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(54) Device for sheet metal forming in surface critical panels

(57) A sheet metal forming apparatus (**8**) for preventing surface defects (**2**) in a perimeter area (**6**) around a local depression (**4**) in a larger forming area (**1**). The apparatus (**8**) comprises a first main forming body (**12**) and a second main forming body (**14**), at least one of said main forming bodies (**12, 14**) being movable towards the other for forming a sheet metal blank (**10**) there-between into a desired shape. The invention is especially characterized in- a separate sub-forming member (**18**) provided in the first main forming body (**12**) at a position corresponding to said local depression (**4**). In a first phase, the forming of said local depression (**4**) is completed before the second main forming body (**14**) reaches a final abutment position and before the sub-forming member (**18**) reaches a retracted position. Then, in a second phase, the sheet metal blank (**10**) within said perimeter area (**6**) is stretched radially outwards around the local depression (**4**) due to continued travel of the sub-forming member (**18**) immediately before the second main forming body (**14**) reaches its final abutment position and before the sub-forming member (**18**) reaches its retracted position.

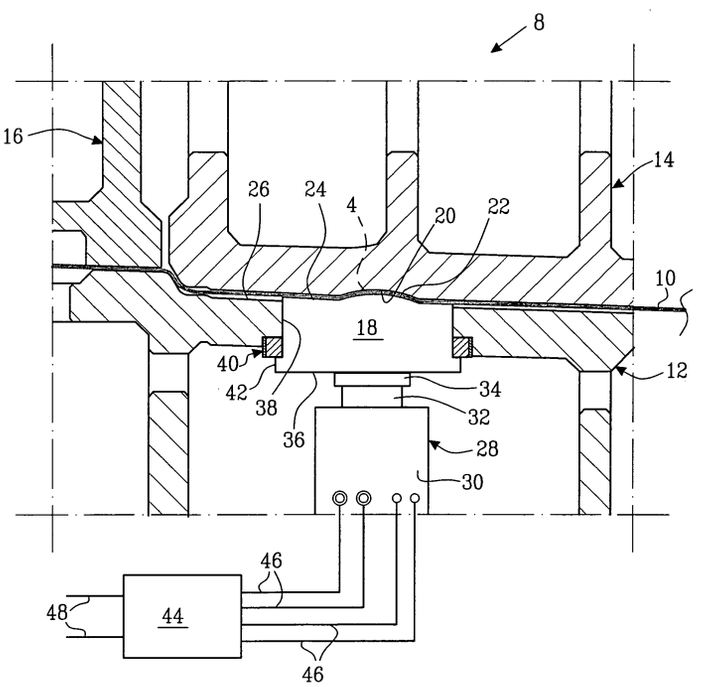

FIG.3

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Description

TECHNICAL FIELD

[0001] The present invention relates to a sheet metal forming apparatus and method for preventing surface defects in a perimeter area around a local depression in a larger forming area. The apparatus comprises a first main forming body and a second main forming body, at least one of said main forming bodies being movable towards the other for forming a sheet metal blank there-between into a desired shape.

BACKGROUND

[0002] Current methods of sheet metal forming may result in minor surface defects around local depressions or abrupt form changes. These defects are particularly undesirable in so called surface critical areas, which may for example be found on automobile body panels. An example of such a surface critical area is a door handle depression in an outer car door panel. Any surface defects in this area will lead to either a rejection of the panel or extensive and costly surface refinishing work.

[0003] The surface defects occur as a result of substantial local variations in tension around the depression as the metal is formed, which in current methods of production often leads to several permanent defects, in the form of uneven surfaces, left after the sheet metal springs back as the formed panel is released and ejected from the forming apparatus.

SUMMARY OF THE INVENTION

[0004] The above mentioned problem is solved by the invention providing a sheet metal forming apparatus for preventing surface defects in a perimeter area around a local depression in a larger forming area. The apparatus comprises a first main forming body and a second main forming body, at least one of said main forming bodies being movable towards the other for forming a sheet metal blank there-between into a desired shape. The invention is especially characterized in:

- a separate sub-forming member provided in the first main forming body at a position corresponding to said local depression,
- said sub-forming member being movably arranged between:
- a protruding position, in which a form surface on the sub-forming member protrudes relative to a surrounding form surface of the first main forming body, and
- a retracted position, in which the form surface on the sub-forming member is level with said surrounding form surface,
- said sub-forming member being biased towards its protruding position by means of a spring element,

whereby, in a first phase, the forming of said local depression is completed before the second main forming body reaches a final abutment position and before the sub-forming member reaches its retracted position, and whereby, in a second phase, the sheet metal blank within said perimeter area is stretched radially outwards around the local depression due to continued travel of the sub-forming member immediately before the second main forming body reaches its final abutment position and before the sub-forming member reaches its retracted position.

