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Cassai et al.

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[54] **DIE ASSEMBLY AND METHOD FOR INTERIOR ROLL-NECKING-IN A TUBULAR MEMBER**

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[52] **U.S. Cl.** .... **72/117;** 72/123; 113/120 AA

[51] **Int. Cl.**^{2} **B21D 41/02**

[58] **Field of Search** .... 72/94, 117, 122, 123, 91; 113/120 AA

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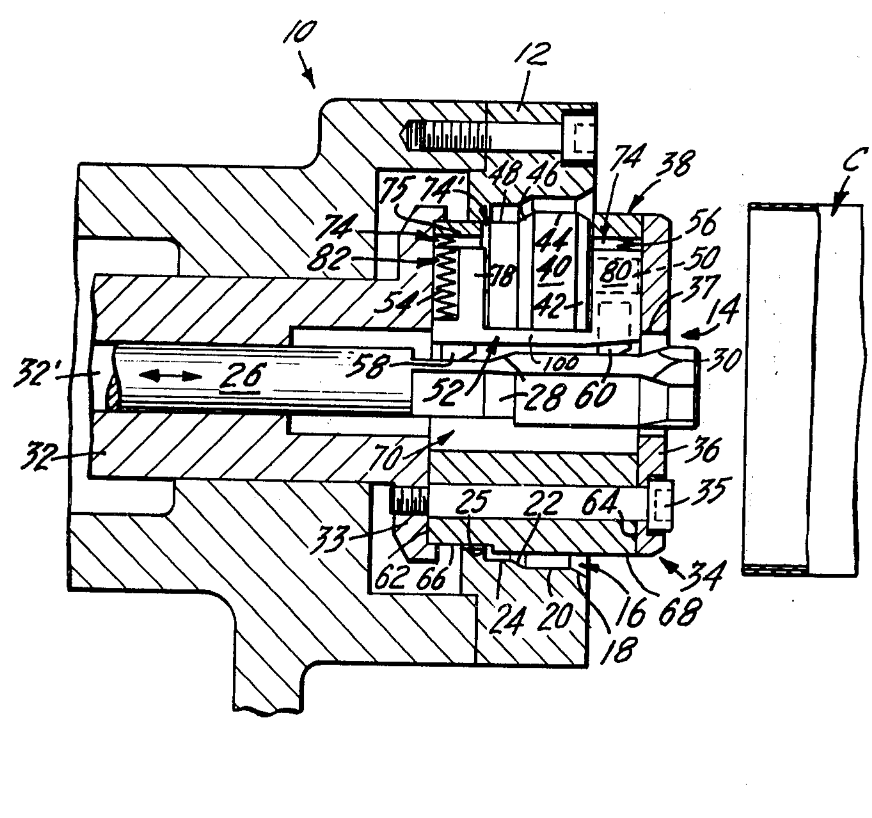
[57] **ABSTRACT**

A die assembly and method for interior roll-necking-in an end portion of a tubular member. The die assembly comprises an outer reducing die and a rotatable spindle assembly concentrically-mounted therewithin and axially-movable in relation thereto. The spindle assembly includes a plunger having cam surfaces thereon and a pilot in turn including a housing having an axial bore therethrough and a radial slot communicating therewith, and a free-wheeling roller axially-mounted between the legs of a substantially U-shaped bracket radially slideably seated within the slot. The bracket includes bracket cam surfaces cooperative with plunger cam surfaces for moving the roller radially when the plunger is moved axially through the housing. The pilot can include biasing means for biasing the bracket and roller radially inward toward the plunger, and cushioning means loosely pin-mounted within cavities in the bracket legs to allow the shoes to slide radially in the cavities to compensate for variations in wall thickness of the tubular member.

The method comprises providing an outer reducing die having a chamber whose walls include an inwardly-angled directing surface and a rim-forming surface, providing a rotatable, radially-movable roller axially-mounted interior of the die chamber, axially moving the marginal edge portion of a tubular member into the chamber mouth, and simultaneously moving the roller vertically toward the marginal edge portion and spinning a portion thereof against the die chamber walls to neck in the tubular member. The method can also include allowing the roller to move radially inward away from a marginal edge portion which is thicker than the rest of the wall of the tubular member.

