

(19)



(11)

EP 1 844 875 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
20.04.2011 Bulletin 2011/16

(51) Int Cl.:
B21J 5/08 ^(2006.01) **B21K 1/10** ^(2006.01)

(21) Application number: **06712616.9**

(86) International application number:
PCT/JP2006/301473

(22) Date of filing: **30.01.2006**

(87) International publication number:
WO 2006/080503 (03.08.2006 Gazette 2006/31)

(54) METHOD AND DEVICE FOR UPSETTING CYLINDRICAL MATERIAL

VERFAHREN UND VORRICHTUNG ZUR STAUCHUNG EINES ZYLINDRISCHEN ARTIKELS
PROCÉDÉ ET DISPOSITIF DE REFOULEMENT D'UN MATÉRIAU CYLINDRIQUE

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI
SK TR**

(30) Priority: **31.01.2005 JP 2005024164**
04.02.2005 US 649552 P

(43) Date of publication of application:
17.10.2007 Bulletin 2007/42

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Description

Technical Field

5 [0001] The present invention relates to an upsetting method for a hollow cylindrical raw material and an upsetting apparatus for a hollow cylindrical raw material for outwardly or inwardly expanding a prescribed portion of the hollow cylindrical raw material by increasing the wall thickness thereof.

Background Art

10 [0002] In general, upsetting is executed to expand a diameter of a processing scheduled portion of a bar-shaped material by pressurizing the bar-shaped raw material in an axial direction thereof. In this upsetting, if a material buckles at the time of the working, the obtained product (upsetting manufactured product) becomes poor in shape (e.g., wrinkles, scratches, etc.), which causes degradation in value as a product. Therefore, in order to prevent the occurrence of such
15 buckling, the following upsetting method is conventionally known.

[0003] That is, in this method, a raw material is secured to a securing die, and the processing scheduled portion of the raw material is inserted into an insertion hole formed in a guide to be held in a buckling prevention state. Subsequently, a guide is moved in a direction opposite to a punch moving direction while pressurizing the processing scheduled portion of the raw material in the axial direction with a punch, to thereby radially expand the processing scheduled of the raw
20 material exposed between the tip end portion of the guide and the securing die (see Patent Documents 1 and 2).

[0004] The aforementioned conventional upsetting method has been applied at the time of expanding the diameter of the processing scheduled portion of the solid raw material.

25 Patent Document 1 : Japanese Unexamined Laid-open Patent Publication No. S48-62646

Patent document 2 : Japanese Unexamined Laid-open Patent Publication No. H09-253782

Disclosure of Invention

30 Problems to be Solved by Invention

[0005] In cases where only an axial part of a hollow cylindrical raw material of a cylindrical shape, such as, e.g., a pipe shape, is to be expanded inwardly or outwardly so as to increase the wall thickness by the conventional upsetting method, in other words, in cases where wall thickness increasing processing of a cylindrical raw member is executed,
35 there were the following problems.

[0006] That is, since the hollow cylindrical raw material has a hollow portion therein, at the time of the upsetting, a part of the raw material tends to bend (buckles) inwardly or outwardly, causing a defective shape.

[0007] The present invention was made in view of the aforementioned technical background, and aims to provide an upsetting method for a hollow cylindrical raw material capable of assuredly expanding a processing scheduled portion
40 of the hollow cylindrical raw material inwardly or outwardly so as to increase the wall thickness of the processing scheduled portion and an upsetting apparatus for a hollow cylindrical raw material suitably used for the upsetting method.

Means for solving the Problem

45 [0008] The present invention provides an upsetting method for a hollow cylindrical raw material as defined in independent claims 1, 13, 25, 77 and 87 and an up setting apparatus as defined in independent claims 37, 50, 63, 97 and 106. Further aspects of the invention are defined in the dependent claims.

50 Effect of Invention

[0009] The present invention has the following effects.

[0010] According to the invention as defined in claim 1, at the time of pressurizing the processing scheduled portion of the raw material with the punch, the internal peripheral surfaces of the processing scheduled portion and the non-
55 processing scheduled portion of the raw material are restrained by the peripheral surface of the core bar and the external peripheral surface of the non-processing scheduled portion is restrained by the peripheral surface of the restraining hole of the restraining die. Therefore, the inward and outward buckling of the non-processing scheduled portion of the raw material is prevented and the inward buckling of the processing scheduled portion is prevented. And, the processing

scheduled portion of the raw material is disposed in the insertion hole of the guide and therefore the external peripheral surface of the processing scheduled portion is restrained by the peripheral surface of the insertion hole. This prevents the outward buckling of the processing scheduled portion. In this state, by moving the guide in a direction opposite to the moving direction of the punch while pressurizing the processing scheduled portion of the raw material with the punch in the axial direction, the processing scheduled portion of the raw material exposed between the tip end portion of the guide and the bottom portion of the molding dented portion can be outwardly expanded assuredly and preferably so that the wall thickness increases within the molding dented portion. Consequently, a high quality cylindrical upsetting manufactured product can be obtained.

[0011] According to the invention as recited in claim 2, the guide can be moved assuredly.

[0012] According to the invention as recited in claim 3, the processing scheduled portion of the raw material can be assuredly formed into a designed shape.

[0013] According to the invention as recited in claim 4, the guide can be moved without using a guide driving apparatus, resulting in simplification of the upsetting apparatus.

[0014] According to the invention as recited in claim 5, the processing scheduled portion of the raw material can be assuredly pressurized with the punch.

[0015] According to the invention as recited in claim 6, the setting work for disposing the core bar in the hollow portions of the processing scheduled portion and the non-processing scheduled portion of the raw material and the setting work for disposing the punch at the axial end portion side of the raw material to pressurize the processing scheduled portion of the raw material with the punch can be performed simultaneously, which can improve the upsetting operation efficiency.

[0016] Furthermore, after completion of the processing, the pulling out work of the core bar for pulling out the core bar from the hollow portions of the processing scheduled portion and the non-processing scheduled portion of the raw material and the removal work of the punch for removing the punch from the position of the axial end portion of the raw material can be done simultaneously, which can further improve the upsetting operation efficiency.

[0017] According to the invention as recited in claim 7, the defect that the position of the core bar shifts in accordance with the movement of the punch or the expansion of the processing scheduled portion of the raw material can be prevented assuredly.

[0018] According to the invention as recited in claim 8, only the deformation resistance of the portion of the processing scheduled portion of the raw material corresponding to the tip end portion of the guide decreases partially. Therefore, the molding pressure can be reduced.

[0019] On the other hand, since the portion of the processing scheduled portion of the raw material corresponding to the portion of the basal end side of the guide rather than the tip end portion of the guide does not decrease in deformation resistance, an increase in molding pressure produced when the end portion of the raw material is crushed in the insertion hole of the guide by the pressure from the punch can be prevented.

[0020] According to the invention as recited in claim 9, the portion of the processing scheduled portion of the raw material corresponding to the tip end portion of the guide can be heated assuredly and very efficiently.

[0021] According to the invention as recited in claim 10, the portion of the processing scheduled portion of the raw material corresponding to the tip end portion of the guide can be heated assuredly and efficiently.

[0022] According to the invention as recited in claim 11, the molding pressure can be reduced substantially.

[0023] According to the invention as recited in claim 12, it is possible to assuredly control that the portion of the processing scheduled portion of the raw material corresponding to the portion of the basal end side of the guide rather than the tip end portion of the guide is heated, which assuredly can prevent deterioration of the deformation resistance of the portion of the raw material.

[0024] According to the invention as recited in claim 13, a cylindrical upsetting manufactured product in which outwardly expanded portions are formed at axial both end portions so that the wall thickness increases can be manufactured efficiently.

[0025] According to the invention as recited in claim 14, each guide can be moved assuredly.

[0026] According to the invention as recited in claim 15, the processing scheduled portion of the raw material can be assuredly formed into a designed shape.

[0027] According to the invention as recited in claim 16, each guide can be moved without using a guide driving apparatus, resulting in simplification of the upsetting apparatus.

[0028] According to the invention as recited in claim 17, each processing scheduled portion of the raw material can be assuredly pressurized with the punch.

[0029] According to the invention as recited in claim 18, the setting work of the core bar halves for disposing each core bar half in the hollow portions of the processing scheduled portion and the non-processing scheduled portion of the raw material and the setting work of the punch for disposing each punch at both the axial end portion sides of the raw material to pressurize the corresponding processing scheduled portion of the raw material with each punch can be performed simultaneously, resulting in enhanced upsetting operation efficiency.

[0030] Furthermore, after completion of the processing, the pull out work of the core bar half for pulling out each core

bar half from the hollow portions of the processing scheduled portion and the non-processing scheduled portion of the raw material and the removal work of the punch for removing each punch from the position of the axial end portion of the raw material can be performed simultaneously, which can further improve the upsetting operation efficiency.

[0031] Furthermore, since the core bar is halved in length by being divided at the axial intermediate portion, the insertion time of the core bar into the prescribed hollow portion can be shortened, which can further improve the upsetting operation efficiency.

[0032] According to the invention as recited in claim 19, the defect that the position of the core bar half shifts in accordance with the movement of the punch or the expansion of the processing scheduled portion of the raw material can be prevented assuredly.

[0033] According to the invention as recited in claim 20, the molding pressure can be reduced for the same reasons as in the invention as recited in the aforementioned Item [8].

[0034] According to the invention as recited in claim 21, the portion of each processing scheduled portion of the raw material corresponding to the tip end portion of the guide can be heated assuredly and very efficiently.

[0035] According to the invention as recited in claim 22, the portion of each processing scheduled portion of the raw material corresponding to the tip end portion of the guide in can be heated assuredly and efficiently.

[0036] According to the invention as recited in claim 23, the molding pressure can be reduced substantially.

[0037] According to the invention as recited in claim 24, it is possible to assuredly control that the portion of each processing scheduled portion of the raw material corresponding to the portion of the basal end side of the guide rather than the tip end portion of the guide is heated, which can assuredly prevent deterioration of the deformation resistance of each portion of the raw material.

[0038] According to the invention as recited in claim 25, at the time of pressuring the processing scheduled portion of the raw material with the punch, the internal peripheral surface of the non-processing scheduled portion of the raw material is restrained by the peripheral surface of the core bar main body, and the external peripheral surfaces of the processing scheduled portion and the non-processing scheduled portion are restrained by the peripheral surface of the restraining hole of the restraining die. Therefore, the inward or outward buckling of the non-processing scheduled portion of the raw material can be prevented, and the outward buckling of the processing scheduled portion is prevented. Furthermore, the guide is disposed in the hollow portion of the processing scheduled portion of the raw material to thereby restrain the internal peripheral surface of the processing scheduled portion by the peripheral surface of the guide. With this, the inward buckling of the processing scheduled portion is prevented. With this state, by moving the guide in a direction opposite to the moving direction of the punch while pressurizing the processing scheduled portion of the raw material with the punch in the axial direction, the processing scheduled portion of the raw material exposed between the tip end portion of the guide and the bottom portion of the molding dented portion can be assuredly and preferably expanded inwardly in the molding dented portion so that the wall thickness increases. Consequently, a high quality cylindrical upsetting manufactured product can be obtained.

[0039] According to the invention as recited in claim 26, the guide can be moved assuredly.

[0040] According to the invention as recited in claim 27, the processing scheduled portion of the raw material can be assuredly formed in a designed shape.

[0041] According to the invention as recited in claim 28, the guide can be moved without using a guide driving apparatus, resulting in simplification of upsetting apparatus.

[0042] According to the invention as recited in claim 29, the predetermined portion of the raw material can be assuredly pressurized with the punch.

[0043] According to the invention as recited in claim 30, the setting work of the core bar for disposing the core bar main body and the small diameter portion in the hollow portion of the non-processing scheduled portion of the raw material and the hollow portion of the processing scheduled portion of the raw material, respectively, and the setting work of the guide for disposing the guide in the hollow portion of the processing scheduled portion of the raw material can be performed simultaneously, which can improve the upsetting operation efficiency.

[0044] According to the invention as recited in claim 31, the defect that the position of the core bar shifts in accordance with the movement of the guide or the expansion of the processing scheduled portion of the raw material can be prevented assuredly.

[0045] According to the invention as recited in claim 32, the molding pressure can be reduced for the same reasons as in the invention as recited in the aforementioned Item [8].

[0046] According to the invention as recited in claim 33, the portion of the processing scheduled portion of the raw material corresponding to the tip end portion of the guide can be heated assuredly and very efficiently.

[0047] According to the invention as recited in claim 34, the portion of the processing scheduled portion of the raw material corresponding to the tip end portion of the guide can be heated assuredly and efficiently.

[0048] According to the invention as recited in claim 35, the molding pressure can be reduced substantially.

[0049] According to the invention as recited in claim 36, it is possible to assuredly control that the portion of each processing scheduled portion of the raw material corresponding to the portion of the basal end side of the guide rather

than the tip end portion of the guide is heated, which can assuredly prevent deterioration of the deformation resistance of each portion of the raw material.

[0050] According to the invention as recited in claims 37 to 49, an upsetting apparatus for a cylindrical raw material which can be suitably used for any one of the upsetting methods for a cylindrical raw material according to claims 1 to 12 can be provided.

[0051] According to the invention as recited in claims 50 to 62, an upsetting apparatus for a cylindrical raw material which can be suitably used for any one of the upsetting methods for a cylindrical raw material according to claims 13 to 24 can be provided.

[0052] According to the invention as recited in claims 63 to 76, an upsetting apparatus for a cylindrical raw material which can be suitably used for any one of the upsetting methods for a cylindrical raw material according to claims 25 to 36 can be provided.

