A deep drawn cup-shaped blank has a wall thickness substantially the same as the sheet metal blank from which it has been formed. The cup-shaped blank is subjected to a separate succession of die and punch members to perform individual forming stages one at a time to effect a decrease in the inside diameter and wall thickness of the cup-shaped blank at a working zone around the periphery of the blank. The working zone is moved along the length of the blank as the blank moves through the die. The punch member used to force the container through a die at each forming stage has an outside diameter that is smaller than the inside diameter of the cup-shaped blank being formed. Consequently, an annular gap is disposed therebetween to a point contiguous to the working zone. A fluid medium is introduced into the annular gap to effect cooling of the metal directly at the working zone. The same frequency of working stroke is effected for all of the punch members operating at each of the forming stages.

24 Claims, 37 Drawing Figures
PROCESS FOR THE NON-CUTTING PRODUCTION OF SHEET STEEL CONTAINERS

BACKGROUND OF THE INVENTION

The present invention relates to a process for the non-cutting production of sheet steel containers. More specifically, the bodies of the containers are made from sheet steel which can be deep drawn on a press mechanism having a mechanical power transfer. One or a multiple of deep drawing stages is used to form a cup-shaped blank from a round shape or sheet metal blank. The wall thickness of the cup-shaped blank is substantially the same and remains the same as the initial sheet metal blank during the deep drawing stages. Subsequently the cup-shaped blank is brought to a desired final height by stretch forming while decreasing the thickness of its wall.

Heretofore, bodies of metal containers were produced in accordance with three different processes. The first process is referred to as one-piece production wherein the body of the container is generally made of aluminum by the cold extrusion method. A round shape or blank of aluminum serves as a starting raw material. A ram operating under high pressure causes the aluminum to flow in the annular gap between the ram and the die cavity wherein the aluminum is drawn over the ram. The complicated method of production along with the use of expensive starting material makes the production of such so-called monoblock containers to be subject to exceedingly high production cost. It is necessary to lacquer finish the inside of the containers which is accessible only with great difficulty. These monoblock containers are therefore used generally only in those cases where outward appearance is of great importance and a high packaging price is acceptable.

The tripartite container comprises a body, bottom and lid. The body of the container is rolled on the body maker insulation from tailored metal sheets. Subsequently, the body is formed with a welded or soldered longitudinal seam and the bottom and lid portions are folded in in an air and water tight manner. This prior art process produces about 600 or more cans per minute. The welded seam is visible from the outside of the cylindrical body. Since the seam not only impairs the outward appearance of the can but also is subject to rusting and cannot be printed over, it represents a decided disadvantage. In addition, the production of the tripartite containers is relatively complicated because of the extensive machine arrangements, the personnel required to effect the process and the soldering or welding material used.

To effect bipartite production, the body of the container is deep drawn from tin coated or tin sheet metal. The valve opening is simultaneously formed during the deep drawing process. The bottom of the container is folded in tightly with the deep drawn container body. While a can produced in accordance with this process has a good appearance, acceptable production costs and may very well be printed around its entire periphery, there are several disadvantages. It is not possible in accordance with known bipartite production processes to permit a high production rhythm during the deep drawing stages. Furthermore, a relatively high consumption of raw material is required to make containers from this process. Practically no reduction of the thickness of the sheet metal occurs during the deep drawing process. Consequently, a relatively large round shape or blank must be used initially. The starting thickness of such a large round shape or blank must be relatively large due to the stresses occurring during the deep drawing steps.

The drawn bipartite container can be maintained in the market at competitive prices only if raw material used in the round shape or blanks can be reduced and if the amount of production can be considerably increased. The known drawing process produces from 50 to 60 container bodies per minute. However, it is not possible to greatly increase the productivity in terms of container bodies per minute because there is a maximum capacity for the raw material to withstand stress and of exceeding the maximum possible drawing speed used during the process.

Heretofore, experts in this field have theorized that sheet steel could not be reshaped at high frequencies of stroke of between 100 and 160 strokes per minute as compared to brass and aluminum. Sheet steel of course offers the advantage of a far more favorable price than brass and aluminum and so it would be preferred for certain types of containers. Thus, up to this point, despite great efforts, the sheet metal industry has not found a satisfactory solution to the problem of mass production of sheet steel containers at a high frequency of stroke and high degree of efficiency.

The use of a combined deep drawing and stretch forming process to produce container bodies has already been attempted. The round metal shape or blank is reshaped into a cup by deep drawing, i.e., while maintaining the original wall thickness throughout the operation. In a second reshaping phase, the preformed cup-shaped blank is rammed in a single stroke of a punch or stamp member through several stretching or die rings which are disposed coaxially and one behind the other in the feed direction of the punch member. The single stroke is effected until the desired thickness of wall is obtained and the finished or final height of the container body is reached. The inside diameter of the cup-shaped blank remains constant during the ramming thereof through the stretching or die rings.

