

Sept. 8, 1959

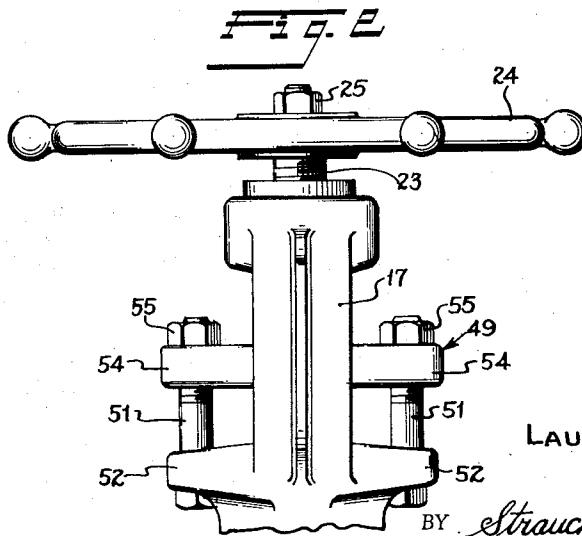
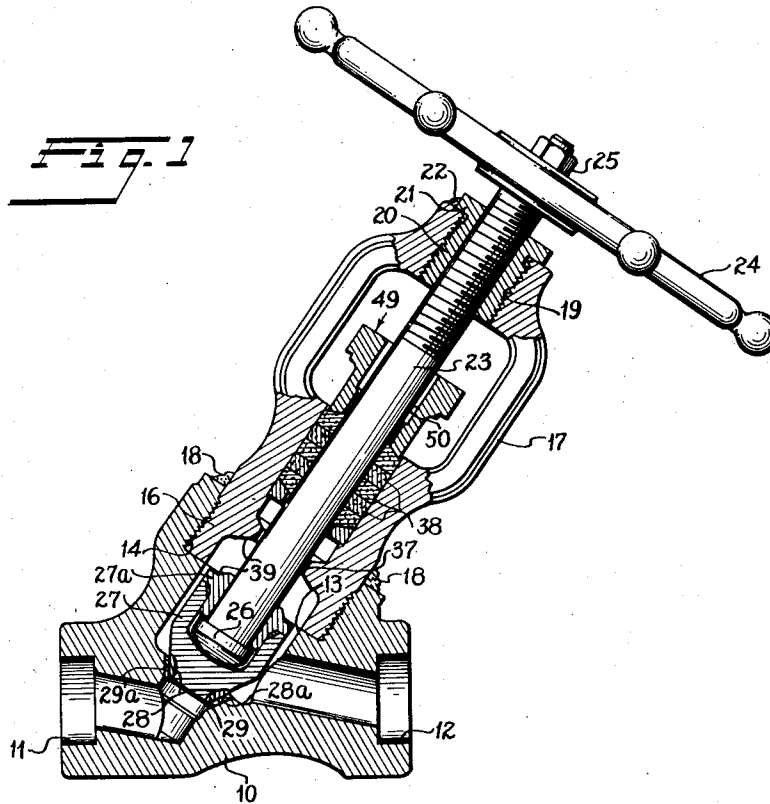
L. H. CARR

2,903,564

METHOD OF PROVIDING A WEAR RESISTANT SURFACE

Filed March 17, 1953

6 Sheets-Sheet 1



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METHOD OF PROVIDING A WEAR RESISTANT SURFACE

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Fig. 3

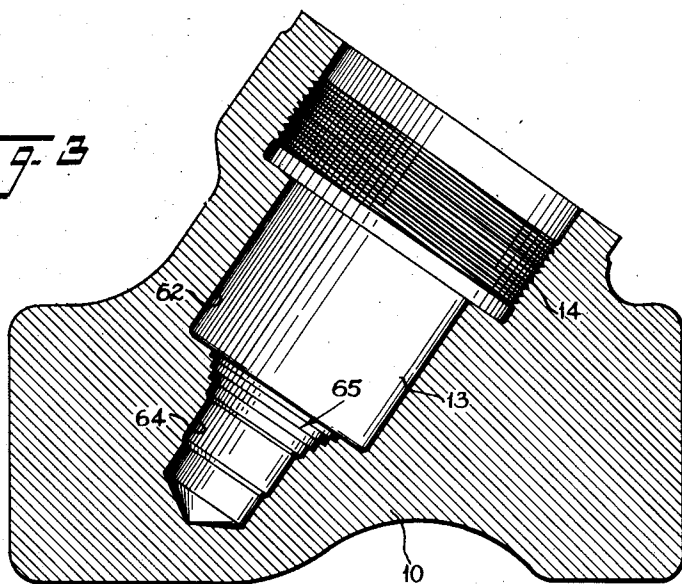


Fig. 4

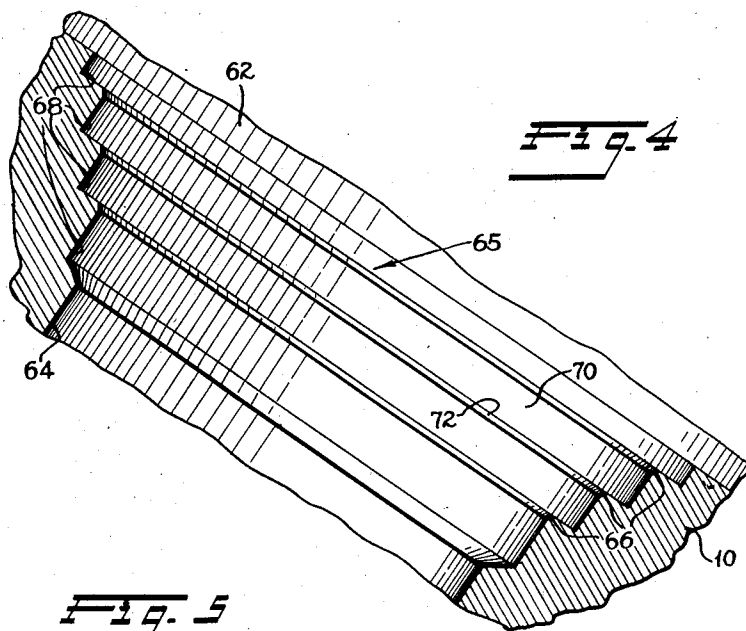
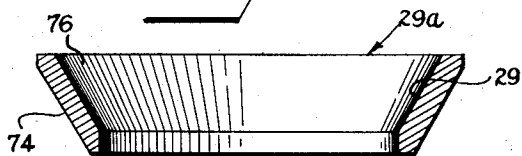


