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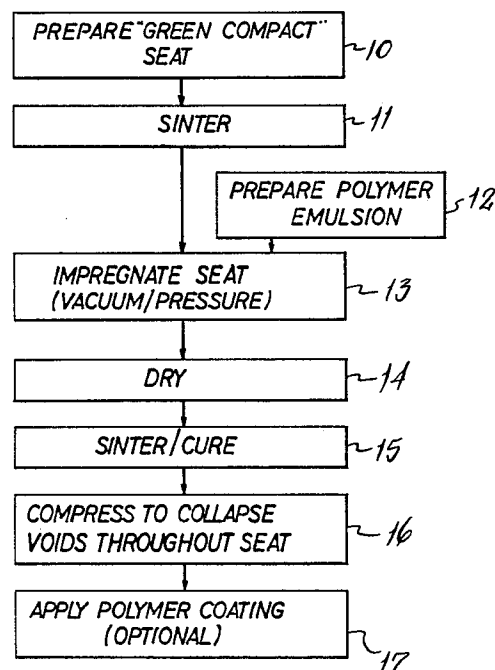
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Sintered metal body and method of making same.

A sintered metal body, having an annular form suitable for use as a valve seat or seal, is impregnated (13) with an uncured polymeric material such as PTFE which is then cured to partially fill the interparticulate spaces in the sintered metal body. The impregnated body is then subjected to applied pressure (16) which preserves the annular shape of the body while collapsing substantially all voids throughout the body to cause the cured polymeric material within the sintered metal body to completely fill the collapsed interparticulate spaces thereby to render the body non-porous throughout. In as much as the interparticulate spaces are completely filled with cured polymeric material, any increases in temperature of the body which result in an expansion of the polymeric material cause a migration of portions of that material from the interior of the body to the exterior surfaces of the body to lubricate the exterior surfaces. The body may, in addition, be completely covered by another layer of cured polymeric material to give the seat additional initial lubricity (17).



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TITLE: SINTERED METAL BODY AND METHOD OF MAKING SAME

This invention relates to sintered metal bodies, and in particular but not exclusively, to such bodies of annular configuration suitable for use as the seat of a plug valve of the ball valve kind.

5 It is desirable to use metal seats in such ball valves under certain conditions since the resultant valve structure can resist higher temperatures and pressures than valves which use other types of seat materials such as plastics materials, for example polytetrafluoroethylene
10 (PTFE). When a metal valve seat is employed in a ball valve, however, there is considerable friction between the ball and its seat which can cause galling problems. Therefore, in an effort to reduce such friction, it is usual for metal valve seats to be used in conjunction with trunnioned ball
15 valve members so that the valve member is self-supporting and the friction between it and its seat is thereby limited. This, however, is a comparatively expensive construction.

Due to the above-mentioned friction problems, metallic

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valve seats are hardly ever used in ball type plug valves having a floating ball. United States patent 3,592,440 seeks to overcome some of these problems and the disclosure of this prior US patent is hereby incorporated in the present application since the US patent discloses manufacturing techniques and materials suitable for use as a first step in the method of the present invention.

The US patent discloses a metal seat for use in a floating type ball valve, the seat being formed of sintered metal of which the exterior surfaces are coated with a layer of cured polymeric material which extends to some extent into the interior pores or interstices of the sintered metal body.

However, the valve seat of this prior US patent is a porous structure which relies upon a continuous surface coating of polymeric material to provide the desired seal, or upon a caulking action of the polymeric material within the seat to effect a desired seal in the event that the polymer coating is destroyed by any means such as fire or abrasion.

We have ascertained that the valve seat of this prior US patent, being essentially porous throughout, tends to leak fluid through the seat when the seat is subjected to pressure if the integrity of the surface coating is impaired and the above-mentioned caulking effect is imperfect.

An object of the present invention is to provide sintered metal bodies and a method of making same offering improvements in relation to one or more of the problems

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identified above.

According to one aspect of the invention there is provided a method of making a sintered metal element, wherein a body of porous sintered particulate metal is impregnated with an uncured polymeric material which is then cured to partially fill the interparticulate spaces in said body with cured polymeric material, characterised by the step of applying pressure to said impregnated body following said curing step, said pressure being sufficient in magnitude to collapse substantially all voids throughout said sintered metal body remaining in said body following said impregnation and curing steps, thereby to cause the cured polymeric material within said sintered metal body to completely fill all the collapsed interparticulate spaces within said body and to render said body nonporous throughout, said pressure being so applied to said body as to produce substantially uniform density throughout said body and at the exterior surfaces of said body upon completion of said pressure-applying step.

