(12) UK Patent Application (19) GB (11) 2 113 647 A

(21) Application No **8233735**
(22) Date of filing **26 Nov 1982**
(30) Priority data
(31) **8107044**
(32) **26 Nov 1981**
(33) **Sweden (SE)**
(43) Application published **10 Aug 1983**
(51) **INT CL³** **B65D 1/40**
(52) Domestic classification **B8D** 1A1 1A4X 1B1 4B 7PY CD **B5A** 1R314C6 1R420 20T10 20T14 20T15 20T17 2A1 2E6 A1 **U1S** 1106 1111 1809 B5A B8D
(56) Documents cited **GB A 2076731** **GB A 2052367** **GB 1536194** **GB 1422528** **GB 1396973** **GB 1389593** **GB 1359704** **GB 1182632** **GB 1102638**
(58) Field of search **B8D** **B5A**

(71) Applicants **PLM AB, (Sweden), Djaknegatan 16, S-201 80 Malmo, Sweden.**
(72) Inventors **Torsten Nilsson, Kjell Mosvoll Jakobsen.**
(74) Agent and/or Address for Service **Page White and Farrer, 5 Plough Place, New Fetter Lane, London EC4A 1HY.**

(54) A container of thermoplastic material and method and apparatus for producing the container

(57) A container (30*d*) of polyethylene terephthalate or similar thermoplastic material has a body (32*d*), a mouth portion (37*d*) and a central bottom part (34*d*), the central bottom part consisting of material which is generally amorphous and/or thermocrystallized and forms a bulge extending towards the interior of the body. An annular support surface (36*d*) is arranged adjacent the transition of the bottom part into the container wall (32*d*), and adjacent the support surface the container has a surrounding circumferential area (35*d*) of material which through stretching and/or reshaping has undergone flow and through heating has contracted and/or has acquired built-in stresses which tend to contract it. The surrounding area (35*d*) of material prevents the inward bulge of the central bottom part from straightening out or turning inside out when the pressure in the container is increased or when the temperature of the container material is raised.

An apparatus for producing the container comprises a mandrel and two mould halves and a mould bottom wherein the mandrel and mould bottom are relatively movable axially of a mould cavity, the mandrel and mould bottom having respective concave and convex surfaces for reshaping and/or stretching parts of the container.

