Dec. 8, 1970 O. L. BROWN 3,545,249

DIMPLE AND METHOD OF FORMING SAME

Filed April 8, 1968

Fig. 1

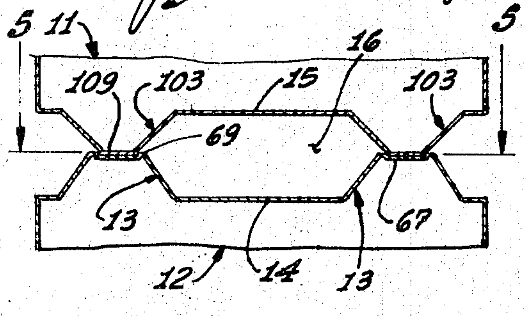


Fig. 2

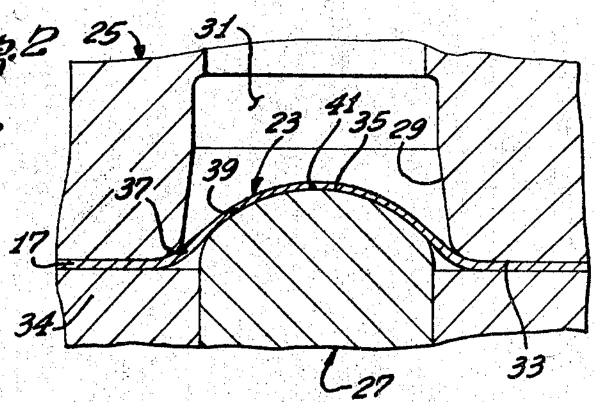


Fig. 3

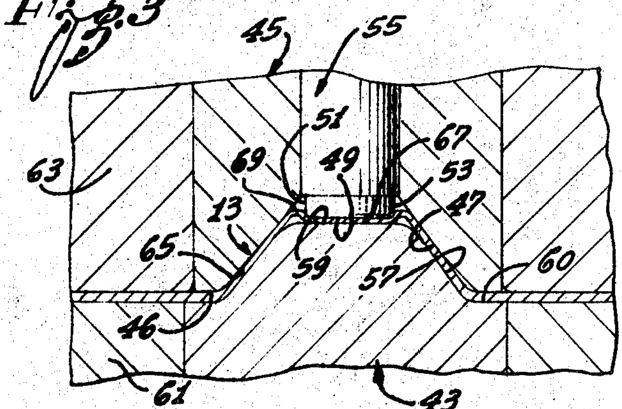


Fig. 4

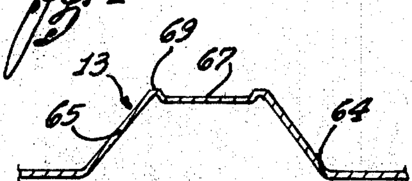


Fig. 6

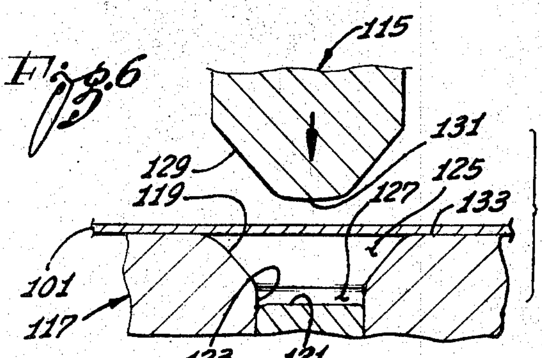


Fig. 5

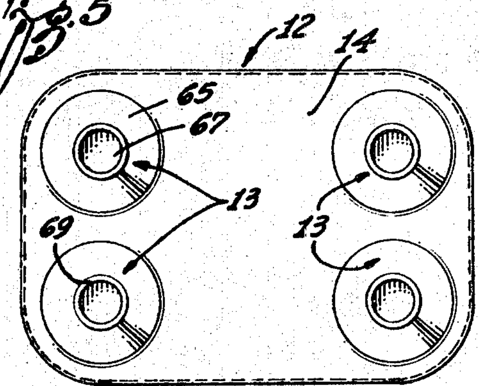


Fig. 7

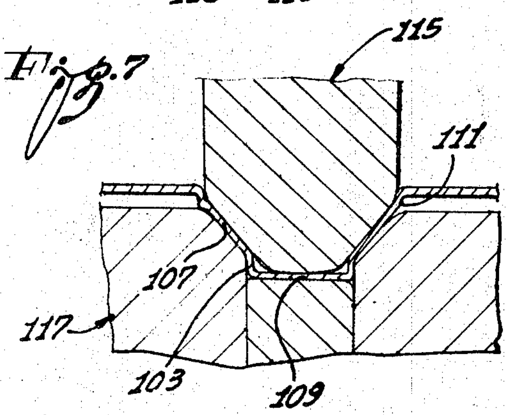
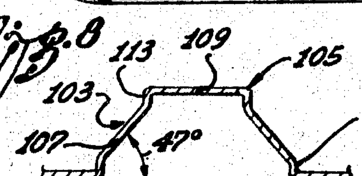


Fig. 8



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DIMPLE AND METHOD OF FORMING SAME

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U.S. Cl. 72—354 21 Claims

ABSTRACT OF THE DISCLOSURE

This specification discloses a method of making a dimple from deformable sheet material including offsetting a portion of the sheet material to form a dimple, squeezing at least a section of the dimple wall to displace at least some of the material thereof and at least substantially flattening the region of the dimple to form a dimple of the desired configuration.

BACKGROUND OF THE INVENTION

For various reasons it is often necessary or desirable to form a dimple or protruberance in sheet material For example, when sheet metal is used to form an enclosure or housing for equipment, such as electrical equipment, it may be desirable to provide feet on the housing to permit airflow thereunder. Such feet may advantageously be integrally constructed of the sheet material of the housing. In other instances, it may be desirable to stack sheet metal enclosures or other articles in nested relationship. Here again appropriately configured integral sheet material dimples may be used to accomplish this function.

This seemingly easy task is complicated by numerous requirements that the dimple must meet. First, it is often desirable to hold the diameter of the dimple across the base to a minimum so that the foot formed thereby will not be unduly large and appear unsightly. In addition, the dimple should not interfere with or overlap any customary formations in the surface of the article in which the dimple is formed. One of the most important requirements is that the dimple must process sufficient strength to support the article on which is formed above a supporting surface. This means that a large amount of material must be forced into the dimple wall to thicken it.

The dimple should have a substantial axial dimension or height in order that it can support the article on which it is formed well above the supporting surface therefor. To improve the support which the dimples provides for the article on which it is formed or an adjacent member, the dimple should have a relatively flat supporting surface at the outer end thereof. Thus when the dimple is used as a foot, the flat supporting surface provides firm support for the article and prevents concentration of stress on the dimple such as would occur if a conventional spherical dimple were used. Finally, the flat supporting surface should be of relatively large diameter to obtain the maximum benefit therefrom.

