July 13, 1965 W. S. EGGERT, JR., ETAL 3,194,047

METHOD OF MAKING A METAL SANDWICH STRUCTURE PANEL

Filed April 24, 1962 4 Sheets-Sheet 1

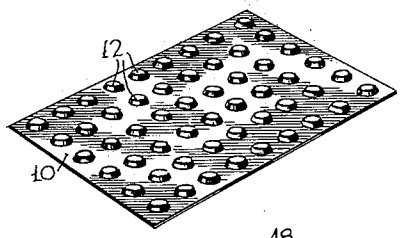


FIG. 1

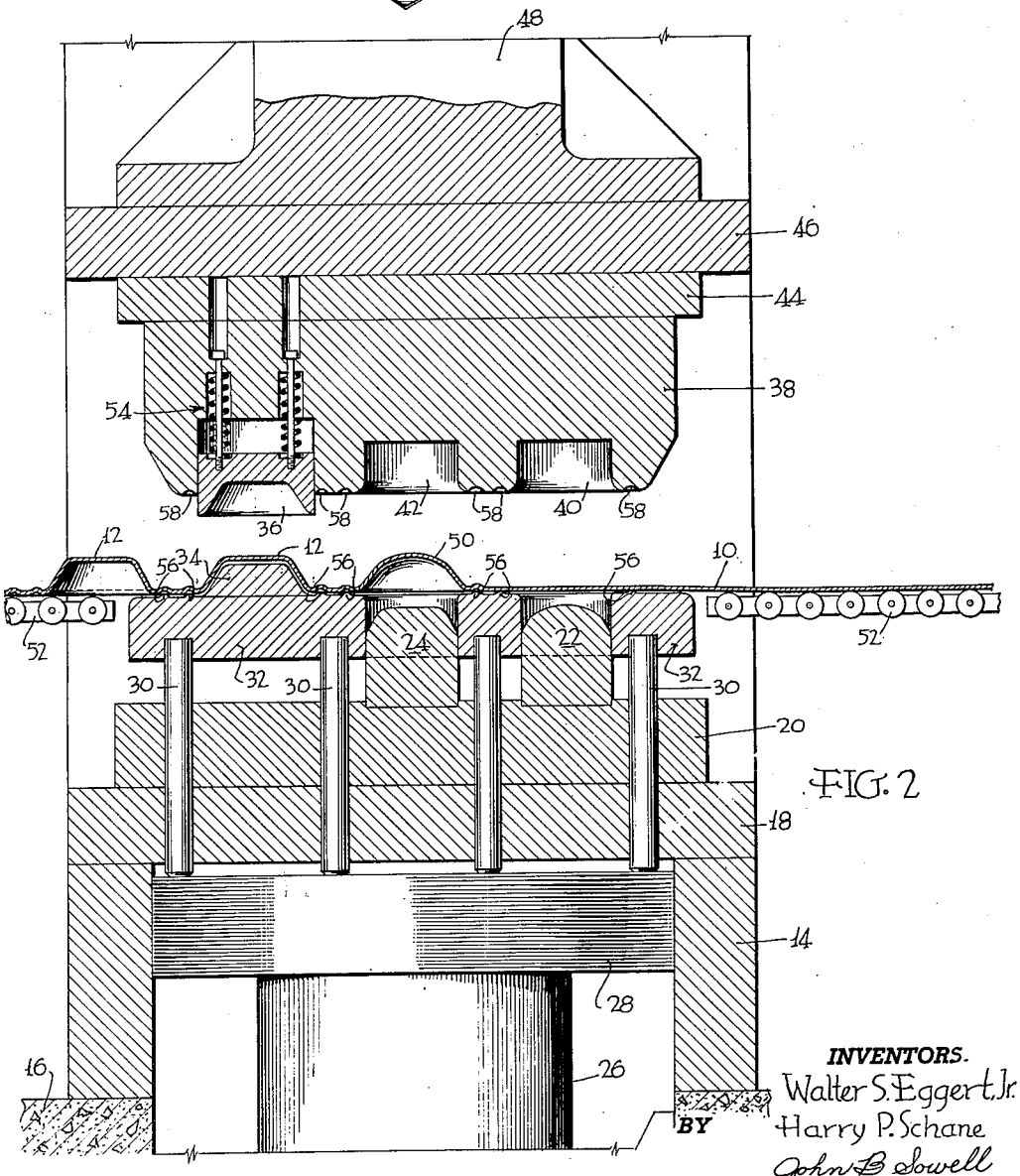


FIG. 2

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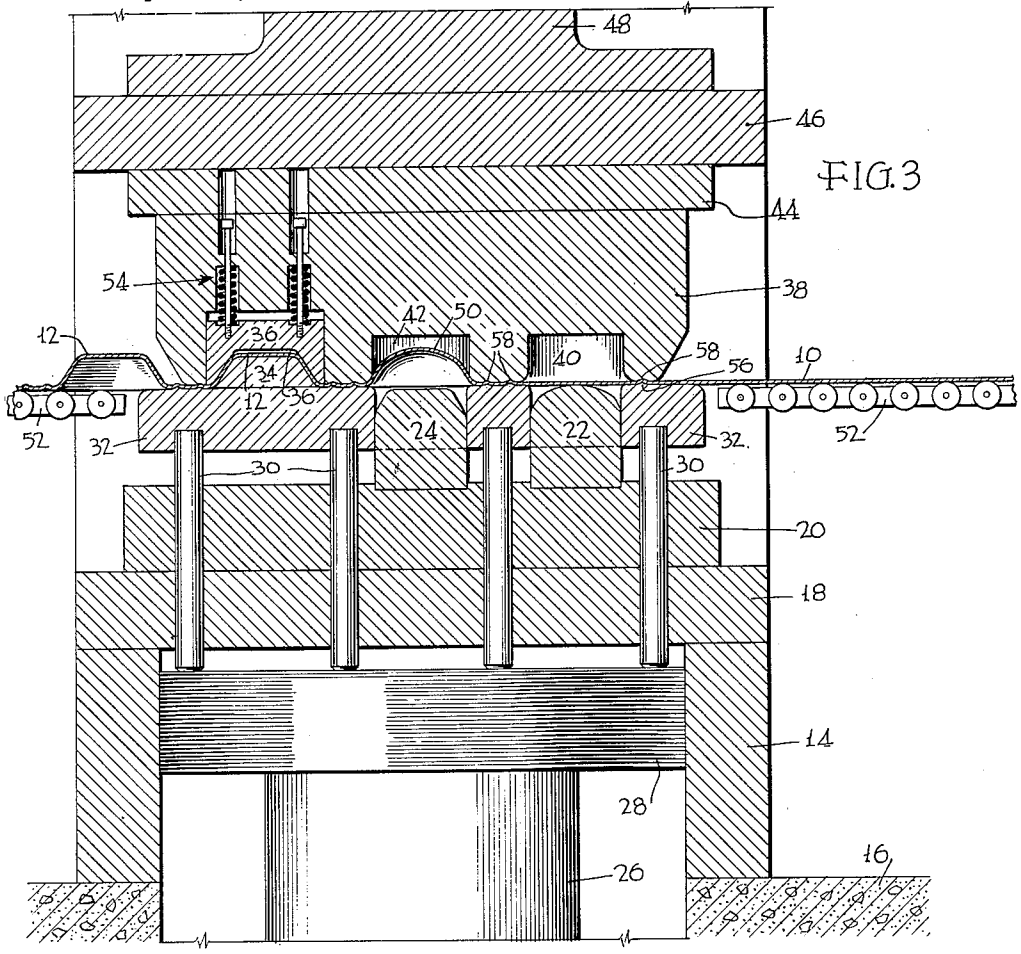


