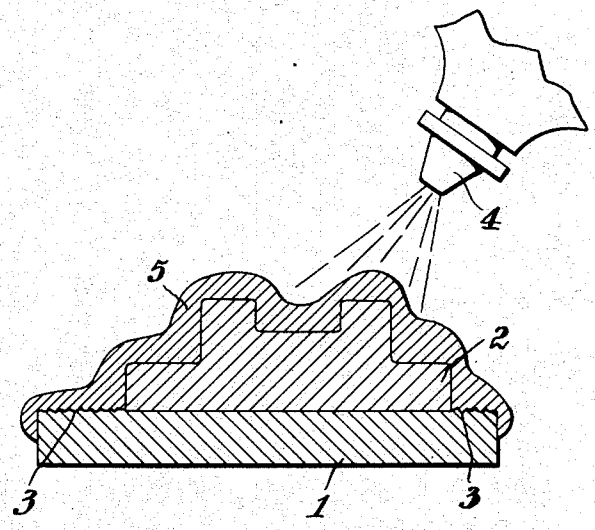
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PROCESS OF MAKING NEGATIVES IN METAL OF SOLID OBJECTS OR SURFACES

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PROCESS OF MAKING NEGATIVES IN METAL OF SOLID OBJECTS OR SURFACES

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This invention relates to a new and useful process of making negatives in metal of solid objects or surfaces.

One object of the invention comprises, inter alia, the making by metal spraying of substantially accurate negatives or molds and reproductions or replicas in metal of solid objects or surfaces and this and other objects will be seen from the following description.

The application of metal coatings to solid objects or surfaces by metal spraying is achieved by the use of a metal spray gun, i. e., a device by which metal is fed to a heating zone from which zone metal particles, at least some of which are molten or in a heat plastic condition, are propelled against the object or surface by a blast of air or other gas. Various types of spray guns are commonly used for this purpose. In order to obtain a substantially coherent coating on the object or surface sprayed, it is essential that the metal particles, as they impinge upon the surface sprayed, enter into a bond with such surface to a sufficient extent to permit the formation of a satisfactory coating thereon. If the bond between the impinging metal particles and the surface sprayed is not sufficient for the formation of a substantially coherent metal coating, the spray metal will not adhere to such surface and is either blown off by the force of the blast from the spray gun or, if it forms flakes upon the surface sprayed, these flakes curl, thus preventing the formation of the desired coating. In such cases it is necessary to provide for the requisite degree of bonding between the impinging metal particles and the surface sprayed by the use of suitable methods well-known in the art to render the surface to be sprayed rough or porous.

For the procurement of detachable spray metal coatings it is requisite that the bonding between the spray metal coating and the surface to which it is applied be of such intermediate degree that not only a satisfactory coating is obtained, but that the same may be removed from the surface sprayed substantially intact, i. e., without injury to the coating. Such intermediate degree of bonding, however, is difficult to achieve.

In the making of negatives or molds and replicas or duplicates in metal of solid objects or surfaces by metal spraying, the object or surface sprayed upon is usually called a "matrix," i. e., a substantially accurate negative of the object or surface to be obtained therefrom. If the matrix is itself a negative of a model, a model being an object or surface desired to be reproduced, it constitutes a mold from which replicas or duplicates of such model can be made, whereas if the matrix is itself a positive of a model, it constitutes a so-called "master" (i. e., either the original of the object or surface desired to be reproduced, or, a substantially accurate replica or duplicate of such object or surface) from which a negative or mold may be made. Such negatives or molds are, for instance, produced for use in the multiple reproduction of articles in various industries and particularly in the plastics, rubber and similar industries.

It is possible to obtain substantially accurate spray metal negatives or molds of solid objects or surfaces without the necessity of procuring any intermediate degree of bonding of the spray metal coating to the matrix sprayed and to obtain a spray metal coating that may be separated and removed from the matrix sprayed substantially intact, i. e., substantially without injury to the coating. This may be accomplished by the use of a special matrix capable of a satisfactory degree of spray metal bonding and removable from an applied spray metal coating by melting. This matrix may consist of a relatively low melting point metal, although for many purposes it is recommended to use a suitable alloy which, when converted from the solid into the fused state, is substantially free from expansion in volume and preferably which additionally, when converted from the fused into the solid state, is substantially free from shrinkage in volume. The melting and softening point of such metal or alloy must be lower than the melting and softening point of the spray metal to be applied thereto. An alloy of the afore-described characteristics is, for instance, a lead-tin-bismuth-antimony alloy consisting essentially of 27.5 to 28.5% lead, 13.5 to 16% tin, and 48 to 50% bismuth, and 7 to 9% antimony; good results are also obtained with a lead-tin-bismuth-antimony alloy consisting essentially of 28.5% lead, 14.5% tin, 48% bismuth and 9% antimony. Another alloy of this type is for instance a bismuth lead alloy consisting essentially of 55 to 60% bismuth and 40 to 45% lead. The preferred alloy of the bismuth-lead type is one consisting essentially of 55.5% bismuth and 44.5% lead. This latter alloy is distinguished by the fact that it will neither substantially shrink nor expand when converted from the solid into the fused or the fused into the solid state. The characteristic of substantial freedom from expansion when melting is preferred for, if the bulk of the matrix expands in volume when melted, injury to the mold surface may result.