Fig. 5



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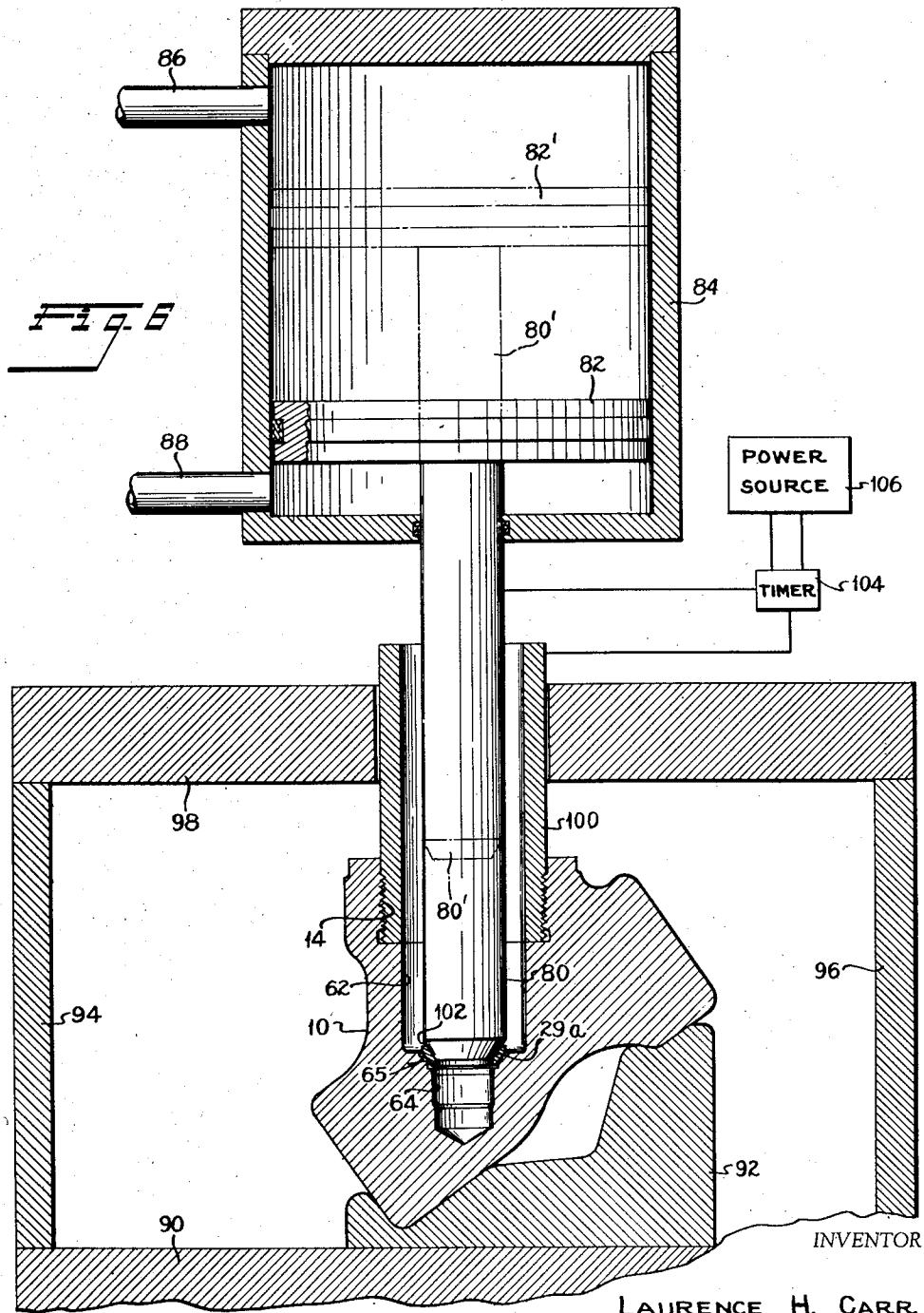
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METHOD OF PROVIDING A WEAR RESISTANT SURFACE

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6 Sheets-Sheet 3



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METHOD OF PROVIDING A WEAR RESISTANT SURFACE

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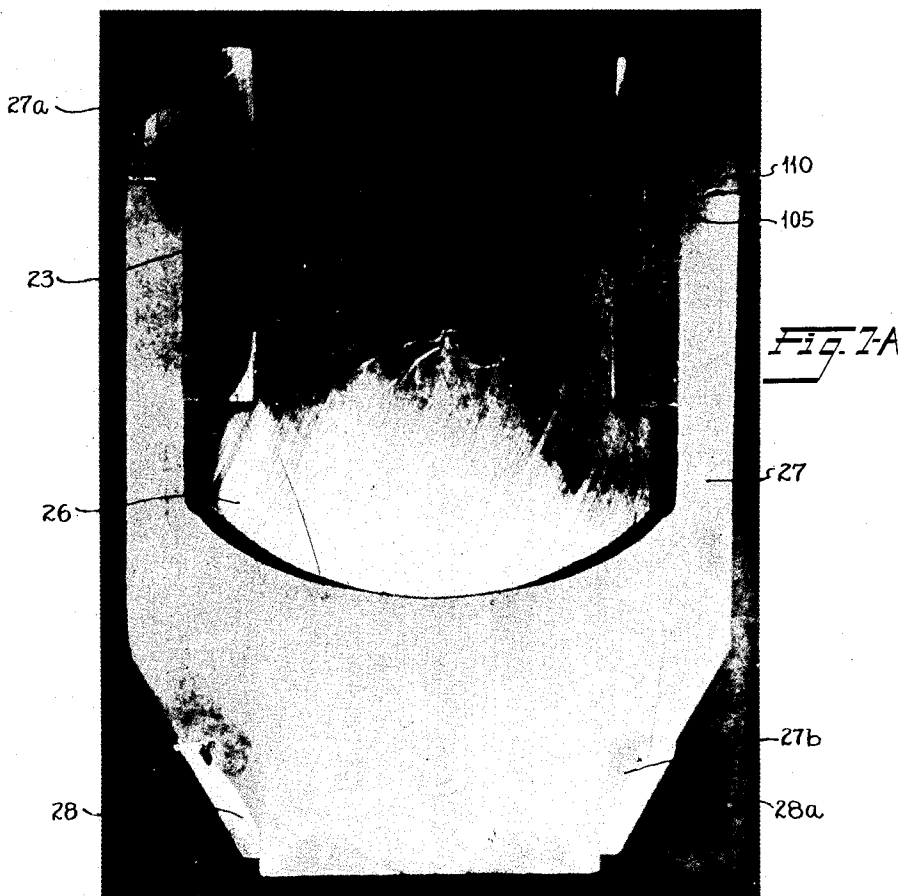


FIG. 8-A

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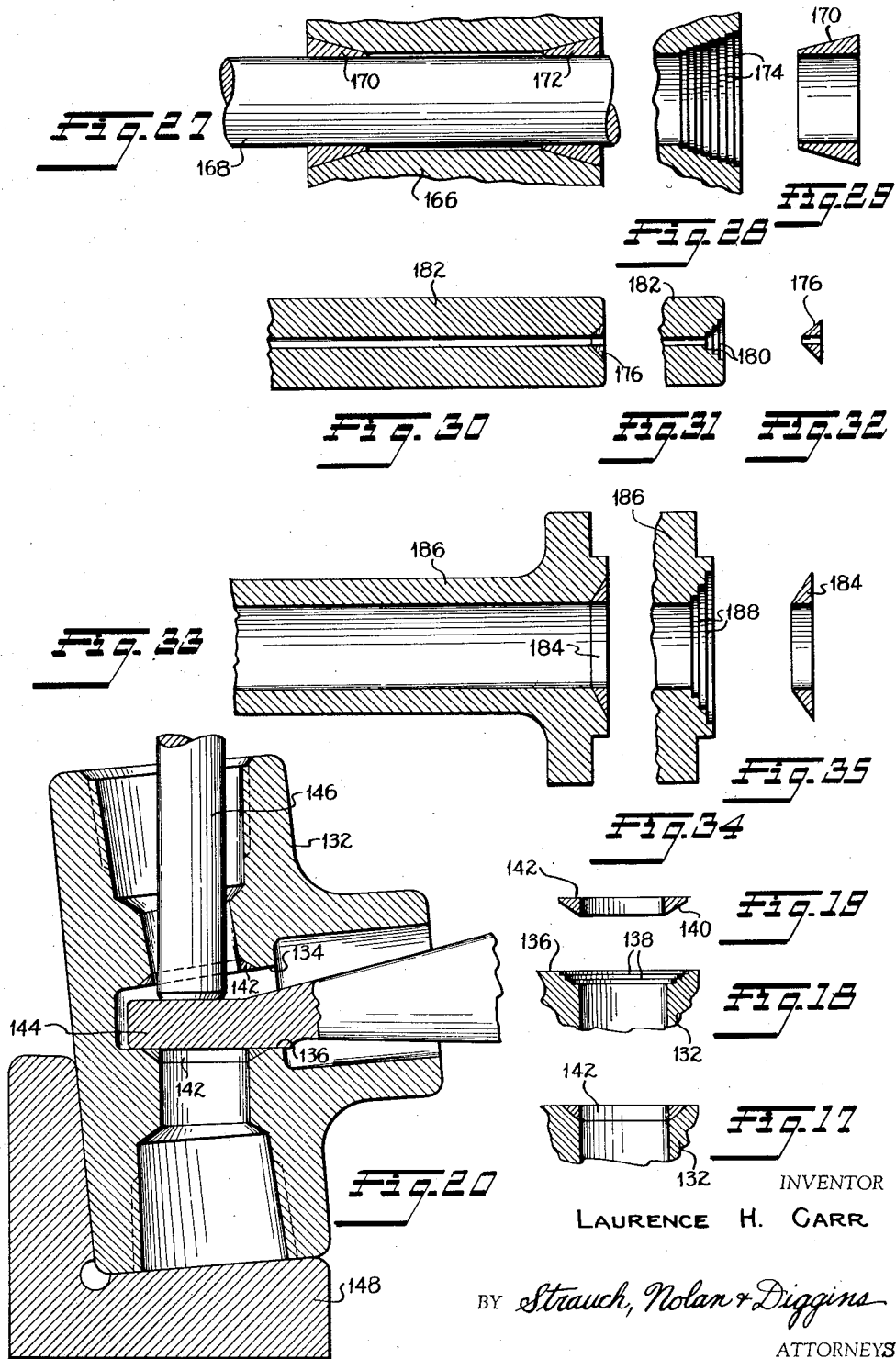
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METHOD OF PROVIDING A WEAR RESISTANT SURFACE

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2,903,564

METHOD OF PROVIDING A WEAR RESISTANT SURFACE

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Application March 17, 1953, Serial No. 342,951

33 Claims. (Cl. 219—107)

The present invention relates to improvements in articles of manufacture embodying metallic bodies having elements or inserts thereon formed of a relatively harder metallic material to provide wear resistant surfaces on such bodies and to improvements in the methods of producing such articles.

