This invention relates to new and useful improvements in the application of sprayed metal coatings to solid objects.

This application is related to applicant's co-pending application Serial No. 792,836, filed December 19, 1947.

The industrial practice of coating a metal is frequently applied to solid objects by metal spraying. For this purpose the metal to be applied is projected against the surface to be covered in the form of a spray, the particles of which are in a molten or heat plastic condition. As a rule, metal spraying is carried out with the use of metal spray guns, i.e., devices in which the 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 surface to be sprayed. The propulsion may be effected either by centrifugal means or by means of a blast of air or other gas. One of the most widely used forms of spraying devices is a metal spray gun utilizing the metal to be sprayed in the form of a rod or wire which is fed by a suitable feed mechanism into a heating zone which is produced by the combustion of a combustible and a combustion supporting gas. Such rod or wire may be a relatively solid rod or wire of such metal, or alternatively it may be composed of particles of such metal bonded together by a suitable binder such as a plastic material. In the latter case the binder is usually of the kind which will volatilize as the result of the applied heat of the spray gun.

Application of sprayed metal is carried out for a variety of purposes, as for example to protect a surface such as a shaft or sleeve surface against corrosion, to provide a coating of the desired ornamental or bearing characteristics or to build up worn sections of parts.

In making spray metal coatings, particularly in the formation or rebuilding of bearings or other working surfaces of machine parts, it is essential that the applied spray metal adheres to the surface to which it is applied with a high degree of bond, for otherwise the applied spray metal may come off. For the purpose of securing the requisite degree of bonding, the surface to which the spray metal is to be applied is usually a rule suitable pre-conditioned. In the past such pre-conditioning treatment has been generally of two kinds—routenizing and heating. Routenizing has been carried out by mechanical routenizing and also routenizing by the deposition of metal by an electrical fusing procedure.

Mechanical routenizing of a metal surface to adapt the same to receive and retain applied spray metal must be of a type involving the formation of a multiple number of closely spaced cavities with peened and splayed edges and interspaces forming a multitude of key ways. In the past, the most common method of procuring such type surfaces has been by sand or grit blasting. Sand or grit blasting, however, is in many cases unsatisfactory and will often not yield a surface capable of bonding applied spray metal with a satisfactory degree of bond. Spray metal has a tendancy to shrink and in many cases a sand or grit blasted surface does not provide a sufficient bonding surface to prevent the separation of the applied metal coating from the base particularly under working conditions. Furthermore, many machine parts or the like, due to their configuration or their structural relation to other parts, are unsuitable for sand or grit blasting. One of the basic disadvantages of the sand or grit blasting procedure is due to the fact that the blasting causes compressive stresses in the blasted surface which frequently results in warpage of the object blasted, particularly where such object has a relatively thin section.

An alternative form of mechanical surface routenizing for spray metal bonding purposes is that of machine routenizing a surface to be sprayed in a particular manner designed to procure the above mentioned surface characteristics essential for spray metal bonding. This surface routenizing method, however, is such that it has the same inherent limitations and drawbacks as the ones involving sand or grit blasting. There is one basic limitation inherent in all of the methods of mechanical routenizing hitherto used for rendering metal surfaces capable of satisfactorily bonding applied spray metal. This limitation resides in the fact that these methods are not adaptable to hardened metal articles or surfaces. Thus, many hardened parts, for instance, cannot be properly surface-conditioned by mechanical routenizing procedures, such as grit or sand blasting or rough machining. Though partly hardened mechanical parts have been prepared by grit or sand blasting, using very hard grit such as aluminum oxide abrasive, nevertheless the bond obtained is usually very unsatisfactory.