Ordinary dimple forming methods simply include offsetting a portion of the sheet material between a bubble punch and a bubble die. This conventional method involves stretching of the offset portion of the sheet material and is totally unsuited for constructing a dimple which would meet the requirements noted above. In particular, the height of the dimple that can be formed by this method for a given base diameter of the dimple is significantly limited. Using this stretching process, the central region of the dimple is stretched more than the regions adjacent the base of the dimple, and accordingly, excessive thinning or fracturing of the central region of the dimple wall will occur long before the requisite dimple height and shape is reached.

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This conventional stretching process perhaps could be used to form a dimple of the desired height; however, in order to obtain such an axial dimension, it would be necessary to provide a dimple having an excessively large base diameter. As explained above, however, the base diameter of the dimple is significantly limited so that this alternative approach is not acceptable. Finally, there is a problem of finding a suitable way to flatten the upper surface of the dimple to provide the supporting surface.

SUMMARY OF THE INVENTION

The present invention provides a method of constructing a dimple which meets all of the requirements outlined above. To obtain a dimple which meets these requirements, the present invention teaches offsetting of a portion of the deformable sheet material to form a dimple having a dimple wall and a central region,squeezing at least a section of the dimple wall between cooperating die members to displace at least some of the material thereof and at least substantially flattening the central region of the dimple. During the step of squeezing, the material of the dimple wall is displaced in both directions along the cooperating die surfaces to permit formation of a dimple having substantial height, a flattened upper surface, relatively thick walls and a relatively small base diameter. The primary direction of flow of the material is toward the central region of the dimple as the flow of material toward the base of the dimple is at least partially blocked off at the base by the cooperating die surfaces. The upward flow of material may be used to increase the axial dimension of the dimple and/or increase the wall thickness adjacent the central region and/or provide sufficient material to allow flattening of the central region without reducing dimple height. Preferably, this squeezing or coining operation is carried out between cooperating conical die surfaces.