Wear resistant surfaces upon relatively softer bodies are needed in many applications. Examples of the need of such surfaces are for bearing surfaces and for the mating faces of valve seats and valve members. In certain of these applications, the wear to which the surfaces are subjected, as for example due to the high velocity flow of high temperature corrosive fluids, is so great that it can be withstood only by the extremely hard metallic alloys. Such alloys cannot be used however, to form the entire body member because they lack certain necessary physical characteristics such as strength and ductility, are extremely expensive, and extremely difficult to machine. In order to utilize the wear resistance of the hard metallic alloys for the surfaces subjected to wear and to avoid the difficulty of machining and high cost it has become customary in industry to provide an inserted element or an inlay of a hard metallic alloy material at the zone of wear in a relatively softer, machinable, less expensive body.

In the past, various methods have been used for mounting these inserted elements at the zone of wear. In the internal combustion engine industry, inserts of wear resistant alloys are provided on valve seats by allowing expansion of the inserts in position on the body member after they have been initially shrunk by subjection to extremely low temperatures as by being packed in Dry Ice. This technique is fully discussed at pages 19 et seq. of a 1939 copyrighted publication of Haynes Stellite Company entitled "Hard-Facing With Haynes Stellite Products." In other types of valves such as high pressure non-return valves, gate valves and the like wear resistant inserts have been provided by threading inserts into position in the valve body or on the valve member. This method may result in leakage after periods of operation even if it is not present when the valve is initially assembled. In the better valves heretofore known it has been customary to provide a wear resistant surface by producing an inlay of the hard alloy at the zone of wear of the valve body or valve member as by welding and to subsequently machine the surface to form a smooth face. These techniques are fully described in a 1935 copyrighted publication of the Haynes Stellite Company entitled "Haynes Stellite Valves." Since in many valves the zone of wear is located internally of the body structure at relatively inaccessible positions, this latter procedure is extremely difficult, time consuming and at best extremely wasteful of the expensive alloy materials since a considerable amount of the alloy is lost in the machining operation.

It is to the provision of hard alloy inserted elements providing wear resistant surfaces upon relatively softer machinable body members at a minimum of cost from

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the viewpoint of both labor and material costs that the present invention is primarily directed.

This fundamental consideration has been achieved by the refinement of the techniques used heretofore in the art of projection welding. The use of projection welding methods for attaching hard alloy metallic inserts to relatively softer bodies has been attempted in the past but, so far as I am aware, the actual techniques used have never produced commercially acceptable results. The prior art methods have resulted in improper alignment of the member and inserted element, distortion or cracking of the inserted element, or leakage between the member and inserted element due to the failure to form a complete bond therebetween. One example of such prior art attempts is disclosed in United States Letters Patent No. 1,732,241 issued October 22, 1929 to T. E. Murray, Jr. for Production of Valves. The present invention has, by refinements of the projection welding techniques used achieved commercially acceptable hard alloy inserts upon steel bodies which are commercially acceptable for the faces of valve seats and valve members, being free of leakage between the insert and the body member at extremely high fluid pressures and permitting the attachment of the insert to the body member without cracking or producing material distortion of the insert so that the wear resistant surface on the insert can be used with but a very light machining operation as a bearing or as a face for a valve seat or a valve member.

It is therefore a further fundamental object of the present invention to provide as an article of manufacture a body member having an inserted element projection welded thereto to form a wear resistant surface thereon in which the juncture between the insert and the body member is formed by the direct fusion of a substantially sharp edge projection on the relatively softer body member with a mating beveled surface on the insert to form a fluid tight bond therebetween without material deformation of the insert and to provide improvements in projection welding techniques by which such article can be manufactured.

More specifically, it is an object of this invention to provide a method of joining hard alloy inserts to a relatively softer metallic body by projection welding techniques in which the welding current, the duration of current application, and the pressure and area of engagement between the insert and body member during the time of current flow are so controlled that the insert is bonded to the body member in fluid tight relation without material deformation or distortion of the insert and without the formation of cracks in such insert.

It is a further fundamental object of this invention to provide commercially acceptable valve components having hard alloy inserts bonded to a relatively softer body member by projection welding to form a fluid tight bond between the insert and the body member without material deformation, distortion or the introduction of cracks into the insert whereby valve members and valve bodies may be produced which have longer life, which may be subjected to more strenuous wear and which, for equivalent performance, can be produced at a lower cost than any valves heretofore known.

Briefly the present invention contemplates the provision of a process for permanently securing in fluid tight relation to a steel member, such as a valve body or valve member, a wear resistant inserted element formed of a relatively hard alloy precision cast or otherwise suitably formed to predetermined dimensions and configuration by resistance welding without distortion or cracking of the element.

This invention contemplates in its preferred form the provision of a process for permanently securing in fluid tight relation to a steel member preformed with a series

of parallel annular concentric ridges spaced apart by grooves, an inserted toroidal element having an exterior frusto-conical surface engageable with the ridges to maintain accurate alignment therebetween by resistance welding of the element to the member by the passage of a high amperage electrical current therebetween for but a fraction of a second while maintaining a high pressure of engagement between the member and element.

This invention further contemplates the provision of a method of so mounting a relatively hard precision cast wear resistant ring on a steel member that the ring is resistance welded to the member in a fraction of a second in proper alignment therewith without material deformation or distortion of the ring.

These and other objects of this invention will become more fully apparent by reference to the appended claims and as the following detailed description proceeds in reference to the accompanying drawings wherein:

Figure 1 is a sectional view of a high pressure high temperature valve having several components embodying and constructed in accordance with the principles of the present invention;

Figure 2 is a fragmentary elevational view of the top portion of the valve of Figure 1;

Figure 3 is a sectional view of a valve body of the valve of Figure 1 and adapted for assembly with a valve seat forming ring in accordance with the present invention;

Figure 4 is an enlarged fragmentary sectional view of the valve body of Figure 3 illustrating the formation of the valve body for the reception of a valve seat forming ring;

Figure 5 is a sectional view of a valve seat forming ring construction in accordance with the principles of the present invention;

Figure 6 illustrates an improved apparatus constructed in accordance with the present invention to facilitate the performance of the valve body and seat ring assembly process of the present invention;

Figure 6A is a reproduction of an enlarged photograph illustrating in cross-section the actual bond between a valve body and seat ring in accordance with the present invention;

Figure 7 is a fragmentary longitudinal sectional view illustrating the component parts of the valve member of the valve of Figure 1 in assembled relation;

Figure 7A is a reproduction of an enlarged photograph illustrating in cross-section the valve member of Figure 7 as actually produced in accordance with the present invention;

Figure 8 is a longitudinal sectional view through the valve member per se;

Figure 9 is a sectional view through the insert ring element per se adapted for projection welding to the valve member illustrated in Figure 8 to form a hard wear resistant surface on the valve member for engagement with the valve seat;

Figure 10 is an enlarged fragmentary sectional view illustrating the mating engagement of the valve stem retainer with the valve member prior to the fusion together of these parts by projection welding;

Figure 11 is a fragmentary view partially in section of a valve member of the type used in intake and exhaust valves in internal combustion engines provided with a projection welding wear resistant hard alloy face in accordance with the present invention;