[0005] In an advantageous embodiment of the invention, the forming of said local depression is adapted to be completed when the second main forming body is at a distance not exceeding 10 mm from its final abutment position.

[0006] In a well adapted embodiment, the forming of said local depression is adapted to be completed when the second main forming body is at a distance not exceeding 4 mm from its final abutment position.

[0007] In a suitable embodiment, the first main forming body is a stationary die and the second main forming body is a movable punch.

[0008] Advantageously, the sub-forming member is adapted to remain in its retracted position during ejection of a finished sheet metal part.

[0009] In a well functioning embodiment, the protrusion distance of the sub-forming member in its protruding position is adjustable by means of an exchangeable spacer element seated between the first main forming body and an abutment flange provided on the sub-forming member.

[0010] In an advantageous embodiment, the spring element is a gas spring assembly. However, it may alternatively be of another suitable kind, such as a coil spring assembly.

[0011] The invention also includes a sheet metal forming method for preventing surface defects in a perimeter area around a local depression in a larger forming area. The method includes the use of a forming apparatus comprising a first main forming body and a second main forming body, at least one of said main forming bodies being movable towards the other for forming a sheet metal blank there-between into a desired shape. The method is especially characterized in:

- a first phase, during which the local depression is formed between the second main forming body and a separate sub-forming member provided in the first main forming body at a position corresponding to said local depression, said sub-forming member being movably arranged between a protruding position, in which a form surface on the sub-forming

member protrudes relative to a surrounding form surface of the first main forming body, and a retracted position, in which the form surface on the sub-forming member is level with said surrounding form surface, said sub-forming member being biased towards its protruding position by means of a spring element, in such a way that said local depression is completed before the second main forming body reaches a final abutment position and before the sub-forming member reaches its retracted position, and

- a second phase, during which the sheet metal blank within said perimeter area is stretched radially outwards around the local depression due to continued travel of the sub-forming member immediately before the second main forming body reaches a final abutment position and before the sub-forming member reaches its retracted position.

[0012] Further features and advantages of the invention will be described in the detailed description of embodiments below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention will now be described in greater detail by way of example only and with reference to the attached drawings, in which

Fig. 1 shows a schematic illustration of surface defects around a door handle depression as produced with current production methods;

Fig. 2 shows a schematic cross-sectional view of a sheet metal forming apparatus according to an embodiment of the invention. The view shows the apparatus in an initial position, wherein a sheet metal blank to be formed has been inserted between the first and second main forming bodies;

Fig. 3 shows a schematic cross-sectional view of the sheet metal forming apparatus as seen in Fig. 2, only in an intermediate position, in which the depression is completed before the second main forming body reaches a final abutment position and before the sub-forming member reaches its retracted position, and

Fig. 4 finally shows a schematic cross-sectional view of the sheet metal forming apparatus as seen in Figs 2 and 3, only in a final position, in which the second main forming body has reached a final abutment position and the sub-forming member is in its retracted position.

DESCRIPTION OF EXEMPLIFYING EMBODIMENTS

[0014] In **Fig. 1,** part of a car door panel **1** is shown as an example of surface defects **2** around a door handle depression **4**, as produced with current, prior art production methods. The surface defects **2** are drawn with dashed lines in **Fig. 1** and - as described initially - frequently occurs as a result of substantial local variations in tension around the depression as the metal is formed. More particularly, the undesired surface defects **2** are in the form of uneven surfaces which are left after the sheet metal springs back as the formed car door panel **1** is released and ejected from the prior art forming apparatus (not shown). It is the general object of the present invention to prevent such surface defects **2** from occurring in a perimeter area **6** around a local depression **4** - in this case the door handle depression - in a larger forming area **1** (i.e. in this case the car door panel). The perimeter area **6** is loosely shown in **Fig. 1** with bold face dash-dotted lines.

[0015] **Fig. 2** shows a schematic cross-sectional view of a sheet metal forming apparatus **8** according to an exemplifying embodiment of the present invention. The view in **Fig. 2** shows the apparatus **8** in an initial position, wherein a sheet metal blank **10** to be formed has been inserted between a first main forming body **12** and a second main forming body **14.** In the widest meaning, at least one of said main forming bodies **12, 14** is movably arranged in a known manner by means of hydraulic or pneumatic actuators (not shown) towards the other for forming the sheet metal blank **10** there-between into a desired shape. However, in the shown exemplifying embodiment, the first main forming body **12** is a stationary die and the second main forming body **14** is a movable punch positioned directly above the die. Thus, in this case, the forming movement is vertical, which is generally the most common arrangement due to the weight and size of the forming apparatus **8.** In the automotive industry, the most common material for car body panels is still steel sheet material, but it should be understood that other metals, such as aluminium may alternatively be used as the sheet metal blank **10**. The thickness of the sheet metal blank **10** is preferably uniform and commonly ranging between 0.5 - 1.5 mm, depending on application.

