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(54) **A method of forming a one piece article comprising a body of base metal having one or more smaller bodies of another material anchored thereto.**

(57) There is disclosed a method wherein a pattern (12) is formed comprising a body (12A) of consumable material having an exterior configuration conforming to that of the body of the base metal and having the smaller bodies supported thereby in positions corresponding to those which they are to occupy on the body of base metal, then confining the pattern within a mold, and pouring molten base metal into an opening (15) in the mold which leads to the body (12A) of consumable material in order to cast the body of base metal and bond the smaller bodies to it.

Fig. 1

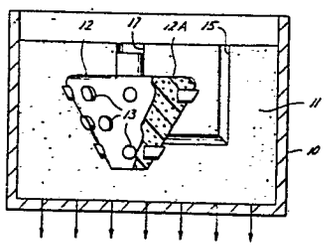
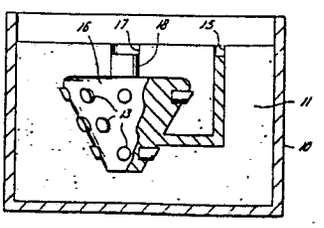


Fig. 2



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This invention relates to an improved method of forming a one piece article comprising a body of base metal having one or more smaller bodies of another material anchored thereto. This invention has particular utility in the formation of articles having abrasive, wear resistant or corrosion resistant inserts embedded in or other smaller bodies thereof bonded to the working surface of the body of base metal.

In the formation of drilling tools, such as drill bits and/or roller cones therefor, stabilizers, mills or the like, inserts of a hard metal, such as tungsten carbide, are normally press-fitted into holes drilled at predetermined locations in the working surface of a steel body. However, these inserts are often pulled loose from the base metal because they do not form a tight bond within the holes, particularly when they are of cylindrical shape to facilitate their being press-fitted into the holes. Also, when the inserts are to be arranged

with their axes extending in different directions, drilling the holes in the base metal to receive them may involve complicated and expensive machining operations.

The primary object of this invention is to provide a method of forming a one piece article of this general type in which the smaller bodies are securely anchored to the body of base metal; and, more particularly, to provide a method of forming a drilling tool of the type described whose inserts are secured to the base metal by a metallurgical as well as a mechanical bond.

Another basic object is to provide such a method which does not require that holes be drilled in the body of base metal, or that other machining operations be performed thereon, preparatory to anchoring of the smaller bodies thereto, whereby the smaller bodies may be positioned on the body of base metal with a minimum of time and effort.

A further object is to provide such a method wherein the inserts may be of most any shape desired in order to fulfill the purposes of the article to be formed.

Still another object is to provide a method wherein smaller bodies of another metal may be cast in place on the body of base metal in such a manner that desired metallurgical effects may be obtained, and/or undesirable metallurgical effects avoided, in one or both of the metals during the casting.

These and other objects are accomplished in accordance with the broader aspects of the present invention, by a method comprising the steps of confining within a mold a pattern comprising a body of consumable material which conforms to the body of base metal of the article to be formed, and which has the smaller bodies of another material supported thereby in positions corresponding to those which they are to occupy with respect to the body when cast, and replacing the consumable material with molten base metal in order to

cast said body of base metal and bond the particles in such positions about the surface thereof. Thus, in accordance with technology in the art known as "full mold" casting, as long as the metal is poured into an opening in the mold leading to the pattern at substantially the same rate the body of consumable material is consumed by its heat, the mold, which is usually unbonded sand packed about the pattern, will not collapse.

In accordance with the preferred and illustrated embodiments of the invention, the smaller bodies are inserts of a hard, wear resistant metal, such as tungtsten carbide, which are embedded in the body of consumable material, and thus anchored to the body of base metal by one or both of a metallurgical and mechanical bond, whereby there is substantially less possibility of their being pulled loose, as during use as wear resistant or abrasive surfaces. The only machining, or other preparation, required in the practice of the present invention is that necessary to enable the inserts to be supported by the body of consumable material; and if holes are preformed in the body of consumable material for this purpose, or if the inserts are molded in the place in the body of consumable material, the preparation is especially simple and inexpensive.

As disclosed, for example, in U. S. Patent No. 2,830,343, the consumable material is one which will be "consumed", as that term is used herein, without excessive residue when subjected to the molten metal. Furthermore, the residue which does occur is thought to actually enhance the atmosphere in which the materials are bonded. The smaller bodies, on the other hand, are of such composition as to maintain their integrity at the high temperature at which the base metal is poured. Thus, for example, although the binder in tungsten carbide inserts may have a melting point substantially the same as or even lower than that of the base metal, the heat of the molten metal will not be instantly transmitted thereto.