12 Claims, 12 Drawing Figures



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SHEET 1

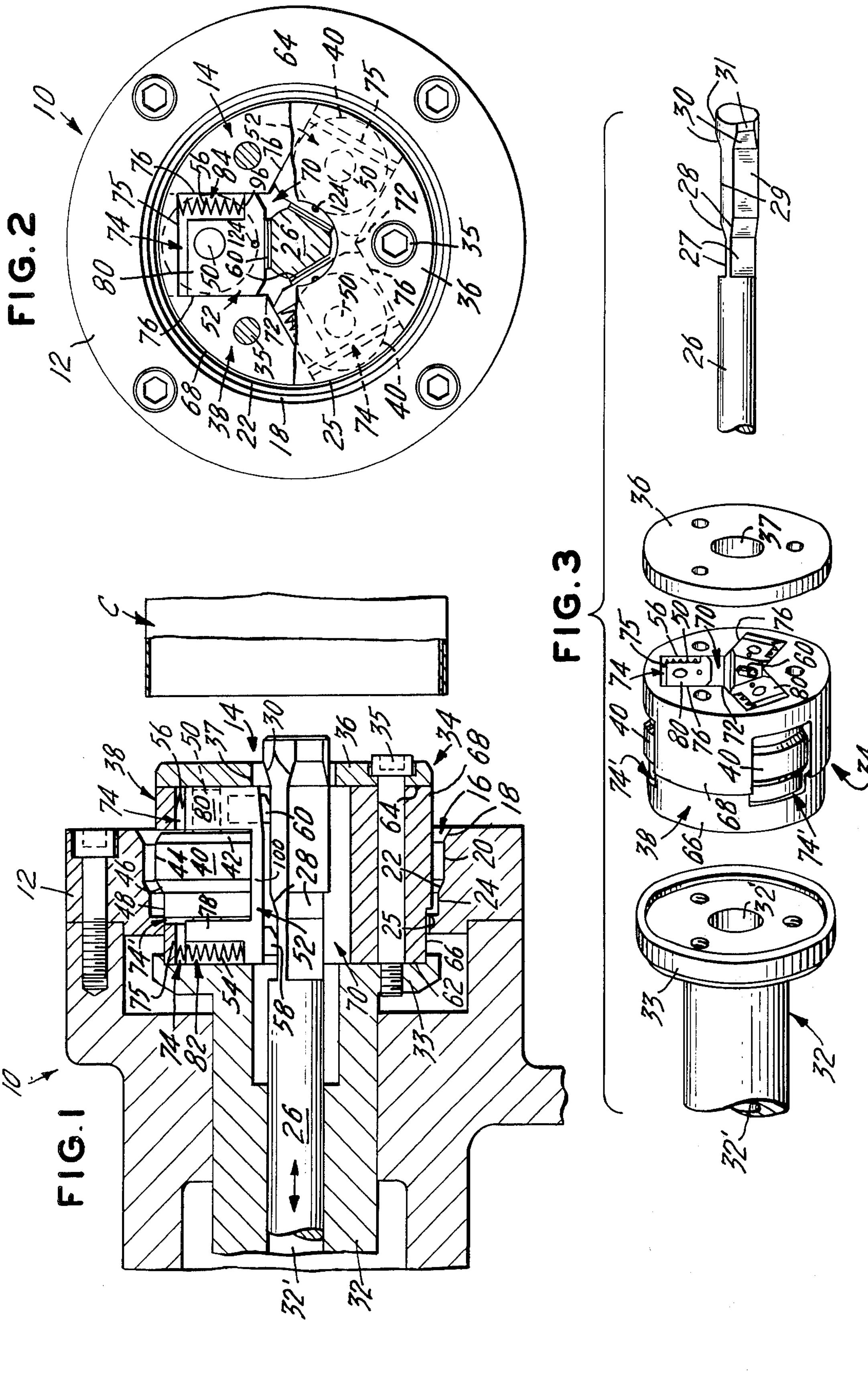


FIG. 1

FIG. 2

FIG. 3

FIG. 4

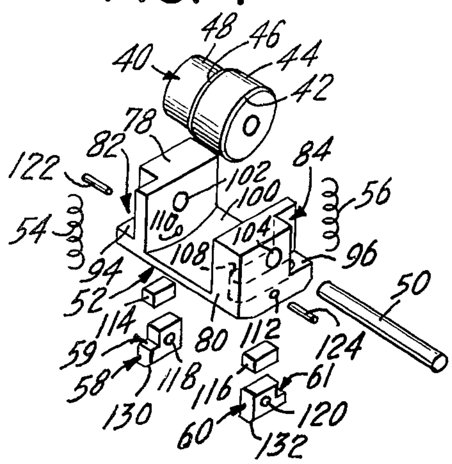


FIG. 5

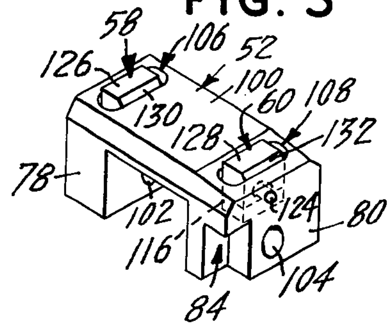


FIG. 6

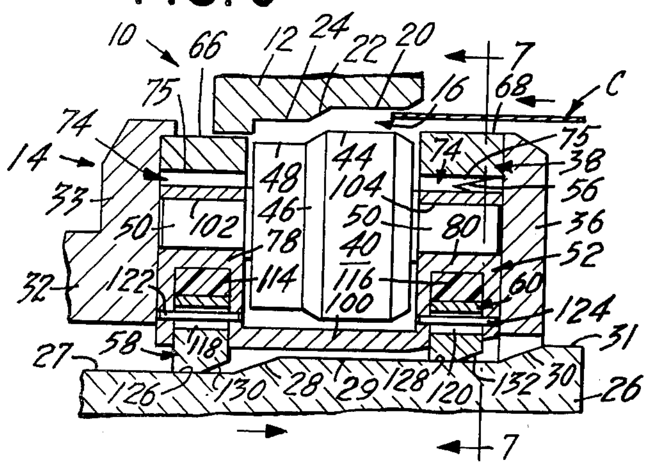


FIG. 7

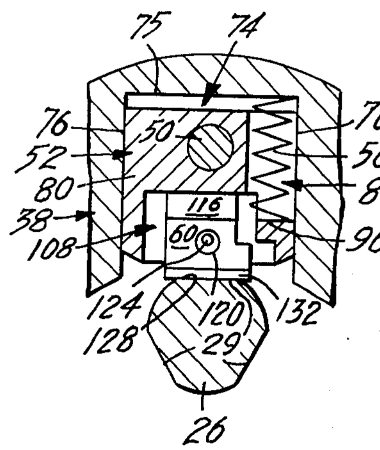


FIG. 8

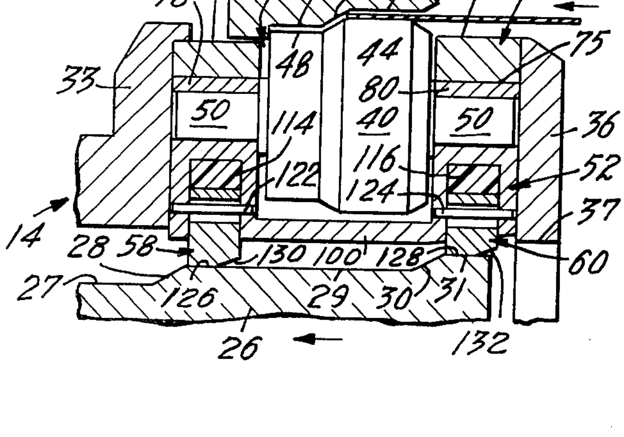


FIG. 9

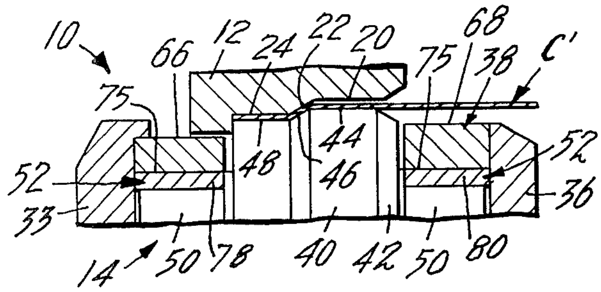


FIG. 10

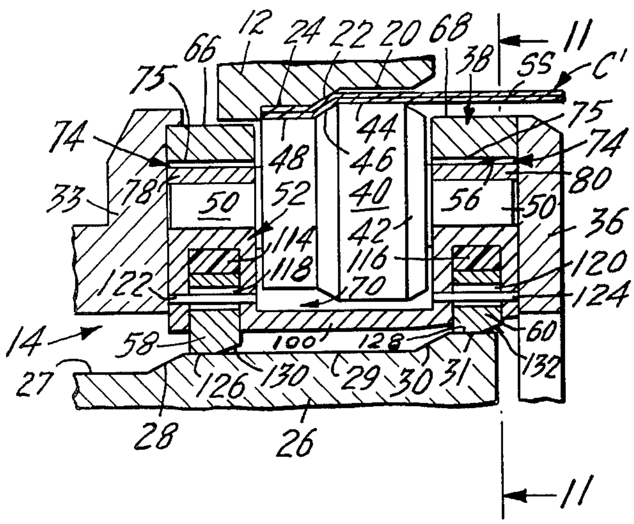


FIG. 11

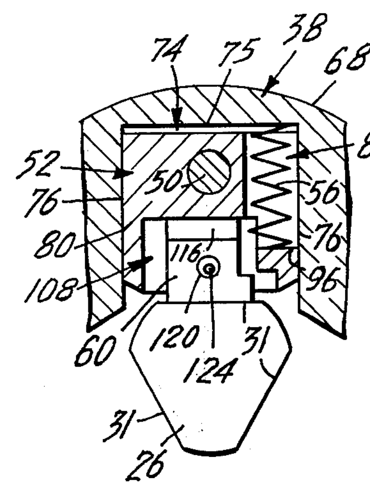
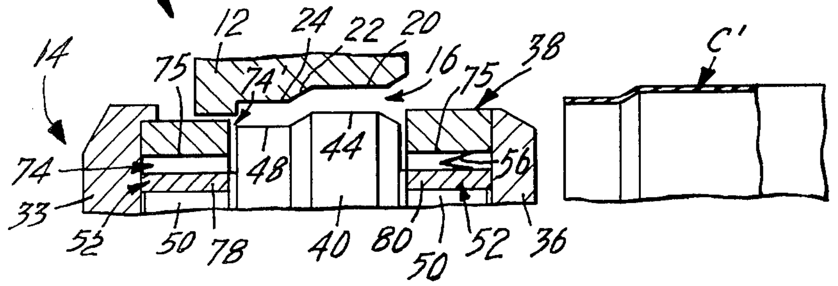


FIG. 12



DIE ASSEMBLY AND METHOD FOR INTERIOR ROLL NECKING-IN A TUBULAR MEMBER

BACKGROUND OF THE INVENTION

This invention relates to the necking-in of tubular members and has particular reference to an apparatus and method for necking-in metal can bodies by use of rollers employed interior of the can bodies.

The art of necking-in tubular members is known and involves reducing the diameter of or forming a neck in one or both ends of tubular members such as metal can bodies whose walls often have side seams of double thickness, and coatings of enamels, inks and other materials on their respective internal and external surfaces.

To date, most necking-in of can bodies is effected by either moving open ends of the bodies between an outer reducing die and an interior pilot of a die assembly, or by rolling or spinning the marginal end portions of the bodies inwardly against a mandrel by use of exterior rollers. Necking-in by either approach has certain disadvantages.