[0016] The skilled man in the art will recognise that the shown orientation and labelling of constituent parts, such as for example the first main forming body **12** and the second main forming body **14,** are not used here in a limiting sense. Alternatively - where appropriate - the first main forming body **12** may thus be referred to as a lower die, whilst the second main forming body **14** may be referred to as an upper punch.

[0017] In a known manner, the sheet metal blank **10** is held in place during the forming by means of a blank holder **16** which is retractable after the forming of the sheet metal blank **10** is finished. Since this is a well-established feature, it will not be discussed in further de-

tail here.

[0018] According to the invention, a separate, movable sub-forming member **16** is provided in the first main forming body **12** at a position corresponding to the local depression **4**. In **Figs. 2-4,** the local depression **4** constitutes a door handle depression in a car door panel **1**, such as the one shown in **Fig. 1**. It should be noted that the apparatus and method is specially suited for application on so called surface critical areas, such as automobile body panels (in this case) or surfaces on other products where high demands on an even finished surface apply.

[0019] For forming the local depression **4**, a form recess **20** is formed in the second main forming body **14** (i.e. the punch in this case), which recess **20** is adapted for engagement with a corresponding projection **22** in a form surface **24** on the movable sub-forming member **18.**

[0020] The sub-forming member **18** is movably arranged between a protruding position, as shown in **Figs 2 and 3,** and a retracted position, as shown in **Fig. 4**. The significance of these two positions will be made readily apparent below.

[0021] In the protruding position, the form surface **24** on the sub-forming member **18** protrudes relative to a surrounding form surface **26** of the first main forming body **12**, i.e. upwards in **Fig. 2**.

[0022] In the retracted position, the form surface **24** on the sub-forming member **18** is level with the surrounding form surface **26.**

[0023] A further feature of the invention is that the sub-forming member **18** is biased towards its protruding position by means of a spring element **28**. The spring element will be further described below.

[0024] In a first phase according to the invention, the forming of said local depression **4** is completed - i.e. fully formed - before the second main forming body **14** reaches a final abutment position and before the sub-forming member **18** reaches its retracted position. Then, in a second phase, the sheet metal blank **10** within said perimeter area **6** is stretched radially outwards around the local depression **4** due to continued travel of the sub-forming member **18** immediately before the second main forming body **14** reaches its final abutment position and before the sub-forming member **18** reaches its retracted position. The term *immediately* here corresponds to the last few millimeters - or thereabout - of the sub-forming member's **18** downward travel.

[0025] The sheet metal forming method for use with the above-described apparatus **8**, thus involves:

- a first phase, during which the local depression **4** is formed between the second main forming body **14** and the separate sub-forming member **18**, and
- a second phase, during which the sheet metal blank **10** within said perimeter area **6** is stretched radially outwards around the local depression **4** due to continued travel of the sub-forming member **18** immediately before the second main forming body **14** reaches a final abutment position and before the sub-forming member **18** reaches its retracted position.

[0026] In **Fig. 3**, the forming of the local depression **4** has just been completed - thus marking the end of the first phase - whereby the sub-forming member **18** begins to move downwards whilst the spring element **28** is compressed - urged by the second main forming body **14**.

[0027] In **Fig. 4,** the second main forming body **14** has reached its final abutment position and the sub-forming member **18** has reached its retracted position, in which the spring element **28** is now fully compressed. Thus, the second phase, which may also be referred to as a stretching phase, is now completed. The sheet metal blank **10** within said perimeter area **6** is - as described above - stretched radially outwards around the local depression **4**, resulting in a more even tension around the local depression **4,** in comparison with prior art forming apparatuses. This even tension prevents the undesired forming of surface defects **2** during spring back in the perimeter area **6** around the local depression **4** in the larger forming area **1** (In this case the car door panel, as illustrated in **Fig. 1).**

[0028] Suitably, the forming of said local depression **4** is completed when the second main forming body **14** is at a distance not exceeding 10 mm from its final abutment position. Succesful tests have been performed at distances ranging from 1-10 mm. More preferably, said distance does not exceed 4 mm from its final abutment position. In an advantageous embodiment in the shown door handle depression application, this distance is preferably in close proximity of 3 mm.

