



(51) International Patent Classification:

B21D 37/10 (2006.01) *B21D 51/38* (2006.01)
B21D 22/28 (2006.01) *B65D 1/14* (2006.01)

(21) International Application Number:

PCT/CA2009/001565

(22) International Filing Date:

30 October 2009 (30.10.2009)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

61/197,976 31 October 2008 (31.10.2008) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,

CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))
- of inventorship (Rule 4.17(iv))

Published:

- with international search report (Art. 21(3))

(54) Title: NECKING DIE WITH SHORTENED LAND AND METHOD OF DIE NECKING

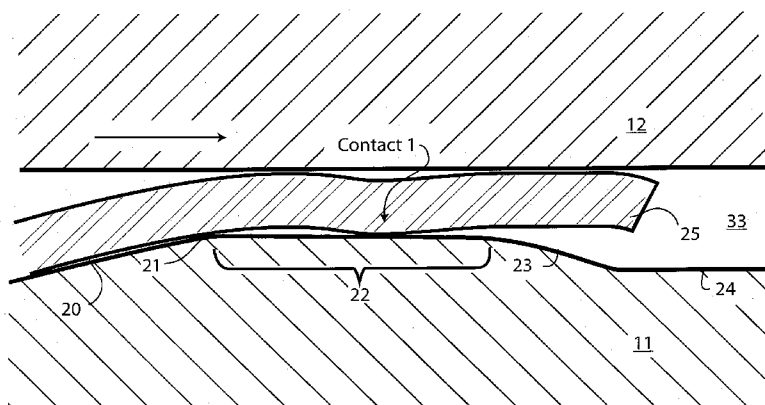


Fig. 5

(57) Abstract: The exemplary embodiments provide a die set comprising a knockout punch and a necking die for necking-in a metal container preform. In an axial direction from front to back of the die, the die has an inwardly tapering in-feed surface, a forming radius, a generally cylindrical land having a die bore diameter, a discharge surface and a relief surface having a diameter larger than the die bore diameter. The land has an axial length of less than 0.1 inch. It is believed that such a length limits the number of metal contacts with the land (rebounds between the knockout punch and the land) to one or two as a metal container preform is necked in the die in conjunction with a knockout punch having a punch diameter that provides a gap between the knockout punch and the land. While the gap may be larger than the topwall thickness of the metal of the preform within the gap, it may alternatively be the same as, or smaller than, the thickness (by up to 10%), to effect re-resizing of the container wall. The exemplary embodiments also provide a method of necking a container preform using such a die.



NECKING DIE WITH SHORTENED LAND AND METHOD OF DIE NECKINGTECHNICAL FIELD

5 This invention relates to the shaping of metal containers by means of a succession of necking steps using dies that gradually modify the container walls into a desired finished shape. More particularly, the invention relates to the design of dies to improve die necking operations and to methods of die necking.

10 BACKGROUND ART

 Thin walled metal foodstuff containers, beverage cans, aerosol canisters, and other such containers for consumer or industrial products are often provided with inwardly- or outwardly-flared walls for aesthetic reasons or for reasons of practicality or economy. For example, beverage can bodies are often provided with an inward flare
15 adjacent to their upper ends primarily to reduce the size of the required metal end closure walls. Such end closure walls are necessarily made of a metal of a much thicker gauge than that required for the walls of the container bodies, so any reduction in their size results in a considerable saving of metal. Containers of this kind are often made from rolled metal sheet that is cut into blanks, cupped, drawn and ironed to elongate
20 the side walls, and then finally trimmed to produce a straight-walled open-ended container body pre-form. Such container body pre-forms are then provided with flared ends or other shapes of the above-mentioned kind by a process known as die necking whereby the open end of a tubular pre-form is forced into a succession of shaped annular dies of ever-decreasing diameter until the desired size reduction of the tubular
25 wall at the open end is achieved. A large number of small changes of diameter are carried out in order to avoid metal buckling, ripping or tearing that generally occurs if abrupt size changes are attempted in a single step. More details of a typical necking operation may be obtained from US patent 5,497,900 issued to Caleffi et al. on March 12, 1996 and from PCT publication WO 2007/136608 A2, published on
30 November 29, 2007 (the disclosures of which documents are specifically incorporated herein by reference).

The necking dies work in conjunction with correspondingly-sized knockout punches that fit within the central openings of the dies and help to support and shape the container pre-forms to be necked. The purpose of the die is to reduce the diameter of the opening and impart a shape that is aesthetically pleasing at the top portion of the container pre-form. The purpose of the knockout punches is to control the metal by diverting it back towards the die so that the size reduction of a particular die necking stage is not larger than intended, to prevent failures of buckling in the neck, and to knock the container pre-form out of the die after shaping has been accomplished in that stage.

As the container pre-form is forced into the die, considerable friction is generated even though a lubricant is usually present on the die and metal surfaces. The friction thus generated hinders the smooth shaping operation and increases the risk of metal buckling. It also limits the degree of necking (the extent by which the open end may be necked-in at each necking step) because the container pre-form can sustain only a certain maximum axial load without deformation, and a greater degree of necking-in requires a greater degree of axial load regardless of the generated friction. Therefore, increased friction detracts from the axial load that can be applied to necking-in.