According to the present invention the central region of the dimple is flattened to provide the required supporting surface. With the present invention, the flattening operation is preferably carried out with the same punch and die that perform the squeezing step.

The concepts of this invention can be conveniently carried out in a single step with a single punch and die. According to this embodiment of the invention, the single punch and die initially offsets a formerly flat section of the deformable sheet material to form a dimple having a dimple wall. During the initial dimple forming process, the material of the dimple is stretched but not to the point were excessive thinning or fracture occurs. Upon further advancing the tooling, the dimple wall is squeezed between tapered working surfaces on the punch and die to extrude at least some of the material thereof along the working surfaces to produce the advantages noted above. A feature of this invention is to provide a relatively flat die surface within the die cavity in which the dimple is formed. Therefore, as the punch and die are advanced relative to each other, the central region thereof is forced against such relatively flat die surface and is supported thereby to effect formation of a flat supporting surface. The primary advantage of this embodiment of the invention is that it can be rapidly carried out as a "one-hit" process.

According to a second embodiment of the invention, a dimple is first formed in a substantially conventional fashion with the dimple being of larger area in plan than the desired dimple. The conventional dimple, which is formed with one set of tooling, is then reformed into the dimple of this invention with another set of tooling. Specifically, the preformed dimple is pushed at least partially to a die cavity and ultimately the dimple wall is squeezed between the working surfaces of the punch and die to extrude some of the material thereof in both directions along such working surfaces. In this form of the invention, the extrusion of the dimple wall urges the central region of the dimple toward a relatively flat die surface which supports the central region to effect flattening thereof. Another feature of this form of the invention is the provision of a generally annular recess in the die cavity surrounding the relatively flat die surface into which material from the dimple wall can flow to form an annular peripheral rim which extends axially beyond, and surrounds, the flattened central region. This rim provides increased height or axial length to the dimple without requiring much additional material and increases the strength of the upper end of the dimple.

To assist in forming of the peripheral rim, it is preferred to squeeze the flattened central region of the dimple between a flattened nose on the punch and the relatively flat die surface. This causes extrusion of the material of the central region radially outwardly to assist in formation of the peripheral rim. As the flattened central region is protected by the rim, the central region may be substantially thinned without the danger of excessively weakening the container wall.

Although this latter described embodiment of the invention requires two separate steps or "hits," it possesses the advantage of providing a large amount of metal for forming the dimple in that the initially formed dimple through the stretching operation is of a larger area in plan than the ultimately formed dimple. It has also been found that the two hit method significantly reduces the wear on the tooling used to form the dimple.

The invention, both as to its organization and method of operation together with further features and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying illustrative drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational sectional view of two articles having the dimples of this invention formed integrally therewith and being stacked with the dimples in nested relationship.

FIG. 2 illustrates the first step of the dimple forming method and is a sectional view through a dimple and the tooling used to form same.

FIG. 3 illusrtates the second and final step in the formation of the dimple and is a sectional view through the dimple and the tooling used to convert the dimple into its final configuration.

FIG. 4 is an enlarged fragmentary sectional view of the dimple.

FIG. 5 is a top plan view of an article of sheet material having a second form of dimple therein.

FIG. 6 is a sectional view through a section of deformable sheet material and a punch and a die used to form the dimple of FIG. 5 in a single step.

FIG. 7 is a fragmentary sectional view similar to FIG. 6 with the tooling having been advanced to form the dimple in a single step.

FIG. 8 is an enlarged fragmentary sectional view illustrating the second form of dimple.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings and in particular to FIGS. 1 and 5 thereof, reference numerals **11** and **12** designate articles formed of sheet material such as sheet aluminum. The article **12** has a plurality of dimples **13** formed integrally with the material of an upper wall **14** thereof. The article **11** has a plurality of dimples **103** formed in a lower wall **15** thereof.