Although a low melting point metal matrix eliminates the problem of spray metal-bond adjustment, such matrix is difficult to handle while spraying onto the same. The use of gas blast type spray guns is usually attended by relatively high temperatures. Considerable precaution must therefore be taken, on account of the relatively low melting point of the matrix material in question, to avoid any appreciable melting or softening of the matrix surface during the spraying operation, at least until a spray metal coating of relative thickness is obtained.

I have discovered a procedure which will substantially eliminate the requirement for the prolonged observance of precautionary conditions in the metal spraying of a matrix of the discussed type and by which it is possible to obtain satisfactory spray metal negatives in a fraction of the time hitherto required for their production.

The invention will be fully understood from the following description read in conjunction with the drawing representing a cross section through a spray metal covered matrix in accordance with the invention.

Referring to the drawing, 1 indicates a base member, 2, a matrix of relatively low melting point metal. The base member 1 has a marginal portion 3 which has been treated by roughening the same to form a seal between the applied spray metal and this marginal portion of the base member. Spray metal is applied from the nozzle of a metal spray gun shown schematically at 4. The spray metal shell 5 is formed over the matrix 2 and is sealed to the marginal portion 3 of the base member 1.

In accordance with my invention the matrix is fitted to a suitable substantially rigid base member as, for instance, a base plate. The base member, at least where covered by the matrix, should have a surface substantially impervious to liquefied matrix material and a melting or softening point materially higher than the melting and softening point of the matrix material. The base member is so selected that it provides a marginal portion, i. e., a surface or surface portion extending substantially from all sides of the matrix placed on the base member. This marginal portion is treated, either before or after the placing of the matrix thereon, for the purpose of conditioning the same to yield a seal between the applied spray metal and the marginal portion, substantially adjacent the matrix, against escape of liquefied matrix material. Such conditioning may comprise any method capable of adapting the marginal base member surface to receive and retain the spray metal applied thereto with a high and relatively close degree of bonding which may be accomplished for instance by sand blasting, grit blasting, machining, acid etching or the like or by any other suitable method imparting to the surface to be sprayed a substantially under-cut roughness or porosity, i. e., a roughness or porosity constituted by a multiple number of relatively closely spaced small depressions and projections with some of the projections overhanging some of the depressions. Spray metal, of a density and thickness sufficient to be substantially impermeable to liquefied matrix material, is thereupon sprayed onto the matrix and onto the pre-conditioned marginal portion of the base member on all sides of the matrix. The coats on the matrix and on the marginal portion are so applied that they form one substantially continuous uniform thin coat of spray metal covering the matrix and sealed to the marginal portion on all sides of the matrix. Spray metal may be thus applied for example by building up the respective coatings on the matrix and on the marginal portion successively to form the desired continuous thin coating, or, alternatively, both these coatings may be built up by uniformly spraying back and forth over the matrix and the marginal base member portion thereby alternately building up spray metal layers on each to form the desired coating. Whatever the procedure, it is important that the coating applied to the marginal portion of the base member is sealed to the latter against liquefied matrix material. A substantially continuous spray metal coating covering the matrix and sealed to the base member of a density of applied spray metal of between 80% and 90% of the normal density of the metal used is preferred. For best results it is recommended to apply a substantially continuous spray metal coating of the requisite density having a thickness preferably less than self-supporting and preferably not heavier than substantially $\frac{15}{1000}$ inch at the thickest place. A satisfactory coating is, for instance, one of approximately between $\frac{3}{1000}$ inch and $\frac{7}{1000}$ inch thickness. The requisite density of the first applied thin continuous spray metal coating in accordance with the invention may be obtained for instance by using a spray metal gun of the wire feed type, i. e., a device in which the metal to be sprayed is progressively fed into the heating zone of the device and using in this gun a fine gauge wire such as an .060 inch to .020 inch diameter wire. When proceeding in this manner, a dense spray metal coating of extreme thinness is formed, uniformly covering the matrix and pre-conditioned marginal portion of the base member, being effectively sealed to the latter on all sides of the matrix and constituted to prevent the leakage or bleeding of any subsequently liquefied matrix material through any portion of the thin coating or the joint between coating and base member. When spraying irregularly shaped matrices and particularly those having projections, it is essential to cover all projections very carefully with spray metal so as to insure an absolutely uninterrupted and continuous thin spray metal coating covering the entire matrix surface. After the thin spray metal coat has been applied in the herein set forth manner to the matrix and base member, the matrix being now effectively sealed inside this coat and the base member, further amounts of metal may be sprayed onto the coated matrix until a coating of satisfactory thickness, i. e., a coating at least capable of separation from the matrix as a substantially self-supporting structure, covering the surface of the matrix, has been formed, which coating is usually referred to as a shell. This application of additional spray metal, however, may now be carried out without observance of special precautionary measures. Furthermore, the additionally to be applied spray metal may now be sprayed at relatively high speeds and without regard to any particular density, temperature, amount or uniformity of application. Within the preferred embodiment of my invention, using a metal spray gun of the wire feed type, I may thus use a relatively much larger gauge wire than was hitherto possible in the making of spray metal molds of matrices of the herein described type, thereby permitting the very rapid building up of the spray metal shell. In this manner, by first