Such a combined drawing and stretching operation is not suited for high frequencies of strokes for several reasons. The material flows in a longitudinal direction of the container body due to the high amount of pressure produced by the punch member during the stretch forming operation. The same punch member is used to effect the passage of the material through the several stretch rings which are disposed consecutively adjacent each other. Only a small part of the developing heat can be eliminated during the process. Consequently, the material is even more solidified during the passage thereof through the stretch rings. It has been found through experience that there is a danger of the material tearing apart when high frequencies of strokes are used for the punch member to ram the material through the plurality of stretching rings.

Furthermore, the inside surface of the container body blank fits closely against the periphery of the stamp or punch member from the very beginning of the known operation. Therefore the contact area between the punch member and the inside of the container body can neither be cooled nor lubricated on the inside during the stretch forming operation. Any cooling medium that is fed from the outside of the container begins to evaporate because of a considerable amount of heat that develops during the stretching operation. Conse-
sequently, a sufficient discharge of heat is not possible under known conditions. Therefore, effecting such a process with a high frequency of stroke in view of the hardening of the material is absolutely impossible if a high productivity output is required.

Moreover, as was ascertained in experiments with the combined deep drawing and stretch forming process, a more or less pronounced tip or ear formation occurs during the deep drawing phase. The tip or ear is formed along the upper edge of the container body which is clamped down by a holding device. Such a formation also depends upon the quality of material in the plate. The tip or ear formation is accentuated by the stretch forming process and may lead to the tearing off of the tips or ears which can result in a considerable disturbance to automatic production of the container bodies.

As indicated above, the container body must be drawn or rammed through the plurality of stroke or die rings with the exception of the last stroke or die ring along its entire length while decreasing its wall thickness. This produces an additional hardening and embrittlement of the material along the upper edge of the container. This upper edge had also become unusable as a result of the formation of the tip or ear. Consequently, the container body must be taken out of the tool and trimmed with considerable loss of material prior to folding over the flanged edge when applying a terminal portion of the container such as a bottom or top lid. The flanging operation must take place in the hardened and embrittled zone.

**PURPOSE OF THE INVENTION**

The primary object of the present invention is to provide a process for producing container bodies having a high productivity rate necessitating a high frequency of stretch strokes and which consumes a considerably reduced amount of raw material when compared to existing processes.

Another object of this invention is to meet the ever growing demand for aerosol and other containers through providing a production process which satisfies the esthetic properties required in the container as well as the profitability associated with its manufacturing cost.

Another object of this invention is to provide a bipartite production process which is economically and commercially feasible and may be used with a sheet steel material.

A still further object of this invention is to provide a combined deep drawing operation with a stretch forming operation wherein a small stroke of the punch or stamp member into the die cavity is effected.

A further object of this invention is to provide an article of manufacture useful in producing containers from sheet steel.

**SUMMARY OF THE INVENTION**

The process as disclosed herein includes the steps of deep drawing a sheet steel blank into a cup-shaped blank having a wall thickness substantially the same as the sheet steel blank. The cup-shaped blank is then subjected to a stretch forming operation including a plurality of individual stretch forming stages. Each of the stretch forming stages includes decreasing the inside diameter and the wall thickness of the cup-shaped blank. Each of the stretch forming stages is carried out on a separate stroke drawing means.

Another feature of the invention is directed to an assembly wherein the stretch forming means includes forming or die ring, a die cavity and a stretching punch member which cooperates with the stretch forming ring and die cavity. The punch member has an outside diameter sufficiently less than the inside diameter of the stretch forming ring to form an annular gap between the inside wall of the cup-shaped blank and the outside surface of the stretching punch member which is urging the cup-shaped blank through the stretch forming ring. Such a combination of stretch forming elements is required for each of the stretch forming stages wherein the inside diameter and the wall thickness of the cup-shaped blank are decreased.

A further feature of the invention is that the frequency of stroke in each of the stretch forming stages is at least as high as the frequency of the stroke used to effect the deep drawing step. Furthermore, a cooling and lubricating material may be applied to the surface of the cup-shaped blank while it is being stretched.

Another feature of the invention is directed to the article of manufacture formed from a blank out from a sheet of metal. A container shaped member has a top terminal section, a bottom terminal section and an intermediate body section contiguous to the terminal sections. The intermediate body section has a wall thickness that is greater than the thickness of the terminal sections. The thickness of the terminal sections is substantially the same as the blank member cut from the sheet of metal.

In one embodiment, the thickness of at least one of the terminal sections is located on the inside of the container shaped member with the outside surface of said terminal section being coextensive with the outside surface of the intermediate body section. This article of manufacture is produced through the use of an elastically resilient member placed on the inside of the cup-shaped container blank. One side of the elastic support member is supported by the punch member and the side opposite said first side is subjected to a pressure member causing the elastically resilient member to expand and move the thickened terminal section inwardly with respect to the wall of the shaped container body.

**BRIEF DESCRIPTION OF DRAWINGS**

Other objects of this invention will appear in the following description and appended claims, reference being made to the accompanying drawing forming a part of the specification wherein like reference characters designate corresponding parts in the several views.