Necking-in with die assemblies usually is disadvantageous because it involves pressing can body wall metal between rigid die surfaces. This often forms folds, puckers, and other irregularities in the metal which in turn form cracks in the necked-in area during subsequent flanging and double seaming operations. Die necking-in also often causes scratches and scores on interior and exterior surface enamels and coatings. These can result in metal pick-up by, and consequent deterioration of, container contents. Further, die necking-in has certain limitations such as not being readily adaptable for working certain materials, such as aluminums used in forming drawn and ironed cans wherein compressive forces often cause the aluminum can walls to buckle or bulge as the cans are being forced into die assemblies. Also, current die assemblies involve extensive machinery and exertions of great amounts of force. With die assemblies, the angle of the shoulder obtainable between the diameter of the regular can body wall and that of the formed neck is usually limited to about 28° or 30°.

Using exterior rollers to roll neck-in can bodies involves progressively moving a roller along the exterior surface of the can body wall. This process inherently initially forms flat areas in the can body wall which, later on in the process, are usually finally permanently iron out. Exterior roll-necking-in cannot be employed to work harder can body materials such as DR–9 steel plate which has a Rockwell hardness of for example about 80 to 82 on the 30T scale. Exterior roll necking-in of can bodies made of such materials causes cracks and other imperfections in the can body walls. Exterior roll necking-in also often causes dimensional variations for example in the roundness, diameter and height of the neck, for one reason because rolled wall material tends to spring back outwardly to its original wall dimensions. Such dimensional variations can cause subsequent problems in fitting end closures onto and double seaming them to necked-in can bodies. Further, like die necking-in operations, exterior roll necking-in requires extensive machinery.