[0029] In the shown embodiment, the spring element **28** is a gas spring assembly, known per se. However, it should be noted that the spring element **28** may alternatively be a coil spring assembly or an assembly comprising an elastically compressible cushion element (not shown). The spring element **28** comprises a cylinder housing **30** and a piston **32,** which piston is arranged in the cylinder housing **30** for movement in the axial direction of the same, i.e. vertically in the shown exemplifying **Figs. 2-4**. The cylinder housing **30** is fixedly attached to the first main forming body **12**, whilst a distal end **34** of the piston is attached to a rear face **36** of the sub-forming member **18.** Preferably, the spring element **28** is of a controllable type, so that the sub-forming member **18** is adapted to remain in its retracted position (as seen in **Fig. 4**) during ejection of a finished sheet metal part. This is achieved by locking the piston **32** in a bottom position and controlling the return stroke of the piston **32.** The spring element **28** is controlled by a control valve unit **44,** which is connected to the cylinder housing **30** via gas & air control conduits **46**. The control valve unit **44** is further connected sources of pressurized air and gas (not shown) via gas & air supply conduits **48**.

For the sake of clarity, the control valve unit **44**, the gas & air control conduits **46** and the gas & air supply conduits **48** are simplified in **Figs. 2-4,** and are drawn schematically.

[0030] In one embodiment of the invention, the spring element **28** biases the sub-forming member **18** with a force (upwardly directed in **Figs. 2-4**) which is sufficient to hold the sub-forming member **18** in a fixed axial position during the first phase until the forming of the local depression **4** is completed and which is then overcome by the second main forming body **14,** thus initiating continued travel in the second phase when the stretching action takes place. In an alternative embodiment, the biasing force is slightly lower, so as to allow continuous downward travel of the sub-forming member **18** also during the first phase, i.e. during the forming of the local depression **4**.

[0031] With reference again to **Fig. 2**, the sub-forming member **18** is axially movable within a bore **38** in the first main forming body **12.** In the shown embodiment, the protrusion distance **D** of the sub-forming member **18** in its protruding position may be adjusted by means of an exchangeable annular spacer element **40** seated between the first main forming body **12** and an abutment flange **42** provided on the sub-forming member **18.** The spacer element **40** is preferably made of steel, but may also be made of other suitable materials. By the term *protrusion distance,* **D,** is meant the distance between the form surface on the sub-forming member **18** and the surrounding form surface **26** of the first main forming body **12,** in the axial direction of the sub-forming member **18**. If the bias-force is adjusted so as to allow continuous downward travel of the sub-forming member **18** also during the first phase, i.e. during the forming of the local depression **4**, the sub-forming member **18** correspondingly has an initial protrusion distance which will accommodate for sufficient axial travel both for the first phase and the second phase of operation..

[0032] Finally, it is to be understood that the invention is by no means limited to the embodiments described above, and may be varied freely within the scope of the appended claims. For example, the first main forming body may be provided with several separate sub-forming members **18** in conjunction with respective local depressions **4** in one large forming area **1**.

LIST OF REFERENCE NUMERALS:

[0033]

1. Car door panel (or Larger forming area)
2. Surface defects (resulting from Prior Art methods)
4. Local depression (e.g. door handle depression)
6. Perimeter area around local depression
8. Sheet metal forming apparatus
10. Sheet metal blank
12. First main forming body
14. Second main forming body
16. Blank holder
18. Sub-forming member
20. Recess in second main forming member
22. Projection on sub-forming member
24. Form surface on sub-forming member
26. Surrounding form surface on first forming member
28. Spring element
30. Piston
32. Cylinder housing
34. Distal end of piston
36. Rear face of sub-forming member
38. Bore for sub-forming member
40. Spacer element
42. Abutment flange
44. Control valve unit
46. Gas & air control conduits
48. Gas & air supply conduits
D: Protrusion distance for sub-forming member

Claims

1. Sheet metal forming apparatus (**8**) for preventing surface defects (**2**) in a perimeter area (**6**) around a local depression (**4**) in a larger forming area (**1**), said apparatus (**8**) comprising a first main forming body (**12**) and a second main forming body (**14**), at least one of said main forming bodies (**12, 14**) being movable towards the other for forming a sheet metal blank (**10**) there-between into a desired shape, **characterized in**:

- a separate sub-forming member (**18**) provided in the first main forming body (**12**) at a position corresponding to said local depression (**4**),
- said sub-forming member (**18**) being movably arranged between:
  - a protruding position, in which a form surface (**24**) on the sub-forming member (**18**) protrudes relative to a surrounding form surface (**26**) of the first main forming body (**12**), and
  - a retracted position, in which the form surface (**24**) on the sub-forming member (**18**) is level with said surrounding form surface (**26**),
  - said sub-forming member (**18**) being biased towards its protruding position by means of a spring element (**28**),

whereby, in a first phase, the forming of said local depression (**4**) is completed before the second main

forming body (**14**) reaches a final abutment position and before the sub-forming member (**18**) reaches its retracted position, and
whereby, in a second phase, the sheet metal blank (**10**) within said perimeter area (**6**) is stretched radially outwards around the local depression (**4**) due to continued travel of the sub-forming member (**18**) immediately before the second main forming body (**14**) reaches its final abutment position and before the sub-forming member (**18**) reaches its retracted position.

2. Apparatus (**8**) according to claim 1, **characterized in that** the forming of said local depression (**4**) is adapted to be completed when the second main forming body (**14**) is at a distance not exceeding 10 mm from its final abutment position.

3. Apparatus (**8**) according to claim 2, **characterized in that** the forming of said local depression (**4**) is adapted to be completed when the second main forming body (**14**) is at a distance not exceeding 4 mm from its final abutment position.

4. Apparatus (**8**) according to claim 1, 2 or 3, **characterized in that** said first main forming body (**12**) is a stationary die and that said second main forming body (**14**) is a movable punch.

5. Apparatus (**8**) according to any of the preceding claims, **characterized in that** the sub-forming member (**18**) is adapted to remain in its retracted position during ejection of a finished sheet metal part.

6. Apparatus (**8**) according to any of the preceding claims, **characterized in that** the protrusion distance (**D**) of the sub-forming member (**18**) in its protruding position is adjustable by means of an exchangeable spacer element (**40**) seated between the first main forming body (**12**) and an abutment flange (**42**) provided on the sub-forming member (**18**).

7. Apparatus (**8**) according to any of the preceding claims, **characterized in that** the spring element (**28**) is a gas spring assembly.

8. Apparatus (**8**) according to any of claims 1 to 7, **characterized in that** the spring element (**28**) is a coil spring assembly.

9. Sheet metal forming method for preventing surface defects (**2**) in a perimeter area (**6**) around a local depression (**4**) in a larger forming area (**1**), said method including the use of a forming apparatus (**8**) comprising a first main forming body (**12**) and a second main forming body (**14**), at least one of said main forming bodies (**12, 14**) being movable towards the other for forming a sheet metal blank (**10**) there-between into a desired shape,
characterized in:

- a first phase, during which the local depression (**4**) is formed between the second main forming body (**14**) and a separate sub-forming member (**18**) provided in the first main forming body (**12**) at a position corresponding to said local depression (**4**), said sub-forming member (**18**) being movably arranged between a protruding position, in which a form surface (**20**) on the sub-forming member (**18**) protrudes relative to a surrounding form surface (**24**) of the first main forming body (**12**), and a retracted position, in which the form surface (**24**) on the sub-forming member (**18**) is level with said surrounding form surface (**26**), said sub-forming member (**18**) being biased towards its protruding position by means of a spring element (**28**), in such a way that said local depression (**4**) is completed before the second main forming body (**14**) reaches a final abutment position and before the sub-forming member (**18**) reaches its retracted position, and

- a second phase, during which the sheet metal blank (**10**) within said perimeter area (**6**) is stretched radially outwards around the local depression (**4**) due to continued travel of the sub-forming member (**18**) immediately before the second main forming body (**14**) reaches a final abutment position and before the sub-forming member (**18**) reaches its retracted position.

10. Method according to claim 9, **characterized in that** the sub-forming member (**18**) remains in its retracted position during ejection of a finished sheet metal part.