U.S. patent 5,711,178 which issued to Hogendoorn et al. on January 27, 1998 discloses a die for use in a die-necking process of a metal body. The die is designed to reduce axial force needed in the die necking steps.

U.S. patent 4,881,394 which issued to Jansen on November 21, 1989 and U.S. patent 5,168,742 which issued to Heyes et al. on December 8, 1992 may also relate to the minimization of axial force, but these patents relate to ironing dies which are quite different from necking dies.

It would therefore be advantageous to provide alternative ways of reducing the amount of friction generated between the metal pre-form and a necking die without compromising a desired shaping operation.

DISCLOSURE OF THE INVENTION

One exemplary embodiment of the invention provides a necking die set for necking-in a metal container preform. The die set comprises a knockout punch having a generally cylindrical surface and a die having, in an axial direction from front to back of the die, an inwardly tapering in-feed surface, a forming radius, a generally cylindrical land defining a die bore diameter, a discharge surface following the land, and a relief surface having a diameter larger than the die bore diameter. The land has an axial length of less than 0.1 inch. This dimension limits the number of metal contacts with the land to one or two as a metal container preform is necked in the die in co-operation with the knockout punch.

The axial length of the land is preferably from 0.010 to 0.0950 inches, and still more preferably from 0.0127 to 0.0827 inches.

The knockout punch preferably has an outer diameter and the die preferably has a bore diameter effective to leave a gap therebetween, the gap being greater than the top-wall thickness of a container preform necked in the die set. Alternatively, the gap may be the same as the top-wall thickness or less than the top-wall thickness, to effect re-drawing of the container preform during the necking step. When the gap is less than the top-wall thickness, the gap is preferably up to 10% smaller than the thickness of the top-wall, and more preferably up to 5% smaller.

The container preform may preferably have a top-wall thickness of 0.0058 to 0.010 inch, and the die may preferably have a forming radius of 0.2 and 0.5 inches.

Another exemplary embodiment provides a necking die set for necking-in a metal container preform. The die set comprises a knockout punch having a generally cylindrical surface and a die having, in an axial direction from front to back of the die, an inwardly tapering in-feed surface, a forming radius, a generally cylindrical land defining a die bore diameter, a discharge surface and a relief surface having a diameter larger than the die bore diameter. The land has an axial length that limits the number of metal contacts to one.

The exemplary embodiments also extend to dies designed for use in the aforesaid die sets.

Another exemplary embodiment provides a method of necking-in a metal container preform having a top-wall thickness. The method includes the steps of
5 directing an open end of a metal container preform surrounding a cylindrical knockout punch into an annular necking die to effect necking-in of the container preform, and then using the knockout punch and optionally pressurized gas to knock out the container body preform from the die. The method also includes providing the die with, or selecting the die to have, a land having an axial length effective to limit a number of
10 contacts between the container preform with the land during the necking step to one or two. The distance between the land and the knockout punch is also preferably reduced to cause a resizing or redistribution of metal of the necked-in part of the container wall.

15 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-section of one form of necking die and knockout punch combination showing surfaces normally provided within such a die;

Fig. 2 is an enlargement of part of the cross-section of Fig. 1 showing the parts within the dashed-line circle of Fig. 1;

20 Fig. 3 is a view similar to Fig. 2, but also showing part of a wall of a container body pre-form inserted into the die;

Fig. 4 is an enlargement of the land region of the die of Fig. 3 showing points of metal contact with the land;

25 Fig. 5 is a view similar to Fig. 4 according to an exemplary embodiment, showing a modification of the region of the land to minimize metal contact;

Figs. 6A and 6B are exaggerated schematic views showing a prior art die (Fig. 6A) and a die according to an exemplary embodiment (Fig. 6B); and

Fig. 7 is a view similar to Fig. 5 but showing a further alternative exemplary embodiment.

BEST MODES FOR CARRYING OUT THE INVENTION

In the following, for the sake of simplicity, reference is made to a “container” rather than a “container body pre-form”, although the latter is generally intended.

5 Figs. 1 and 2 of the accompanying drawings show a necking-in die set 10 comprising a combination of a die 11 and a knockout punch 12. This combination is shown in cross-section but is generally symmetrical about an axial centerline (central axis 14). The die has a front 16 at the left hand side of the drawing (where the container is inserted during necking) and a rear 17 at the right hand side. In a direction
10 front to back of the die 11, the internal surfaces of the die are made up of an inwardly-tapering in-feed surface 20, a forming radius 21 (sometimes referred to as an inflection point), an annular land 22 having a surface that is parallel to the axial centerline 14 and a specific bore diameter D_1 , a discharge surface 23 at the rear end of the land, and a relief surface 24 (often referred to as a cut-back surface) of greater diameter D_2 than
15 the land. Knockout punch 12 fits within the central opening or bore of the annular die and is generally cylindrical in shape with a diameter D_3 . This diameter is typically 0.001 to 0.002 inch smaller than the bore diameter D_1 minus twice the thickness of the metal
25 (see Fig. 3) forming the top of the container wall undergoing the die necking stage under consideration (the so-called top-wall thickness). Because of this smaller
20 diameter D_3 , there is a spacing or degree of free play between the wall of the container and the opposing land 22 and knockout punch 12 during a die necking step. For aluminum beverage containers, the top wall of the un-necked container will generally range between 0.0058 and 0.010 inch, depending on whether the container body is intended for an aluminum beverage can or an aluminum bottle.