The apparatus of this invention overcomes the aforementioned and other disadvantages by providing radially-moveable profiled rollers interior of a can body. The profile of the rollers corresponds to that of an outer reducing die and the rollers gradually interior roll neck-in or spin the metal wall of a can body radially outwardly against the reducing die surfaces as the marginal end portion of the can is moved into the reducing die. Interior roll necking-in does not involve compression of wall metal but rather a gradual spinning of a progressively greater axial length of wall metal outwardly against the interior surfaces of the outer die. Interior roll necking-in prevents folds and cracks, and tends to reduce scratches in can body wall surfaces. The subject invention can be used to neck-in tubular members made of any strength metal, without being limited by dimensional variations. Shoulder angles can vary from 10° to greater than 60° for can bodies and approaching even 85° for other types of tubular members. Also, less machinery and force are needed than with die assemblies or exterior rollers because can body material is spun and moved rather than being merely or mostly compressed.

Numerous other objects and advantages of the invention will be apparent as it is better understood from the following description, which, taken in connection with the accompanying drawings, discloses a preferred embodiment thereof.

SUMMARY OF THE INVENTION

This invention is in a die assembly and method for interior roll-necking-in an end portion of a tubular member. The die assembly comprises an outer reducing die having a chamber whose walls include an annular inwardly-angled directing surface and an annular rim-forming surface adjoining and axially interior of the directing surface, and a rotatable spindle assembly concentrically mounted within the outer reducing die, the spindle assembly and reducing die being axially movable in relation to each other. The spindle assembly includes an axially-movable elongated plunger having cam surfaces thereon, a hollow spindle having a pilot-mounting means thereon, and a pilot, the pilot including a cylindrical housing mounted onto the pilot mounting means, the housing having inner and outer end walls, a circumferential side wall, a bore running from the inner end wall axially through the housing for receiving the plunger, and a slot communicating axially with the bore and extending radially from the bore through a slot extension in the side wall, a free-wheeling roller mounted within the housing so that the axis of the roller is parallel to that of the housing, the roller including a frustoconical portion and an adjoining axially-interior cylindrical portion, the circumferential profile of the roller substantially corresponding to the profile of the reducing die chamber surfaces, and means for mounting the roller within the housing slot so that its axis is parallel to that of the housing and so that the roller is radially movable within the slot. The roller mounting means can include a substantially U-shaped bracket radially slideably seated within the slot, and biasing means for biasing the roller radially inward toward the plunger. The bracket has a back wall and legs extending perpendicularly from the back wall for mounting the roller between the legs, roller pin holes extending axially into the bracket legs, and a roller pin for pin-mounting the roller thereon, the roller being pin-mounted between the legs. The roller mounting means can include bracket cam surfaces which cooperate with the plunger cam surfaces to allow the roller to

be moved radially outward and inward as the cam surfaces engage and disengage each other and the plunger is moved axially through the housing. The cam surfaces can be on the bottoms of a pair of shoes, each of the shoes being pin-mounted in cavities cut vertically into the bracket back wall and extending into each one of the legs. The biasing means can include a helical spring mounted in cutouts in the bracket legs so that the helical spring runs radially between and has its end portions engaging portions of the housing and the bracket. The bracket legs include resilient cushioning means seated in the cavities and held there by the shoes. The shoe pin holes can be larger than the diameter of the shoe pins so that the shoes are loosely pin-mounted to the bracket to allow the shoes to slide radially in the bracket cavities and compensate for any variations in wall thickness of the tubular member. The die assembly can include a plurality of rollers pin-mounted within the roller housing.

The method of this invention comprises providing an outer reducing die having a chamber whose walls include an annular inwardly-angled directing surface, and an annular rim-forming surface adjoining and axially interior of the directing surface, providing a rotatable roller axially-mounted on a pilot axially interior of the die chamber, axially aligning the marginal edge portion of the wall of an open end of a tubular member with the chamber mouth, axially moving the marginal edge portion gradually into the die chamber so that the outer wall surface of the marginal edge portion engages the chamber surfaces, and simultaneously with the axial moving step, moving said roller vertically towards the rim-forming surface and spinning a portion of the marginal edge portion against the chamber surfaces so that the rim-forming surface imparts a neck of reduced diameter to the portion of the marginal edge portion of the tubular member. The method can also include the step of compensating for extra thicknesses in the wall of the marginal edge portion of the tubular member by allowing the roller to move radially inward away from the marginal edge portion when the roller engages a portion of the wall marginal edge portion which is thicker than the rest of the wall of the tubular member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows the marginal end portion of a tubular can body aligned with a reducing die, each being shown in partial cross section.

FIG. **2** is an end view of the die assembly of this invention showing the outer reducing die and inner pilot with portions broken away.

FIG. **3** is an exploded perspective view of the components of the spindle assembly of this invention.

FIG. **4** is an exploded perspective view of a bracket for pin-mounting a roller therein according to this invention.

FIG. **5** is a perspective view of the bracket of FIG. **4**, after it has been assembled and inverted.

FIGS. **6** through **12** are enlarged partial cross sections showing the workings of the die assembly of this invention during a necking-in operation. FIG. **6** shows the roller in a collapsed position radially removed from the reducing die as the lip of a tubular member enters the reducing die.

FIG. **7** is a partial cross section taken substantially along line **7**—**7** of FIG. **6**.

FIG. **8** shows the roller in its expanded position abuttingly engaging a marginal edge portion of the tubular member.

FIG. **9** shows the tubular member fully within the reducing die.

FIG. **10** shows the roller compensating for the double thickness of a can side seam.

FIG. **11** is an enlarged cross section taken substantially along the line **11**—**11** of FIG. **10**.

