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Sato et al.

[11] **3,861,191**

[45] **Jan. 21, 1975**

[54] **METHOD OF MANUFACTURING AN ARTICLE HAVING A PERIPHERAL WALL AND INTEGRAL THIN-WALLED PORTIONS EXTENDING RADIALLY INWARDLY THEREFROM**

[75] Inventors: **Kazuo Sato**, Tokyo; **Soji Takahashi**, Kodaira, both of Japan

[73] Assignee: **Hitachi, Ltd.**, Tokyo, Japan

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[30] **Foreign Application Priority Data**

Nov. 22, 1971 Japan 46-93109

[52] **U.S. Cl.** **72/267**, 72/334, 72/354

[51] **Int. Cl.** **B21c 23/20**

[58] **Field of Search** 72/267, 358, 354, 334; 29/25.17, 25.18; 313/356

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Primary Examiner—Richard J. Herbst
Attorney, Agent, or Firm—Craig & Antonelli

[57] **ABSTRACT**

A method of manufacturing a cylindrical article having a peripheral wall and integral thin-walled portions extending radially inwardly therefrom includes a first step of subjecting a blank of a circular sheet material to a rearward extrusion to form a cup-shaped semi-finished article, a second step of subjecting the semi-finished article to forging to form the same into a shape having thin-walled vanes extending from the peripheral wall radially inwardly toward the axis thereof and thin-walled bottom interconnecting the radial vanes, and a third step of punching out the thin-walled bottom to form a finished article. All of the steps are carried out by wholly utilizing plastic working whereby the method is performed in dimensionally accurate and timesaving manner. Simultaneously with the formation of the vanes, the bottom wall can be formed therein with grooves or recesses. After the punching-out of the bottom wall, a pair of finished article can be secured together in bottom to bottom abutting relationship to form a composite article having apertures extending through the vanes for accommodating a strap ring.

5 Claims, 18 Drawing Figures

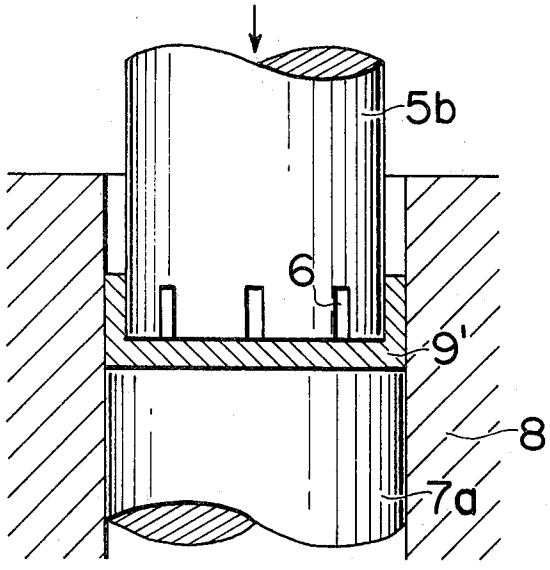


FIG. 1A

FIG. 1B

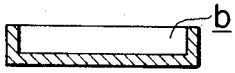


FIG. 1C

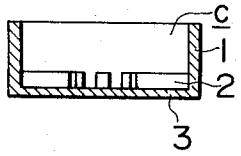


FIG. 1D

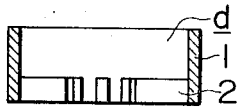


FIG. 1A'

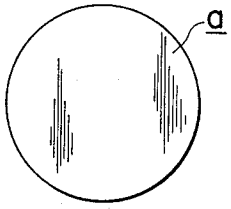


FIG. 1B'

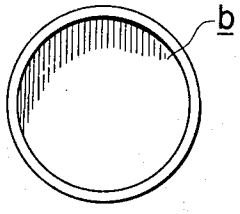


FIG. 1C'

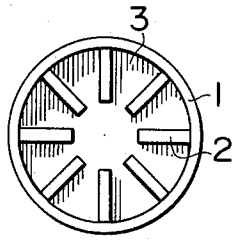


FIG. 1D'