As explained in the aforementioned U. S. Patent, full mold casting is particularly well suited to the casting of irregular shapes, because, since the pattern is consumed, it need not be removed from within the mold prior to pouring of the molten metal. Thus, although the ability to cast such shapes is not the primary objective of this invention, it is an additional advantage which stems therefrom.

The consumable material is conventionally a cellular plastic material which is sufficiently rigid to resist collapse under the weight of the sand. Although explanations vary as to the exact phenomenon which occurs, it is believed that the effluent from consumption of the consumable material aids in supporting the sand. Furthermore, the particular consumable material to be used may be selected to accomplish desired metallurgical purposes with respect to one or both of the metals. Thus, for example, inasmuch as polystyrene foam or other suitable consumable materials, have a high carbon content, they are believed to generate an atmosphere, as they are consumed, which enhances metallurgical bonding of the inserts to the body of base metal.

Preferably, the mold is a flask which contains unbonded sand to which vacuum may be applied as the consumable material is replaced by the molten base metal. The vacuum is not only useful in drawing off the gas from the combustion of the consumable material, and presumably in holding the sand in place, but also in holding the inserts in place, although, in accordance with the broader aspects of the present invention, it is contemplated that the inserts may be held in place in the absence of such a vacuum. Preferably, the inserts have inner ends which are of varying cross section along their lengths and thus more firmly anchored to the body of base metal when cast. Also, the inner ends of the inserts may be of non-circular cross section, and thus resist rotation as well as withdrawal from embedded position during use. Thus, the

shape of the inserts has no bearing on the casting process so that inserts of most any shape may be bonded to the base metal.

If there are voids in the outermost portions of the separation between the inserts and the holes in the body of cellular plastic material in which the inserts are embedded, the unbonded sand or other pulverulent refractory material in the flask of the mold may work its way between the inserts and consumable material. Furthermore, if the exposed, outer ends of the inserts are first coated with a mold wash, which may be desirable to reduce oxidation of the insert upon removal from the mold, the particles of the wash may also enter the voids. As will be understood, any such interference with a tight fit between the inserts and body of consumable material will detract from both the mechanical and metallurgical bond between them.

Since the inserts or other smaller bodies are formed of a material different than that of the body of base metal, there may be a tendency for the one or both of the materials to diffuse or migrate from one to the other during pouring. This is particularly true in the case of a material such as tungsten carbide which has a high carbon content as compared with a relatively low carbon steel from which the body of base metal may be formed. As a result, the insert material may be diluted to such an extent that it is very brittle or otherwise less suitable for wear-resistant purposes. This problem may be particularly acute in the case of a drill bit due to the large mass of base metal relative to that of the inserts.

Difficulty may also be encountered in supporting smaller bodies on the surface of the body of consumable material, rather than embedding them therein. This is particularly true when the smaller bodies are crushed particles or chips which are to be anchored in one or more layers to the surface of the base metal. Although glues such as rubber cement will evaporate in the presence of

heat from the molten metal, and are thus consumable to permit the base metal to bond to the inserts, they are slow to dry and, unless dry, may permit the smaller bodies to move out of the positions which they are to occupy in the finished article.

Furthermore, in order to support small bodies of crushed particle size or chips, the glue must be placed not only at the interface between the particles and body of consumable material (which of course requires proper orientation of the surface of the body of consumable material), but also between the particles themselves, and preferably over the particles so as to to submerge them. This of course is an even more time-consuming process since it may require the application of several layers of cement. Still further, as the cement drys, it may pull away from the particles so that they are more susceptible to being dislodged.

When the pattern is confined within a mold comprising a flask containing unbonded sand, the sand must be sufficiently coarse to permit a vacuum to be applied thereto, as above described. Although the coarse sand is desirable from this standpoint, it may nevertheless be found to permit the formation of small protrusions of the base metal between the grains of sand. The resulting rough finish on the cast articles may for various reasons be highly undesirable.

It is therefore a further object of this invention to provide a method of the character above described wherein sand from the mold, or a mold wash or other foreign material, is excluded from voids between the inserts and body of consumable material by means which doesn't interfere with the casting process, and which, in fact, is condusive to a better metallurgical bond between the inserts and base metal and which also preferably reduces the likelihood of oxidation of the outer ends of the inserts.

Yet a further object of this invention is to provide a method of the character above described which deters diffusion of or migration between the materials from which the smaller bodies are made and the base metal, particularly in the forming of articles such as drill bits wherein the base metal is a low carbon steel and the smaller bodies are inserts of tungsten carbide or other wear-resistant material of high carbon content.

A still further object is to provide a method of the character above described in which the smaller bodies, and particularly one or more layers of particles of crushed tungsten carbide or the like, are so supported on the surface of the consumable material as to prevent their movement out of positions they are to occupy in the finished article.