According to another aspect of the invention there is provided a valve member or seat or seal comprising a body of sintered particulate metal impregnated with a cured polymeric material, characterised in that the interparticulate spaces within said body are completely filled with said cured polymeric material.

In an embodiment of the present invention described below, the foregoing disadvantages of the structure disclosed in the prior US patent are largely mitigated by providing

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a seat for a floating ball valve consisting of a sintered metal matrix of which the interparticulate spaces are completely filled with cured polymeric material, whereby the seat structure, in addition to being of metal construction and therefore adapted for use in those applications where metal seats are desirable, is nonporous throughout without regard to the presence or absence of a surface coating of polymeric material. While such a surface coating can be provided to achieve additional initial lubricity, the provision of such a surface coating is optional only since the cured polymeric material which fills the interstices of the sintered metal matrix and in particular the portion thereof which is adjacent the surface of the seat, provides the desired lubricity. Any increase in temperature of the seat with a resultant expansion of the polymeric material within the seat, causes an extrusion or migration of said polymeric material from the interior of the seat through the surface of the seat to provide additional lubricity. In other words, since no voids are present within the seat itself, upon expansion of the polymeric material within the seat and the resultant increase in the internal pressure of the seat, the expanded interior polymeric material is obliged to migrate through the matrix of sintered material towards the exterior surface of the seat and to exude from the matrix onto the seat surface thereby increasing the lubricity of the seat at the seat/ball interface of the valve.

A sintered metal body such as a valve member or valve

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seat according to the present invention can be prepared by a series of steps, and by using metal and polymeric materials in accordance with the disclosure of the above-mentioned United States patent. A sintered metal "green compact" structure is initially fabricated in the form and shape conventionally employed for ball valve seats and members, and then the green compact is sintered to fuse adjacent metal particles to each other. Then the resultant valve member or seat is impregnated with an emulsion of uncured polymeric material having lubricity, the impregnation being effected by means of a vacuum and/or positive pressure step. The liquid vehicle employed in the emulsion is then dried, and then the residual polymeric material is cured by heating.

According to the disclosure of the above-mentioned US patent, a valve seat prepared by a series of steps as described above is considered to be completely fabricated except for a final surface finishing step such as grinding, to provide the seat with a desired surface accuracy, and the final seat is porous throughout except for a layer of polymeric material which covers the exterior surfaces of the seat.

In contrast, in accordance with the present invention, the product of the above steps constitutes only the starting point for a further portion of the manufacturing process and, following the above-mentioned curing step, the valve seat or member is placed in a die and subjected to extremely high pressures which operate to collapse substantially all

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of the interparticulate cavities and voids throughout the seat onto the portions of the cured polymeric material within the sintered metal matrix. As a result, following completion of this pressure-applying step, the cured
5 polymeric material within the sintered metal seat or member completely fills all of the collapsed interparticulate spaces within the seat and the seat is rendered nonporous throughout. The seat can then be surface-finished, if necessary, or the seat can optionally be coated with a
10 further layer of polymeric material which is thereafter surface-finished if necessary.

Sintered metal bodies have been suggested in previous publications, see for example US patents:

US 4,118,009 (Chmura)
15 US 3,856,478 (Iwata)
US 3,751,005 (Earley)
US 3,643,916 (Sandenburgh)
US 3,445,148 (Harris)

In some cases the sintered metal elements are proposed to
20 be associated with a lubricant or polymeric material, see for example the United States patent:

US 3,818,564 (Tsuya)
US 3,790,352 (Niimi)
US 2,893,793 (Ryshavy)
25 US 2,788,324 (Mitchell)

in addition to the above-discussed US patent 3,592,440 (McFarland). In some cases, moreover, prior workers in the field have proposed the use of a "coining" or compression

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of a sintered metal body - see for example the above-mentioned Chmura and Harris patents, but these proposals have been such that the resultant structure exhibits a high density or nonporous portion adjacent the surface of the body only, and a lower density porous structure under-
5 lies the surface of the body. In contrast, the pressure-applying step of the present invention is such that the valve seat or body so produced exhibits substantially uniform density throughout and is nonporous throughout.