Electrical methods of fusing or welding electrode metal to a base metal to produce a roughened surface consisting of the applied electrode metal have been used as a means for pre-conditioning metal surfaces for receiving and bonding applied spray metal. Such methods, however, have had the disadvantage of requiring special expensive electrical transformer equipment and also the further additional limitation that the
roughening or preparing of surfaces by these methods is slow and laborious and requires considerable skill on the part of the operator. One of the most important limitations of the electrical methods of surface preparation resides in the fact that a poor bond can be inadvertently produced by an operator because of the fact that poorly deposited electrode surfaces cannot be readily detected from that which is properly applied. Another limitation of the electrical methods of surface preparation lies in the fact that such methods cause localized heating of the base metal to relatively high temperatures. Such heating frequently causes localized changes in the metal structure of the base which materially reduces the fatigue strength of the base metal. Another disadvantage of the electrical method of fusing or welding electrode metal to a base metal to produce a roughened surface is due to the fact that such electrical method tends to produce tensile stress in the surface of the object treated and such stresses frequently cause warpage, particularly on an object that has a relatively thin section.

The heating method of surface conditioning of a metallic base to bond thereto applied spray metal involves the heating of the surface to a relatively high temperature and thereafter spraying the hot surface with metal. This method is not widely used and requires, as a general rule, considerable skill and elaborate equipment and is relatively expensive. Furthermore, in most cases the temperature to which the surface or base must be heated is so high that it tends to warp or otherwise destroy the article to which the metal spray is to be applied. A further limitation in the method of heating to produce bonding resides in the fact that most metals oxidize to an objectionable degree when heated in air. Another limitation inherent in the heating method is the fact that it is not feasible for use on most hardened metal articles as they will soften and thus lose their hardness if they are heated to the temperatures necessary to secure the desired degree of bonding to the spray metal applied thereto.

There is the basic limitation inherent in practical all of the hitherto used conditioning methods for rendering metal surfaces capable of satisfactory bonding applied spray metal. This limitation resides in the fact that all hitherto used conditioning methods materially adversely affect the surface condition of the base to which they are applied and all such methods require a distinct and costly step of pre-conditioning the base surface before the metal spraying operation can be performed.

One object of the invention comprises, inter alia, a method for applying spray metal to surfaces of inorganic materials including surfaces of metal and non-metal, and of the latter preferably vitreous surfaces such as glass or ceramic, which method is substantially free from the aforementioned limitations inherent in hitherto known practices.

Another object of this invention is to provide a method for bonding spray metal to surfaces and particularly to surfaces of metal and non-metal vitreous surfaces such as glass and other vitreous surfaces including ceramics, which does not materially affect the structure of more than a thin skin of the surface to which the spray metal is applied.

A further object of the invention is the novel spray metal coated articles in which the spray metal adheres to the base surface in a novel manner and with a high degree of bond.

The foregoing and still further objects of the invention may be seen from the following description:

The invention is essentially an improvement in the method for applying spray metal to an inorganic surface, particularly a surface of metal or of non-metal vitreous material, with a high degree of bond thereto. It consists essentially in coating the surface for spray metal bonding by spraying at least a flash coating of molybdenum thereon and thereafter spraying metal onto the thusly coated surface.

The invention is particularly applicable to surfaces which are usually not adapted to receive and retain applied spray metal with a desired degree of bond, such as for example relatively smooth surfaces. No other conditions or heating treatments need be applied.

Within the broad concepts of the invention the molybdenum sprayed onto the surface, to be therefrom coated with spray metal, may be applied to any desired thickness. By way of lower limit, a flash coating of the molybdenum suffices, i.e., a relatively thin coating as may be obtained, for instance, by a relatively low orifice size in the spray gun and not necessarily presenting a continuous coating. The more continuous the coating is, however, the better will be the bonding strength with which the subsequently applied spray metal will adhere to the base surface. If only relatively low bonding requirements exists, i.e., as for example when spraying relatively thin coatings of lower melting point metals, a smaller degree of continuity of the flash coating is required than would be necessary, for instance, a thicker coating of a higher melting point metal to be applied. In the latter case the higher bonding requirements necessitate a greater continuity of the flash coating. For best results, however, I find it of advantage to apply a substantially continuous flash coating of molybdenum onto the base. Within the limits of the embodiment of the invention at least .0005 inch and preferably .002 inch of substantially continuous molybdenum coating is recommended. The upper limit of the molybdenum coating is only dictated by practical and economical considerations. Once a coating thickness of the desired bonding characteristics is applied, any additional thickness will not further substantially improve the bonding characteristics of the molybdenum layer.

