in it to flow like water. The Syntron vibrating feeder provides an efficient and economical way of feeding powdered material and causing it to fall like a curtain of powder. By adjusting the vibrations, the rate of flow of the powder can be simply and easily controlled. By varying the depth of the Syntron trough, the length of articles with metal powder can be conducted on a large scale for mass production of armored metal articles commercially. Such an operation is like sieving the powdered material through a screen and sprinkling the falling material on the surface of the tooth or metal article to be coated. In large quantity production, this operation is very facile and efficient. A typical powder for this purpose may consist of a mixture of powdered Stellite, powdered Haystellite (tungsten carbide), and powdered borax preferably with a suitable halite such as a chloride and/or a fluoride of an alkali metal and/or an alkaline earth metal and/or mixtures and/or zinc chloride. The matrix is a hard metal alloy of non-eutectic character having a substantial softening or plastic temperature range between the liquidus and solidus points below the melting point of the metal article or tool to be coated and a plastic temperature range of about 1500°F (or about 1600°, 1700°, 1800° or 1900°F) to about 2500°F (or about 2000°, 2100°, 2200°, 2300°, or 2400°F). Stellite is essentially an alloy containing cobalt,chromium, tungsten and carbon, and has a softening or plastic range somewhere in the neighborhood of about 1900°F or 2000°F to about 2300°F or 2400°F. The shellac solution holds the powder mixture in place on the surfaces upon which coating is desired until the point where the borax performs the holding action. The shellac-alcohol mixture is subjected to pyrolysis by the heating operation which causes the volatile constituents to evaporate and/or to burn to produce products of combustion, such as carbon monoxide, carbon dioxide, etc., the residual constituents to remain as a carbonaceous residue after which the borax protects the grains of the Stellite in the coating and the surface of the base metal of the article or piece being treated.

The function of the reducing flame is described in general in U.S. Patent No. 1,973,541.

It is not surprising that the improved process embodying the present invention may be utilized with other types of heating than the oxyacetylene flame by maintenance of a reducing or carburizing atmosphere by the use of a carbide or reducing or carburizing gas or both, and the application of heat by some means, such as induction heating. When a substantial period of time of heating is employed, a reducing, carburizing or non-detrimental atmosphere is used, but when the heating is short or momentary or even almost instantaneous as in induction heating, then no special atmosphere has to be used.

Tungsten carbide, in the diamond substituent component of the powder mixture, is not melted when heated to the sweating temperature of the base metal as coated and the unmelted tungsten carbide particles are thus interspersed in the molten surface and prevent the melted portions of the coating material from coalescing and forming an appreciable curved or dome shaped surface. In this manner, a relatively flat, smooth surface of uniform thickness is provided on the surface of the coated metal article, such as a tool. The smoothness of the surface depends, among other things, upon the size of carbide particles, the time of heating above the plastic range or fusion zone or melting or softening point or range of the brazing or carburizing material, the solution of the matrix metal or alloy, the fluxing, the smoothness of the initial coating, etc. In the plastic range or fusion zone, the temperature is such that the matrix dissolves some of the surface of the carbide particles.

When a tool such as a tooth is being coated, it is permitted to cool and then, before it is returned to the bath in the reactor, the powdered mixture was applied now has a hard wearing surface which reproduces the contour of the underlying base and which is thin, practically smooth and firmly bonded to the remainder of the tooth. This thin hard surface, layer or coating may be termed a glaze, a skin or an enameled surface. Grinding of all is required for use and, in service, the tooth is substantially free of any tendency for the hard surface layer to chip off or to be sheared away. In the foregoing manner, an armored tooth is produced in situ and is ready for service in the as-produced condition, i.e., after the heat treatment of the base steel. In service operation the tooth is self-sharpening since the softer underside wears away gradually from the top surface layer leaving a sharp edge.

In lieu of the combination of Stellite and Haystellite referred to above, Stellite alone may be used, but a close control of temperature is required. However, for saw teeth, the combination is preferred, since Haystellite gives a harder surface than Stellite, while Stellite in the combination favors a smooth surface. Moreover, when tungsten carbide is present and when the matrix or brazing alloy like Stellite begins to melt, the carbide dissolves in the melt and becomes essentially a carbide in a matrix. When the carbide is being kept in the plastic state or plastic stage, and, thus, preventing it from running off or drawing up into a dome shaped surface.

It is to be understood that for various applications of this invention any of the diamond substitutes or refractory materials, known to the art, such as the carbides of silicon, tungsten, molybdenum, chromium, tantalum, columbium, vanadium, titanium, hafnium and zirconium may be used, as the purpose for which the tool is to be used shall dictate. Of course, in place of carbides, borides, nitrides, silicides and the like may be used singly or in mixtures as those skilled in the art understand. The melting points or ranges of the foregoing or mixtures thereof vary from about 3000°–4000°F to about 6000°–7000°F, as known to those skilled in the art.

In lieu of the Stellites for the matrix, pure chromium and cobalt in very finely powdered form can be used in combination with tungsten carbide to form the hard surface. In this case, carbides of certain of the constituents are formed from the carbon of the carbide and by the action of the torch and a slower heating should therefore be employed than is necessary when prepared carbides are used. Tungsten carbide is preferably employed for the refractory or diamond substitute rather than pure tungsten because of the high temperature or the long time required to form it.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

The structural characteristics shown in FIGS. 1 to 3 are based on those shown by microscopic examination of various specimens of saw teeth armored in accordance with the present invention.

In the invention, as illustrated in FIGS. 1, 2 and 3, an armored insert saw tooth is shown having a ferrous base 1, a surface layer 3 and an interface layer 5, the surface layer 3 being firmly and substantially uniformly bonded to the base 1 through the interface layer 5. In one embodiment of the invention shown in FIGS. 1 and 3, the surface layer contains metallic carbide particles 7 embedded in a fused matrix 9 and the interface layer 5 comprising essentially said fused matrix with the ferrous base. When a combination of Stellite and Haystellite, for example, is employed in the powdered mixture, the surface layer 3 contains tungsten carbide particles 7 embedded in a fused matrix 9 containing tungsten carbide, cobalt and carbon and the interface layer 5 comprises essentially an alloy containing tungsten, chromium, co-
ball, iron and carbon. The interface layer 5 comprising the matrix and the ferrous base shows an interalloying and diffusion of a substantial matrix and the ferrous base, resulting in a fused matrix, as illustrated in FIGS. 1 and 3, with a probability that there is an interfacial layer or zone between the matrix and the surface of the carbide particles. The self-sharpening feature of tools armored in accordance with the present invention is clearly shown in FIG. 1. The curved portion of the underside of the ferrous base shown by reference to line L, as shown in FIG. 1, is caused by the softer ferrous base wearing more rapidly during use than the surface layer 3, so that more of the hard surface layer is continuously exposed, thereby providing a hard, sharp cutting edge by reference character 13 at all times.