Figure 12 is a fragmentary view in elevation of the valve member of Figure 11 prior to the attachment thereto of the inserted alloy ring element by projection welding;

Figure 13 is a sectional view of the inserted alloy element for the valve member of an internal combustion engine as illustrated in Figure 11 prior to its attachment to the valve member of Figure 12 by projection welding;

Figure 14 is a fragmentary sectional view of a valve body member having an inserted alloy ring element form-

ing a valve seat for coaction with a valve member of the type illustrated in Figure 11;

Figure 15 is a sectional view of the member in which the valve seat is formed prior to the projection welding of the inserted element thereto;

Figure 16 is a sectional view of the alloy valve seat forming element prior to its projection welding to the member illustrated in Figure 15 to form the valve seat illustrated in Figure 14;

Figure 17 is a fragmentary sectional view through a gate valve of the type illustrated in Figure 20 having an inserted alloy element valve seat projection welded therein in accordance with the present invention;

Figure 18 is a fragmentary sectional view of the valve body for a gate valve as adapted for the projection welding therein of an inserted alloy element to form a valve seat;

Figure 19 is a sectional view of the gate valve seat ring prior to its projection welding to the valve body as illustrated in Figure 18 to form the hard alloy valve seat illustrated in Figure 17;

Figure 20 is a fragmentary sectional view illustrating the gate valve body having projection welded hard alloy seats and the fixture and apparatus used in assembling the inserted element illustrated in Figure 19 within the valve body by projection welding;

Figure 21 is a longitudinal sectional view of a pump shaft seal having a thrust bearing formed by a hardened alloy element projection welded in position in accordance with the present invention;

Figure 22 is a fragmentary sectional view of the member to which inserted element is to be projection welded in the assembly of Figure 21;

Figure 23 is a sectional view of the inserted element which when projection welded to the member illustrated in Figure 22 forms a thrust bearing for the pump shaft seal illustrated in Figure 21;

Figure 24 is a longitudinal sectional view through a drill or guide bushing provided at its opposite ends with projection welded hard alloy wear rings;

Figure 25 is fragmentary sectional view of the member illustrated in Figure 24 as adapted for the projection welding thereto of the inserted wear ring element;

Figure 26 is a sectional view of the inserted hard alloy wear ring element as adapted for projection welding to the member illustrated in Figure 25 to form the wear ring of the bushing assembly illustrated in Figure 24;

Figure 27 is a fragmentary sectional view illustrating an assembly having shaft bushings or bearings projection welded into a body member;

Figure 28 is a fragmentary sectional view of the member adapted for the projection welding thereto of the inserted bushing or bearing elements;

Figure 29 is a sectional view of the inserted bushing or bearing element adapted for projection welding to the member illustrated in Figure 28 to form the assembly illustrated in Figure 27;

Figure 30 is a fragmentary longitudinal sectional view through a burner nozzle illustrating the provision of a wear resistant insert at its discharge end by projection welding;

Figure 31 is a fragmentary sectional view of the body member of the nozzle adapted for the projection welding of an insert in the end thereof;

Figure 32 is a sectional view of the insert element adapted for projection welding to the body member illustrated in Figure 31 to form the assembly illustrated in Figure 30;

Figure 33 illustrates the provision of a gasket or union face on a member by projection welding;

Figure 34 is a fragmentary sectional view through the member adapted for the projection welding thereto of an insert element; and

Figure 35 is a sectional view through an insert element adapted for projection welding to the member illustrated

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in Figure 34 to form the gasket or union face for the member illustrated in Figure 33.

As has been indicated, it is believed that one of the most important applications of the principles of the present invention will be in the assembly of components of valve assemblies. To illustrate the use of valve components embodying the principles of and construction in accordance with the method of the present invention, I have shown in Figures 1 and 2 a high pressure high temperature valve including several of such components. The structure and mode of operation of this valve will be described briefly to facilitate the understanding of this application of the present invention.

Referring now more particularly to Figures 1 and 2, 10 indicates a valve body preferably formed of steel and having inlet and outlet passages 11 and 12 respectively which communicate in spaced points with an internal chamber 13 which at its upper end terminates and opens into an enlarged threaded bore 14. The internally threaded bore receives a lower externally threaded extension 16 of a forged steel yoke 17. The yoke 17 is preferably locked in place by one or more tack welds 18. At its upper end yoke 17 is provided with a threaded aperture 19 in axial alignment with the cylindrical wall of chamber 13. A yoke bushing 20 preferably of bronze having a flange 21 overlying a portion of yoke 17 is threaded into aperture 19 and preferably locked by one or more tack welds or brazing 22. A stem 23 is threaded into bushing 20 and extends downwardly into the chamber 13. At its upper end, stem 23 is provided with a hand wheel 24 held in place by a nut 25.

At its lower end, the stem 23 is provided with a knob like extension 26. A valve member 27 is secured upon extension 26 by a retainer 27a which heretofore would have been threadedly engaged therewith but which, is now preferably projection welded thereto as will be described in detail hereinafter in reference to Figures 7, 7A and 9. The valve member 27 is provided with an annular hard alloy inserted element 28 having a conical external face 28a which, in the fully closed position of the valve, sealingly engages a complementary seating surface 29 provided adjacent the lower inlet end of the chamber 13 by an annular hard alloy inserted element 29a. Inserted elements 28 and 29a, which were formerly formed by machining off an inlay of alloy material, are now bonded in position in fluid tight relation to valve member 27 and body 10 respectively by projection welding as will be described in detail hereinafter in reference to Figures 7 through 9 and 3 through 6A respectively.

An annular back seat 37 is formed on yoke 17 at the upper end of the chamber and packing rings 38 are provided in surrounding relation to the stem 23 above the back seat 37. The back seat 37 and the retainer 27a are provided with cooperating tapering surfaces 39 which are in sealing engagement when the valve is in its fully opened position.

As is best shown in Figure 2, a pair of bolts 51 are mounted on studs 52 extending from opposite sides of the lower portion of yoke 17 and extend upwardly through ears 54 of gland 49. Nuts 55 are screwed on the bolts 51 above ears 54 to force gland 49 downwardly, adjustably compressing packing rings 38.

The fundamental principles of the present invention will now be described in detail in reference to the projection welding of the element 29a to the body 10 to form a valve seat as is illustrated in Figures 3 through 6A.

It has been stated that the primary aim of the present invention was the assembly of a thin hard alloy ring to a relatively large steel member by the direct fusion of the ring to the member without distortion or deformation of the ring so that, with but a slight finishing operation on the external face of the ring, a finished product is formed. As applied to the provision of a

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hard alloy valve seat 29 within the body 10, this means that the object of the invention is the projection welding of the insert element 29a, which is preferably a precision cast hard alloy ring, to the body 10 in accurate alignment with and at the bottom of the chamber 13 in a completely fluid tight seal with the body 10 without deforming, distorting or cracking the element 29a so that the surface 29 thereof will function as a valve seat with but a light machining operation such as by lapping or a light cut (.005 to .010 in.) on a precision boring machine.

I have discovered that there are certain major problems which arise in fabricating a valve body and seat ring assembly by projection resistance welding. The most important considerations are as follows:

a. The time of fusion must be sufficiently short to prevent oxidation of the fused metals.

b. The contacting surfaces of the ring and body member must be such that fusion occurs first and predominantly at such area of contact rather than in the body of the ring.

c. The current flow pattern between the ring and body member must be uniformly distributed about the periphery of the ring so that a uniformly fluid tight bond is achieved by a region of uniform fusion of the ring to the member or without misalignment of the ring relative to the member.

d. The body member and seat ring must be forced together under a high contact pressure without producing misalignment during the fusion of the contacting surfaces so that the plastic deformation of the contacted portions of the body and ring occurs in aid of the formation of the metallic bond therebetween during the extremely short period of fusion.

e. If commercially acceptable rates of production are to be achieved, the seat ring must be formed of a metal having a sufficiently high percentage of elongation under tensile test at room temperature to prevent formation of cracks in the seat ring under the necessary pressure and should be of substantially the same coefficient of expansion as the member to which it is attached to prevent cracking of the ring during and after assembly due to thermal expansion forces.

f. The cross-sectional area of the inserted elements must be kept as small as possible and the amount of metal removed after welding must be kept to a minimum because the suitable alloys of which they are made are extremely expensive, the alloys are very hard to machine and have a high electrical resistivity.

g. The inserted elements must be subjected to a practical minimum of strain during projection welding as they are inherently brittle.

h. The temperature range for workability between a state of high hardness at red heat and the melting temperature of suitable alloys is extremely narrow due to the chemical nature of these alloys. For example, ordinary steel is about as plastic at 1000° F. as these alloys are at 1700° F. and whereas ordinary carbon steel does not melt until it reaches 2800° F., these alloys melt at 2300° F.