The metal spraying is preferably carried out by the use of a metal spray gun, using wire or rod as a source of metal.

The molybdenum that I may use in accordance with my invention may be pure molybdenum or a molybdenum alloy or composition. In the latter case I prefer a relatively high molybdenum content, such as an alloy or composition having 90% or more molybdenum. I may, however, use any alloy of molybdenum having 50% or greater molybdenum content and alloyed with any other metals which are known to alloy with molybdenum.

Wherever the term “molybdenum” is used herein, it is intended to designate thereby substantially pure molybdenum as well as alloys or compositions containing at least 40% molybdenum. When referring to a molybdenum composition I mean thereby a composition containing finely divided metallic molybdenum in combination with other elements or metals and not necessarily alloyed therewith.

The surface of the object to be metal sprayed...
may be perfectly smooth and no roughening or other conditioning treatment other than cleaning (if necessary) is required. The surface to be sprayed upon with molybdenum should, however, be a clean surface. Cleaning may be accomplished satisfactorily in numerous ways, such as by abrasion, light sand blasting, acid etchings, and the like procedures. These are particularly to be used with metals when there is any danger of oxides being present on the surface. If the surface is relatively clean of oxides and is merely to be freed from dirt particles or greasy matter, it may suffice if the same is cleaned with a suitable solvent or the like. Ordinarily after machining metals without the use of a lubricant or coolant, a surface emerges sufficiently clean to be immediately sprayed upon with molybdenum. In the case of glass, the degree of adhesion of the applied spray metal to the base may be further enhanced, if desired, if the glass surface is slightly abraded or frosted as by etching, light grinding or the like. This may be particularly advantageous when spraying onto a relatively cool glass surface to counteract or ameliorate the effects of possible heat shock.

A metal which is capable of being sprayed may then be sprayed directly onto the molybdenum sprayed surface. The final metal to be sprayed is selected according to its characteristics to meet the requirements of the particular job being done. For example, the journal of a rotating shaft may require hard-faced metal to operate in a journal bearing. For a case of this sort, a common metal to use would be high carbon steel. The journal would first be sufficiently undercut, such as by machining or grinding, to provide space for the application of the sprayed metal, a suitable molybdenum would then be metal sprayed onto the undercut surface of the shaft to a thickness of, for instance, .001 inch to .003 inch, and thereafter the high carbon steel would be metal sprayed onto the journal section to a sufficient thickness to permit machining or grinding of the metal sprayed surface to a desired final journal size.

Sometimes it is advantageous to preheat the surface of the object to be sprayed before the spray application of the molybdenum or after such application and prior to the application of the final coating of sprayed metal. In either case, the preheating tends to reduce the stress in the final sprayed-on coating and is carried out at relatively low temperatures (as compared with temperatures required by heat bonding methods). The preheating temperatures are of the order of magnitude of about 300°F. In the case of glass and ceramic objects, mild preheating may sometimes be advantageous to reduce the effect of heat shock on the glass. Heat shock sometimes results, when spraying on glass, at localized points where partially heated sprayed metal strikes the cold glass and cause strains which may subsequently become the focal points of localized fractures.

It is also at times of advantage to provide grooves and ridges or other forms of an irregular contour on the surface of the base to be metal sprayed. Such grooves or other irregular contours have several advantageous functions although they are not a necessary requirement of the bonding procedure set forth in this invention. One of the advantageous functions of grooves or other irregular contours of the base, is the increase in surface area which such contours provide, which results in an increase bond to the sprayed metal due to such increased area of bonding. Another advantageous function of such contours is the beneficial effect on the structure of the sprayed metal layer. Such beneficial effect is due to the folding of the stratification layers of such sprayed metal structure. Sprayed metal structures resulting from spraying onto a surface with an irregular contour are generally stronger due to the folding of stratifications or lamination than the structures resulting from the spraying of the same metal onto a substantially even surface.