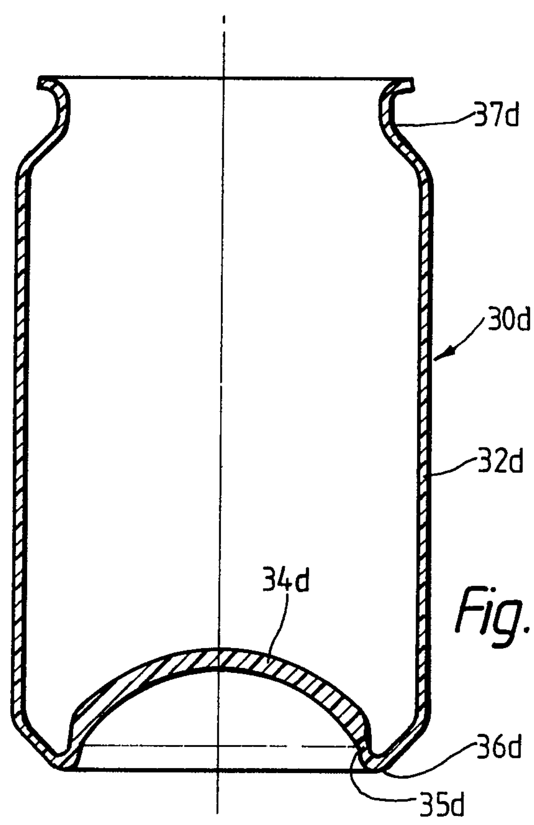

Fig. 6

GB 2 113 647 A

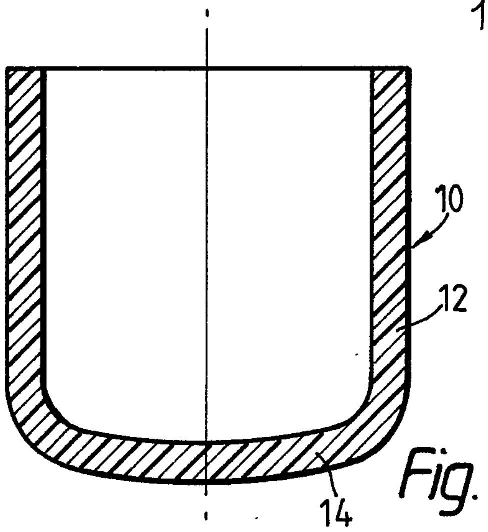

Fig.1

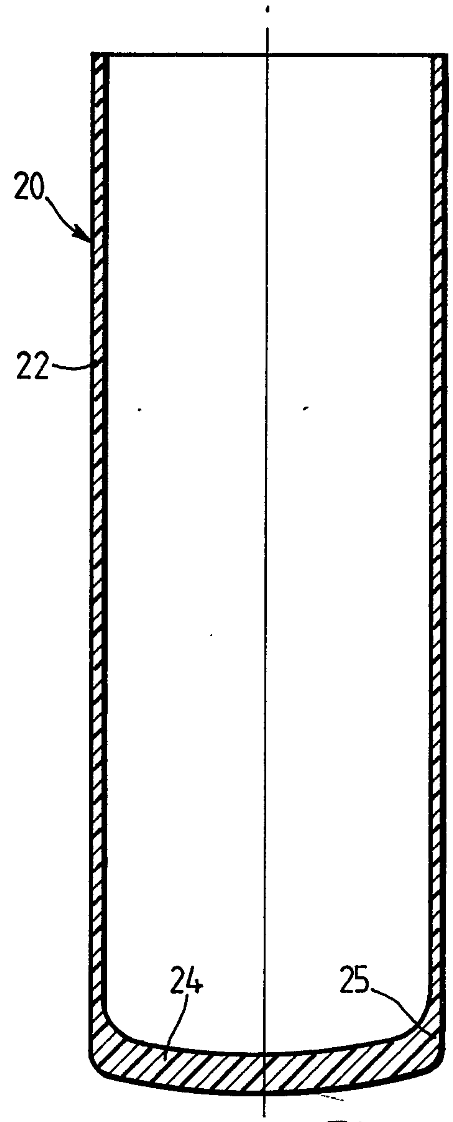

Fig. 2

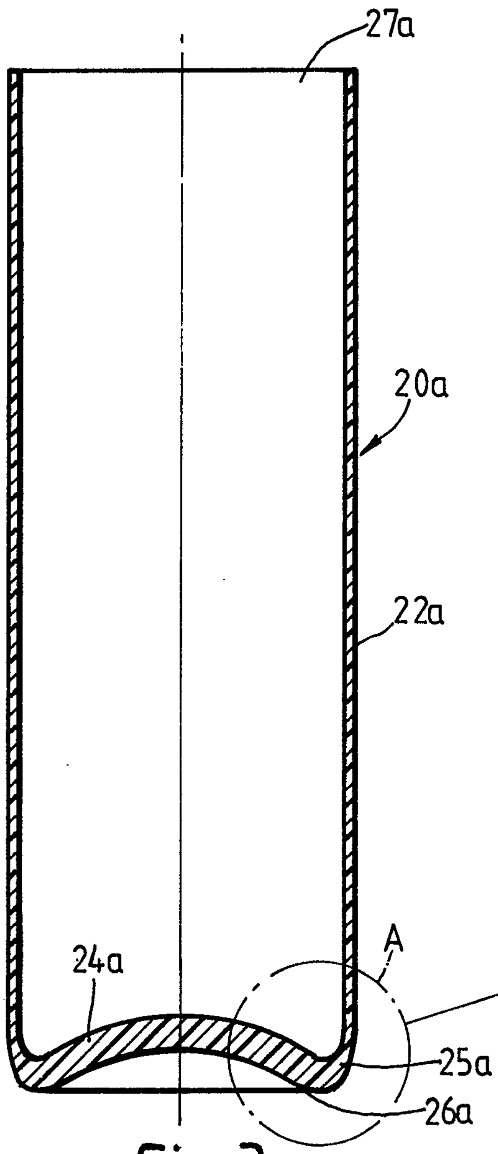

Fig. 3

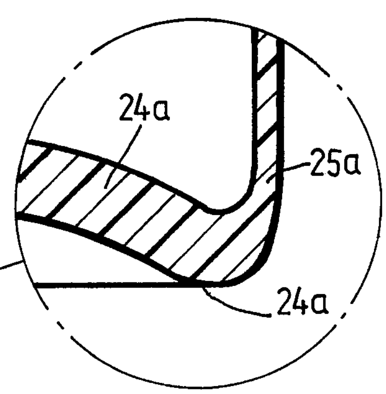

Fig. 3a

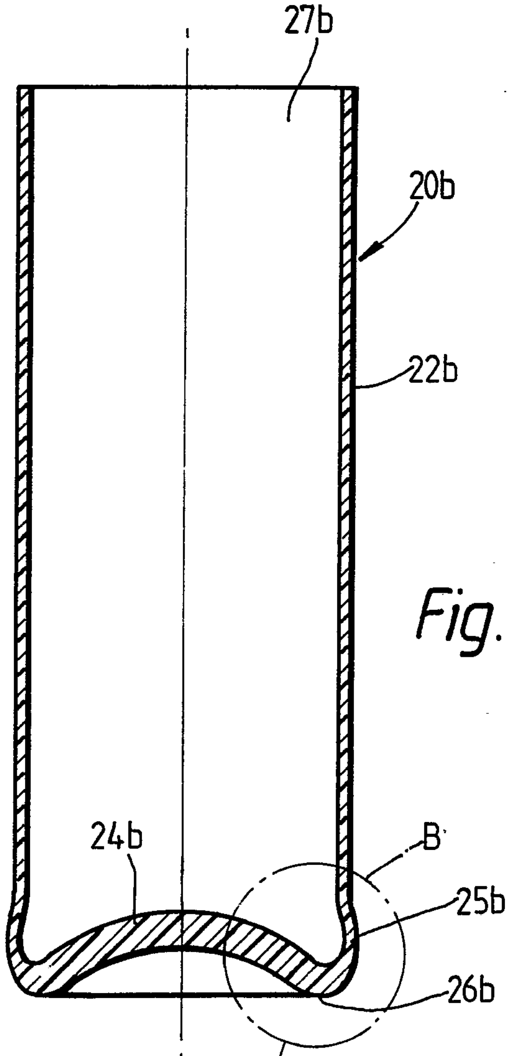

Fig. 4

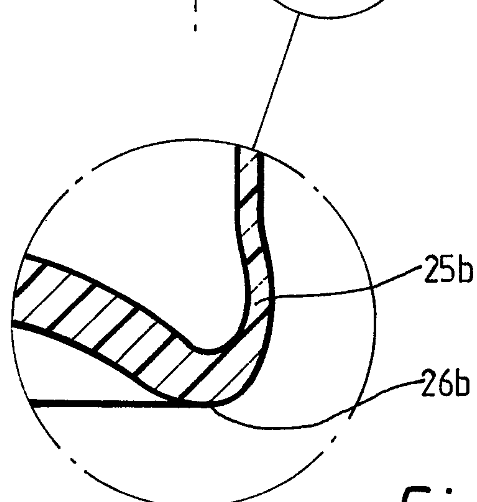

Fig.4a