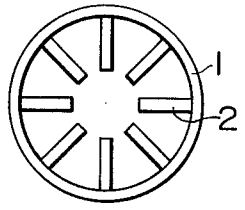


FIG. 2

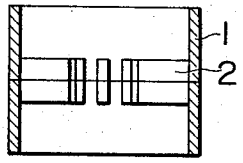


FIG. 3A

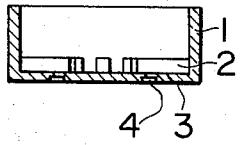


FIG. 3B

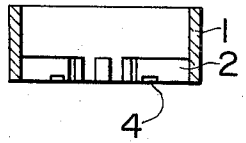


FIG. 4

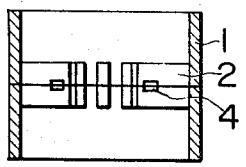


FIG. 5A

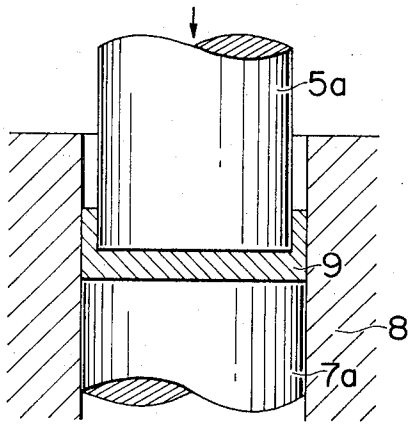


FIG. 5B

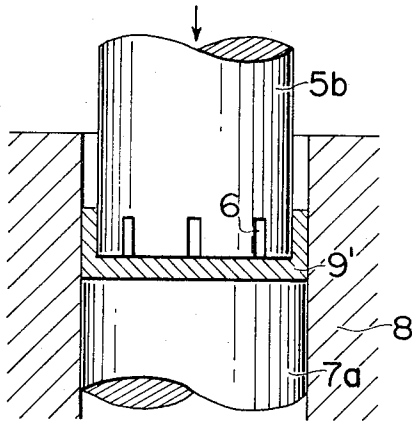


FIG. 6A

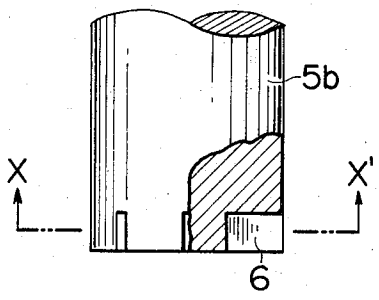


FIG. 6B

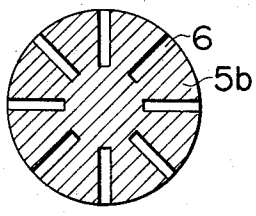


FIG. 7B

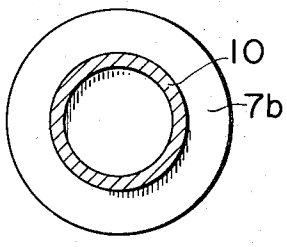
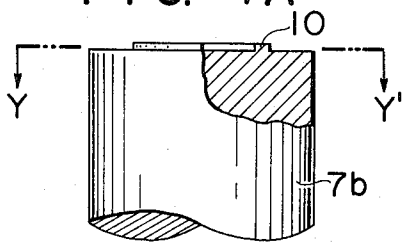


FIG. 7A



METHOD OF MANUFACTURING AN ARTICLE HAVING A PERIPHERAL WALL AND INTEGRAL THIN-WALLED PORTIONS EXTENDING RADIALLY INWARDLY THEREFROM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of manufacturing an article having a cylindrical peripheral wall and a plurality of thin-walled portions or vanes extending radially inwardly therefrom toward the axis of the peripheral wall, such as, for example, a magnetron anode.

2. Description of Prior Art

One of heretofore known methods of manufacturing magnetron anodes employs a step of silver-brazing a plurality of plate-like elements to the inner peripheral surface of a previously formed tubular member. Because of this step, the method is time-consuming and expensive. In addition, the mentioned step tends to result in inaccurate dimensions between the vanes of a finished article, which in turn results in the production of an oscillating tube of a decreased concentration factor of frequency.