25 During neck forming, as represented in Fig. 3, the die is usually held stationary and the open end 26 of a container 27 is pushed into the die. The open end 26 is guided into the die by the in-feed surface 20 which causes a reduction of diameter of the container and provides the container body with a desired shoulder shape 30. The wall of the container passes the forming radius 21 of the die (where bending

commences), contacts the knockout punch 12 and is fed into the die bore formed by land 22 to form a neck-in portion 31 of reduced diameter. This operation is assisted by the knockout punch 12 which is moved in the same direction as the container and at approximately the same speed during this stage of the operation. At the end of the necking step, the knockout punch 12 is reversed in direction and, usually assisted by pressurized air introduced into the container through a central channel (not shown) in the knockout punch, is used to push the container out of the die. A step 28 of enlarged diameter formed on the knockout punch 12 contacts the open end of the container to effect this pushing step. The discharge surface 23 at the end of the land 22, being ramped, aids the removal of the necked-in portion 31 of the container from the die without damaging the surface coating (if any) provided on the outer surface of the container. This may be necessary as the container may have a slightly larger diameter than the bore diameter at the land 22, particularly at the open end where there is often an outward flare, as shown.

As previously mentioned, and as shown more clearly in the still further enlarged view of Fig. 4, the spacing between the outer surface of the knockout punch 12 and the adjacent surface of the land 22 is preferably slightly greater than the thickness of the metal of the container wall at this stage of the operation (usually between 0.0005 inch to 0.001 inch greater) so that the metal does not wedge itself in the gap between the die and the knockout punch (which could result in axial collapse of the container). As the metal forced into the die passes the forming radius 21, it first contacts the outer surface of the knockout punch 12, and is then diverted back into contact with the surface of the land 22 (shown as "Contact 1" in the drawing). The metal is then diverted back again into contact with the knockout punch 12, and is once again diverted back into contact with the land 22 ("Contact 2"). This kind of rebound of the metal between the knockout punch and the land may occur several more times or, after the second contact, the metal may stay in continuous contact with the knockout punch before the metal passes the land and enters the gap 33 between the knockout punch 12 and the relief surface 24. Alternatively, in some instances, the metal may remain in

continuous contact with the land 22, or there may be a mix of rebounds and continuous contact. As previously mentioned, at this stage of the necking operation, the knockout punch 12 moves in the same direction as the container wall 25 (from front to back of the die, as indicated by the arrow) and offers no real resistance to the movement of the metal since the knockout punch is moved at approximately the same speed as, or faster than, the metal and no resistive friction is developed. However, friction is generated at the positions where the metal contacts the surface of the land 22 and the friction increases with the number of contacts (or area of contact) between the metal and the land. As the friction increases, the force or axial loading required to push the container into the die increases, and there is a greater chance of the container jamming in the die or buckling under the pushing force.

An exemplary embodiment of the present invention minimizes the friction generated in this way by reducing the axial length of the land below the minimum length conventionally employed (about 0.1 inch). This decreases the number of times the metal contacts the surface of the land 22 and/or decreases the area of contact. Ideally, the land is made so short that there is only one contact of the metal with the land, but as many as two metal contacts may be accepted. This is illustrated schematically in Fig. 5 of the accompanying drawings. This limited number of contacts reduces the friction, which will in turn reduce the axial load required to push the container into the die during necking.

It may be possible to determine the number of contacts made with the land by microscopic examination of the land surface of a well-used die since the contacts change the surface appearance or physical wear on the land surface, which appear as surface bands. Moreover, a test die made of a tough transparent material, e.g. polycarbonate or other strong polymer, may be used to allow visual observation of movements of the container wall during the necking-in process.

The axial length of the land 22 required to produce the desired reduction in friction is a function of the forming radius 21, the metal properties of the top wall of the container, the top wall thickness of the un-necked container body (generally 0.0058 to

0.010 inch), and the clearance between the knockout punch and the land. For most applications using aluminum can body stock (e.g. container bodies made of alloys AA3004, AA3014, X319, X343, etc.) the forming radius 21 will fall between 0.2 and 0.5 inches, and the knockout punch and die clearance over metal (the metal being at the gauge to which it thickens in that stage of the necking operation) will fall between 0.0005 and 0.001 inch per side. In such circumstances, the preferred land lengths will be within the range of 0.027 and 0.060 inch in axial length. It should be noted that the length of the land is the length of the portion that is parallel to the central axis 14 and does not include any part of the discharge surface 23 or the forming radius 21. The preferred working range for the length of the land is 0.010 to 0.0950 inch, and generally an amount less than 0.1 inch. These dimensions are normally suitable for all conventional necking speeds and stroke lengths.

Table 1 below shows the land lengths that are optimum for achieving a single contact with the die land.

15

TABLE 1

FORMING RADIUS (inch)	MINIMUM LAND LENGTH (inch)	MAXIMUM LAND LENGTH (inch)
0.01	0.0127	0.0129
0.1	0.0217	0.0341
0.2	0.027	0.0421
0.3	0.0314	0.0484
0.5	0.0385	0.0583
0.8	0.0468	0.0701
1.0	0.0515	0.0767
1.2	0.0558	0.0827

Thus, it can be seen from the above table that, for forming radii below 1.2 inch, the land preferably has a minimum length above about 0.1 inch and a maximum length below about 0.095 inch, and preferably below 0.09 inch.