FIG. 3

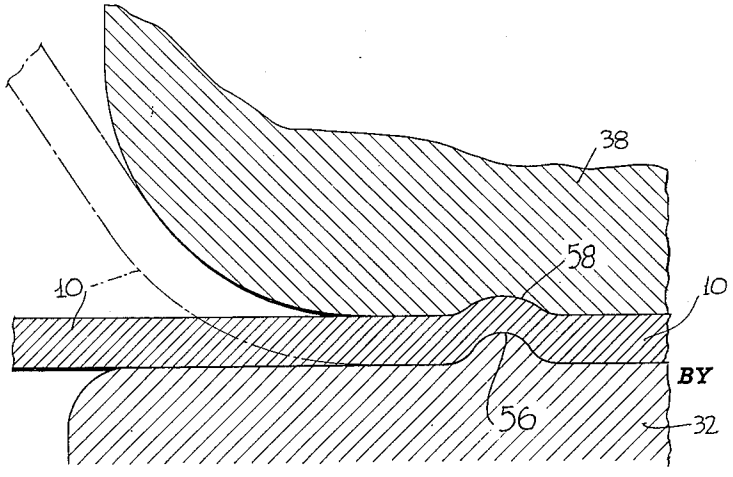


FIG. 6

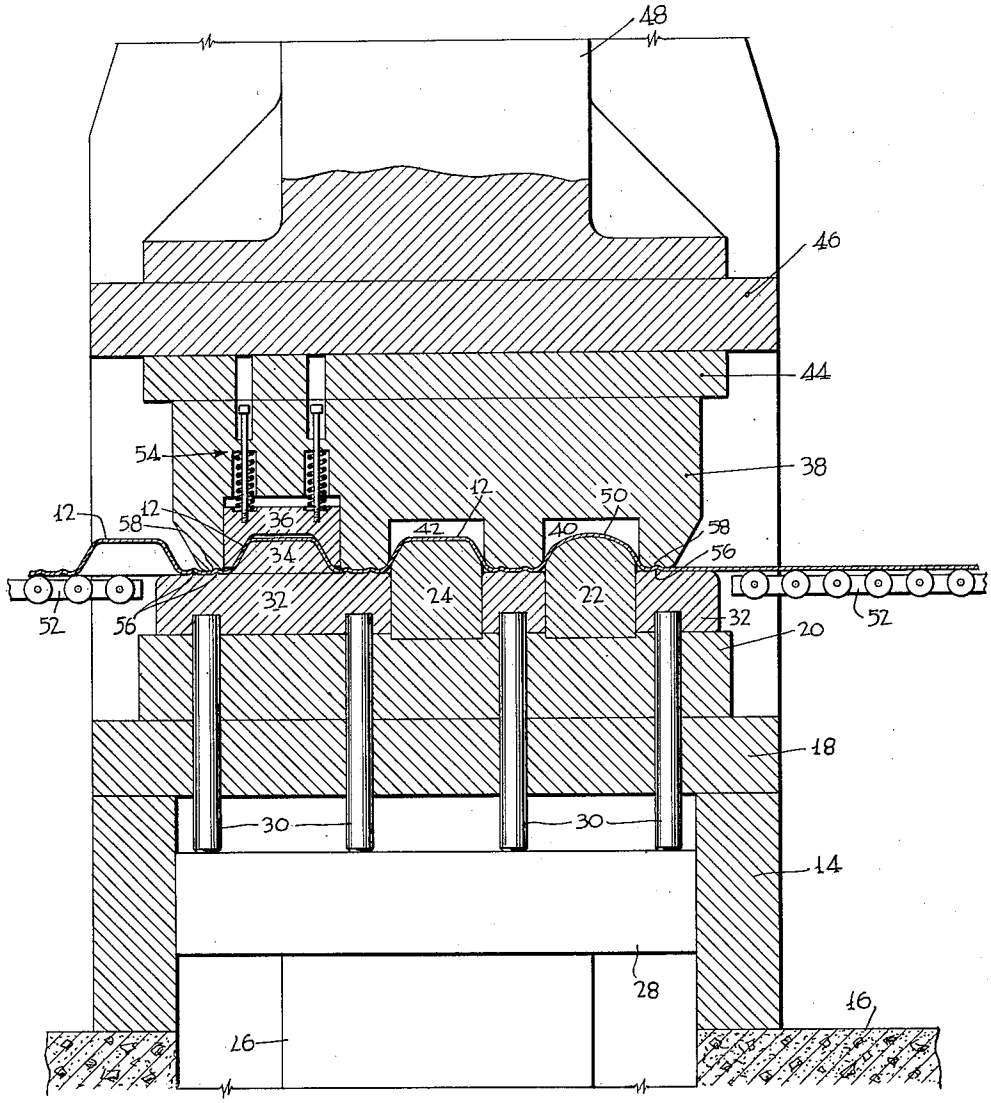
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FIG.4.