In the tools embodying the present invention, the bond of the surface layer to the ferrous base through the interface layer is so strong that, when the softer ferrous base wears away thereby exposing more of the hard surface layer, the bond is not weakened and the hard surface layer exhibits substantially no tendency to chip off or be sheared off during use. The bond is of such strength that the force required to separate the surface layer from the base is not substantially less than the force required to shear or tear apart the ferrous base itself. Further, the bond between the surface layer and the interface layer is at least as strong as the bond between the interface layer and the base. Moreover, whether the edge of the tool breaks off or not is also a function of (1) the ultimate strength and (2) the thickness of the matrix or brazing alloy. It is the strength imparted to the armor by these two factors that determines the load capable of being carried by the bond to the metal base. In marked contrast, tools armored in accordance with prior art methods are not self-sharpening and, when the softer base metal wears away leaving a thin surface layer of armor exposed, the bond between the surface layer of armor and base metal is so weak that the armored layer is likely to be readily chipped off or sheared away or the matrix is so weak that the cracking is likely to occur in the matrix itself. In addition to being less firmly bonded, surface layers of armor applied in accordance with prior art methods are not substantially uniform as in the case of the hard surface layers of the tools embodying the present invention.

In FIG. 2, an armored insert saw tooth prepared without the use of Haystellite in the powdered mixture is shown. In this embodiment of the invention, the surface layer 3 does not contain metallic carbide particles embedded in a fused matrix, but consists essentially of a fused matrix alone. Where Stellite, for example, is employed, the surface layer 3 will comprise essentially an alloy of cobalt, chromium and tungsten-containing chromium carbide, the surface layer being bonded to the ferrous base 1 through an interface layer 5 comprising essentially a fusion bond containing cobalt, chromium, tungsten, iron and carbon.

The enlarged section of the edge of a saw tooth shown in FIG. 3 illustrates the same structural characteristics shown in FIGS. 1 and 2, and is based on photomicrographs showing the maximum size of the tungsten carbide particles about 7 to be approximately about 80 microns. In practice, sizes intermediate the foregoing are preferred, such as about 20 to 44 microns, depending on the end use. Smaller tungsten carbide particles 15 are also shown. It is preferred that the carbide particles 7 be entirely covered by the layer 5, as shown in FIG. 3, which furnishes protection for the particles against the pressure of the work for which the tool is used, and prevents them from being readily separated. Strength is needed in the overhanging lip as those skilled in the art will readily appreciate. Carbide particle sizes larger than 80 microns are not objectionable for certain purposes, if they are sufficiently protected from separation by the fused matrix.

FIGS. 4 and 5 illustrate a saw tooth provided with an armored coating produced in accordance with the principles of this invention. A typical insert saw tooth is illustrated in these figures and has the conventional construction. The saw tooth comprises a main body M provided with sharp cutting edges E and square corners C. The face F has the usual slope 5. Armor A coats the top, sides and corners thus providing armor protection for the cutting edges. In practice, the armor A extends to a line L indicated by the present invention provides thin, flat, flexible, uniform hard armor coating which conforms accurately to the underlying surfaces including square corners, vertical sides, etc. The thickness varies with the use and the type of tool. With an insert saw tooth, an armor coating of a thickness of about 0.002" to about 0.005" has been found to give satisfactory service.

FIG. 6 represents a photomicrograph at 50 magnifications of a cross section of an armored saw tooth embodying the present invention. This saw tooth has been in service and has cut about 72,000 B.F.M. of 1" and 2" boards. It will be observed that the edge has remained sharp. The armor coating has a thickness of about 0.005", is flat, uniform and hard and contains diamond substitutes. The steel of the tooth is "undercut" by wood chips and sawdust and is automatically self-sharpening. Even after the foregoing service, the armored saw tooth has not worn an appreciable heel or lost sides or top clearances.

FIGS. 7 and 8 are photomicrographs showing the fusion bond at the interface between the armor coating and the base metal of the article. These photomicrographs were taken at 200 and 250 magnifications, respectively. In such photo, the top portion of the base metal of the article is shown where the fragmentation lines on the sides and the bottom. On the surface of the base metal, the armor is clearly visible as being fusion bonded thereto. In FIG. 7 the bond appears to penetrate the surface of the base metal and extend into the grain boundaries. This bond might be characterized as one involving intergranular penetration. Similarly, in FIG. 8, the fusion bond between the armor and the base metal is clearly shown. As in FIG. 7, there appears to be intergranular penetration. The carbide particles are distributed within the matrix of the armor. FIG. 8, certain of the carbide particles project or extend slightly beyond the exterior surface.

For the purpose of giving those skilled in the art a better understanding of the invention, the following illustrative examples are given:

**EXAMPLE I**

An alcohol-shellac mixture of the following composition is prepared:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percent by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange shellac</td>
<td>3.75</td>
</tr>
<tr>
<td>80% denatured alcohol</td>
<td>96.25</td>
</tr>
</tbody>
</table>

The shellac and alcohol are mixed to form a solution of the foregoing composition which is like those used in the paint art having a paint consistency and which is applied by dipping. As a general rule, it is preferred to add sufficient liquid, such as alcohol, to the liquid binder to make it thin so as to function like a liquid.

A powder mixture having the following compositions is formed:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percent by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flux</td>
<td>11.4</td>
</tr>
<tr>
<td>Haystellite</td>
<td>32.6</td>
</tr>
</tbody>
</table>

The powder contains particles having a range of sizes from about 100 mesh (about 0.0050" or about 0.0050") to about 300 mesh (about 0.0025" or 0.0025") to about 250 mesh. The metallic components of the powder mixture constitute a non-eutectic type of alloy forming the matrix and having a substantial plastic or softening temperature range between the liquidus and solidus points below the melting point of the metal article and within a wide temperature range, such as somewhere within a range of about 1500°F to about 2500°F, respectively.
say, for instance, about 1600°–1800° F. to about 2200°–2400° F. The tooth with its surface coating of shellac-alcohol solution is passed through a fine curtain of the powdered material so as to coat the top and sides of the cutting portion of the tooth with the powdered material. The moistened tooth retains only a thin, uniform layer of the powdered mixture; the outer side of said layer being dry allows the excess powdered material to fall off or be shaken or jarred off. This effects a removal of the excess of powdered or granulated coating mixture or alloy so that substantially a single layer is retained by the binder or adhesive film on the surface of said tooth or metal article when the binder or adhesive is made of shellac solution the viscosity of this solution must be taken into consideration with respect to the thinness of the film of adhesive and the layer of metal powder.

