June 30, 1964 A. L. COEN 3,138,864

METHOD OF WORKING METAL

Filed May 25, 1961 2 Sheets-Sheet 1

Fig. 1.

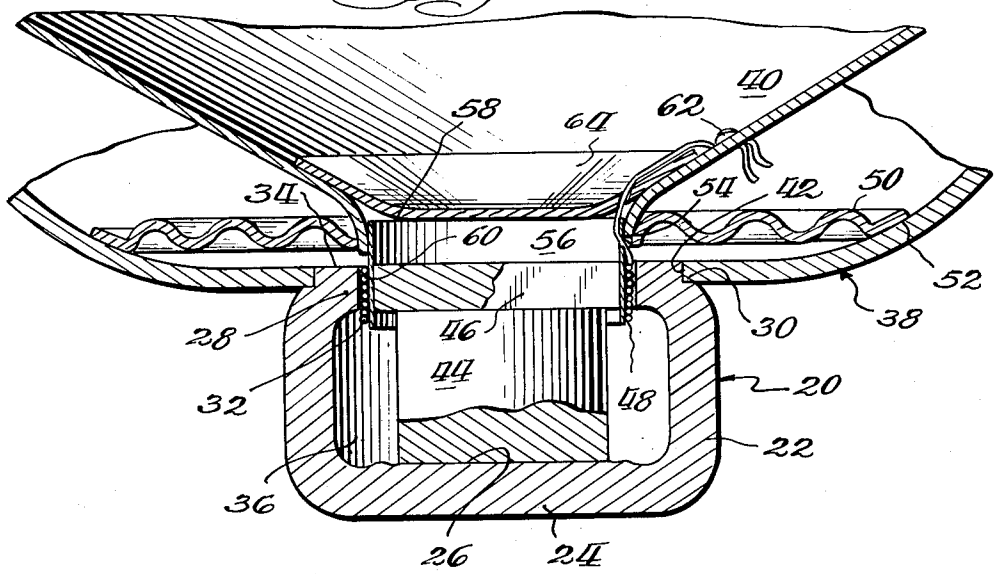


Fig. 9.

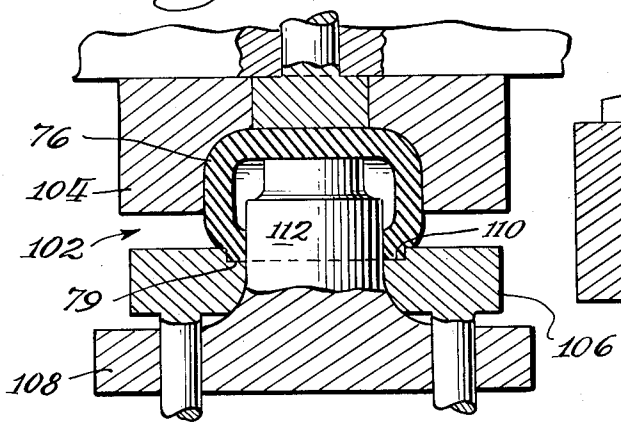
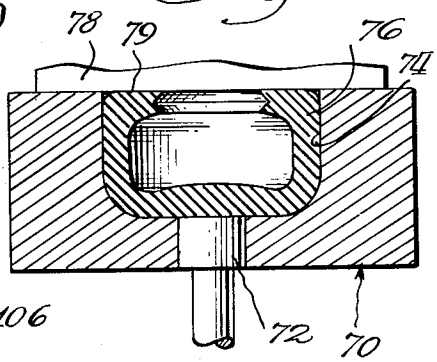


Fig. 2.



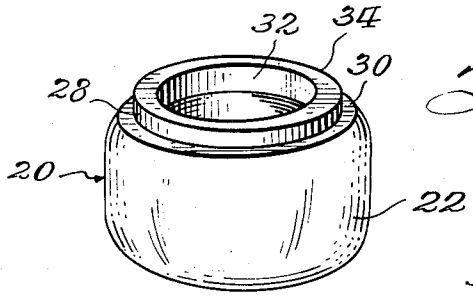


Fig. 10.

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June 30, 1964 A. L. COEN 3,138,864

METHOD OF WORKING METAL

Filed May 25, 1961 2 Sheets-Sheet 2

Fig. 3.