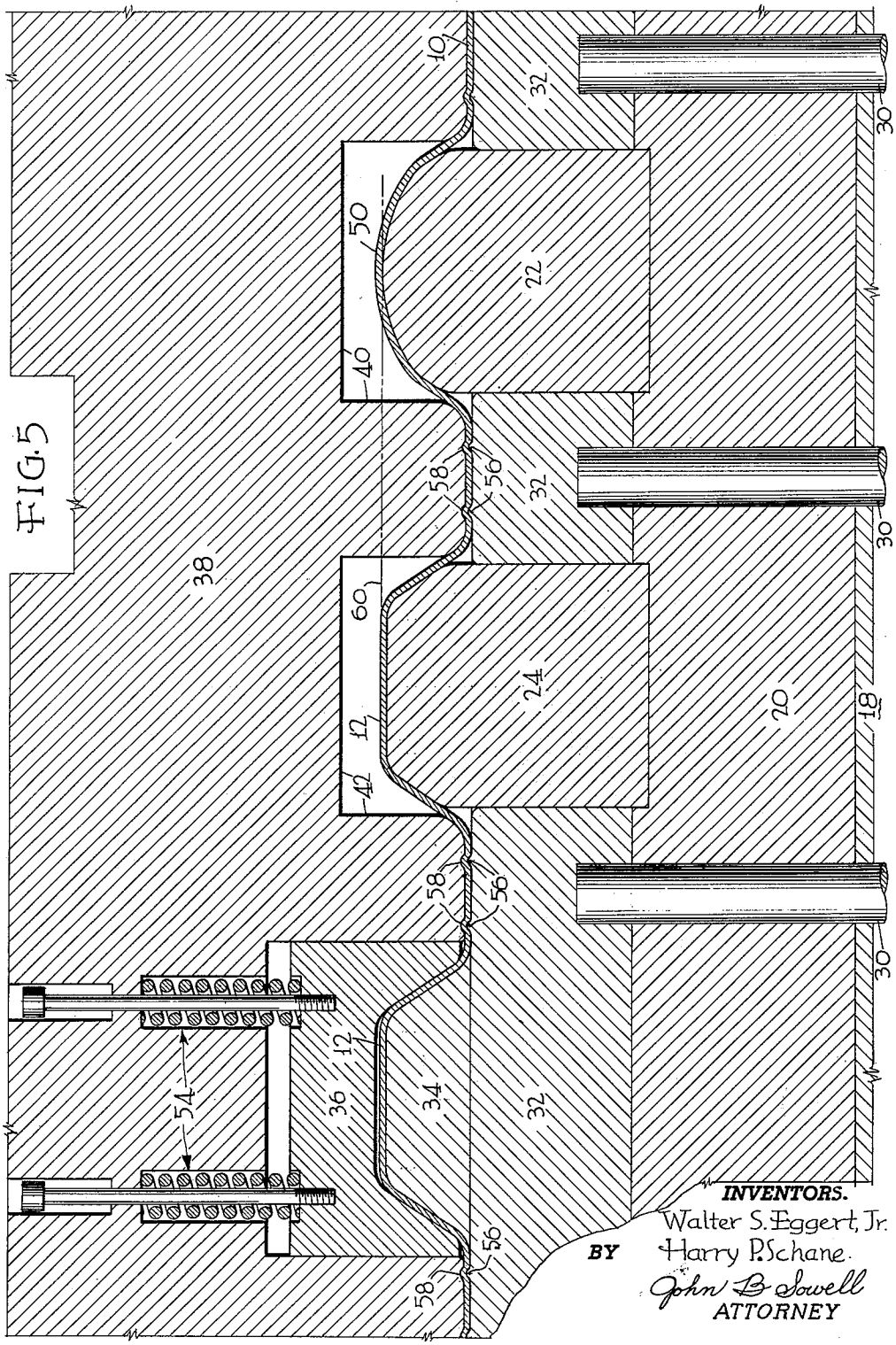
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FIG. 5



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METHOD OF MAKING A METAL SANDWICH STRUCTURE PANEL

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6 Claims. (Cl. 72—349)

This invention relates to forming smooth metal plate into sandwich panel shapes and more particularly to a method of deep forming individual shapes into a blank while maintaining the size of the blank constant.