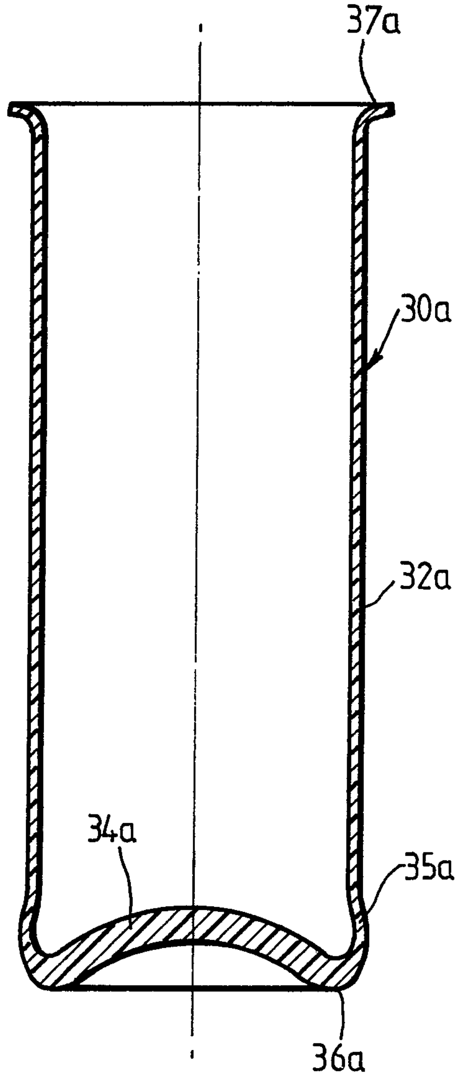

Fig. 5a

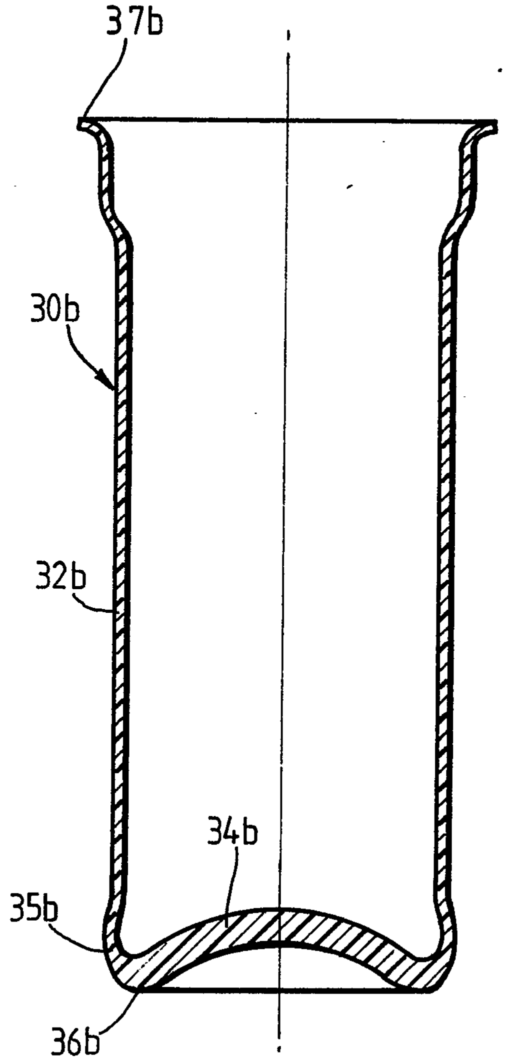

Fig. 5b

2113647

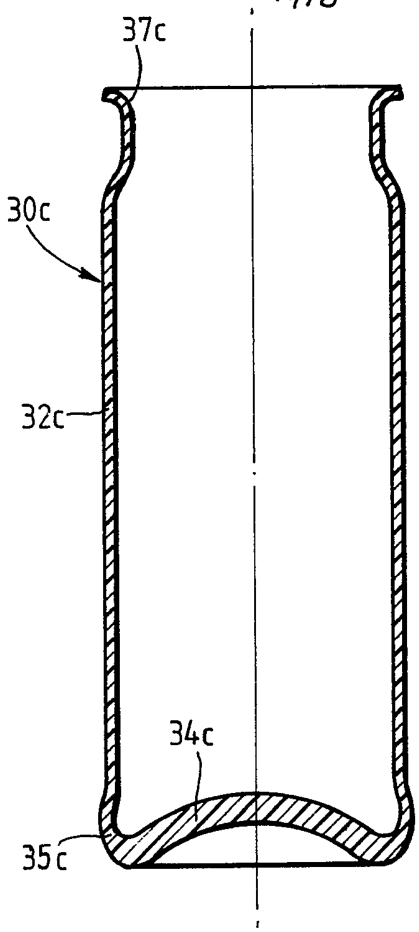

Fig.5c

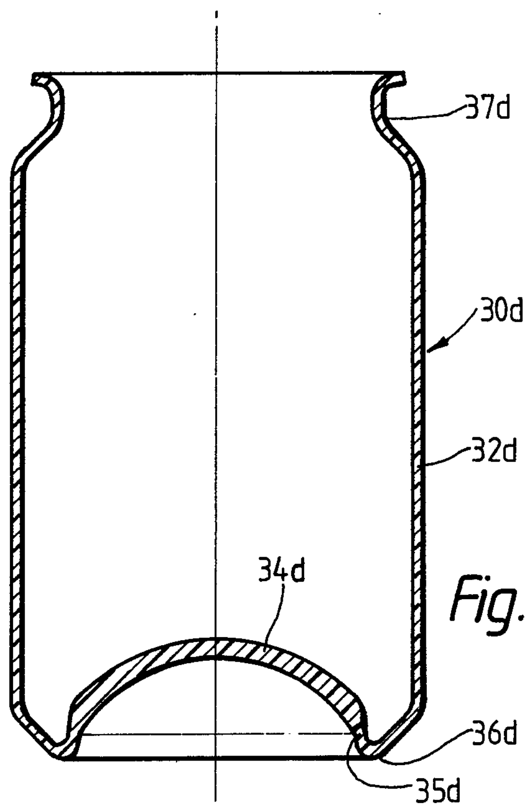

Fig. 6

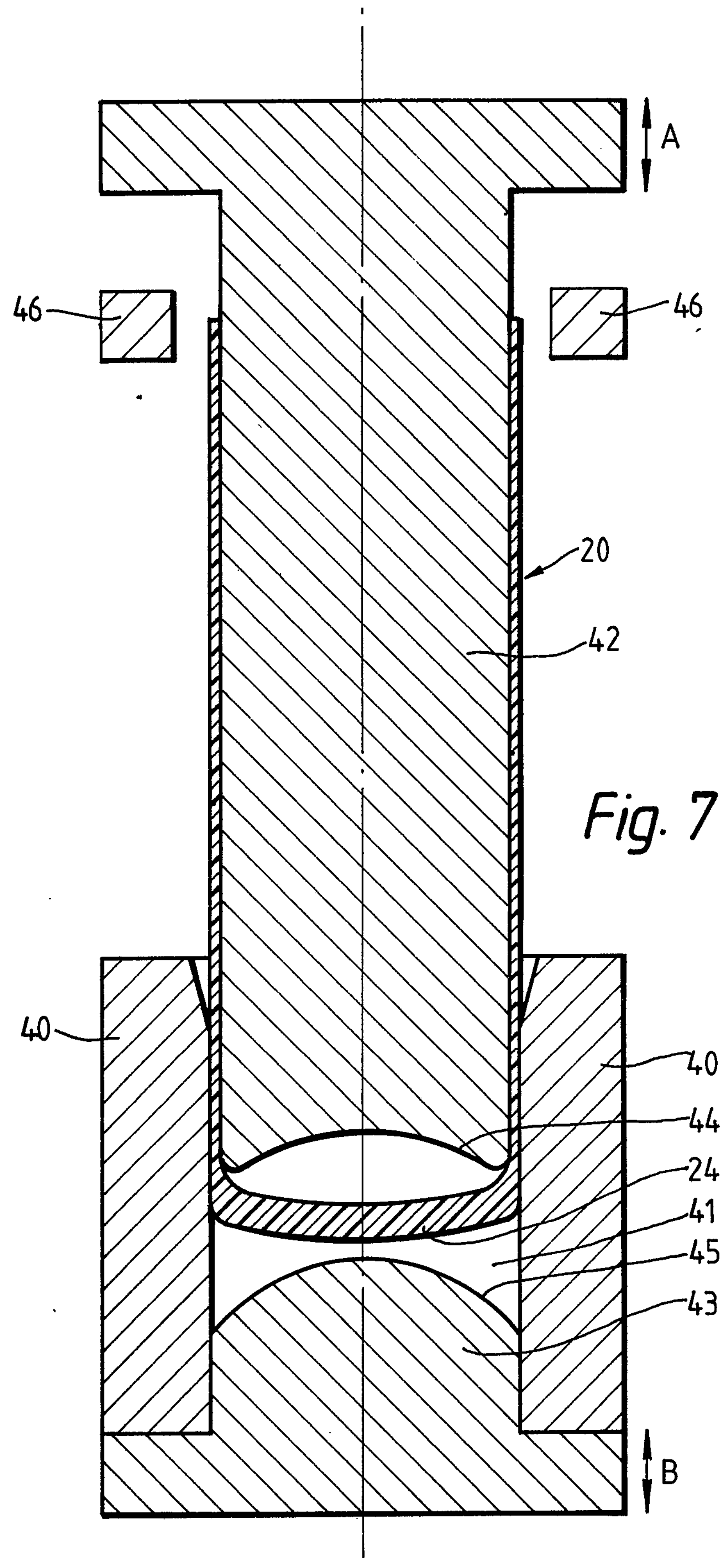

Fig. 7

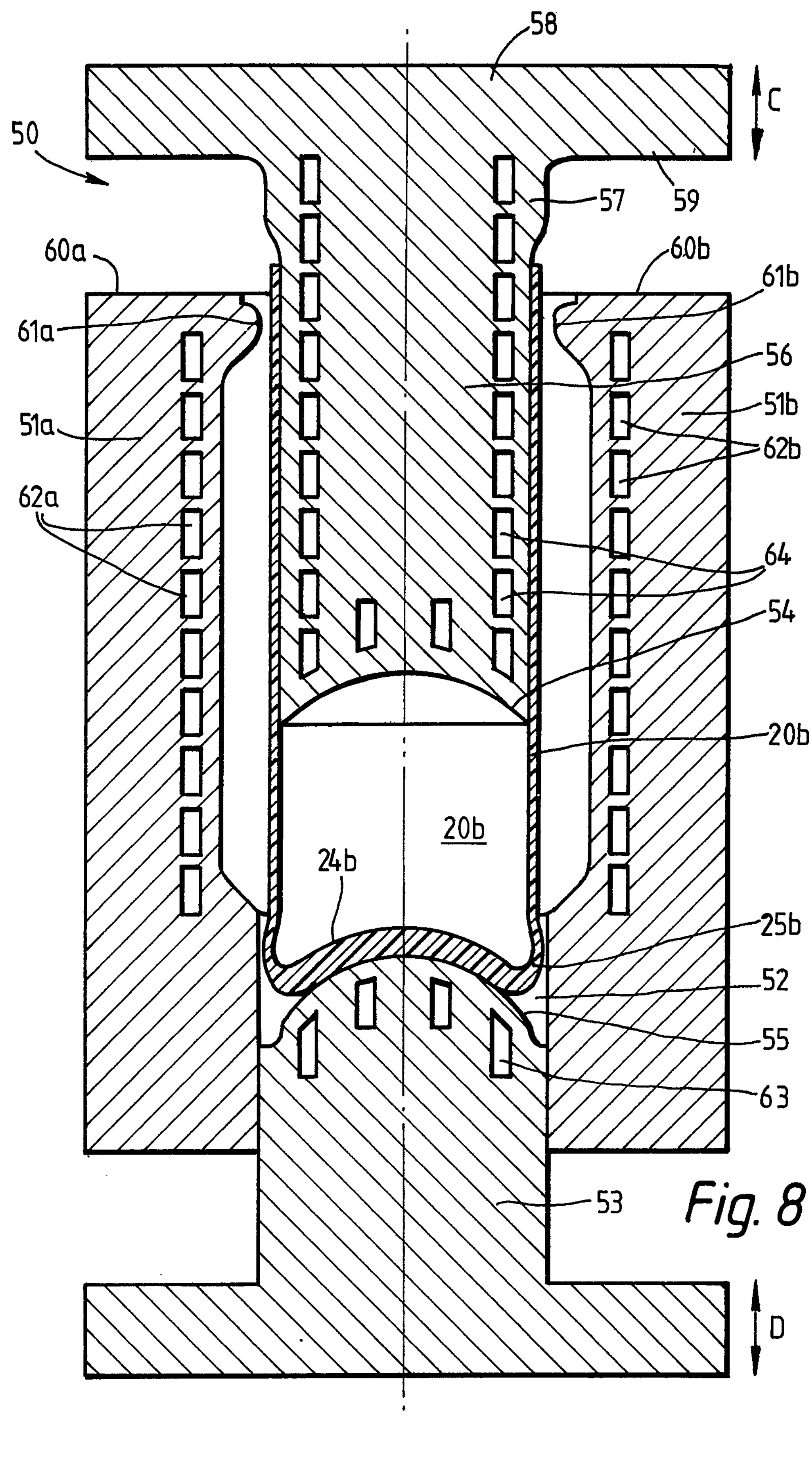
58
C
50
57
59
60a
60b
61b
61a
56
51a
51b
62b
62a
64
54
20b
20b
24b
25b
52
55
63
53
D