[0053] According to the invention as recited in claim 77, at the time of pressurizing the processing scheduled portion of the raw material with the punch, the internal peripheral surfaces of the processing scheduled portion and the non-processing scheduled portion of the raw material are restrained by the fluid pressure and the external peripheral surface of the non-processing scheduled portion is restrained by the peripheral surface of the restraining hole of the restraining die. Therefore, the inward and outward buckling of the non-processing scheduled portion of the raw material is prevented, and the inward buckling of the processing scheduled portion is prevented. And, the processing scheduled portion of the raw material is disposed in the insertion hole of the guide and therefore the external peripheral surface of the processing scheduled portion is restrained by the peripheral surface of the insertion hole. This prevents the outward buckling of the processing scheduled portion. In this state, by moving the guide in a direction opposite to the moving direction of the punch while pressurizing the processing scheduled portion of the raw material with the punch in the axial direction, the processing scheduled portion of the raw material exposed between the tip end portion of the guide and the bottom portion of the molding dented portion can be outwardly expanded assuredly and preferably so that the wall thickness increases within the molding dented portion. Consequently, a high quality cylindrical upsetting manufactured product can be obtained.

[0054] Furthermore, since the hollow portions of the non-processing scheduled portion and the processing scheduled portion of the raw material are filled not with a core bar but with pressure fluid, the frictional force acting on the processing scheduled portion of the raw material at the time of the processing can be reduced. Therefore, the molding pressure can be reduced substantially. Furthermore, there is an advantage that it is not required to pull out the core bar from the hollow portion of the upsetting manufactured product after completion of the processing.

[0055] According to the invention as recited in claim 78, the guide can be moved assuredly.

[0056] According to the invention as recited in claim 79, the processing scheduled portion of the raw material can be assuredly formed in a designed shape.

[0057] According to the invention as recited in claim 80, the guide can be moved without using a guide driving apparatus, resulting in simplification of upsetting apparatus.

[0058] According to the invention as recited in claim 81, the processing scheduled portion of the raw material can be assuredly pressurized with the punch.

[0059] According to the invention as recited in claim 82, only the portion of the processing scheduled portion of the raw material corresponding to the tip end portion of the guide partially decreases in deformation resistance. Therefore, the molding pressure can be further reduced.

[0060] On the other hand, since the portion of the processing scheduled portions of the raw material corresponding to the portion of the basal end side of the guide rather than the tip end portion of the guide is not heated, the portion does not deteriorate in deformation resistance. Therefore, the defect that the end portion of the raw material is crushed by the pressure from the punch into a defective shape can be prevented.

[0061] According to the invention as recited in claim 83, the portion of the processing scheduled portion of the raw material corresponding to the tip end portion of the guide can be heated assuredly and very efficiently.

[0062] According to the invention as recited in claim 84, the portion of the processing scheduled portion of the raw material corresponding to the tip end portion of the guide can be heated assuredly and efficiently.

[0063] According to the invention as recited in claim 85, the molding pressure can be reduced substantially.

[0064] According to the invention as recited in claim 86, it is possible to assuredly control that the portion of each processing scheduled portion of the raw material corresponding to the portion of the basal end side of the guide rather than the tip end portion of the guide is heated, which can assuredly prevent deterioration of the deformation resistance of each portion of the raw material.

[0065] According to the invention as recited in claim 87, a high quality cylindrical upsetting manufactured product in which outwardly expanded portions are formed at both the axial end portions so that the wall thickness increases can be provided.

[0066] According to the invention as recited in claim 88, each guide can be moved assuredly.

[0067] According to the invention as recited in claim 89, the processing scheduled portion of the raw material can be

assuredly formed into a designed shape.

[0068] According to the invention as recited in claim 90, the guide can be moved without using a guide driving apparatus, resulting in simplification of upsetting apparatus.

[0069] According to the invention as recited in claim 91, each processing scheduled portion of the raw material can be assuredly pressurized with the punch.

[0070] According to the invention as recited in claim 92, for the same reasons as in the invention of claim 82, the molding pressure can be further reduced, and the defect that each end portion of the raw material is crushed by the pressure from the punch into a defective shape can be prevented.

[0071] According to the invention as recited in claim 93, the portion of each processing scheduled portion of the raw material corresponding to the tip end portion of the guide can be heated assuredly and very efficiently.

[0072] According to the invention as recited in claim 94, the portion each processing scheduled portion of the raw material corresponding to the tip end portion of the guide can be heated assuredly and efficiently.

[0073] According to the invention as recited in claim 95, the molding pressure can be reduced substantially.

[0074] According to the invention as recited in claim 96, it is possible to assuredly control that the portion of each processing scheduled portion of the raw material corresponding to the portion of the basal end side of the guide rather than the tip end portion of the guide is heated, which can assuredly prevent deterioration of the deformation resistance of each portion of the raw material.

[0075] According to the invention as recited in claims 97 to 105, an upsetting apparatus for a cylindrical raw material which can be suitably used for any one of the upsetting methods for a cylindrical raw material according to claims 77 to 86 can be provided.

[0076] According to the invention as recited in claims 106 to 114, an upsetting apparatus for a cylindrical raw material which can be suitably used for any one of the upsetting methods for a cylindrical raw material according to claims 87 to 96 can be provided.

Brief Description of Drawings

[0077]

Fig. 1 is a schematic vertical cross-sectional perspective view showing a principal portion of an upsetting apparatus according to the first embodiment of the present invention.

Fig. 2 is a vertical cross-sectional view of the upsetting apparatus showing the state in which a core bar and a punch are being set to prescribed positions.

Fig. 3 is a vertical cross-sectional view of the upsetting apparatus showing the state before processing the processing scheduled portion of the raw material with the upsetting apparatus.

Fig. 4 is a vertical cross-sectional view of the upsetting apparatus showing the state in which the processing scheduled portion of the raw material is being processed with the upsetting apparatus.

Fig. 5 is a vertical cross-sectional view of the upsetting apparatus showing the state after processing the processing scheduled portion of the raw material with the upsetting apparatus.

Fig. 6 is a perspective view of the upsetting manufactured product obtained by the upsetting apparatus.

Fig. 7 is a schematic cross-sectional perspective view of the principal portion of the upsetting apparatus according to the second embodiment of the present invention.

Fig. 8 is a vertical cross-sectional view of the upsetting apparatus showing the state before processing the processing scheduled portion of the raw material by the upsetting apparatus.

Fig. 9 is a vertical cross-sectional view of the upsetting apparatus showing the state in which the processing scheduled portion of the raw material is being processed with the upsetting apparatus.

Fig. 10 is a vertical cross-sectional view of the upsetting apparatus showing the state after processing the processing scheduled portion of the raw material with the upsetting apparatus.

Fig. 11 is a perspective view of the upsetting manufactured product obtained by the upsetting apparatus.

Fig. 12 is a vertical cross-sectional view of the upsetting apparatus showing the state before processing the processing scheduled portion of the raw material with the upsetting apparatus according to the third embodiment of the present invention.

Fig. 13 is a vertical cross-sectional view of the upsetting apparatus showing the state in which the processing scheduled portion of the raw material is being processed with the upsetting apparatus.

Fig. 14 is a vertical cross-sectional view of the upsetting apparatus showing the state after processing the processing scheduled portion of the raw material with the upsetting apparatus.

Fig. 15 is a vertical cross-sectional view of the upsetting apparatus showing a modification of the first embodiment of the upsetting apparatus.

Fig. 16 is a vertical cross-sectional view of an upsetting apparatus showing another modification of the upsetting

apparatus of the third embodiment.

Fig. 17 is a vertical cross-sectional view of the upsetting apparatus showing the state before processing the processing scheduled portion of the raw material with the upsetting apparatus according to the fourth embodiment of the present invention.

Fig. 18 is a vertical cross-sectional view of the upsetting apparatus showing the state in which the processing scheduled portion of the raw material is being processed with the upsetting apparatus.

Fig. 19 is a vertical cross-sectional view of this upsetting apparatus showing the state after processing the working predetermined portion of the raw material with the upsetting apparatus.

Fig. 20 is a vertical cross-sectional view of the upsetting apparatus showing the state before processing the processing scheduled portion of the raw material with the upsetting apparatus according to the fifth embodiment of the present invention.

Fig. 21 is a vertical cross-sectional view of the upsetting apparatus showing the state in which the processing scheduled portion of the raw material is being processed with the upsetting apparatus.

Fig. 22 is a vertical cross-sectional view of the upsetting apparatus showing the state after processing the processing scheduled portion of the raw material with the upsetting apparatus.

Fig. 23 is a vertical cross-sectional view of the upsetting apparatus showing the state before processing the processing scheduled portion of the raw material with the upsetting apparatus according to the sixth embodiment of the present invention.

Fig. 24 is a vertical cross-sectional view of the upsetting apparatus showing the state in which the processing scheduled portion of the raw material is being processed with the upsetting apparatus.

Fig. 25 is a vertical cross-sectional view of the upsetting apparatus showing the state after processing the processing scheduled portion of the raw material with the upsetting apparatus.

Description of the Reference Numerals

[0078]

- 1A, 1B, 1C...Upsetting apparatus
- 1...Raw material
- 2...Processing scheduled portion
- 2a...Hollow portion
- 3...Non-processing scheduled portion
- 3a...Hollow portion
- 4...Expanded portion
- 5...Shank portion
- 6A, 6B, 6C...Upsetting manufactured product
- 10...Restraining die
- 11...Restraining hole
- 12...Molding dented portion
- 12a...Bottom portion
- 20...Guide
- 20a...Tip end portion
- 21...Insertion hole
- 21a...Chamfered portion
- 25...Moving direction of guide
- 30...Punch
- 35...Moving direction of punch
- 40...Core bar
- 40a...Core bar half
- 41...Core bar main body
- 42...Small diameter portion
- 50...Extensible device
- 51...Fluid pressure cylinder
- 52...Spring
- 60...Guide driving apparatus
- 70...Punch driving apparatus
- 80...Heating means
- 81...Induction heating means

81a...Induction heating coil
 85...Cooling means
 85a...Cooling fluid passage
 90...Pressure fluid filling means
 91...Pressure fluid supplying passage
 92...Pressure fluid supplying portion
 95...Pressure fluid

Detailed Description of the Preferred Embodiments

[0079] Next, some embodiments of the present invention will be explained below with reference to the drawings.

[0080] Figs. 1 to 6 are schematic views for explaining an upsetting method using an upsetting apparatus of a cylindrical raw material according to a first embodiment of the present invention.

[0081] In Fig. 1, "1A" denotes an upsetting apparatus according to the first embodiment, and "1" denotes a cylindrical raw material. Furthermore, in Fig. 6, "6A" denotes a cylindrical upsetting manufactured product manufactured by the upsetting apparatus 1A. This upsetting manufactured product 6A is used as, for example, a preform for manufacturing a part of a cylindrical color component to be mounted at the central portion of a bush (e.g., vibration reduction bush) for vehicles, such as, e.g., automobiles or railroad vehicles, a preform for manufacturing a part of a shank member of an arm for vehicles, or a preform for manufacturing a component in which a screw hole is to be formed at the end portion of a cylindrical shank portion. In addition, "5" denotes a shank portion of the upsetting manufactured product 6A constituted by the non-processing scheduled portion 3 of the raw material 1, and "4" denotes an expanded portion formed at the end portion of the shank portion 5. This expanded portion 4 is expanded in the wall thickness outwardly of the raw material 1 (i.e., in the radially outward direction of the raw material 1).

[0082] As shown in Figs. 1 and 2, the raw material 1 is a straight cylindrical member, in detail, a straight round pipe made of, e.g., aluminum (including its alloy, hereinafter simply referred to as "aluminum"). The raw material 1 is round in cross-section, and the internal diameter, the external diameter, and the wall thickness of the raw material 1 are constant in the axial direction, respectively. Moreover, the raw material 1 is made of, e.g., an extruded material.

[0083] In the meantime, in the present invention, the material of the raw material 1 is not limited to aluminum, but can be metal, such as, e.g., brass, copper, or stainless steel, or plastic.

[0084] The processing scheduled portion 2 of the raw material 1 is located at one end portion of the axial end portions of the raw material 1, or at one axial end portion of the raw material 1. In other words, the axial one end portion of the raw material 1 corresponds to the processing scheduled portion 2. On the other hand, the non-processing scheduled portion 3 of this raw material 1 is located at the axial other end portion of the raw material 1. In other words, the axial other end portion of the raw material 1 corresponds to the non-processing scheduled portion 3. By processing the processing scheduled portion 2 of the raw material 1 to increase the wall thickness into a designed shape, as shown in Fig. 5, an outwardly expanded portion 4 increased in wall thickness is formed at one end portion of the raw material 1 (the shank portion 5).

[0085] The upsetting apparatus 1A is configured to expand the processing scheduled portion 2 of the raw material 1 so as to increase the wall thickness thereof. This upsetting apparatus 1A is equipped with a core bar 40, a restraining die 10, a molding dented portion 12, a guide 20, a punch 30, a guide driving apparatus 60, and a punch driving apparatus 70.

[0086] The core bar 40 is a straight bar-shaped member circular in cross-section to be inserted into the hollow portions 2a and 3a of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 to thereby restrain the internal peripheral surfaces of the processing scheduled portion 2 and the non-processing scheduled portion 3 with the peripheral surface of the core bar 40 in a buckling preventing state. The core bar 40 is set to be constant in diameter in the axial direction.

[0087] The restraining die 10 has a restraining hole 11 round in cross-section extended in the axial direction. This restraining hole 11 is configured to hold the non-processing scheduled portion 3 of the raw material 1 inserted therein to restrain the external peripheral surface of this non-processing scheduled portion 3 with the peripheral surface of the restraining hole 11 in the buckling preventing state.

[0088] "15" denotes a bottom portion of the restraining die 10. This bottom portion 15 closes the bottom of the restraining die so that the non-processing scheduled portion 3 of the raw material 1 disposed in the restraining hole 11 is unexpectedly extruded through the opening of the bottom of the restraining hole 11.

[0089] The restraining die 10 is longitudinally divided into a plurality of pieces (e.g., two pieces). That is, it is a split mold.