FIG. 1 is a schematic drawing showing the manner in which round shapes or blanks are punched from a metal ribbon or blank;

FIGS. 2 through 8 are schematic diagrams showing various stages of production of the cup-shaped blank during the deep drawing operation of this invention;

FIGS. 9 and 10 are schematic diagrams showing the cross-sectional shape of the cup-shaped blank after piercing and cooling the neck portion prior to the stretch forming operation;

FIGS. 11 through 14 are schematic diagrams showing the cross-sectional shape of the cup-shaped blank as it is subjected to each separate stage in the stretch forming operation of this invention;

FIGS. 15 and 16 are partial cross-sectional views of mechanisms used to effect separate stages in the deep drawing operation of this invention;
FIGS. 17 and 18 are partial cross-sectional views of an assembly used to effect the stretch forming operation of a commercial size food container.

FIG. 19 is a partial cross-sectional view of an assembly used for forming an aerosol can having a dome-like tapering neck;

FIG. 20 is a partial cross-sectional view of an assembly used to effect a finishing operation on a container shaped member;

FIG. 21 is a schematic drawing showing the manner in which round shapes or blanks are punched from a metal ribbon or band;

FIGS. 22 and 23 are schematic illustrations showing another embodiment of the deep drawing operation of this invention;

FIGS. 24 through 28 are schematic illustrations showing a plurality of stretch forming stages of this invention;

FIGS. 29 through 32 are schematic drawings showing finishing operations associated with the formation of an aerosol can;

FIG. 33 is an illustration the same as FIG. 1 showing an initial sheet metal blank member to effect a further embodiment of the invention;

FIG. 34 is a schematic illustration of the double round shape or blank being located at a separating station;

FIGS. 35 and 36 are schematic diagrams showing deep drawing operations being effected on the separated round shapes or blanks after having been received from the separating station.

An assembly as shown in FIGS. 15 and 16 may be used to accomplish the desired function. The assembly includes a die member 3, a sheet holder 4, a stamp or punch member 5 and an ejector member 6. The stamp or punch member 5 is driven into the die cavity in the direction of arrow 7 and in doing so forms a cup-shaped blank 8a as shown in FIG. 2. This individual deep drawing stage is referred to as a "stop draw." A further stop draw is accomplished by the assembly as shown in FIG. 16 forms the cup-shaped blank 8b as shown in FIG. 3. The punch member 10 is guided in a draw bushing 9 and presses the cup-shaped blank 8b against a retreating biased ejector member 11.

Further deep drawing stages are then repeated in this manner with the thickness of the wall remaining substantially the same as a practical matter with a successive decrease of the diameter of the cup-shaped blank until the cup-shaped blank 8g is reached as shown in FIG. 8. Each of the cup-shaped blanks 8a through 8g are effected with separate deep drawing assemblies.

In this particular embodiment, a curled neck 12 is formed as shown in FIG. 9 and subsequently the cup-shaped blank is turned over as shown in FIG. 10 in preparation for the stretch forming operation.

FIG. 11 shows a passageway in the form of a passageway 14 for the transfer of the cup-shaped blank 8g to the next passageway 15. The passageway 14 is shown to be the form of a passageway 17, with the wall thickness of the cup-shaped blank 8g substantially the same as the thickness of the round shape or blank 2 which is initially punched from the metal ribbon or blank 1. The scale in which the illustration of FIG. 1 is based does not correspond to the scale of the cup-shaped blanks in FIGS. 2 through 14. Space limitation required a relatively small illustration for the showing of the sheet metal blanks 2 cut from the metal ribbon 1 in FIG. 1.

The cup-shaped blank 8i is next subjected to a stretch forming operation to produce a shaped container body. The stretch forming step includes a plurality of individual stretch forming stages each of which includes decreasing the inside diameter and the wall thickness of the cup-shaped blank. Reference is specifically made to FIGS. 11 through 14 which show various stages in this stretch forming step.

In this particular embodiment, a container body used to form an aerosol can having a constricted dome-shaped neck is being formed. A stretch forming assembly as shown in FIG. 19 is used to effectuate the process in this particular embodiment. As indicated, the inside diameter D is reduced during each of the individual stretch forming stages and offers the excellent possibility for supplying cooling and lubricating material such as liquid compositions against the surface of the sheet metal being stretched. Furthermore, the use of the individual stages with the decreasing diameter D may be carried out at the same stroke frequency or possibly even at a higher operating stroke frequency than the deep drawing processes. As shown in FIGS. 10, 11, and 12, the diameter of the cup-shaped blanks 8i is D1, and changes to D2 and D3 in the cup-shaped blanks 8k and 8m, respectively.

The container body as shown in FIGS. 2-14 is an embodiment which is especially intended for the production of aerosol containers having a folded-in bottom member and an attachable atomizer valve. The process of the invention, however, can be used to produce any kind of container bodies having a circular, elliptical, polygonal, tapered, Greek column, barrel, or any other geometrically shape of cross-section adaptable to the process.

The term "finished height" refers to the perpendicular or vertical measurement h of the container body as shown in FIG. 14.

