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PROCESS OF BONDING METAL

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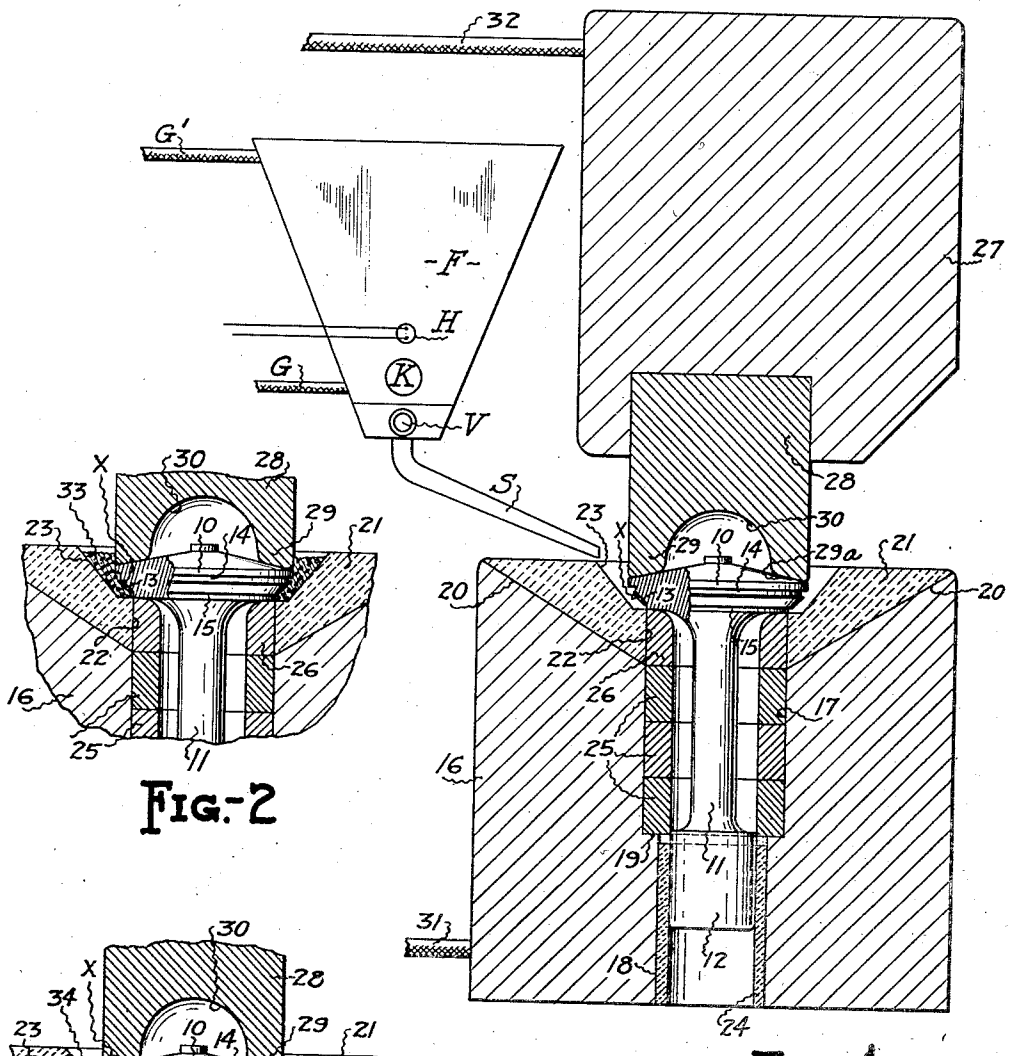


FIG.-1

FIG.-2

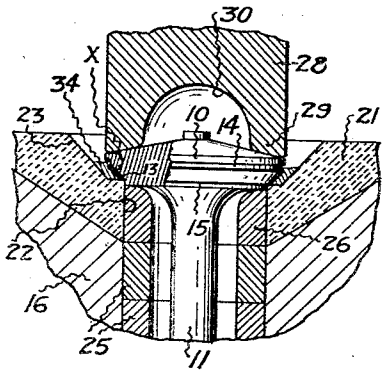


FIG.-3

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PROCESS OF BONDING METAL

Antonio Longoria, South Euclid, and Christian Girl, Madison, Ohio, assignors, by direct and mesne assignments, of one-half to said Antonio Longoria and one-half to Unit Rays, Inc., Cleveland, Ohio, a corporation of Ohio