[0090] The molding dented portion 12 is, as shown in Fig. 2, formed at the axial one end portion of the restraining die 10 continuously from the restraining hole 11. That is, this molding dented portion 12 is formed by forming an annular dented portion in the peripheral surface of the axial one end portion of the restraining hole 11 of the restraining die 10.

[0091] The guide 20 has an insertion hole 21 round in cross-section extended in the axial direction. This insertion hole

21 is configured to hold the processing scheduled portion 2 of the raw material 1 inserted therein so as to allow the axial movement in a buckling preventing state. This insertion hole 21 penetrates the guide 20 in the axial direction thereof.

[0092] The guide 20 is movable in a direction 25 opposite to the moving direction 35 of the punch (see Fig. 4).

[0093] Moreover, the opening edge portion of the insertion hole 21 of the tip end portion 20a of the guide 20 is chamfered, and therefore the edge portion is formed into a round cross-sectional shape. "21a" denotes a chamfered portion formed at the edge portion.

[0094] The punch 30 is for axially pressurizing the processing scheduled portion 2 of the raw material 1. The tip end portion of this punch 30 is formed into a cross-sectional shape corresponding to the cross-sectional shape of the axial end portion (i.e., processing scheduled portion 2) of the raw material 1, i.e., the tip end portion of the punch 30 is cylindrical in cross-section.

[0095] Furthermore, a hollow portion extended in the axial direction is formed in the punch 30, and an extensible device 50 extensible in the axial direction is disposed in this hollow portion. And, as shown in Fig. 2, the core bar 40 is connected to the punch 30 via the extensible device 50 so as to extend in the axial direction of the punch 30.

[0096] In this embodiment, the extensible device 50 is a fluid pressure cylinder 51 operated by fluid pressure, such as, e.g., hydraulic pressure or gas pressure. At the tip end portion of the extensible rod 51a of this fluid pressure cylinder 51, the core bar 40 is fixed.

[0097] The punch driving apparatus 70 is for moving the punch 30 in the axial direction of the raw material 1 to give a pressure for pressurizing the processing scheduled portion 2 of the raw material 1 to the punch 30. This punch driving apparatus 70 is connected to the punch 30 to give driving force to the punch 30 by fluid pressure (hydraulic pressure, gas pressure, etc.) This punch driving apparatus 70 does not require a speed controller since it is possible to make the speed of a punch constant when the target shape (designed shape) is determined. However, by employing a pressurizing speed controller, it becomes possible to arbitrarily control the upset shape (shape of expanded portion).

[0098] The guide driving apparatus 60 is for moving the guide 20 in a direction opposite 25 to the moving direction 35 (i.e., the pressure direction to the raw material processing scheduled 2 with the punch 30) (see Fig. 4). This guide driving apparatus 60 is connected to the guide 20 to give driving force to the guide 20 with, e.g., fluid pressure (hydraulic pressure, gas pressure), an electric motor, a spring. This guide driving apparatus 60 does not require a speed controller since it is possible to make the speed of the guide constant when the target shape (designed shape) is determined. However, by employing a speed controller, it becomes possible to control the upset shape (shape of expanded portion).

[0099] Next, an upsetting method using the aforementioned upsetting apparatus 1A of the first embodiment will be explained below.

[0100] First, as shown in Fig. 2, the non-processing scheduled portion 3 of the raw material 1 is inserted in the restraining hole 11 of the restraining die 10. With this, the processing scheduled portion 2 of the raw material 1 is placed in the molding dented portion 12 of the restraining die 10. In this state, the external peripheral surface of the non-processing scheduled portion 3 of the raw material 1 is restrained by the peripheral surface of the restraining hole 11.

[0101] Subsequently, in a state in which the core bar 40 is connected to the punch 30 via the fluid pressure cylinder 51 as the extensible device 50, the core bar 40 is inserted into the hollow portions 2a and 3a of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 [Setting work of the core bar 40]. Through this operation, as shown in Figs. 1 and 3, the punch 30 is placed at the initial position located at the axial end portion side of the raw material 1 [Setting work of the punch 30]. In this state, the internal peripheral surfaces of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 are restrained by the peripheral surface of the core bar 40.

[0102] Furthermore, the processing scheduled portion 2 of the raw material 1 is inserted in the insertion hole 21 of the guide 20. With this, the external peripheral surface of the processing scheduled portion 2 of the raw material 1 is restrained by the peripheral surface of the insertion hole 21 of the guide 20.

[0103] Furthermore, as shown in Fig. 3, an initial clearance X is set between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12. In the state before initiating the movement of the punch 30 (i.e., pressurization to the raw material processing scheduled portion 2 with the punch 30), the distance of this initial clearance X is set to be not larger than the buckling limit length X_0 (preferably, less than the buckling limit length X_0) at the cross-sectional area of the exposed portion of the processing scheduled portion 2 of the raw material 1 exposed between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12. In the present invention, the buckling limit length denotes a buckling limit length at the punch pressurizing force.

[0104] Subsequently, as shown in Fig. 4, while axially pressurizing the processing scheduled portion 2 of the raw material 1 with the punch 30 by moving the punch by operating the punch driving apparatus 70, the guide 20 is moved in a direction 25 opposite to the moving direction 35 of the punch 30 by operating the guide driving apparatus 60. With this, the processing scheduled portion 2 of the raw material 1 exposed between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12 is outwardly expanded so that the wall thickness increases within the molding dented portion 12. Furthermore, the rod 51a of the fluid pressure cylinder 51 is retracted in accordance with the movement of the punch 30 to prevent the axial displacement of the core bar 40.

[0105] Here, it is preferable to set a time lag to between the moving initiation of the punch 30 and the moving initiation of the guide 20. That is, in the case of initiating the pressurization of the processing scheduled portion 2 of the raw material 1 with the punch 30, the position of the guide 20 is fixed to the initial position, and then the processing scheduled portion 2 of the raw material 1 is axially pressurized with the punch 30 by moving the punch 30. After the lapse of the time lag t_0 , while continuously pressurizing the processing scheduled portion 2 of the raw material 1 with the punch 30, the guide 20 is moved in a direction 25 opposite to the moving direction 35 of the punch 30. At this time, the traveling speed of the guide 20 is controlled by the controller of the guide driving apparatus 60 so as not to exceed the buckling limit length at the cross-sectional area of the exposed portion of the processing scheduled portion 2 of the raw material 1 exposed between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12. Moreover, when the processing conditions are determined, a cylinder or a machine cam of a designed constant speed can be used.

[0106] With the movements of the punch 30 and the guide 20, the processing scheduled portion 2 of the raw material 1 is gradually outwardly expanded so that the wall thickness increases within the molding dented portion 12, and the material of the processing scheduled portion 2 is gradually filled in the molding dented portion 12 under pressure.

[0107] As shown in Fig. 5, when the tip end portion of the punch 30 has reached the stop position X_p corresponding to the bottom portion 12a of the molding dented portion 12 obtained from the design volume of the expanded portion 4, the movement of the punch 30 is terminated. When the tip end portion 20a of the guide 20 has reached the stop position X_g corresponding to the bottom portion 12a of the molding dented portion 12 defined by the tip end portion 20a of the guide 20, the movement of the guide 20 is terminated. At this time, the material of the processing scheduled portion 2 of the raw material 1 has been completely filled in the molding dented portion 12, and the processing scheduled portion 2 has been expanded into the designed shape.

[0108] Through the aforementioned procedures, the wall thickening processing for the processing scheduled portion 2 of the raw material 1 is completed.

[0109] Next, in order to pull the core bar 40 out of the hollow portions 2a and 3a of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1, the punch 30 is moved in the axially outward direction of the raw material 1 from the position of the axial end portion of the raw material 1. Thus, the punch 30 is removed from the position of the axial end portion of the raw material 1, and the core bar 40 is pulled out [Pulling out work of the core bar 40 and removal work of the punch 30]. Then, the upsetting manufactured product 6A is pulled out of the restraining hole 11 of the restraining die 10.

[0110] In the first embodiment, the stop position X_p of the tip end portion of the punch 30 with respect to the bottom portion 12a of the molding dented portion 12 and the stop position X_g of the tip end portion 20a of the guide 20 with respect to the bottom portion 12a of the molding dented portion 12 coincide with each other. However, in the present invention, it is not always required that X_p and X_g coincide with each other.

[0111] Thus, in the aforementioned upsetting method of the first embodiment, in pressurizing the processing scheduled portion 2 of the raw material 1 with the punch 30, the internal peripheral surfaces of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 are restrained by the peripheral surface of the core bar 40, and the external peripheral surface of the non-processing scheduled portion 3 is restrained by the peripheral surface of the restraining hole 11 of the restraining die 10. Therefore, inward and outward buckling of the non-processing scheduled portion 3 of the raw material 1 is prevented, and the inward buckling of the processing scheduled portion 2 is prevented. Furthermore, the processing scheduled portion 2 of the raw material 1 is placed in the insertion hole 21 of the guide 20, so that the external peripheral surface of the processing scheduled portion 2 is restrained by the peripheral surface of the insertion hole 21. With this, the outward buckling of the processing scheduled portion 2 is prevented. In this state, by moving the guide 20 in a direction 25 opposite to the moving direction 35 of the punch 30 while axially pressurizing the processing scheduled portion 2 of the raw material 1 with the punch 30, the processing scheduled portion 2 of the raw material 1 exposed between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12 is outwardly expanded assuredly and favorably so that the wall thickness is increased within the molding dented portion 12. Consequently, a high quality cylindrical upsetting manufactured product 6A can be obtained.

[0112] As mentioned above, this upsetting manufactured product 6A is used as, e.g., a preform for manufacturing a part of a color member for bushes, a preform for manufacturing a part of a shank member of an arm for vehicles, or a preform for manufacturing a member in which a screw hole is formed at an end portion of a cylindrical shank portion. Furthermore, this upsetting manufactured product 6A is used as a member in which another member is to be integrally secured to an end portion of a cylindrical shank portion by a friction stir welding, i.e., a joint member for a friction stir welding. Concretely, it can be used as a preform for manufacturing the aforementioned shank portion of an arm for vehicles.

[0113] In order to obtain a cylindrical upsetting manufactured product in which an expanded portion 4 is outwardly expanded so that the wall thickness increases at prescribed portion, conventionally, the processing was usually performed by a hydroform method or a hot bulge method, which required an expensive and large-scale facility. Moreover, the

hydroform method and the hot bulge method were mainly used as a processing method for obtaining a large product. As processing for obtaining a small product, machining, such as, e.g., cutting, was conventionally used. According to the upsetting method of the aforementioned embodiment, since no large molding pressure is not required at the time of the processing, the processing apparatus can be simplified. Furthermore, it also becomes possible to remarkably improve the tact time as compared with a conventional method in cases where the punch 30 and the guide 20 are combined with a high-speed hydraulic cylinder or a machine cam into a die set and this die set is installed in a mechanical press machine. Furthermore, the yield can be significantly improved as compared with machining, which in turn can attain a large cost cut effect.

[0114] Furthermore, in this embodiment, since the guide 20 is moved by the driving force of the guide driving apparatus 60, the guide 20 can be moved assuredly.

[0115] Furthermore, since the tip end portion of the punch 30 is formed into a cross-sectional shape corresponding to the cross-sectional shape of the axial end portion of the raw material 1, the processing scheduled portion 2 of the raw material 1 can be assuredly pressurized with the punch 30.

[0116] Furthermore, since the core bar 40 is connected to the punch 30 so as to extend in the axial direction of the punch 30, the setting work of the core bar 40 for placing the core bar 40 into the hollow portions 2a and 3a of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1, and the setting work of the punch 30 for placing the punch 30 to the axial end portion side of the raw material 1 in order to pressurize the processing scheduled portion 2 of the raw material 1 with the punch 30, can be performed simultaneously, resulting in an improved operation efficiency of the upsetting.

[0117] Furthermore, after completion of the processing, a pull-out work of the core bar 40 for pulling out the core bar 40 from the hollow portion 2a and 3a of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 and the removal work of the punch 30 for removing the punch 30 from the position of the axial end portion of the raw material 1, can be performed simultaneously, resulting in further improved operation efficiency of the upsetting.

[0118] Furthermore, since the core bar 40 is connected to the punch 30 via the extensible device 50 which can be extended and contracted in the axial direction and the extensible device 50 is contracted with the movement of the punch 30, a problem that the position of the core bar 40 shifts in accordance with the movement of the punch 30 or the expansion of the processing scheduled portion 2 of the raw material 1 can be prevented assuredly.

[0119] Furthermore, since the fluid pressure cylinder 51 is used as the extensible device 50, such fault can be prevented assuredly.

[0120] Furthermore, since the chamfering work (the chamfered portion 21a) is given to the insertion hole opening edge portion of the tip end portion 20a of the guide 20, the back pressure of the material of the processing scheduled portion 2 of the raw material 1 effectively acts on the tip end portion 20a of the guide 20 at the time of the processing. Consequently, the driving force of the guide driving apparatus 60 for moving the guide 20 can be decreased, which makes it possible to miniaturize the guide driving apparatus 60.

[0121] Next, preferable processing conditions for the upsetting method of this embodiment will be explained below.

[0122] Hereinafter,

"P" denotes an average moving speed of the punch 30 from the moving initiation thereof,

"G" denotes an average moving speed of the guide 20 from the moving initiation thereof,

"X₀" denotes a buckling limit length at the cross-sectional area of the processing scheduled portion 2 of the raw material 1 before the upsetting,

"X" denotes an initial clearance between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12 ($0 \leq x \leq x_0$),

"L₀" denotes the length of the raw material 1 before the upsetting required for the expanded portion 4,

"X_p" denotes the stop position of the tip end portion of the punch 30 with respect to the bottom portion 12a of the molding dented portion 12 obtained from the design volume of the expanded portion 4,

"X_g" denotes the stop position of the tip end portion 20a of the guide 20 with respect to the bottom portion 12a of the molding dented portion 12 defined by the design, and

"t₀" denotes the time lag from the moving initiation of the punch 30 to the moving initiation of the guide 20 ($0 \leq t_0$).