The deep drawing stages as shown in FIGS. 2 through 8 and the stretch forming stages as shown in FIGS. 11 and 12 are carried out in one embodiment of the invention with the same working stroke, i.e., the same frequency of stroke for the punch member to move in and out of the die cavity. This means that the cup-shaped containers may be fed from one drawing or forming assembly to the next in appropriate sequence and in a synchronized manner. Appropriate conveying grips would have to be used to move the cup-shaped blank from one drawing or forming stage to the next. Thus it is possible to reduce the cup-shaped blank from one stretching or die ring to the next successively in its diameter whereby the raw material of the blank is rearranged at each stretch forming stage and as a result is protected against excessive embrittlement. It is further possible, however, to carry out the stretch forming operation of
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this invention at a faster or slower stroke frequency or cadence than the deep drawing press. For example, two stretch forming presses might be used to work in combination with a deep drawing step which produces a double round shaped blank as discussed hereinafter with a further embodiment of this invention.

In another embodiment showing the formation of a commercial sized food can, reference is made to FIG. 17. The stretch forming assembly is shown at the beginning of a stretch forming stage. The assembly includes a stretch ring 13, a punch member 14, a die member 17 and an ejector member 16. The cup-shaped blank 8i is forced downwardly in the direction of the arrows by the stamp or punch member 14 through the stretch ring 13 thereby effecting the desired decrease in the inside diameter and wall thickness of the blank 8i at a working zone located around the periphery of the blank 8i. It is evident from the disclosure that the working zone is moved along the length of the blank 8i as it moves through the die ring 13. The stamp or punch member 14 is adapted to the inside contour of the container body 8k as shown in FIG. 18 while the cup-shaped blank 8i still has the shape as shown in FIG. 17. The cup-shaped blank 8i representing the commercial size food can corresponds in its degree of processing to the cup-shaped blank 8i as shown in FIG. 10 wherein an aerosol can is being produced.

An annular gap exists between the ring member 13 and the punch member 14 to a point contiguous to said working zone as is evident from the drawings. It is the distance between these members which constitutes a factor in determining the amount of decrease in the diameter D during the operation. The wall thickness of the cup-shaped blank 8i is decreased as it passes between the stretch ring 13 and the punch member 14.

The punch member 14 has an outside diameter sufficiently less than the inside diameter of the stretch forming ring 13 and smaller than the inside diameter of the cup-shaped blank to form an annular gap 15 between the inside wall of the cup-shaped blank and the outside wall of the punch member 14.

The annular gap 15 exists at the beginning of the stretch forming operation between the punch member 14 and the inside wall of the cup-shaped blank 8i. The annular gap 15 is advantageously used to supply a cooling agent and lubricant against the material in the cup-shaped blank during the stretch forming operation. As is evident, the fluid medium is effective for cooling the metal directly at the working zone. The cooling agent and lubricant may be commercial liquid emulsions which are applied by a spray nozzle hitting the stamp or punch member 14 on the upper part thereof and allowed to flow downwardly into the gap 15 along the periphery of the punch 14.

The application of such a cooling and lubricating material results in excellent cooling and lubrication of the cup-shaped blank for the container body. Therefore, harmful heating which would irrevocably lead to cracking of the parts at the intended high frequency of punching stroke is precluded. In addition, the cooling and lubricating material being applied to the inside wall of the cup-shaped blank has a favorable effect on the peeling off or removability and ejection of the blank from the punch member 14 after the particular stretch forming stage has been completed.

As shown in FIG. 17, the punch member 14 is about to enter the opening of the stretching ring 13. The bottom of the cup-shaped blank 8i is supported by the ejector member which is biased by an elastic medium such as compressed air. The punch member 14 is guided in the bore defining the die cavity of the die member 17. During downward movement of the stamp or punch member 14, the diameter D of the cup-shaped blank is reduced. At the same time, the wall thickness is made to flow under high pressure so that it is decreased while the cup-shaped blank of the container body has its height correspondingly increased. A corresponding shaping also takes place in accordance with the shape of the punch member 14 and its cooperating parts.

Each stretch forming stage takes place in a fraction of a second. The cooling agent and lubricant is supplied to the cup-shaped blank for the container body in the annular gap 15. Further supply of cooling and lubricant liquid may be provided through the groove shaped channels 19 disposed between the die member 17 and the stretching or die ring 13. Use of the channel 19 provides a cooling and lubricating material to the outside of the cup-shaped blank 8i above and below the working zone thereby providing the attendant advantages such as the avoidance of corrosion of the outside wall due to the wetting-out properties of the cooling and lubricating medium.

The punch member 14 includes a center bore or channel 18 through which the cooling agent and lubricant introduced in annular gap 165 may be partially expelled and the liquid of an additional blow out and eliminating heat from the punch member 14. The cooling agent and lubricant is also partially expelled upwardly through the annular gap 15 as the punch member 14 is rammend through the stretching ring 13.