Application March 18, 1942, Serial No. 435,216

2 Claims. (Cl. 219—12)

This invention relates to a process of bonding metals, and has for its general object to enable metals having different melting points to be bonded together without the migration of a substantial or detrimental proportion of either of the metals into the other. A field wherein the prevention of such migration is particularly important is the production of valves for internal combustion engines, such as those which are employed with airplane engines, wherein the tapered or frusto conical seating portions of the valve heads are provided with rings of an alloy known as Stellite, the said rings being so employed because they possess the properties of being "hot hard"; of being resistant to shock as by impact, as well as resistant to oxidation by the lead content of the high octane fuels used in said engines. It has been found difficult heretofore to prevent, during the bonding operation, the detrimental migration of one or more of the constituents of the alloy of the valve head from entering into the alloy of the Stellite ring in such proportion as to render it incapable of retaining, substantially unimpaired, all of the properties which are essential to its continuous satisfactory operation.

It is the general purpose and object of our invention to provide a method for bonding metals of different melting points, and more particularly for bonding Stellite rings to the seating portions of the aforesaid valve heads, in such manner that any detrimental migration of one or more of the constituents of the alloy of the valve head into the alloy of the Stellite ring will not occur; also that any detrimental migration of one or more of the constituents of the alloy of the Stellite ring into the alloy of the valve head will not occur.

As is well known to those familiar with the construction of valves for airplane engines, the alloy of which the heads of these valves are usually composed consists of steel alloyed with nickel and/or chromium; that is to say, the heads of these valves are made of steel alloyed with nickel and, in the case of valve heads as produced by leading manufacturers for the exhaust valves of airplane motors, these heads also contain chromium. The alloy of which the Stellite rings are composed consists principally of cobalt alloyed with chromium, and the proportions of chromium to cobalt may vary from 10% to 50% by weight of the former to the weight of the latter, as stated in Hackh's Chemical Dictionary, published by P. Blakiston's Son & Co. Inc. in 1929. In addition, the alloy also usually contains a small percentage of tungsten.

It is well known that the alloys from which the valve heads referred to are made have melting points varying between 2700° F. and 2800° F., while the Stellite which we have used has a melting point varying from about 2300° F. to 2400° F. Hence it follows that, in order to provide the seating portions of the valve heads with Stellite coverings or rings, it is first necessary to bring the surfaces of said seating portions to a temperature sufficient to render the same soft or semisoft, in order that they may be in suitable condition for molten Stellite to form a satisfactory bond therewith. Notwithstanding the fact that great care must be taken in the performance of this operation, a certain amount of intermingling of metal from the valve-head alloy with the Stellite has frequently occurred, such intermingling being of a sufficient extent to render the latter unsuitable for performing its intended functions. We are enabled to prevent metals comprised within a valve-head alloy, such as described herein, as well as those within the Stellite alloy, from migrating from one of such alloys into the other to any substantial or detrimental extent, by interposing, between the tapered seating portion of the said head and the Stellite to be bonded thereto, what we term an "isolator," said isolator possessing a melting point higher than that of the Stellite and no higher than, and preferably approximately the same as, that of the valve-head alloy, and having been suitably applied to the seating portion of the valve head previously to the operation of bonding the Stellite thereto, and said isolator also being capable of forming a satisfactory bond with both the seating portion of the valve head and the Stellite ring.