One of the primary commercial advantages of this invention resides not only in the cost saving that results from the elimination of the previously required surface preparation step but frequently also in the saving of the spraying of the additional metal necessary to fill the intricacies and other spaces provided by roughening methods of surface preparation and also the saving in the additional time and expense required in machining or grinding the final sprayed metal surface. When roughening methods are used, the rough contours of the base are partially reproduced on the final surface and must be removed by machining or otherwise if an even surface is required. By the method in accordance with my invention it is possible for the first time to apply sprayed metal coatings to smooth surfaces, without the use of excessive heat or the use of roughening methods, and hence reduce the amount of metal spraying required and also the amount of final machining and grinding required on a typical metal sprayed machine element.

An outstanding advantage of the sprayed metal objects produced in accordance with this invention is the fact that the sprayed metal coating may be made extremely thin and may be even ground clear through to the base, producing a coating with a feather edge which will still remain securely bonded to the base. With previous methods of surface preparation, particularly methods involving mechanical roughening, such thin coatings, including feather edges, were not practical due to the failure of the bond at localized areas adjacent to the very thin sections of the sprayed coating.

In accordance with my invention it is entirely practical, not only to select molybdenum or a molybdenum alloy or composition for the first coating applied to the surface of the object, but also to use the same or a different molybdenum or molybdenum alloy or composition for the subsequently applied sprayed metal coating. In this case the entire coating could be of the same molybdenum or molybdenum alloy. The use of molybdenum for the subsequently applied sprayed metal layer is particularly advantageous for thin coatings such as could be used for restoring worn pressed fit areas of a shaft which is pressed into a hub. In such cases, it is unnecessary to undercut the shaft by machining or grinding in the usual manner since no additional minimum space is required for the sprayed metal. The worn areas are sprayed with molybdenum and thereafter ground to size. This practice produces very thin coatings with feather edges as they approach the ends of the worn area. This cannot be satisfactorily done with previously known methods of spray metal bonding by surface preparation.

When within the preferred application of the molybdenum a metallizing gun of the wire type is used for the carrying out of my invention, I
prefer to use a rod or wire of essentially pure molybdenum produced by sintering powdered molybdenum. Such a sintered rod or wire may be sprayed directly in such a metallizing gun but I prefer to mechanically work the sintered material by swaging and/or drawing to produce the final rod or wire.

Although the application of one subsequent metal to the first coating of molybdenum alloy on the object to be metal sprayed has been previously discussed, it is obvious that any number of different metals may be subsequently applied to form as many layers of different kinds of metal as desired.

The following examples are furnished by way of illustration but not of limitation:

**Example 1**

A carbon steel shaft having a carbon content of .45% is first mounted in a lathe and the area to be built up with sprayed metal is first reduced in diameter by a cutting tool to a diameter such as to leave sufficient space for the desired thickness of the therest-to-be-applied sprayed metal coating. In this case the desired coating is to be approximately .030 inch thick and it is desired that the finished sprayed metal coating be flush with the original diameter of the shaft. Therefore the original diameter of the shaft is undercut to .060 inch smaller in diameter than the original throughout the area to be sprayed.

The cutting with the tool in the lathe is done dry without use of lubricant or coolants so as to avoid contamination of the metal surface.

A flash coating, in this case approximately .002 inch thick, of molybdenum is then applied by spraying to the undercut surface of the shaft. This coating is applied by a conventional metallizing gun of the wire feed type, utilizing .091 inch diameter sintered and drawn molybdenum wire. The gun nozzle is held at a distance of about 5 inches from the surface of the shaft. The gun is adjusted so as not to have an excessively oxidizing type flame. During the application of the molybdenum coating, the shaft is rotated in the lathe and the gun is moved so as to cause the spray to rapidly traverse the surface of the shaft in order to apply the desired thickness of molybdenum in about two passes of the spray.