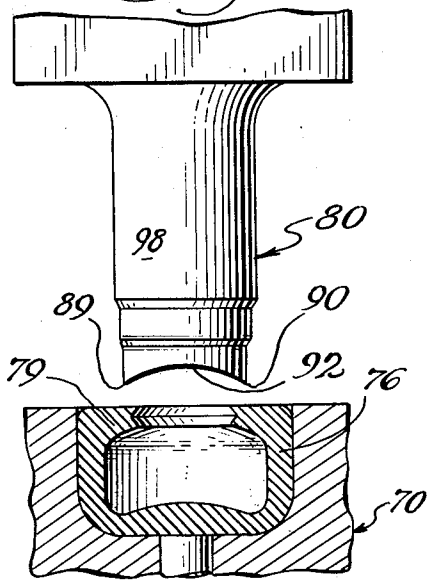


Fig. 4.

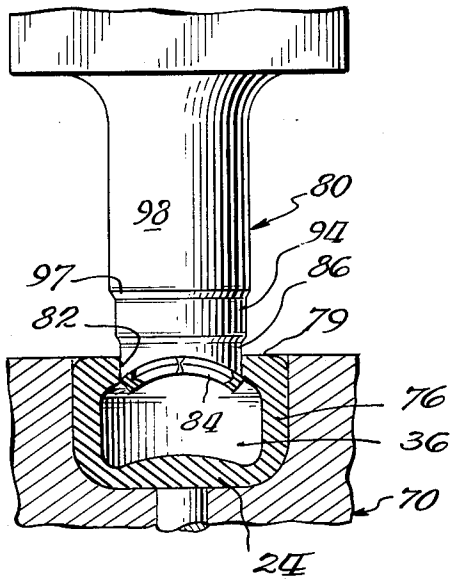


Fig. 8.

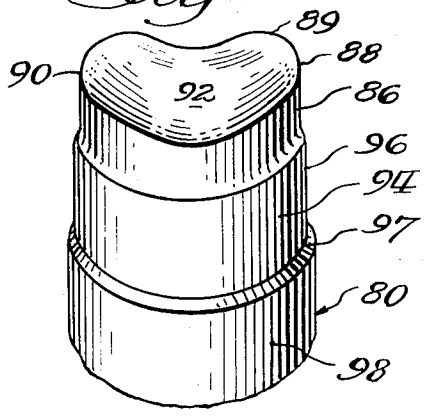


Fig. 5.

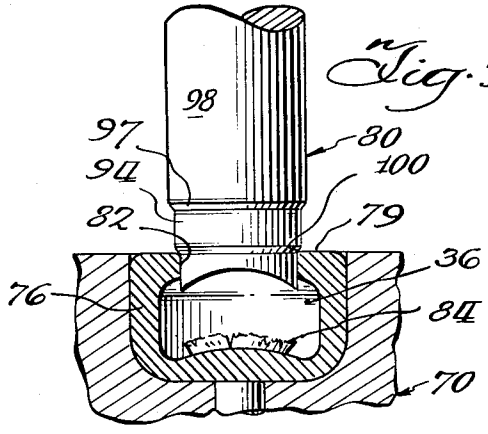


Fig. 7.

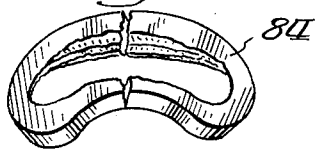
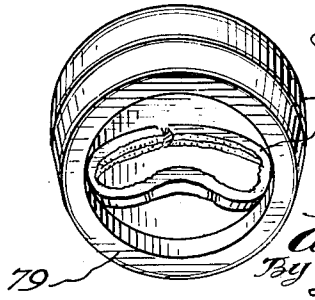


Fig. 6.



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3,138,864

METHOD OF WORKING METAL

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Filed May 25, 1961, Ser. No. 112,664
10 Claims. (Cl. 29—537)

This invention relates generally to the art of manufacturing metal products and more particularly, relates to a novel method of working metal for producing a metal product comprising a substantially cylindrical, hollow body having an opening in either one or opposite ends thereof.

The invention herein disclosed is useful in connection with the manufacture of a large variety of metal products wherein an opening or openings into the interior of the hollow body is to be provided which is somewhat smaller in diameter than the diameter of the hollow body and in which critical relationships in dimensions of the opening with respect to other portions of the hollow body must be maintained for efficient and proper operation and use of the metal product. Representative of such metal products as are contemplated can be manufactured by means of the invention herein are the outer race of ball bearings, magnetic yokes for transducers, such as the so-called pot of a loudspeaker, and other parts and products of general re-entry shape.