Another known method includes a step of subjecting a cylindrical workpiece to forward and rearward extrusion to form a sleeve of an H-shaped cross-section which is then subjected to forging to form vanes rising up from a bottom wall. Thereafter, the bottom wall is removed by mechanical machining or cutting. Although the other method is improved over the first said method in that the the other method not only requires shortened working time and provides a finished product with improved accuracy in the dimensions between the vanes thereof, the other method requires that, when the bottom wall is machined off, the spaces defined between the vanes of a semi-finished product be filled with a quantity of mould compound so as to secure the vanes together for reinforcing the same. The other method, therefore, encounters difficulties in the filling-up of the mould compound before machining and removal thereof after the machining and in the removal of burr produced by the machining.

With both of the known methods, moreover, when it is required to mount strap rings on finished articles or magnetron anodes, mechanical machining or cutting is employed to form grooves for receiving the strap rings. This machining or cutting tends to provide dimensionally inaccurate grooves and, in addition, increases the number of steps of the method with descrease in the working efficiency. By mechanical machining or cutting, it is difficult to form a groove (or apertures for fitting a strap ring) of a complicated shape.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved method of manufacturing a cylindrical article having a peripheral wall and integral vanes projecting radially inwardly therefrom which method wholly utilizes plastic working and which provides an improved dimensional accuracy and requires reduced number of steps and shortened working time.

It is another object of the present invention to provide an improved method of manufacturing a magnetron anode which method wholly utilizes plastic working and which provides an improved dimensional accuracy and requires reduced number of steps an shortened time.

The method according to the present invention includes a first step of subjecting a circular workpiece of a metal such as copper to a rearward extrusion to form a cup-shaped semi-finished article, a second step of subjecting the semi-finished article to warm forging to deform the semi-finished article into a shape having a cylindrical peripheral wall, vanes radially inwardly extending therefrom toward the axis of the peripheral wall and bottom wall interconnecting the radial vanes, and a third step of punching out the bottom wall to form a finished article.

Simultaneously with the formation of the vanes, the bottom wall may be formed therein, by plastic working, with grooves or recesses for accommodating or receiving a strap ring. After punching the bottom wall out of the semi-finished article, a pair of such articles can be secured together in bottom to bottom abutting relationship to form a composite article having apertures extending through the vanes thereof for accomodating a strap ring.

The above and other object, features and advantages of the present invention will be made apparent by the following description with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIGS. 1A through 1D illustrate in axial sections a workpiece in successive steps of an embodiment of the method of manufacturing an article having a cylindrical peripheral wall and integral vanes radially inwardly extending therefrom;

FIGS. 1A′ through 1D′ are top plan views of the workpiece in the respective steps of the method shown in FIGS. 1A through 1D, respectively;

FIG. 2 is an axial sectional view of a composite article mad by securing a pair of finished articles manufactured by the steps shown in FIGS. 1A through 1D;

FIGS. 3A and 3B illustrate in axial sections a semi-finished article and a finished article produced by a modified embodiment of the present invention;

FIG. 4 is an axial sectional view of a composite article made by securing a pair of finished articles manufactured by the modified embodiment of the invention shown in FIGS. 3A and 3B;

FIGS. 5A and 5B are fragmentary, diagramatic, partially sectional views of dies and punches used to perform the method of the present invention;

FIG. 6A is a fragmentary, partially sectional side elevation of the upper punch shown in FIG. 5B;

FIG. 6B is a cross-sectional view of the upper punch taken along line X – X′ in FIG. 6A;

FIG. 7A is a fragmentary side elevation of a counter punch used in the modified embodiment of the invention shown in FIGS. 3A and 3B; and

FIG. 7B is a partially cross-sectional top plan view of the counter punch taken along line Y – Y′ in FIG. 6A.

DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is made first to FIGS. 1A through 1D and 1A′ through 1D′ of the drawings illustrating the successive steps of the method of the present invention. As will be apparent from these figures, the invention includes a first step of subjecting a circular workpiece or blank *a* of a metal such as copper or aluminium, shown in FIGS. 1A and 1B, to rearward extrusion to form a

semi-finished cup-shaped article *b*, shown in FIGS. 1B and 1B'. By a second step of the invention, the semi-finished cup-shaped article *b* is subjected to forging to form a semi-finished article *c* having a peripheral wall **1**, a plurality of vanes **2** and a thin-walled bottom **3** interconnecting the vanes. Preferably, the forging is warm forging in the case where the workpiece is of copper or the like metal whereas the forging is cold forging when the workpiece is of aluminium or the like metal. The semi-finished article *c* is subjected to a further step of punching out the thin-walled bottom **3** to form a finished article *d* having a peripheral wall **1** and a plurality of vanes **2** extending radially inwardly therefrom, as shown in FIGS. 1D and 1D'.

While the finished article *d* is usable as it is in a case, a pair of finished article *d* may be assembled together in bottom to bottom abutting relationship and secured together, for example, by silver-brazing to form a composite article, shown in FIG. **2**, which may be used as a magnetron anode.

FIGS. 3A and 3B illustrate a modified embodiment of the invention in which grooves or recesses are formed in the intermediate portions of the bottom surfaces of the vanes **2**, FIG. 3A corresponding to FIG. 1C while FIG. 3B corresponds to FIG. 1D. More specifically, the second step of the method discussed above is modified such that grooves or recesses **4** are formed by plastic working in the bottom surface of the bottom **3** simultaneously with the forming of the vanes **2**. The modified second step is followed by the third step in which the bottom wall **3** is punched out to obtain a finished article having recesses **4** in the intermediate portions of the bottom surfaces of the vanes **2**, as shown in FIG. 3B. The recesses **4** cooperate together to define a circumferentially interrupted circular groove for receiving a strap ring when the finished article is used as a magnetron anode. THe portion of the bottom surface of each vane **2** at which a recess **4** is formed is not limited to the intermediate portion as described and illustrated but may be determined so as to comply with a requirement by a particular strap ring to be incorporated. It is also to be understood that the recess **4** in each vane **2** is not limited to the shape shown but may have any other shape suitable for accommodating a particular strap ring.

FIG. **4** illustrates a composite article usable as a magnetron anode and corresponding to the composite article shown in FIG. **2** but formed by securing a pair of finished articles shown in FIG. 3B in bottom to bottom abutting relationship. As will be seen in FIG. **4**, the magnetron anode has formed in the vanes thereof apertures which circumferentially extend through the vanes and can accommodate a strap ring for short-circuiting the inner ends of every other vanes or some of the vanes. It is known that a magnetron anode having a strap ring extending through the vanes thereof provides a good electric performance.

FIG. 5A illustrates the construction and operation of a tool comprising a male die and a female die employed in the first step of the method of the invention to form a semi-finished cup-shaped article *b* as shown in FIG. 1B. Similarly, FIG. 5B shows the operation and construction of a tool employed in the second step of the method to form a semi-finished article *c* as shown in FIG. 1C. More specifically, the tool shown in FIG. 5A includes a male die comprising an upper punch **5***a* and a lower or counter punch **7***a* and a female die **8**. A workpiece *a* is placed on the counter punch **7***a* within the female die **8** and is subjected to a rearward extrusion by means of the upper punch **5***a* to form a semi-finished article **9** corresponding to the semi-finished article *b* shown in FIG. 1B. The upper punch **5***a* has an outer diameter substantially equal to the inner diameter of the peripheral wall **1** of a desired finished cylindrical article. The counter punch **7***a* has an outer diameter substantially equal to the outer diameter of the peripheral wall **1** of the desired finished cylindrical article.