After the molybdenum coating has been applied a sprayed metal coating of an 18-8 type stainless steel is applied. This coating is applied using the same metallizing gun, a ¾” diameter wire of stainless steel being utilized in the gun and employing a standard spraying procedure by moving the spraying gun back and forth over the rotating shaft sufficiently rapidly to produce layers of metal approximately .005 inch thick with each pass of the gun. The gun is held with its nozzle approximately 6 inches distant from the surface of the shaft. The spraying is continued until the coating has been built up to a diameter approximately .015 inch larger than the original shaft diameter.

The sprayed stainless steel coating is ground to the original shaft diameter, utilizing conventional grinding equipment for the purpose.

**Example 2**

A cold finished mild steel plate approximately 2” x 3” x ¼” thick is used. One flat surface of the plate is cleaned with fine emery paper leaving a clean, substantially smooth surface.

A flash coating, in this case approximately .003 inch thick, of molybdenum is then applied by spraying onto the clean surface of the plate. The spraying is done by the use of a conventional spray gun of the wire feed type and molybdenum wire approximately .091 inch in diameter is used. The coating is applied by moving the gun so as to cause the spray to traverse the plate at a rate to apply the molybdenum coating in about five passes, holding the gun at a distance of approximately 6 inches.

High carbon steel containing approximately 80% carbon is then sprayed onto the sprayed metal surface on the plate using the same metal spray gun and a ¾ inch steel wire. The gun is operated in a conventional manner and a coating is applied by moving the gun so as to cause the spray to traverse the work at a rate such as to deposit between about .005 inch and .006 inch steel at a pass. The spraying is continued until a thickness of approximately ¼ inch of spray metal coating is obtained on the plate.

**Example 3**

A plate similar to the one prepared in Example 2 is prepared in the same manner and sprayed with a molybdenum layer in the same manner as set forth in Example 2. After the spraying of the molybdenum layer, a coating of aluminum bronze (approximately 9% aluminum) is applied, using the same metal spray gun and applying it in the same manner as described above in Example 2 for the application of high carbon steel. The aluminum bronze is applied to the same final thickness of approximately ¼ inch.

**Example 4**

As a means of evaluating the bond strength between the applied spray metal coatings and the base, the following test is conducted:

Plates are prepared, as set forth above in Examples 2 and 3. These plates consist of mild steel plates with thin coatings of sprayed molybdenum and coatings approximately ¼ inch of high carbon steel and aluminum bronze respectively. One end of each plate is smoothed so as to expose the boundary between the sprayed metal and the base. Pieces of these coatings are removed from the sprayed plates by placing the sharp point of a chisel at the edge of the ground surface of the plate at the boundary between the sprayed metal coating and the base and driving the chisel. Both the removed pieces of coating and the exposed surface of the base are then examined. The pieces of sprayed high carbon steel show continuous coatings of sprayed molybdenum on the side of the piece adjacent the plate, and the plate to which they were bonded also shows a continuous coating of molybdenum. The pieces of aluminum bronze show no evidence of molybdenum on the surface adjacent the plate, and the plate from which they were removed shows a continuous coating of aluminum bronze covering the sprayed molybdenum coating.

The test shows that the strength of the molybdenum layer in a direction perpendicular to the plate is stronger than the internal strength of the sprayed aluminum bronze in the same direction but weaker than the strength of the sprayed high carbon steel in this direction.

**Example 5**

The following further shows the strength with which the applied spray metal coating adheres to the base:

A test piece of a cold finished mild steel bar about 1 inch in diameter and about 2 inches long is used. A ¾ inch hole is then coaxially drilled
through the center of the rod. A cold finished mild steel rod, substantially closely but slidably fitting the bar, is ground flush with the first end to a smooth finish. Using the equipment and procedure as for instance outlined in Example 1, a 0.03 inch application slightly beyond the first end and leaving a handle portion at the second end. The rod is then secured in this position in the axial bore and is ground flush with the first end to a smooth finish. Applying the equipment and procedure as for instance outlined in Example 2, a 0.03 inch application is made on the ground surface covering the entire first end including the flush end of the rod. The rod is then pulled back, thereby shearing with a relatively sharply defined edge, the coating over the rod end from the coating over the first end of the bar. After removal of any surface burns the rod is replaced to its original position with the molybdenum surfaces flush with each other. 10% carbon steel is then sprayed, in the manner set forth in Example 2, to a thickness of about 1/4 inch. The thus prepared test piece is then placed in a testing device in which measurable pull is exerted on the handle portion of the rod and the amount of pull in pounds is observed which is required to break the rod from the applied spray metal. In this case the total pull required divided by the area of the molybdenum rod gives the tensile strength in pounds per square inch of the bond between the rod surface and applied spray metal. In this case the bond strength in tension is about 2000 pounds per square inch. Failure takes place within the molybdenum coating.