spraying with a small gauge wire a very thin preliminary coating of relatively high density onto the matrix in the manner indicated, and thereafter spraying with heavier gauge wire, molds of low melting point metal matrices can be made in a fraction of the time and with materially less skill than was hitherto required. Once the shell has been formed, as described, the same may be further backed up, if desired, by either spraying with metal or in any other manner, such as by casting a backing thereon.

When proceeding in accordance with the invention, an adjustment of the spraying conditions, in a manner to substantially eliminate any appreciable melting or softening of the surface of the matrix, is necessary only during the formation of the first applied thin spray metal coat of relatively high density and the formation of the spray metal seal of that coat to the base member. Such adjustment of the spraying conditions may, for instance, comprise spraying the matrix with relative slowness and/or at a greater distance from the spray gun, cooling the matrix, if necessary, etc. Once the first applied coherent spray metal coat and its seal to the base member is procured no further precautions relative the melting or softening of the matrix surface are necessary. On the contrary, I find it of advantage to so conduct the spraying that an amount of heat is imparted to the sprayed matrix sufficient to effect the melting thereof so that, at the completion of the spraying operation, the metal or alloy of the matrix is sufficiently fused to permit its removal from the spray metal shell in substantially molten condition. Such procedure substantially eliminates the necessity for an additional or extra heating of the matrix, after the completion of the spraying operation. In this procedure the further advantage is realized that it is possible to spray the matrix of the type hereinbefore set forth at a relatively high temperature and to thus obtain a spray metal shell of increased density and strength.

The spray metal should be so selected with respect to the matrix material that it possesses a melting and softening point higher than the melting and softening point of the metal or alloy of the matrix.

In general the separation of the spray metal shell from the matrix is effected by bringing the matrix to a temperature above the melting point of the matrix metal or alloy and below the softening point of the spray metal shell to thereby fuse the matrix, whereupon the spray metal shell will be released substantially intact and carrying on its surface in negative the design of the matrix. This may be accomplished by subjecting the matrix to the desired temperature either after the removal of the base member, or after the breaking of the spray metal seal between the spray metal coat and the base member, or, alternatively, prior to such removal or breaking. In the latter case the molten matrix material may be removed by way of the base in any suitable manner. A suitably plugged hole in the base member or base plate, for instance, may serve this purpose satisfactorily and the substantially molten matrix material may be removed therethrough by removing the plug. It is also possible, if desired, to drill a hole in the base member to release the molten matrix material. The removal of the matrix material in molten condition by way of the base member is sometimes found convenient in connection with the preferred embodiment of my invention, i. e., the spray metal application onto the matrix, subsequent to the formation of the coherent spray metal coat and its seal to the base member, under conditions effecting a substantial melting of the matrix material while spraying.

In many cases it may not be necessary to subject the entire matrix to the fusion temperature of the matrix material or to effect a fusion of the matrix in toto; the desired removal of the matrix material may be often successfully accomplished by the fusion of but the surface of the matrix.

The foregoing description is furnished for purposes of illustration and not of limitation and it is therefore my intention that the invention be limited only by the appended claims or their equivalents in which I have endeavored to claim broadly all inherent novelty.