The articles **11** and **12** may be enclosers or housings for certain equipment and the dimples **13** and **103** may be used as feet or short legs for such housings. In the form shown in FIG. 1, the dimples **13** are formed so as to

receive a portion of the dimples **103** thereabove to thereby support the housings **11** and **12** in nested relationship with a substantial air or clearance space **16** therebetween. Of course, any numbers of dimples **13** and **103** may be utilized and the uses suggested therefore are stated solely by way of illustration.

The present invention is directed to dimple construction and to a method of forming the dimples **13** and **103**. The dimples **13** and **103** are of slightly different construction and a preferred method of making the dimple **13** is illustrated in FIGS. 2 and 3 while the preferred method of making the dimple **103** is shown in FIGS. 6 and 7. The dimple **13** is formed with a two-step or two "hit" method whereas the dimple **103** is formed with a single step or "hit." Briefly, the method of making the dimple **13** includes forming a bubble or dimple **23** as shown, for example, in FIG. 2 and then reforming the bubble into the dimple **13** as illustrated in FIG. 2.

The bubble **23** is formed from the deformable sheet material of the wall **14** by offsetting a portion thereof utilizing a bubble die **25** and a bubble punch **27**. The die **25** has an interior surface **29** which defines a die cavity **31** and an exterior surface **33**. The punch **27**, which may be held in a punch holder **34**, has an arcuate, rounded working surface **35**, which engages the sheet material and urges a portion thereof into the die cavity **31** in a well known manner. During the formation of the bubble **23**, the sheet material thereof is stretched and therefore thinned to a thickness less than the original thickness of the panel **17**. Preferably, the interior surface **29** of the die blends into the exterior surface **33** with a relatively large radius to permit drawing of sheet material into the bubble **23** from an area surrounding the dimple.

The bubble **23** has a base **37**, a continuous unbroken dimple wall **39**, and a central region **41**. The area in plan of the bubble **23** is larger than the area in plan of the dimple **13**, and therefore, the diameter across the base **41** is greater than the corresponding diameter of the dimple **13**.

With reference to FIG. 3, the bubble **23** is reformed by a punch **43** and a die **45** into the dimple **13**. The die **45** has an exterior surface **46**, a tapered interior die surface **47**, a relatively flat die surface **49** located generally centrally of the tapered die surface and a lateral die surface **51** which extends from the flat die surface **49** to the tapered die surface **47**. The die surfaces **47**, **49**, and **51** define a die cavity and the surfaces **49** and **51** may be considered to define an annular space or a ring-like extension **53** of the die cavity. The die surfaces **49** and **51** may be formed by the inner end of a projection or anvil **55** positioned within the die.

The punch **43** has a tapered working surface **57**, a relatively flat nose **59** and a peripheral face **60**. The punch **43** and a die **45** are held within suitable tool holders **61** and **63**, respectively.

During the reforming operation, the punch **43** and die **45** are relatively advanced so that the exterior surface **46** of the die **45** engages a peripheral region of the bubble **23** to collapse or flatten the latter against the face **60** of the punch **43**. The punch **43** engages the dimple wall **39** to force the dimple into the die cavity of the die **45** to thereby tend to conform the dimple to the shape of the die cavity. Upon further relative advance of the punch **43** and the die **45**, the dimple wall **39** will be squeezed between the tapered die surface **47**, and the tapered working surface **57** to extrude the material thereof in both directions along such surfaces. The primary flow of material will be upward, i.e., toward the central region of the dimple, because the flow of the material downwardly is to some extent blocked by the face **46** and the surface **60** which grip the sheet material surrounding the base of the dimple **13**.

As best seen in FIG. 4, the dimple **13** includes a base **64**, a sloping peripheral dimple wall **65**, a flattened central region or transverse end wall **67** and a peripheral double layer rim or annular flange **69** extending axially above and surrounding the end wall 67. The upper surface of the rim 69 forms a supporting surface for a member placed thereon. During the reforming operation a peripheral region of the bubble 23 is converted into a circumscribing zone of sheet material surrounding the dimple 13 and an inner region of the bubble 23 is converted into the dimple 13. As shown in FIG. 4, the axial length of the dimple from the section of sheet material to the end wall is greater than the axial length of the dimple from the end wall to the axial outer end of the rim.