[0123] In this upsetting method, it is preferable that "G" satisfies the following expression (i).

[0124]

$$G = (X_g - X) P / (L_0 - X_p - P t_0) \dots (i)$$

[0125] When G satisfies the aforementioned equation (i), the processing scheduled portion 2 of the raw material 1 can be assuredly formed into the designed shape.

[0126] The reasons for setting aforementioned equation (i) about G will be explained below.

[0127] If "t" denotes a time (i.e., upsetting time) from the moving initiation of the punch 30 to the upsetting completion, the distance between the tip end portions of punch 30 and the bottom portion 12a of the molding dented portion 12 at the time t of the upsetting completion, i.e., the position X_p of the tip end portion of punch 30 with respect to the bottom portion 12a of the molding dented portion 12, can be given by the following equation (i-a).

[0128]

$$L_0 - Pt = X_p \quad \dots (i-a)$$

$$\therefore t = (L_0 - X_p) / P \quad \dots (i-b)$$

[0129] And, the distance between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12 at the time t of the upsetting completion, i.e., the position X_p of the tip end portion 20a of the guide 20 with respect to the bottom portion 12a of the molding dented portion 12 is given by the following equation (i-c).

[0130]

$$X + G(t - t_0) = X_g \quad \dots (i-c)$$

[0131] The equation (i) can be derived by substituting the equation (i-b) for the equation (i-c), and arranging about G.

[0132] Here, in the first embodiment, at the time of the upsetting, the guide 20 is moved by the driving force of the guide driving apparatus 60. However, in the present invention, it is not required that the guide 20 is moved by such driving force. That is, in the present invention, the guide 20 can be moved by the pressing-back force acting on the guide 20 by pressing the material of the processing scheduled portion 2 of the raw material 1 into the molding dented portion 12. In this case, the guide 20 can be moved without using the guide driving apparatus 60, which in turn can simplify the setting apparatus 1A.

[0133] Figs. 7 to 11 are schematic views for explaining an upsetting method using an upsetting apparatus for a cylindrical raw material according to a second embodiment of the present invention.

[0134] In Fig. 7, "1B" denotes an upsetting apparatus according to the second embodiment, and "1" denotes a cylindrical raw material. In Fig. 11, "6B" denotes a cylindrical upsetting manufactured product manufactured by the upsetting apparatus 1B. This upsetting manufactured product 1B can be used as, e.g., a preform for manufacturing a cylindrical color member to be mounted in the center portion of a bush for automobiles, a preform for manufacturing a shank member of an arm for vehicles, or a preform for manufacturing a member in which a screw hole is formed at both end portions of a cylindrical shank portion. Furthermore, this upsetting manufactured product can be used as a member in which another member is to be integrally secured to an end portion of a cylindrical shank portion by a friction stir welding, i.e., a joint member for a friction stir welding. In other words, this upsetting apparatus 1B can be, for example, a manufacturing apparatus of a preform for bush color members, a manufacturing apparatus of a preform for a shank portion member for vehicle arms, or a manufacturing apparatus of a joining member for friction stir welding. In addition, "5" denotes a shank portion of the upsetting manufactured product 6B made of the non-processing scheduled portion 3 of the raw material 1, "4" denotes an expanded portion formed at each of both end portions of the shank portion 5. Each of the expanded portion 4 is expanded so that the wall thickness of the raw material 1 increases outwardly.

[0135] The structure of the upsetting apparatus 1B of this second embodiment will be explained below focusing on the differences with that of the first embodiment 1A.

[0136] As shown in Figs. 7 and 8, this rawmaterial 1 is a straight cylindrical member, in detail, a straight round pipe, like the raw material of the first embodiment.

[0137] In this raw material 1, the axial intermediate portion of the raw material 1 corresponds to the non-processing scheduled portion 3, and the axial both side portions of the raw material 1, i.e., the axial both end portions of the raw material 1, correspond to the processing scheduled portions 2 and 2, respectively. By executing the wall thickening processing of each processing scheduled portion 2 and 2 of the raw material 1 into a designed shape, expanded portions 4 and 4 outwardly expanded so that the wall thickness increases are formed at both end portions of the raw material 1 (shank portion 5).

[0138] The upsetting apparatus 1B is for outwardly expanding the processing scheduled portion 2 and 2 of the axial both end portions of the raw material 1 so that the wall thickness increases. This upsetting apparatus 1B is equipped

with a core bar 40, a restraining die 10, two molding dented portion 12 and 12, two guides 20 and 20, two punches 30 and 30, two guide driving apparatuses 60 and 60, and two punch driving apparatuses 70 and 70.

[0139] The core bar 40 is a straight bar-shaped member round in cross-section, and is inserted in the hollow portions 2a, 2a and 3a of both processing scheduled portions 2 and 2 and the non-processing scheduled portion 3 of the raw material 1 to restrain the internal peripheral surfaces of both the processing scheduled portion 2 and 2 and the non-processing scheduled portion 3 in a buckling preventing state by the peripheral surface of the core bar 40. The core bar 40 is set to be constant in diameter in the axial direction.

[0140] Furthermore, this core bar 40 is evenly divided into two pieces at the axial intermediate portion, i.e., it is constituted by two pieces of core bar halves 40a and 40a. These two core bar halves 40a and 40a are the same in length.

[0141] The restraining die 10 has a restraining hole 11 extended in the axial direction thereof. The non-processing scheduled portion 3 of the raw material 1 is inserted into the restraining hole 11, and the external peripheral surface of the non-processing scheduled portion 3 is restrained by the peripheral surface of the restraining hole 11 in a buckling preventing state. This restraining hole 11 is formed in the restraining die 10 in the axial penetrated manner.

[0142] Each molding dented portion 12 is formed at the axial both side portions (in detail, both end portions) of the restraining die 10 continuously from the corresponding restraining hole 11.

[0143] Each guide 20 has an insertion hole 21 extended in the axial direction of the guide. The corresponding processing scheduled portion 2 of the raw material 1 is inserted in each of this insertion hole 21 so that the corresponding processing scheduled portion 2 is movably held in the insertion hole 21 in a buckling preventing state. Each insertion hole 21 penetrates the guide 20 in the axial direction thereof.

[0144] Each guide 20 is movable in a direction 25 opposite to the moving direction 35 of the punch.

[0145] Moreover, the opening edge portion of the insertion hole 21 of the tip end portion 20a of each guide 20 is chamfered, and therefore the edge portion is formed into a round cross-sectional shape. "21a" denotes a chamfered portion formed at the edge portion.

[0146] Each punch 30 is for axially pressurizing the corresponding processing scheduled portion 2 of the raw material 1.

[0147] Furthermore, a hollow portion extended in the axial direction is formed in each punch 30, and an extensible device 50 extensible in the axial direction is disposed in this hollow portion. And, the corresponding core bar half 40a is connected to each punch 30 via the extensible device 50 so as to extend in the axial direction of the punch 30.

[0148] The extensible device 50 is a fluid pressure cylinder 51. At the tip end portion of the extensible rod 51a of this fluid pressure cylinder 51, the core bar half 40a is fixed.

[0149] Each punch driving apparatus 70 is for moving each punch 30 in the axial direction of the raw material 1 to give a pressure for pressurizing the corresponding processing scheduled portion 2 of the raw material 1 to the punch 30. Each punch driving apparatus 70 is connected to the corresponding punch 30.

[0150] Each guide driving apparatus 60 is for moving each guide 20 in a direction opposite 25 to the corresponding moving direction 35. Each guide driving apparatus 60 is connected to the corresponding guide 20.

[0151] Next, an upsetting method using the aforementioned upsetting apparatus 1B of the second embodiment will be explained below.

[0152] First, as shown in Figs. 7 and 8, the non-processing scheduled portion 3 of the raw material 1 is inserted in the restraining hole 11 of the restraining die 10. With this, each processing scheduled portion 2 of the raw material 1 is placed in the molding dented portion 12 of the restraining die 10. In this state, the external peripheral surface of the non-processing scheduled portion 3 of the raw material 1 is restrained by the peripheral surface of the restraining hole 11.

[0153] Subsequently, in a state in which the core bar half 40a is connected to each punch 30 via the fluid pressure cylinder 51 as the extensible device 50, one of the core bar halves 40a is inserted into the hollow portions 2a and 3a of one of the processing scheduled portions 2 of the raw material 1 and one of the non-processing scheduled portions 3 of the raw material 1, and the other of the core bar halves 40a is inserted into the hollow portions 2a and 3a of the other of the processing scheduled portions 2 of the raw material 1 and the other of the non-processing scheduled portions 3 of the raw material 1 [Setting work of the core bar 40]. Through this operation, each punch 30 is placed at the initial position located at the corresponding axial end portion side of the rawmaterial 1 [Setting work of the punch 30]. Simultaneously with this, the tip end portions of both the core bar halves 40a and 40a come into contact with each other in the hollow portion 3a of the non-processing scheduled portion 3 of the rawmaterial 1. In this state, the internal peripheral surfaces of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 are restrained by the peripheral surface of both the core bar halves 40a and 40a.

[0154] Furthermore, the corresponding processing scheduled portion 2 of the raw material 1 is inserted in the insertion hole 21 of each guide 20. With this, the external peripheral surface of each processing scheduled portion 2 of the raw material 1 is restrained by the peripheral surface of the insertion hole 21 of the guide 20.

[0155] Furthermore, as shown in Fig. 8, an initial clearance X is set between the tip end portion 20a of each guide 20 and the corresponding bottom portion 12a of the molding dented portion 12. In the same manner as in the first embodiment, the distance of each initial clearance X is set to be not larger than the buckling limit length X_0 at the cross-sectional area of the exposed portion of the processing scheduled portion 2 of the raw material 1 exposed between the tip end portion

20a of each guide 20 and the corresponding bottom portion 12a of the molding dented portion 12.

[0156] Subsequently, as shown in Fig. 9, while axially simultaneously pressurizing each processing scheduled portion 2 of the raw material 1 with the corresponding punch 30 by simultaneously moving both the punches 30 and 30 by operating both the punch driving apparatuses 70 and 70, each guide 20 is moved in a direction 25 opposite to the moving direction 35 of the corresponding punch 30 by simultaneously operating both the guide driving apparatuses 60 and 60. With this, the processing scheduled portion 2 of the raw material 1 exposed between the tip end portion 20a of each guide 20 and the corresponding bottom portion 12a of the molding dented portion 12 is outwardly expanded so that the wall thickness increases within the corresponding molding dented portion 12. Furthermore, the rod 51a of the fluid pressure cylinder 51 is retracted in accordance with the movement of each punch 30 to prevent the axial displacement of the core bar half 40a.

[0157] Here, a time lag t_0 is set between the moving initiation of each punch 30 and the moving initiation of the guide 20. That is, in the case of initiating the pressurization of the processing scheduled portion 2 of the raw material 1 with each punch 30, the position of each guide 20 is fixed to the initial position, and then each processing scheduled portion 2 of the raw material 1 is axially pressurized with the corresponding punch 30 by moving the punch 30. After the lapse of the time lag t_0 , while continuously pressurizing the corresponding processing scheduled portion 2 of the raw material 1 with each punch 30, each guide 20 is moved in a direction 25 opposite to the moving direction 35 of the corresponding punch 30. At this time, the traveling speed of each guide 20 is controlled by the controller of the guide driving apparatus 60 so as not to exceed the buckling limit length at the cross-sectional area of the exposed portion of the processing scheduled portion 2 of the raw material 1 exposed between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12. Moreover, when the processing conditions are determined, a cylinder or a machine cam of a designed constant speed can be used.

[0158] With the movement of each punch 30 and each guide 20, each processing scheduled portion 2 of the raw material 1 is gradually outwardly expanded so that the wall thickness increases within the corresponding molding dented portion 12, and the material of the processing scheduled portion 2 is gradually filled in the molding dented portion 12.

[0159] As shown in Fig. 10, when the tip end portion of each punch 30 has reached the stop position X_p with respect to the bottom portion 12a of the molding dented portion 12 obtained from the design volume of the corresponding expanded portion 4, the movement of the punch 30 is terminated. When the tip end portion 20a of each guide 20 has reached the stop position X_g with respect to the bottom portion 12a of the molding dented portion 12 defined by the tip end portion 20a of the guide 20, the movement of each guide 20 is terminated. At this time, the material of the processing scheduled portion 2 of the raw material 1 has been completely filled in the corresponding molding dented portion 12, and the processing scheduled portion 2 has been expanded into the designed shape.

[0160] Through the procedures, the wall thickening processing for both the processing scheduled portions 2 of the raw material 1 are completed.

[0161] Next, in order to pull each core bar half 40a out of the hollow portions 2a, 2a and 3a of both the processing scheduled portions 2 and the non-processing scheduled portion 3 of the raw material 1, each punch 30 is moved in the axial direction of the raw material 1 from each position of the axial end portion of the raw material 1. Thus, each punch 30 is removed from the position of the axial end portion of the raw material 1, and at the same time each core bar half 40a is pulled out [Pulling out work of the core bar half 40a and removal work of the punch 30]. Then, the upsetting manufactured product 6B is pulled out of the restraining hole 11 of the restraining die 10.

[0162] In the second embodiment, the stop position X_p of the tip end portion of each punch 30 with respect to the bottom portion 12a of the molding dented portion 12 and the stop position X_g of the tip end portion 20a of each guide 20 with respect to the bottom portion 12a of the molding dented portion 12 coincide with each other. However, in the present invention, it is not always required that X_p and X_g coincide with each other.

[0163] The average moving speed G from the moving initiation of each guide 20 preferably satisfies the aforementioned equation (i).