20

Figs. 6A and 6B are somewhat exaggerated schematic views illustrating the difference between conventional necking dies and those of some of the exemplary embodiments. Thus, it will be seen that in the exemplary embodiments illustrated by Fig. 6B, the land 22 is much shorter than that in the conventional die design illustrated in Fig. 6A.

The inventor has also surprisingly found that, when the length of the land is shortened in the indicated manner, the free play or spacing conventionally provided between the container wall and the confronting surfaces of the land 22 and knockout punch 12 may be eliminated without increasing friction unacceptably and without increasing any tendency of the container to jam in the die. This was evident by the fact that containers necked in this way did not collapse during the necking step, even when provided with a weakened mid section (e.g. a narrow waist). It is also noted that, when the free play or spacing is eliminated, or the spacing between land and knockout punch is made slightly less than the thickness of the adjacent container wall (top-wall thickness), the metal in the container wall may be redistributed or "re-sized" to eliminate or reduce circumferential irregularities of thickness that may build up as the container is necked-in. Indeed, the wall thickness after the neck reduction may be reduced in this process by 10% or less, and preferably 5% or less, when compared to an equivalently necked container where conventional free play or spacing is provided. This wall thickness reduction produces an even wall-smoothing effect. This advantage can be achieved without further modifying the land, i.e. while maintaining the flat cross-sectional profile of the surface of the land 22, as shown. It is theorized that, although the re-sizing of the container wall can be accomplished in this way, this can be done without significant increases in friction because the re-sizing of the metal takes place only over a short axial distance due to the reduced length of the land.

This embodiment is illustrated in Fig. 7 of the accompanying drawings, from which it can be seen that the gap between the knockout punch 12 and the land 22 is the same as the adjacent topwall thickness of the container 27. Again, there is just one contact, but the container remains in contact with the land 22 over substantially the

entire length of the land. Essentially, metal rebound between the knockout punch and the land has been eliminated, but the area of metal contact (compared to a conventional die) has been reduced.

CLAIMS:

1. A necking die set for necking-in a metal container preform, which die set comprises a knockout punch having a generally cylindrical surface and a die having, in an axial direction from front to back of the die, an inwardly tapering in-feed surface, a forming radius, a generally cylindrical land defining a die bore diameter, a discharge surface following said land, and a relief surface having a diameter larger than the die bore diameter, wherein the land has an axial length that is less than 0.1 inch.
2. A die set according to claim 1, wherein said axial length of the land limits a number of metal contacts with the land to one or two as a metal container preform is necked in the die in co-operation with said knockout punch.
3. A die set according to claim 1, wherein said axial length is from 0.010 to 0.0950 inches.
4. A die set according to claim 1, wherein said axial length is from 0.0127 to 0.0827 inches.
5. A die set according to any one of claims 1 to 4, wherein said knockout punch has an outer diameter and said die has a bore diameter effective to leave a gap therebetween, said gap being greater than a top-wall thickness of said container preform necked in said die set.
6. A die set according to any one of claims 1 to 4, wherein said knockout punch has an outer diameter and said die has a bore diameter effective to leave a gap therebetween, said gap being the same as a top-wall thickness of said container preform necked in said die set.
7. A die set according to any one of claims 1 to 4, wherein said knockout punch has an outer diameter and said die has a bore diameter effective to leave a gap

therebetween, said gap being less than a thickness of a wall of said container preform to be necked in said die set.

8. A die set according to claim 7, wherein said gap is less than said thickness by an amount of up to 10% of said thickness.

9. A die set according to claim 7, wherein said gap is less than said thickness by an amount of up to 5% of said thickness.

10. A die set according to any one of claims 1 to 9, wherein dimensioned to neck a container preform having a top-wall thickness of 0.0058 to 0.010 inch.

11. A die set according to any one of claims 1 to 10 wherein said forming radius is in a range of 0.2 and 0.5 inches.

12. A necking die set for necking-in a metal container preform, which die set comprises a knockout punch having a generally cylindrical surface and a die having, in an axial direction from front to back of the die, an inwardly tapering in-feed surface, a forming radius, a generally cylindrical land defining a die bore diameter, a discharge surface and a relief surface having a diameter larger than the die bore diameter, wherein the land has an axial length that limits the number of metal contacts between with the land to one.

13. A die set according to claim 12, wherein said axial length is from 0.010 to 0.0950 inches.

14. A die set according to claim 12, wherein said axial length is from 0.0127 to 0.0827 inches.

15. A die set according to any one of claims 12 to 14, wherein said knockout punch has an outer diameter and said die has a bore diameter effective to leave a gap therebetween, said gap being the same as a thickness of a wall of said container preform to be necked in said die set.

16. A die set according to according to any one of claims 12 to 14, wherein said knockout punch has an outer diameter and said die has a bore diameter effective to leave a gap therebetween, said gap being less than a thickness of a wall of said container preform to be necked in said die set.

17. A die set according to claim 16, wherein said gap is less than said thickness by an amount of up to 10% of said thickness.