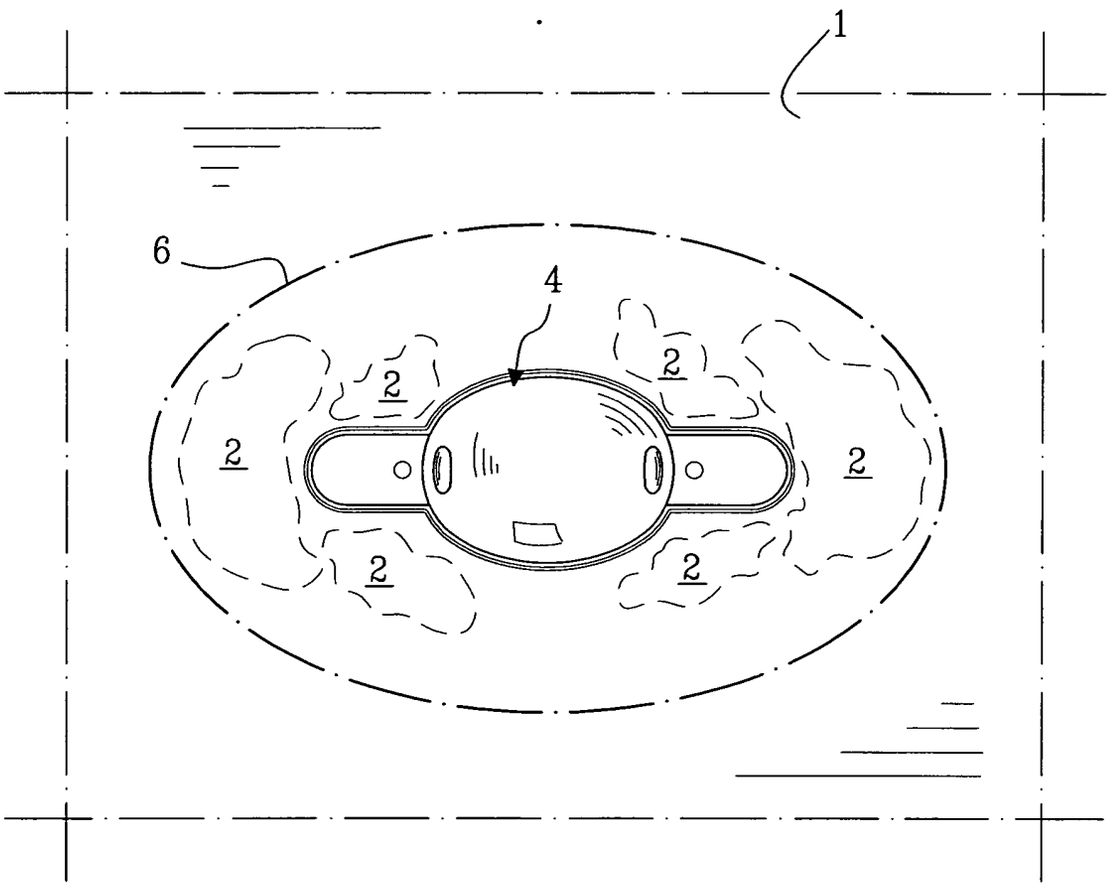

FIG. 1

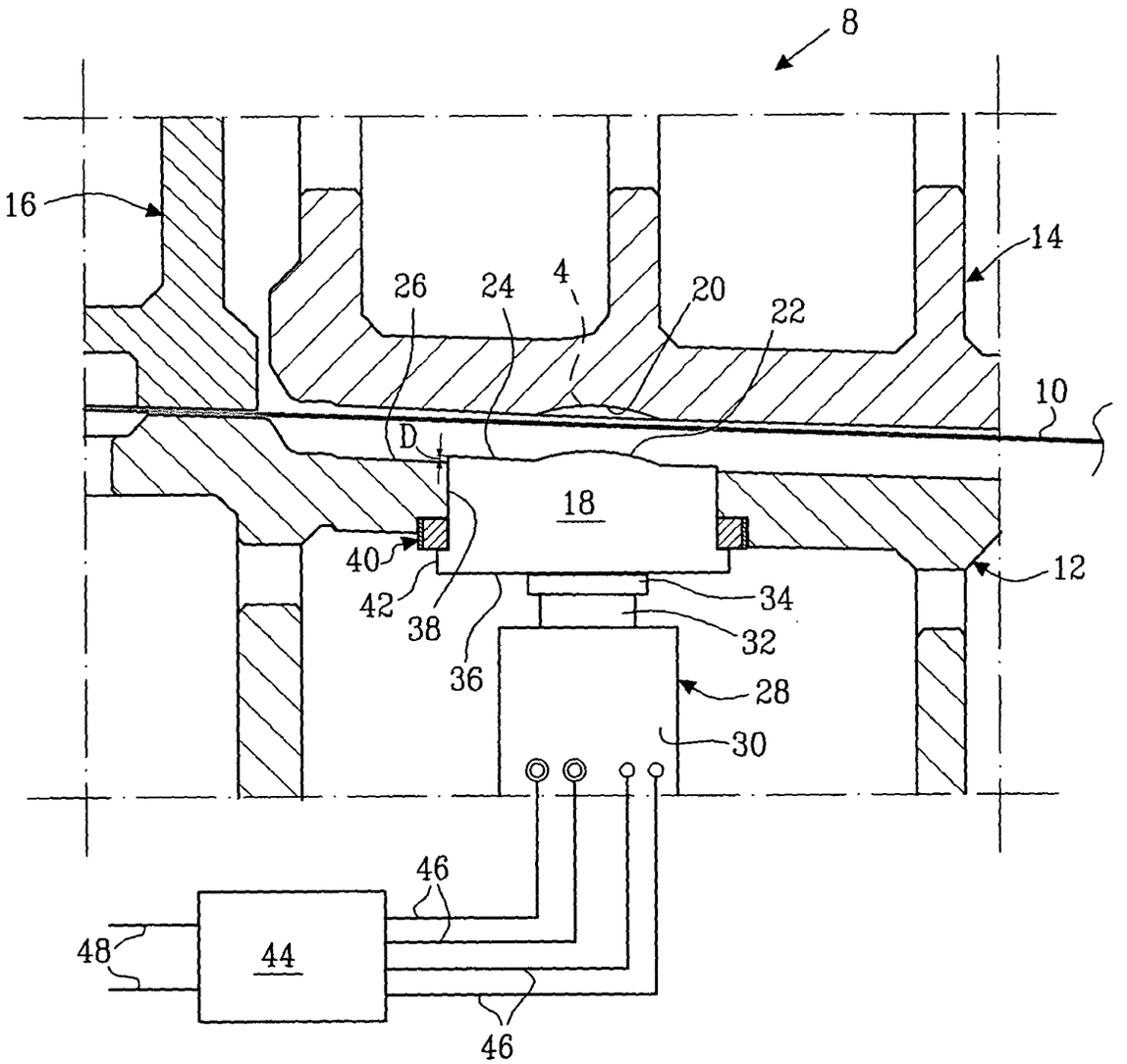

FIG.2

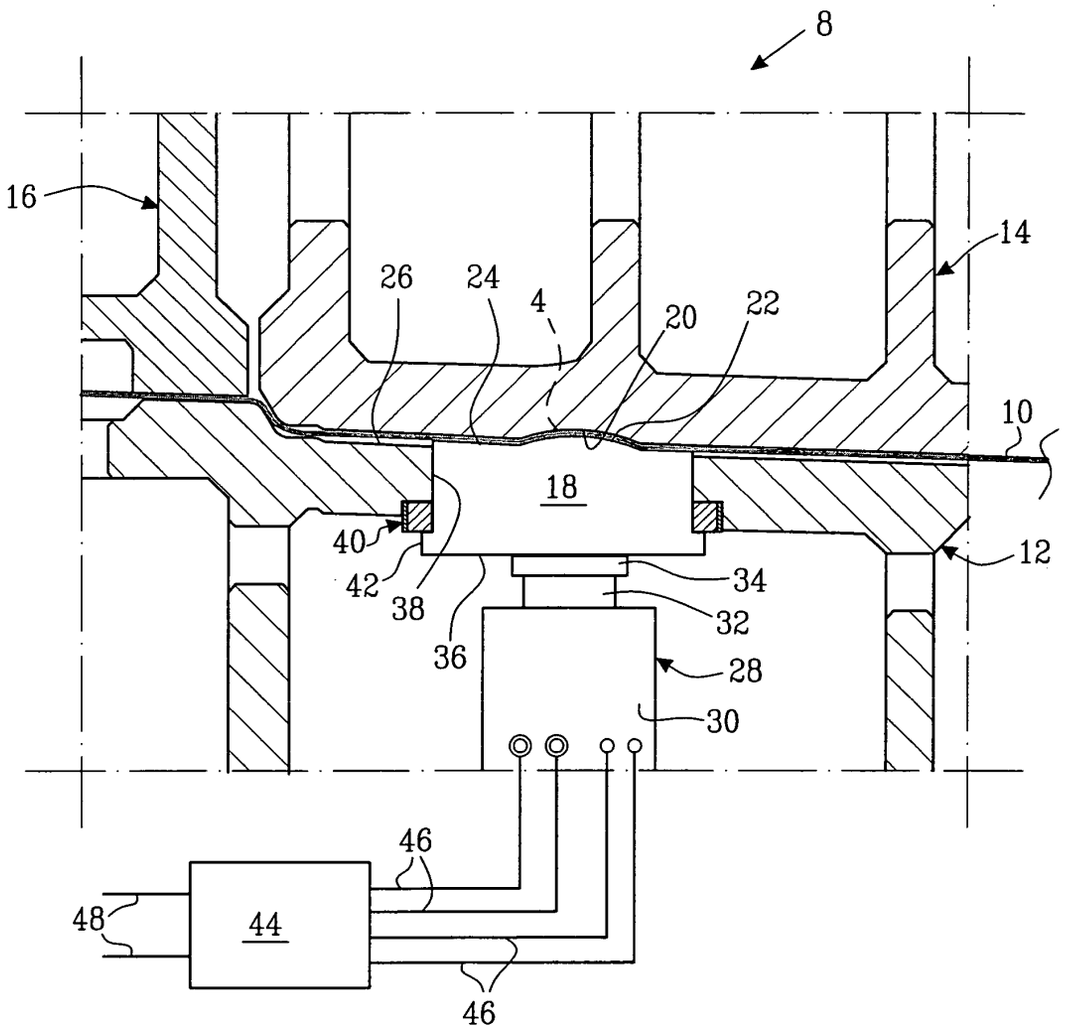

FIG.3