FIG. 5B illustrates the construction and operation of a tool employed in the second step of the invention. The tool is the same as the tool shown in FIG. 5A except that the upper punch **5***a* is replaced by another upper punch **5***b* having radial grooves **6** formed in the bottom or forward surface thereof. The other punch **5***b* is operated to subject the semi-finished article **9** to forging by which the latter is formed into a semi-finished article **9'** corresponding to the semi-finished article *c* shown in FIG. 1C and having a cylindrical peripheral wall **1**, a plurality of vanes **2** projecting radially inwardly therefrom and a thin-walled bottom **3** interconnecting the vanes.

As will be seen in FIGS. 6A and 6B, the upper punch **5***b* has an outer diameter substantially equal to the inner diameter of the cylindrical peripheral wall **1** of a desired finished cylindrical article having vanes and is formed at the bottom or forward surface thereof with radial grooves **6** complementary in shape to the vanes **2** and each having a width or circumferential dimension substantially equal to that of a vane **2**.

As described above, since the method of the invention does not include a mechanical machining or cutting step which is employed in the prior art method of this kind, vanes formed in the second step remain as they are in a finished article. For the reason, the tool employed in the second step of the method has such a construction that the upper punch **5***b* has its radial grooves **6** accurately machined so as to comply with the accuracy or precision required for a finished article.

By the third step of the method of the invention, the bottom wall **3** left with the semi-finished article *c* after the second step is removed by punching out the bottom wall to obtain a finished article shown in FIGS. 1D and 1D'. The third step is carried out by use of an upper punch similar to the upper punch **5***b* but having radial grooves of larger axial dimensions than those of the grooves **6** in the punch **5***b* so that the bottom wall **3** are punched out in one stroke.

FIGS. 7A and 7B illustrate a counter punch **7***b* which can be used in the above-discussed modified second step of the invention to form, by plastic working, the recesses **4** in the bottom faces of the vanes **2** for providing circumferentially interrupted circular groove for receiving a strap ring. The punch **7***b* is provided on the upper or forward surface thereof with an annular projection **10** of such arrangement as to form the recesses **4** in the bottom faces of the vanes **2**. Stated in other words, the formation of the recesses **4** by plastic working can simply be carried out by use of a counter punch **7***b* having an annular projection **10**. The projection **10** is not limited to the continuous annular shape shown in FIG. 7B. For example, the projection **10** may have such a shape that a resultant circumferentially interrupted ring of recesses accomodates a strap ring which short-

circuits either every other vanes **2** or some of the vanes **2** at their inner ends.

As an example, when the finished articles shown in FIGS. **1D**, **1D'** and **3B** are used as magnetron anodes having the following dimensions;

Outer diameter of peripheral wall	45.4 mm
Inner diameter of peripheral wall 1	40.0 mm,
Height (axial dimension) of peripheral wall 1	17.5 mm,
Width (circumferential dimension) of vane 2	1.1 mm,
Length (radial dimension) of vane 2	15.0 mm,
Height (axial dimension) of vane 2	5.0 mm,
Width (circumferential dimension) of recess 4 in vane 2	1.1 mm,
Length (radial dimension) of recess 4	5.7 mm, and
Depth (axial dimension) of recess 4	1.2 mm,

a circular workpiece *a* of copper may have the following dimensions:

Outer diameter	45.5 mm, and
Thickness	5.5 mm.

With this example, the upper punch **5***a* used in the first step is downwardly moved about 3.5 mm with downward pressure of about 130 tons to subject the workpiece *a* to a rearward extrusion with a result that the thickness of the workpiece *a* in the bottom is reduced to about 3.0 mm to produce a bottomed semi-finished article *b*. The second step is carried out by the upper punch **5***b* with downward pressure of about 190 tons to subject the semi-finished article *b* to warm forging so that the bottom wall thereof is pressed to rise-up vanes **2**. The vanes **2** are about 3.5 mm in height at this time while the thin-walled bottom **3** has a thickness of about 1.5 mm. In the case where the counter punch **7***b* is used in this second step, the bottom wall **3** is formed therein with recesses **4** of about 1.2 mm in depth (axial dimension). In the third step of the method, an upper punch having radial grooves of larger axial depths than those of the grooves **6** in the punch **7***b* is employed to punch out the portions of the bottom wall **3** interconnecting the vanes **2** with a result that a finsihed magnetron anode having vanes **2** of about 5 mm in height is obtained.