18. A die set according to claim 16, wherein said gap is less than said thickness by an amount of up to 5% of said thickness.

19. A necking-in die for a die set according to any one of claims 1 to 11.

20. A necking-in die for a die set according to any one of claims 12 to 18.

21. A method of necking-in a metal container preform having a top-wall thickness, comprising the steps of:

directing an open end of a metal container preform surrounding a cylindrical knockout punch into an annular necking die to effect necking-in of said container preform, and then using the knockout punch and optionally pressurized gas to knock out the container body preform from the die;

wherein the method includes providing said die with, or selecting said die to have, a land having an axial length effective to limit a number of contacts between said container preform with said land during said necking step to one or two.

22. A method according to claim 21, wherein said axial length of said land is made less than 0.1 inch.
23. A method according to claim 21, wherein said axial length of said land is made to be from 0.010 to 0.0950 inches.
24. A method according to claim 21, wherein said axial length of said land is made to be from 0.0127 to 0.0827 inches.
25. A method according to any one of claims 21 to 24, wherein said die and said knockout punch are made to form a gap between said knockout punch and said land that is greater than said thickness of said metal by an amount in a range of 0.0005 to 0.001 inches.
26. A method according to any one of claims 21 to 24, wherein said die and said knockout punch are made to form a gap between said knockout punch and said land that is the same as or less than said top-wall thickness of said container preform.
27. A method according to claim 26, wherein said gap is less than said top-wall thickness by up to 10% of said thickness.
28. A method according to claim 26, wherein said gap is less than said top-wall thickness by up to 5% of said thickness.
29. A method according to any one of claims 21 to 28, wherein an aluminum alloy is selected for said container body preform.