FIG. **12** shows the necked-in can body removed from the die assembly.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to the drawings in detail, FIG. **1** is a cross section through a die assembly, generally designated **10**, and, aligned therewith, a portion of a tubular can body, generally designated C. Die assembly **10** is comprised of outer reducing die **12** and, to the interior thereof, a rotatable spindle assembly generally designated **14**. Outer reducing die **12** comprises a chamber **16** having at its mouth an inwardly-angled orienting surface **18**, a guiding surface **20**, an inwardly-angled directing surface **22**, a rim-forming surface **24**, and a stopwall **25**.

Spindle assembly **14** is concentrically mounted within reducing die **12** and includes an axially movable elongated plunger **26** having angled cam surfaces **28** and **30**, a hollow spindle **32** having a flange **33**, and, a pilot generally designated **34** affixed to spindle flange **33** by bolt **35**.

Pilot **34** includes a cylindrical housing **38** and a freewheeling roller **40** having an orienting surface **42**, a large diameter first cylindrical portion **44**, a frustoconical portion **46** and a smaller diameter second cylindrical portion **48**. Housing **38** includes means for mounting roller **40** within the housing, which includes roller pin **50** in turn mounted within a substantially U-shaped bracket **52**, biasing means such helical springs **54, 56** for biasing the bracket and roller radially towards plunger **26**, and means for moving the roller radially outward, including shoes **58, 60**.

Housing **38** has inner end wall **62**, outer end wall **64**, circumferential side walls **66, 68**, and an axial bore **70** running through inner end wall **62** and outer end wall **64**, and defined by bore edges **72** for receiving plunger **26**. Housing **38** has a plurality of radial slots generally designated **74** defined by wall **75** and upper side walls **76** (FIG. **2**). Slots **74** run axially through housing **38**, and communicate with inner and outer end walls **62, 64** and axially with bore **70**.

Substantially U-shaped bracket **52** has vertically extending legs **78, 80** which receive roller pin **50**, and which respectively have vertical cutouts **82, 84** therein (**82** shown). Helical springs **54, 56** are respectively mounted in cutouts **82, 84**, helical spring **54** being mounted between slot upper wall **75** and cutout bottom wall **94**.

FIG. **2** is an end view of die assembly **10** with portions of the assembly broken away. More particularly, FIG. **2** shows reducing die orienting surface **18** and, axially interior thereto, directing surface **20** and stop wall **25**. FIG. **2** also shows spindle assembly **14** concentrically located within reducing die **12**, the broken away portion of housing face plate **36** exposing housing outer wall **64** having a bolt **35** (cross sectioned) and cavity **70** passing axially therethrough. Bore **70** is defined by edges **72** and communicates with slots **74** defined by upper wall 75 and side walls 76. Rollers 40 are axially mounted by pins 50 through legs 80 of brackets 52 slideably positioned within radial slots 74. Adjacent to the center of FIG. 2, a portion of shoe 60, axially mounted within bracket wall 80 by shoe pin 124, abuttingly engages a planar surface of plunger 26.

FIG. 3 is an exploded perspective view of the components of spindle assembly 14. More particularly, the left side of FIG. 3 shows spindle 32 having a bore 32′ and flange 33 for mounting thereto adjacently shown pilot generally designated 34. Seated in pilot housing bore 70 and slots 74 are brackets 52 whose legs 80 hold roller pins 50 for mounting rollers 40. To the right of pilot housing 38 is pilot faceplate 36 having bore 37 therethrough. FIG. 3 also shows plunger 26 having narrow relieved opposing planar surfaces 27, cam surfaces 28, raised planar surfaces 29 and cam surfaces 30. Plunger 26 passes through spindle bore 32′, housing cavity 70 and faceplate bore 37. Spindle 32, pilot 34 and faceplate 36 have three radially spaced holes for receiving bolts 35 therethrough for affixing the components together.

FIG. 4 is an exploded perspective view of the means for mounting roller 40 within housing 38 in a manner that positions the axis of roller 40 parallel to that of the housing and that renders the roller radially movable within slot 74 and slot extension 74′ through housing circumferential side walls 66 and 68. More particularly, FIG. 4 shows that U-shaped bracket 52 of FIG. 1 has a back wall 100 and two substantially vertically extending legs 78 and 80. The legs have holes 102, 104 respectively running axially therethrough for receiving roller pin 50 and mounting free-wheeling roller 40 thereon. Legs 78, 80 have cutouts 82, 84 running substantially length of the legs toward back wall 100, cutout 82 having a bottom wall 94 and cutout 80 having a bottom wall 96. Cutouts 82, 84 are for seating helical springs 54, 56 therein.

FIG. 4 also shows that bracket 52 has cavities 106 (not shown) and 108 (dashed line) each of which enters through the rear of back wall 100, extends vertically into respective legs 78, 80. Bracket 52 also has pin holes 110, 112 which extend axially into legs 78, 80 and communicate with cavities 106, 108. Cavities 106, 108 receive resilient cushion pads 114, 116 and shoes 58, 60 the shoes having shoe pin holes 118, 120 axially therethrough and being pin-mountable in cavities 106, 108 by pins 122, 124 which can pass through pin holes 110, 112 (see FIG. 5). Cavities 106, 108 extend into cutout bottom walls 94, 96, and shoes 58, 60 have cutaway 59, 61 therein so that no portion of the shoes protrudes onto bracket cutouts 82, 84. The interior surface of bracket back wall 100 is concavely arcuate to allow for the mounting and rotation of roller 40 or pin 50 between legs 78 and 80.

FIG. 5 is a perspective view of bracket 52 and its components as assembled, the bracket being shown in an inverted position. More particularly, FIG. 5 shows that cavities 106, 108 extend vertically into the rear of bracket back wall 100, that the bottom portions of shoes 58, 60 have planar surfaces 126, 128 and angled cam surfaces 130, 132, and that shoes 58, 60 are mounted within bracket 52 by pins 122 (not shown) and 124. Shoes 58, 60 hold cushioning pads 114, 116 in cavities 106, 108.