As has been indicated, among the important factors which must be controlled if commercially acceptable projection welds are to be achieved are the area of the contacting surfaces of the ring and the member to which it is to be welded and the maintenance of accurate alignment between the ring and member. These two factors are controlled primarily by controlling the configuration of the mating faces of the ring and member as will now be explained in reference to Figures 3 through 5.

Referring now in detail to Figures 3 and 4, the valve body 10 is formed with a pair of coaxial recesses 62 and 64, the smaller recess 64 having, at its outer end, a portion 65 which is of generally frusto-conical form. This frusto-conical portion 65 of the recess 64, which is shown in an enlarged sectional view in Figure 4, is located co-

axially in the end wall of the larger recess 62 forming the chamber 13. As is shown in Figure 4, this frusto-conical recess portion is formed by a plurality of axially spaced annular lands 66 which are coaxial with the recess 62 and 64 and which are separated by coaxial annular grooves 68. In the preferred form the grooves 68 are formed by the junction of a cylindrical wall 70 with a generally radial wall 72 meeting at a 90° angle and which are respectively parallel and normal to the recess axis. This groove formation is preferred because the grooves can be cut in this shape by a simple plunge reaming operation but likewise is not essential to the present invention in its broader aspects. For example, a V-shaped thread of the proper pitch and depth has been found to produce satisfactory results. These grooves 68 are thus separated by generally parallel annular projections the edges of which in the preferred form are parallel, coaxial, axially spaced and of progressively increasing diameter so that the lands 66 lie in a substantially conical envelope. While, in the illustrated embodiments, the lands are shown as lying in a conical envelope as this will be the most usual construction, it is to be understood that the present invention is not limited thereto in its broader aspects, conoidal forms and forms other than surfaces of revolution be equally suitable but practically less desirable. Each projection is of tapered cross section, being narrowest at its surface of initial contact with the insert prior to weld initiation and widest at its base. By this construction as fusion of the projection takes place the cross-sectional area of the largest fused zone progressively increases at a uniform rate until the entire projection has been fused to the insert as illustrated in Figure 6A. This uniform increase in the fused cross-sectional area is of importance because the welding current density necessary to effect complete fusion of a tapered projection in this manner is much less than that necessary to fuse the base cross-sectional area without the tapered projection.

While the provision of plural projections rather than a single projection forming an annular ridge is not essential to the present invention in its broader aspects, it is preferable because it assures accurate alignment of the valve seat ring 29a within the valve body 10 in assembly, distributes the stress induced in the ring 29a to decrease the chance of fracture of the ring 29a during assembly and by increasing the area of engagement between the body 10 and the ring 29a at which fusion will occur assures a higher rate of acceptable assemblies in mass production operations.

The total area of lands 66 forming the tips of the projections and the shape of the projections must be such that the highest heat concentration is at these areas of contact between the body member and inserted ring element so that direct fusion between the ring and projections will take place rather than fusion occurring within the ring or at its face contacting the applied electrode.

The projections must also be of uniform cross-section radially to assure a uniform rate of fusion around the projection.

The valve body is customarily formed of a suitable alloy steel which, for example, may have the following analysis: carbon—0.10 to 0.20, manganese—0.30 to 0.80, phosphorus—0.040 maximum, sulfur—0.40 maximum, silicon—0.10 to 1.00, chromium—0.80 to 1.50, molybdenum—0.45 to 0.65, and the remainder iron.

The valve seat ring 29a shown in Figure 5 is preformed in the general shape of a thin wall frusto-conical member, its outer frusto-conical surface 74 having an apex angle approximately equal to that of the recess portion 65 and the surface defined by lands 66 so that the ring 29a can be placed within the body member 10 in abutment with the lands 66 of the recess portion 65 at the bottom of and in alignment with the larger recess 62.

The inserted alloy element must have a beveled face of suitable configuration to mate with the projections on

the member to which it is to be welded to assure a uniform weld and accurate alignment. The thickness of the inserted element must be sufficiently small so that the electrical resistance 74 is not sufficient to materially impede the passage of the high electrical current there-through necessary during the welding operation but must be sufficiently thick to prevent cracking of the ring. I have found that the optimum thickness is approximately three-thirty seconds of an inch with a range of from one sixteenth to one fourth of an inch producing quite satisfactory results.

The face on the inserted element against which the electrode is to abut during the welding operation should have an apex angle of no less than sixty degrees if sticking and welding between the ring and electrode is to be avoided.

The metallic alloys which I have found to be sufficiently durable for use as inserted elements in high pressure high temperature valve components have a hardness and corrosion resistance at least equal to that of stainless steel and preferably 25 Rockwell "C" or greater and at least 2% elongation in tensile test to avoid cracking of the alloys of suitable hardness. Examples of those which can be assembled within the valve body by resistance welding on a production basis are indicated in the following table.

1. COBALT BASE

Co	Cr	Ni	Mo	W	Hardness, Rockwell C
60	25	3	5	---	40
60	25	1	---	5	40
50	20	10	---	15	35
33	25	40	5	---	30
50	25	15	5	---	35
50	25	10	---	8	40
50	18	10	---	15	35

2. NICKEL BASE

Ni	Cr	Mo	W	Co	B	Hardness, Rockwell C
60	16	17	5	---	---	35
78	13	---	---	---	---	25
42	20	---	---	20	---	25
30	20	8	---	20	---	---
80	10	---	---	---	2	30

3. IRON BASE

Ni	Cr	Mo	W	Co	Cb	Hardness, Rockwell C
20	20	3	---	20	---	25
10	20	10 (or less)	---	---	2 (or less)	15
35	8	10 (or less)	---	---	2 (or less)	20
18	35	10 (or less)	---	---	2 (or less)	20
---	16	---	---	---	---	20
---	13	---	---	---	---	30

Of the foregoing alloys, those listed as nickel and cobalt base alloys have been found to produce the best results.

The method in accordance with the present invention of fabricating a valve body and seat ring assembly from a steel valve preformed as explained in reference to Figures 3 and 4 and from a hard metallic alloy seat ring preformed as explained in reference to Figure 5 preferably by precision casting will now be explained in reference to Figure 6 which illustrates the relation of a resistance welding apparatus and workpiece supporting fixture to the valve body 10 and seat ring 29a prior to the initiation of the actual resistance welding operation.

The illustrated apparatus comprises a movable electrode 80 of the non-consumable type which is coaxially fixed to the bottom face of a piston 82 of a fluid actuated cylinder 84. The piston 82 and movable electrode 80 are illustrated in full lines in their lower operative posi-

tions and in phantom lines in their retracted positions at which they are designated 82' and 80' respectively. Suitable fluid conduits 86 and 88 connected to a pressure fluid source (not shown) are provided at the upper and lower ends of the cylinder 84 to permit appropriate introduction and discharge of fluid from the cylinder 84. The cylinder 84 is rigidly mounted above the base structure 90 by any suitable mounting structure (not shown) appropriate provision being made to electrically insulate electrode 80 from the base structure 90. During the welding operation, the valve body member 10 is supported upon a fixture 92 resting upon the base structure 90 and having contact with the body member 10 adjacent the ends at which the inlet 11 and outlet 12 (Figure 1) are to be formed. The valve body is further supported by a frame formed of spaced uprights 94 and 96 at a cross member 98 at the center of which is suitably releasably mounted as by a toggle clamp (not shown) a sleeve 100. Sleeve 100 is externally threaded at its lower end and is threaded into the threaded recess 14 of the valve body 10 to provide a firm brace for the body member 10 against the supporting fixture 92. The sleeve 100, which is formed of copper, coats with the fixture 92, the base structure 90, and the support structure 94, 96 and 98, all of which are formed of metal, to define a fixed electrode and thereby to provide a first electrically conducting path to the zone of fusion between the inserted element and body member 10. The second conducting path to this portion of valve body 10 is defined by the movable electrode 80 and the inserted seat ring element 29a which is in abutment therewith.