It is the squeezing of the dimple wall 39 which causes extrusion of the material thereof upwardly toward the ring-like extension 53 of the die cavity. Such upward flow of material urges the central region 41 against the flat surface 49 to effect flattening thereof to form the flattened central region 67. As the flat die surface 49 prevents further upward movement of the central region 67, the additional material extruded from the dimple wall 65 flows upwardly into the extension 53 to form the double layer peripheral rim 69.

The die surface 47 and the working surface 57 are preferably generally frustoconical and in the embodiment illustrated, extend upwardly at an angle of about 52° although other angles may be used. The wall 65 may also be frustoconical and the wall 67 may be circular. Preferably, the dimple peripheral wall 65 becomes thinner as it extends upwardly away from the base 64 of the dimple 13. Such progressive thinning of the wall 65 may be accomplished by utilizing slightly different angles on the surfaces 47 and 57 to cause these surfaces to taper toward each other as they extend toward the central region 67.

Another feature of this invention is to squeeze the end wall 67 between the flat die surface 49 and the flat nose 59 to extrude the material thereof radially outwardly to assist information of the rim 69. This extrusion of the wall 67 provides additional material for the formation of the rim 69 to increase the height and wall thickness thereof. Such extrusion of the material of the wall 67 thins the wall and therefore, it may not be desirable to follow this practice if the wall 67 is to directly support a load as, for example, shown in FIG. 1. However, where the direct load will be applied to the rim 69, extrusion of the wall 67 is useful to increase the size and strength of the rim.

As the dimple 13 must have a flat area high up in the dimple, considerable material is required for the formation thereof. By extruding the dimple wall during the reforming operation as described herein, a large amount of material is provided high up in the dimple 13 to permit the dimple to have a substantial axial dimension, substantial wall thickness and the necessary flattened area. With the dimple 13 either the wall 67 or the rim 69 can be used as a supporting surface.

The method shown in FIGS. 2 and 3 possesses the advantage of providing a large amount of sheet material for formation of the protuberance or dimple by initially forming the relatively large diameter bubble 23. This embodiment also holds tool wear to a minimum.

The method shown in FIGS. 6 and 7 may be utilized to form the dimple 103. The dimple 103 shown in FIG. 8 has a dimple wall 105 having a sloping frustoconical section 107 and a circular central region or transverse end wall 109. The dimple wall 105 also has a lower cylindrical extension 11 and an upper cylindrical extension 113. The height of the dimple 103 may be slightly less than the height of the stacking dimple 13. In the embodiment shown the end wall 109 and the extension 113 are sufficiently small to fit within the rim 69 and rest on the wall 67 as shown in FIG. 1. Thus, the extension 113 and the rim 69 are nested in interlocking relationship so that the housing 11 is firmly supported on the housing 12. Of course, the dimple 103 may be used for other purposes.

The dimple 103 is formed in a one-hit process by a punch 115 and a die 117 (FIGS. 6 and 7). The die 117 has a tapered preferably frustoconical die surface 119 and a relatively flat die surface 121 disposed generally centrally

of the tapered die surface and a cylindrical surface 123 extending between the surfaces 119 and 121. Ths surfaces 119, 121 and 123 define a die cavity 125, and the surfaces 121 and 125 define an extension 127 of the die cavity 125.

The punch 115 has a tapered preferably frustoconical working surfce 129 which smoothly blends into a relatively small diameter flat nose surface 131. The punch 115 and the die 117 offset an initially flat portion of the can end 101 shown in FIG. 6.

By relatively advancing the punch 115 and the die 117 toward each other, the nose surface 131 of the punch engages a portion of the sheet material of the can end 101 to urge the latter into the die cavity 125. During this initial phase of the operation, the material urged into the die cavity 125 is stretched and, if desired, material from an area surrounding the ultimately formed dimple 113 may be drawn into the wall 105 of the dimple. This may be accomplished, for example, by providing a surface having a relatively large radius for blending the tapered die surface 119 into an exterior face 133 of the die 117.