Yet another object is to provide a method of the character above described wherein the pattern is confined within a mold comprising a flask containing a bed of unbonded sand which is of such construction that the resulting article has a relatively smooth outer surface, and yet wherein there is little or no interference with the application of vacuum to the sand.

These latter objects are accomplished, in accordance with one or more embodiments of the present invention, by the application of a sheet of consumable material to the surface of the pattern across the separation between the body of consumable material and the outer end of each of the inserts. Preferably, the sheets cover not only the outer ends of the separation, but also the outer surfaces of the inserts, so as to not only exclude foreign matter from voids in the outer ends of the separations, but also enable the application of a mold wash prior to pouring of the molten base metal in order to reduce oxidation of the outer ends of the inserts.

The consumable material of which the sheets are formed preferably comprises a common, off the shelf, plastic tape having high carbon content. Thus, like the

body of consumable material which also has a high carbon content, the sheets create a high carbon atmosphere which enhances the metallurgical bond between small bodies and the base metal. In addition, an adhesive side of the tape provides a convenient means for adhering it to the surface of the pattern without the need for applying cement thereto; and, when both sides of the tape are adhesive, the tape also provides a convenient means to which the smaller bodies may be applied prior to adhering of the tape to the surface of the body of consumable material.

In accordance with another novel aspect of the present invention, migration or diffusion of the material of the smaller bodies and the body of base metal is deterred by quickly cooling the cast article, both during casting of the article and after the article is heat treated following casting, as is preferred. In the preferred and illustrated embodiments of the invention wherein the mold is a flask which contains unbonded sand or other pulverulent refractory material, such sand is "fluidized" just as soon as the desired metallurgical bond between the small bodies and base metal has been accomplished following the pour of the molded base metal. For this purpose, air, preferably in the form of an inert gas, is caused to move upwardly through the unbonded sand to the extent necessary to cause the sand to act as a fluid, and thus to conduct heat quickly from casting through the sand, rather than to insulate the casting, as occurs when the unbonded sand is "solidified". The unbonded sand may be again fluidized in order to transfer heat to the cast article for heat treating purposes, and then quickly cool the heat treated article. Casting and subsequent heat treating may, if desired, be practiced in different molds and then different beds of sand.

When the smaller bodies are particles to be applied as one or more layers to the surface of the base metal, they may first be applied as a layer to one side of the sheet, as by means of a suitable cement. Even though

the cement may not have dried, the sheet may be applied to the body of consumable material to support the particles in desired positions thereon. Thus, the sheet acts as a carrier or mat which may itself be adhered to the surface of the consumable material. In a further embodiment of the invention, still another sheet of consumable material will be applied over the first-mentioned sheet, and the outer edges thereof adhered to the surface of the body of consumable material.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a vertical, sectional view of a flask containing unbonded sand which forms a mold to confine a pattern comprising a body of cellular plastic material having inserts embedded in the surface thereof in accordance with one illustrative embodiment of the present invention;

FIG. 2 is a vertical sectional view similar to Fig. 1, but wherein the consumable material has been replaced by a molten base metal in order to cast the body of base metal and bond the inserts thereto;

FIG. 3A is an enlarged detail view of a modified insert having a reduced cross-sectional area about its inner end into which the base metal flows to securely anchor the insert to the body of the base metal;

FIG. 3B is another enlarged detail view of another modified insert supported on the body of consumable material in such a manner that a bell bottom on its inner end will be securely anchored to the body of base metal when cast;

FIG. 4A is a longitudinal sectional view of a portion of a body of consumable material having an insert embedded therein, and a sheet of consumable material applied to the surface of the body of consumable material to cover the flush outer end of the insert as well as a separation between it and the body of consumable material;

FIG. 4B is an elevational view of the outer surface of the body of consumable material of Fig. 4A, showing the outer end of the insert embedded therein and the covering sheet of consumable material applied thereto;

FIG. 5 is a longitudinal sectional view of a portion of a body of consumable material having a sheet of consumable material applied to the surface thereof, and with a strip of tungsten carbide, or other highly abrasive material, adhered to the outer side of the tape so as to be supported in a predetermined position on the outer surface of the body of consumable material;

FIG. 6A is a sectional view of a surface on which a sheet of consumable material is supported, and with a layer of crushed particles adhered to the upper surface of the sheet;

FIG. 6B is a view similar to Fig. 6A, but wherein a film of cement has been applied over the layer of crushed particles;

FIG. 6C is a sectional view of a portion of a body of consumable material, similar to Figs. 4A and 5, but wherein the sheet of consumable material shown in Fig. 6B has been applied to the outer surface thereof, and another sheet of consumable material has been applied over the outer surface of the first sheet with its overhanging edges adhered to the outer surface of the body of consumable material so as to support the layer of crushed particles in a predetermined position upon the surface of the body of consumable material; and

FIG. 6D is an elevational view of the outer surface of the portion of consumable material shown in Fig. 6C, as well as the layer of crushed particles supported thereon.