The fixture 92 is so formed that it contacts the valve body 10 at areas of such size and so located relative to the frusto-conical recess portion 65 that, in cooperation with the sleeve 100, the current density through the recess portion 65 during the welding operation is substantially uniformly distributed around the axis thereof. This results in uniform fusion of the contacting faces of the seat ring 29a and the recess portion 65 so that the seat ring is forced uniformly downward into the recess portion 65 to form a complete annular fluid tight bond therebetween rather than non-uniform fusion about the axis of the recess portion 65. Non-uniform fusion results in the formation of fused sections spaced apart by sections which are unfused or fused to a lesser degree which prevent the valve seat ring from being compressed uniformly against the recess portion 65.

It is apparent that the shape of the electrodes will be varied and the relation of the fixed and movable electrodes to the member and inserted element may be interchanged as necessary to produce the desired results within the foregoing considerations to accommodate varying shapes of the body member and inserted element.

From the foregoing, it is apparent that the steps preparatory to the actual initiation of the resistance welding operation are, while the electrode 80 is in its upper position 80', placing a valve seat ring 29a within a valve body in axial alignment and abutment with the lands 68 of the recess portion 65 as shown, placing the valve body on the fixture 92 as illustrated, threading the sleeve 100 into the threaded recess 14 of the body 10, securing the sleeve 100 to the cross member 98 by the toggle clamp (not shown) to rigidly secure the valve body 10 in a position such that its recesses 62 and 64 are coaxial with the electrode 80, and lowering the electrode 80 into abutment with the seat ring 29a by the introduction of fluid under pressure into the cylinder 84 above the piston 82 through the conduit 86. In practice, I have found that a force in the order of 5,000 to 20,000 per square inch of weld with a rapid follow up during the welding cycle produces a satisfactory bond by resistance welding without deforming or cracking the inserted element.

The preferred fluid is a compressible fluid such as air which gives a rapid follow up to the electrode as the projections melt down. When a hydraulic fluid is used,

an air cushion must be provided between the piston and the welding electrode.

The electrode 80 and the sleeve 100 are suitably electrically connected through a timing device 104 to opposite terminals of a welding current power supply 106 to permit imposition of an electrical potential upon the current conducting paths to the abutting faces of the recess portion 65 and valve seat ring 29a previously described. The welding current may be either direct or alternating, alternating being the more usual. For a satisfactory bond to be formed, I have found that the length of time of passage of the welding current is quite critical, the acceptable current application time range being equivalent to from 2 to 20 cycles of 60 cycle alternating current depending upon the cross-section of the inserted element, to weld time for the most usual applications being equivalent to from 8 to 14 cycles of 60 cycle alternating current. The welding current must be quite high, in the order of from 75,000 to 350,000 amperes per square inch of weld and must be of uniform density throughout the zone to be fused.

Since the width and number of the lands 66 against which the seat ring 29a abuts are such that the area of maximum electrical resistance in the electrical path between the terminals of the power supply is at the contacting areas of the seat ring 29a with the lands of the projections and since a high amperage short duration electrical current is applied, fusion of the contacted portion of the seat ring 29a on the lands 66 and the body projections immediately behind lands 66 is effected without material internal melting of the seat ring 29a or overheating of the contacting surfaces between the seat ring 29a and the electrode 80 and without oxidation of the fused metal. The pressure exerted by the electrode 80 is such that during the extremely short period of fusion of the contacting portion of the body and seat ring, the heated body projections defined by surfaces 88 and 72 immediately behind the lands 66 are caused to collapse by plastic deformation to form a permanent bond between the seat ring and body member. The resultant bond of the ring 29a to the body 10 is illustrated in cross-section in Figure 6A. After termination of the flow of electrical current, the pressure exerted by the electrode 80 is released to permit removal of the valve body and seat ring assembly thus formed. This release is effected by introducing hydraulic fluid through the conduit 88 below the piston 82 and relieving the pressure exerted through the conduit 86 above the piston 82 to return the piston 82 to its upper inoperative position.

Having now described in detail the fundamental principles of the present invention in reference to the projection welding of the valve seat within the valve body, it is believed that it will suffice, in order to illustrate the wide application of the present invention, to briefly describe certain other presently contemplated applications of the present invention other than the foregoing. Since it is believed that the necessary modifications of the configuration of the electrodes and interchange of the movable and fixed electrodes relative to the insert element and body members to permit the projection welding of insert elements to the body members for the various applications hereinafter discussed are obvious mechanical expedients, I have not illustrated such modifications.

Referring first to Figures 7 and 7A, as has been previously indicated and inserted element 28 is provided on the valve member 27 to form thereon a wear resistant valve seat engaging face. The form of the valve member prior to having the inserted element projection welded thereto as illustrated in Figure 8. As in the provision of the valve seat within the valve body, the valve member 27 is provided with a plurality of external parallel relatively sharp edged annular projections 101. The inserted ring element 28, illustrated in Figure 9, is provided with a mating internal frusto-conical face 103 which, in the projection welding operation, abuts against each of the projections 101 on the valve member 27 prior to the initia-

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tion of the current flow and, upon projection welding to the valve member 27 in accordance with the method hereinbefore described, forms an annular zone of direct fusion 27b best shown in Figure 7A, between the valve member and inserted ring element 28 for each projection. The electrode contacting the inserted element during the projection welding operation abuts against the external frusto-conical face thereof.

The retainer 27a for the valve stem 23 is likewise projection welded to the valve member 27 at 105. Figure 10 is an enlarged fragmentary illustration showing the projections 107 on the valve member 27 abutting against the frusto-conical face 103 on the retainer 27a prior to the initiation of current flow for the projection welding operation. The fusion of the retainer 27a to the valve member 27, which takes place in the manner as described hereinabove, presents a difficult problem due to the necessity to limit the axial movement of the retainer 27a relative to the valve member 27 during the projection welding operation to leave sufficient end play for the extension 26 to permit free rotation of the stem 23. The necessary end play is established by controlling the axial distance between the lower face of annular flange 110 and the lower end face of the retainer 27a. Since retainer 27a is normally not formed of a hard alloy, the conditions of current, pressure and time are not as critical but the other limitations are important. The assembly illustrated in Figure 7A of retainer 27a to member 27 was made with a force of 3000 pounds and a 75,000 ampere current for twelve cycles.

Figure 12 illustrates a valve member 114 of the type used in internal combustion engines provided with a series of external annular parallel projections 116 to permit projection welding thereto of a thin wall annular insert element 118 (Figure 13) provided with an internal frusto-conical face 120 for engagement with the projections 116 to form the valve member 122 of Figure 11.

Figure 15 illustrates a member 124 provided with a series of parallel annular thin edged projections 126 to permit projection welding thereto of the annular inserted element 128 of Figure 16 having an external frusto-conical face 130 adapted to mate therewith. Figure 14 illustrates the assembly resulting from the projection welding of the inserted element 128 to the member 124. This assembly provides a valve seat for co-action with a valve member of the type illustrated in Figure 11 for use in internal combustion engines.

Figures 17 through 20 illustrate the application of the teachings of the present invention to provide wear resistant valve seats in gate type valves. In Figure 20 I have illustrated a gate type valve body member 132 having opposed valve seating faces 134 and 136. These valve seat faces 134 and 136 are each initially provided with a series of parallel annular projections 138 as is illustrated in Figure 18 to engage the frusto-conical face 140 upon the inserted ring element 142 illustrated in Figure 19. The final assembled relationship of the ring 142 to the valve body 132 after completion of the projection welding operation is illustrated in fragmentary sectional form in Figure 17.

Due to the configuration of the body member of a gate valve, it is necessary to provide an electrically conductive pressure distributing plate 144 intermediate the movable electrode 146 and the inserted ring element 142 to permit assembly of the ring 142 within the gate valve body 132 by projection welding as is illustrated in Figure 20. With the exception of the use of a modified holding fixture 148 and the use of the pressure distribution plate 144, the apparatus may be identical with that illustrated in Figure 6. The projection welding of the inserted ring element 142 to form the wear resistant portion of the valve face 134 is effected by inversion of the valve body 132.

