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DRAWINGS ATTACHED

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(54) METHOD AND MEANS FOR PRODUCING CASES HAVING ROUNDED SIDES AND BEING OPEN AT BOTH ENDS

(71) I, JOHANNES SIGURD PEDERSEN, a subject of the King of Denmark, trading as AARHUS METALEMBALLAGE INDUSTRI, of 89 Gjellerupvej, Aabyhoej, Denmark, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of producing a case from a blank consisting of a rectangular piece of sheet-metal, the case being rounded at two opposite sides, preferably of circular cross-section, and open at both ends, one of said two rounded case sides being formed by a zone of the blank on both sides of a middle line thereof, the other one of said rounded case sides being formed by the two borders of the blank parallel to said middle line.

In the production of metal cases from rectangular pieces of sheet-metal hitherto the adjoining edges of the work have been interconnected by seaming. This involves, however, the development of a longitudinal bead, usually inside the case. In many cases, and particularly when the cases produced are of small dimensions, such as those used for small electric cells, and particularly when the cases are of circular cross section or when the length of the cross-section is only slightly larger than its width, such beads cannot be tolerated.

It has been proposed to produce such cases by drawing, so that the wall of the case is smooth, but this procedure has proved to be too expensive. Such drawn cases require a considerable number of finishing operations, partly to obtain the exact required length of the case, and partly to apply thereto the printings frequently required.

Only in a very few cases is the case required to be liquid-tight or air-tight, and, therefore, it has also been proposed to produce such cases by a bending-process. The methods hitherto proposed for such a bend-

ing-process result in a gap being provided between the adjoining edges of the work-piece, and this gap has such a width that during transport or when passing a sorting and distributing drum, the cases are pushed into one another, and that agglomerations result, which can be separated by hand only. An object of the present invention is to obviate or at least mitigate the above disadvantages.

According to a first aspect of the invention, there is provided a method of producing a case from a blank consisting of a rectangular piece of sheet-metal, the case being rounded at two opposite sides and open at both ends, one of said two rounded case sides being formed by a zone of the blank on both sides of a middle line thereof, the other one of said rounded case sides being formed by the two borders of the blank parallel to said middle line, in which method

- I the blank is bent by pressing along both borders to provide curved border zones each having at cross-section subtending an angle of from 75° to 120°, and having a radius of curvature smaller than the final radius of one of the two rounded case sides to be formed by the two borders of the blank;
- II the workpiece thus obtained is bent to a symmetrical U-shape along its middle line with the two curved border zones facing each other and with the bottom of the U subtending an angle of from 125° to 175° and having a radius of curvature smaller than the radius of one of the two rounded sides of the case formed about the middle line of the workpiece; and
- III the now U-shaped workpiece is placed on a mandrel having a cross-section corresponding to the internal cross-section of the case to be produced, but having smaller dimensions so as to produce a sliding fit, whereupon the work-piece, is pressed between first and second press dies, the recesses of which

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together define a cavity having dimensions; corresponding to the external dimensions of the case to be produced, and each being adapted to form the entire rounding of the case along a corresponding side thereof, said first die being adapted to act on the workpiece symmetrically with respect to the middle line thereof, and said second die being adapted to act on the workpiece symmetrically with respect to the curved border zones of the work, said second die being first pressed towards the mandrel, until the distance between the edges of its recess and the surface of the mandrel exceeds slightly the thickness of the workpiece, whereupon said first die is pressed towards the mandrel, until its distance from the mandrel is of the same order of magnitude as is the distance of said second die from the mandrel, whereafter the said two dies are simultaneously pressed together to enclose the workpiece and the mandrel.

According to a second aspect of the invention, there is provided a mandrel for use in a method as defined in the preceding paragraph, comprising first and second parts for use in stages II and III respectively of the method, said second part having curved side edges and having a smooth transition to said first part, said first part having a longitudinal middle zone adapted to shape the bottom rounding of the U, and side walls receding in relation to the legs of the U-shaped workpiece to be formed by means of said first mandrel part, the centre axis of said second mandrel part being displaced in relation to the centre axis of that zone of said first mandrel part adapted to shape the rounding of the U such that the rounded border zones of the U-shaped workpiece are approximately in alignment with the curved side edges of the second mandrel part.