As the relative advance of the punch 115 and die 117 continues, the dimple wall 105 and in particular the section 107 thereof, is squeezed between the working surface 129 and the die surface 119 to displace the material thereof in both directions along such surfaces. The material flowing toward the base of the dimple 103 follows the outline of the punch and forms the lower extension 111 while the material flowing toward the central region 109 causes the formation of the upper extension 113 which takes the shape of the surface 123. The flow of material toward the central region 109 also urges the central region against the flat die surface 121 to effect flattening thereof. The punch 151 may be appropriately sized and shaped so that the nose surface 131 engages or nearly engages the inner surface of the central region 107 at the completion of the dimple forming operation. With this embodiment, the central region 109 is a relatively flat circular surface which forms the supporting surface for supporting a member thereabove.

Although exemplary embodiments of the invention have been shown and described, many changes, modifications, and substitutions may be made by one having ordinary skill in the art without necessarily departing from the spirit and scope of this invention.

What is claimed is:

1. A method of making a dimple from deformable sheet material comprising:

providing a die having a tapered die surface and a relatively flat die surface disposed generally centrally of said tapered die surface and at least partially defining a die cavity therewith;

providing a punch having a tapered working surface;

relatively advancing the punch and die to force a relatively flat portion of the sheet material into said die cavity and to stretch such portion of the sheet material to form a dimple having a dimple wall and a central region; and

continuing said step of relatively advancing to squeeze at least a section of the dimple wall between said tapered die surface and said tapered working surface of said punch to displace at least some of the material of said section of the dimple wall toward the central region of the dimple, the relative advance of the punch and die forcing the central region of the dimple against the relatively flat surface to substantially flatten the central region of the dimple.

2. A method as defined in claim 1 wherein said relatively flat die surface is spaced axially from said tapered die surface to define a shallow centrally disposed extension of the die cavity and wherein said step of continuing displaces at least some of the material of the dimple wall into the extension of said die cavity to thereby form an axially extending protrusion on the dimple.

3. A method as defined in claim 1 wherein each of said tapered die surface and said tapered working surface are at least substantially frustoconical.

4. A method of making a dimple from deformable sheet material comprising:

forming a dimple in the sheet material having a dimple wall and a central region with the dimple wall having axial length;

providing a die having a tapered die surface and a relatively flat die surface located generally centrally of the tapered die surface and at least partially defining a die cavity therewith;

providing a punch having a tapered working surface;

relatively advancing said punch and die toward each other to push at least a portion of the dimple into the die cavity to reduce the area of the dimple in plan; and

continuing said step of relatively advancing to squeeze at least a section of the wall between the tapered die surface and the tapered working surface of said punch to displace at least some of the material of the dimple wall toward a central region of the dimple, the relative advance of the punch and die forcing the central region against the relatively flat die surface to substantially flatten the central region of the dimple.

5. A method as degned in claim 4 wherein said relatively flat die surface is located axially intermediate the ends of the tapered die surface and said die has a surface circumscribing the flat die surface and extending from the flat surface to the tapered die surface least to at partially define a generally ring-like extension of said die cavity and said step of continuing includes displacing at least some of the material of said section into said ring-like extension to form a peripheral rim surrounding the flattened central region of the dimple.

6. A method as defined in claim 5 wherein the punch has a relatively flat nose and including further advancing said punch and die to squeeze the central region of the dimple between the flat nose of the punch and the flat die surface to extrude at least some of the material of the central region radially outwardly to assist in forming the peripheral rim.

7. A method as defined in claim 4 wherein each of said tapered die surface and said tapered working surface of said punch are generally frustoconical.

8. A method of making a dimple from deformable sheet material comprising:

converting a portion of the sheet material into a dimple having a dimple wall and a central region with the dimple protruding from the sheet material surrounding the dimple;

providing a die having a tapered die surface at least partially defining a die cavity and a projection extending axially from the inner end of the die cavity and defining a centrally disposed relatively flat die surface spaced radially inwardly from the adjacent portion of the tapered die surface whereby a generally annular space separates a portion of the projection from the tapered die surface;

providing a punch having a tapered working surface; and

a relatively advancing the punch and die to squeeze the dimple wall between the tapered die surface and the tapered working surface of the punch to displace at least some of the material of the dimple wall toward the central region of the dimple and into the annular space to form an upstanding rim surrounding the central region of the dimple to thereby form the dimple.