FIGS. 6–12 show the manner in which straight-walled can body C is necked in with die assembly 10. The figures show what occurs at various stages during the necking-in operation but do not necessarily show that the operation stops at each stage. Preferably, the operation is continuous. It is to be noted that according to this invention, the can body, the outer reducing die, the spindle assembly or any combinations thereof may be moved to effect the relative movement between die assembly 10 and can body C that is required to neck-in the can body.

FIGS. 6–12 shown the preferred method of effecting the necking-in operation, that is, wherein outer reducing die is held steady, and can body C is moved into die assembly 10 between outer reducing die 12 and spindle assembly 14. It is to be noted taht although FIGS. 6–12 only show an upper portion of die assembly 10 and only one bracket 52, one roller 40, etc., it is to be understood that any suitable number brackets and rollers, and that what is disclosed applies to any of the brackets, rollers, etc., employed in the die assembly and method of this invention.

FIG. 6 is an enlarged partial cross section of the upper portion of die assembly 10 of FIG. 1, as the lip and marginal end portion of substantially straight-walled can body C is brought into close proximity with the die assembly. More particularly, FIG. 6 shows that when the lip of the wall of can body C enters chamber 16 of outer reducing die 12, plunger 26 is in its extended position and protrudes beyond the vertical plane of housing faceplate 36, and rollers 40 are therefore collapsed or radially inward and not in working position for necking-in the marginal edge portion of can body C. FIG. 6 shows that when plunger 26 is extended, the upper end of helical springs 54 (not shown) and 56 abut upper wall 75 of slot 74 and bias brackets 52 radially inward toward plunger 26 at the center of spindle assembly 14. Because rollers 40 are axially pin-mounted by pins 50 within holes 102, 104 of bracket legs 78, 80, rollers 40 are also biased radially inward toward the center of spindle assembly 14. In this position, the exterior wall surface of large diameter first cylindrical roller portion 44 is substantially aligned with housing circumferential wall 68 and there is a large gap between outer reducing die chamber walls 20, 22, 24 and roller 40. It is also to be noted that shoe bottoms 126, 128 respectively abuttingly engage plunger planar surfaces 27, 29 and shoe cam surfaces 130, 132 are respectively axially displaced from plunger cam surfaces 28, 30.

FIG. 7 is a partial cross section taken substantially along line 7—7 of FIG. 6 and shows that when plunger 26 is extended and rollers 40 are collasped, helical spring 56, between housing slot upper wall 75 and bracket cutout bottom wall 96, biases bracket 52 radially inward toward plunger 26 leaving a gap between the upper portion of bracket 52 and slot upper wall 75. Cushioning pad 116 is not depressed and shoe bottom 128 is in contact with a planar surface 29 of plunger 26. It is to be noted that shoe pin hole 120 has a larger diameter than shoe pin 124 and that when plunger 26 is extended, pin 124 is eccentrically located toward the upper portion of shoe pin hole 120.

As shown in FIG. 8, while plunger 26 is in its forward, extended position, substantially straight-walled can body C is moved further within outer reducing die chamber 16 until the marginal edge portion of can body C is fully alongside the length of reducing die guiding surface 20, and the edge of the can body wall is adjacent inwardly angled rim-forming surface **22**. Plunger **26** is then withdrawn fully within housing **38**. As plunger **26** is being fully withdrawn (to the left) within housing **38**, longitudinally stationary bottom **126** of shoe **58** slides along plunger planar surface **27** and is cammed radially outward (upward in FIG. **8**) by smaller diameter plunger camming surface **28** until shoe bottom **126** engages and rests upon larger diameter plunger planar surface **29**. Likewise, bottom **128** of shoe **60** slides along larger planar surface **29**, is cammed upwardly by plunger cam surface **30** and, when plunger **26** is fully withdrawn shoe bottom **128** engages and rests on the planar nose **31** of plunger **26**. When shoes **58** and **60** are thereby cammed radially outward cushioning pads **114**, **116** remain normal, i.e., not compressed, bracket **52** is moved radially outward against the bias of springs **54**, **56** (not shown), roller pin **50** and roller **40** are thereby moved radially outwardly, in a manner that the axis of the roller remains parallel to the axis of the housing and the axis of the pilot, to place roller **40** in an expanded position where it protrudes through housing slot extension **74'**, and large diameter cylindrical portion **44** of roller **40** engages the inner surface of the marginal edge portion of substantially straight wall of non-rotated can body C. As plunger **26** is being withdrawn within housing **38**, spindle assembly **14** is being rotated by drive means not shown so that when cylindrical roller portion **44** contacts marginal edge portion of can body C, rotational motion is imparted to free-wheeling roller **40**. FIG. **8** shows that shoe pins **122**, **124** are still in their eccentric upper positions relative to shoe pin holes **118**, **120**.

Once outer reducing die **12**, can body C and spindle assembly **14** are in the relative position shown in FIG. **8**, can body C is gradually moved fully into reducing die **12** (FIG. **9**) while spindle assembly **14** rotates to gradually interior roll neck-in a marginal edge portion of can body C to obtain a necked-in can body C'. While this is occurring, the relative positions of plunger **26**, shoes **58**, **60**, cushioning pads **114**, **116**, bracket **52** and its components, are as shown in FIG. **8**. In FIGS. **8** and **9**, there is no gap between bracket **52** and slot upper wall **75**.