Fig. 8

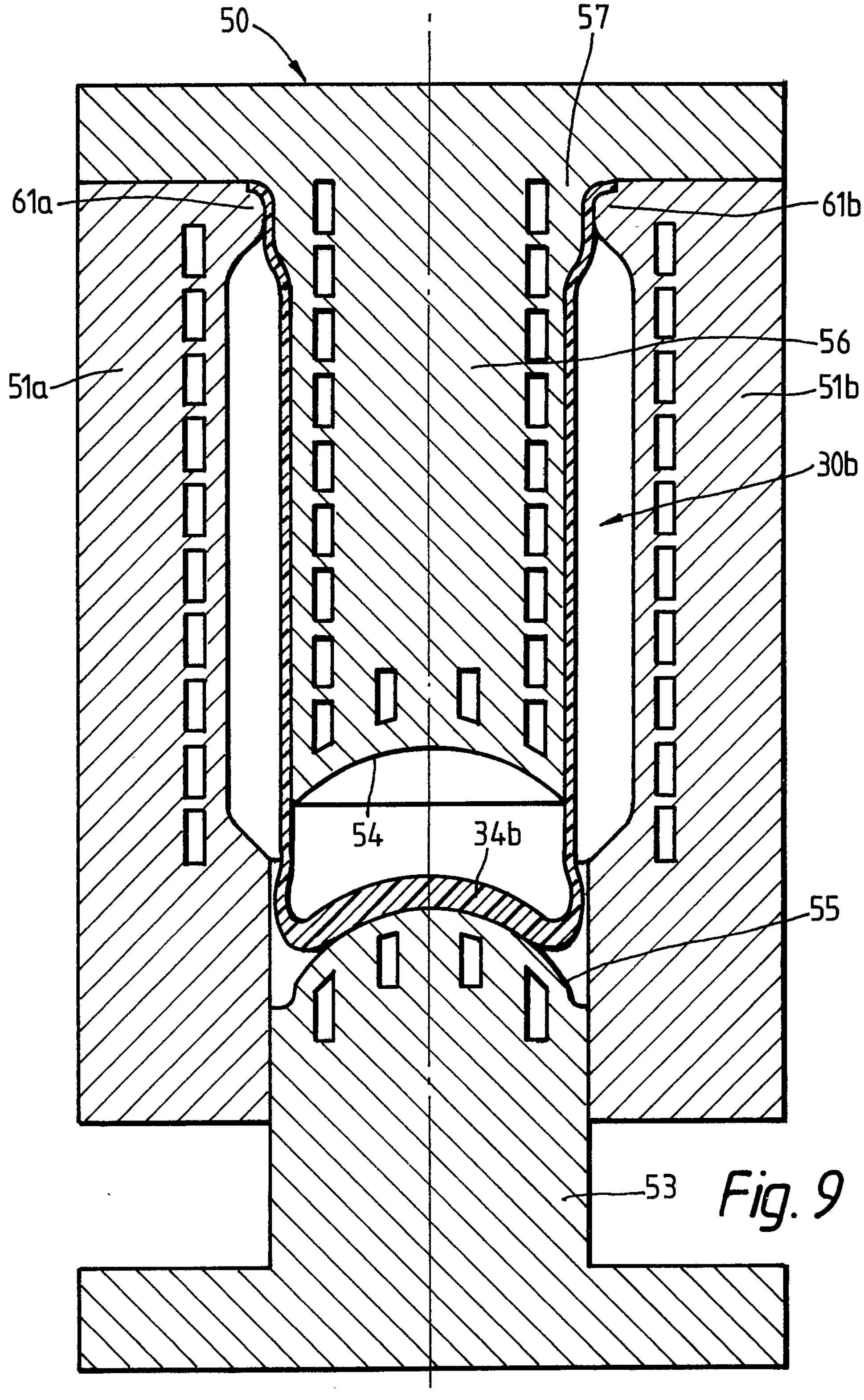

Fig. 9

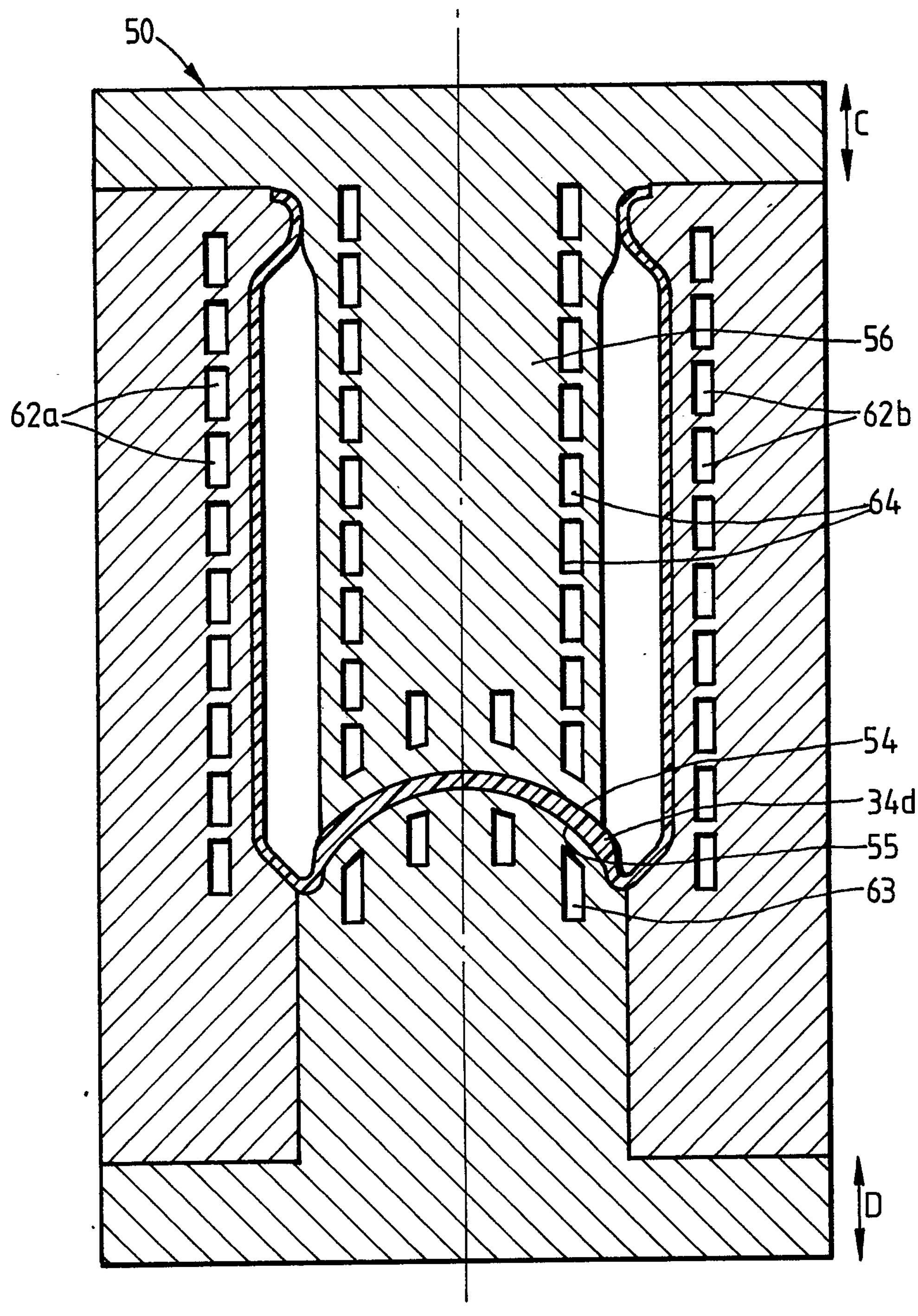

Fig. 10

SPECIFICATION

A container of thermoplastic material and method and apparatus for producing the container

The present invention relates to a container of thermoplastic material, preferably of polyethylene terephthalate or similar material, and to a method and apparatus device for producing the container.

In the field of packaging there exists a need for containers of thermoplastic material capable of resisting an internal pressure of at least 7 kgf/cm^2 for the storage of carbonated beverages, e.g. beer or solf drinks. It has not so far been possible at reasonable cost to achieve can-shaped free-standing containers, for example, which under unfavourable conditions, e.g. at high temperatures, are deformed by such a negligible degree that the deformation can be accepted in regard to shape change, volume change, standing stability, etc.