The saw tooth with the powdered layer held in place by the shellac solution, which dries rapidly, is heated after drying with a reducing flame of an oxyacetylene torch to the “swelling temperature,” i.e., one which is above the melting or softening point or range of the brazing or matrix material whereupon there is a fusion at the interface of the surface layer and the ferrous base of the tool by melting or fusing or bonding. In this heating operation, the surface of the saw tooth is heated to a temperature within the aforesaid plastic range at which said coating alloy will displace said non-metallic adhesive material (for example, borax and/or boric acid and/or mixtures thereof) and will fusion bond with the surface of said saw tooth or other tool or metal article. The shellac binder is subject to pyrolysis during heating and the flux, which is preferably borax in part, takes over the functions as binder and holds the carbide grains of the Stellite in place and protects them from oxygen. Borax functions as a non-volatile, non-metallic inorganic binder or adhesive material with plastic holding properties at the fusion bonding temperature. A smooth thin hard layer is formed on the surfaces treated so as to accurately reproduce its contour. It is tightly bonded to the remainder of the tooth and requires no grinding operation. The tooth can be heat treated just as though the surface had not been applied and will substantially retain its hardness.

As indicated hereinabove, the composition of the final surface layer should be determined by the conditions of use to which the article will be subjected. For example, where the shock to which the tool is to meet is not too great, silicon carbide or boron carbide are preferably included. Such a product is particularly useful for abrasion surfaces.

An insert saw tooth manufactured in accordance with the foregoing examples has a hard thin surface which is self-sharpening during use, unless the tooth is chipped or broken by contact with rocks or foreign substances in dirty timber when it may require some resharpening; has a relatively smooth, hard surface when initially applied requiring no grinding on the coated surfaces prior to use; is produced by a method more quickly, easily and inexpensively applied than by methods heretofore known; wears from two to 20 times as long as saw teeth which have not been hard surfaced; may be heat treated without rupturing the bond between the ferrous tool and the hard surface; retains during normal heat treating of the ferrous tool the desirable quality of hardness of the hard surface; is relatively free from tendency to chip or shear off the hard surface during use; and is produced by a process resulting in a substantial saving of materials over methods previously known. Of course, for the proper cutting angle should be maintained on the cutting tool, such as a tooth, especially when it is worn and/or when it is restored. This is accomplished by grinding on the face in a manner well known to those skilled in the art.

**EXAMPLE II**

The proportions set forth in the foregoing Example I can be varied, but are preferably of the following order:

**Wet portions:**
- Orange shellac
- 80% denatured alcohol

**Dry portions:**
- Powdered sugar (optional) 0.05 to 0.5
- Borax (flux) 5 or 10 to 10 or 15
- Stellite (matrix) 30 to 40
- Haystellite (diamond substitute) 50 to 65

The dry portion is composed of powder having a size range varying from about 20 mesh (about 0.030" or 0.033") to about 300 mesh (about 0.001" or 0.0017") The matrix or brazen metal powder may likewise vary from about 30 mesh (590 microns) to about 325 mesh (44 microns). Of course, the flux is screened to obtain the same size range.

In lieu of borax together with calcium chloride and zinc chloride, or either together with borax, a suitable commercial borax mixture is sold as Oxweld Brazo Flux. Analysis of this flux shows it consists of a borax mixture containing boric acid.

As those skilled in the art know, a flux functions in a number of ways including covering or enveloping the surface or surfaces to protect them from oxidation by the atmosphere while heating, dissolving any oxides formed on the metallic surface or surfaces, and lowering the surface tension of the melt, softening or plasticized matrix to allow it to flow or spread sufficiently to coat all adjacent parts, surfaces, and/or particles and to form a fusion bond at the interface of the metal base and the armor or coating.

The temperature and humidity at the time of application will affect the proportion of alcohol in the shellac solution. Too little alcohol will result in balling up of the material on the surface of the tool to be coated and will result in an uneven application of the hard surface material as well understood by those skilled in the art, the alcohol acts as liquid vehicle.

Other carbohydrates such as molasses and syrup may be substituted for the powdered sugar, although sugar is preferred. Glue may be substituted for the shellac but does not seem to work quite as well. The temporary binder must be part of a composition which does not decompose into volatile constituents too quickly. Molasses, syrup, or the like may also act as an adhesive with or without the shellac solution.

**EXAMPLE III**

**Wet portions:**
- Shellac
- Alcoholic or Shellac Solvent

**Dry portions:**
- Diamond substitutes Coarse granules (about 10, 20 or 30 mesh)
- Diamond substitutes Finer granules (about 200, 300 or 325 mesh)
- Stellite Matrix alloy
- Flux Borax mixture containing boric acid

**The first operation**—Article is coated with a film of shellac solution by any desired method known to the art of painting.

**The second operation**—Distribute coarse granules of a diamond substitute of a size that the thickness requires over the adhesive covered surface or surfaces in any desired pattern in order to get a substantially even distribution.

**The third operation**—Distribute a fairly coarse size of matrix granules over the coarse granules of the diamond substitute. This will cause a lesser amount of matrix to fall between the coarse diamond substitute granules so that
after fusing and bonding the coarse granules will protrude slightly.

Alternative to third operation.—A mixture of 100 mesh and finer or any grain size required by the finished article of matrix alloy and diamond substitute which would fill up the spaces between the coarse granules of the diamond substitute and cause less protrusion of the diamond substitute.

The fourth operation.—Overcoat the entire coating with a flux like borax which will function as a binder or adhesive until the matrix softens or fuses and becomes plastic. A very thin coating of shellac solution should be applied before each operation if there is any evidence of insufficient wetting by the shellac solution previously applied.

EXAMPLE IV

The proportions set forth in Example III will be used and some practical selected patterns will be utilized.