FIG. **10** shows the relative positions of the components of bracket **52** when roller **40** engages the double metal thickness of a can body side seam SS. When this occurs, roller pin **50** and roller **40** do not collapse but are axially displaced radially inward toward plunger **26**. This action similarly displaces bracket **52** to put pressure upon and compress resilient cushioning pads **114**, 116 against the tops of respective shoes **58**, **60** which do not move radially because they abut plunger **26**. As bracket **52** is displaced radially inward, it likewise displaces shoe pins **122**, **124** within shoe pin holes **118**, 120 so that, as also shown in FIG. **11**, pins **122**, **124** are eccentrically positioned toward the bottom portion of shoe pin holes **118**, **120**. FIG. **11** also shows that whereas the upper surface of bracket leg **80** abutted upper slot wall **75** of housing **38** when roller **40** engaged a can body wall of a single thickness (FIGS. **8** and **9**), when roller **40** engages side seam SS of double wall thickness, roller pin **50**, roller **40** and bracket **52** are displaced radially downward in slot **74** toward plunger **26**, there is a gap between bracket **52** and upper slot wall **75**. A comparison of FIG. **8** and FIGS. **10** and **11** shows that the displacement of roller **40** caused by the side seam is absorbed by cushioning pads **114**, **116**. It is to be noted that the displacement action of one roller is independent of and does not effect the position or operation of any of the other rollers which might be mounted to pilot **34**.

When spindle assembly **14** has rotated a sufficient number of times to reduce the diameter of straight-walled can body C and form necked-in tubular can body C', plunger **26** is then returned to its extended, forward position so that the biases of helical springs **54**, 56 put a radially downward pressure on bracket **52** and, as the plunger is moved, shoes **58**, **60** pass downwardly along angled plunger cam surfaces **28**, **30** to where they engage plunger planar surfaces **27**, **29**. This cooperative movement of shoes **58**, **60** and plunger **26** move bracket **52**, and pin **50** radially inward towards plunger **26** so that free-wheeling roller **40** is similarly moved and collapsed, leaving a large gap between roller **40** and reducing die chamber surfaces **20**, **22**, **24**. As shown in FIG. **12**, when roller **40** is in its collapsed position, roller **40** does not protrude through slot extension **74'** and necked-in tubular can body C' can be easily removed without interference or obstructtion from roller **40** or spindle assembly **14**. Because bracket **52** is displaced radially inward towards plunger **26**, the gap between the upper surface of bracket **52** and upper slot wall **75** is again enlarged to the extent shown in FIGS. **1**, **2**, **6** and **7**.

From the foregoing description, it can be seen that the method of interior roll necking-in a tubular member in accordance with this invention involves providing an outer reducing die having a chamber which includes an annular inwardly-angled directing surface, and an annular rim-forming surface adjoining and axially interior of the directing surface, providing a rotatable roller mounted on a pilot axially interior of the chamber, axially aligning the marginal edge portion of the wall of an open end of a tubular member with the chamber mouth, and axially moving the marginal edge portion gradually into the die chamber so that the outer surface of the marginal edge portion engages one of the chamber surfaces, and simultaneously with the axial moving step, moving the roller vertically towards the rim-forming surface and spinning a portion of the marginal edge portion against the chamber surfaces so that the chamber surfaces impart a neck of reduced diameter to a portion of the marginal edge portion of the tubular member. The method can also include the step of allowing the roller to move radially inward away from the marginal edge portion to compensate for any extra thickness in the wall of the marginal edge portion of the tubular member.

Although the preferred method described involves moving a substantially straight-walled tubular member or can body into die assembly **10**, there is no limitation to the sequence of operations which can be employed, so that for example, the can body could be held steady by conventional means while die assembly **10** is moved into working relationship therewith. Similarly, although it has been found advantageous to keep spindle assembly **14** rotating continuously, rotation of the assembly can be effected only after roller **40** contacts the can body wall. Any conventional means such as a gear drive can be employed to rotate spindle assembly **14**.

The components of die assembly **10** can be constructed of any suitable materials. For example, outer reducing die **12** can be constructed of carbide steel and roller **40** of hardened chrome-plated steel. Any conventional means such as cam means can be employed for independently advancing and retracting the reducing die and the spindle assembly so that roller **40** is moved axially inward and spins against and necks-in a marginal edge portion of the tubular member, and then is moved radially outward to allow the necked-in can to be removed from the die assembly.

Although roller **40** is shown having first and second cylindrical portions **44** and **46,** roller **40** need only comprise second cylindrical portion **48** and frustoconical portion **46** and a small orienting surface adjacent frustoconical portion **46,** because the marginal edge portion of can body C is substantially straight initially and the only portions of die assembly **10** which actually reduce the diameter of the can body wall are inwardly-angled outer die directing surface **22,** roller frustoconical portion **46,** and outer die rim-forming surface **24** and second cylindrical roller portion **48.** When an outer die guiding surface **20** is employed, it has been found advantageous to provide it with a diameter slightly larger than the outer diameter of tubular can body C so that when the marginal edge portion of the can body is between guiding surface **20** and, for example, cylindrical roller portion **44,** a clearance is provided which allows variations in thicknesses of can body walls and facilitates moving of the can body wall marginal edge portion into the groove a gap between die directing surface **22** and frustoconical roller portion **46.**

Although it has been found advantageous to employ three rollers mounted within three brackets as shown in FIG. **3,** more or less rollers can be employed though the speed of the rotation of the spindle must respectively be decreased and the speed of the feed of the can body into the die assembly varied accordingly. Also, portions of the means for mounting roller **40** need not be as shown, for example, the camming surfaces on shoes **58, 60** and on plunger **26** could be reversed so that rollers **40** would be collapsed when plunger **26** is fully withdrawn into die assembly **10,** and fully expanded when plunger **26** is extended forward but not outside the plane of faceplate **36** of pilot housing **38.**

It is thought the invention and many of its attendant advantages will be understood from the foregoing description and it will be apparent that various changes may be made in the form, construction and arrangement of parts of the die assembly mentioned herein and in the steps and order of their accomplishment in the method described herein, without departing from the spirit and scope of the invention or sacrificing all of its material advantages, the die assembly and method hereinbefore described being merely a preferred embodiment thereof.