Referring now to the details of the above-described drawings, the flask 10 and bed 11 of unbonded sand contained therein are of conventional construction well suited for use in the "full mold" casting process. As illustrated diagrammatically by the

arrows in Fig. 2, a means is provided for drawing a vacuum on the bed of sand within the flask. The upper end of the flask is open to permit the sand to be packed around a pattern, and a means (not shown) may also be provided for vibrating the flask or otherwise assisting the same in compacting about the pattern.

As shown in Fig. 1, and as previously described, the pattern 12 comprises a body 12A of consumable material having an external configuration which conforms to that of the body of base metal of the article to be formed. In this particular illustrative example, the body of the article to be formed, and to which the body of consumable material conforms, is a roller cone for a drill bit. As known in the art, such an article is generally conical, and inserts 13 of tungsten carbide are embedded in its working surface in order to both break down the formation being drilled and increase the wear resistance of the bit. More particularly, these inserts are normally arranged in rows about the cone, with their outer ends protruding slightly from the outer surface of the body of base metal.

In accordance with the present invention, and as shown in Fig. 1, these inserts are initially embedded in and thus supported by the body of consumable material in positions corresponding to those which they are to occupy on the body of the cone. When so positioned, the inserts extend at different angles with respect to one another and with respect to the outer surface of the body of consumable material. As shown in Fig. 3A, the inner ends of inserts 13A may be provided with a circumferential groove into which base metal will flow in order to more securely anchor the inserts thereto. As shown in Fig. 3B, the inner ends of inserts 13B have bell bottoms which are inserted into enlarged holes in the surface of consumable material, and another preformed body 14 of consumable material, which may be glue, is disposed between the insert and the hole, whereby the base metal which replaces the consumable materials will securely anchor the inserts

in their preset positions. The glue or other consumable material making up body 14 may be relatively dense, while the large body 12A thereof in which the holes are formed may be of low density, and thus more readily consumable. As also shown in Fig. 3B, the outer end of body 14 tapers inwardly toward the outwardly projecting end of insert 13B so that, when the base metal is cast, stress will be better distributed between the insert and the base metal, or stress between them will be eliminated.

As previously described, in accordance with the preferred embodiment of the invention, the body 12A of consumable material is a cellular plastic material which is burned or vaporized, and thus in any event gasified, by the heat of a molten charge of base metal as the latter replaces it during the casting process. Although, polystyrene, which is manufactured under the trademark "Styrofoam", is preferred for this purpose, similar materials such as polyurethane and other thermoplastic, resinous materials such as polypropylene, cellulose, acetate, acrylate, may be used if desired.

Ordinarily, it is desired to pull off a large portion of the gas by means of the vacuum drawn on the bed of sand. This of course reduces the possibility of an objectionable carbon build up on the surface of the base metal. Also, this concern for carbon build up may dictate the use of a consumable material having less carbon content than polystyrene foam.

On the other hand, and as previously mentioned, a high carbon content material such as styrene foam may be desired because of the carbon rich atmosphere which it generates when heated. In fact, and as previously described, a certain amount of residue resulting from gasification of the consumable material may actually enhance bonding. Thus, such an atmosphere is believed to permit the formation of a metallurgical bond between the inserts and body of base metal without the eta phase often experienced when carbide is heated. In any event, the

availability of consumable materials having varying characteristics enables one to be selected in order to attain, or avoid, certain metallurgical results during casting.

As also previously described, cellular plastic materials are preferred not only because they are easily formed into complex shapes and leave little or no residue in the mold, but also because they are structurally strong, and thus not easily deformed when confined within the mold of unbonded sand. Still further, insofar as the present invention is concerned, although not easily deformable, such materials may nevertheless permit the inserts to be pressed into desired positions in the outer surface thereof. Alternatively, the invention contemplates that the inserts may be molded with the body of consumable material in accordance with standard procedures. In either case, holes would not have to be formed on the surface of the body of consumable material to receive the inserts, and thus the inserts may be of most any shape.

Although shown to be solid, the body 12A of consumable material may instead be hollow. Also, it may be of composite construction, with an inner core of relatively low density cellular plastic material so as to reduce the amount of gas, and with the inserts supported by a relatively high density cellular material on the outside of the inner core.