Pattern "A"

On a saw tooth, a row of a diamond substitute of coarse granules may be placed at intersections between back clearance surface and side surfaces of tooth. Then the surfaces would be coated in the regular manner, permitting the regular coating to also cover the coarse granules. This would cause better maintenance of corners in service since the center (i.e., the space between the coarse granules) would tend to wear back instead of protruding as it does now. During the life of the tooth, the period would be considerably lengthened before it needed reshaping.

Pattern "B"

In scarifiers were abrasion is great and clearance is impaired rather rapidly, a row of coarse granules may be put along the leading edge of the clearance and each successive row may be of a smaller grain size as it follows back on the clearance.

The reason for arranging the granules in this manner is that the smaller grains in back will not be dislodged and the undercutting of the face will be more pronounced. It will have a tendency to maintain a shape that is desired for service operation.

It is to be observed that the present invention provides an improved process for producing a novel armored metal article resulting in a coating of approximately 50 to 75% of the hard surfacing material over the customary coating processes because the resultant layer is produced in situ and is very thin. This is because the coating applied by the present invention requires no grinding for many purposes, whereas the previous coatings were applied thickly and ground down. Moreover, for many applications of the invention no grinding machinery is required. Furthermore, the novel armored metal articles can be embodied in ferrous tools, such as wood or light metal cutting tools requiring relatively high precision in reproducing the underlying contours whereas prior cutting devices, such as earth scarifiers or the like, did not require this high precision.

It is also to be observed that the present invention provides an improved armored metal article, such as a ferrous tool, having a thin, hard, flexible coating, layer, film, glass, enamel or the like, which has a thinness of about 0.001, 0.002 or 0.003 of an inch to about 0.005, 0.006 or 0.007 of an inch, which has a fusion or interfacial bond located or interposed between the surface of the metal article and the coating and possessing tenaciousness and toughness capable of sustaining intense loads, which conforms exactly to the shaping of a regular or irregular underlying surface including horizontal, inclined and vertical surfaces and sharp corners, which has continuity of coverage over the selected coated area to be covered, and which possesses hardness and wear resistance even at high temperatures.

It is manifest that the present invention provides an improved armored metal article produced in situ by a novel method which involves, generally speaking, (1) the coating of the article with a temporary liquid binder composition which spreads evenly over the surface and which is dissipated by the heat of the process, (2) the application of a metallic fine or powder particles of liquid binder to which it adheres, and (3) the heating of the coated article which eliminates the temporary liquid binder which effects a bonding of the powder to the article.

It is likewise to be noted that the temporary binder to be used in carrying the invention into practice is practically chemically inert or, in any event, is not chemically harmful to the piece or metal article to be armored and to the armor material, is dissipated or otherwise removed by the heat of the process, is compatible with all operating conditions of the process, is a liquid or a softened fluid or plastic which flows or spreads evenly over the entire surface upon contact, is sufficiently adhesive to support the powder and remain even on vertical, inclined, irregular or internal surfaces while supporting the powder and is of such a nature that it continues to function until the powder adheres to the surface of the article become sufficiently tacky or plastic under the heat to cause sticking or adherence of the particles even to a vertical surface or the like without any further aid of the temporary binder. As explained herein, the flux like borax functions as part of the temporary binder and continues to retain the metal powder after the shellac or initial adhesive is dissolved. Borax or similar flux continues to function until the matrix alloy softens or becomes plastic or melts and forms a fusion bond to unite the armor coating to the metal base.

Furthermore, the invention contemplates the use of a matrix material which has a melting point lower than the melting point of the piece or article and lower than the melting point of the hard metal portion of the armor including refractory particles, diamond substitutes, etc. (if the matrix alone is to provide the armor it need only be more wear resistant and hard than the base), which has a melting point at substantially the temperature at which the binder disappears, and which has the property when melting or softening or plasticizing of bonding both to the piece or article and to the hard coating.

It is clear that the present invention provides an improved armored metal article having controlled properties, such as thinness, hardness, abrasion resistance, corrosion resistance, surface smoothness, and the like or combinations of these properties, and such properties are controllable within reasonable limits both by appropriate formulation and suitable variation of the operations and by subsequent heat treatment effecting the properties of the base metal.

Likewise, it is within the contemplation of the invention to use various powders having a variety of degrees of fineness so long as the powder is not so coarse that it slurs or does not conform accurately to the degree required for the particular part to the entire surface formation of the portion to be armored. Such a powder can be applied to the surface wetted with the liquid temporary binder in a variety of ways, if it assures that the coating of powder conforms accurately to the underly ing surface formation. The powder can be applied to the wetted surface in the form of a coating, layer, film, skin, glaze or enamel having various degrees of thinness so long as it is not too thin to provide a serviceable armor covering the entire area of the selected surface or too thick to preserve in the completed armor an accurate reproduction of the underlying surface formation.
The invention also contemplates the provision of improved armored metal articles having thin coatings of the order of about 0.001" to about 0.002" to about 0.004" provided in situ, being very hard and flat and having fairly smooth surfaces and straight edges suitable for cutting edges which will outweigh conventional coated metal articles and which will provide comparatively permanent self-sharpening or edge-retaining characteristics provided that more characteristics are produced in armored metal articles by the present invention and includes armor which follows or conforms to the contours, curves, square corners or other variations or irregularities in the shape of the article, which can be spotted or patterned as desired, which is bonded or fused to the parent metal of the base and thus eliminates chipping or spalling under normal conditions of service, which withstands bending, swaging and metal treating cycles and which retains its hardness and alloyed bond.

The present invention contemplates a heat treatment process for producing, a novel armored metal article with a metallic material having at least in part a melting point lower than the melting point of the base, which comprises, wetting the surface of the area or of the article to be covered with a liquid composition having the property of disintegration as an incident of the process and of a material of a composition such that it spreads evenly and at a uniform thickness on such surface upon contact thereon, coating the wetted surface with the material so finely powdered that it adheres readily thereto in a thin layer having the contour of the surface, at least a part of said armor powder having the property when melting of bonding with the base, and quickly raising by ambient heat the temperature of the armor powder to the melting point to remove the wetting composition and melt the armor powder onto the base in a self-conforming fused layer of uniform thickness throughout.

It is likewise within the contemplation of the invention to provide a novel armored metal article produced by an improved process, comprising, applying to the surface a thin liquid film of a binder material having a consistency such that it coats evenly all parts of the surface in a composition such that it adheres thereto, is chemically inert to the material of the surface and to the material of the armor, is compatible with all operating conditions of the process, and dissipates as an incident thereof, applying to the binder coating a fine powder composition, a hard layer of a metallic material which latter has a melting point below the melting point of said surface material and below the melting point of the hard metal and which has the property when melting of bonding with both, continuing the application of the powder until sufficient powder adheres to the binder to reproduce thereon exactly the entire area and contour of the underlying article surface.