10 An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig 1 diagrammatically illustrates a plurality of steps forming a method of making a sintered body in accordance
15 with the present invention; and

Fig 2 is a cross-sectional view of a valve seat manufactured in accordance with the present invention, together with an associated die utilised in the compression step of Fig 1.

20 Referring to Fig 1, in a first step 10 of the method of the present invention a quantity of powdered metal (e.g. stainless steel or bronze) is placed in a die whose interior configuration corresponds to the configuration desired of the final structure (e.g., an annular configuration when the
25 object being prepared is a seat for use in a ball valve), and the powdered metal is subjected to pressures of the order of 30 tons per square inch to form a unitary metal body having the desired configuration. At this point in

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the fabrication operation, the individual metal particles are held together simply by interparticle friction, and the structure is termed a "green compact" in the parlance of the trade. In a second step 11, the green compact is then
5 placed in a furnace and subjected to a high temperature which is less than the melting point of the metal material in the seat but which is sufficiently high to cause a coalescing of the interfaces between the various particles in the green compact to unify the structure into a sintered
10 metal matrix. The resultant structure is porous.

In a step 12, which may be performed before, concurrently, or after steps 10 and 11, a PTFE emulsion is formed by mixing a quantity of submicron PTFE particles in an appropriate vehicle such as water, along with some wetting agents;
15 it must be understood, however, as discussed in the aforementioned US patent 3,592,440 (McFarland), that other uncured polymeric materials can be employed and entrained or suspended in other liquid vehicles. The emulsion produced in step 12, and the sintered metal seat produced by step
20 11 are then, in a step 13, placed in a vacuum chamber, initially in spaced relation to one another, and a vacuum is applied to the chamber to remove all air from the voids or pores in the sintered metal seat. The sintered metal seat is then immersed in the emulsion, and the vacuum is broken
25 (if desired, a positive pressure may also be introduced into the chamber) to drive the emulsion into the pores of the sintered metal seat. The resultant polymer impregnated seat is then removed from the chamber and permitted

to dry, in a step 14, e.g., at a temperature which is below the boiling point of water or which is otherwise suitable to remove the water or other liquid vehicle constituents from the emulsion, leaving a residue of PTFE (and/or of whatever other polymer is employed) in the pores of the sintered metal seat.

When the liquid vehicle is removed by the aforementioned drying step, voids are created within the seat and the interparticulate spaces of the sintered metal matrix are no longer completely filled with polymer i.e., the structure at this point is still somewhat porous. Following the drying step, the impregnated seat is again placed in a furnace in a step 15, and is heated to sinter and cure the PTFE at an appropriate "Teflon-sintering" temperature, i.e.

one which is considerably lower than the sintering temperature previously employed for the metal seat alone. By way of example, if the green compact prepared in step 10 constitutes stainless steel particles, it would be sintered at approximately 1371°C (2500°F) whereas Teflon is sintered (in step 15) at around 371°C (700°F). Sintering step 15 is needed to coalesce the Teflon particles, previously in the emulsion, with one another since, otherwise, the Teflon particles would be driven out of the pores in the sintered metal seat when the seat is later subjected to fluid pressure. However during this second sintering step 15, the coalescing action of the Teflon particles tends to cause some shrinkage of the PTFE in the pores of the sintered metal seat, and this, together with the voids

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which were created when the water or other liquid vehicle was removed or driven off in step 14, makes this structure even more porous following completion of step 15 than it was prior to the commencement of that step.

5 In order to render the overall structure nonporous, the structure is then subjected, in a step 16, to extremely high pressures which collapse substantially all of the interparticulate cavities and voids throughout the seat onto the enclosed PTFE or other cured polymer within the seat, to
10 eliminate all interparticulate voids in the sintered metal seat to the extent possible, and to render the complete seat impervious to fluid flow, i.e., to make the final product "leak free" throughout. Step 16 can be effected in the manner shown in Fig 2 wherein the annular, polymer
15 impregnated, sintered metal seat 20, produced by method steps 10-15 described above, is placed in a die 21 which has a cooperating plunger 22 that, together, define exterior surfaces which closely conform to all of the exterior surfaces of seat 20, whereafter extremely high pressures,
20 in the order of 40 tones per square inch, are applied to the seat to collapse all voids within the seat material and to render it nonporous and of substantially uniform density throughout.