We have found that certain metals of the iron-chromium-cobalt-nickel-manganese group possess melting points higher than that of Stellite and approximating the melting point of the valve head alloy. Of the metals possessing such melting point (chromium, cobalt and nickel), our experience with chromium shows that it is admirably adaptable as a bonding isolator, due not only to its ability to form a satisfactory bond between the seating portion of the valve head and the Stellite ring but also because it is itself a constituent, to a large degree, of the alloys of which the valve heads and the Stellite rings are composed. It can be electrically deposited upon the seating portions of the valve heads; its melting point is considerably higher than the melt-

ing point of Stellite and is substantially the same as the melting point of the alloy steel used in the production of valve heads. Furthermore, when applied to the seating surfaces of the valve heads by being electrically deposited thereon, it not only provides a covering or coating for said portions, but, as experience has shown, is firmly bonded thereto by the penetration, to a shallow depth, of portions of the inner surfaces thereof into the outer surfaces of the seating portions of the valve heads. When the chromium is applied to the seating portion of the valve head by electrical deposition, the coating or covering is much thicker than that which is ordinarily used for purely protective coverings, being from .005 to .010 inch in thickness.

The chromium coating may be applied only to the seating portions of the valve heads by protecting the remainder of the valve head surfaces which are immersed in the plating bath with any of the well known coatings employed for such purpose; or the whole valve head may be plated and the surplus plating removed during the final machining operations.

It will be obvious that, where the seating portion of the valve body is heated to a temperature whereby the skin thereof becomes softened, the chromium thereon will soften to about the same degree, but without intermingling with the alloy steel of the valve head to any appreciable extent, other than the limited intermingling between the inner skin of the chromium and the outer skin of the valve head necessary to provide a sufficient bond.

In carrying out our invention, we preferably employ the apparatus shown in the drawing hereof, wherein Fig. 1 is a vertical sectional view through the means for supporting and heating the valve body and for supplying heat to the surface of the tapered frusto conical seating portion thereof, the valve being shown in sectional elevation; and an electric furnace, having means for controlling the temperature thereof and means for automatically cutting off the supply of current to the peripheral portion of the valve, being shown schematically; Fig. 2 a detail in sectional elevation of the valve head, mold and electrode shown in the preceding view and wherein the Stellite within the mold is in a divided condition; and Fig. 3 a view similar to Fig. 2, but wherein the Stellite is employed in the shape of a preformed ring of the same.

The apparatus shown in Fig. 1 is substantially identical with that shown, described and claimed in the application of Antonio Longoria, filed February 4, 1942, Serial No. 429,556 (now Patent No. 2,377,163, dated May 29, 1945), and the portions of the apparatus shown in Figs. 2 and 3 are substantially the same as those shown in the application of Antonio Longoria, Serial No. 431,605, filed February 19, 1942 (now Patent No. 2,358,090, dated September 12, 1944).

Describing briefly the apparatus shown in Fig. 1, 10 denotes generally the head of a valve, such as is employed with the engines of airplanes, and 11 the stem thereof, the said stem having an enlarged cylindrical lower end 12 and being also provided with a tapered or frusto conical seating portion 13, shoulders 14 and 15 being shown as provided respectively above and below the said seating portion. It will be understood that the drawing does not show the valve in the final machined condition which it will assume before it may be assembled into an engine. The surplus metal appearing thereon in various places facilitates the application of the Stellite facing thereto and the machining of said facing, as well as subsequent processing steps.

16 denotes a block of material possessing high electrical conductivity and incidentally high heat conductivity. The material which we prefer to use is copper, because it possesses high electrical conductivity. As will be noted, this block is of large cross-sectional area, whereby it is capable of carrying a heavy or high current without becoming unduly heated thereby; it is shown as provided with an upper cylindrical bore section 17 and a lower cylindrical bore section 18 constituting an extension of the upper section but being of less diameter than the same, there being an annular shoulder 19 interposed between the said bore sections.

The upper surface of the block 16 is formed into an inverted frusto conical seat 20, extending outwardly from the upper end of the bore section 17. This seat supports a mold 21 of refractory material, such as lava rock, which will not carburize the metal therewithin and which will not short-circuit the current. The mold is shown as provided with a bore 22 constituting an extension of the bore section 17. This bore 22 extends preferably upwardly as far as the bottom of the lower shoulder 15 of the valve head, the said bore being preferably of the same diameter as that of the shoulder. An annular mold cavity 23 is provided between the upper surface of the mold and the peripheral tapered portion of the valve head. The mold is shown as extending above the upper shoulder 14 of the valve body, for purposes to be described hereinafter.

24 denotes a bushing of refractory material fitted within the lower bore section 18 and serving as a means for centering the lower end 12 of the valve stem and electrically insulating the latter from the block 16.