The invention also provides a process for producing a novel armored metal article having on the area to be covered a plurality of faces merged in relatively sharp corners in a vertical or inclined or irregular surface and undersides produced by an improved process which comprises wetting the entire surface of the area to be covered with a liquid composition decomposable by heat and of a consistency such that it flows evenly thereon upon contact to provide a binder film that retains the exact configuration of the surface of the article and powdering the applied binder with a fine powder comprising an armor material which adheres to the binder in a thin layer conforming precisely to the configuration of the surface beneath the binder, at least a part of said armor material having a melting point lower than the melting point of the material constituting the surface to be covered but permanently and preferably lower than the decomposing temperature of the binder and having the property when melting of bonding with said surface material, and heating the powdered surface to decompose the binder and melt the powder directly upon the underlying surface evenly in a surface-bonded layer replacing the binder and thereby, to the same height as the binder, retaining the configuration of the underlying surface. Thus, the liquid, plastic, softened, fused or mushy binder contains sufficient borax to hold the grains of metallic powder from the time the shell ice burns or is dissolved away until the matrix or braze takes over the holding function. As is known to the art, borax is anhydrous sodium tetraborate (Na$_2$B$_4$O$_7$) and does not decompose until about 2867° F, whereas a matrix like Stellite melts, fuses or softens within a range of about 2000° F. to about 2400° F.

It is to be observed that in carrying the invention into practice, the size of the metal powders can be varied. The powders sold on the market by different manufacturers have different sizes of mesh. For preferred armorizing, it is preferable to use metal powders having a size ranging from about 0.001" mesh (about 600 mesh or about 149 microns) to about 200 mesh (about 0.0029" or about 74 microns). In general, metal powders can be used varying in size from about 20 mesh (about 0.0331" or about 840 microns) or 30 mesh (about 0.0234" or about 590 microns) to about 250 mesh (about 0.0017" or about 44 microns). In some instances, coarser particles may be present, say about 4 mesh (about 0.187" or about 4760 microns), as well as finer particles, say of flour fineness, such as obtained in conventional "bag powders." Too many fines should not be included in the metal powder as they tend to cause balling-up in lump on the surface of the liquid adhesive and to interfere with free and uniform feeding by the Syntron feeder. An appropriate amount of fines can be included in the metal powder and will be distributed or dispersed between the coarser or larger particles. When so distributed, especially as a single layer, the particles tend to hold the liquid adhesive close to and in contact with the surface of the article to be armored. Generally, the liquid adhesive including a flux like borax surrounds and/or envelops the particles, although some of the coarser or larger particles may extend beyond or project through the liquid film, especially hard refractory articles and matrix carbide or other diamond substitute.

The present invention is not to be confused with old inventions in the prior art. Thus, an alloy rod interdispersed with diamond-substitute granules or a tube rod filled with diamond substitute granules is held above the surface to be coated and a molten mass flowed on by means of heat, such as provided by a torch or electric arc. (See, for example, U.S. Patents Nos. 1,650,905; 1,757,601; 1,803,875 and 2,033,594.) This prior method lacks control of thickness of surface and distribution of diamond substitute granules. It cannot precisely follow the contour of the surface. This is particularly true where unprotected square corners are rounded and melted off due to the difficulty of controlling the heat of the welding torch. Ruptile marks are likewise left on the surface when hard welding with an electric torch is used. When working from a rod or tube with a torch, it is practically impossible to melt an even amount from the supply end of the rod and spread it uniformly over several different unit areas in the thickness tolerance contemplated by the present invention. In fact, the degree of precision involved in producing a uniform thickness of the article produced by this invention is so much greater than that made, intended or required for use by the old tube method that this old method is entirely differ-
ent from the present improved method of armoring. When it becomes necessary to smooth the surface as by grinding, the best part of the coating is ground away. Another method involves the distribution of refractory grains or particles onto a surface which is then brazed with atomic hydrogen. (See, for example, U.S. Patent No. 2,331,060.) The surface to be armored is heated until a very thin layer of the base metal becomes molten. Before this molten surface has an objectionable amount of oxides formed, the diamond substitute granules are distributed or dispersed over the molten area. They sink in and cause the base metal to be bonded thereto. With this method, the cost of armoring under which the distribution is done require so much skill that it is very costly for industrial production and that it can only be used for certain situations. It is practically impossible in a convenient manner to do the underside of an article and very difficult to do the sides. Minute contours are almost impossible to follow, especially sharp corners, thin projections, etc., without burning off. Still another prior method involves coating a surface with refractory grains and then heating it very rapidly to produce tungsten carbide on the surface of the base metal. (See, for example, U.S. Patent No. 1,824,166.) Tungsten or a tungsten-containing material is mixed with carbon and applied to the surface with an adhesive. By use of some instantaneous method of high heat, such as by an arc, the tungsten-containing material is reduced by the carbon and tungsten functions like finely divided tungsten and reacts with carbon to form tungsten carbide which sinks into the molten surface of the base metal caused by the instantaneous application of the heat. In general, it takes an appreciable time and/or temperature above the melting point of the steel to form tungsten carbide in appreciable quantities. If the temperature were raised above the melting point of the steel, it would obviously be impossible to reproduce the contour of the part with accuracy. Any attempt to use the high temperature required would need an atomic hydrogen arc which would inevitably melt the sharp cutting edges to be armored. These operations are difficult to carry into practice on an industrial scale for commercial production. Another disadvantage of these operations is that they produce a very uneven coating, burn-off sharp edges, etc., and involve electroplating of hard chrome on the surface of the metal article. The hard chrome was for the purpose of prolonging the life of a tool. However, the chrome-plated article did not hold an edge and the coating was not thick enough to provide strength required for cutting. For example, a hollow drill with ¼" or ¾" hole. The present invention involves inserting brazed and sintered pieces or inserts and sold them under such trade names as Carbolyte. The inserts were brazed to tools. The disadvantages are: first, high cost due to the larger amount of expensive material and the greater labor required to make them; second, the thicker insert is not self-sharpening. When resharpening is necessary, it is much easier to work the present armored article. Although grading is preferred, the present armored articles can be filled to sharpen them. This is made possible by the extremely thin coating made by the present invention. The prior inserts were brazed to tools and were used on earth scarifiers, cutting tools, etc.