In my co-pending application, Serial No. 99,414, filed March 30, 1961, there is described and claimed a metal product which can be made efficiently and properly by means of the herein invention. Said metal product comprises a novel field or yoke structure for magnetic speakers which includes a hollow, metal body of generally cylindrical, cup-like configuration in the interior of which a permanent magnet is to be mounted co-axially. The hollow body has a re-entry opening at one end thereof which will be closed substantially by a pole piece with the exception of a gap formed between the pole piece and the rim of the opening. As explained in said co-pending application, the rim surrounding said opening was required to have a flange of substantially lesser diameter than that of the hollow body so that an undercut was necessary. Screw machine techniques theretofore had been employed to manufacture this general structure which contributed to a high degree of waste of material as well as higher cost of manufacture. The invention of said co-pending application provided a method of making such a hollow body of metal from sheet steel as a stamping or drawing using presses and forming dies of generally conventional structure. The bulging and necking techniques disclosed in said co-pending application can be utilized in connection with the herein invention.

This application is a continuation-in-part of said co-pending application, Serial No. 99,414 filed March 30, 1961, insofar as it relates to the disclosed method of said co-pending application pertaining to the manufacture of a field or yoke structure from sheet metal for the magnetic circuit of a loudspeaker.

It is a major object of the herein invention to provide a novel method of manufacturing a metal product which includes a hollow body having at least one re-entry opening the diameter of which is somewhat smaller than the diameter of the hollow body, said method comprising, punching said opening in the circumferential wall of said hollow body while the hollow body is confined in the cavity of a jig or die.

Another important object of the invention is to provide a method of manufacturing a metal product of the character described in which said re-entry opening is punched in a portion of the circumferential wall of said hollow

body which is suspended in air without inwardly collapsing or materially distorting the hollow body.

Another object of the invention is to provide a novel method of manufacturing a metal product comprising a field or yoke structure for a transducer, such as the magnetic pot of a loudspeaker made of sheet metal which has been bulged and necked or drawn with accompanying saving of material, labor cost and manufacturing expense.

The foregoing and other objects of the invention will become apparent from the ensuing disclosure in which a preferred embodiment has been described in detail and illustrated in the accompanying drawings. Minor variations in the technique of carrying out the method embodying the invention may occur to the skilled artisan without departing from the scope or sacrificing any of the advantages thereof.

In the drawings:

FIG. 1 is a sectional view taken through a portion of a loudspeaker including a magnetic field or yoke structure representative of the type of metal produce capable of being manufactured by the method embodying the invention and which is disclosed and claimed in said co-pending application.

FIG. 2 is a diagrammatical sectional view taken through a punch press and showing a stage in the manufacture of the speaker field structure preparatory to producing the desired re-entry opening therein by means of the herein invention.

FIG. 3 is a diagrammatical view similar to FIG. 2 and showing the structure produced by the operation illustrated in FIG. 2 in position to have the upper portion of the press lowered to perform the punching operation of the invention.

FIG. 4 is a view similar to FIG. 3 in which the upper portion of the press has been lowered to perform the first step of the method embodying the invention; FIG. 5 is a view similar to FIG. 4 showing the second and third steps of said method performed.

FIG. 6 is a perspective view of the magnetic yoke or field structure removed from the press of FIG. 5 after performance of the steps of said method and showing the resulting portion of the circumferential wall of the structure punched therefrom on the interior of said structure.

FIG. 7 is a perspective view of said punched out portion of said field or yoke structure removed from said structure.

FIG. 8 is a fragmentary perspective view illustrating the operative end of the punch employed in performing the operations of FIGS. 3 through 5.

FIG. 9 is a diagrammatic sectional view taken through a punch press and showing the final step in manufacture of the magnetic field or yoke structure.

FIG. 10 is a perspective view of the completed field structure.

The method embodying the invention may be employed as part of a series of metal forming or working operations in the manufacture of a metal product formed of an integral sheet of steel as a stamping or drawing. In addition, it is contemplated that the invention can be utilized successfully in the manufacture of representative metal products of generally re-entry configuration but formed possibly by other than stamping or drawing techniques. The invention is practiced without conventional support means subtending the portion of the metal body worked upon, such as by a mating die. Accordingly, a portion of the hollow body of metal is removed or punched out by means of the invention to provide an opening thereinto which has critical relationships in dimensions with the remaining portions of the metal body.