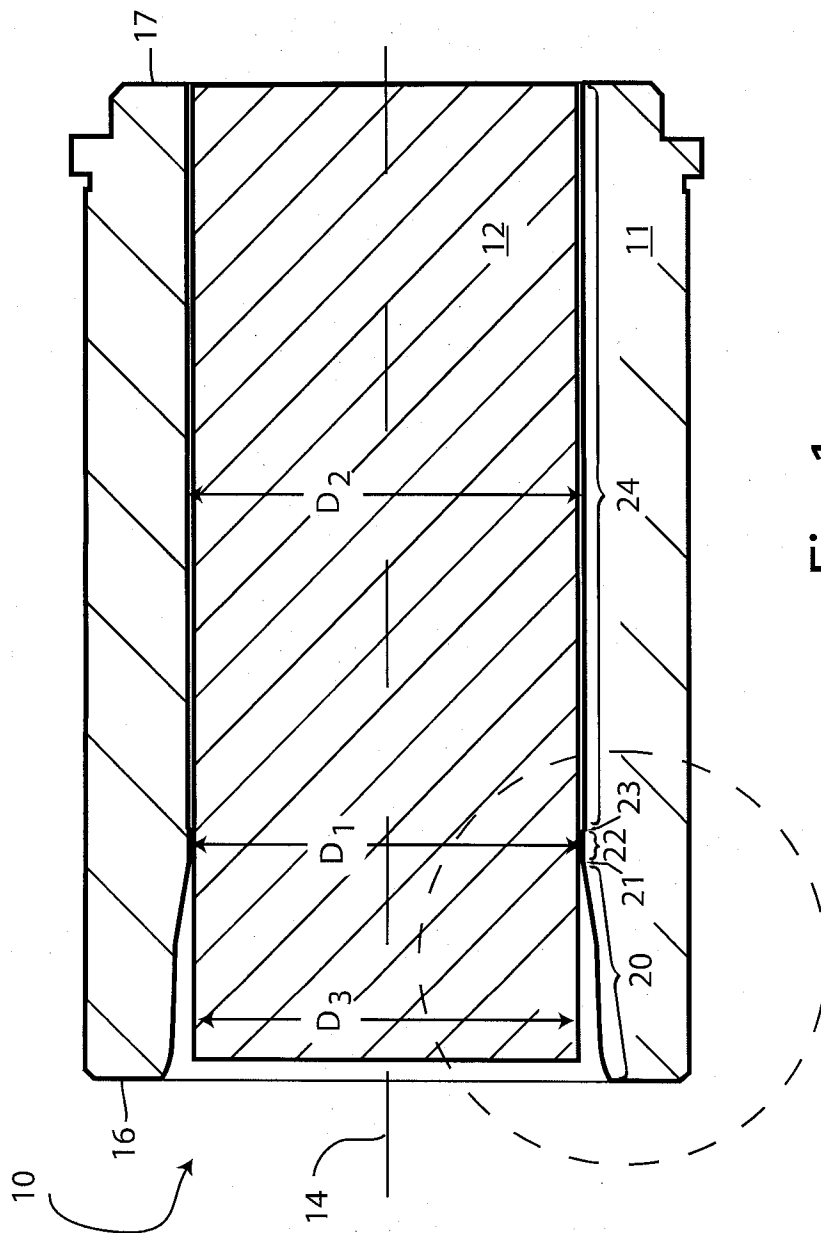


Fig. 1

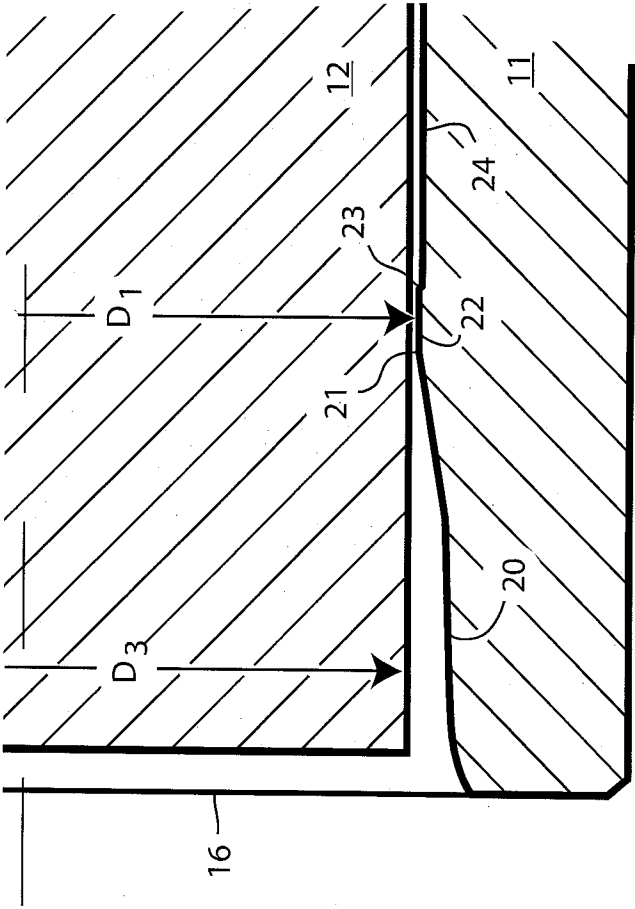


Fig. 2

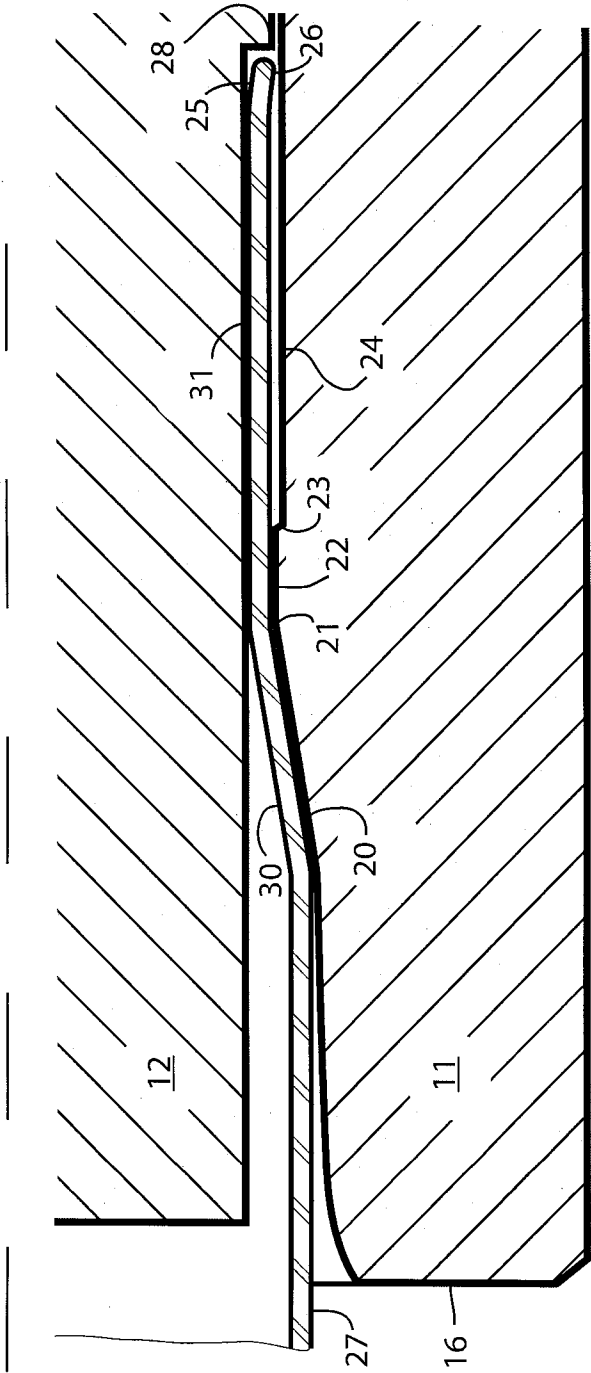


Fig.3

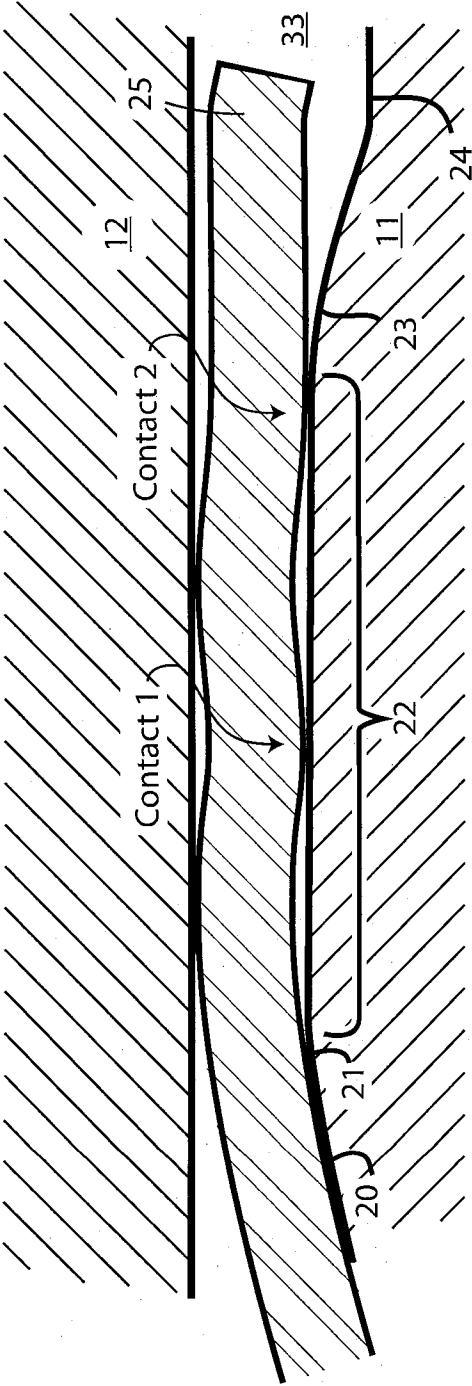