[0164] In the upsetting method of the second embodiment, by moving each guide 20 in a direction 25 opposite to the moving direction 35 of the corresponding punch 30 while simultaneously pressurizing each processing scheduled portion 2 of the raw material 1 with the corresponding punch 30 in the axial direction, both the processing scheduled portions 2 and 2 of the raw material 1 are simultaneously expanded outwardly. Therefore, an upsetting manufactured product 6B in which expanded portions 4 and 4 are outwardly expanded in the axial both end portions can be manufactured efficiently.

[0165] Furthermore, the setting work of the core bar half 40a for placing each core bar half 40a in the hollow portions 2a and 3a of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 and the setting work of the punch 30 for placing each punch 30 at the axial end portion side of the raw material 1 to pressurize the corresponding processing scheduled portion 2 of the raw material 1 with each punch 30 can be performed simultaneously, resulting in improved upsetting operation efficiency.

[0166] Furthermore, after completion of the processing, the pulling out work of the core bar half 40a for pulling each core bar half 40a out of the hollow portions 2a and 3a of the processing scheduled portion 2 and the non-processing

scheduled portion 3 of the raw material 1 and the removal work of the punch 30 for removing each punch 30 from the position of the axial end portion of the raw material 1 can be performed simultaneously, resulting in further improved upsetting operation efficiency.

[0167] Furthermore, since the core bar 40 is divided into two halves at the axial intermediate portion and therefore the length is shortened, the insertion time for inserting the core bar 40 into the prescribed hollow portions 2a and 3b can be shortened, which can further improve the operation efficiency of the upsetting.

[0168] In the second embodiment, although each guide 20 is moved by the driving force of the guide driving apparatus 60 at the time of the upsetting, the present invention does not necessarily require that each guide 20 is moved by such driving force. That is, in the present invention, each guide 20 can be moved by the pressing-back force acting on the guide 20 by press-fitting the material of each processing scheduled portion 2 of the raw material 1 into the molding dented portion 12. In this case, even if each guide driving apparatus 60 is not always used, each guide 20 can be moved. Therefore, the upsetting apparatus 1B can be simplified.

[0169] Figs. 12 to 14 are schematic views for explaining an upsetting method using an upsetting apparatus of a cylindrical raw material according to the third embodiment of the present invention.

[0170] In Fig. 12, "1C" denotes an upsetting apparatus according to the third embodiment, and "1" denotes a cylindrical raw material. Furthermore, in Fig. 14, "6C" denotes a cylindrical upsetting manufactured product manufactured by the upsetting apparatus 1C. This upsetting manufactured product 6C is used as, for example, a preform for manufacturing a shank member of an arm for vehicles, or a preform for manufacturing a component in which a screw hole is to be formed at both end portions of a cylindrical shank portion. Or, the product can be used as a member in which another member is to be integrally secured to an end portion of a cylindrical shank portion by a friction stir welding, i.e., a joining cylindrical member for a friction stir welding. "5" denotes a shank portion of the upsetting manufactured product 6C constituted by the non-processing scheduled portion 3 of the raw material 1, and "4" denotes an expanded portion formed at the end portion of the shank portion 5. This expanded portion 4 is expanded so that the wall thickness of the raw material 1 increases inwardly (i.e., toward the radially inward direction of the raw material 1).

[0171] The structure of the upsetting apparatus 1C of this third embodiment will be explained below focusing on the differences with the apparatus 1A of the first enforcement.

[0172] As shown in Fig. 12, just like the raw material of the first embodiment, the raw material 1 is a straight cylindrical member, in detail, a straight pipe round in cross-section.

[0173] The processing scheduled portion 2 of the raw material 1 is located at one end portion of the axial end portions of the raw material 1, or at one axial end portion of the raw material 1. In other words, the axial one end portion of the raw material 1 corresponds to the processing scheduled portion 2. On the other hand, the non-processing scheduled portion 3 of this raw material 1 is located at the axial other end portion of the raw material 1. In other words, the axial other end portion of the raw material 1 corresponds to the non-processing scheduled portion 3. By processing the processing scheduled portion 2 of the raw material 1 to increase the wall thickness into a designed shape, as shown in Fig. 14, an inwardly expanded portion 4 increased in wall thickness is formed at one end portion of the raw material 1 (the shank portion 5).

[0174] The upsetting apparatus 1C is configured to inwardly expand the processing scheduled portion 2 of the raw material 1 so as to increase the wall thickness thereof. This upsetting apparatus 1C is equipped with a core bar 40, a restraining die 10, a molding dented portion 12, a guide 20, a punch 30, a guide driving apparatus 60, and a punch driving apparatus 70.

[0175] The core bar 40 has a core bar main body 41 and a small diameter portion 42 integrally formed at the axial one end portion of the core bar main body 41 and smaller than the core bar main body 41 in diameter. In this core bar 40, the core bar main body 41 is inserted in the hollow portion 3a of the non-processing scheduled portion 3 of the raw material 1, and restrains the internal peripheral surface of the non-processing scheduled portion 3 in a buckling preventing state with the peripheral surface of the core bar main body 41. The small diameter portion 42 of the core bar 40 is placed in the hollow portion 2a of the processing scheduled portion 2 of the raw material 1, and forms the molding dented portion 12 between the internal peripheral surface of the processing scheduled portion 2 and the small diameter portion 42.

[0176] The restraining die 10 has a restraining hole 11 extended in the axial direction. This restraining hole 11 is configured to hold the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 inserted therein to restrain the external peripheral surfaces of the processing scheduled portion 2 and the non-processing scheduled portion 3 with the peripheral surface of the restraining hole 11 in the buckling preventing state.

[0177] The restraining die 10 is longitudinally divided into a plurality of pieces. That is, it is a split mold.

[0178] The punch 30 is for axially pressurizing the processing scheduled portion 2 of the raw material 1. The tip end portion of this punch 30 is formed into a cross-sectional shape corresponding to the cross-sectional shape of the axial end portion (i.e., processing scheduled portion 2) of the raw material 1, i.e., the tip end portion of the punch 30 is cylindrical in cross-section.

[0179] Furthermore, a hollow portion 31 extended in the axial direction is formed in the punch 30. This hollow portion 31 penetrates the punch 30 in the axial direction.

[0180] The guide 20 is placed in the hollow portion 2a of the processing scheduled portion 2 of the raw material 1, and restrains the internal peripheral surface of the processing scheduled portion 2 by the peripheral surface of the guide 20.

[0181] This guide 20 is movable in a direction 25 opposite to the moving direction 35 of the punch. This guide 20 is placed in the hollow portion 31 of the punch 30 in the axially movable manner.

[0182] Moreover, the peripheral edge portion of the tip end portion 20a of the guide 20 is chamfered, and therefore the peripheral edge portion is formed into a round cross-sectional shape. "21a" denotes a chamfered portion formed at the peripheral edge portion.

[0183] Furthermore, the guide 20 has a hollow portion extended in the axial direction, and a fluid pressure cylinder 51 is placed in the hollow portion as an extensible device 50 capable of being extended and contracted in the axial direction. To this guide 20, the core bar 40 is connected via the fluid pressure cylinder 51 so as to extend in the axial direction of the guide 20. At the tip end portion of the extensible rod 51a of this fluid pressure cylinder 51, the small diameter portion 42 of the core bar 40 is detachably attached.

[0184] The punch driving apparatus 70 is for giving pressurizing force for pressurizing the processing scheduled portion 2 of the raw material 1 to the punch 30 by moving the punch 30 in the axial direction of the raw material 1. This punch driving apparatus 70 is connected to the punch 30.

[0185] The guide driving apparatus 60 is for moving the guide 20 in a direction opposite 25 to the moving direction 35 of the punch. This guide driving apparatus 60 is connected to the guide 20.

[0186] Next, an upsetting method using the aforementioned upsetting apparatus 1C of the third embodiment will be explained below.

[0187] Initially, as shown in Fig. 12, the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 are inserted in the restraining hole 11 of the restraining die 10. With this, the external peripheral surfaces of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 are restrained by the peripheral surface of the restraining hole 11.

[0188] Subsequently, in a state in which the core bar 40 is connected to the guide 20 via the fluid pressure cylinder 51, the core bar main body 41 is inserted into the hollow portion 3a of the non-processing scheduled portion 3 of the raw material 1, and the small diameter portion 42 of the core bar 41 is inserted into the hollow portion 2a of the processing scheduled portion 2 of the raw material 1 [Setting work of the core bar 40]. Through this operation, the guide 20 is placed at the hollow portion 2a of the processing scheduled portion 2 of the raw material 1 [Setting work of the guide 20]. In this state, the internal peripheral surface of the processing scheduled portion 2 of the raw material 1 is restrained by the peripheral surface of the guide 20.

[0189] Furthermore, the guide 20 is inserted into the hollow portion 31 of the punch 30, and this punch 30 is placed at the initial position at the axial end portion side of the raw material 1.

[0190] Furthermore, an initial clearance X is set between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12. In the state before initiating the movement of the punch 30, the distance of this initial clearance X is set to be not larger than the buckling limit length X_0 at the cross-sectional area of the exposed portion of the processing scheduled portion 2 of the raw material 1 exposed between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12.

[0191] Subsequently, as shown in Fig. 13, while axially pressurizing the processing scheduled portion 2 of the raw material 1 with the punch 30 by moving the punch by operating the punch driving apparatus 70, the guide 20 is moved in a direction 25 opposite to the moving direction 35 of the punch 30 by operating the guide driving apparatus 60. With this, the processing scheduled portion 2 of the raw material 1 exposed between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12 is inwardly expanded so that the wall thickness increases within the molding dented portion 12. Furthermore, the rod 51a of the fluid pressure cylinder 51 is extended in accordance with the movement of the punch 30 to prevent the axial displacement of the core bar 41.

[0192] Here, it is preferable to set a time lag to between the moving initiation of the punch 30 and the moving initiation of the guide 20. That is, in the case of initiating the pressurization of the processing scheduled portion 2 of the raw material 1 with the punch 30, the position of the guide 20 is fixed to the initial position, and then the processing scheduled portion 2 of the raw material 1 is axially pressurized with the punch 30 by moving the punch 30. After the lapse of the time lag to, while continuously pressurizing the processing scheduled portion 2 of the raw material 1 with the punch 30, the guide 20 is moved in a direction 25 opposite to the moving direction 35 of the punch 30.

[0193] With the movement of the punch 30 and the guide 20, the processing scheduled portion 2 of the raw material 1 is gradually inwardly expanded so that the wall thickness increases within the molding dented portion 12, and the material of the processing scheduled portion 2 is gradually filled in the molding dented portion 12 under pressure.

[0194] As shown in Fig. 14, when the tip end portion of the punch 30 has reached the stop position X_p with respect to the bottom portion 12a of the molding dented portion 12 obtained from the design volume of the expanded portion 4, the movement of the punch 30 is terminated. When the tip end portion 20a of the guide 20 has reached the stop position X_g with respect to the bottom portion 12a of the molding dented portion 12 defined by the tip end portion 20a of the guide 20, the movement of the guide 20 is terminated. At this time, the material of the processing scheduled portion 2 of the

raw material 1 has been completely filled in the molding dented portion 12, and the processing scheduled portion 2 has been expanded into the designed shape.

[0195] Through the aforementioned procedures, the wall thickening processing for the processing scheduled portion 2 of the raw material 1 is completed.

[0196] Subsequently, the fluid pressure cylinder 51 and the core bar 40 are separated, and the bottom portion 15 of the restraining die 10 is removed. Then, the core bar 40 is pulled out of the hollow portion 3a of the non-processing scheduled portion 3 of the raw material 1, and the guide 20 and the punch 30 are also removed.

[0197] In the third embodiment, the stop position X_p of the tip end portion of the punch 30 with respect to the bottom portion 12a of the molding dented portion 12 and the stop position X_g of the tip end portion 20a of the guide 20 with respect to the bottom portion 12a of the molding dented portion 12 coincide with each other. However, in the present invention, it is not always required that X_p and X_g coincide with each other.

[0198] It is preferable that the average moving speed G of the guide 20 from the moving initiation satisfies the aforementioned equation (i).

[0199] Thus, in the aforementioned upsetting method of the third embodiment, at the time of pressurizing the processing scheduled portion 2 of the raw material 1 with the punch 30, the internal peripheral surface of the non-processing scheduled portion 3 of the raw material 1 is restrained by the peripheral surface of the core bar main body 41, and the external peripheral surfaces of the processing scheduled portion 2 and the non-processing scheduled portion 3 are restrained by the peripheral surface of the restraining hole 11 of the restraining die 10. Therefore, inward and outward buckling of the non-processing scheduled portion 3 of the rawmaterial 1 is prevented, and the outward buckling of the processing scheduled portion 2 is prevented. Furthermore, the guide 20 is placed in the hollow portion 2a of the processing scheduled portion 2 of the raw material 1, and therefore the internal peripheral surface of the processing scheduled portion 2 is restrained by the peripheral surface of the guide 20. With this, the inward buckling of the processing scheduled portion 2 is prevented. In this state, by moving the guide 20 in a direction 25 opposite to the moving direction 35 of the punch 30 while axially pressurizing the processing scheduled portion 2 of the raw material 1 with the punch 30, the processing scheduled portion 2 of the raw material 1 exposed between the tip end portion 20a of the guide 20 and the bottom portion 12a of the molding dented portion 12 is expanded assuredly and favorably so that the wall thickness increases within the molding dented portion 12. Consequently, a high quality cylindrical upsetting manufactured product 6C can be obtained.

[0200] Furthermore, since the guide 20 is moved by the driving force of the guide driving apparatus 60, the guide 20 can be moved assuredly.

[0201] Furthermore, since the tip end portion of punch 30 is formed into the cross-sectional shape corresponding to the cross-sectional shape of the axial end portion of the raw material 1, the processing scheduled portion 2 of the raw material 1 can be assuredly pressurized with the punch 30.