The shoulder 19 is shown as supporting a plurality of rings 25 of carbon possessing relatively high electrical resistivity and low heat conductivity, the said rings engaging the surrounding wall of the bore section 17. These rings extend upwardly as far as the bottom of the mold 21.

26 denotes an electrode in the form of a ring of carbon of high heat resistivity and somewhat lower specific electrical resistivity than the rings 25. The carbon which we prefer to use for this purpose is graphite. It will be noted that the ring 26 fits within the bore 22 of the mold and that its upper end is beveled outwardly from the interior thereof, whereby only a limited annular contact area is provided between the top of the ring and the lower shouldered portion 15 of the valve head, adjacent to the bottom of the surface of the tapered portion 13 of the valve head. Due to this beveling of the graphite ring, its electrical resistance is greatly increased where it contacts with the valve head.

27 denotes an upper block, preferably of copper, having a large diameter whereby it is capable of carrying a heavy electrical current without being unduly heated thereby.

28 denotes an electrode which is mounted within a cavity provided therefor in the lower end of the block 27, the said electrode also being preferably of graphite, for purposes explained in connection with the electrode ring 26, and having its lower end formed into an external ring 29 surrounding a central cavity 30, said ring having a downwardly and outwardly beveled surface 29a which is adapted to engage the upper external

portion of the valve head above the shoulder 14 and above the upper end of the surface of the tapered seating portion 13. The effect of beveling the lower end of the ring 29 is the same as that accomplished by beveling the upper end of the ring 26.

The electrodes 26 and 28 and the rings 25 are removable for purposes of renewal, reshaping and substitution.

F indicates schematically an electric furnace provided with heating conductors G, G' and with a thermostat, indicated at H, which operates, in connection with one of the well-known types of current regulators, to control the temperature of the molten metal in the furnace. K denotes a pyrometer for indicating visually the temperature of the molten metal; it can be used also in connection with hand-operated means for controlling the current which heats the furnace and thereby the temperature of the molten metal. Through the employment of an apparatus such as shown in Fig. 1 and just described, electric current will be supplied through the conductors 31, 32, the conductor blocks 16 and 27 and the rings 22, 25, 26 and 29 through the peripheral portion of the valve head including the chromium coating X, whereby said coating will become softened to an extent to enable it to form a bond with molten Stellite introduced into the mold from the furnace F. The chromium coating having thus been rendered suitable for forming a bond with the Stellite and the molten Stellite having been delivered into the mold, the supply of current is discontinued. The Stellite will become firmly bonded to the chromium and thereby to the portion 13 of the valve head. Should the outer skin or surface of the portion 13 of the valve head become softened during this operation, there will be no substantial intermingling of the chromium with the alloy steel of the valve head, the intermingling being limited to the contacting skin portions of the chromium and the valve head; and the molten Stellite will be bonded to the chromium, but the iron constituent of the valve metal cannot intermingle with the Stellite because of the action of the chromium as an isolator between the Stellite and the valve head, due to the fact that the affinity between the iron constituent of the valve head and the chromium is greater than the affinity between such iron constituent and the cobalt in the Stellite. However, should there be a slight migration of the chromium into the Stellite, it should not interfere with the characteristic performance of the Stellite as a valve facing, since it already contains a high percentage of chromium. Furthermore, should there be a slight intermingling of the chromium with the valve metal alloy, due to the affinity between the iron of the valve metal alloy and the chromium, this intermingling would be negligible in its results, since the valve metal contains a substantial percentage of chromium.

Since, as has been pointed out, the chromium has been firmly bonded to the surface 13 during the electroplating process and since this bonding will be increased during the heating period, and since, further, the latter is in a softened or semi-softened condition, a solid bonding of the Stellite with the metal of the valve head shoud be effected, and without the undesirable intermingling of any of the metallic constituents of the Stellite and valve body.