The metal spray gun of the wire feed type used in the above described examples is one having a normal capacity for spraying about 10 pounds of a 1/4 inch 10% carbon steel wire per hour. Oxidizing different capacity or other metal spraying devices of different type may be used, in which case the particular operating conditions are to be adapted to those regulating the normal spraying procedure of the particular equipment used, and if necessary with the additional provision of appropriate safeguards or adjustment to avoid excessive oxidizing conditions.

The molybdenum wire specified in the various preceding examples is a commercial sintered and drawn molybdenum wire conventionally designated as "black oxide finish—no anneal." It is a substantially pure molybdenum wire, and the wires or rods of molybdenum or molybdenum alloys or compositions may be substituted for the specific molybdenum used in the aforesaid examples with good results. Such are, for instance, molybdenum wire or rods commercially designated as "hydrogen cleaned and annealed" and "chemical plus hydrogen cleaned and annealed" and also such molybdenum alloys or compositions as 50-50 molybdenum-tungsten, 60-40 molybdenum - tungsten, 70 - molybdenum - 30-iron, and the like.

Particularly strong bonding characteristics are exhibited by the use of the molybdenum coating in conjunction with the alloys of steel, including stainless alloys of steel and also with the alloys of aluminum and of magnesium.

Any number of bases in combination with any number of applied spray metals may be prepared in accordance with the invention. Test pieces of various combinations which were prepared utilizing the equipment and procedures set forth in the preceding examples, showed in each case satisfactory adhesion of the applied spray metal to the base, failure usually occurring by fracture in either the molybdenum or the superimposed spray metal. By way of exemplification, suitable base metals for instance include steel, carbon steel and other steel and iron alloys either in the soft or hardened condition, including cast iron, nickel and the various nickel alloys such as Monel, Inconel and the like, copper and various copper alloys including brass, zinc, lead, tin, aluminum and aluminum alloys, magnesium and magnesium alloys, chromium - cobalt - and/or tungsten compositions or alloys. The following spray metals may be applied to these bases: aluminum and aluminum alloys, copper and copper alloys, including bronzes and brasses, steel, steel alloys including various carbon steels and also including stainless steel alloys, iron, zinc, lead and lead alloys including babbitt, tin and various other metals conventionally used for metal spraying.

During spraying operations it is advisable, as for instance set forth in the examples, to avoid conditions of oxidation during spraying. The reason is that excessive oxidation of the subdivided molybdenum particles will impair the adhesion characteristics of the ultimately applied spray metal coating to the base. Excessive oxidation conditions may be avoided by using a relatively slow wire speed for the molybdenum as it feeds through the gun and by using oxygen as little as possible and still obtain a sufficiently high temperature in the melting zone.

Under certain circumstances, it is recommended and may be desirable to reduce oxidation conditions during the spraying process by spraying in an atmosphere of a substantially inert gas and/or by utilizing a substantially inert gas as the blast conveying gas for the propulsion of the spray metal.

In the application of the invention to metallic surfaces, the same has proven useful for a variety of purposes, particularly in such cases as the repair of cylinder cracks, cracks across valve seats, filling cracks, defects or blow-holes in castings, etc. In addition to the relatively high degree of adhesion between the applied spray metal and the base, the products obtained in accordance with the invention show a relatively high resistance to corrosive influence upon the surface of the base. They are further characterized by relatively high shear strength, i.e., resistance to cleaving forces exerted through direction parallel to the surface direction of the base.