[0202] Furthermore, since the core bar 40 is connected to the guide 20 so as to extend in the axial direction of the guide 20, the setting work of the core bar 40 for placing the core bar main body 41 into the hollow portion 3a of the non-processing scheduled portion 3 of the raw material 1 and placing the small diameter portion 42 into the hollow portion 2a of the processing scheduled portion 2 and the setting work of the guide 20 for placing the guide 20 into the hollow portion 2a of the processing scheduled portion 2 of the raw material 1 can be performed simultaneously, which makes it possible to improve the operation efficiency of the upsetting.

[0203] Furthermore, since the fluid pressure cylinder 51 is extended with the movement of the guide 20, the problem that the position of the core bar 40 shifts in accordance with the movement of the guide 20 or the expansion of the processing scheduled portion 2 of the raw material 1 can be prevented assuredly.

[0204] Furthermore, since the fluid pressure cylinder 51 is used as the extensible device 50, such defect can be prevented assuredly.

[0205] Furthermore, since the chamfering work (the chamfered portion 21a) is given to the peripheral edge portion of the tip end portion 20a of the guide 20, the back pressure of the material of the processing scheduled portion 2 of the rawmaterial 1 effectively acts on the tip end portion 20a of the guide 20 at the time of the processing. Consequently, the driving force of the guide driving apparatus 60 for moving the guide 20 can be decreased, which makes it possible to miniaturize the guide driving apparatus 60.

[0206] Here, in the third embodiment, although the guide 20 is moved by the driving force of the guide driving apparatus 60 at the time of the upsetting, the present invention does not necessarily require that the guide 20 is moved by such driving force. That is, in the present invention, the guide 20 can be moved by the pressing-back force acting on the guide 20 caused by pressing the material of the processing scheduled portion 2 of the raw material 1 into the molding dented portion 12. In this case, the guide 20 can be moved without using the guide driving apparatus 60, resulting in a simplified upsetting apparatus 1C.

[0207] Fig. 15 is a schematic view showing a modified embodiment of the upsetting apparatus 1A of the first embodiment.

[0208] In this modification, a compression spring 52 is used as the extensible device 50. This spring 52 is configured

to be compressed with the movement of the punch 30 at the time of the processing.

[0209] This spring 52 can also be applied to each extensible device 50 in the upsetting apparatus 1B of the second embodiment.

[0210] Fig. 16 is a schematic view showing another modification of the upsetting apparatus 1C of the third embodiment.

[0211] In this modification, a coil spring 52 is used as the extensible device 50. This spring 52 is configured to extend with the movement of the guide 20 at the time of the processing.

[0212] Figs. 17 to 19 are schematic views for explaining an upsetting method using an upsetting apparatus for a cylindrical raw material according to the fourth embodiment of the present invention.

[0213] In Fig. 17, "1D" denotes an upsetting apparatus for a cylindrical raw material according to the fourth embodiment. In Figs. 17 to 19, the same mark is allotted to the same component as the structural element of the upsetting apparatus 1B of the second embodiment shown in Figs. 7 to 10. Hereinafter, the structure of the upsetting apparatus 1D of the fourth embodiment will be explained focusing on the difference with the structure of the upsetting apparatus 1B of the second embodiment.

[0214] The cylindrical upsetting manufactured product manufactured by the upsetting apparatus 1D of the fourth embodiment is the same as the cylindrical upsetting manufactured product 6B shown in Fig. 11.

[0215] As shown in Fig. 17, this upsetting apparatus 1D is further equipped with two heating means 80 and 80 and two cooling means 85 and 85 in addition to all of the structures of the upsetting apparatus 1B of the second embodiment shown in Fig. 17.

[0216] Two heating means 80 and 80 are the same in structure. Each heating means 80 partially heats the portion 2x corresponding to the tip end portion 20a of the guide 20 in each processing scheduled portion 2 of the raw material 1. The heating means 80 is an induction heating means 81 having an induction heating coil 81a and a power supply portion 81b for supplying AC current (or AC voltage) to the coil 81a.

[0217] The surface of the induction heating coil 81a is covered with an insulating layer (not shown) consisting of, e.g., an insulating tape. Furthermore, the coil 81a is embedded in the axial both end portions of the restraining die 10 in such a manner that it surrounds the corresponding molding dented portion 12.

[0218] The restraining die 10 is made of hard conductive material (e.g., heat resistant metal material) having heat resistance, such as, e.g., steel material.

[0219] With this induction heating means 81, when a current (voltage) of a prescribed frequency (e.g., high frequency or low frequency) is supplied to the coil 81a by the power supply portion 81b, the axial end portion of the restraining die 10 is partially induction-heated by the coil 81a of the induction heating means 81. With this, the portion 2x of the processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is partially heated by the heat of the axial end portion of the restraining die 10. That is, it is configured such that the heat of the axial end portion of the restraining die 10 is conducted to the portion 2x of the raw material 1 to thereby partially heat the portion 2x. Furthermore, this induction heating means 81 is configured such that the portion 2x can be partially heated into a half-molten state by increasing the current supplying amount or the like to the coil 81a to thereby raise the heating temperature of the portion 2x of the raw material 1.

[0220] Two cooling means 85 and 85 are the same in structure. Each cooling means 85 partially cools the portion 2y of each processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide rather than the tip end portion 20a of the guide 20. This cooling means 85 has a cooling fluid passage 85a. This cooling fluid passage 85a is formed in the basal end portion of the guide 20 as the basal end side portion rather than the tip end portion 20a of the guide 20. This cooling means 85 is configured to partially cool the portion 2y of the raw material 1 by circulating cooling fluid, such as, e.g., cooling water, in this cooling fluid passage 85a.

[0221] In addition, "88" and "88" denote two cooling fluid passages formed in the axial intermediate portion of the restraining die 10. Each cooling fluid passage 88 controls the conduction of the heat generated by the coil 81a of the induction heating means 81 to the other portions of the restraining-die 10 by circulating the cooling fluid therein.

[0222] The other structure of the upsetting apparatus 1D of this fourth embodiment is the same as the structure of the upsetting apparatus 1B of the second embodiment.

[0223] Next, the upsetting method using the upsetting apparatus 1D of the fourth embodiment will be explained below.

[0224] First, as shown in Fig. 17, the non-processing scheduled portion 3 of the raw material 1 is inserted in the restraining hole 11 of the restraining die 10. With this, each processing scheduled portion 2 of the raw material 1 is placed in the corresponding molding dented portion 12 of the restraining die 10. In this state, the external peripheral surface of the non-processing scheduled portion 3 of the raw material 1 is restrained by the peripheral surface of the restraining hole 11.

[0225] Next, the setting work of the core bar 40 and the setting work of the punch 30, which were explained in the second embodiment, are performed. With this, the internal peripheral surfaces of both the processing scheduled portions 2 and 2 and the non-processing scheduled portion 3 of the raw material 1 are restrained by the peripheral surface of the core bar 40 (in detail, both the core bar halves 40a and 40a).

[0226] Furthermore, each processing scheduled portion 2 of the raw material 1 is inserted in the corresponding insertion

hole 21 of each guide 20. With this, the external peripheral surface of each processing scheduled portion 2 of the raw material 1 is restrained by the peripheral surface of the insertion hole 21.

[0227] Furthermore, depending on the needs, it is preferable to form an initial clearance X (see Fig. 8) between the tip end portion 20a of each guide 20 and the bottom portion 12a of the corresponding molding dented portion 12.

[0228] Furthermore, the axial both end portions of the restraining die 10 are partially induction-heated by the coil 81a of each induction heating means 81 by supplying a current of a prescribed frequency to the coil 81a of each induction heating means 81 by the power-supply portion 81b. With this, the portion 2x of each processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is partially heated by the heat of the axial end portion of the restraining die 10. Consequently, the deformation resistance in the portion 2x of the raw material 1 decreases partially.

[0229] This heating temperature is not specifically limited, and can be a temperature which causes deterioration of the deformation resistance of the portion 2x of the raw material 1. Concrete examples of the preferable heating temperature are as follows.

[0230] For example, in cases where the raw material 1 is made of aluminum or aluminum alloy, 200 to 580 °C (especially preferably 350 to 540 °C) can be exemplified as a preferable heating temperature range. Furthermore, in cases where the portion 2x of the raw material 1 is heated into a half-molten state, 580 to 625 °C (especially preferably 600 to 615 °C) can be exemplified as a preferable heating temperature range. However, in the present invention, the heating temperature is not limited to the aforementioned range.

[0231] Furthermore, the portion 2y of each processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide 20 rather than the tip end portion of the guide is partially cooled by circulating cooling fluid, such as, e.g., cooling water of a normal temperature, in the cooling fluid passage 85a of each cooling means 85. With this, the deterioration of the deformation resistance of the portion 2y of the raw material 1 can be controlled.

[0232] As the preferable cooling temperature in this case, 30 to 80 °C (especially preferably 40 to 60 °C) can be exemplified. In the present invention, however, the cooling temperature is not limited to the aforementioned range.

[0233] Moreover, cooling fluid of a normal temperature is circulated in each cooling fluid passage 88 formed in the restricted die 10. With this, the conduction of the heat generated by the coil 81a of each induction heating means 81 to other portions of the restraining die 10 can be controlled.

[0234] Next, while maintaining such a state, as shown in Figs. 18 and 19, in the same procedures as in the upsetting method shown in the second embodiment, both the processing scheduled portions 2 and 2 of the raw material 1 are simultaneously expanded outward in the molding dented portion 12 and 12 so that the wall thickness increases.

[0235] After expanding both the processing scheduled portions 2 and 2 of the raw material 1 into a designed shape, the pulling out work of the core bar 40 and the removal work of punch 30, which were explained in the second embodiment, are performed. Thereafter, by removing the raw material 1 from the restraining hole 11 of the restraining die 10, the cylindrical upsetting manufactured product 6B shown in Fig. 11 is obtained.

[0236] In this upsetting method, it is preferable that the average moving speed G of each guide 20 from the moving initiation thereof satisfies the aforementioned equation (i).

[0237] Thus, in the upsetting method of the fourth embodiment, there are the following advantages in addition to the same advantages as those of the upsetting method of the second embodiment.

[0238] That is, since each processing scheduled portion 2 of the raw material 1 is expanded with the portion 2x of each processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 partially heated, the portion 2x of each processing scheduled portion 2 of the raw material 1 partially deteriorates in deformation resistance. As a result, the molding pressure can be reduced. On the other hand, as to the portion 2y of each processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide 20 rather than the tip end portion 20a of the guide 20, since it is not heated, the portion does not deteriorate in deformation resistance. Therefore, the increase in the molding pressure produced when each end portion of the raw material 1 is crushed in the insertion hole 21 of the guide 20 by the pressure from the punch 30 can be prevented.

[0239] Furthermore, since the portion 2x of each processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is partially heated with the heat of the axial end portion of restraining die 10 by partially induction-heating the axial both end portions of the restraining die 10 with the induction heating means 81, the portion 2x of the raw material 1 can be heated assuredly and efficiently.

[0240] And, in the fourth embodiment, the portion 2x of the raw material 1 can be heated into a half-molten state partially by raising the heating temperature. In this case, the molding pressure can be reduced substantially. The upsetting in this case is classified under the category of Thixomolding.

[0241] Furthermore, each processing scheduled portion 2 of the raw material 1 is expanded in a state in which the portion 2y of each processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide 20 rather than the tip end portion 20a of guide 20 is partially cooled by the cooling means 85. Therefore, the heating of the portion 2y of the raw material 1 can be prevented assuredly, which in turn can assuredly prevent the deterioration of the deformation resistance of the portion 2y of the raw material 1.

[0242] Therefore, according to the upsetting method of the fourth embodiment, a high quality cylindrical upsetting manufactured product 6B having an expanded portion 4 outwardly expanded with the increased wall thickness at each of the axial both end portions can be manufactured.

[0243] In the fourth embodiment, the portion 2x of each processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is partially heated with the heat of the axial end portion of the restraining die 10 by partially induction heating both the axial end portions of the restraining die 10 by the induction heating means 81. In the present invention, however, the portion 2x of the raw material 1 can be partially induction-heated by the induction heating means 81. In this case, the portion 2x of the raw material 1 can be heated assuredly and very efficiently. Furthermore, in this case, the restraining die 10 can be made of hard conductive material (e.g., heat resistant metal material) having heat resistance, such as, e.g., steel material, and also can be hard non-conductive material having heat resistance, such as, e.g., ceramics.

[0244] Furthermore, in the fourth embodiment, the number of the processing scheduled portion 2 of the raw material 1 is two. In the present invention, however, the number of the processing scheduled portion 2 can be one.

[0245] Here, in the fourth embodiment, each guide 20 is moved by the driving force of the guide driving apparatus 60 at the time of the upsetting. In the present invention, however, it is not necessarily required that each guide 20 is moved by such driving force. That is, in the present invention, each guide 20 can be moved by the pressing-back force acting on the guide 20 caused by the pressing of the molding dented portion 12 of the material of each processing scheduled portion 2 of the raw material 1. In this case, each guide 20 can be moved without using each guide driving apparatus 60, resulting in simplification of the upsetting apparatus 1D.

[0246] Figs. 20 to 22 are schematic views for explaining an upsetting method using an upsetting apparatus for a cylindrical raw material according to the fifth embodiment of the present invention.

[0247] In Fig. 20, "1E" denotes an upsetting apparatus for a cylindrical rawmaterial according to the fifth embodiment. In Figs. 20 to 22, the same reference mark is allotted to the same component as the structure element of the upsetting apparatus 1C of the third embodiment shown in Figs. 12 to 14. Hereinafter, the structure of the upsetting apparatus 1E of the fifth embodiment will be explained focusing on the difference with the structure of the upsetting apparatus 1C of the third embodiment and the upsetting apparatus 1D of the fourth embodiment.