Another advantage of the multi-stage stretch forming process is that each of the individual blanks do not need to be stretched or drawn entirely through the stretching ring 13. That is, the stretch forming process can be terminated prior to reaching the upper edge of the cup-shaped blank 8i so that the upper part or terminal section of the body can maintain the original wall thickness thereof of the deep drawn cup-shaped blank.

This operation is shown in FIG. 18 shortly after a stretch forming stage. Cooling channels 18 and 19 have been omitted from this particular drawing for the sake of clarity and simplicity. As shown, the upper terminal portion 20 of the cup-shaped blank 8k and the bottom terminal portion 21 have a considerably greater wall thickness than the cylindrical intermediate wall section 22. The cup-shaped blank 8k is ejected from the die cavity by the ejector member 16 in the direction of the arrow 23.

As indicated hereinafter, the stretch forming assembly as shown in FIG. 19 is used to form a container shaped member usable for producing an aerosol can. This is the type of container body being formed in the process illustrated in FIGS. 2 through 14. In FIG. 19, the punch member 14 has the outline or surface configuration which is adapted to the desired shape of the aerosol container being formed. Reference is made to the left half of FIG. 19 which shows the cup-shaped blank for the container with a pulled end but not yet curled neck element 25. In this instance, the perforation or piercing operation followed by the curling is completed after the stretch forming process.

In the embodiment as shown in the right hand of FIG. 19, the neck portion has been provided with a curl 26 before the stretching forming process. Whenever the shape in FIG. 12 has been reached in an additional
stretch forming stage, the stamping of the annular flange 15 as shown in FIG. 13 is used to fold in or interconnect the bottom portion of the container. The trimming of the annular flange 15 takes place as shown in FIG. 14. Contrary to known processes, the operations of stamping the annular flange and trimming thereof take place within the power press itself.

The ejector means which supports the dome of the container in the embodiments shown in FIG. 19 includes a casing 27a and a central ejector bar 28a as shown in the left hand side of the drawing. The casing 27b and a central ejector bar 28b are shown in the right hand side of the FIG. 19. In these embodiments, the casing members 27a or 27b are supported by compressed air and the ejector bars 28a and 28b are supported by springs.

The blank member 8k as shown in FIG. 19 includes a top terminal section 27, a bottom terminal section 24 and a middle area or intermediate section 28. The wall thickness of the terminal sections 24 and 27 amount to a multiple of the wall thickness prevailing in the intermediate section 28. The thicker reinforced terminal sections 24 and 27 are intentionally left at the original thickness of the round shapes or blanks cut from the sheet metal ribbon 1. Therefore, the body of the container has the rigidity required for folding in the bottom or to receive an atomizer valve or a lid member. In this embodiment, the top terminal section 27 extends over the entire constricted neck portion. The height c as shown in FIG. 20 of the lower or bottom terminal section 24 can correspond to the width b of the annular flange 29 of the finished container body.

The container body produced from the operation as shown in FIG. 19 provides a thickening of the lower terminal portion 24 to be directed outwardly. This would give the finished container an unappealing appearance. In order to overcome or correct this disadvantage, the container body is subjected to an additional work process as shown in FIG. 20 wherein the annular flange 29 is clamped between the front surface of the die member 30 and a stripper member 31 having an annular cross-section. A shaping stamp or punch member 32 is supported by an ejector member 33 and includes a beveled annular shoulder 34. The punch member 32 projects into the inside of the container body and the shoulder 34 serves as a counter support for an annular elastically resilient pressure cushion 35.

The right half of FIG. 20 shows the pressure cushion 35 with its diameter somewhat below the inside diameter of the die cavity and in a relaxed state. A pressure stamp or punch member 36 is disposed above the pressure cushion 35. When the punch member 36 is moved downwardly in a direction toward the die member 30, the outside surface of the pressure cushion 35 comes to fit against the adjacent inside wall of the container body. As the pressure stamp 36 continues to be lowered, a strong pressure is exerted by way of the pressure cushion 35 onto the inside surface of the container shaped member. The pressure is transmitted by the material of the pressure cushion 35 in all directions as in a liquid and forces the adjacent section of the container body against the inside surface of the die cavity bore. At the same time, the thicker terminal section 24 of the container body which initially projects outside of the container body, penetrates the pressure cushion 35 and thus moves inwardly so that the thicker terminal portion 24 is located on the inside of the container shaped member with the outside surface of the terminal section being coextensive with the outside surface of the intermediate body section.

A further embodiment of the process of this invention is shown in FIGS. 21-32. In this embodiment, the following work processes are accomplished:

FIG. 21 shows round shapes or blank 41 being punched from a sheet metal ribbon 42.

FIG. 22 shows a first deep drawing stage to form a cup-shaped member.

FIG. 23 shows the deep drawing of the cup-shaped member of FIG. 22 in an upside down position whereby the cup-shaped blank becomes taller and has a decrease in its diameter. The outside of the cup-shaped blank as shown in FIG. 22 now comes to lie on the inside of the cup-shaped figure shown in FIG. 23.

FIG. 24 illustrates a first stretch forming step.

FIG. 25 shows a second stretch forming step.