The above description is directed to an embodiment of the method of the invention in which a magnetron anode is produced. It is, however, to be understood that the application of the method of the invention is not limited to the described embodiment and the invention is applicable widely to the manufacture of any other article having peripheral wall and integral thin-walled vane-like portions extending inwardly therefrom. In addition, it will be appreciated to those skilled in the art that the respective steps of the method of the present invention can be continuously or discontinuously carried out.

The method of the present invention provides the following advantages:

1. Since vanes are formed by precision forging, a finished article is provided with geometrically accurate dimensions;
2. Since all the steps of the method utilize plastic working to eliminate troublesome operations such as filling-up of mould compound and reval of burr, the invention provides an efficient and economical method of manufacturing magnetrons;
3. The invention particularly simplifies the production of magnetron anodes of a type that includes strap rings extending circumferentially through the vanes thereof; and
4. Since the method of the invention can employ punches having radial grooves less deeper then those of punches used in prior art simultaneous forming of an article of the kind concerned, the punches used by the invention are improved in strength with a result that the invention makes it possible to form vanes of larger axial dimensions than the vanes formed by prior art method.

Thus, the present invention can be applied, with noticeable industrial advantage, to the manufacture of articles, such as magnetron anodes, each having a peripheral wall and integral thin-walled vane-like portions extending radially inwardly therefrom.

What is claimed is:

1. A method of manufacturing an article having a cylindrical peripheral wall and integral thin-walled portions extending radially inwardly therefrom, said method including the steps of:

providing a female die means and male die means to form a semi-finished article, said female die means having a both open ended bore and an inner diameter which is substantially equal to the outer diameter of the cylindrical peripheral wall, said male die menas being disposed in said bore and comprising a first punch having an outer diameter substantially equal to the inner diameter of the cylindrical peripheral wall and having a plane end surface, and a counter punch having an outer diameter substantially equal to the inner diameter of said bore;

subjecting a disc-shaped workpiece disposed on said counter punch within said female die means to a rearward extrusion by said first punch to form a semi-finished cup-shaped article;

providing a second punch having an outer diameter substantially equal to the inner diameter of the cylindrical peripheral wall and formed with a plurality of radially extending grooves; and

subjecting said semi-finished cup-shaped article disposed on said counter punch in said female die means to forging by operating said second punch after the operation of said first punch to form an article having a cylindrical peripheral wall and integral thin-walled portions extending radially inwardly therefrom.

2. A method of manufacturing an article having a cylindrical peripheral wall and integral thin-walled portions extending radially inwardly therefrom, said method including the steps of:

providing a female die means and male die means to form a semi-finished article, said female die means having a both open ended bore and an inner diameter which is substantially equal to the outer diameter of the cylindrical peripheral wall, said male die means being disposed in said bore and comprising a first punch having an outer diameter substantially equal to the inner diameter of the cylindrical peripheral wall and having a plane end surface, and a counter punch having an outer diameter substantially equal to the inner diameter of said bore;

subjecting a disc-shaped workpiece disposed on said counter punch within said female die means to a rearward extrusion by said first punch to form a semi-finished cup-shaped article;

providing a second punch having an outer diameter substantially equal to the inner diameter of said cy-

lindrical peripheral wall and formed with a plurality of radially extending grooves, and a second counter punch having projections arranged in an annular form on the surface of a forward end portion thereof; and

subjecting said semi-finished cup-shaped article to forging by operating said second punch and said counter punch.