Drawing has been defined as a process of cold-forming a flat precut metal blank into a hollow vessel without excessive wrinkling, thinning or fracturing. Heretofore, when a flat blank was drawn, as by die forming, a change in its shape was brought about by making the metal flow on a plane approximately parallel to the die face in such a manner that its thickness and surface are remained about the same as the blank. Heretofore, drawing has included operations in which metal is pulled or drawn into suitable containing tools from flat sheets into deep or shallow shapes. Geometrical and analytical methods have been devised to determine the size of blank necessary to obtain a particular drawn cup or dimple. In normal drawing operations amount of reduction is expressed as the actual percentage reduction in the blank diameter due to drawing or shrinking the original diameter of the blank. The present method of deep drawing is performed without changing the blank size, thus the meaning given to percentage reduction heretofore is not applicable. Hereinafter, percentage reduction shall mean the reduction in blank thickness due to elongation and shear forming of the metal.

Plate materials have a fixed value of maximum elongation expressed as a percentage factor which is obtained by testing a specimen of the plate in tension until it ruptures. Heretofore, it has been impossible to elongate a specimen by tension die forming beyond the theoretical (or actual) maximum elongation.

Heretofore, adherence to the rule of feeding metal into the area being deep formed has created distortions in the metal surrounding the die area which necessitates redrawing, ironing and trimming operations to eliminate the distortions. These distortions have prevented economic staging and indexing on the deep drawn shapes. Moreover, deep drawing has heretofore, been limited to the forming of flat plates. The present invention contemplates a novel method which permits a flat plate to be first formed into regular compound curvature shapes and subsequently deep drawn in isolated areas to form a curved sandwich structure plate. Sandwich structure plates made from the formed curved and/or flat plates may be connected by welding to similarly formed plates. Welding creates a cast metal structure which does not draw well. Very large compound curvature shapes may be made by welding after forming to avoid any limit as to size or shape, for the edges of the individual plates in the present invention, both before and after deep drawing, maintain the exact dimension.

Therefore, it is a primary object of the present invention to deep draw shapes in isolated areas of a metal plate without distorting the remaining area portions of the metal plate;

It is another primary object of the present invention to deep draw a plurality of formed shapes in a metal plate by staging and indexing on previously formed shapes;

It is another object of the present invention to provide a novel method of deep drawing metal plate.

The above and other objects and advantages of the invention will be apparent from the following description of an exemplary embodiment thereof, reference being made to the accompanying drawings wherein:

FIG. 1 is a perspective view of a sandwich structure plate having deep drawn dimpled formations therein formed by the present novel method;

FIG. 2 is a section in elevation of the novel staging dies installed in a typical hydraulic press showing the dies in open position;

FIG. 3 is a section in elevation of the novel staging dies of FIG. 2 showing the dies in a half-closed position;

FIG. 4 is a section in elevation of the novel staging dies shown in FIGS. 2 and 3 showing the dies in closed position;

FIG. 5 is an enlarged section in elevation of the working portion of the dies shown in FIG. 4;

FIG. 6 is an enlarged detail in section showing the detail of the novel locking bead.

Referring now to the drawings, FIG. 1 shows a metal plate **10** having deep drawn dimples **12** formed therein. Two metal plates **10** are welded together at the mating face of the deep drawn dimples **12** to form a sandwich structure. It is to be understood that these drawn sandwich plates may be made from the same set of dies to be described hereinafter, but compound curvatures having non-symmetric plate structures may require a set of dies for each of the plate structures.