In contrast with the prior art, the present invention involves a novel armored metal article and contemplates the use of an improved method of armoring a selected surface of a metal article with a thin, flat, hard wearing surface of smooth and uniform character and of uniform thickness containing particles of a diamond substitute and coated onto the exact contour of the selected surface. The armor or hard facings comprises a hard matrix, such as Stellite, martensite iron, nickel boride or equivalent, containing hard refractory or diamond substitute particles, such as tungsten carbide or the like. The coating of armor is extremely thin, such as from about 0.006 to 0.003" thick. The surface being armored, the coating can have thicknesses up to about 0.015". The thin coating of armor accurately reproduces the underlying contour including irregularities, square corners, etc. All prior coats made the corners round. The new invention contemplates the provision of a liquid binder which tends to flow evenly over the article or piece being armored, and to form a thin film on the selected area. Such a film retains a uniform thickness of metal powder comprising matrix alloy and hard refractory particles when the powder is dusted or sprinkled over the metal piece. The prior coats fail to provide means for obtaining a uniform thickness. Consequently, the prior processes cannot be used where accurate reproduction of a contour is to be effected. Armor can be applied to internal slots, holes, etc., by the present invention whereas prior processes requiring a torch or electric current for heating could not be used for such purposes. On cutting tools, the improved method applies armor to the flank instead of on the face as is effected by most prior hard-facing processes. The armoring of the flank allows the tool to be sharpened as many times while the cutting edge of the tool is being sharpened only, wear on the face of the tool sharpens the cutting edge of the armor. Such flank armoring of tools makes it much easier to sharpen them as the amount of carbide to remove is relatively small due to the thinness of the armor coating. The extremely thin coat of armor applied by the present invention makes it possible to restore the corner of a tool by swaging. This is impossible with thicker coats of armor applied by prior processes.

The present invention is a continuation-in-part of my co-pending United States patent application for Metal Coatings, Serial No. 367,543, filed July 13, 1953, now abandoned, which is a continuation-in-part of my parent application, Serial No. 41,180, filed July 28, 1948. Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. For instance, instead of a ferrous base for the tool or metal article, non-ferrous bases can be used, such as copper bases (brasses, bronzes, etc.) or nickel bases or cobalt bases or molybdenum bases or the like. Instead of the shellac solution, other suitable adhesive or binder materials can be used. For example, equivalent solutions containing natural or synthetic resins and/or resins, such as glyptals, silicones, phenol-formaldehyde resins of the Bakelite type, cycopolys (sold by Oliver Johnston Paint Company), Ltdex or Lytrel, and santo Chemical Company). Varnish lacquer or tung oil may be used. Solutions of sodium silicate may likewise be substituted. Instead of borax, other equivalent materials may be employed, such as borax- or borate-containing materials, boric acid, sodium or potassium fluoride, sodium or potassium silicate, and lithium salts such as fluoride, metabolate or tetraborate. As those skilled in the art will know, the melting points of these fluxes vary up to about 1000° F., 1500° F., 2000° F. or so. Similarly, the operations can be varied. Thus, the metal powders and fluxes can be added to the solution of adhesive or binder, dipping, brushing, spraying
or otherwise painting the adhesive or binder solution on the entire or selected area, drying the solution to form a dried coating, and finally, heating the surface with a welding torch to fuse the armor coating to metal base. On the other hand, the surface to be armored can be painted with binder or adhesive solution and then powdered refractory particles of diamond substitutes, such as tungsten carbide, can be sprinkled onto the film of adhesive or other admixtures, and the mixture formed into a matrixed layer such as Stellite, a flux such as borax and optionally a carbohydrate can be sprinkled over the surface to surround the particles of diamond substitutes. The coated metal article can be dried and then subjected to heating with appropriate means, such as a welding torch, to fuse the matrix and bond the armor coating to the metal base. Another variant is to sprinkle all powdered materials on together. Instead of a welding torch, an electric furnace can be used for heating with a controlled atmosphere, such as dissociated ammonia. The latter heating operation can be varied by adding methane (CH₄) or natural gas to the dissociated ammonia atmosphere. Still another variant is to heat with an electric induction heater in the air with or without a protective atmosphere. The powdered materials can be put on the adhesive film on the article separately. For instance, the diamond substitute can be applied first, the brazing or matrix alloy second, and the flux third. The powdered materials of the brazing or matrix alloy can be put on first, then the diamond substitute and finally the flux. Of course, various other combinations can be used including the application of several coats with or without additional films or layers of adhesive. Some modifications and variations are considered to be within the purview and scope of the invention and appended claims.

I claim:

1. An improved armored steel saw tooth having a hard-wearing, non-brittle armor coating produced in situ from powdered metallic particles comprising a steel saw tooth constituting a structural base having an uncoated slope and having at least one working and wearing surface usually subject to being worn away in use and having a top, vertical sides, square corners, a slope and a sharp cutting edge; a hard-wearing armor coating covering and protecting a selected surface, including said working surface, of the top, vertical sides and square corners and constituted of a thin, hard matrix alloy composed of powdered particles consisting essentially of chromium, cobalt and tungsten and fused together in situ and having a thickness up to about 0.015 in. and conforming exactly to the shape of the saw tooth having any combination of horizontal, inclined and vertical surfaces and sharp corners; and a plurality of particles of refractory metallic carbides selected from the group consisting of carbides of silicon, tungsten, molybdenum, chromium, tantalum, niobium, vanadium, titanium, zirconium, boron and mixtures thereof and embedded in the armor coating; and an interfacial metallic layer interposed between and fused via a fusion bond to the surface of the steel tooth and via another fusion bond to the armor coating, exhibiting intergranular penetration of said steel tooth, and made of an alloy composed of constituents of the matrix of said armor coating including chromium, cobalt and tungsten and of iron from said steel tooth of the saw tooth whereby an armored steel saw tooth is provided which is capable of sustaining intense loads without cracking, chipping and shearing.