 The seat 20, following completion of step 16, is of
25 sintered metal construction wherein cured PTFE (or whatever other polymer having desired lubricity is employed) fills the interparticulate spaces or collapsed voids of the sintered metal matrix throughout the body of the seat. The

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seat is, accordingly, nonporous throughout. Indeed, seats constructed in accordance with the present invention have been found to hold bubble tight on helium, which is a most stringent leakage test. Those incremental portions of the polymer material which are adjacent the surface of the seat act as a lubricant at said surface. Moreover, since all interparticulate voids have been collapsed by step 16, when the seat is used in an application where the temperature is higher than room temperature, the cured polymer within the seat expands but has no place to go; and the resultant expansion is therefore manifested as an increase in the internal pressure of the seat through the matrix of sintered metal material, which experiences a migration of the cured polymer toward the surface of the seat and causes some extrusion of the polymer from the seat surface to increase the lubricity of the seat at the seat/ball interface.

Following step 16, the seat may, in a step 17, be dipped in a PTFE emulsion which is much more viscous in consistency than the emulsion in steps 12 and 13, to coat the seat with a layer of Teflon or other polymer having desired lubricity, whereafter the coating layer is again sintered and cured to provide the seat with an outer envelope which gives the seat additional initial lubricity. As indicated in Fig 1, however, this final step is optional. Moreover, if desired, the outer polymer layer, if provided, may be characteristically coloured to clearly identify the type of seat which has been produced.

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While I have thus described a preferred embodiment of the present invention, many variations will be apparent to those skilled in the art. For example, the method of the present invention can be used to fabricate valve seats or
5 seals of other kinds, such as stem seals for a variety of valve types, or seats for use in gate valves. It is believed that in some circumstances it may be desirable to manufacture a valve member such as the ball of a ball type plug valve by the method according to the invention and the
10 claims are to be construed to cover such a valve member. It must therefore be understood that the foregoing description is intended to be illustrative only and not limitative of the present invention and all such variations and modifications as are in accord with the principles
15 described are meant to fall within the scope of the appended claims.

CLAIMS:

1 A valve member or seat or seal comprising a body of sintered particulate metal impregnated with a cured polymeric material, characterised in that the interparticulate spaces within said body are completely filled with said cured polymeric material.

2 A valve member or seat or seal according to claim 1 characterised in that said valve member comprises an annular body of sintered particulate material and said polymeric material which fills the interparticulate spaces within said body has lubricity whereby said polymeric material renders said body nonporous throughout the interior of said body whereby increases in the temperature of said body which result in expansion of the polymeric material within said body effect a migration of portions of said cured polymeric material from the interior of said body to the exterior surfaces of said body to lubricate said exterior surfaces.

3 A valve member or seat or seal according to claim 2 characterised in that the exterior surface portions of said body have substantially the same density as the interior of said body.

4 A valve member or seat or seal according to any one of claims 1 to 3 characterised in that said polymeric material comprises polytetrafluoroethylene.

5 A valve member according to any one of claims 1 to 4 characterised in that the exterior of said body is completely covered by a layer of cured polymeric material.

6 A valve member according to claim 5 characterised in that said layer of cured polymeric material comprises polytetrafluoroethylene.

7 A method of making a valve member or seat or seal, wherein a body of porous sintered particulate metal is impregnated with an uncured polymeric material which is then cured to partially fill the interparticulate spaces in said body with cured polymeric material, characterised by the step of applying pressure to said impregnated body following said curing step, said pressure being sufficient in magnitude to collapse substantially all voids throughout said sintered metal body remaining in said body following said impregnation and curing steps, thereby to cause the cured polymeric material within said sintered metal body to completely fill all the collapsed interparticulate spaces within said body and to render said body nonporous throughout, said pressure being so applied to said body as to produce substantially uniform density throughout said body and at the exterior surfaces of said body upon completion of said pressure-applying steps.