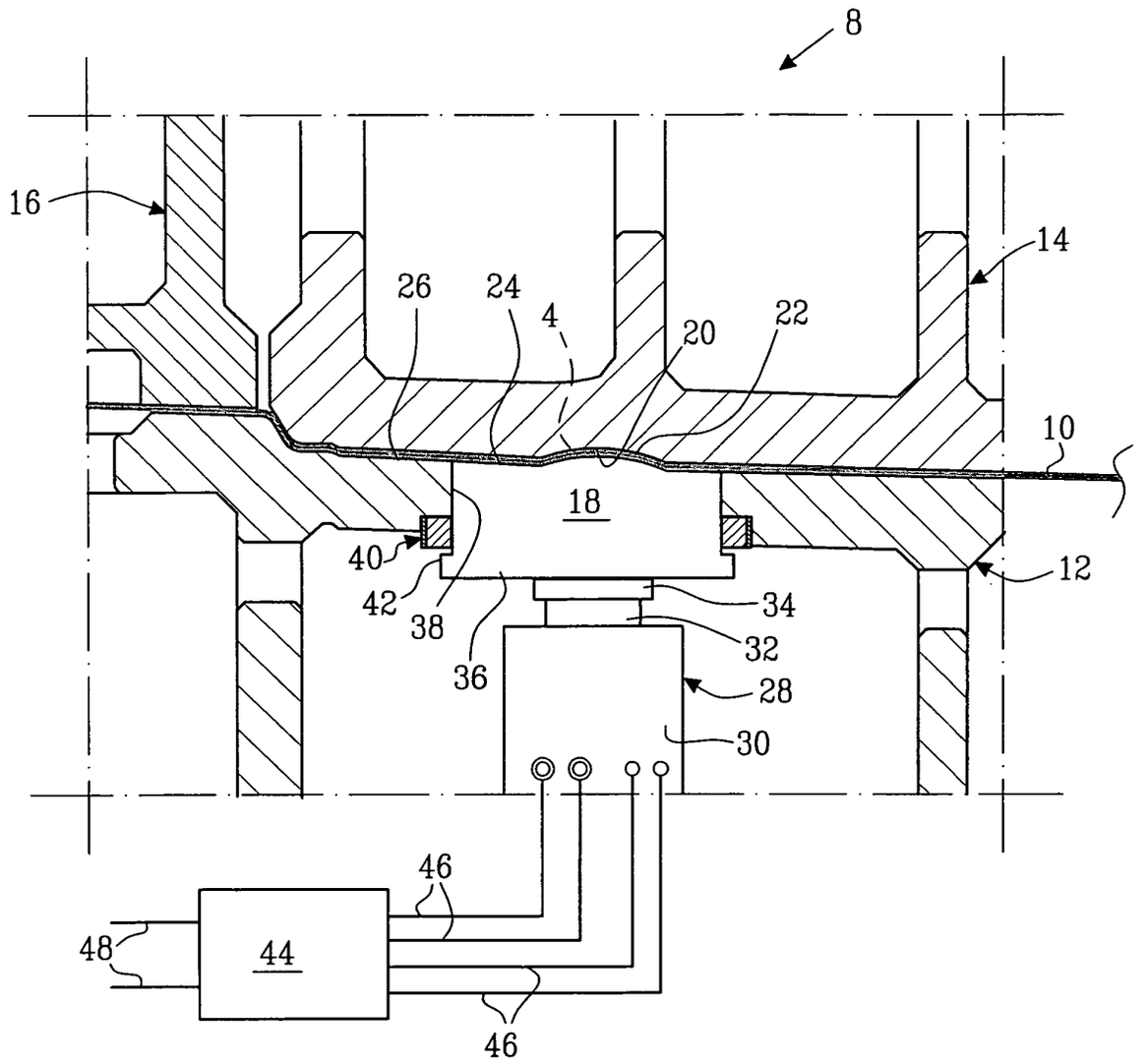

FIG.4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 00 0331

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 June 2004	Vinci, V

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 00 0331

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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