In the application of the invention to nonmetal substantially vitreous surfaces and particularly to surfaces of glass and ceramics, the molybdenum is applied in essentially the same manner as specified in the hereinabove enumerated examples, using essentially the same spraying technique and equipment. The ultimately applied spray metal adheres to the base with a high degree of bond and no surface preparation of pre-treatment other than cleaning is necessary.

The following examples are furnished by way of illustrating the application of the invention to these type surfaces:

Example 6

The surface of a glass-lined steel tank from which a portion of the glass had been accidently chipped is desired to be repaired. The crack should be enlarged sufficiently to permit easy application of the metal spray by means of a small portable grinder. The edges of the glass should be ground to a taper and an area surrounding the defect should be ground slightly.
A flash coating of molybdenum just thick enough to completely cover the defect is applied by metal spraying in a manner using the equipment set forth in the preceding examples. In this case, however, the nozzle is set at a distance of approximately 12 inches away from the glass surface in order to avoid heat shock to the glass giving rise to an impairment of its strength.

Pure tin is then sprayed onto the molybdenum-coated defective area, using conventional metal spraying equipment and technique, to a sufficient thickness to permit of finishing to the original surface contour of the glass tank.

The tin is then finished by grinding with a portable grinding tool, to as nearly as possible conform to the original contour of the glass-lined tank. If desired, the tin surface may be hand polished, such as by use of a fine abrasive cloth.

Example 7

A glazed ceramic insulator to which it is desired to attach a metal ring may be prepared for soldering by metal spraying as follows: the glazed surface of the porcelain to which it is desired to solder is coated with a thin layer of molybdenum by metal spraying approximately .002 inch thick in the manner set forth in the preceding example. Prior to metal spraying the area which is not to be coated, is protected from the metal spray by masking with a suitable mask such as conventional adhesive masking tape.

Thereafter a coating of approximately .005 inch of copper-bearing spray is sprayed in the conventional manner, as for instance set forth in the preceding examples, onto the surface covered by the molybdenum.

The sprayed copper coating firmly adheres to the porcelain and may then be soldered by using lead-tin solder in the conventional manner.

Magnesium or aluminum alloy can be substituted for the porcelain in the above example, thereby making available for the first time an effective method for the satisfactory soldering to these metals and their alloys.

In the application of the molybdenum spray onto non-metallic surfaces, it is of course understood that the surface to which the spray is to be applied should be one which does not tend to decomposition at the temperature to which the surface sprayed becomes heated.

In the application of the process to vitreous surfaces, adhesion of the applied spray metal to the base is of a high order, tests showing failure to occur in the vitreous material. As set forth in the example, when spraying molybdenum onto vitreous surfaces, it is desirable to spray at a somewhat greater distance from the surface to be sprayed than is normally used when spraying metallic surfaces. This is in order to avoid heat shock. Alternatively, however, the vitreous surface may be pre-heated and in some cases it may be desirable to resort to a combination of pre-heating and spraying at a greater distance from the base. In all cases, however, the distance should not be so great that the spraying efficiency is interfered with by over-cooling of the propelled metal spray before it reaches the base surface to which it is applied.

Another advantageous application of the invention by way of preferred embodiment thereon is the manufacture of thin bearing shells. Thin shells of a hard metal such as steel lined with a still thinner inner coating of a bearing metal are used extensively for bearing bushings to operate with rotating journals of shafts, such as crank shafts in automobiles, aircraft engines, etc. In the past, it has not been practical to apply the bearing metal to such thin shells because the method of preparation for bonding sprayed metal have been destructive to such shells by causing severe warpage. For economically applying sprayed metal to such shells it is necessary that any method of preparation used leave a relatively smooth surface because of the very thin amount of bearing metal.

The following example is furnished by way of illustrating the manufacture of such thin bearing shells having a sprayed bearing metal thereon:

Example 8

A thin bearing shell for use for the backing of a bearing metal for an aircraft engine connecting rod bearing is to be surfaced with a suitable bearing metal. The shell in this case consists of a strip of steel 1" wide and ¼" thick which has been formed into the shape of a semi-circle 2½" in diameter. The inner surface of the shell is to be coated with silver with a final thickness after finishing of .005 inch.