FIG. 2, by way of a preferred embodiment, illustrates a hydraulic press having a frame **14** mounted on a concrete super structure **16**. A lower cross frame **18** is connected to the frame **14** and provides a mounting structure for the lower die plate **20**. Connected to the lower die plate **20** is a first male forming die **22**, here shown to be a preforming punch, and a second forming die **24**, here shown to be a final forming punch. Connected to the concrete super structure is a lower hydraulic cylinder or cushion ram **26**. Affixed to the movable ram **26** of the cylinder (not shown) is a floating platen **28** which provides support for a plurality of pilot pins **30** which extend through apertures in the lower cross frame **18** and the lower die plate **20** and provide support for the floating lower die ring **32**. Affixed to the lower die ring **32** is a male gage plug **34**; opposite the male gage plug **34** is a spring loaded female gage positioner **36** guided in an aperture provided in an upper die forming ring **38**. A female upper preforming die ring or retainer ring **40** and a final forming die ring or retainer ring **42** are shown to be formed in the upper die forming ring **38** axially aligned with their respective male forming dies **22** and **24**. It is to be understood that the die rings or retainer rings **40** and **42** while shown to be an integral part of the upper die forming ring **38** may be constructed as individual parts mounted in an upper die forming ring **38** and attached to the upper die plate **44**. Upper die plate **44** is attached to an upper bolster **46** which is carried by a vertically movable upper ram **48**. Shown inserted between the floating lower die ring **32** and the upper die forming ring **38** is a metal plate **10** having a deep drawn dimple **12** formed therein indexed over the male gage plug **34**. A preformed dimple **50** which has been formed by the male forming die **22** is shown indexed over the male forming die **24** prior to the die structure being closed. It will be understood that the plate **10** shown in FIG. 2 has already undergone two complete die forming operations to be described hereinafter. Floating rollers **52** are provided to aid in feeding the plate **10** into the staging die structure.

Referring now to FIG. 3 wherein the die structure of FIG. 2 is shown in a half closed position. Female gage positioner **36** is seated on the sloping sides of the formed

dimple 12 at the upper surfaces of the metal plate 10, and the male gage plug 34 is seated on the sloping portions of the dimple 12 at the lower surface of the dimple 12. Gage positioner 36 and its associated spring loading means 54 have been compressed during the downward stroke of the upper ram 48 carrying the upper die assembly. Cooperation of plug 34 and positioner 36 affixes the plate 10 in a predetermined position prior to the mating of die ring 32 and die ring 38. Die ring 32 has male locking and coining beads 56 thereon, and die ring 38 has female locking and coining grooves 58 therein. These cooperating locking and coining beads and grooves when employed for a single stage operation may be varied to some extent as will be explained later. When the die 38 is moved downward vertically by the ram 48 it contacts the metal plate 10 and forces it against the floating lower die ring 32. Male locking beads 56 represent the highest surface of the mating die rings. Beads 56 initially contact the plate 10 to coin grooves in the plate. Continued downward movement of the ram 48 causes the pilot pins 30 to force the floating platen 28 downward against the ram 26 of the hydraulic cylinder provided with a constant pressure device such as a metering orifice, well known in the hydraulic press art. The metering orifice causes the ram 26 to exert a constant force on the floating platen 28 so long as the ram 48 moves pivot pins 30 downward at a constant velocity. Thus, plate 10 is struck and coined at the area opposite the bead 56 and groove 58 isolating a blank area inside of the locking bead and groove opposite the male punch 22. The bead and groove also firmly lock to prevent any movement of metal outside of the locking bead and groove. As the ram 48 is continued to be lowered, the male punch is forced into engagement with the metal plate 10 causing the metal opposite the male punch 22 to be wrapped around and formed by said male punch. Simultaneously during the forming operation by male punch 22, the male punch 24 is being forced into the preformed dimple 50 and causes the preformed dimple to be stretched over the male punch 24 to take the exact shape of the final forming punch 24. As already explained with regard to male punch 22, locking beads 56 and grooves 58 prevent any flow of metal outside of the area encompassed by the locking beads. Ram 48 continues downward until die ring 32 finally touches against the lower die plate 20 mounted on the lower cross frame 18. This terminates the downward movement of the ram 48 and causes a rapid increase in the hydraulic pressure which is actuating ram 48. As is well known in the hydraulic press art, a reversing switch, not shown, may be tripped by a critical pressure indicative of this terminal condition which causes a reversal of the movement of the ram 48 thus opening the die assembly to permit advancement of the plate 10.