Although the inserts 13 are shown to be embedded and to protrude from the working surface of the body of consumable material, and thus from the cast body of base metal, the inserts may instead be flush with the surface, as in the case of modified inserts 13A, as well as in the case of inserts shown in Figs. 4A and 4B to be described hereinafter. Also, the inserts may be supported by the body of consumable material without being embedded - i.e., with their inner ends flush with the surface thereof, as

shown in Fig. 5. In this case, for examble, the inner ends of the inserts could be glued directly to the working surface, or otherwise supported thereon as will be described in connection with Fig. 5.

Although unbonded sand is preferred as the forming material of the mold, the mold may instead be made of bonded sand or other common foundry forming materials. In any event, unbonded sand is easily packed around the pattern, as shown in Fig. 1, and is also susceptible to vibration in order to enhance its tight packing to form a smooth mold surface about the pattern, or to fluidizing in order to more easily position the article pattern therein or remove the cast article therefrom as well as to facilitate the heating and cooling thereof.

As shown in Fig. 1, molten metal may be poured into an opening 15, commonly known as a gate or filling tunnel, formed in the bed of unbonded sand and leading to the pattern. As previously described, and as known in the art of full mold casting, the molten metal is poured at substantially the same rate as the pattern is consumed so as to replace same. When the body 16 of base metal hardens in the mold, the inserts are metallurgically bonded thereto, or mechanically bonded thereto, or both, in positions predetermined by their support on the surface of the pattern.

As illustrated, the cast article is the end product - i.e., in this case, a roller cone for a drill bit. The invention contemplates, however, that the cast article may be an intermediate product - e.g., a strip of base metal in which the inserts are embedded as a one piece casting, and which may be wrapped around or otherwise fastened to a body to be protected from wear or to be used for cutting purposes.

Alternatively, the articles to be formed may, for example, be valves or valve parts, such as bodies, seats or closure members. In this case, inserts of bronze, stainless steel, or the like may be supported upon

a body of base metal so as to provide, when finish machined, a corrosion resistant as well as abrasion resistant sealing surface.

As previously noted, casting such articles in a bed of unbonded sand will, according to some theories, facilitate the escape of the gas from the combustion of the consumable material. Drawing a vacuum on the bed of sand may be found to not only facilitate removal of the gas, but also assist in holding the inserts in place as the body of consumable material is replaced by the charge of metal. If desired, and as shown in Fig. 1, another opening 17 may be formed in the bed of sand to receive a runner of consumable material on the body of consumable material, whereby an excess of the molten metal may enter opening 17 to form a riser 18 on the cast article, as shown on Fig. 2.

With reference now to the embodiment of the invention shown in Figs. 4A and 4B, a cylindrical insert 20 of tungsten carbide or other suitable highly abrasive material is pressed into a similarly shaped hole 21 formed in the outer surface 22 of a body of consumable material. As in the case of the insert shown in Fig. 3A, the outer end of insert 20 is flush with the outer surface of the body of consumable material.

Furthermore, and in accordance with another novel aspect of the present invention, a sheet 23 of consumable material is applied to the outer surface of the body of consumable material so as to cover the separation between the insert 20 and the hole 21 which receives the insert so as to prevent grains of unbonded sand, or other fine particles of foreign material, from entering voids which might be present in the separation between the insert and the hole. As previously mentioned, such foreign material may comprise particles of a mold wash, which is preferably applied over the outer surface of the body of the consumable material, as indicated in broken lines in Fig. 4A, prior to the installation of the pattern

within a bed of unbonded sand in the flask of the mold. As shown in Fig. 4B, the sheet 23 also covers the outer end of the insert 20 so as to lessen any tendency for the tungsten carbide to be oxidized upon removal of the cast article from the mold.

As also previously mentioned, the sheet 23 may be a commercially available tape of suitable plastic having adhesive on one or both sides. This not only provides a means by which the inner side of the tape may be applied to the outer surface of the body of consumable material, but also tends to hold the body of consumable material in place and prevent it from shrinking away from the insert as the pour begins.

Still further, and as also previously described, the sheet contributes to the metallurgical bond between the insert and the base metal in that it further enhances the carbon atmosphere in which casting takes place as the consumable material is consumed. This, of course, is especially true when, as is contemplated in preferred embodiments of the invention, the body of base metal is steel and the inserts are of a material such as tungsten carbide having a high carbon content. It has been observed that the sheet has a capillary affect in that the molten base metal has a tendency to fill the void which it leaves as it is consumed, even to the extent of forming a thin film or skin over the outer end of the insert.