The thin metal shell is coated with a flash coating of molybdenum by metal spraying just thick enough to completely cover the inner surface. The spraying of the molybdenum in this case is carried out the same as described in connection with Example 1.

The molybdenum coated inner surface of the shell is then sprayed with silver using the same metal spray gun and .991 inch diameter silver wire to a thickness of .007 inch.

The shell is then machined to a smooth surface about .002 inch of silver being removed to produce the desired finish and diameter.

It is understood that any bearing metal may be applied in accordance with the invention to any relatively thin shell of a relatively hard backing metal. Within the preferred application of this embodiment of my invention the sprayed bearing metal is applied onto a molybdenum sprayed hard metal backing shell substantially not exceeding ¼" thickness.

It is apparent from the foregoing that the novel spray metal coated article in accordance with the invention thus broadly comprises an article having a substantially inorganic surface, such as a metal or non-metal surface, a layer of spray metal and intermediate said inorganic surface and said layer of spray metal, in surface-to-surface bond therewith, a layer of sprayed molybdenum of at least flash coating thickness.

The foregoing specific description is for the 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 equivalent wherein I have endeavored to claim broadly all inherent novelty.

I claim:

1. In the method for applying spray metal to a substantially inorganic surface with a high degree of bond, the improvement which comprises conditioning such surface for spray metal bonding by spraying from substantially molten condition at least a flash coating of molybdenum thereon and thereafter spraying from substantially molten condition metal onto the thusly coated surface.

2. The improvement in accordance with claim 1
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in which said molybdenum is sprayed from substantially molten condition onto a metal surface.

5. The improvement in accordance with claim 2 in which said molybdenum is sprayed from substantially molten condition onto said metal surface to form substantially a coating of at least about .002 inch thereon.

4. The improvement in accordance with claim 2 in which said molybdenum is sprayed from substantially molten condition onto said metal surface to form substantially a coating of at least about .0005 inch thereon.

5. The improvement in accordance with claim 3 in which said molybdenum is substantially pure molybdenum sprayed from substantially molten condition onto a steel surface.

6. The improvement in accordance with claim 3 in which said molybdenum is substantially pure molybdenum sprayed from substantially molten condition onto a magnesium alloy surface.

7. The improvement in accordance with claim 3 in which said molybdenum is substantially pure molybdenum sprayed from substantially molten condition onto an aluminum alloy surface.

8. The improvement in accordance with claim 3 in which said molybdenum is sprayed from substantially molten condition onto a substantially non-metal substantially vitreous surface to form substantially a coating of at least about .0005 inch thereon.

9. The improvement in accordance with claim 2 in which said molybdenum is sprayed from substantially molten condition onto a glass surface to form substantially a coating of at least about .0005 inch thereon.

10. The improvement in accordance with claim 2 in which said molybdenum is sprayed from substantially molten condition onto a substantially vitreous ceramic surface.

11. In the method for applying spray metal to a substantially inorganic surface with a high degree of bond, the improvement which comprises conditioning such surface for spray metal bonding by spraying from substantially molten condition a coating of molybdenum of at least about .0005 inch thickness thereon.

12. Method for preparing thin bearing shells which comprises conditioning the bearing surface of a relatively thin shell of relatively hard backing metal for spray metal bonding by spraying from substantially molten condition at least a flash coating of molybdenum thereon, and thereafter spraying bearing metal onto the thusly coated surface.

13. Method in accordance with claim 12 in which said shell is not over substantially 1/4" thick and in which said molybdenum is sprayed from substantially molten condition to form substantially a coating of at least about .0005 inch thereon.

14. Method in accordance with claim 12 in which said bearing metal is silver and in which said molybdenum is sprayed from substantially molten condition to form substantially a coating of at least about .0005 inch thereon.

ARTHUR P. SHEPARD.

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