2. An armored steel saw tooth having a hard-wearing, non-brittle armor coating produced in situ from powdered metallic particles comprising a steel saw tooth constituting a structural base having an uncoated slope and having at least one working and wearing surface usually subject to being worn away in use; a hard-wearing armor coating covering and protecting a selected surface, including said working surface, of the top, vertical sides and square corners of a thin, hard matrix alloy composed of powdered particles consisting essentially of chromium, cobalt and tungsten and fused together in situ and having a thickness up to about 0.015 in. and conforming exactly to the shape of the saw tooth having any combination of horizontal, inclined and vertical surfaces and sharp corners; a plurality of particles of refractory metallic carbides selected from the group consisting of carbides of silicon, tungsten, molybdenum, chromium, tantalum, niobium, vanadium, titanium, zirconium, boron and mixtures thereof and embedded in the armor coating; and an interfacial metallic layer interposed between and fused via a fusion bond to the surface of the steel tooth and via another fusion bond to the armor coating, exhibiting intergranular penetration of said steel tooth, and made of an alloy composed of constituents of the matrix of said armor coating including chromium, cobalt and tungsten and of iron from said steel tooth of the saw tooth whereby an armored steel saw tooth is provided which is capable of sustaining intense loads without cracking, chipping and shearing.

3. An improved armored ferrous saw tooth having a hard-wearing, non-brittle armor coating produced in situ from powdered metallic particles comprising a ferrous saw tooth constituting a structural base having an uncoated slope and having at least one working and wearing surface usually subject to being worn away in use; a hard-wearing metallic armor coating covering and protecting a selected surface, including said working and wearing surface, of said saw tooth and constituted of a thin, tough, hard metallic matrix alloy composed of metallic particles sweated together in situ, conforming exactly to the shape of an underlying surface of any character including sharp corners and horizontal, curved, inclined, vertical, irregular and internal and external contours; a plurality of particles of diamond substitutes interspersed in said armor coating and having their surfaces welded and bonded to the matrix alloy and being selected from the group consisting of carbides, boride, nitride and silicide and mixtures thereof; and an interfacial metallic layer interposed between the surface of the steel tooth and the armor coating and being fused on the bottom to said steel tooth and on the top to said armor coating, and composed of an alloy containing constituents of the matrix of said armor coating and of said steel whereby an armored steel saw tooth is provided which is capable of sustaining intense loads without cracking, chipping and shearing.

4. An improved armored steel saw tooth having a hard-wearing, non-brittle armor coating produced in situ from powdered metallic particles comprising a steel saw tooth constituting a structural base having an uncoated slope and having at least one working and wearing surface usually subject to being worn away in use; a hard-wearing metallic armor coating covering and protecting a selected surface, including said working and wearing surface, of said saw tooth and constituted of a thin, tough, hard metallic matrix alloy composed of metallic particles sweated together in situ, conforming exactly to the shape of an underlying surface of any character including sharp corners and horizontal, curved, inclined, vertical, irregular and internal and external contours; a plurality of particles of diamond substitutes interspersed in said armor coating and having their surfaces welded and bonded to the matrix alloy and being selected from the group consisting of carbides of silicon, tungsten, molybdenum, chromium, tantalum, niobium, vanadium, titanium, zirconium, boron and mixtures thereof; and an interfacial metallic layer interposed between the surface of the steel tooth and the armor coating and being fused on the bottom to said steel tooth and on the top to said armor coating, and composed of an alloy containing constituents of the matrix of said armor coating and of said steel whereby an armored steel saw tooth is provided which is capable of sustaining intense loads without cracking, chipping and shearing.
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21 refractory matrix of said armor coating including chromium, cobalt, and tungsten and of iron and carbon of said armor coating whereby an improved armor steel tool is provided in which the force required to shear the armor coating from the steel base is not substantially less than the force required to shear the steel base.

5 An improved armored ferrous tool having a hardwearing, non-brittle armor coating produced in situ from powdered metallic particles comprising a ferrous tool constituting a structural base having an uncoated slope adapted to be undercut in use and having at least one working and wearing surface usually subject to being worn away in use and composed of a ferrous member of the group consisting of steel, semi-steel, cast steel, iron and cast iron; a hard-wearing, flexible armor coating covering and protecting a selected surface, including said working and wearing surface, of said ferrous tool and constituted of a thin hard metallic matrix composed of powdered refractory metallic particles sweated together in situ, having a thinness of about 0.002 in. to about 0.005 in. and accurately reproducing the exact contour of the underlying surface of any character including sharp corners and horizontal, curved, inclined, vertical, irregular and internal and external contours, having uniformity and continuity of coverage over the selected armored area, and possessing hardness, non-brittleness and wear resistance even at high temperatures; a plurality of particles of diamond substitute dispersed in the armor coating and selected from the group consisting of a carbide, boride, nitride and silicide of tungsten, molybdenum, chromium, tantalum, columbium, vanadium, hafnium and zirconium and mixtures thereof; and an interfacial metallic layer interposed and fused via fusion bonds between the surface of the ferrous base and with the armor coating, exhibiting intergranular penetration of said ferrous base, and composed of an alloy containing constituents of the metallic matrix of said armor coating and of said steel base whereby an improved armored ferrous tool is provided which has a substantially flat and a fairly smooth surface, which has straight armored edges suitable for cutting edges and capable of outwearing conventional ferrous tools, and which possesses substantially free from ripple marks and piled-up areas.

22 An improved armored steel article having a hardwearing, non-brittle armor coating produced in situ from powered metallic particles comprising a steel article constituting a structural base and having at least one working and wearing surface usually subject to being worn away in use; a hard-wearing, metallic armor coating covering and protecting a selected surface, including said working and wearing surface, of said steel article and constituted of a thin, hard, refractory matrix alloy composed of powdered metallic particles sweated together in situ and having a thinness up to about 0.007 in., accurately and uniformly reproducing the underlying surface of any character including sharp corners and horizontal, curved, inclined, vertical, irregular and internal and external contours, having uniformity and continuity of coverage over the selected armored area, and possessing hardness, non-brittleness and wear resistance even at high temperatures; a plurality of metallic carbide particles dispersed in said matrix and having their surfaces sweated within and bonded to the matrix alloy, and being selected from the group consisting of carbides of silicon, tungsten, molybdenum, chromium, tantalum, niobium, titanium, strontium, boron and mixtures thereof; and an interfacial metallic layer interposed and fused via fusion bonds between the surface of the steel article and the armor coating, and composed of an alloy containing constituents of the matrix of said armor coating and of said steel base wherein an armored steel article is provided with armor coating substantially free from ripple marks and piled-up areas.