9. A method as defined in claim 8 wherein the punch has a relatively flat nose and including the step of further relatively advancing the punch and die toward each other to squeeze the central region of the dimple between the relatively flat die surface and the flat nose of the punch to extrude some of the material thereof radially outwardly to further flatten the central region and to provide additional material for the upstanding rim.

10. A dimple formed integrally with a section of sheet material comprising:

a peripheral wall protruding outwardly from a surrounding region of sheet material to an outer end of the peripheral wall, said peripheral wall being integrally joined to the surrounding region of sheet material;

a relatively flat end wall constructed of sheet material; and

a peripheral continuous rim formed of sheet material and integrally joining said end wall to the outer end of said peripheral wall, said rim being formed from a double layer of sheet material and projecting outwardly in a generally axial direction beyond said end wall, said rim strengthening said dimple.

11. A dimple as defined in claim 10 wherein said peripheral wall is generally frustoconical, said rim is generally annular in plan and said end wall is generally circular in plan.

12. A dimple as defined in claim 10 wherein said peripheral wall is of progressively decreasing thickness as it extends from said surrounding region of sheet material to said rim.

13. A dimple as defined in claim 10 wherein the axial length of the dimple from the section of sheet material to the end wall is greater than the axial length of the dimple from the end wall to the axial outer end of the rim and said peripheral wall slopes radially onwardly as it extends outwardly away from said surrounding region.

14. A method of making a dimple from deformable sheet material comprising:

forming a dimple of the sheet material with the dimple having a dimple wall and a central region and with the dimple protruding from the sheet material surrounding the dimple;

providing a die having a tapered die surface and a relatively flat die surface disposed generally centrally of said tapered die surface with said die surfaces at least partially defining a die cavity;

providing a punch having a tapered working surface and an end surface; and

relatively advancing the punch and die to squeeze a section of the dimple wall between said tapered die surface and said tapered working surface of said punch thereby extruding at least some of the material of said section toward the central region of the dimple and forcing the central region of the dimple against the relatively flat die surface to at least substantially flatten said central section of the dimple.

15. A method of making a dimple form deformable sheet material comprising:

forming a dimple having a base, a sloping dimple wall and a central region with the dimple wall protruding outwardly from the sheet material surrounding the dimple and sloping radially inwardly as the dimple wall extends toward the central region of the dimple;

squeezing at least a section of the sloping dimple wall between coperating die members to displace at least some of the material thereof toward the central region of the dimple; and

at least substantially flattening the central region of the dimple to thereby form an end wall for the dimple while allowing at least a major portion of the dimple wall to slope radially inwardly as its extends toward the end wall.

16. A method as defined in claim 15 wherein said step of forming includes stretching a region of the sheet material to thereby at least assist in converting at least a portion of said region into said dimple.

17. A method as defined in claim 15 including restraining the end wall against movement away from the base of the dimple while allowing movement of a zone of the dimple contiguous the end wall away from the base

of the dimple whereby the displacement of material toward the central region results in said movement of said zone to thereby form a rim contiguous the end wall.

18. 18. A method as defined in claim 15 including squeezing the end wall to extrude some of the material thereof into the rim.

19. A method as defined in claim 15 wherein the dimple is imperforate.

20. A method of making a dimple from deformable sheet material comprising:

forming a dimple having a dimple wall and a central region with the dimple protruding outwardly from the sheet material surrounding the dimple;

squeezing at least a section of the dimple wall between cooperating die members to displace at least some of the material thereof toward the central region of the dimple; and

restraining the central region of the dimple against movement away from the sheet material surrounding the dimple while allowing movement of a zone of the dimple surrounding the dimple away from the sheet material surrounding the dimple whereby the

displacement of material toward the central region causes said movement of said zone to thereby form a rim which surrounds the central region contiguous thereto and which projects outwardly to terminate in an outer end, said central region lying axially intermediate the sheet material surrounding the dimple and the outer end of the rim.

21. A method as defined in claim 20 including squeezing the central region to extrude some of the material thereof into said rim.

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LOWELL A. LARSON, Primary Examiner

U.S. Cl. X.R.

72—379; 113—116; 348—346