[0248] The cylindrical upsetting manufactured product manufactured by the upsetting apparatus 1E of the fifth embodiment has, as shown in Fig. 22, an expanded portion 4 inwardly expanded so that the wall thickness increases at the axial one end portion, i. e., it is the same as the cylindrical upsetting manufactured product 6C manufactured by the upsetting apparatus 1C of the third embodiment.

[0249] As shown in Fig. 20, this upsetting apparatus 1E is equipped with a heating means 80 and a cooling means 85 in addition to all of the structures of the upsetting apparatus 1C of the third embodiment.

[0250] The heating means 80 partially heats the portion 2x of the processing scheduled portion 2 of the rawmaterial 1 corresponding to the tip end portion 20a of the guide 20. The heating means 80 is an induction heating means 81 having an induction heating coil 81a and a power-supply portion 81b for supplying AC current (or AC voltage) to the coil 81a.

[0251] The surface of the induction heating coil 81a is covered by an insulating layer (not shown) consisting of an insulating tape, etc. Furthermore, this coil 81a is embedded in the axial one end portion of the restraining die 10 so as to surround the molding dented portion 12.

[0252] The restraining die 10 is made of hard conductivematerial (e.g., heat resistant metal material) having heat resistance, such as, e.g., steel material, or hard non-conductive material having heat resistance, such as ceramics.

[0253] With this induction heating means 81, when a current (voltage) of a prescribed frequency (e.g., high frequency or low frequency) is supplied to the coil 81a by the power supply portion 81b, the portion 2x of the processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is partially heated by the coil 81a of the induction heating means 81. Furthermore, this inductionheatingmeans 81 is configured such that the portion 2x of the raw material 1 can be partially heated into a half-molten state by increasing the current supplying amount or the like to the coil 81a to thereby raise the heating temperature of the portion 2x of the raw material 1.

[0254] The cooling mean 85 partially cools the portion 2y of each processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide rather than the tip end portion 20a of the guide 20. This cooling means 85 has a cooling fluid passage 85a formed in the basal end portion of the guide 20. This cooling means 85 is configured to partially cool the portion 2y of the raw material 1 by circulating cooling fluid, such as, e.g., cooling water, in this cooling fluid passage 85a.

[0255] "88" denotes a cooling fluid passage formed in the restraining die 10. The cooling fluid passage 88 controls the conduction of the heat generated by the coil 81a of the induction heating mean 81 to the other portions of the restraining die 10 by circulating the cooling fluid therein.

[0256] The other structure of the upsetting apparatus 1E of this fifth embodiment is the same as the structure of the upsetting apparatus 1C of the third embodiment.

[0257] Next, the upsetting method using the upsetting apparatus 1E of the fifth embodiment will be explained below.

[0258] First, as shown in Fig. 20, the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 are inserted in the restraining hole 11 of the restraining die 10. With this, the external peripheral surfaces of the processing scheduled portion 2 and the non-processing scheduled portion 3 of the raw material 1 are restrained by the peripheral surface of the restraining hole 11 in a buckling preventing state. Next, in the state in which the core bar 40 is connected to the guide 20 via the fluid pressure cylinder 51, the core bar main body 41 is inserted in the hollow portion 3a of the non-processing scheduled portion 3 of the raw material 1, and the small diameter portion 42 of the core bar 40 is inserted in the hollow portion 2a of the processing scheduled portion 2 [Setting work of the core bar 40]. With this operation, at least the tip end portion 20a of the guide 20 is placed in the hollow portion 2a of the processing scheduled portion 2 of the raw material 1 [Setting work of the guide 20]. In this state, the internal peripheral surface of the processing scheduled portion 2 of the raw material 1 is restrained by the peripheral surface of guide 20 in a buckling preventing state.

[0259] Furthermore, depending on the needs, it is preferable to set an initial clearance X (see Fig. 12) between the tip end portion 20a of each guide 20 and the bottom portion 12a of the corresponding molding dented portion 12.

[0260] Furthermore, the portion 2x of the processing scheduled portion 2 of the raw material 1 is partially induction-heated by the coil 81a of the induction heating means 81 by supplying a current of a prescribed frequency to the coil 81a of the induction heating means 81 by the power-supply portion 81b. With this, the portion 2x of the processing scheduled portion 2 of the raw material 1 is partially decreased in deformation resistance.

[0261] The preferable heating temperature range in this case is the same as the preferable heating temperature range in the fourth embodiment.

[0262] Furthermore, the portion 2y of the processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide 20 rather than the tip end portion of the guide 20 is partially cooled by circulating cooling fluid, such as, e.g., cooling water of a normal temperature, in the cooling fluid passage 85a of each cooling means 85. With this, the deterioration of the deformation resistance of the portion 2y of the raw material 1 can be controlled.

[0263] The preferable cooling temperature range in this case is the same as the preferable cooling temperature range in the fourth embodiment.

[0264] Moreover, cooling fluid of a normal temperature is circulated in the cooling fluid passage 88 formed in the restricted die 10. With this, the conduction of the heat generated by the coil 81a of the induction heating means 81 to other portions of the restraining die 10 can be controlled.

[0265] Next, while maintaining such a state, as shown in Figs. 21 and 22, in the same procedures as in the upsetting method shown in the third embodiment, the processing scheduled portion 2 of the raw material 1 is expanded inward in the molding dented portion 12 and 12 so that the wall thickness increases.

[0266] After expanding the processing scheduled portion 2 of the raw material 1 into a designed shape, the fluid pressure cylinder 51 and the core bar 40 are detached, and the bottom portion 15 of the restraining die 10 is removed. Then, the core bar 40 is pulled out of the hollow portion 3a of the non-processing scheduled portion 3 of the raw material 1, and the guide 20 and the punch 30 are also removed. With this, a desired cylindrical upsetting manufactured product 6C is obtained.

[0267] In this upsetting method, it is preferable that the average moving speed G of each guide 20 from the moving initiation thereof satisfies the aforementioned equation (i).

[0268] Thus, in the upsetting method of the fifth embodiment, there are the following advantages in addition to the same advantages as those of the upsetting method of the third embodiment.

[0269] That is, since the processing scheduled portion 2 of the raw material 1 is expanded with the portion 2x of the processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 partially heated, only the portion 2x of the processing scheduled portion 2 of the raw material 1 partially deteriorates in deformation resistance. As a result, the molding pressure can be reduced. On the other hand, as to the portion 2y of the processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide 20 rather than the tip end portion 20a of the guide 20, since it is not heated, the portion does not deteriorate in deformation resistance. Therefore, the increase in the molding pressure produced when the end portion of the raw material 1 is crushed in the insertion hole 21 of the guide 20 by the pressure from the punch 30 can be prevented.

[0270] Furthermore, since the portion 2x of the processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is partially heated with the induction heating means 81, the portion 2x of the raw material 1 can be heated assuredly and efficiently.

[0271] And, in the fifth embodiment, the portion 2x of the raw material 1 can be heated into a half-molten state partially by raising the heating temperature. In this case, the molding pressure can be reduced substantially. The upsetting in this case is classified under the category of Thixomolding.

[0272] Furthermore, the processing scheduled portion 2 of the raw material 1 is expanded in a state in which the portion 2y of the processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide 20 rather than the tip end portion 20a of guide 20 is partially cooled by the cooling means 85. Therefore, the heating of the portion 2y of the raw material 1 can be prevented assuredly, which in turn can assuredly prevent the

deterioration of the deformation resistance of the portion 2y of the raw material 1.

[0273] Therefore, according to the upsetting method of the fifth embodiment, as shown in Fig. 22, a high quality cylindrical upsetting manufactured product 6C in which an expanded portion 4 is formed at the axial end portion so that the wall thickness increases can be manufactured.

[0274] In the fifth embodiment, the portion 2x of the processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is partially heated with the induction heating means 81. In the present invention, however, the axial one end portion of the restraining die 10 can be partially induction-heated by the induction heating means 81, to thereby partially heat the portion 2x of the raw material 1 with the heat of the axial one end portion of the restraining die 10. In this case, the portion 2x of the raw material 1 can be heated assuredly and efficiently. Furthermore, in this case, it is preferable that the restraining die 10 is made of hard conductive material (e.g., heat resistant metal material) such as, e.g., steel material.

[0275] Here, in the fifth embodiment, the guide 20 is moved by the driving force of the guide driving apparatus 60 at the time of the upsetting. In the present invention, however, it is not necessarily required that the guide 20 is moved by such driving force. That is, in the present invention, the guide 20 can be moved by the pressing-back force acting on the guide 20 caused by the pressing of the molding dented portion 12 of the material of the processing scheduled portion 2 of the raw material 1. In this case, the guide 20 can be moved without using the guide driving apparatus 60, resulting in simplification of the upsetting apparatus 1E.

[0276] Figs. 23 to 25 are schematic views for explaining an upsetting method using an upsetting apparatus for a cylindrical raw material according to the sixth embodiment of the present invention.

[0277] In Fig. 23, "1F" denotes an upsetting apparatus for a cylindrical raw material according to the sixth embodiment. In Figs. 23 to 25, the same mark is allotted to the same component as that of the structure element of the upsetting apparatus 1B of the second embodiment shown in Figs. 7 to 10. Hereafter, the structure of upsetting apparatus 1F of this sixth embodiment will be explained focusing on the difference with the structure of the upsetting apparatus 1B of the second embodiment and that of the upsetting apparatus 1D of the fourth embodiment.

[0278] The cylindrical upsetting manufactured product manufactured by the upsetting apparatus 1F of the sixth embodiment is the same as the cylindrical upsetting manufactured product 6B shown in Fig. 11.

[0279] Unlike the upsetting apparatus 1D of the fourth embodiment, this upsetting apparatus 1F is not equipped with the core bar and the extensible device as shown in Fig. 23. This upsetting apparatus 1F is equipped with two heating means 80 and 80, two cooling means 85 and 85, and a pressure fluid filling means 90.

[0280] The two heating means 80 and 80 are the same in structure. Each heating means 80 is the same in structure as the heating means 80 of the upsetting apparatus 1D of the fourth embodiment, i.e., each heating means 80 is an induction heating means 81 having an induction heating coil 81a and a power-supply portion 81b.

[0281] The two cooling means 85 and 85 are the same in structure. Each cooling means 85 is the same in structure as the cooling means 85 of the upsetting apparatus 1D of the fourth embodiment, i.e., each cooling means 85 has a cooling fluid passage 85a.

[0282] The pressure fluid filling means 90 fills pressure fluid (pressure medium) 95 in the hollow portions 3a, 2a and 2a of the non-processingscheduled portion 3 located at the axial intermediate portion of the cylindrical raw material 1 and the processing scheduled portion 2 and 2 located at the axial both end portions, to thereby restrain the internal peripheral surfaces of the non-processing scheduled portion 3 of the raw material 1 and both the processing scheduled portions 2 and 2 by the fluid pressure (i.e., pressure of the pressure fluid) in a buckling preventing state.

[0283] This pressure fluid filling means 90 has a pressure fluid supplying passage 91 formed in one of the punches 30 and 30 in an axially penetrated manner, and a pressure fluid supplying portion 92 for supplying the pressure fluid 95 into the hollow portion 3a, 2a and 2a of the raw material 1 through the supplying passage 91. The supplying port 9a of the pressure fluid supplying passage 92 is provided at the tip end face of the punch 30 in communication with the hollow portion 2a. The pressure fluid supplying portion 92 has a pressure tank (not shown) in which the pressure fluid is filled as a pressure fluid supplying source.

[0284] Gas, such as, e.g., argon or air, is used as the pressure fluid 95. In the present invention, however, the pressure fluid 95 is not limited to gas, and can be liquid, such as, e.g., water or oil.

[0285] At the tip end portion of each punch 30, a fitting convex portion 32 to be fitted in the opening portion of the axial end portion of the raw material 1 is formed. This fitting convex portion 32 prevents the deformation of the axial end of the raw material 1 by supporting the axial end portion from its inner side.

[0286] Next, the upsetting method using the upsetting apparatus 1F of the sixth embodiment will be explained below.

[0287] First, as shown in Fig. 23, the non-processing scheduled portion 3 of the raw material 1 is inserted in the restraining hole 11 of the restraining die 10. With this, each processing scheduled portion 2 of the raw material 1 is placed in the corresponding molding dented portion 12 of the restraining die 10. In this state, the external peripheral surface of the non-processing scheduled portion 3 of the raw material 1 is restrained by the peripheral surface of the restraining hole 11.

[0288] Next, the corresponding processing scheduled portion 2 of the raw material 1 is inserted in the insertion hole

21 of each guide 20. With this, the external peripheral surface of each processing scheduled portion 2 of the raw material 1 is restrained by the peripheral surface of insertion hole 21 in a buckling preventing state.

[0289] Furthermore, the corresponding punch 30 is inserted in the insertion hole 21 of each guide 20. With this, each punch 30 is placed at the initial position located at the axial end portion of the raw material 1, and each fitting convex portion 32 of the tip end portion of each punch 30 is closely fitted in the opening portion of the axial end portion of the raw material 1 to support the end portion in a deformation prevention state by the convex portion 32 from its inner side. Furthermore, the opening portions of both the axial end portions of the raw material 1 are blocked by the fitting of the fitting convex portion 32 as mentioned above.

[0290] Next, the pressure fluid 95 is fully filled in the hollow portions 3a, 2a and 2a of the non-processing scheduled portion 3 and both the processing scheduled portion 2 and 2 by the pressure fluid filling means 90 from the pressure fluid supplying portion 92 through the pressure fluid supplying passage 91. At the time of this filling, it is preferable to set a gap between the opening portion of one of the axial end portions of the raw material 1 and the tip end portion of the punch 30 since it becomes easy to fill the pressure fluid 95 in the hollow portion 3a, 2a and 2a of the raw material 1. It is preferable that the filling pressure of the pressure fluid 95 is set so as to fall within the range of 5 to 50 MPa (especially preferably 15 to 30MPa). In the present invention, however, the range of the filling pressure is not limited to the aforementioned range, and the filling pressure can fall within the range in which the non-processing scheduled portion 3 and both the processing scheduled portion 2 and 2 of the raw material 1 are not buckled inwardly at the time of the processing.

