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METHOD OF PRODUCING POWDER METAL ARTICLES

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Fig. 1.

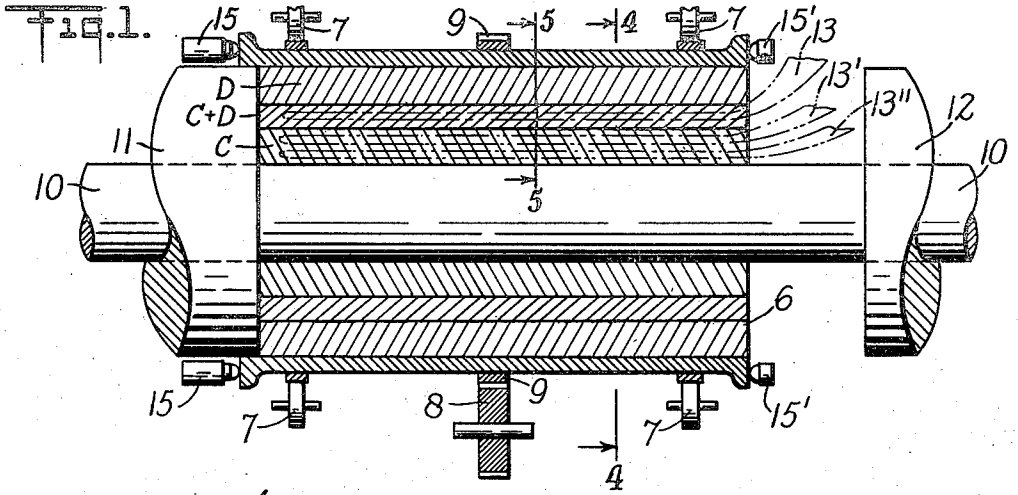


Fig. 4.



Fig. 2.

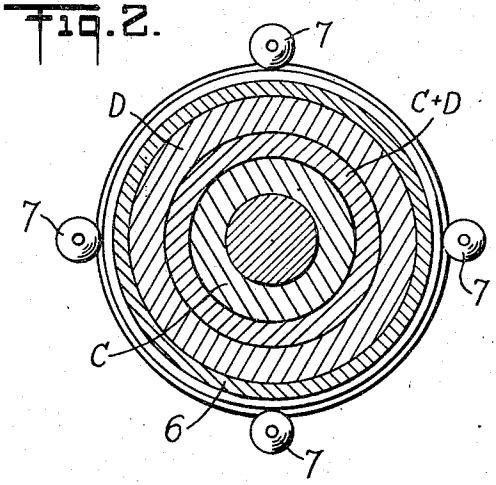
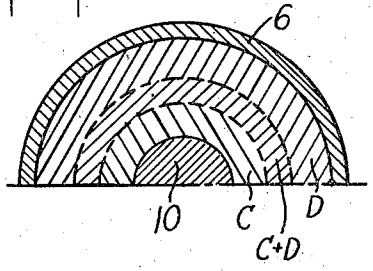


Fig. 3.



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METHOD OF PRODUCING POWDER METAL ARTICLES

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This invention relates to a method of producing powder metal articles.

In a broad sense the invention has for an object the production of powder metal articles that are constituted, at least in part, by a combination of zones of metals that have different characteristics and which are, in the article, so intermingled and interlocked that they will constitute one integral body in which there is no clear line of demarcation or cleavage between the metallic zones.

A further object of the invention resides in the production of powder metal articles of the constituency above referred to, in which various zones will have different heat dissipation and other characteristics, and yet which, during use, will maintain their integral structures.

A still further object of the invention resides in forming such articles by centrifugal arrangement of the metal powders and by pressure, which articles may subsequently be sintered and if desired hardened in whole or in part.

A still further object of the invention resides in forming the articles by centrifugal arrangement of the metal powders and the application of centrifugal force or pressure to the articles, and by force or pressure exerted at right angles or at substantially right angles to the application of the centrifugal force.

It is a still further object of the invention to form the articles so that between zones of metal powder there will be a preformed zone of metal powder that partakes of the nature of the adjacent or first mentioned zones and between which and said adjacent or first mentioned zones there will be no clear line of demarcation or cleavage.