In general, it is the bottom of the container which gives rise to problems since if the bottom of the container becomes deformed the standing stability of the container is reduced. There is also a risk that the bottom will split or that it will turn inside out. In order to meet the demand for resistance to internal pressure and for standing stability, the bottom of such containers it is known to make the bottom to have a substantial spherical shape and then to fit to the container a separate base which is glued, welded or clipped into position. Of course, such a construction is expensive because extra manufacturing operations are necessary and because the two separate parts have to be assembled. In addition, the bottom part of the assembled container requires an undesirably large quantity of material.

The currently known free-standing containers which do not have a separate base have been found to be lacking in strength. Attempts have been made to use such containers for the purposes described but they have split when the pressure has risen during filling and/or the handling of the filled containers.

It is essential that the cost of packaging be kept at an acceptable level relative to the price of the packaged product to the consumer. Packaging costs often weigh heavily because the packaging is manufactured and used in large quantities. In accordance with known techniques it has so far been possible, by using a large quantity of material for each package, to produce a free-standing package of thermoplastic material with the ability to meet the previously specified requirements. However, the quantity of material used has been so great that the costs have become far too high to enable such packages to be acceptable.

Using known methods it is possible to produce bottles of thermoplastic material which have a mouth portion of monoaxially oriented material, a generally cylindrical container body of biaxially oriented material, and a central bottom part of amorphous or thermal crystallized material. Such containers have a body in which biaxial stretching of the material has been obtained by a process in which the degree of stretching of the material in the axial direction of the container body and in the circumferential direction of the container body is in the main determined by the ability of the material itself to elongate when the preform is subjected to internal pressure in conjunction with being blown into the shape of the container. In general, the material is insufficiently stretched along the axis of the container although in attempts have made to improve this stretching by means of a mechanical device in the form of a mandrel which extends the preform along its axis in the initial stage of blowing it into the shape of the container Examples of this technique are described in Brisith Patent specifications Nos. 1 536 194 and 2 052 367. This known technique is related solely to the production of bottles and not to the production of containers in the nature of cans.

In US Patent Specification No. 4,152,667 it is explained that polyethylene terephthalate, henceforth abbreviated to PET, acquires extremely good material properties when stretched monoaxially and particularly biaxially about three times in the direction of each axis. An extremely sure and effective method of achieving such stretching is to stretch the material until it undergoes flow: Examples of techniques where such stretching occurs are described in British Patent Specifiations Nos. 2 052 365 and 2 052 367.

PET which has been stretched such that it has undergone flow has extremely high tensile strength combined with little elongation. Thus, when reshaping preforms containing such material it is not possible to stretch the further material in the earlier stretching direction in order to obtain the desired shape of the container.

Further, on heating PET which has been stretched and thereby oriented, the material shrinks in the stretching direction. Shrinking occurs both when stretching has been carried so far that flow has occurred in the material and also in the case of lesser stretching conditions and regardless of whether stretching is monoaxial or multiaxial, e.g. biaxial. These properties accentuate the problems associated with reshaping a preform into a container.

The physical properties described above do not apply solely to PET but to a greater or lesser extent to many other thermoplastic materials. Examples of such materials are polyhexamethylene-adipamide, polycaprolactum, polyhexamethylene-sebacamide, polyethylene-2.6-naphthalate and polyethylene-1.5-naphthalate, polytetramethylene-1.2-dioxybenzoate and copolymers of ethylene terephthalate, ethylene isophthalate and other similar polymer plastics.

According to a first aspect of the present invention there is provided a container of thermoplastic material having a container body, a mouth portion, a central bottom part of material which is generally amorphous and/or thermo-crystallized, and a closed support surface surrounding the central bottom part, in which the central bottom part extends towards the interior of the container body, characterised in that the central bottom part, merges into an area of material surrounding the central bottom part and adjacent to the support surface, the material of the said area having through stretching and/or reshaping undergone flow and through heating undergone contraction and/or through heating acquired built-in stresses which tend to contract it, whereby said surrounding area prevents the inward bulge of the central bottom part from straightening out and/or turning inside out when the pressure inside container is raised and/or when the temperature of the container material is raised.

In an embodiment, the container has a central bottom part which consists of amorphous, oriented and/or thermo-crystallized material, the said central bottom part being surrounded by an annular area of oriented material. The central bottom part is displaced inwardly towards the centre of the container and as a result an annular support surface is created adjacent to and generally outside the central bottom part. The annular surrounding area of material is formed through stretching to flow generally amorphous material which, as in a tubular blank, is situated adjacent the bottom closure of the blank and which before stretching is a ring-shaped and mainly amorphous part of material in the blank. The ring-shaped part of material in the blank may be at least partially situated at a shorter distance from the axis of the blank than the material forming the generally cylindrical walls of the blank. Through stretching to flow, the material in the ring-shaped part is oriented generally along the axis of the container, to which is added a certain preferably lesser orientation in the circumferential direction of the material. The annular surrounding area of material thus forms in the container a transition between the material in the container body and the central bottom part of the container.

The material stretched to flow in the annular surrounding area has undergone a certain degree of shrinking by the material being heated to a temperature higher than TG. However, the central bottom part situated inside the annular area of material prevents complete shrinkage corresponding to the raised temperature of the material whereby forces are built into the annular area which act to contract the material still further. As a result, the annular area of material has an extremely small tendency to elongate and prevents the inward bulge of the central bottom part from straightening out and/or turning inside out as a result of raised internal pressure in the container and/or raised temperature of the container material.

The material in the annular area has in the case of PET a maximum crystallization of aproximately 17% which has arisen in connection with stretching of the material to flow, to which is added thermal crystallization which has been formed in connection with heat treatment of the material and which amounts to a maximum of about 15% and is preferably less than 10%.

In an embodiment, all material in the cylindrical portion of the blank is stretched to flow, whereby the parts of material which are situated nearest the bottom closure of the stretched blank correspond to the annular area of material. In a container which has been shaped from such a blank, the container body and mouth portion of the material consist of material oriented along the axis of the container with an orientation corresponding to the orientation the material is given in connection with monoaxial stretching to flow. In addition to orientation along the axis of the container, the material also has a certain preferably lesser orientation in the circumferential direction of the container as well as certain preferably lesser thermal crystallization.

In one form the container has the shape of a straight cylinder whose walls consists of material oriented along the axis.

In a second alternative form the walls of the container, in addition to the axial orientation, have an orientation in the circumferential direction of the container.

In a third, alternative form the central bottom part contains parts of material, the original thickness of which has been reduced through compression to an extent which gives the material improved properties corresponding to the material properties obtained in connection with stretching the material to flow. In the case of PET, for example, such improved properties begin to appear at approximately two-fold compression. In accordance with the invention it is possible to shape these reinforced parts of material in the form, for example, of squares, concentric rings, ribs directed towards the walls of the container body, and as combinations of these.

In one embodiment of the invention the container is stable in shape up to a certain raised temperature. This has been achieved through heating of the material at least to the said temperature. Also a certain degree of thermal crystallization arises in the material in addition to the crystallization arising through orientation.

If required, the material in the central bottom part may have raised thermal crytallization compared with the other material of the container.

Alternatively, the central bottom part may have thicker reinforced sections of material which form a pattern of squares, concentric rings radial ribs, etc. The reinforced sections of material preferably have a raised thermal crystallization.

In the case of PET and with the material stretched to flow, the material in the container body and in the mouth portion has a crystallization in the range 15% to 33%, preferably in the range 15% to 25%. Crystallization consists partly of the crystallization arising in connection with orientation of the material and partly of thermal-conditioned crystallization. The crystallization arising through orientation amounts in the case of biaxial orientation to a theoretical maximum of about 33% but in the majority of applications orientation conditions are used which limit the crystallization achieved through orientation to about 25%.

In an embodiment the crystallization arising through orientation is limited to a maximum of about 17% to which is added, where applicable, thermal crystallization amounting to a maximum of about 15% and preferably less than 10%.

In the second embodiment the crystallization arising through orientation may reach the stated theoretical maximum of about 33% but in most applications it will have a value in the range 15% to 25% to which is added, where applicable, thermal crystallization amounting to a maximum of 15% and preferably less than 10%.