FIG. 26 shows a third stretch forming step.

FIG. 27 shows a step wherein the neck portion 38 of the container is predrawn.

FIG. 28 shows the final drawing of the neck portion 38.

FIG. 29 shows the pressing of the bottom terminal section forming a flanged edge.

FIG. 30 shows the trimming of the flanged edge of the bottom terminal section.

FIG. 31 shows the piercing of the neck portion 38.

FIG. 32 illustrates the curling of the neck portion 38.

In accordance with a special embodiment of this variant, the deep drawing stages may operate at a pressure stroke of 180 mm. This corresponds to a total or overall stroke path of 360 mm. In utilizing a maximum drawing speed of 52 meters per minute, a stroke number of 144 strokes per minute will result according to the formula $52 \times 1/0.36 = 144$.

The subsequent stretch forming and final shaping operations can also be carried out with this same stroke number of 144 strokes per minute. This same stroke number may be used at a press stroke of 420 mm for producing 6 oz. cans and 450 mm for producing 8 oz. cans.

Both the deep drawing steps and the stretch forming steps can be carried out on either of two interlinked automatic presses or on a single special press. However, the latter would have to be equipped with two different ram strokes.

An essential condition for the attainable high stroke number of 144 strokes per minute is to have a small distance of 150 mm existing between the tool assemblies used to effect each separate operational stage. This small distance between the operational stages results because the diameter of the round shape or sheet metal blank may be as small as 126 mm in diameter. When compared to known processes, which operate at a maximum ram stroke number of 60 strokes per minute, there is an increase in the performance of about 140% if the process of the present invention is used.

The cup-shaped blank as shown in FIG. 27 has a retracted neck portion 38 comprising a cylindrical portion 39 and a curved transitional portion 40 and serves for the insertion of a valve. By properly shaping the head of the stretching stamp or punch member used in accordance with the process of this invention, it is possible to decrease the wall thickness of the container body in the stretch forming stages for the purpose of saving material up into the curved transitional portion 40.
A further increase in efficiency can be achieved as shown in FIGS. 33-36. In this embodiment of the process according to the invention, a connected double round shape or blank of sheet metal ribbon 43. Subsequently, the double round blank 37 is separated as shown in FIG. 34 and each of the individual blanks is then subjected to deep drawing operations as shown in FIGS. 35 and 36. This particular process attains the results of having at least 280 parts per minute being produced. The blanks 37 are stamped out in the zigzag method as in the earlier embodiments. The separated round blanks must be pulled somewhat apart by a distance which gives due consideration of the dimensions of the tools being used. The lateral disposition of the separated blanks may be accomplished by magnets.

The deep drawing operations as shown in FIGS. 35 and 36 correspond to those as shown in FIGS. 22 and 23. These are run twice at a stroke member of, for example, 140 strokes per minute. Correspondingly, the subsequent stretch forming operations including the final shaping operations, can be carried out at twice the rate, that is, at 280 strokes per minute or each of the separate lines supplies can be moved to two stretch forming presses each operating at 140 strokes per minute.

The particular way in which the present process is effected enables the productivity of sheet steel containers to rise considerably above the rate of 160 strokes per minute which was thought before to be unattainable by experts. More specifically, steel sheet containers may be produced at operating frequencies of between 100 and 160 strokes per minute. It is now possible, as shown, to increase the productivity up to over 200 strokes per minute which constitutes a large advancement over the prior art. It may be considered as having been well known by the man skilled in the art that dwell time during the course of the stretch forming process results in a structural change in the metal. In most cases this has a negative effect. That is, the dwell time results in the formation of embrittled material and thus can subsequently be the cause of cracks in the material in addition to other unpleasant phenomena.

A further question associated with the process of this invention is in the design of the conveying system enabling the stampings to be moved continuously from one station to the next. This is particularly important due to the drastic increase in the number of strokes being used per minute to effectuate the deep drawing and stretch forming operations. A decisive improvement in the conveying system was achieved by placing the grippers against the stampings before the stamp is withdrawn from the die cavity for conveyance to the next operational mechanism. The saving in time that can be achieved thereby is considerable in the case where there are large numbers of strokes being used.

A further feature of the invention is directed to the manner in which the lubricating and cooling fluid is applied to the annular gap 15 as shown in FIG. 37. A first embodiment of a device used to provide lubricating and cooling fluid is ring 47 having radial conduits 49 through which the fluid is directed as shown by arrow 48. The fluid is applied to the outer surface of the punch member 14 during the operation thereof. The angle of incidence $\alpha$ of the fluid may vary from between 0° and 90°.

A further embodiment of a device is the use of fluid conduits 44 located inside a stripper member 45. The lubricating and cooling fluid is applied at an angle $\alpha$ of 90° in this embodiment. The stripper member 45 is used to effect removal of the stretched container body 8 when the punch member 14 is withdrawn from the die member 17.