3. A method of manufacturing an article having a cylindrical peripheral wall and integral thin-walled portions extending radially inwardly therefrom, said method including the steps of:

providing a female die means and a male die means to form a primary semi-finished article, said female die means having both open ended bore and an inner diameter which is substantially equal to the outer diameter of the cylindrical peripheral wall, said male die means being disposed in said bore and comprising a first punch having an outer diameter substantially equal to the inner diameter of the cylindrical peripheral wall and having a plane end surface, and a counter punch having an outer diameter substantially equal to the inner diameter of said bore;

subjecting a disc-shaped workpiece disposed on said counter punch in said female die means to a rearward extrusion by said first punch to form a primary semi-finished cup-shaped article;

providing a second punch having an outer diameter substantially equal to the inner diameter of said cylindrical peripheral wall and formed with a plurlaity of radially extending grooves, and a second counter punch having projections arranged in an annular form on the surface of a forward end portion thereof;

subjecting said semi-finish cup-shaped article to forging by operating said second punch and said second counter punch to form a secondary semi-finished article having a peripheral wall with a plurality of thin-walled portions on its inner surface corresponding to the grooves of said second punch and a bottom wall connected with said cylindrical peripheral wall and integral with said thin-walled portions;

providing a third punch having radial grooves of a larger axial dimension than said radial grooves in said second punch; and

removing said thin-walled bottom portion by operating said third punch after the operation of said second punch to form a finished article.

4. A method of manufacturing a magnetron anode having a cylindrical peripheral wall, integral thin-walled vanes extending radially inwardly therefrom and grooves fromed in the intermediate portions of the bottom surface of the vanes for receiving a strap ring, said method comprising the steps of:

providing a female die means and a male die means to form a primary semi-finished article, said female die means having a both open ended bore and an inner diameter which is substantially equal to the outer diameter of the cylindrical peripheral wall, said male die means being disposed in said bore and comprising a first punch having an outer diameter substantially equal to the inner diameter of the cylindrical peripheral wall and having a plane end surface, and a counter punch having an outer diameter substantially equal to the inner diameter of said bore;

subjecting a disc-shaped workpiece of copper disposed on said counter punch in said female die means to a rearward extrusion by said first punch to form a primary semi-finished cup-shaped article;

providing a second punch having an outer diameter substantially equal to the inner diameter of said peripheral cylindrical wall and having a plurality of grooves formed in a forward end portion thereof and radially extending with respect to the axis thereof, and a second counter punch having projections arranged in an annular form on the surface of a forward end portion thereof for forming grooves adapted to receive the strap ring;

subjecting said primary semi-finished cup-shaped article to forging by operating said second punch and said second counter punch to form a secondary semi-finished article having a cylindrical peripheral wall with a plurality of thin-walled portions on its inner surface corresponding to the grooves of said second punch and a bottom wall connected with said cylindrical peripheral wall and integral with said thin-walled portions with grooves arranged in an annular form on the outer surface of the bottom wall;

providing a third punch having radial grooves of a larger axial dimension than said radial grooves in said second punch; and

removing said thin-walled bottom wall by operating said third punch after the operation of said second punch to form a finished article.

5. A method of manufacturing an article having a cylindrical peripheral wall and integral thin-walled portions extending radially inwardly therefrom, said method including the steps of: providing a female die means and male die means to form a semi-finished article, said female die means having a both open ended bore and an inner diameter which is substantially equal to the outer diameter of the cylindrical peripheral wall, said male die means being disposed in said bore and comprising a first punch having an outer diameter substantially equal to the inner diameter of the cylindrical peripheral wall and having a plane end surface, and a counter punch having an outer diameter substantially equal to the inner diameter of said bore;

subjecting a disc-shaped workpiece disposed on said counter punch within said female die means to a rearward extrusion by said first punch to form a primary semi-finished cup-shaped article;

providing a second punch having an outer diameter substantially equal to the inner diameter of the cylindrical peripheral wall and formed with a plurality of radially extending grooves;

subjecting said primary semi-finished cup-shaped article disposed on said counter punch in said female die means to a forging by operating said second punch after the operation of said first punch to form a secondary semi-finished cup-shaped article having a peripheral wall with a plurality of thin-walled portions on its inner circumference corresponding to the grooves of said second punch and a bottom wall connected with said cylindrical peripheral wall and integral with said thin-walled portions;

providing a third punch having radial grooves of a larger axial dimension than said radial grooves in said second punch; and

removing said thin-walled bottom portion by operating said third punch after the operation of said second punch to form a finished article.

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