Depending on which alternative version of the bottom part is chosen, crystallization in the material of the bottom part varies from a few per cent up to about 25 to 30%, where the thermal-conditioned crystallization is usually less then 10 to 15%.

The crystallization values given in this patent application are based on the theory advanced in the publication "Die Makromolekulare Chemie" 176, 2459-2465 (1975). The values refer to the material PET. In applications of the invention using other materials, crystallization values characteristic of these materials will of course be obtained.

The present invention also extends to a method of producing a container from a preform having a bottom closure of generally amorphous material and a body portion which at least adjacent to the closed end of the preform consists of material oriented along the axis of the preform with an orientation corresponding to that produced in a sheet of material stretched monoaxially to cause material flow and which adjacent to the closed end forms a surrounding transition area of material, characterised in that the bottom closure is reshaped to form a bulge extending towards the interior of the container, and in that the material in the transition area is heated to a temperature higher than the glass transition temperature range of the material.

In one embodiment a tubular blank of generally amorphous material is used and is closed at one end. The material in the walls of the tube is stretched to flow at least in a ring-shaped area of material adjacent the bottom closure of the blank.

In a preferred embodiment the material is stretched by passing the whole blank through a draw ring at the same time as a mandrel occupies the interior of the blank. In this way the blank is elongated by an amount corresponding to the reduction in the thickness of the walls of the blank. In the case of PET the elongation is about three times. During the passage of the blank through the draw ring, at the transition between the material that has already passed through the draw ring and the material that is just about to pass through it, a transitional zone is formed between material stretched along the axis of the blank, i.e. oriented material, and material which has not yet been stretched, i.e. generally amorphous material. Heat is released as a result of the restructuring of the molecules which takes place during the passage of the material through the draw ring. Both the internal mandrel and the draw ring are maintained at a temperature in the vicinity of or in the range of the glass transition temperature of the material, henceforth designated TG. Passages may be arranged both in the mandrel and in the draw ring through which liquid can be flowed for regulating the temperature of the mandrel and draw ring. If the temperature in the material at the transitional zone is excessively high, contact between the material and the draw ring is lost in parts of the transitional zone, which leads to unwanted effects in the material that is to pass through, or has passed through, the draw ring. As it passes through the draw ring the material is temporarily allowed to assume a temperature somewhat in excess of TG. In the case of PET, temperatures in excess of 105°C are in general unsuitable. A method of material stretching using draw rings is described in German Offenlegungsschrift No. 31 21 524.6.

Preferably, as the material in the walls of the blank is stretched, the bottom closure is given a shape which substantially coincides to the final shape of the central bottom part of the container that is to be shaped. Shaping of the bottom part takes place by means of a die on the internal mandrel and a stamp or punch arranged on an external element, the die and the stamp being adjustable relative to each other along the axis of the mandrel. Reshaping of the bottom closure normally takes place at a temperature in the TG range. However, reshaping in some embodiments of the invention also takes place above or below the TG range. The major portion of the material in the bottom part is therefore, also immediately after the actual reshaping process, generally amorphous or alternatively thermally crystallized.

During reshaping of the bottom closure of the blank the stamp, during the latter part of its relative movement towards the die, moves the material in the bottom closure in a direction towards the opening part of the blank at the same time as the bottom closure is arched towards the inside of the blank. The profile length of the material in the bottom part is thereby increased and this subjects the material in the bottom closure, which merges with the material in the wall of the blank which is axially oriented and has been stretched to flow, to such high tensile forces that material flow occurs in the aforementioned transitional zone at material temperatures in the TG range or below. In addition to the material in the wall of the blank already stretched to flow, a ring of material stretched to flow is formed which outwardly limits the otherwise generally amorphous material in the bottom part and forms the transition between the substantially cylindrical portion of the container and the central bottom part of the container. The forming space which is formed between the stamp and the die when their movement towards each other is terminated is arranged to correspond to the desired final shape of the bottom of the container which is in the process of manufacture or is arranged to correspond to a shape suitable for the next reshaping stage. Depending on the desired properties of the material inside the ring of stretched material, the forming space is designed in order to form or process reinforcement ribs, etc. in the bottom part in accordance with the alternatives mentioned above. In some embodiments the temperature of the stamp and/or die may be raised so that the material in the bottom part undergoes thermal crystallization simultaneously with its reshaping.

In the next stage the mouth opening of the blank is enlarged or reduced in size. This is accomplished most simply by pressing the blank down over a conical mandrel or a sleeve. The maximum permissible increase in the circumference of the opening is adapted to the material stretching necessary in order to obtain material flow. In the case of PET the maximum permissible increase is about three times.

During reshaping of the mouth the material has a temperature in excess of TG. The temperature is further chosen in regard to and normally higher than the maximum temperature to which the container will be exposed in use.

In one embodiment of the invention the remaining material in the blank is heated to the same temperature, which means that the material which has already been stretched to flow, shrinks. The amorphous material in the bottom part of the blank is also subjected to shrinkage forces when heated which tend to restore the generally amorphous material in the bottom part to the shape the material had before it was reshaped by means of the stamp and die. The ring of material stretched to flow nevertheless prevents a return to the original shape because the ring contracts and does not allow amorphous material adjacent to the ring to move back to the position the material had before reshaping of the bottom part. Depending on the degree of thermal crystallization it is desired to achieve in the material in the bottom part, the material is retained at the temperature specified above for a shorter or longer period of time. The blank treated in this manner now forms a finished container or a preform which has no tendency to shrink at all temperatures below the temperature at which shaping of the mouth section and shrinking of the stretched material was achieved.

In cases where the preform is to be reshaped, which usually takes place in a blow mould, the preform is heated to a blow temperature higher than the TG of the material but lower than the temperature at which the mouth portion was shaped. Shape changing of the preform when the temperature of the material is adjusted to reshaping temperature is avoided in this way.

The preform is preferably preheated and obtains its final temperature adjustment to blow temperature in the blow mould. For example, the preheated preform may be heated additionally in the mould or, alternatively, the preform may be allowed to cool slightly when it is placed in the blow mould. Temperature adjustments may be carried out by any known methods, e.g. by means of an internal mandrel, circulating liquid, hot mould walls, etc. With the material in the preform at blow temperature the interior of the preform is pressurized and the preform is expanded until it is in contact with the walls of the blow mould while the profile length of the material is simultaneously retained. This is achieved by moving the bottom of the preform towards the opening of the preform while simultaneously moving the central bottom part of the blow mould. In the final stage of forming the container the moved central bottom part forms in the blow mould even transitional surfaces with adjacent surfaces at the same time as the expanded preform is in contact with all forming surfaces in the blow mould. In an embodiment, the material is thermally crystallised in addition to the crystallization of the material obtained through the axial and transversal stretching by coming into contact with the forming surfaces of the blow mould.

Thermal crystallization of the material in the container may be concluded in conjunction with the final forming of the preform and/or in conjunction with the forming of the central bottom part.

It is possible to produce a container which is shape-permanent on being heated to temperature in the vicinity of the blow temperature of the material and/or the temperature of the forming surfaces of the blow mould. The blow temperature and the temperature of the forming surfaces of the blow mould are usually lower than the temperature at which the material in the mouth portion of the blank was reshaped.

Embodiments of the present invention will hereinafter be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 shows an axial cross-section through a blank of generally amorphous material,

Figure 2 shows an axial cross-section through a preform formed from the blank of Figure 1.

Figure 3 shows the preform of Figure 2 with the bottom thereof reshaped,

Figure 3a shows an enlarged view of the area A of Figure 3,

Figure 4 shows the preform of Figure 3 after it has been heated to relax the material,

Figure 4a shows an enlarged view of the area B of Figure 4,

Figures 5a to *5c* show alternative embodiments of a container formed by reshaping the mouth portion of the preform shown in Figure 4,

Figure 6 shows a container formed by reshaping the container shown in Figure 5*b*,

Figure 7 shows apparatus for reshaping the bottom part of the preform of Figure 2, and

Figures 8 to *10* show apparatus for reshaping a preform to form a container as shown in Figure 6 and illustrate successive stages in the reshaping process.

Figure 1 shows a tubular blank 10 of generally amorphous material having a cylindrical portion 12 and a closure 14 at one end.

Figure 2 shows a preform 20 which has been formed from the blank 10 by stretching the material in the cylindrical portion 12 of the blank 10 to flow. The preform thus formed has a cylindrical portion 22 and a bottom part 24.