The angle of incidence $\alpha$ will be determined as a function of the various flow conditions prevailing in the lubricating and cooling fluid being used during the stretching operation. For example, it may be necessary to use a particular angle of incidence $\alpha$ to avoid certain operational disadvantages such as the formation of vapor when a lubricating and cooling fluid is applied to the punch member 14. The lubricating and cooling medium may be a solid which is in particular form, a liquid or a gaseous material.

A further possibility for impinging cooling and lubricating fluid on the outside of the container body 8 is in the use of conduits 46 located in the stretch ring 13 just above the point at which the material in the container body 8 is to be deformed upon passage through the stretch ring 13 as shown in FIG. 37.

It is noted that the expression sheet steel is defined as comprising all kinds of steel, especially steel alloys and steel sheets bearing metallic or non-metallic coatings such as tin, plastics, rubber and the like. A steel alloy has been used as the metal in each of the embodiments as described herein.

In those embodiments relating to the production of aerosol containers, the container body is shaped first in one piece with a dome-like narrowed upper portion with the bottom portion of the container being folded in. In this method, the fold which serves to hold the bottom in place constantly comes in contact with the liquid contents of the aerosol container. The gaseous portion of the contents of the container is in the dome-shaped upper portion of the container. In those instances where a highly corrosive material or acid containing filling material is used in the aerosol container, it is possible to produce the container body first in one piece with the bottom and subsequently fold in the dome-shaped upper portion of the container. In this way, one might place the folded material which is more subject to corrosion in the area of the gas of the contents of the container and thus not be subjected to the more corrosive liquid material in the bottom portion of the container.

**ADVANTAGES OF THE INVENTION**

It is well known that a container having a wall thickness of 0.1 mm would be sufficient to satisfy the requirements for strength and pressure in aerosol cans. The thickness of the wall in the commercially available cans in the cylindrical portion is presently of up to 0.35 mm with an initial thickness for the blank of 0.35 mm. Therefore, the reduction of the wall thickness in question by stretch forming to a dimension between about 0.10 and 0.12 mm will result in enormous decrease of the operational weight and of the diameter of the initial round shape or blank 2. The latter is also a determining factor for the mutual distances which must exist between the individual separated drawing and forming assemblies. The smaller the distances are, the higher can be the frequency of the stroke.

In accordance with this invention, the thickness of the wall in the middle or intermediate section of the container body is reduced in the stretch forming operation. For example, a round shape for sheet metal blank having a thickness from between about 0.30 mm and
Having thus set forth and disclosed the nature of this invention, what is claimed is:

1. Process for the production of metal containers, comprising the steps of:
   a. deep drawing a sheet metal blank into a cup-shaped blank with a cylindrical portion having a wall thickness substantially the same as said sheet metal blank,
   b. providing a plurality of individual forming stages each of which includes a die and corresponding punch member for decreasing the inside diameter of the cup-shaped blank and decreasing the wall thickness of the cup-shaped blank,
   c. subjecting said cup-shaped blank only to a separate succession of die and punch members to perform said individual forming stages one at a time to effect a decrease in the inside diameter and wall thickness of the cup-shaped blank at a working zone around the periphery of the blank,
   d. said working zone being moved along the length of the blank as said blank moves through said die,
   e. providing the punch member at each forming stage with an outside diameter that is smaller than the inside diameter of the cup-shaped blank being formed so that an annular gap is disposed therebetween to a point contiguous to said working zone,
   f. introducing a fluid medium into said annular gap to effect cooling of the metal directly at the working zone, and
   g. effecting the same frequency of working stroke for all of the punch members operating each of the forming stages.

2. A process as defined in claim 1 wherein said fluid medium introducing step includes directing said fluid medium onto the outside surface of the cup-shaped blank above and below the working zone.

3. A process as defined in claim 1 wherein said metal is sheet steel.

4. A process as defined in claim 1 wherein the deep drawn blank has a height about one-third to two-thirds of the desired final height of the sheet steel container body.

5. A process as defined in claim 1 wherein each said individual forming stage is effected at a frequency of stroke that is at least as high as the frequency of stroke used to effect said deep drawing step.

6. A process as defined in claim 1 wherein at least one marginal strip remains unstretched at the end of the shaped container body after the completion of the individual forming stages.

7. A process as defined in claim 1 wherein said individual forming steps include providing a shaped punch member having a cambered transition portion and an adjacent cylindrical portion, said transition and cylindrical portions being placed adjacent the inside surface of a terminal section in the cup-shaped blank to form a cambered transitional portion in the container body useful to produce an aerosol container with a constricted dome-shaped neck portion.

8. A process as defined in claim 1 wherein said shaped container body is formed in one piece and constitutes a bottom portion of a container.
a dome-shaped upper portion of the container is provided, and said upper portion is connected to the bottom portion with a flanged configuration.

9. A process as defined in claim 1 wherein the thickness of the sheet metal blank is from about 0.30 mm to about 0.35 mm and the thinnest wall thickness of the shaped container body is from about 0.10 mm to about 0.12 mm.