The result obtained by the present method is probably due to the fact that the internal stresses produced in the plate material through the operations I and II, and tending to open the work, as a consequence of the increase of the radii of curvature of the curved zones provided by operation III, are not only relieved, but also replaced by new internal stresses which, in spite of the longitudinal edges of the case contacting one another without any overlapping, are sufficient to maintain intercontact of the edges under a relatively high pressure.

This pressure becomes particularly high, when the case is of circular cross section, or when it is only moderately avoided but it decreases with increasing length/width ratio of the cross section of the case, as a consequence of the resilience of the resulting flat side-parts of the case. The present method,

can, however, be effectively utilized for producing cases having flat side parts even when, depending on the thickness of the plate, the cross sectional length/width ratio is higher than 3, and for production of cases of elliptical cross sections presenting still higher values of the said ratio.

In most cases it is further an advantage if one of the free ends of the case produced is immediately thereafter provided with a substantially U-shaped beading, whereby the case is made stronger, so that during transportation or handling it will not be deformed by lateral pressures tending to displace the adjoining and contacting longitudinal edges from the position directly opposite to one another, which would involve overlapping of the borders, whereafter it would be difficult to re-condition such cases, and the cases might easily be subjected to further deformation.

With a view to the beading referred to, and to a subsequent, and usually likewise necessary, beading of the other end of the case, it may be appropriate that the rectangular blank used is bevel-cut, at least at the two corners of one end edge thereof, preferably at all four corners.

The present mandrel provides the advantage that, upon completion of stage II of the method, it is only necessary to displace the resulting work axially along the mandrel, which displacement can conveniently be effected through automatic means, and on to the part of the mandrel adapted for the performance of stage III, whereby the work on the mandrel will automatically move into the position most convenient for stage III, with the curved borders arranged close to the corresponding part of the mandrel, and whereby owing to its shape the work is retained firmly in the proper position without use of any retaining means.

In order to enable the invention to be more readily understood, reference will now be made to the accompanying drawings, which illustrate diagrammatically and by way of example an embodiment thereof, and in which:—

Fig. 1 is an elevational view of a blank for use in connection with the method according to the invention;

Figs. 2 and 3 are cross sectional views of the work subsequent to it having been subjected to a first and a second operation respectively;

Fig. 4 is an end view of a case produced by the method according to the invention, viewed towards the non-beaded end,

Figs. 5 and 6 are together an elevational side view of a mandrel adapted for use in connection with the method according to the invention,

Fig. 7 is a top view of one end of the mandrel appearing in Figs. 5 and 6.

Fig. 8 is a cross sectional view taken on line VIII—VIII in Fig. 5, and showing, moreover, a workpiece positioned on the mandrel and a press die for the performance of the second operation, and

Fig. 9 is correspondingly a sectional view taken on line IX—IX in Fig. 5, and further showing press dies not shown in Fig. 5.

The blank 10 to be used for the new method is constituted by a rectangular piece of sheet-metal, as shown in Fig. 1. All corners of the blank 10 are bevel-cut as at 12. The blank 10 is first pressed between two press tools to provide curved borders 14, Fig. 2. The curvature of these borders 14 conforms approximately with a circular arc of an angle of 90° and having a radius of curvature that is 30° smaller than the radius of the circular cylindrical case 16 to be produced, Fig. 4.

The workpiece 10 now obtained and provided with the curved borders 14 is then placed on the right-hand part 18 of the mandrel 20, shown in Figs. 5 and 6.

The mandrel part 18, having a length somewhat exceeding the length of the workpiece 10, is supported by a foot 22, through which it is firmly held in position.

The mandrel part 18 has an upper surface 24 of semi-circular shape and having a radius about 30% smaller than the radius of the case 16 to be produced, shown in Fig. 4. The semi-cylindrical surface 24 continues into parallel, vertical side walls 26 having a height approximately corresponding to $1/5$ of the width of the blank 10, shown in Fig. 1. The mandrel part 18 is connected to the foot 22 by means of a connecting member 28, which is somewhat thinner than the mandrel part 18.

The top of the mandrel part 18 is provided with a longitudinal groove 30, adapted to receive sliding means for displacing the workpiece along the mandrel 20.

When the workpiece 10 (Fig. 2) has been placed symmetrically over the mandrel part 18, it is pressed down over the same by means of a press die 32, Fig. 8, having a length somewhat exceeding the length of the workpiece 10, and provided with a recess 34, the bottom 36 of which has a cross-section formed as a circular arc of an angle of about 150° , and having a radius corresponding to the radius of the mandrel surface 24. The curved bottom 36 continues into outward beveling plane side walls 38, forming between them an angle of about 30° , and each provided at the lower surface of the press die with a curved transition portion 40.