FIG. 4 shows the condition when the dies are completely closed and the ram 48 is at its lowermost position causing die ring 32 to bottom on die plate 20.

Referring now to FIG. 5, it will be noted that the metal plate 10 formed by the male punch 22 is formed into die ring 40 which has a larger diameter than the male punch 22. This permits the male punch to uniformly stretch a portion of unrestrained metal between the die ring 40 and the punch 22. It will be noted that die 22 has a rounded nose which is deeper than the die 24 as indicated by the dotted line 60. Also the nose of the die 22 is more narrow than the nose of the final formed die 24. In the novel method of staging with a preforming punch 22 and final forming punch 24. the preformed dimple 50 is actually drawn to a deeper depth than required for the final form. When the final forming punch 24 is driven into the preformed dimple 50, the nose of the male die 24 initially contacts the sloping portion of the preformed dimple 50 causing the metal at the flat nose of the die 24 to be stretched outward and pulled down, into contact with the final forming die 24. It is to be understood that the preforming die shown illustrates a method of deep drawing to a depth which could not be achieved in two ordinary deep drawing steps.

A preferred shape of the male punch which will draw and elongate the metal past its maximum elongation takes the form of a parabola which will fit the sloping sides of the male punch at approximately 60°. While the nose of the punch in FIG. 5 is not shaped for its deepest possible draw it illustrates that the dimple 50 is drawn deeper than final form and can be final formed by a very slight flow of material to the shape of the dimple 12. By employing a preform punch of the preferred shape it was discovered that deeper shapes could be obtained than with two drawing stages.

A detail of the novel coining and locking bead 56 and groove 58 is shown in FIG. 6. The distance from the top of the male locking bead 56 to the bottom of the female locking groove 58 is made approximately 30% less than the distance between the face of the die ring 32 and the face of the die ring 38. It was discovered that the die ring 38 presses the plate 10 upon the bead 56 and thins the metal between the bead and the groove 56, 58 causing the metal to flow outward from the bead and groove. The plate thickness adjacent to the bead and groove was formed thicker than the remainder of the plate. When a substantial pressure was exerted upon the upper die ring 38, the pressure was concentrated at the coining bead and groove and the adjacent material thereto which has been caused to be thickened. The area of plate material encompassed by the bead and groove is held substantially in a locked position by the material which is thickened, and by the locking bead and groove at the thinned area. Not only does the novel blocking bead and groove prevent the metal outside the locking bead area from being formed, but it also provides a means whereby the pressure exerted on the upper die forming ring is distributed equally around the closed perimeter formed by the bead and groove. Should a plurality of dies such as those shown in FIGS. 2, 3 and 4 be employed to operate simultaneously, the pressure imparted to the ram 48 is distributed equally to each of the rings formed by the locking beads and grooves. This eliminates any unequal distribution of pressure when a plurality of locking beads and a plurality of male punches are employed at the preforming stage and at the final forming stage.

It is intended that the dies 32 and 38 may be curved to any desired compound curvature and that the dies 32 and 38 be provided with the novel locking bead and locking groove. When the die structure is operated, only the metal inside the locking bead and locking groove is deformed, and any compound curvature shape is maintained in its original curved shape because no metal is drawn into the die forming area which would cause wrinkles and distortions and/or change the curvature of the metal plate being so formed.