For purposes of illustrating a representative metal

product capable of being formed utilizing the invention herein, in FIG. 1 and FIG. 10 is illustrated a magnetic field or yoke structure designated generally by the reference character 20. The structure 20 is substantially identical to the field structure 10 of said co-pending patent application and comprises, a generally cylindrical hollow metal body 22 of integral construction. Said hollow body 22 has a circular bottom wall 24 provided with an interior flat face 26. At its upper end, the hollow body 22 has a radially inwardly extending annular flange 28 having an annular exterior shoulder 30, an annular interior surface or rim 32 of cylindrical configuration and an axially facing end surface 34 of circular configuration. The internal diameter of the annular flange 28 is somewhat less than the internal diameter of the body 22 so that a considerable portion of said flange overhangs the interior cylindrical chamber 36 in said body.

For efficient and proper operation of the body 22 in a field or yoke structure for a transducer, such as a loudspeaker, certain critical dimensions of the structure are desirable. These include accurate parallelism between the interior flat face 26 of the bottom wall 24 and the shoulder 30 and accurate co-axial relationship between the cylindrical interior of the flange 28 and the shoulder 30. Although not as critical, it is desirable that upper surface 34 of the flange be parallel with the flat face 26 of the wall 24. The reference character 38 identifies generally a so-called speaker basket operatively associated with the hollow body 22 in FIG. 1 to illustrate wherein said critical dimensional relationships are required.

The speaker basket 38 is formed of sheet metal in the form of a framework or cage for the paper cone 40 supported on the interior thereof. The basket 38 has a co-axial opening 42 of suitable dimension to surround the flange 28 and engage upon shoulder 30. Ordinarily, the basket and hollow body or pot 22 are rigidly connected together. A cylindrical permanent magnet 44 is co-axially cemented to the surface 26, said magnet having a disc-like pole piece 46 mounted to the top end thereof. The diameter of the pole piece 46 is somewhat less than the inner diameter of the cylindrical surface 32 so as to provide a narrow gap or annular space 48 between the pole piece and said surface 32 which establishes a high flux density path for the flux created by the permanent magnet 44. In FIG. 1, the size of the gap 48 is exaggerated for purposes of illustration.

A varnished, resilient buckram or linen suspension spider 50 is cemented to the interior of the basket at 52. The inner end or apex of the cone is cemented to the diaphragm 50 at 54, and short cylindrical tube 56 of relatively thin paper or cardboard is secured to the cone at 58 and extends through the gap 48 co-axially of the pole piece 46. This short tubular member 56 serves as the former for several turns of wire 60 which comprise the voice coil, the wire being arranged on the former 56 so that the field created by the wire as electrical current passes therethrough will cut the lines of force extending across the gap between the pole piece and flange. The wires from the voice coil are shown at 62 extending up through the interior of the cone and out through the walls thereof to the source of audio frequency current. A felt disc 64 protects the mechanism just described from dust. The suspension spider or diaphragm 50 serves as resilient means to oppose movement of the former 56 and the cone 40.

To describe the manner in which the invention herein is carried out, attention is invited first to FIG. 2 which represents one stage of manufacture of the hollow body or pot 22. The reference character 70 identifies the lower die member of a punch press and a knock-out of some kind is shown at 72. The cavity 74 in die member 70 has a metal work piece 76 seated therein formed from a sheet of steel by means of a series of passes through a group of presses or stages of one press as particularly described in said co-pending application. A flat plate 78 is shown bearing down upon the upper edge 70 of the work piece 76 to flatten and curl the upper edge for the purpose of producing desired additional necking. When this step of the operation is completed, to form the hollow body or pot 22, it is necessary to form the entrance or re-entry opening to the field structure within which the pole piece will be disposed to provide the desired gap. This step is carried out by means of the method embodying the invention as will be described in connection with FIGS. 3 through 5.

The work piece 76 can be retained in the same lower die member 70 of a press, the plate 78 having been removed. A punch 80 is shown poised over the work piece 76 in position to be moved into the work piece as shown in FIG. 3. The punch 80 is shown already driven into the work piece in FIG. 4 and having cut a cylindrical opening 82 therein through the surface 79. In FIG. 5, the punch 80 has been moved inwardly into the cavity 36 of the work piece, having severed the portion 84 from the work piece with the said severed or punched-out ring portion 84 dropping to the bottom wall 24. The punch 80 will then be moved inwardly into the cavity 36 to complete a burnishing and chamfering operation, after which the work piece 76 can be completed by means of the step which will be described subsequently in connection with FIG. 9.