It is another object of the invention to form articles from powder metal which are made up of superimposed zones of different metals which have different coefficients of expansion and so to intermingle or interlock the metals of said zones that the coefficient of expansion of one zone will blend into the coefficient of expansion of another zone, with the result that there will be no clear line of demarcation between the zones of different coefficients of expansion.

A still further object of the invention resides in imparting movement to powder metal particles in a mold in at least three directions during the emplacement and compacting of the powder metals.

The method includes, broadly, the placing of a layer of powder metal or an aggregation of powder metals in a mold, then placing, in the mold, a layer of powder metal which includes the first

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placed powder metal or at least one of the first placed powder metals of the aggregation, when an aggregation is first placed instead of a single metal, and includes also the powder metal next placed in the mold, or, when an aggregation of metals is next placed in the mold, which includes at least one of said metals of said next placed aggregation, then placing a layer of another powder metal or aggregation of powder metals in the mold. After such emplacement of the three layers of powder metals, centrifugal pressure is applied to the same to arrange and compact them into the form of the mold. Following this, the thus partly formed article is removed from the mold and sintered and, if desirable in any particular instance, is partly or wholly hardened as, for instance, by heat treatment and may then be machined to the desirable form. Of course the amount of pressure necessary and the temperatures of sintering and hardening are well known in the art.

In a more specific aspect of the invention it includes the application of centrifugal force to the various layers of metals or aggregations of metals as they are arranged in the mold and before the application of such pressure to cause the powder particles to rearrange themselves one upon another to produce a compact mass with a reduced number of voids and with greater surface contact between the metal particles and to cause the layers to definitely conform to the form of the mold.

The method is capable of producing articles of various forms, for instance a clutch or brake member, which includes a friction element and a backing or carrier element, or a cylinder such as used in a compressor or an internal combustion engine, which includes a cylinder lining or bore in which the piston operates and heat dissipating fins on the outside.

It will be immediately recognized that many other articles, which need not here be enumerated, may be produced by this method and, so, for the purpose of illustration only, we will describe the method as applied to the formation of a clutch element and as applied to the formation of a cylinder of the type above referred to.

In the drawings:

Figure 1 is a sectional view, in conventional representation, showing a centrifugal mold after the powder metals have been emplaced and primarily subjected to centrifugal action;

Figure 2 is a section taken on the line 4—4 of Figure 1;

Figure 3 is a fragmentary section as on the line

5—5 of Figure 3 through the centrifugal mold after the powder metals have been subjected to the complete centrifugal action; and

Figure 4 is an elevation of the injector.

Describing now the method as employed in the formation of a cylinder, and assuming that it is desired to form a cylinder which has an inner zone of one metal and an outer zone or envelope of another metal, we will designate the inner zone as made up of powder metal C, the outer zone as made up of powder metal D and the intermediate zone as made up of powder metals C plus D. Here again it is to be understood that metals C may be a single metal or an aggregration of metals, as may also be powder metal D. If it is desired to form a cylinder such as used in a gas compressor or an internal combustion engine, for instance, where heat is developed and must be dissipated, the metal forming the facing of the cylinder should of course be resistant to wear and the effect of heat and the metal forming the envelope should have a high degree of heat radiation. Such metals are well known in the art.

Our method may be performed by using a hollow rotatable mold that will have the desired cross sectional form, such, for instance, as circular, angular or irregular.

A circular cross sectional mold is indicated at 6 in the drawing, is mounted for rotation on suitable bearers 7, and is driven at the desirable high speeds to develop the desired centrifugal force, by suitable means such as a cooperating gear and rack 8—9. A core 10, having the desired exterior configuration, extends longitudinally and axially of the mold and is mounted to be driven with the mold, preferably at the same speed, by any suitable means [not shown]. Plungers 11 and 12 are mounted adjacent the open ends of the mold 6. One of these plungers, 11 for instance, is so mounted that it will close one end of the mold and the other is so mounted that it may be backed away from the adjacent mold end. Each of the plungers 11 and 12 is adapted to enter the adjacent mold and by suitable and well known mechanism, be forced into the mold under great pressure.