I claim:

1. In a process of making spray metal negatives of a matrix, which matrix consists essentially of a metallic material of low melting point, by spraying said matrix with metal, having a softening point and melting point higher than the softening point and melting point of said matrix material, removing the matrix material of at least the surface of said matrix in substantially fused condition and recovering the spray metal coating formed substantially intact, the steps comprising fitting such matrix to a substantially rigid base member, the surface of said base member underlying said matrix being substantially impervious to liquified matrix material, applying to said matrix, under conditions substantially assuring surface rigidity of said matrix, a coherent thin coat of spray metal, applying to the marginal portion of said base member, said marginal portion having been substantially preconditioned to receive and retain applied spray metal with a high degree of bonding adapted to form a seal against liquified matrix material, a coherent thin coat of spray metal, said coats of spray metal on said matrix and on said marginal portion being applied to form one substantially continuous uniform thin coat of spray metal covering said matrix and sealed to said marginal portion on all sides of said matrix and of a density and thickness sufficient to be substantially impermeable to liquified matrix material, thereafter applying to at least that portion of said continuous thin coat overlying the matrix at least one spray metal coat of a thickness at least sufficient to form with said continuous coat a substantially self-supporting shell.

2. In a process in accordance with claim 1 in which said last applied spray metal coat is applied under conditions substantially effecting the fusion of at least the surface of said matrix and in which said matrix is removed with at least the surface thereof still in substantially fused condition as the result of said spraying.

3. In a process of making spray metal negatives of a matrix, which matrix consists essentially of a metallic material of low melting point, by spraying said matrix with metal, having a softening point and melting point higher than the softening point and melting point of said matrix material, removing the matrix material of at least the surface of said matrix in substantially fused condition and recovering the spray metal coating formed substantially intact, the steps comprising fitting such matrix to a substantially rigid base member, the surface of said base member underlying said matrix being substantially impervious to liquified matrix material, applying to said matrix, under conditions including

rate of speed of spray metal application, substantially assuring surface rigidity of said matrix, a coherent thin coat of spray metal, applying to the marginal portion of said base member, said marginal portion having been substantially preconditioned by providing the same with an undercut roughness sufficient to receive and retain applied spray metal with a high degree of bonding adapted to form a seal against liquified matrix material, a coherent thin coat of spray metal, said coats of spray metal on said matrix and on said marginal portion being applied to form one substantially continuous uniform thin coat of spray metal covering said matrix and sealed to said marginal portion on all sides of said matrix and of a density not less than substantially 80% of the normal density of the metal sprayed and of a less than substantially self-supporting thickness, thereafter applying to at least that portion of said continuous thin coat overlying the matrix, at a rate of speed of spray metal application greater than the rate of speed of spray metal application at which said coherent thin coat of spray metal is applied to said matrix, at least one spray metal coat of a thickness at least sufficient to form with said continuous coat a substantially self-supporting shell.

4. In a process in accordance with claim 3 in which said continuous coat has a density substantially between 80% and 90% of the normal density of the metal sprayed and a thickness substantially between $^{3}/_{1000}$ and $^{7}/_{1000}$ inch.

5. In a process of making spray metal negatives of a matrix, which matrix consists essentially of a metallic material of low melting point, by spraying said matrix with metal, having a softening point and melting point higher than the softening point and melting point of said matrix material, removing the matrix material of at least the surface of said matrix in substantially fused condition and recovering the spray metal coating formed substantially intact, the steps comprising fitting such matrix to a substantially rigid base member, the surface of said base member underlying said matrix being substantially impervious to liquified matrix material, spraying onto said matrix under conditions, including rate of speed of spray metal application, substantially assuring surface rigidity of said matrix, a coherent thin coat of spray metal, spraying onto the marginal portion of said base member, said marginal portion having been substantially preconditioned by providing the same with an under-cut roughness sufficient to receive and retain applied spray metal with a high degree of bonding adapted to form a seal against liquified matrix material, a coherent thin coat of spray metal, said coats of spray metal on said matrix and on said marginal portion being applied by the use of a metal spray gun of the wire feed type, using therein a .060 inch to .020 inch diameter wire to form one substantially continuous uniform thin coat of spray metal covering said matrix and sealed to said marginal portion on all sides of said matrix and of a density not less than substantially 80% of the normal density of the metal sprayed and of a less than substantially self-supporting thickness, thereafter spraying metal with such spray gun onto said continuous thin spray metal coat at a rate of speed of spray metal application greater than the rate of speed of spray metal application at which said coherent thin coat of spray metal is applied to said matrix and using a wire in such spray gun in excess of the diameter size of said first used wire and continuing such spraying at least until a spray metal coat is obtained of a thickness at least sufficient to form with said continuous coat a substantially self-supporting shell.

6. In a process in accordance with claim 5 in which said last applied spray metal coat is applied under conditions substantially effecting the fusion of at least the surface of said matrix and in which said matrix is removed with at least the surface thereof still in substantially fused condition as the result of said spraying.

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