Attention is directed to the manner in which the operations of FIGS. 3 through 5 are performed with the portion of the work piece 76 worked on by the punch 80 subtended by the cavity 36 and entirely unsupported by any conventional means such as a mating die. In effect, the punching out of portion 84 is done in "air," but without collapsing the work piece 76 or distorting the same in any way notwithstanding the substantial compression forces against the work piece and the sheet force of the punch. This is possible for reasons which will be explained and which in addition, permit the punched out portion 84 to be removed from the work piece conveniently and rapidly.

Referring to FIG. 8, the punch 80 is comprised of three principal working portions which permit the punching, burnishing and chamfering operations to be carried out in a single pass of the punch. The first portion 86 comprises the cutter portion which is cylindrical in configuration and circular in cross-section with the dimensions thereof selected to cut the desired opening 82 in the work piece. However, the cutting edge 88 at the end of the punch is formed of a pair of identical arcuate segments 89 and 90 and the end face 92 of the portion 86 is concave. The arcuate segments 89 and 90 may be seen to be symmetrical about a plane extended through the longitudinal axis of portion 86. The second portion 94 likewise is cylindrical and circular in cross-section and has a circumferential burnishing surface 96. The portion 94 is very slightly larger in diameter than the cutter portion 86 without adverse consequence. In the view, this is exaggerated. The third portion 97 comprises a chamfering shoulder at the juncture of the cylindrical shank 98 with the second portion 94, the shank 98 being somewhat larger in diameter than the portion 94 to provide the annular shoulder 97.

Referring again to FIGS. 4 and 5, when the punch is urged against the work piece 76, initially, the cutting edge 88 removes or cuts the center out of the cup to provide the opening 82 of desired size and configuration. However, the ring portion 84 which is cut out is bent to conform with the concave end face 92 and may even be broken into two parts as seen in FIG. 7. When the cutting edge 88 has completed the punching operation, the ring portion 84 falls to the bottom of the work piece. As the punch continues its movement inwardly into the work piece, the inside surface of the opening 82 is burnished to size by the surface 96. The burnishing operation may distort the edges of the top surface 79, but this is not a material disadvantage since a high

degree of accuracy of parallelism between surface **79** and the inner surface **26** of the pot **22** is not critical. The punch continues its inward movement until the work piece is engaged by the shoulder **97** which slightly bevels or smoothens the inner circumferential edge **100** of the opening **79**.

When the series of operations performed by the punch **80** is completed, the punch is removed and the work piece **76** can be removed from the die member **70** and inverted, as seen in FIG. 6, for ready removal of the punched out portion **84**. It should be noted that although the portion **84** has been illustrated severed into two parts, this is not absolutely necessary. A medial bend in the portion **84** caused by the concave end face **92** of the punch is sufficient to provide a decreased diameter for the ring portion **84** which will permit the portion **84** to be removed from the work piece through the cylindrical opening **82**.

After the punched out portion **84** has been removed, the work piece **76** can be completed in the manner shown in FIG. 9. The work piece **76** can be placed in another press **102** having an upper die member **104** provided with a suitable cavity for seating the work piece. The press **102** has a travelling ring **106** supported on the lower die member **108** thereof which coins the shoulder **30** without distorting the rest of the work piece. There is an annular groove **110** in the ring **106** which seats and retains the trueness of the upper surface **79** of the work piece which becomes the surface **34** of the structure **20**. A center punch **112** flattens the interior bottom surface of the work piece **76** to produce the accurate magnet seat **26** which is required and which has been described previously as surface **26**. When removed from the press **102**, the work piece **76** is completed as the field structure **20** seen in FIG. 10.

It will be seen that the punching operation carried out by means of the punch **80** provides for a minimum of scrap and can be carried out successfully because the punched out portion **84** is removable readily from the structure. The punching operation does not cause any distortion of the hollow body **22** notwithstanding the substantial compression and shear forces applied to the body during the punching operation. It is believed that by confining the work piece **76** in lower die member **70** during the punching out operation, the compression forces are transmitted by the annular walls of the work piece to the chamber or body of the die member. Although there would be required a sufficient gauge of metal for the work piece so that it could withstand the shear forces of the cutting end of the punch without collapsing inwardly, it is believed that the circular shape of the work piece makes this requirement less stringent. It is apparent that after the opening **82** is punched out, no machining or like operation is required because of this operation. The herein invention is specially suitable for incorporating into manufacture of such metal products by methods employing familiar bulging, forming, necking and curling techniques by machine on a mass production basis with desirable accuracy and low rate of rejects.