Our method of interposing an isolator between the Stellite and the seating portion 13 may also be employed where the Stellite is placed in a divided condition around the seating portion 13, as shown at 33 in Fig. 2, or may be applied in ring-form to said portion, as shown at 34 in Fig. 3, all of the Stellite in the former case, and at least the portion of the Stellite in contact with the seating surface in the latter case, being melted by raising the outer surface of the portion 13 of the valve head and the chromium plating thereon to a temperature sufficient to render the chromium plating suitable for forming a bond with the molten Stellite in contact therewith.

It will be evident that the apparatus shown herein is only illustrative of one means for heating the insulating coating and the tapered seating portion of the valve head.

It is within the purview of our invention to apply the chromium to the seating portion 13 of the valve head in other manners than by electrically depositing the same thereon. If desirable, it may be formed into a ring of suitable shape to be fitted upon the outer surface of the portion 13; and, when the surface of the said portion 13 and the surrounding chromium ring are heated to a temperature sufficient to soften the chromium, it will be firmly bonded to the said portion; and the Stellite may be bonded to said ring at this time, or by a subsequent heating operation in the manner hereinbefore described. The chromium may also be bonded to the seating portion 13 of the valve head in any other well known manner, prior to utilizing the same as an isolating means for bonding the Stellite to the said seating portion.

It is believed that nickel can also be used in the same manner as chromium for the purpose of enabling Stellite rings to be bonded to the seating portions of valve heads without any substantial or detrimental migration of one or more of the constituents of the valve-head alloy into the Stellite alloy, and also without any substantial or detrimental migration of one or more of the constituents of the Stellite alloy into the valve-head alloy; also without any substantial or detrimental migration of the isolator metal into the Stellite or into the valve-head alloy.

An important contributory factor to the realization of the objects of our invention is the shortness of time occupied in uniting the metal of lower melting point (as Stellite) to the metal of higher melting point through the interposed isolator.

The amount of current necessary to be delivered through the peripheral portions of the valve heads and the chromium coatings thereon in order to effect the bonding operation within the desired short period of time will vary with the diameter and other proportions of the heads. Where a valve head of about three-inch diameter is to be provided with a Stellite ring and the head is of the hollow sodium-cooled type, an alternating current of approximately 80,000 amps. and 3.15 volts will be effective in raising the temperature of the chromium coating to the desired degree to form a bond with the molten Stellite surrounding the same in from 12 to 18 seconds. Under like operating conditions, similar results can be obtained where nickel coatings are employed in place of chromium coatings.

Having thus described our invention, what we claim is:

1. The process of providing a frusto-conical peripheral portion of a valve head consisting of alloyed steel, with a surrounding ring of cobalt alloyed with chromium and tungsten and having a melting point lower than that of the said frusto-

conical peripheral portion, said process comprising the steps of electrically depositing upon said frusto-conical peripheral portion a covering of a metal selected from the group consisting of chromium and nickel and having a melting point approximating that of the frusto-conical peripheral portion of the said valve head but higher than that of the said alloy of cobalt, chromium and tungsten; placing the alloy for producing said surrounding ring in contact with the external surface of the said covering, throughout the entire circumferential extent of the latter; and simultaneously passing a heating electrical current only throughout the peripheral portion of the valve head and the entire extent of the covering, thereby to raise the temperature of the latter to a point sufficient to enable the external surface of the same to form a bond with the portion of the alloy of copper, chromium and tungsten in contact therewith, but with no appreciable mingling of the elements of the valve head with the elements of the said alloy surrounding the same.

2. The process of providing a frusto-conical peripheral portion of a valve head consisting of alloyed steel, with a surrounding ring of cobalt alloyed with chromium and tungsten and having a melting point lower than that of the said frusto-conical peripheral portion, said process comprising the steps of electrically depositing upon said frusto-conical peripheral portion a covering consisting essentially of chromium and having a melting point approximating that of the frusto-conical peripheral portion of the said valve head but higher than that of the material of which said ring is composed; placing a ring composed of such alloy of cobalt with chromium and tungsten in contact with the external surface of the said covering, throughout the entire circumferential extent of the latter; and simultaneously passing a heating electrical current only through the entire peripheral portion of the valve head and the entire covering thereby to raise the covering to a temperature sufficient to enable the external surface of the covering to form a bond with the portion of the ring in contact therewith, but with no appreciable mingling of the elements of the valve head with the elements of the said ring.

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