In carrying out our method in the formation of a cylinder such as referred to above, we first inject metal powder D into the mold which has, preferably, already been set in rotation at the desired speed. This injection may be accomplished by an injector 13 which is connected to a source of powder metal D under pressure. The powder metal D is forced from orifice 14 in the injector toward the inner wall of the mold to form a layer of powder metal D of the desired and controllable thickness against the inner wall of the mold. During the rotation of the mold the powder metal D arranges itself in a substantially even thickness around the inner wall of the mold and the centrifugal action will maintain the powder metal in this condition. After the lapse of a suitable period the injector is withdrawn from the mold and after being connected to a source of powder metal of a preformed admixture of C plus D [or replaced by another injector already connected to such a source] is inserted in the mold further away from the mold wall and spaced from the inner face of the already emplaced powder metal D, the distance being sufficient to permit the building up of a layer of powder metal C plus D. This admixture of powder metal C plus D is then injected into the mold under pressure from the source and

against the inner face of the previously emplaced layer of powder metal D until a layer of the admixture of the desired thickness is built up. This admixture of powder metals C plus D will arrange itself in substantially uniform thickness around the inner face of the already emplaced layer of powder metal D. The position of the injector is indicated in dotted lines 13'. The injector is then withdrawn and after being connected to a source of powder metal C it is reinserted [in the position indicated at 13''] in the mold adjacent the core 10 [or the injector may be replaced by an injector already connected to a pressure source of powder metal C].

The powder metal C is then projected under pressure from the source into the space between the core 10 and the inner face of the layer of the admixture of powder metals C plus D, so as to substantially fill the remaining space.

Thus three layers are formed between the mold and the core [but these may be increased in number if desired], one of powder metal D, one of an admixture of powder metals C plus D, and one of powder metal C.

If desired, the rate of rotation of the mold may, after the emplacement of the layers of powder metals, be increased to develop a greater centrifugal force. This rotation is continued until the metal particles have rearranged themselves to eliminate the voids to a great extent until the layers have blended into each other and until the embryonic cylinder is sufficiently compacted and formed.

In one phase, the mold is then stopped and the plungers operated to exert pressure on the embryonic cylinder in a manner as previously described, and one plunger may then be withdrawn and the other advanced to eject the thus formed embryonic cylinder. The embryonic cylinder may be then sintered in the usual manner, as is well known in the art, and when desired, finally hardened in whole or in part and machined.

During the rotation of the mold the centrifugal force will cause the powder metals to arrange themselves radially and will cause them to commingle and interlock. In other words the metal particles of each zone will rearrange themselves to eliminate voids to a great extent and the portion of the powder metal C adjacent the admixture of powder metal C plus D will penetrate and interlock with the adjacent portion of the powder metal admixture C plus D, and the portion of the powder metal C plus D adjacent the powder metal D will penetrate and interlock with the adjacent powder metal D, with the result that the layers or laminations will be destroyed, as such, and will become indistinct zones with powder metal D on the outside, powder metal C on the inside and the admixture of C plus D blended with and interlocked with the two powder metals C and D.

Thus there will be no distinct line of demarcation between the zones of metals or between their coefficients of expansion.

Moreover, with this procedure the powder metals are compacted both radially or transversely and also longitudinally, and thus formed into an interwoven or unitary structure.

Our invention also contemplates the imparting of other motion to the powder metals as they are emplaced with the result that there will be further tendency to eliminate voids. This we may accomplish by vibrating the mold as it rotates, that is, by imparting to it longitudinal rapid reciprocations. Means for accomplishing these movements is illustrated as air hammers 15 which

are located adjacent one end of the mold and resilient buffers 15' which are located adjacent the other end of the mold, the hammers and buffers coacting to cause the longitudinal reciprocations of the mold.

We have said that the article, whatever its form, may be heat treated or hardened in whole or in part. In other words, the entire article may be heat treated or hardened if desired, or only a portion of the article may be heat treated or hardened. As, for instance, in the case of the clutch element, the clutch plate or carrier may be heat treated or hardened to the desired depth and in the case of the cylinder the internal surface may be heat treated or hardened to the desired depth.

There are many known ways of heat treating or hardening parts or the whole of metal bodies.