When the workpiece 10, shown in Fig. 2, has been pressed between the mandrel part 18 and the press die 32, it has been given the cross sectional shape shown in Fig. 3, being approximately U-shaped, with the curved bottom 42 of the U following the

middle-line of the workpiece, and having a radius of curvature approximately 30% smaller than the radius of the case to be produced, shown in Fig. 4.

After the second pressing operation stated, the free edges of the curved borders 14 of the workpiece will reach under the mandrel part 18 and have an interdistance slightly larger than the thickness of the connecting part 28. Thus, the work cannot be pulled vertically up from the mandrel, but is pushed by means of sliding means, not shown, guided by the groove 30 and displaced onto the mandrel part 44, shown to the left in Fig. 5, which has a circular cross section with a radius corresponding to the radius of the case 16 to be produced, shown in Fig. 4, but being so much smaller than the latter as corresponding to a sliding fit. Thus the mandrel part 44 has a diameter exceeding the width of the mandrel part 18. The centre axis of the mandrel part 44 is located in alignment with the bottom edges of the side-surfaces 26 of the mandrel part 18. Between the mandrel part 18 and the mandrel part 44, as shown in Fig. 5, there is a transitional part 46, securing a smooth transition between the outer surfaces of the mandrel part 18 and the connecting part 28 and the outer surface of the mandrel part 44. Therefore, when the workpiece is displaced along the mandrel 20, from the mandrel part 18 onto the mandrel part 44, its curved borders 14 will be forced somewhat apart and engage the lower sides of the mandrel part 44, as will be apparent from Fig. 9, and will be retained in this position through the clamping effect thereby obtained.

The mandrel part 44 has a length slightly over double the length of the workpiece 10, and the workpiece is first moved from the mandrel part 18 onto the adjacent part of the mandrel part 44. On this part the workpiece 10 is pressed between a lower die 48 and an upper die 50, having opposite recesses 52 and 54 respectively. Both these recesses 52 and 54 are of semi-cylindrical cross section with the same radius as the external radius of the case 16.

During the pressing operation the lower press die 48 is first forced upwards, until the upper edges of its recess 52 has a distance from the mandrel part 44 slightly exceeding the thickness of the work 10, preferably being double this thickness. Thereafter the upper press die 50 is forced downwards towards the mandrel part 44. Thereby it is pressed against the longitudinal curved portion 42 of the workpiece and forces the workpiece downwards into the recess 52 of the lower press die alongside the walls thereof, whereby the curved borders 14 of the work are expanded to a certain extent, approaching one another at the same time. This displacement of the press die 50 continues,

until it reaches a position approximately symmetrical to the lower press die 48 relative to a horizontal plane through the axis of the mandrel part 44, whereafter both press dies 48 and 50 are pressed symmetrically against one another. Thereby the workpiece is given a cylindrical shape and the edges of the curved borders 14 are in direct contact, exerting a pressure on one another. The press dies 48 and 50 are thereafter again moved apart, and by means of a movable gripper, not shown, the workpiece is moved onto the outer portion of the mandrel part 44, shown in Fig. 6, where the work is allowed to rest during the pressing of the following workpiece 10 between the dies 48 and 50.

At the outer end of the mandrel part 44, by means of a stud 56, Fig. 6, a beading tool 58 is attached having over the greater part of its length the same diameter as has the mandrel part 44, but provided, adjacent thereto, with a circumferential groove 60. The length of the beading tool 58 outside the groove 60 is exactly equal to the length of the case to be produced. At its free end face the beading tool 58 is provided with a bead 62.

The case on the outer portion of the mandrel part 44, after a resting period corresponding to the pressing of a workpiece on the inner portion of the mandrel part 44, is displaced fully onto the beading tool 58, and so that the end-edge thereof facing the mandrel part 44 is located at a small distance from the outer edge 64 of the groove 60. Thereafter a press cheek, not shown, is brought to engage the groove 60 and is forced into close contact with the edge 64. Thereafter a beading tool, known *per se* but not shown, is forced axially towards the case, which when engaged by the tool is displaced to the right in Fig. 6, until its inner end-edge contacts the cheek. The beading tool, thereafter, in co-operation with the beading bead 62, will produce a beading 66 at the outer end-edge of the case, as appears from Fig. 4.