8 An improved armored steel article having a hardwearing, non-brittle armor coating produced in situ from powered metallic particles comprising a steel article constituting a structural base and having at least one working and wearing surface usually subject to being worn away in use; a hard-wearing, flexible armor coating covering and protecting a selected surface, including said working and wearing surface, of said steel article and constituted of a thin, hard-wearing, refractory matrix alloy composed of powdered metallic particles sweated together and having a thinness up to about 0.015 in., forming exactly to the shape of an underlying surface of any character including sharp corners and horizontal, curved, inclined, vertical, irregular and internal and external contours, having uniformity and continuity of coverage over the selected armored area, and possessing hardness, non-brittleness and wear resistance even at high temperatures; a plurality of tungsten carbide particles dispersed throughout said armor coating; and an interfacial metallic layer interposed between the surface of the steel base and the armor coating and having a fusion bond with said steel base and another fusion bond with said armor coating; and an interfacial metallic layer interposed between the surface of the steel base and the armor coating, and having a fusion bond with said steel base and another fusion bond with said armor coating; and an interfacial metallic layer interposed between the surface of the steel base and the armor coating, and having a fusion bond with said steel base and another fusion bond with said armor coating; and an interfacial metallic layer interposed between the surface of the steel base and the armor coating, and having a fusion bond with said steel base, and another fusion bond with said hard-wearing, flexible armor coating covering and protecting a selected surface, including said working and wearing surface, of said steel article and constituted of an armor coating, which has a substantially flat and a fairly smooth surface, which has straight armored edges suitable for cutting edges and capable of outwearing conventional metal tools, and which possesses substantially free from ripple marks and piled-up areas.
surface, of said article and constituted of a thin, hard-wearing metallic matrix composed of powdered refractory metallic particles sweated together in situ and having a thickness up to about 0.015 in., and having a fusion bond with said base and another with said coating, said fusion bond exhibiting intergranular penetration of said metallic matrix and of the metal article whereby an improved armored metal article is provided which has an armor coating which has a substantially flat and a fairly smooth surface, which has straight armored edges suitable for cutting edges and capable of withstanding conventional forms of abrasion, such as one working and wearing surface usually subject to being worn away in use; a hard-wearing, flexible metallic armor coating covering and protecting a selected surface, including said working and wearing surface, of said ferrous matrix composed of powdered refractory metallic particles sweated together in situ and having a thickness of about 0.002 in. to about 0.005 in., conforming exactly to the shape of an underlying surface of any character including sharp corners and horizontal, curved, inclined, vertical, irregular and internal and external contours, having uniformity and continuity of coverage over the selected armored area, and possessing hardness, non-brittleness and wear resistance even at high temperatures; a plurality of particles of diamond substitutes selected from the group consisting of carbides, borides, nitriles and silicides dispersed in said metallic matrix and having their surfaces sweated within and bonded to the metallic matrix; and an interfacial metallic layer interposed between the surface of the ferrous article and the armor coating, made of an alloy composed of constituents of the matrix of said armor coating and of said ferrous base, and having the lower part fused via a fusion bond to the ferrous base and the upper part fused via another fusion bond to the metallic matrix whereby an improved armored ferrous article is provided with a hard-wearing armor coating substantially free from areas of piled-up particles and substantially free from burned-off corners and projections.

11. An improved armored metal article having a hardening, non-brittle armor coating produced in situ from powdered metallic particles comprising a metal article constituting a structural base and having at least one working and wearing surface usually subject to being worn away in use; a thin, flat, undeground, hard, flexible and continuously covering and protecting a selected surface, including said working and wearing surface, of said article and constituted of a thin, hard-wearing metallic matrix composed of powdered metallic particles sweated together and having a thickness of about 0.001 in. to about 0.007 in., conforming exactly to the shape of an underlying surface of any character including sharp corners and horizontal, curved, inclined, vertical, irregular and internal and external contours, having uniformity and continuity of coverage over the selected armored area, and possessing hardness, non-brittleness and wear resistance even at high temperatures; and an interfacial metallic layer interposed between the surface of the metallic base and the armor coating and having a fusion bond with said base and another with said coating, said fusion bond exhibiting intergranular penetration of said metallic base and composed of a tungsten carbide layer of the metallic matrix and of the metal article whereby an improved armored metal article is provided in which the fusion bond between the armor coating and the interfacial layer is at least as strong as the fusion bond between the interfacial layer and the ferrous base.

12. An improved armored metal article having a hard-wearing, non-brittle armor coating produced in situ from powdered metallic particles comprising a metal article constituting a structural base and having at least one working and wearing surface usually subject to being worn away in use; a hard-wearing flexible armor coating covering and protecting a selected surface, including said working and wearing surface, of the article and constituted of a thin, hard-wearing, refractory metallic matrix composed of powdered metallic particles sweated together in situ and having a thickness up to about 0.015 in., conforming exactly to the shape of an underlying surface of any character including sharp corners and horizontal, curved, inclined, vertical, irregular and internal and external contours, having uniformity and continuity of coverage over the selected armored area, and possessing hardness, non-brittleness and wear resistance even at high temperatures; a plurality of particles of diamond substitutes selected from the group consisting of carbides, borides, nitriles and silicides dispersed in said metallic matrix and having their surfaces sweated within and bonded to the metallic matrix; and an interfacial metallic layer interposed between the surface of the metallic base and the armor coating and interalloyed with said base and said coating with a fusion bond exhibiting intergranular penetration of said metallic base and said metallic base and said coating, said metallic base being constituted of an alloy composed of the constituents of the metallic matrix of said armor coating and of said metallic base of the article whereby an improved armored metal article is provided in which the force required to shear the armor coating from the metallic base is not substantially less than the force required to shear the metallic base.

13. An improved armored metal article having a hard-wearing, non-brittle armor coating produced in situ from powdered metallic particles comprising a metal article constituting a structural base and having at least one working and wearing surface usually subject to being worn away in use; a hard-wearing, flexible metallic armor coating covering and protecting a selected surface, including said working and wearing surface, of said article and constituted of a thin, hard-wearing, refractory metallic matrix composed of powdered metallic particles sweated together in situ and constituting the surface of the metallic base and the armor coating being fused via a fusion bond at the bottom to the metallic base and via another fusion bond at the top to the armor coating, said interfacial layer composed of an alloy containing constituents of the matrix of said armor coating and of said metallic base whereby an improved armored metal article is provided having controlled properties including thickness, hardness, abrasion-resistance, corrosion-resistance and surface smoothness.

14. The armored saw tooth set forth in claim 1 in which the slope has a suitable cutting angle and in which the steel of the tooth is undercut by wood chips and saw dust and is automatically self-sharpening in service
operation whereby the saw tooth wears about 2 to about 20 times as long as a saw tooth which has not been armored.

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