Fig. 4

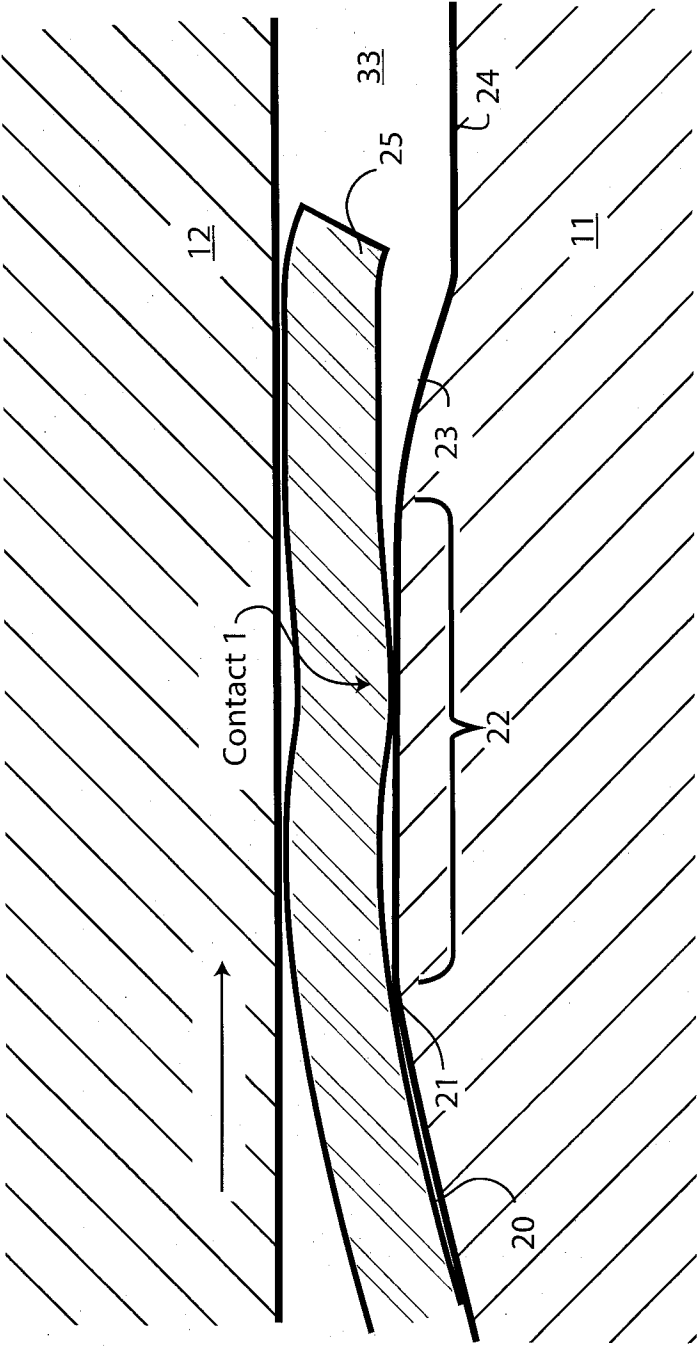


Fig. 5

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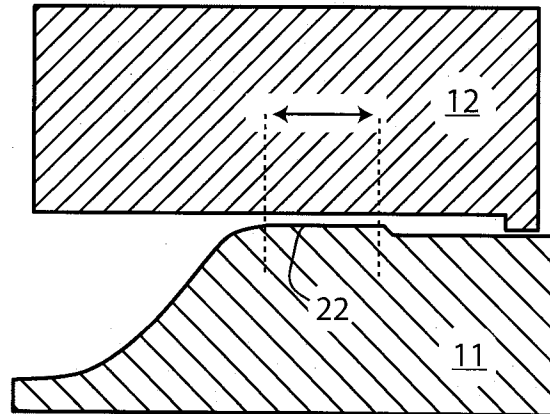