In conclusion, it should be appreciated that although the method embodying the invention has been described and illustrated with particularity in the manufacture of magnetic yoke or field structures for transducers, such as the pot **20** of a speaker basket **30**, the invention may be employed in the manufacture of other metal products from sheet metal having a general re-entry configuration. By "re-entry configuration" is meant a generally hollow body in which an opening or openings is required to be made having decreased diametrical dimensional relationship with the remainder of the hollow body. Accordingly, the invention, in its broader significance, comprises a method of working metal products of such general re-entry configuration and specifically, magnetic yoke structures for transducers, such as loudspeakers.

What it is desired to secure by Letters Patent of the United States is:

1. A method of working sheet metal to make a substantially cylindrical, hollow body having a re-entry opening in at least one end thereof the diameter of which is substantially smaller than the internal diameter of the hollow body: said method comprising, forming said hollow body from a sheet of metal to the internal configuration and dimensions desired for the completed hollow body and with an interior lip at said one end thereof, confining said hollow body only on its exterior with said lip exposed, said lip being subtended only by said hollow portion thereunder then punching a ring portion from said hollow body including the inner surface of said lip to the desired configuration and diameter of said re-entry opening while concurrently deforming said ring portion sufficiently to permit withdrawal thereof through said re-entry opening from the interior of the hollow body and without accompanying deformation of said hollow body.

2. The method described in claim 1, and further including the steps of successively burnishing and chamfering selective portions of said re-entry opening after said ring portion is punched.

3. The method described in claim 1 in which said ring portion is allowed to drop to the bottom of the hollow body after such punching thereof.

4. A method of making a magnetic field structure for a transducer comprising, forming a disc of sheet metal into a cylindrical cup having a closed rounded bottom and a necked opening opposite said bottom having an interior lip, flattening the upper edge of the lip with said rounded bottom confined, punching a ring portion from the inside edge of the lip to a cylindrical configuration of predetermined external diameter substantially smaller than the inner diameter of the cup while said cup is confined and with said lip subtended by air, said punching being carried out with accompanying deformation of the ring portion to permit withdrawal thereof through the resulting opening in the cup after same has been punched out.

5. A method as described in claim 4, and further including the steps of successively burnishing and chamfering the wall of said resulting opening after said punching step.

6. A method of making a magnetic field structure for a transducer comprising, forming a disc of sheet metal into a cylindrical cup having a closed rounded bottom and a necked opening opposite said bottom having an interior lip, flattening the upper edge of the lip with said rounded bottom confined, punching a ring portion from the inside edge of the lip to a cylindrical configuration of predetermined external diameter substantially smaller than the inner diameter of the cup while said cup is confined and with said lip subtended by air, said punching being carried out with accompanying deformation of the ring portion to permit withdrawal thereof through the resulting opening in the cup after same has been punched out, withdrawing said ring portion and then, flattening the inner surface of said rounded bottom.

7. In a method of making a field structure for the magnetic circuit of a loudspeaker from sheet metal in the configuration of a cylindrical cup having a closed bottom end and an open mouth of diameter substantially less than the inner diameter of said cup and in which a metal disc is formed into cup configuration with a rounded bottom and an interior lip on the upper edge of said cup, the upper edge of said lip being flattened while the rounded bottom confined, the herein invention of forming said open mouth without accompanying substantial deformation of the cup configuration comprising, confining said cup in the conforming cavity of a die and punching a ring portion from the center of the cup including the inner surface of the lip of cylindrical configuration and predetermined external diameter to provide said mouth.

8. In a method as described in claim 7 in which said punching is carried out with accompanying deformation of said ring portion to permit withdrawal thereof from the interior of the cup through said mouth after severance thereof.

9. A method as described in claim 7, and further including the steps of successively burnishing and chamfering the wall of said mouth after said punching step.

10. A method of forming a hollow body from sheet metal, said method comprising, forming the hollow body from a sheet of metal to the internal configuration and dimensions desired for the completed hollow body and with an interior lip at said one end thereof, confining said hollow body only on its exterior with said lip exposed,

said lip being subtended only by said hollow portion thereunder, then punching a ring portion from said hollow body including the inner surface of said lip to the desired configuration and diameter to define a re-entry opening, and slightly enlarging the said opening.

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Disclaimer and Dedication

3,138,864.—*Aldo L. Coen*, Chicago, Ill. METHOD OF WORKING METAL. Patent dated June 30, 1964. Disclaimer and dedication filed Aug. 7, 1973, by the assignee, *Alpha Products, Inc.*

Hereby disclaims and dedicates to the Public the remaining term of said patent.

[*Official Gazette April 23, 1974.*]