Figures 3 and 3*a* show the preform of Figure 2 after the bottom part 24 has been reshaped to produce bottom part 24*a*. In certain embodiments the bottom part 24 is reshaped with the material at a temperature in a range lower than the thermoelastic temperature range of the material (in or below the TG range). The increase in the profile length of the bottom part 24 that the reshaping entails means that the preform shown in Figures 3 and 3*a* is provided in conjunction with the reshaping with an annular area 25*a* of material stretched to flow, henceforth also referred to as the annular transition, which is formed from amorphous material which in the blank 10 was situated in the transition between the closure 14 of the blank and the cylindrical portion 12 of the blank. The corresponding area of material in the preform 20 of Figure 2 has undergone a certain degree of stretching, although less than the stretching necessary to cause material flow. On reshaping of the bottom part 24 the prestretched transition area of material is subjected to additional stretching with the result that the material flows. Accordingly, material flows in the blank 10 and the material which flows is situated closer to the axis of the blank than the material which in the blank forms the cylindrical portion 12. The material of the annular transition has a smaller initial radius than the material in the cylindrical portion. It will be seen from Figures 3 and 3*a* that the preform also has a support surface 26*a* and a mouth portion 27*a*.

In an alternative embodiment the bottom part 24 of the preform 20 is reshaped with the material at a temperature within the thermoelastic temperature range of the material. The profile length of the bottom part is increased during reshaping and the thickness of the material in the bottom part is decreased during simultaneous elongation of the material. The equivalent to the annular transition of material which is stretched to flow as described in the previous paragraph consists of an annular area of material stretched to flow which was formed during the passage of the blank through the draw ring and which is situated adjacent the bottom part 24 of the blank. Figures 3 and 3*a* are also representative of the annular area of material which is formed in this embodiment and which is accordingly assigned reference numeral 25*a* in the drawings.

Figures 4 and 4*a* show the preform of Figures 3 and 3*a* after it has been heated to a temperature higher than the TG range of the material. In the case of PET the material has been heated to a temperature preferably higher than the TG range by at least about 40°C, i.e. has been heated to at least about 120°C. As is clearly shown in the drawings, the preform shrinks to have a smaller axial length on heating and its cylindrical portion 22*b* has a smaller diameter. The reduction in the diameter of the annular transition 25*a* produces a sharper bend in the bottom part 24*b* of the preform 20*b* than in the bottom part 24*a* and consequenty the bottom part 24*b* bulges deeper into the cylindrical portion than the bottom part 24*a*. In the embodiment in which the annular transition 25*a* has been formed by amorphous material closer to the axis of the blank than the material in the cylindrical walls of the blank, the contracting effect in the annular transition 25*a* is intensified, and in general this results in greater inward bulging of the bottom part 24*b* into the cylindrial portion 22*b*.

Figures 5*a* to 5*c* show alternative embodiments of containers 30*a*, 30*b* and 30*c* which have been formed by reshaping the mouth portion 27*b* of preform 20*b*. The container 30*a* shown in Figure 5*a* has a flared mouth portion 37*a*. In Figure 5*b* the container 30*b* has a generally conical flared mouth portion 37*b*, whilst in Figure 5*c* the container 30*c* is shown to have a constricted mouth portion 37*c*. The mouth portions are designed for cooperation with a sealing end-section which is not shown in any of the Figures. It will be seen that each of the containers 30*a*, 30*b*, 30*c* has a respective central bottom part 34*a*, 34*b* 34*c*, a respective annular transition 35*a*, 35*b*, 35*c* and a respective annular support surface 36*a*, 36*b*, 36*c*.

In an alternative embodiment of a container 30*d* shown in Figure 6, the contour length of the material stretched to flow in the mouth portion 37*d*, of the cylindrical portion 32*d*, and of the annular transitional zone 35*d* is each substantially the same as the corresponding contour length of the mouth portion 27*b*, of the cylindrical section 22*b*, and of the annular transition 35*b* of the preform 20*b*. The central bottom part 34*d* of the container is not as thick as the central bottom part 24*b* of the preform 20*b*. In a preferred embodiment, the central bottom part 34*d* is also thinner in the parts closest to the axis of the container. Between the central bottom part 34*d* and the annular support surface 36*d* of the container is the annular area 35*d* of material stretched to flow which stabilizes the shape of the bottom part 34*d* and prevents the bottom part from turning inside out when the pressure in the container rises and/or when the container is heated. The annular area 35*d* of material corresponds to the annular area 25*a* of material of preform 20*a*. It is clear from Figure 6 that the material in the cylindrical portion 32*d* and the mouth portion 37*d* of the container has been stretched in the circumferential direction of the container in addition to its stretching along the axis of the container.

At maximum the material is circumferentially stretched sufficiently to cause material flow.

Figure 7 shows schematically apparatus for reshaping the preform 20 of Figure 2 into the preform 20*a* of Figure 3. The apparatus of Figure 7 comprises a locating body 40 having a cylindrical cavity 41, the diameter of which corresponds to the outer diameter of the preform 20. A mandrel 42 has an outer diameter which is substantially equal to the inner diameter of the preform 20. This mandrel 42, which is movable axially of the cavity 41, forms a first forming element and is movable relative to a second forming element 43. The first forming element 42 is located inside the preform 20 and the second forming element 43 is located on the other side of the bottom part 24 of the preform. The first forming element 42 presents a concave forming surface 44 at the bottom part 24 and the second forming element presents a convex forming surface 45 to the bottom part. For the sake of simplicity, drive and control means for moving the forming elements are omitted from the drawings. It will be appreciated that suitable drive and control means can be provided. The movement of the forming elements towards each other is controlled such that in the final forming position the distance between the forming surfaces of these forming elements is substantially equal to the thickness of the reshaped bottom part 24*a*. Stops 46 for determining the maximum movement of the first forming element 42 in the direction towards the locating body 40 are provided. The directions of movement of the first and second forming elements 42 and 43 are represented in Figure 7 by the respective double-headed arrows A and B.

Figures 8 to 10 show an embodiment of an apparatus for final forming of a preform as shown in Figures 3 or 4. In Figure 8, the apparatus is shown with a heat shrunk preform 20*b*, but the apparatus can also be used with a preform as 20*a* shown in

Figure 3.

The apparatus shown in Figure 8 comprises a blow mould 50 having two mould halves 51*a* and 51*b*. At the lower part of the blow mould the two mould halves 51*a* and 52*]b* define a cylindrical cavity 52 whose diameter is sufficient to enable the preform 20*b* to pass into the cavity. The blow mould has a bottom part 53 which is movable within the cavity 52 in the direction of the double-headed arrow D. The upper end position of the bottom part 53 is shown in Figure 10. The bottom part 53 correspnds to the second forming element 43 of the apparatus of Figure 7 and is provided with a convex forming surface 55. The apparatus also includes a substantially cylindrical mandrel 56 whose external diameter is substantially equal to the inner diameter of the preform 20*b* such that the mandrel can be inserted into the preform 20*b*. The mandrel 56 corresponds to the first forming element 42 of the apparatus of Figure 7 and is arranged with a concave forming surface 54. The upper part 57 of the mandrel has an increased diameter and terminates in a flange 58 which defines a lower contact surface 59. This contact surface 59 is arrange to abut against upper contact surfaces 60*a* and 60*b* formed on the mould halves 51*a* and 51*b*. The mandrel 56 is movable back and forth in the direction of arrow C. The lower end position of the mandrel 56 is shown in both Figures 9 and 10. The blow mould halves 51*a* and 51*b* each have an upper part 61*a*, 61*b* which is shaped to define with the upper part 57 of the mandrel, when the mandrel is in its lower end position a forming space defining the shape of the mouth portion of the container being formed in the apparatus. In addition, when the mandrel 56 is in its lower end position, and the bottom part 53 is in its upper end position, i.e. the positions shown in Figure 10, a forming space for defining the shape of the central bottom part 34*d* of the container is formed.

Passages 62*a*, 62*b*, 63 and 64 through which cooling and/or heating fluids can be flowed are arranged in the mould halves 51*a*, 51*b*, in the bottom part 53 of the blow mould, and in the mandrel 56.

In order to simplify the drawings, drive and control means for movement of the mould halves 51, of the bottom part 53 and of the mandrel 56, and passages for the pressure medium for the blowing process, have been omitted.