As has been previously indicated, the principles of the

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present invention may be utilized to provide bearing and bushing inserts within relatively softer body members to form wear resistant surfaces thereon as well as for providing component parts for valve assembly as has been hereinbefore described. Figure 21 illustrates the provision of an inserted element 150 on a member 152 to provide a thrust bearing face for a pump shaft seal about the shaft 154. The provision of a series of parallel annular projections 156 in the end face of the member 152 is illustrated in Figure 22, and the configuration of the inserted element 150 prior to its projection welding to the member 152 is illustrated in Figure 23. The electrode contacting the insert element 150 abuts its end face 157 during the welding operation.

Figure 24 illustrates a drill or pin guide bushing 158 provided with hard alloy wear rings 160 and 162 at its opposite end by the projection welding of the inserted element illustrated in Figure 26 to the annular projections 164 preformed in the opposite end faces of the member 158.

The principles of the present invention may likewise be used to provide plain bushings or bearings within a member such as 166 of Figure 27 for journalling a shaft 168. These bushings 170 and 172 are in the form illustrated in Figure 29 and the opposite ends of the member 166 are preformed with a series of annular projections 174 against which the ring 170 or 172 is projection welded to provide the bearing for the shaft 168.

A further application of the techniques of the present invention is in the provision of a wear resistant insert at the discharge end of the burner nozzle to resist the wear resulting from the abrasive effects of the fuel injected through the nozzle and the wear resulting from the extremely high temperatures to which the end of the nozzle is subjected. This application is illustrated in Figures 30 through 32, the inserted element 176 being of substantially conical form as illustrated in Figure 32 and having a frusto-conical face 178 for abutment against the parallel annular projections 180 of the body member 182 of the nozzle. The assembly of these parts is illustrated in Figure 30.

A further application of the principles of the present invention is the provision of a hard alloy wear resistant insert 184 as shown in Figure 35 for a gasket or union face of a member 186 as is illustrated in Figure 33. The end face of the member 186 is provided with a plurality of internal parallel annular projections 188 against which the insert element 184 is projection welded to form the assembly illustrated in Figure 33.

From the foregoing detailed description it is apparent that the article of manufacture of the present invention may take many and varied forms and the projection welding method in accordance with the present invention is of wide applicability in the provision of hard wear resistant alloy inserted elements on a relatively softer steel body. The present invention is of particular importance in the valve industry wherein it is necessary to provide a fluid tight bond between a wear resistant insert or inlay and wherein it is extremely necessary to provide such wear resistant face to resist the corrosion and wear resulting from the flow of high temperature high velocity fluid through the valves. The present invention results in the production of valve components having much greater life, and which, being simpler, much less time consuming and much less wasteful of material in assembly, results in a product which can be manufactured and sold at a lower cost than those assembled by prior art methods.

In applications in which the complete fluid tight relationship between the inserted element and the body member is not as critical as it is in valves for high pressure fluids, the present invention is still of extreme importance in that it provides a method of rapidly and economically assembling hard alloy inserts into a relatively softer body material in a manner which results in

accurate alignment of the insert relative to the body member, which requires very little machining after completion of the projection welding, the removal from five-thousandth to ten-thousandth of an inch of material being the most that is necessary, and which eliminates wastage due to cracking and deformation of the inserted element.

In each instance, the bond between the inserted element and the member to which it is secured is formed by a continuous annular zone of direct fusion of each projection on the member with the abutting beveled face on the inserted element to form a fluid tight bond therebetween.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A method of assembling a relatively thin hard metallic element having a continuous uniformity beveled face upon a member having at least two continuous projections capable of simultaneous continuous contact with said beveled face to provide a surface upon said member of a different hardness characteristic from that of said member comprising the steps of placing said element in alignment with and with the beveled face thereof in continuous surface engagement with both said projections, producing a high pressure of engagement between said element face and said projections while maintaining the alignment therebetween, and passing a short duration high amperage electrical current between said insert and body member through said projections to fuse said body member and insert together.

2. The method defined in claim 1 wherein said element is of a uniform thickness in the range of from $\frac{1}{16}$ to $\frac{1}{4}$ of an inch.

3. The method defined in claim 1 wherein said element is formed of an alloy having a hardness and corrosion resistance at least equal to that of stainless steel.

4. The method defined in claim 1 wherein said element is formed of an alloy having a hardness at least equal to 25 Rockwell "C" and an elongation of at least 2%.

5. The method defined in claim 4 wherein the base of said alloy is selected from the group consisting of nickel and cobalt.

6. The method defined in claim 1 wherein said member is steel, said element is a hard metallic alloy, and said high pressure of engagement is in the order of 5000 to 20,000 pounds per square inch of weld upon initiation of electrical current flow wherein there is a rapid follow-up in pressure application during the time of current flow.

7. The method defined in claim 1 wherein said member is steel, said element is a hard metallic alloy, and the current flow is of substantially uniform density along the length of said projections and wherein the welding current is in order of 75,000 to 350,000 amperes per square inch of weld.

8. The method defined in claim 1 wherein said member is steel, said element is a hard metallic alloy, and the duration of current flow is the equivalent of from 2 to 20 cycles of 60 cycle alternating current.

9. A method of providing a wear resistance surface upon a relatively softer metallic body comprising the steps of providing a member having at least two continuous projections, providing an element having a uniformly beveled surface capable of simultaneous and continuous contact with said continuous projections, placing said element in alignment with and with its beveled surface in continuous contact with both said projections, producing

a high pressure of engagement between said element and said projections without producing misalignment therebetween, and passing a short duration high amperage electrical current between said element and body member through said projections to directly fuse said body member and element together.

10. A method of providing a wear resistance surface upon a relatively softer metallic member comprising the steps of providing a steel member having a plurality of parallel annular coaxial axially spaced projections of progressively increasing diameter whereby the edges of such projections lie substantially in a common conical envelope, providing a toroidal hard alloy insert having a frusto-conical face the apex angle of which is substantially equal to that of the conical envelope of the edges of said projections, placing said insert in alignment with and with its frusto-conical surface in engagement with said projections, producing a high pressure of engagement between said insert and said projections without producing misalignment therebetween, and passing a short duration high amperage electrical current between said insert and body member through said projections to fuse said body member and insert together.

11. A method of assembling a relatively thin hard alloy toroidal element upon a relatively large steel element to provide a wear resistant surface on said steel element in fluid tight relation therewith, one of said elements being formed with at least one continuous annular projection and the other of said elements being formed with a continuous annular beveled surface adapted to engage the projection on said one element in a continuous annular uniform region of contact, said method comprising the steps of placing said elements together with said projection in continuous contact with said beveled surface in an annular zone of contact coaxial with said projection and said beveled surface, producing a high contact pressure between said projection and said surface while maintaining the alignment therebetween, and passing a high amperage short duration current between said elements through said projection and surface to uniformly fuse the region of contact therebetween and produce plastic flow of the materials of said elements under the applied pressure to produce an annular fluid tight bond therebetween.

12. The method defined in claim 11 wherein said one element is formed with a plurality of axially spaced radially offset annular projections capable of simultaneous continuous contact with said beveled surface.

13. The method defined in claim 11 wherein said large steel element is a valve body and the wear resistant surface provided by said alloy element is a valve seat.

14. The method defined in claim 11, wherein said large steel element is a valve disk and the wear resistant surface provided by said alloy element is a valve seat engaging valve face.

15. A method of fabricating a steel part protected from wear by a toroidal hard alloy element comprising the steps of providing a toroidal insert element of hard alloy material, providing a steel part having a generally frusto conical portion against which said toroidal element can be assembled in coaxial alignment and in continuous annular contact, so assembling said element in alignment with said part portion, and producing electrical resistance fusion of the contacting portions of said element and part to produce a permanent fluid tight bond therebetween, and establishing and maintaining axial pressure of engagement between said element and part prior to and during the period of fusion of said contacting portions.