8 A method according to claim 7 characterised in that said sintered metal body is fabricated in annular form for

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use as a valve seat or seal prior to impregnation of said body with said polymeric material, said curing and pressure-applying steps being effective to maintain said annular form.

9 A method according to claim 7 or claim 8 characterised in that said polymeric material comprises polytetrafluoroethylene.

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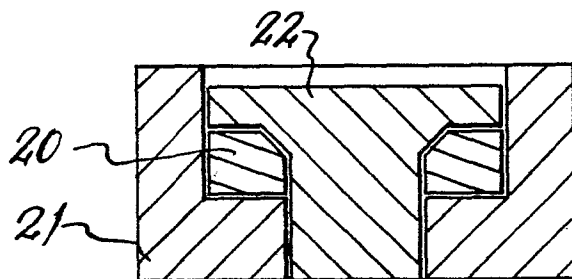
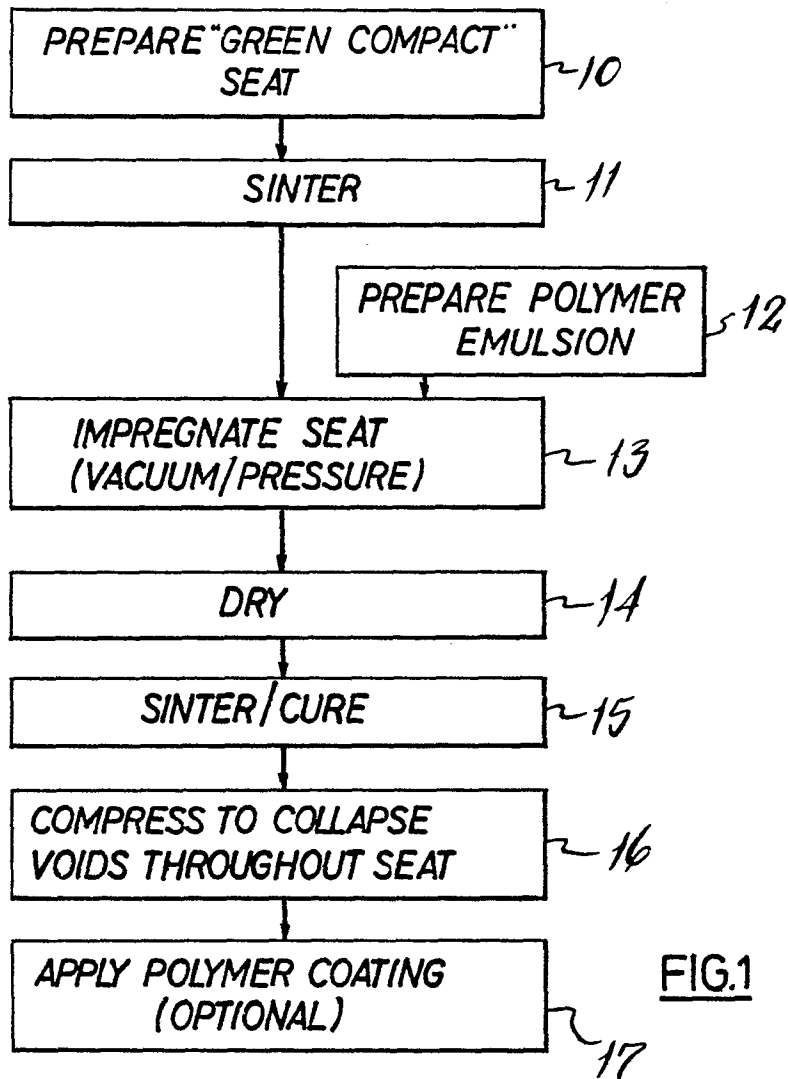


FIG.2

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European Patent
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EUROPEAN SEARCH REPORT

Application number

EP 82 30 4852

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X,Y	US-A-2 838 829 (R.V. GOSS et al.) * Column 3, line 12 - column 4, line 20 *	1-9	B 22 F 3/24
Y	GB-A- 674 056 (W.P. WILLIAMS) * Page 1, line 51 - page 2, line 65; claims 1,3,4 *	1-3,7	
Y,D	US-A-3 592 440 (R. McFARLAND et al.) * Column 4, line 42 - column 5, line 75 *	1-9	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			B 22 F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11-05-1983	Examiner SCHRUIERS H. J.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			