As also previously discussed, in the practice of the preferred embodiments of the present invention, wherein the inserts are of high carbon content relative to the relatively low carbon content of the body of base metal, there may be excessive migration of the two materials one to the other in the presence of the heat of the molten base metal. This tendency of the materials to go into solid solution could cause the insert tungsten carbide to become brittle or otherwise unsuitable as a hard, wear-resistant material. Thus, in accordance with a further novel aspect of the present invention, the

temperature of the cast article is so controlled as to reduce any tendency of the materials to migrate, but at the same time heat them to the extent necessary to obtain a good metallurgical bond between them. Preferably, this is accomplished by fluidization of the unbonded sand within the flask of the mold which causes the sand to act as a conductor and thereby transfer the heat from the article.

For this latter purpose, the body of sand may be subjected to a positive pressure, as by means of the introduction of air upwardly through the bottom of the flask to the extent necessary to cause it to act as a fluid, rather than a solid. Following casting of the article, it may be heat treated by the transfer of heat thereto through the fluidized bed of sand, and the heat then quickly dissipated therefrom, either in the same or another mold, to again prevent the excessive migration of the dissimilar materials.

In accordance with a still further novel aspect of the present invention, the bed of relatively coarse sand within the flask which facilitates the application thereto of a vacuum, as described in connection with Fig. 1, is modified to the extent that that portion thereof immediately surrounding the pattern is instead formed of a relatively fine sand. This has been found to reduce to a minimum the formation of protrusions on the outer surface of the cast article, without any significant effect on the casting process. That is, while filling the voids into which the base metal might otherwise flow or be drawn to form protrusions, the fine sand nevertheless interferes to only an insignificant extent with the free flow of gas therethrough during the vacuum step.

As illustrated in connection with Fig. 5, a one piece body of material 24, in the form of a strip of tungsten carbide or other highly abrasive material is applied to a sheet 25 of consumable material, which, similarly to the sheet 23, may be a plastic tape of any

suitable commercially available type having one or both of its sides of adhesive. In this case, the inner side of the strip 24 may be applied to one adhesive side of the tape 25, and the opposite side of the tape 25 then applied to the outer surface 26 of a body of consumable material so as to support the body 24 in a predetermined position on the outer surface of the body of consumable material. When the tape is of a type having adhesive on both sides, its inner side may merely be adhered to the outer surface of the body of consumable material for so supporting the body 24. As will be appreciated, this embodiment of the present invention enables several such one piece bodies 24 to be applied in supported positions at desired locations about the outer surface of the body of consumable material. As in the case of the sheet 24, since the sheet 25 is of a highly carbonaceous material, it further enhances the high carbon atmosphere in which the casting of the body 24 to the body of base metal occurs on consumption of the body of consumable material.

As shown in Fig. 6A, a sheet 27 of consumable material, which may also be commercially available adhesive plastic tape, is supported on a generally horizontal surface 28 so as to permit a layer of crushed particles or chips 29 to be spread evenly over its upper surface. Since the upper surface of the tape is adhesive, the particles will tend to remain adhered thereto for this reason alone, but, if desired, the particles may be pressed tightly against the upper adhesive side of the sheet. Preferably, however, a film 30 of cement is applied over the layer of particles 29 so as to fill the voids between them as well as to cover their upper sides.

The sheet 30 thus provides a mat or carrier for the particles 29 which may be applied to the outer surface 31 of a body of consumable material, as shown in Figs. 6C and 6D. For this purpose, the upper surface of the film 30, as shown in Fig. 6B, is applied directly to the outer surface of the body of consumable material, and the sheet

27 has overlapping edges 32 which are caused to adhere to the outer surface of the body of consumable material along the four edges of the film 30. It is contemplated that the mat may be so applied before the film 30 is dry, - i.e., as long as it is not so wet that it will run and thus cause the particles 29 to be displaced from their supported positions on the sheet 27. Thus, the surface of the still wet glue of the film 30 will further enhance the support of the mat to the outer surface of the body of consumable material.

It will be appreciated that, upon mounting or supporting of one or more bodies of tungsten carbide or the like on the outer surface of a body of consumable material, as described in connection with Fig. 5 and Fig. 6A to 6D, the casting procedure above described may be followed so as to form a one piece article.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the method.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Claims

1. In a method of forming a one piece article comprising a cast body of base metal having smaller bodies of another material anchored thereto, the steps of confining within a mould a pattern which comprises a body of consumable material having an exterior configuration conforming to that of the body of base metal and having the smaller bodies supported thereby in positions corresponding to those which they are to occupy on the body of base metal, and replacing the consumable material with molten base metal while the smaller bodies are so supported in order to cast said body of base metal and bond said smaller bodies thereto.

2. A method of the character defined in Claim 1, wherein the other material is another metal and the smaller bodies are metallurgically bonded to the body of base metal.

3. A method of the character defined in Claim 1 or Claim 2, wherein the smaller bodies are inserts which are embedded in the body of consumable material.