16. A method of fabricating a steel valve body provided with a hard metallic alloy valve seat comprising the steps of providing a steel valve body having coaxial inner and outer bores of relatively lesser and greater diameters respectively and interconnected by a region of generally frusto conical form, providing a toroidal hard metallic alloy insert element of generally frusto conical form and

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having an internal frusto conical valve seat forming face, said element being of such size that it can be placed within the larger of said valve body bores in abutment with said valve body region, placing said element within said outer bore in coaxial alignment therewith and with its outer face in abutment and continuous annular contact with said valve body region, one of the surfaces of engagement between said element and valve body being a frusto conical face coaxial with said bores and tapering inwardly of said body and the other of said surfaces being the edge of a continuous annular projection of uniform wedge shape cross section, subjecting said valve body and element to the effect of a high pressure of engagement directed axially of said bores, and passing a high amperage short duration current between said element and body through said surfaces of engagement to produce a generally frusto conical region of fused metal of said body and insert element while maintaining said pressure.

17. A method of fabricating a steel valve disk provided with a hard alloy valve face comprising the steps of providing a steel valve disk having at one end an external region of generally frusto conical form, providing a toroidal hard metallic alloy insert element of generally frusto conical form and having an external frusto conical face adapted to engage a valve seat, said element being of such size that it can be placed upon said valve disk in abutment and continuous annular contact with said valve disk region, so placing said element on said valve disk region, one of the surfaces of engagement between said element and said valve disk being a frusto conical face coaxial with said element and tapering inwardly of said body and the other of said surfaces being the edge of an annular projection of uniform wedge shape cross-section, subjecting said valve disk and element to the effect of high pressure of engagement directed axially of said element and of said disk, and passing a high amperage short duration current between said element and disk through said surfaces of engagement to produce a generally frusto conical region of fused metal of said disk and insert element while maintaining said pressure.

18. A method of assembling a relatively thin hard metallic alloy insert element upon a massive ferro metallic body element to provide a wear resistant surface upon said body element, one of said metallic elements having a continuous uniformly beveled face and the other of said elements having at least two continuous projections capable of simultaneous continuous contact with said beveled face, said method comprising the steps of placing said elements in alignment with the beveled face of said one element in continuous surface engagement with both said projections of the other element, producing a high pressure of engagement between said element face and said projections while maintaining the alignment therebetween, and passing a short duration high amperage electrical current between said elements through said projections to fuse said elements together.

19. The method defined in claim 18, wherein said insert element is of a uniform thickness about its circumference in the range from $\frac{1}{16}$ to $\frac{1}{4}$ of an inch.

20. The method defined in claim 18, wherein said insert element is formed of an alloy having a hardness and corrosion resistance at least equal to that of stainless steel.

21. The method defined in claim 18, wherein said element is formed of an alloy having a hardness at least equal to 25 Rockwell C and elongation of at least 2%.

22. The method defined in claim 21, wherein the base of said alloy is selected from the group consisting of nickel and cobalt.

23. The method defined in claim 18, wherein said member is steel and said insert element is a hard metallic alloy and said pressure of engagement is in the order of 5,000 to 20,000 pounds per square inch of weld upon initiation of electrical current flow and wherein there is

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rapid follow up in pressure application during the time of current flow.

24. The method defined in claim 18, wherein said body element is steel and the current flow is of substantial uniform density along the length of said projection and wherein the welding current is in the order of 75,000 to 350,000 amperes per square inch of weld.

25. The method defined in claim 18, wherein said member element is steel, and the duration of current flow is equivalent of from 2 to 20 cycles of 60 cycle alternating current.

26. A method of fabricating a metallic body element protected from wear by a toroidal hard metallic alloy element comprising the step of pressure welding such an element to such a body in a generally frusto conoidal region of interdiffused metal of said elements substantially equal in axial length to the axial length of said toroidal element by localized heating of said region to welding temperature under pressure while maintaining the remainder of said body and element below their welding temperatures.

27. A method of fabricating a metallic body element protected from wear by a toroidal hard alloy element comprising the steps of providing a toroidal insert element of hard alloy material, providing a metallic body element having a generally frusto-conoidal portion against which said toroidal element can be assembled in coaxial alignment and in continuous annular contact, assembling said element in alignment with said part portion, and bonding said elements together in fluid tight relation in a continuous annular region by pressure welding utilizing localized heating of said region to welding temperature under pressure while maintaining the remainder of said elements below their welding temperatures.

28. A method of assembling a relatively thin hard toroidal metallic alloy insert element upon a massive ferrometallic body element to provide a wear resistant surface upon said body element, one of said metallic elements having a continuous face in the form of a surface of revolution and the other of said elements having at least one continuous annular projection capable of continuous contact with said face in a band substantially narrower than the axial length of said insert element, said method comprising the steps of placing said elements in alignment with the face of said one element in engagement with said projection of the other element in an annular band, and bonding the contacting portions of said elements to produce a permanent bond therebetween by pressure welding utilizing localized heating of the region of contact between said elements to welding temperature under pressure while maintaining the remainder of said element below their welding temperatures.

29. The method defined in claim 28 wherein said step of producing bonding of the contacting portions of said elements comprises passing an electrical current between said elements through the engaged surfaces of said elements and establishing and maintaining axial pressure of engagement between said elements prior to and during the period of fusion of the contacting portions thereof.

30. A method of fabricating a steel valve body provided with a hard metallic alloy valve seat comprising the steps of providing a steel valve body having a recess and a fluid passage of smaller cross-section than said recess opening into said recess, providing a toroidal hard metallic alloy insert element, said element being of such size that it can be placed within said valve body recess in abutment with said valve body at the juncture of said passage with recess, placing said element within said recess concentric with said passage and with its outer face in abutment and continuous annular contact with said valve body at the juncture of said recess and passage, one of the surfaces of engagement between said element and the valve body being a continuous surface of revolution coaxial with said passage and tapering inwardly

of said body passage and the other of such surfaces being a narrow annular band of a continuous annular uniformly convex projection, and bonding the contacting portions of said element and body together by pressure welding to produce a permanent fluid tight bond therebetween by localized heating of the region of contact between said element and body to welding temperature under pressure while maintaining the remainder of said element and body below their welding temperatures.

31. A method of fabricating a steel valve body provided with a hard metallic alloy valve seat comprising the steps of providing a steel valve body having a cylindrical recess and a cylindrical fluid passage of smaller cross-section than said recess opening concentrically into said recess, providing a toroidal hard metallic alloy insert element, said element being of such size that it can be placed within said valve body recess in abutment with said valve body at the juncture of said passage with recess, placing said element within said recess concentric with said passage and with its outer face in abutment and continuous annular contact with said valve body at the juncture of said recess and passage, one of the surfaces of engagement between said element and the valve body being a continuous surface of revolution coaxial with said passage and tapering inwardly of said body passage and the other of such surfaces being a narrow annular band of a continuous annular uniformly convex projection, and bonding the contacting portions of said element and body together by pressure welding to produce a permanent fluid tight bond therebetween utilizing localized heating of the region of contact between said element and body to welding temperature under pressure while maintaining the remainder of said element and body below their welding temperatures.

32. A method of providing a hard metallic alloy valve seat within a valve body at the juncture of intercommunicating fluid passages of different diameter therein comprising the step of pressure welding a toroidal hard

alloy element to the body at such juncture in a generally frusto conoidal region of interdiffused metal of said element and body substantially coaxial with the axis of the smaller of said passages by localized heating of the region of contact between said body and element to welding temperature under pressure while maintaining the remainder of said element and body below their welding temperatures.

33. A method of providing a hard metallic alloy valve seat within a valve body at the juncture of intercommunicating fluid passages of different diameter therein, said method consisting of the step of pressure welding a toroidal hard alloy element preformed with an annular valve seat face to the body at such juncture in a generally frusto conoidal region of interdiffused metal of said element and body by localized heating of the region of contact between said body and element to welding temperature under pressure while maintaining the remainder of said element and body below their welding temperatures, the region of bond between said element and body being substantially equal in axial length to the axial length of said element.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,903,564

September 8, 1959

Laurence H. Carr

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 41, after "is" insert -- a --; column 8, in Table I, under "1. COBALT BASE", first column, under the heading "Co", fourth item thereof, for "33" read -- 30 --; column 12, line 32, for "reulting" read -- resulting --; column 13, line 25, for "uniformity" read -- uniformly --; column 14, line 59, for "conical" read -- conoidal --.

Signed and sealed this 19th day of April 1960.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

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