We claim:

1. A die assembly for interior roll-necking-in an end portion of a tubular member comprising:

an outer reducing die having a chamber whose walls include an annular inwardly-angled directing surface and an annular rim-forming surface adjoining and axially interior of said directing surface,

a rotatable spindle assembly concentrically mounted within said outer reducing die, said spindle assembly including

a. an axially-movable elongated plunger having cam surfaces thereon,

b. a hollow spindle having pilot mounting means thereon,

c. a pilot, said pilot including

i. a cylindrical housing mounted onto said pilot mounting means, said housing having inner and outer end walls, a circumferential sidewall, a bore running from said inner end wall axially through said housing for receiving said plunger, a slot, and a slot extension formed in said side wall, said slot communicating axially with said bore and extending radially from said bore through said slot extension,

ii. a free-wheeling roller mounted within said housing in a manner that the axis of said roller is parallel to the axis of said housing, said roller including a frustoconical portion and an adjoining axially-interior cylindrical portion, the circumferential profile of said roller substantially corresponding to the profile of said outer reducing die chamber surfaces,

iii. means for mounting said roller within said housing slot so that its axis is parallel to that of said housing and so that said roller is radially movable within said slot,

iv. biasing means for biasing said roller radially inward toward said plunger,

v. means for moving said roller radially outward to allow the outer surfaces of said frustoconical and cylindrical roller portion to protrude through said slot extension in said side wall to allow the surfaces of said roller portions to engage the interior wall surfaces of a tubular member placed within the outer reducing die, and

vi. means for axially retaining said roller mounting means within said slot;

vii. means for rotating said pilot housing; and means for independently advancing and retracting said plunger such that when a marginal edge portion of said tubular member is within said reducing die chamber, all of said previously recited means cooperate to move said roller axially outward and cause it to spin against and neck-in said portion of said tubular member and to move said roller radially inward away from said necked-in portion so that said necked-in portion clears said roller when said tubular member is withdrawn from said die assembly.

2. The die assembly of claim **1** wherein said roller mounting means includes bracket means including a substantially U-shaped bracket radially slideably seated within said slot, said bracket having a backwall and legs extending perpendicularly from said backwall for mounting said roller between the legs, roller pin holes extending axially into said bracket legs, and a roller pin for pin-mounting said roller thereon, said roller being pin mounted on said pin between said legs.

3. The die assembly of claim **2** wherein said roller mounting means includes bracket cam surfaces which cooperate with said plunger cam surfaces to allow said roller to be moved radially outward and inward as said respective cam surfaces engage and disengage each other when said plunger is moved axially through said housing.

4. The die assembly of claim **3** wherein said biasing means includes a helical spring mounted radially between and having its end portions engaging portions of said housing and said bracket.

5. The die assembly of claim **4** wherein one of said bracket legs has a cutout therein running substantially the length of and through a portion of said leg, said cutout being for seating said helical spring therein.

6. The die assembly of claim **2** wherein said roller mounting means includes cam surfaces on said plunger, a pair of cavities in said bracket, each cavity being cut vertically into said bracket backwall and extending into one of said legs, a pair of shoe pins for mounting shoes thereon, axial pin holes in said bracket each pin hole communicating with each of said cavities, and a pair of shoes, each of said shoes being pin-mounted in one of said cavities, each of said shoes having a top and bottom, said bottom having an angled cam surface thereon exposed beyond the plane of said bracket backwall, each of said plunger and shoe cam surfaces being cooperative to allow said roller to be moved radially outward and inward as said respective plunger and shoe cam surfaces engage and disengage each other when said plunger is moved axially through said housing.

7. The die assembly of claim **6** wherein said bracket legs include resilient cushioning means seated in said cavities and held there by said shoe top walls, and wherein the diameter of said shoe pin holes are larger than the diameter of said shoe pins so that said shoes are loosely pin-mounted to said bracket, to allow said shoes to slide radially in said bracket cavities and thereby compensate for any variations in wall thickness of said tubular member.

8. The die assembly of claim **7** wherein said roller mounting means includes bracket cam surfaces which cooperate with said plunger cam surfaces to allow said roller to be moved radially outward and inward as said respective cam surfaces engage and disengage each other when said plunger is moved axially through said housing.

9. The die assembly of claim **8** wherein said biasing means includes a helical spring mounted in said cutout radially between and having its end portions engaging portions of said housing and said bracket.

10. The die assembly of claim **9** wherein said pilot includes a plurality of said rollers pin-mounted to said roller housing.

11. A method of interior roll-necking-in a tubular member which comprises:

providing an outer reducing die having a chamber whose walls include an annular inwardly-angled directing surface, and an annular rim-forming surface adjoining and axially interior of said directing surface,

providing a plurality of rotatable rollers pin-mounted to a pilot axially interior of said die chamber in a manner that the axes of the rollers are parallel to that of the pilot.

axially aligning the marginal portion of the wall of an open end of a tubular member with the chamber mouth,

axially moving said marginal edge portion gradually into the die chamber so that the outer wall surface of the marginal edge portion engages one of said chamber surfaces, and

simultaneously with said axial moving step, moving said rollers vertically towards said rim-forming surface in a manner that the axes of the rollers remain parallel to that of the pilot, and spinning a portion of said marginal edge portion against said chamber surfaces so that said rim-forming surface imparts a neck of reduced diameter to said portion of said marginal edge portion of said tubular member.

12. The method of claim **11** wherein there is included the step of compensating for extra thicknesses in said wall of said marginal edge portion of said tubular member by allowing each of said rollers to move independently radially inward away from said marginal edge portion when each of said rollers engages a portion of said wall marginal edge portion which is thicker than the rest of the wall of said tubular member.

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