10. A process as defined in claim 1 wherein said deep drawing step comprises two separate stages with the sheet metal blank being drawn in a first direction to form a cup-shaped blank and subsequently said cup-shaped blank is deep drawn in a direction opposite said first direction to produce a cup-shaped blank for the subsequent individual forming steps.

11. A process as defined in claim 1 wherein said sheet metal blank is stamped from a sheet of steel and has two connected round portions, said round portions being subsequently cut into separated round-shaped sheet metal blanks, each said sheet metal blank being subjected to two deep drawing stages to form a cup-shaped blank.

12. A process as defined in claim 11 wherein said individual forming stages are carried out at a stroke frequency that is twice as large as the stroke frequency used the deep drawing step.

13. A process as defined in claim 1 wherein said individual forming stages are effective to produce a shaped container body having a top terminal section, an intermediate section and a bottom terminal section, said intermediate section having a wall thickness that is less than the wall thickness of said top terminal and bottom terminal sections.

14. A process as defined in claim 13 wherein the thickness of said top terminal section and said bottom terminal section is substantially the same as the original thickness of said sheet metal blank.

15. A process as defined in claim 13 wherein said bottom terminal section which is thicker than said intermediate section is disposed against the inner wall of a die cavity, said bottom terminal section is supported from the inside by an elastically resilient member, a pressure is exerted on said elastically resilient member to cause the thicker terminal section to move inwardly with respect to the walls of the shaped container body.

16. A process as defined in claim 15 wherein said elastically resilient member is a ring with one side being contiguous to the inside diameter of the intermediate section of the shaped container body and the other side of said annular resilient member is firmly supported while pressure is applied to compress the elastic member so that it expands in a direction transverse to the direction of movement of said applied pressure to cause the thicker terminal section to move inwardly with respect to the wall of the shaped container body.

17. A process as defined in claim 1 wherein said individual forming stages are effected at a stroke frequency of greater than 100 strokes of a punch member per minute.

18. A process for the production of a thin-walled metal container from a cup-shaped metal blank, comprising the steps of:

a. providing a plurality of individual forming stages each of which includes a die and corresponding punch member for decreasing the inside diameter of the cup-shaped blank and decreasing the wall thickness of the cup-shaped blank,

b. subjecting said cup-shaped blank only to a separate succession of die and punch members to perform said individual forming stages one at a time to effect a decrease in the inside diameter and wall thickness of the cup-shaped blank at a working zone around the periphery of the blank,

c. said working zone being moved along the length of the blank as said blank moves through said die,

b. providing the punch member at each forming stage with an outside diameter that is smaller than the inside diameter of the cup-shaped blank being formed so that an annular gap is disposed therebetween to a point contiguous to said working zone,

d. introducing a fluid medium into said annular gap to effect cooling of the metal directly at the working zone, and

e. effecting the same frequency of working stroke for all of the punch members operating each of the forming stages.

19. A process as defined in claim 18 wherein said fluid medium introducing step includes directing said fluid medium onto the outside surface of the cup-shaped blank above and below the working zone.

20. A process as defined in claim 18 wherein said metal is sheet steel.

21. Apparatus for the production of metal containers, comprising:

a. means for deep drawing a sheet metal blank into a cup-shaped blank with a cylindrical portion having a wall thickness substantially the same as said sheet metal blank,

b. means for providing a plurality of individual forming stages each of which includes a die and corresponding punch member for decreasing the inside diameter of the cup-shaped blank and decreasing the wall thickness of the cup-shaped blank,

c. means for subjecting said cup-shaped blank only to a separate succession of die and punch members to perform said individual forming stages one at a time to effect a decrease in the inside diameter and wall thickness of the cup-shaped blank at a working zone around the periphery of the blank,

d. said working zone being moved along the length of the blank as said blank moves through said die,

e. means for providing the punch member at each forming stage with an outside diameter that is smaller than the inside diameter of the cup-shaped blank being formed so that an annular gap is disposed therebetween to a point contiguous to said working zone,

f. means of introducing a fluid medium into said annular gap to effect cooling of the metal directly at the working zone, and

g. means for effecting the same frequency of working stroke for all of the punch members operating each of the forming stages.

22. An apparatus as defined in claim 21 wherein said punch member includes a bore means for reflux of the fluid medium.
23. An apparatus as defined in claim 21 wherein said individual forming means includes a forming die ring, a die cavity, a punch member, and an ejector member which cooperates with said punch member, said punch member having a slightly beveled annular shoulder, an elastically resilient pressure cushion is placed adjacent said annular shoulder which provides a counter support for said cushion, the outside surface of said resilient pressure cushion in its relaxed state is disposed within the diameter of the die cavity, and a pressure stamp member is disposed above said resilient cushion to provide a compression force there-

against to expand said cushion in a direction transverse to the movement of said pressure stamp member.

24. An article of manufacture formed from a blank cut from a sheet of metal, comprising:
   a. a container-shaped member having a bottom terminal section and a thin-walled section contiguous to the bottom terminal section,
   b. said bottom terminal section having a thickness substantially the same as the blank member cut from said sheet of metal,
   c. said container-shaped member being formed by the method of claim 1.

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