For instance, the article may be heat treated or hardened in part or in whole by the electrical induction heating method which is well known in the art and involves, broadly speaking, the use of an induction heating coil which carries a high frequency alternating electric current and which is set up adjacent to, within or around the article to be treated. The current sets up a magnetic field around a coil and with each alternation of current the magnetic field is reversed in direction. The placing of a metal article within the field sets the particles of metal in violent agitation and this results in heat. If the surface is to be hardened it is of course subsequently quenched, but if it is to be unhardened so as to retain its toughness and elasticity no quenching is indulged in.

It is thought unnecessary to illustrate this method of heating or hardening as it is believed that the above statement is sufficient to identify it with the well known art.

It will thus be seen that the method will produce articles whether flat [as exemplified by a clutch element] or cylindrical as [exemplified by a compressor or internal combustion engine cylinder] or of another form, wherein the powder metals of two spaced zones will be joined by an intermediate zone of powdered metal that partakes of the nature and characteristics of the powder metals of contiguous zones and wherein there is no line of demarcation or cleavage between the zones. The finished structure will thus be unitary or integral and may be worked to form it into articles of various configurations and for various uses.

Of course the selection of the metals for the various articles is controlled by the requirements of the articles to be formed, and since the characteristics of such metals are well known and the invention contemplates the use of a wide variety of metals, it is thought unnecessary to here list the metals that may be used.

The product formed by this method will include a zone of a powder metal or powder metals of certain characteristics, a zone of powder metal or powder metals of different characteristics and an intermediate zone that includes the powder metals of the first-mentioned zones, and wherein the three zones will have no clear line of demarcation between them but will be blended, interlocked and intermingled each with the other. After the article has been sintered it of course may be used in applicable instances in its sintered condition, or it may be worked into the desired form. When the article is to be used where it is desirable to have a part thereof hardened or heat treated that part of course will have the characteristics which are imparted to it by either heat treatment or hardening.

While we have illustrated and described our method and product and mechanism which may be used in performance of the method, we do not intend to be limited to the precise details as many variations may be made within the scope of the invention and as herein explained and as defined in the appended claims.

We claim:

1. The method of creating hollow cylindrical powder metallurgy articles which comprise an inner zone including one metal, an outer zone including a different metal and an intermediate zone including said metals of said inner and outer zones in a hollow mold having a core arranged axially therein with its outer face spaced from the inner face of the mold: which includes rapidly rotating said mold, injecting the powder metal which is to form said outer zone into said rapidly rotating hollow mold, continuing the rapid rotation of said mold until said injected powder metal arranges itself in a hollow cylinder against the inner surface of said mold to form the outer zone, thereafter continuing the rapid rotation of said mold and injecting the powder metals that are to form said intermediate zone into said rapidly rotating mold and in direct contact with the interior surface of the metal of said outer zone, thereafter continuing the rapid rotation of said mold until said last mentioned injected powder metals arrange themselves in a hollow cylinder against the interior surface of the hollow cylindrical outer zone formed by said first mentioned powder metal, thereafter continuing the rapid rotation of said mold and injecting the powder metal that is to form said inner zone into said rapidly rotating mold and in direct contact with the interior surface of the powder metal of said intermediate zone until the injected powder metals extend substantially from the inner surface of said mold to the outer surface of said core, thereafter continuing the rapid rotation of said mold until said last injected powder metal has penetrated the powder metals of said intermediate zone and the powder metals of said intermediate zone have penetrated said metal of said outer zone, arresting the rotation of said mold and thereafter applying reactive forces to said metal powders in directions substantially parallel with the axis of said mold to compact said metal powders into a substantially hollow cylindrical mass between said core and said mold.

2. The method of creating hollow cylindrical powder metallurgy articles which comprise an inner zone including one metal, an outer zone including a different metal and an intermediate zone including said metals of said inner and outer zones in a hollow mold having a core arranged axially therein with its outer face spaced from the inner face of the mold: which includes rapidly rotating said mold, injecting the powder metal which is to form said outer zone into said rapidly rotating hollow mold, continuing the rapid rotation of said mold until said injected powder metal arranges itself in a hollow cylinder against the inner surface of said mold to form the outer zone, thereafter continuing the rapid rotation of said mold and injecting the powder metals that are to form said intermediate zone into said rapidly rotating mold and in direct contact with the interior surface of the metal of said outer zone, thereafter continuing the rapid rotation of said mold until said last mentioned injected powder metals arrange themselves in a