4. A method of the character defined in Claim 1 or Claim 2, wherein the smaller bodies are supported on the surface of the body of consumable material.

5. A method of the character defined in any of the preceding claims, wherein the consumable material is a cellular plastic material.

6. A method of the character defined in Claim 3 or Claim 5, wherein the base metal is steel and the inserts are tungsten carbide.

7. A method of the character defined in Claim 5, wherein the consumable material is polystyrene.

8. A method as claimed in Claim 1 of forming a one piece article, wherein the base metal is of relatively low carbon steel and the smaller bodies are of relatively high carbon content such as tungsten carbide, and the temperature of the mould is controlled, so as quickly to cool the cast article to prevent excessive migration from the material of the smaller bodies to the body of base metal.

9. A method as claimed in Claim 8 further including the step of heat treating the article by heating it following cooling and then quickly recooling it to again prevent excessive migration between the material of the smaller bodies and the body of base metal.

10. A method as claimed in Claim 8 or Claim 9, wherein the mould is a flask which contains a pulverulent refractory material which is fluidised to quickly cool the article.

11. A method as claimed in Claim 1 including the step of applying a sheet of consumable material to the surface of the pattern across the separation between the body of consumable material and the outer end of each of the inserts, confining the pattern within a pulverulent refractory material contained within a flask, and replacing the body of consumable material with molten metal in order to cast said body of base metal and bond said inserts thereto.

12. A method as claimed in Claim 11, wherein the sheets have an adhesive side which is adhered to the pattern.

13. A method as claimed in Claim 11, wherein the sheets cover the outer surfaces of the inserts.

14. A method as claimed in Claim 1, wherein each of the smaller bodies is adhered to a sheet of consumable material and each sheet is adhered to the surface of the body of consumable material.