Fig. 6A
(Prior Art)

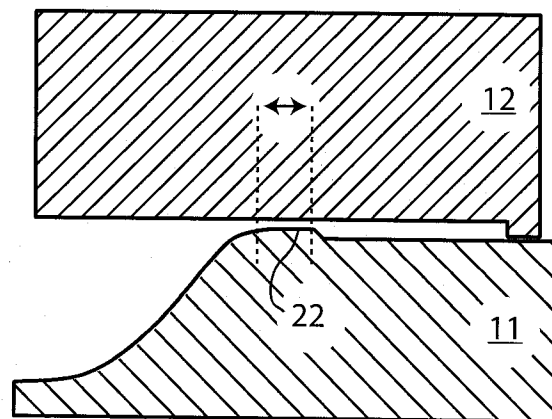


Fig. 6B

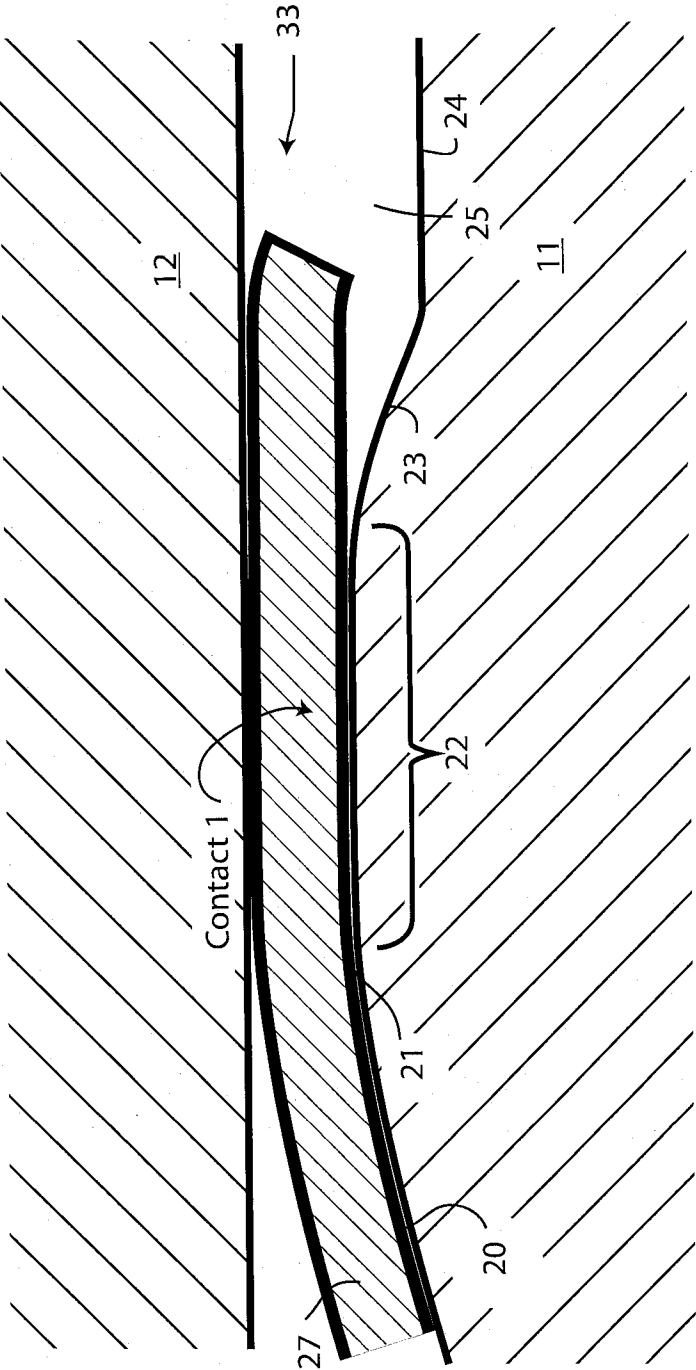


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2009/001565

A. CLASSIFICATION OF SUBJECT MATTER IPC: B21D 37/10 (2006.01) , B21D 22/28 (2006.01) , B21D 51/38 (2006.01) , B65D 1/14 (2006.01) According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC (2006.01): B21D all; B65D 1/14 U.S. Cl.: 72/* Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used) Canadian Patent Database, EPODOC, WEST keywords: container, canister, can, aluminum, metal, necking, drawing, ironing, die, mandrel, knockout, friction, gap, clearance, land, neck zone		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/0035871 A1 (CHUPAK, T.) 26 February 2004 (26-02-2004) * entire disclosure, figure 15-18	1, 3-5, 10, 11, 19
X	WO 2007/136608 A2 (ALCOA INC.) 29 November 2007 (29-11-2007)	1-5, 10-14, 19-25 and 29
Y	* para 0036-0037 and figure 2	1-6, 10-15, 19-26 and 29
Y	US 5,713,235 A (DIEKHOF, H.) 03 February 1998 (03-02-1998) * claim 1, figures 4 and 5	2, 12-14, 19-25 and 29
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* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
Date of the actual completion of the international search 6 January 2010 (06-01-2010)	Date of mailing of the international search report 13 January 2010 (13-01-2010)	
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Authorized officer Craig MacMillan (819) 934-3422	

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