WHAT I CLAIM IS:—

1. A method of producing a case from a blank consisting of a rectangular piece of sheet-metal, the case being rounded at two opposite sides and open at both ends, one of said two rounded case sides being formed by a zone of the blank on both sides of a middle line thereof; the other one of said rounded case sides being formed by the two borders of the blank parallel to said middle line, in which method

I the blank is bent by pressing along both borders to provide curved border zones each having a cross-section subtending an angle of from 75° to 120°, and having a radius of curvature smaller than the final radius of one of

the two rounded case sides to be formed by the two borders of the blank;

II the workpiece thus obtained is bent to a symmetrical U-shape along its middle line with the two curved border zones facing each other and with the bottom of the U subtending an angle of from 125° to 175° and having a radius of curvature smaller than the radius of one of the two rounded sides of the case formed about the middle line of the workpiece; and

III the now U-shaped workpiece is placed on a mandrel having a cross-section corresponding to the internal cross-section of the case to be produced, but having smaller dimensions so as to produce a sliding fit, whereupon the workpiece is pressed between first and second press dies, the recesses of which together define a cavity having dimensions; corresponding to the external dimensions of the case to be produced, and each being adapted to form the entire rounding of the case along a corresponding side thereof, said first die being adapted to act on the workpiece symmetrically with respect to the middle line thereof, and said second die being adapted to act on the workpiece symmetrically with respect to the curved border zones of the work, said second die being first pressed towards the mandrel, until the distance between the edges of its recess and the surface of the mandrel exceeds slightly the thickness of the workpiece, whereupon said first die is pressed towards the mandrel, until its distance from the mandrel is of the same order of magnitude as is the distance of said second die from the mandrel, whereafter the said two dies are simultaneously pressed together to enclose the workpiece and the mandrel.

2. A method as claimed in claim 1 wherein the case is of circular cross-section.

3. A method as claimed in claim 1 or 2 wherein the curved border zones subtend an angle of 90°.

4. A method as claimed in any preceding claim wherein the curved border zones each have a radius after stage I) which is from 20 to 40% smaller than that of the final radius of the sides of the case.

5. A method as claimed in any preceding claim wherein the bottom of the U of stage II) has a radius of curvature which is from 20 to 40% smaller than said two rounded sides of the case.

6. A method as claimed in any preceding claim wherein one of the free end edges of the case produced is immediately thereafter provided with a substantially U-shaped beading.



until it reaches a position approximately symmetrical to the lower press die 48 relative to a horizontal plane through the axis of the mandrel part 44, whereafter both press dies 48 and 50 are pressed symmetrically against one another. Thereby the workpiece is given a cylindrical shape and the edges of the curved borders 14 are in direct contact, exerting a pressure on one another. The press dies 48 and 50 are thereafter again moved apart, and by means of a movable gripper, not shown, the workpiece is moved onto the outer portion of the mandrel part 44, shown in Fig. 6, where the work is allowed to rest during the pressing of the following workpiece 10 between the dies 48 and 50.

At the outer end of the mandrel part 44, by means of a stud 56, Fig. 6, a beading tool 58 is attached having over the greater part of its length the same diameter as has the mandrel part 44, but provided, adjacent thereto, with a circumferential groove 60. The length of the beading tool 58 outside the groove 60 is exactly equal to the length of the case to be produced. At its free end face the beading tool 58 is provided with a bead 62.

The case on the outer portion of the mandrel part 44, after a resting period corresponding to the pressing of a workpiece on the inner portion of the mandrel part 44, is displaced fully onto the beading tool 58, and so that the end-edge thereof facing the mandrel part 44 is located at a small distance from the outer edge 64 of the groove 60. Thereafter a press cheek, not shown, is brought to engage the groove 60 and is forced into close contact with the edge 64. Thereafter a beading tool, known *per se* but not shown, is forced axially towards the case, which when engaged by the tool is displaced to the right in Fig. 6, until its inner end-edge contacts the cheek. The beading tool, thereafter, in co-operation with the beading bead 62, will produce a beading 66 at the outer end-edge of the case, as appears from Fig. 4.