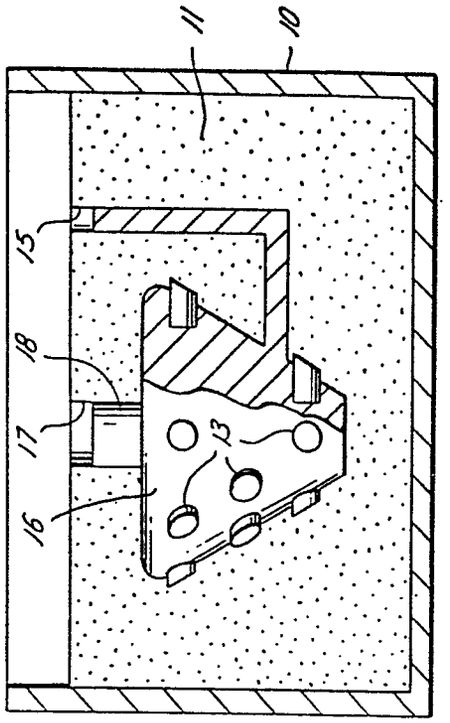


Fig. 2

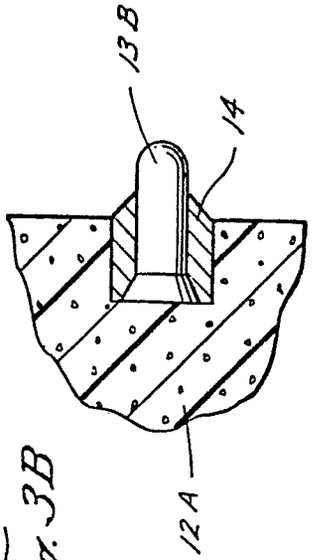


Fig. 3B

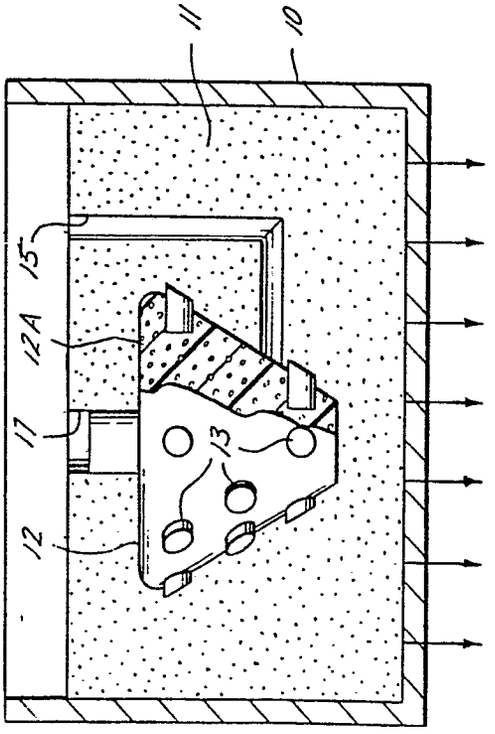


Fig. 1

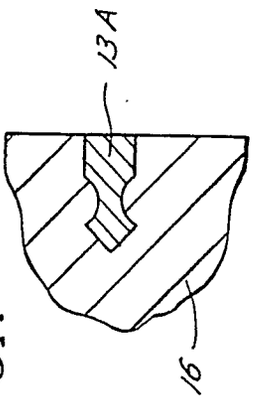


Fig. 3A

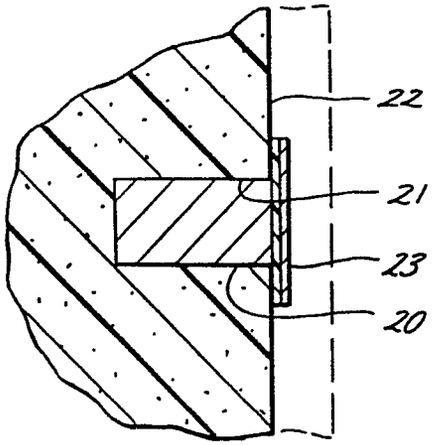


Fig. 4A

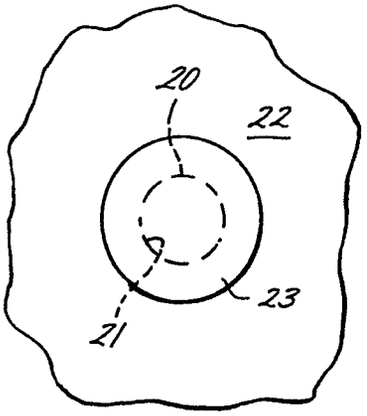


Fig. 4B

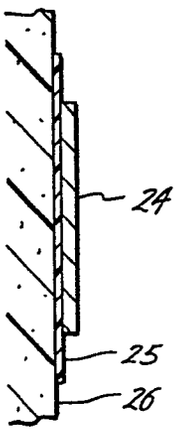


Fig. 5

Fig. 6A

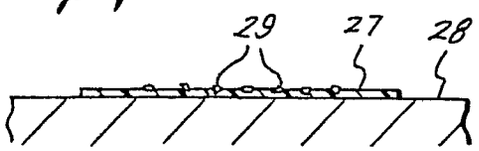


Fig. 6B

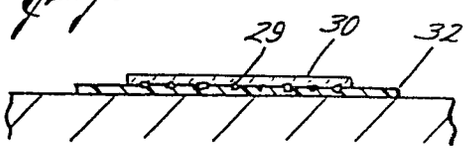


Fig. 6C

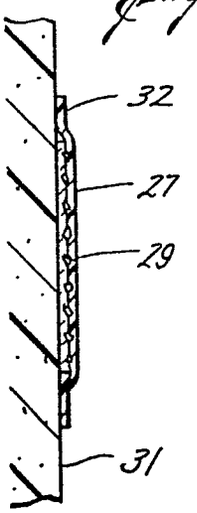
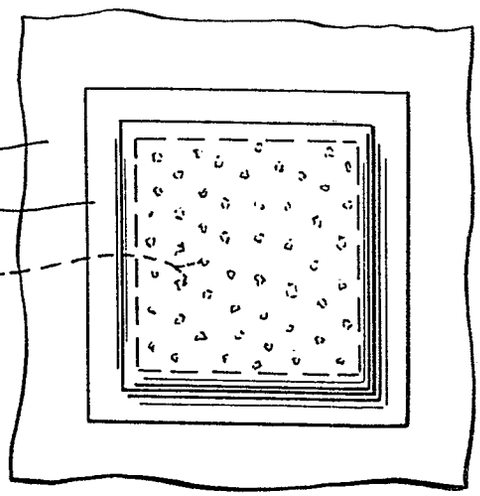


Fig. 6D



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EUROPEAN SEARCH REPORT

Application number

EP 82 30 2288.4

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)
A	DE - B - 1 433 954 (GRÜNZWEIG & HARTMANN) * claims 1, 2 *	1	B 22 C 7/02 B 22 C 9/04 B 22 D 19/00 B 22 D 19/06
A	DE - U - 7 220 947 (A. LÄPPLE GMBH) * claim 6 *	6	
A	US - A - 3 695 340 (GROSS) * abstract *	1	
A	US - A - 3 635 280 (PARSONS) * abstract *	1	TECHNICAL FIELDS SEARCHED (Int.Cl. 3)
D,A	US - A - 2 830 343 (H.F. SHROYER) * claim 1 *	1	B 22 C 7/00 B 22 C 9/00 B 22 D 19/00

CATEGORY OF CITED DOCUMENTS

X particularly relevant if taken alone
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D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	28-06-1982	GOLDSCHMIDT