The formation of the preform 20 from the blank 10 has been described above. Reshaping of the preform 20 to form the preforms 20*a* or 20*b* may be commenced in apparatus as shown in Figure 7. The preform 20 is placed over the mandrel 42 and is introduced thereby into the cavity 41 until the bottom part 24 of the preform abuts the convex forming surface 45 of the second forming element 43. The movement of the mandrel 42 towards the second forming element 43 is continued until a forming space which corresponds to the shape of the desired bottom part 24*a* of the preform 20*a* is defined between the convex surface 45 of the forming element 43 and the concave surface 44 of the mandrel.

In one embodiment the material of the preform 20, at least at the lower part of the preform 20, is at a temperature in the TG range or below, such that the annular transition 25*a* is formed.

In an alternative embodiment the material of at least the lower part of the preform 20 is at a temperature higher than the TG range, such that the material has rubber-like properties and reshaping takes place during successive stretching of the material in the bottom part 24. Depending on which of the versions of the central bottom part is desired in the container which is being manufactured, the material in the bottom part is heated or cooled on coming into contact with the concave and convex surfaces 44, 45.

A comparison of Figures 7 and 8 will clearly reveal that reshaping of preform 20 into the preform 20*a* can also take place in apparatus as shown in Figure 8, such that the preform 20*a* can be formed during the initial stage of forming the container 30*d*.

When using apparatus as shown in Figures 8 to 10, the mouth portion of the future container is also formed during the initial stage of reshaping the preform, the increased diameter upper part 57 of the mandrel 56 moving the material of the preform radially outwardly towards the upper parts 61*a*, 61*b* of the mould halves. The preform is then generally able to withstand the axial forces without undergoing deformation. In cases where the processing temperaure and the material have been so chosen that the axial strength of the preform is insufficient, forming of the mouth portion of the future container can be carried out more suitably in a separate device having a cylindrical cavity for supporting the preform more or less along its entire length.

Heating the material of the preform 20*a* transforms it into the preform 20*b* as is described above. The preform 20*a* may be heated in separate heating ovens or alternatively it may be heated in the blow mould 50. Of course, the preform may be heated in ovens and then its temperature adjusted in the blow mould. The preferred temperatures of the preform during the various forming stages have been described above.

Regardless of whether a heated preform 20*a* or a heat-treated preform 20*b* is inserted into the blow mould 50, movement of the mandrel 56 to its lower end position tranforms the preform into the intermediate product 30*b* shown in Figure 9. In certain applications this product 30*b* is the desired end product whilst in other applications the mandrel has a larger axial length in order to enable reshaping and heat treatment of the bottom part 34*b*.

In the event that a container 30*d* is to be produced the interior of the container 30*b* is pressurized and as a result the walls of the container 30*b* are blown out or expanded to make contact with the forming surfaces of the mould halves 51*a* and 51*b*. At the same time the bottom part 53 of the blow mould is moved upwardly such that the reshaping takes place whilst the profile length of the section of material of the intermediate product consisting of material stretched to flow is maintained. In its upper position (Figure 10) the concave forming surface 54 and the convex forming surface 55 together define a forming space adapted to the shape of the central bottom part 34*d* of the desired container.

Through the passages 62*a*, 62*b* 63 and 64 hot or cold liquid is flowest, depending upon which of the embodiments described is required. If the internal pressure in the formed container is retained and simultaneously heat is supplied to the forming surfaces, a container is produced in which thermal crystallization is also obtained in the parts of the material which have been crystallized due to stretching.

In the embodiments illustrated and described both the blank and the preform have a cylindrical portion. Of course, the cross-section of both the blank and the preform as well as that of the formed container need not be circular.

The invention has been described generally relative to the preform having a cylindrical portion in which the material has been stretched to flow. However, the invention also relates to the production of a container from a preform where only an area of material adjacent to the bottom closure of the preform consists of material that has been stretched to flow.

The invention relates to the production of containers from blanks formed both by injection-moulding and by extrusion.

CLAIMS

1. A container of thermoplastic material having a container body a mouth portion, a central bottom part material which is generally amorphous and/or thermocrystallized, and a closed support surface surrounding the central bottom part, in which the central bottom part extends towards the interior of the container body, characterized in that the central bottom part merges into an area of material surrounding the central bottom part and adjacent the support surface, the material of the said area having through stretching and/or reshaping undergone flow and through heating undergone contraction and/or through heating acquired built-in stresses which tend to contract it, whereby said surrounding area prevents the inward bulge of the central bottom part from straightening out and/or turning inside out when the pressure inside the container is raised and/or when the temperature of the container material is raised.

2. A container as claimd in Claim 1, wherein said surrounding area of material incorporates material which before flow is situated closer to the axis of the future container than the material forming the container body.

3. A container as claimed in Claim 1 or 2, wherein said surrounding area of material is situated between the support surface and the axis of the container.

4. A container as claimed in Claim 1 or 2, wherein the support surface is situated between said surrounding area of material and the axis of the container.

5. A container as claimed in Claim 1 or 2, wherein the support surface is at least partially formed by said surrounding area of material.

6. A container as claimed in any preceding claim, wherein the container body and the mouth portion each comprise material oriented along the axis of the container with an orientation corresponding to that arising in a sheet of material which has been monoaxially stretched to cause material flow.

7. A container as claimed in Claim 6, wherein the material in the container body and in the mouth portion has additionally been oriented in the circumferential direction of the container with an orientation corresponding at most to that arising in a sheet of material when stretched monoaxially to cause material flow.

8. A container as claimed in any preceding claim, wherein the material in the container body in the mouth portion, and in said surrounding area has a crystallization in the range 15% to 33%, preferably in the range 15% to 25%, and the material in the central bottom part of the container has a maximum crystallization of approximately 30%.

9. A container as claimed in any preceding claim of polyethylene terephthalate.

10. A method of producing a container as claimed in any preceding claim from a preform having a bottom closure of generally amorphous material and a body portion which at least adjacent to the closed end of the preform consists of material oriented along the axis of the preform with an orientation corresponding to that produced in a sheet of the material stretched monoaxially to cause material flow and which adjacent to the closed end forms a surrounding transition area of material, characterized in that the bottom closure is reshaped to form a bulge extending towards the interior of the container, and in that the material in the transition area is heated to a temperature higher than the glass transition temperature range of the material.

11. A method as claimed in Claim 10, in which at least the material in the body portion of the preform is expanded with the material at forming temperature to make contact with forming surfaces of a blow mould.

12. A method as claimed in Claim 10 or 11, in which when the bottom closure is reshaped to form the inward bulge the material thereof has a temperature in or below the glass transition temperature (TG) range of the material, such that during reshaping the generally amorphous material in the bottom closure situated adjacent the material stretched to flow in the transition area is stretched to flow.

13. A method as claimed in Claim 11, or Claim 12 when appended to Claim 11, in which during expansion of the preform the inward bulge is moved by forming elements along the axis of the preform towards the centre of the preform and relative to the body portion thereof such that the contour length of the material stretched to flow is maintained, and preferably during enclosure of the inward bulge between the forming elements.

14. A method as claimed in Claim 13, wherein the forming elements reduce the thickness of the enclosed part of the material, preferably during simultaneous reshaping of it to form the central bottom part of the container.

15. A method as claimed in Claims 13 to 14, wherein forming surfaces of the forming elements and/or of the blow mould are at a temperature within

the thermal crystallization range and preferably at a temperature somewhat higher than the temperataure at which thermal crystallization of the material is at maximum.

16. A method as claimed in any of Claims 10 to 15, wherein during an initial stage of forming the container a conical mould part expands the mouth portion while moving towards the bottom closure or the inward bulge and interacting with an external mould part.

17. Apparatus for performing a method as claimed in Claim 13, comprising an internal mandrel, two mould halves for defining mould, and a bottom part, wherein the mandrel and the bottom part are arranged to move along the axis of the mould relative to each other and relative to the mould halves during forming of the container, and wherein the mandrel has a concave end surface and the bottom part has a convex end surface for enclosing and reshaping the bottom closure or the inward bulge.

18. A container of thermoplastic material substantially as hereinbefore described with reference to and as illustrated in Figures 5 and 6 of the accompanying drawings.

19. A method of producing a container of thermoplastic material substantially as hereinbefore described with reference to the accompanying drawings.

20. Apparatus for producing a container of thermoplastic material substantially as hereinbefore described with reference to and as illustrated in Figures 7 to 10 of the accompanying drawings.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1983.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.