WHAT I CLAIM IS:—

1. A method of producing a case from a blank consisting of a rectangular piece of sheet-metal, the case being rounded at two opposite sides and open at both ends, one of said two rounded case sides being formed by a zone of the blank on both sides of a middle line thereof, the other one of said rounded case sides being formed by the two borders of the blank parallel to said middle line, in which method

I the blank is bent by pressing along both borders to provide curved border zones each having a cross-section subtending an angle of from 75° to 120°, and having a radius of curvature smaller than the final radius of one of

the two rounded case sides to be formed by the two borders of the blank;
II the workpiece thus obtained is bent to a symmetrical U-shape along its middle line with the two curved border zones facing each other and with the bottom of the U subtending an angle of from 125° to 175° and having a radius of curvature smaller than the radius of one of the two rounded sides of the case formed about the middle line of the workpiece; and

III the now U-shaped workpiece is placed on a mandrel having a cross-section corresponding to the internal cross-section of the case to be produced, but having smaller dimensions so as to produce a sliding fit, whereupon the workpiece is pressed between first and second press dies, the recesses of which together define a cavity having dimensions; corresponding to the external dimensions of the case to be produced, and each being adapted to form the entire rounding of the case along a corresponding side thereof, said first die being adapted to act on the workpiece symmetrically with respect to the middle line thereof, and said second die being adapted to act on the workpiece symmetrically with respect to the curved border zones of the work, said second die being first pressed towards the mandrel, until the distance between the edges of its recess and the surface of the mandrel exceeds slightly the thickness of the workpiece, whereupon said first die is pressed towards the mandrel, until its distance from the mandrel is of the same order of magnitude as is the distance of said second die from the mandrel, whereafter the said two dies are simultaneously pressed together to enclose the workpiece and the mandrel.

2. A method as claimed in claim 1 wherein the case is of circular cross-section.

3. A method as claimed in claim 1 or 2 wherein the curved border zones subtend an angle of 90°.

4. A method as claimed in any preceding claim wherein the curved border zones each have a radius after stage I) which is from 20 to 40% smaller than that of the final radius of the sides of the case.

5. A method as claimed in any preceding claim wherein the bottom of the U of stage II) has a radius of curvature which is from 20 to 40% smaller than said two rounded sides of the case.

6. A method as claimed in any preceding claim wherein one of the free end edges of the case produced is immediately thereafter provided with a substantially U-shaped beading.



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7. A method as claimed in any preceding claim, wherein the blank is bevelled at least at two adjacent corners.

8. A method as claimed in claim 7, wherein the blank is bevelled at all four corners.

9. A mandrel for use in a method as claimed in any preceding claim, comprising first and second parts for use in stages II and III respectively of the method, said second part having curved side edges and having a smooth transition to said first part, said first part having a longitudinal middle zone adapted to shape the bottom rounding of the U, and side walls receding in relation to the legs of the U-shaped workpiece to be formed by means of said first mandrel part, the centre axis of said second mandrel part being displaced in relation to the centre axis of that zone of said first mandrel part adapted to shape the rounding of the U such that the rounded border zones of the U-shaped workpiece are approximately in alignment with the curved side edges of the second mandrel part.

10. A mandrel as claimed in claim 9 for use in a method as claimed in claim 7 or 8, wherein a beading tool constituting an extension of the mandrel is provided there being a circumferential groove adapted to receive a press cheek between said beading tool and the mandrel proper, the free end face of said beading tool being provided with a circumferential beading bead, the distance between which and the near edge of said groove being equal to the desired length of the case to be produced.

11. A mandrel as claimed in claim 10 wherein the beading tool is exchangeably connected to the mandrel proper.

12. A method as claimed in claim 6 in

which a mandrel having a beading tool as defined in claim 10 or 11 is used, wherein after the case has been formed on the second mandrel part, it is displaced onto the beading tool over such a length that its rear edge is situated outside the edge of the groove nearest the free end face of the beading tool, and thereupon a press cheek is brought to engage the groove and to press against the last said edge thereof, whereafter a beading die is pressed axially against the free edge of the case, now located outside the end face of the beading tool, for displacing the case towards the press cheek and in co-operation with the beading bead of the end face to provide the last said end edge of the case with the beading.

13. A method of producing a metal case, rounded at two opposite sides and open at both ends, from a blank consisting of a rectangular flat piece of sheet-metal, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

14. A mandrel for use in producing cases rounded at two opposite sides and open at both ends, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

15. A case of sheet-metal rounded at two opposite sides and open at both ends, produced by a method as claimed in any one of claims 1 to 8, 12 or 13.

FITZPATRICKS,
Chartered Patent Agents,
Warwick House, Warwick Court,
London, WC1R 5DJ,
and
14-18 Cadogan Street,
Glasgow, C.2.

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