hollow cylinder against the interior surface of the hollow cylindrical outer zone formed by said first mentioned powder metal, thereafter continuing the rapid rotation of said mold and injecting the powder metal that is to form said inner zone into said rapidly rotating mold and in direct contact with the interior surface of the powder metal of said intermediate zone until the injected powder metals extend substantially from the inner surface of said mold to the outer surface of said core, thereafter continuing the rapid rotation of said mold until said last injected powder metal has penetrated the powder metals of said intermediate zone and the powder metals of said intermediate zone have penetrated said metal of said outer zone, applying endwise vibrations to said mold during the injection of all of said metal powders and during the rotation of said mold, arresting the rotation of said mold and thereafter applying reactive forces to said metal powders in directions substantially parallel with the axis of said mold to compact said metal powders into a substantially hollow cylindrical mass between said core and said mold.

3. The method of creating cylindrically curved powder metallurgy articles which comprise an inner zone including one metal, an outer zone including one metal and an intermediate zone including at least two metals in a hollow mold; which includes rotating said mold sufficiently rapidly to develop sufficient centrifugal force to cause the powder metals subsequently injected into said mold to arrange themselves as hereinafter recited, injecting the powder metal which is to form said outer zone into said rapidly rotating hollow mold, continuing said rapid rotation of said mold until said injected powder metal arranges itself against the inner surface of said mold to form the outer zone, thereafter continuing said rapid rotation of said mold and injecting the powder metals that are to form said intermediate zone into said rapidly rotating mold and in direct contact with the interior surface of the metal of said outer zone, thereafter continuing said rapid rotation of said mold until said last mentioned injected powder metals arrange themselves against the interior surface of the outer zone formed by said first mentioned powder metal, thereafter continuing said rapid rotation of said mold and injecting the powder metal that is to form said inner zone into said rapidly rotating mold and in direct contact with the inner surface of the powder metal of said intermediate zone, and thereafter continuing said rapid rotation of said mold until metal of said last injected powder metal has penetrated the powder metals of said intermediate zone and metal of said powder metals of said intermediate zone has penetrated said metal of said outer zone.

4. The method of centrifugally forming powder metallurgy articles having a plurality of contiguous zones of powder metals which includes creating an outer zone of a powder metal in a confined space by rotating a mass of said powder metal sufficiently rapidly to cause said powder metal to arrange itself in said space by centrifugal action, creating an intermediate zone of a mixture of powder metals against the face of said outer zone by rotating a mass of said mixture sufficiently rapidly to cause said mass to arrange itself against said face by centrifugal action, creating an inner zone of a powder

metal against a face of said intermediate zone by rotating a mass of said last mentioned powder metal sufficiently rapidly to cause said mass to arrange itself against said face by centrifugal action, and thereafter exerting force against said created zones of powder metal.

5. The method of centrifugally forming a powder metallurgy article having a plurality of contiguous zones of powder metals which includes forming an outer zone of a powder metal against a confining wall by rotating a mass of said powder metal sufficiently rapidly to cause said powder metal to arrange itself against said wall by centrifugal action, forming an intermediate zone of a mixture of powder metals in contact with and against a face of said outer zone by rotating a mass of said mixture sufficiently rapidly to cause said mass to arrange itself against said face by centrifugal action, forming an inner zone of powder metal in contact with and against a face of said intermediate zone by rotating a mass of said last mentioned powder metal sufficiently rapidly to cause said mass to arrange itself against said last mentioned face by centrifugal action, and thereafter continuing rotation of said masses sufficiently rapidly and for a sufficient time to cause said masses to intermingle with each other and to be compactly and permanently formed into an article.

6. The method of centrifugally forming a powder metallurgy article having a plurality of contiguous zones of powder metal which includes forming an outer zone of a powder metal against a confining wall by rotating a mass of said powder metal sufficiently rapidly to cause said powder metal to arrange itself against said wall by centrifugal action, forming an inner zone of powder metal different from the powder metal of said outer zone in contact with and against a face of said outer zone by rotating a mass of said last mentioned powder metal sufficiently rapidly to cause said mass to arrange itself against said face of said outer zone by centrifugal action, and thereafter continuing rotation of said masses sufficiently rapidly and for a sufficient time to cause said masses to intermingle with each other and to be compactly and permanently formed into an article.

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