By way of example, if it is desired to form flat plate material to be used for the floor of a railway car, the staging dies shown in FIGS. 2, 3 and 4 may be employed or a plurality of dies similar to the dies shown in FIGS. 2, 3 and 4 may be employed. A piece of flat plate 10 is selected having the desired outside dimensions of the finished sandwich structure shape. Plate 10 is first fed into the first stage or preformed dies and is locked into position by the coining and locking beads and grooves. A preformed shape is embossed in the plate and the dies are released. The metal plate 10 is advanced, and preformed shape 50 is placed opposite the final forming die 24. A set of locking beads 56 and grooves 58 provided on ring 32 and ring 38 at the second stage may be made to the exact dimensions of the locking bead and locking grooves used in the previous stage, but instead of coining a new groove the locking bead and locking groove, merely fit into the groove previously formed in the metal plate 10. After the preformed dimple 50 is shaped to its final form 12 the press is again open and the plate 10 advanced to

the third stage. The third stage is not a forming stage but merely positions the plate by forcing a formed dimple over a gage plug 34 having the exact shape as the final forming punch 24. Thus, it can be seen that an indefinite length of plate 10 can be fed into the novel staging dies which continue to locate and position the plate at the first and second stage by positioning on a dimple 12 previously formed at the stages, and will maintain critical indexing from stage to stage only because the plate is not distorted.

The metal drawn inside the locking bead and groove is formed as an isolated area where there is no distortion, buckling or wrinkling in the basic contour or shape of the plate formed. Thus, any shape such as cylinders, spheres or toroids may be made as sandwich structures by first forming smooth curved plate sections that are to be welded together to form the desired structure, and then drawing the dimpled shapes in the plate sections without distorting the basic curvature of the formed plate. If a flat rectangular plate is drawn by the present method, the dimpled shapes may be drawn therein without changing the perimeter or edges of the plate, thus, enabling a plurality of such plates to be welded together after they are drawn without the necessity of trimming or reforming the flat portions of the plate in any way. Any compound curvature may be imparted to a plate before being die drawn. Drawing is accomplished without distorting or altering the basic perimeter of the formed plate.

While one embodiment of the invention has been described for purposes of illustration it is to be understood that the novel locking beads and locking grooves can be employed on other types of forming dies and that the sandwich structures may be formed with other shapes of dimples which may be formed by either the final forming or preforming dies or both.

What is claimed is:

1. The method of making a metal sandwich structure panel from a sheet metal blank, said method comprising the steps of positioning the blank between a pair of die members, one of said pair of die members having a bead projecting outwardly from its face and the other having a complemental groove to matingly receive the bead therein, subjecting the blank to the closing action of the dies to reduce the thickness of the blank along a line by said bead and groove, said closing action of said dies causing metal of the blank to flow in opposite directions away from said line to increase the thickness of the blank along immediate adjacent inner and outer margins of said line, the locus of said line enclosing an area of said blank, clamping said blank at the thickened margins of said line with a high degree of pressure and simultaneously deforming the enclosed area encompassed by said line whereby the material outside of the area being deformed is prevented from flowing into the area.

2. The method of making a metal sandwich structure panel from a sheet metal blank, said panel comprising a plurality of longitudinally-spaced laterally-extending

rows of spaced dimples, each dimple comprising a flat circular end wall and a tapered side wall, said method comprising the steps of: intermittently feeding said blank through a preforming station and a final forming station; preforming rows of laterally-spaced rounded-end dimple-like shapes, at said preforming station, in successive portions of said blank, each row being preformed by simultaneously cold drawing the metal within laterally-spaced areas to form such shapes and preventing the flow of metal into such areas and thereby prevent dimensional distortion of said blank outside of such areas; and final forming said rows of said rounded-end dimple-like shapes into said dimples at said final forming station by simultaneously holding said blank around said dimple-like shapes of each row as each row passes through said final forming station, and stretching said rounded-end dimple-like shapes to form said dimples.

3. The method of claim 2 wherein said preventing is done by coining said blank around said areas and holding the portions thus coined.

4. The method of claim 3 wherein said coining is accomplished by pressing said blank between upper and lower die members provided with coining beads and coining grooves between which the metal blank is squeezed.

5. The method of claim 2 wherein said drawing is accomplished by pressing die rings against one side of said blank and rounded-end male dies against the other side of said blank so as to stretch said metal within said areas over said male dies and thereby form said rounded-end dimple-like shapes.

6. The method of claim 2 wherein said feeding comprises indexing said blank to position it in said preforming and final forming stations, by grasping dimples that have already been formed, immediately prior to any preforming and final forming steps.

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