[0291] Furthermore, according to need, it is preferable to set an initial clearance X (see Fig. 8) between the tip end portion 20a of each guide 20 and the corresponding bottom portion 12a of the molding dented portion 12.

[0292] Furthermore, the axial both end portions of the restraining die 10 is partially induction-heated by the coil 81a of each induction heating means 81 by supplying current of a prescribed frequency to the coil 81a of each induction heating means 81 by the power-supply portion 81b. With this, the portion 2x of each processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is partially heated by the heat of the axial end portion of the restraining die 10. Consequently, the deformation resistance of the portion 2x of the raw material 1 deteriorates partially.

[0293] The preferable heating temperature range in this case is the same as the preferable heating temperature range in the fourth embodiment.

[0294] Furthermore, the portion 2y of the processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide 20 rather than the tip end portion of the guide 20 is partially cooled by circulating cooling fluid, such as, e.g., cooling water of a normal temperature, in the cooling fluid passage 85a of each cooling means 85. With this, the deterioration of the deformation resistance of the portion 2y of the raw material 1 can be controlled.

[0295] The preferable cooling temperature range in this case is the same as the preferable cooling temperature range in the fourth embodiment.

[0296] Moreover, cooling fluid of a normal temperature is circulated in the cooling fluid passage 88 formed in the restricted die 10. With this, the conduction of the heat generated by the coil 81a of the induction heating means 81 to other portions of the restraining die 10 can be controlled.

[0297] Next, while maintaining such a state, as shown in Figs. 24 and 25, in the same procedures as in the upsetting method shown in the second embodiment, both the processing scheduled portions 2 of the raw material 1 are simultaneously expanded outward in the molding dented portion 12 and 12 so that the wall thickness increases. When both the processing scheduled portions 2 and 2 of the raw material 1 are being expanded, it is preferable to adjust the fluid pressure so that the fluid pressure in the hollow portion 3a, 2a and 2a of the raw material 1 becomes constant.

[0298] After expanding both the processing scheduled portions 2 of the raw material 1 into a designed shape, a desired cylindrical upsetting manufactured product 6B is obtained by removing the raw material 1 from the restraining hole 11 of the restraining die 10.

[0299] In this upsetting method, it is preferable that the average moving speed G of each guide 20 from the moving initiation thereof satisfies the aforementioned equation (i).

[0300] Thus, in the upsetting method of the sixth embodiment, there are the following advantages.

[0301] That is, at the time of pressuring each processing scheduled portion 2 of the raw material 1 with the punch 30, the internal peripheral surfaces of the non-processing scheduled portion 3 and both the processing scheduled portion 2 and 2 are pressurized and restrained by the fluid pressure, and the external peripheral surface of the non-processing scheduled portion 3 is restrained by the peripheral surface of the restraining hole 11 of the restraining die 10. Therefore, the inward and outward buckling of the non-processing scheduled portion 3 of raw material 1 is prevented, and the inward buckling of each processing scheduled portion 2 is prevented. And, each processing scheduled portion 2 of the raw material 1 is placed in the insertion hole 21 of the guide 20, and therefore the external peripheral surface of each processing scheduled portion 2 is restrained by the peripheral surface of the insertion hole 21. This prevents the outward buckling of the processing scheduled portion 2. Performing the upsetting in this state assuredly and efficiently enables each processing scheduled portion 2 of the raw material 1 to be expanded within the molding dented portion 21 so that

the wall thickness increases, resulting in a high quality cylindrical upsetting manufactured product 6B.

[0302] Furthermore, since the hollow portion 3a, 2a and 2a of the processing scheduled portion 2 and both the processing scheduled portions 2 and 2 are filled with not a core bar but pressure fluid 25, the frictional force which acts on each processing scheduled portion 2 at the time of the processing can be reduced. This significantly reduces the molding pressure. Furthermore, there is an advantage that there is no need to remove a core bar from the hollow portion of the upsetting manufactured product 6B after completion of the processing.

[0303] Furthermore, since each processing scheduled portion 2 of the raw material 1 is expanded in a state in which the portion 2x of each processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is heated partially, only the portion 2x of each processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 partially deteriorates in deformation resistance. Therefore, the molding pressure can be reduced. On the other hand, since the portion 2y of each processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide 20 rather than the tip end portion 20a of the guide 20 is not heated, the deformation resistance does not deteriorate. Therefore, it is possible to prevent that each end portion of the raw material 1 is crushed and deformed by the pressure from the punch 30.

[0304] Furthermore, since the portion 2x of each processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is partially heated with the heat of the axial end portion of the restraining die 10 by partially induction heating with the induction heating means 81, the portion 2x of the raw material 1 can be heated assuredly and efficiently.

[0305] And, in the sixth embodiment, the portion 2x of the raw material 1 can be heated into a half-molten state by raising the heating temperature. In this case, the molding pressure can be reduced substantially. The upsetting in this case is classified under the category of Thixomolding.

[0306] Furthermore, each processing scheduled portion 2 of the raw material 1 is expanded in a state in which the portion 2y of each processing scheduled portion 2 of the raw material 1 corresponding to the basal end side portion of the guide 20 rather than the tip end portion 20a of guide 20 is partially cooled by the cooling means 85. Therefore, the heating of the portion 2y of the raw material 1 can be prevented assuredly, which in turn can assuredly prevent the deterioration of the deformation resistance of the portion 2y of the raw material 1.

[0307] Therefore, according to the upsetting method of the sixth embodiment, a high quality cylindrical upsetting manufactured product 6B having an expanded portion 4 outwardly expanded with the increased wall thickness at each of the axial both end portions can be manufactured.

[0308] In the sixth embodiment, the portion 2x of each processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 is partially heated by partially induction heating both the axial end portions of the restraining die 10 by the induction heating means 81. However, in the present invention, the portion 2x of the raw material 1 can be partially induction-heated by the induction heating means 81. In this case, the portion 2x of the raw material 1 can be heated assuredly and very efficiently. Furthermore, in this case, the restraining die 10 can be made of hard conductive material (e.g., heat resistant metal material) having heat resistance, such as, e.g., steel material, and also can be hard non-conductive material having heat resistance, such as, e.g., ceramics.

[0309] Furthermore, in the sixth embodiment, the number of the processing scheduled portion 2 of the rawmaterial 1 is two. However, in the present invention, the number of the processing scheduled portion 2 can be one.

[0310] Here, in the sixth embodiment, each guide 20 is moved by the driving force of the guide driving apparatus 60 at the time of the upsetting. In the present invention, however, it is not necessarily required that each guide 20 is moved by such driving force. That is, in the present invention, each guide 20 can be moved by the pressing-back force acting on the guide 20 caused by the pressing of the molding dented portion 12 of the material of each processing scheduled portion 2 of the raw material 1. In this case, each guide 20 can be moved without using each guide driving apparatus 60, resulting in simplification of the upsetting apparatus 1F.

[0311] Although some embodiments of the present invention were explained above, the present invention is not limited to the aforementioned embodiments, and the embodiments can be modified in a various manner.

[0312] For example, the upsetting apparatus according to the present invention is not limited to an apparatus for manufacturing a preform for color members for bushes, a preform for a shank portion member for an arm for vehicles, or a cylindrical jointing member for friction stir welding, but also can be used as an apparatus for manufacturing preforms for various products.

[0313] Furthermore, in the present invention, a processing scheduled portion of a raw material located at the axial intermediate portion of the raw material can be inwardly or outwardly expanded by the upsetting method of the present invention so that the wall thickness increases to thereby form an expanded portion at the axial central portion of the raw material.

[0314] Furthermore, in the present invention, the processing scheduled portion of a raw material can be processed with the raw material heated to a prescribed temperature or with the raw material not heated. That is, the upsetting method according to the present invention can be a hot upsetting method or a cold upsetting method.

[0315] In the present invention, the restraining die and the guide can be divided members. In addition, the dividing

number and the dividing position of the restraining die and the guide can be variously set according to the shape of the raw material and/or the upsetting manufactured product.

[0316] In the present invention, the raw material can be a cylindrical member, or an angular member for example.

[0317] Furthermore, in the present invention, the heating means 80 is not limited to the induction heating means 81, and can be any other heating means.

Examples

[0318] Next, concrete examples of the present invention will be shown below. However, the present invention is not limited to the examples shown here.

[0319] A cylindrical raw material 1 made of extruded material was prepared. The raw material 1 was 30 mm in internal diameter, 40 mm in external diameter, and 5 mm in wall thickness. Each processing scheduled portion 2 of the raw material 1 was 120 mm in length. The material of the raw material 1 was JIS (Japanese Industrial Standards) A6061 aluminum alloy.

[0320] In Example 1, the raw material 1 was subjected to the upsetting by the same method as the upsetting method explained in the sixth embodiment using the upsetting apparatus 1F of the fourth embodiment. The molding pressure required at the time of the upsetting was measured. The results are shown in Table 1.

[0321] In Example 2, the raw material 1 was subjected to the upsetting by the same method as the upsetting method explained in the fourth embodiment using the upsetting apparatus 1D of the sixth embodiment. The molding pressure required at the time of the upsetting was measured. The results are shown in Table 1.

[0322] In Example 3, the raw material 1 was subjected to the upsetting using the upsetting apparatus 1D of the fourth embodiment. In Example 3, however, the entire raw material 1 was heated and was subjected to the upsetting. The molding pressure required at the time of the upsetting was measured. The results are shown in Table 1.

[0323]

[Table 1]

	Restraining means	Heating mode	Heating temperature	Cooling	Forming pressure
Example 1	Pressure fluid	Partial heating	500 °C	Yes	1.8x10 ⁷ Pa
Example 2	Core bar	Partial heating	500 °C	Yes	2.7x10 ⁷ Pa
Example 3	Core bar	Entire heating	400 °C	No	4.7x10 ⁷ Pa

[0324] In Table 1, "Restraining means" denotes a means for restraining the internal peripheral surfaces of the non-processing scheduled portion 3 and both the processing scheduled portions 2 and 2. In Example 1, as the restraining means, pressure fluid 95 consisting of argon gas was used. In Examples 2 and 3, as the restraining means, a core bar 40 was used.

[0325] In the "Heating mode" column, "Partial heating" denotes the case in which the portion 2x of each processing scheduled portion 2 of the raw material 1 corresponding to the tip end portion 20a of the guide 20 was heated partially. "Entire heating" denotes the case in which the entire raw material 1 was heated with the heating furnace, and then this raw material 1 in the heated state was quickly set to the upsetting apparatus 1D and subjected to the upsetting.

[0326] In the "Cooling" column, "Yes" denotes the case in which the portion 2y of each processing scheduled portion 2 of the raw material 1 corresponding to the portion of the basal end side rather than the tip end portion 20a of the guide 20 was partially cooled by each cooling means 85. "No" denotes the case in which no cooling was performed.

[0327] As shown in Table 1, when the pressure fluid 95 was used as a restricted means (Example 1), the molding pressure could have been reduced as compared with the case (Examples 2 and 3) where the core bar 40 was used.

[0328] Furthermore, when partial heating was performed (Examples 1 and 2), the molding pressure could have been reduced as compared with the case (Example 3) where the entire heating was performed.

[0329] It should be understood that the terms and expressions used herein are used for explanation and have no intention to be used to construe in a limited manner, do not eliminate any equivalents of features shown and mentioned herein, and allow various modifications falling within the claimed scope of the present invention.

Industrial applicability

[0330] The present invention can be applied to an upsetting method for a hollow cylindrical raw material capable of inwardly or outwardly expanding the processing scheduled portion of the hollow cylindrical raw material so that the wall thickness increases, and an upsetting apparatus for a hollow cylindrical raw material.

Claims

1. An upsetting method for a hollow cylindrical raw material (1), comprising:

- disposing a core bar (40) in hollow portions of a processing scheduled portion (2) and a non-processing scheduled portion (3) of the hollow cylindrical raw material (1), to thereby restrain internal peripheral surfaces of the processing scheduled portion (2) and the non-processing scheduled portion (3) by a peripheral surface of the core bar (40);
- disposing the non-processing scheduled portion (3) of the hollow cylindrical raw material (1) in a restraining hole (11) formed in a restraining die (10) and extended in an axial direction thereof, to thereby restrain an external peripheral surface of the non-processing scheduled portion (3) with a peripheral surface of the restraining hole (11);
- disposing the processing scheduled portion (2) of the hollow cylindrical raw material (1) in a molding dented portion (12) formed at an axial end portion of the restraining die (10);
- disposing the processing scheduled portion (2) of the hollow cylindrical raw material (1) in an insertion hole (21) formed in a guide (20) and extended in the axial direction thereof; and
- then, moving the guide (20) in a direction opposite to a moving direction of a punch (30) while pressurizing the processing scheduled portion (2) of the hollow cylindrical raw material (1) with the punch (30) in an axial direction to thereby outwardly expand the processing scheduled portion (2) of the hollow cylindrical raw material (1) exposed between the tip end portion (20a) of the guide (20) and the bottom portion (12a) of the molding dented portion (12) so that a wall thickness of the hollow cylindrical raw material (1) increases within the molding dented portion (12).

2. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 1, wherein the guide (20) is moved by driving force of a guide driving apparatus (60).

3. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 1, wherein "G" satisfies an equation of

$$G = (X_g - X) P / (L_0 - X_p - P t_0)$$

where

"P" denotes an average moving speed of the punch (30) from the moving initiation thereof,

"G" denotes an average moving speed of the guide (20) from the moving initiation thereof,

"X₀" denotes a buckling limit length at a cross-sectional area of the processing scheduled portion (2) of the hollow cylindrical raw material (1) before the upsetting,

"X" denotes an initial clearance between a tip end portion of the guide (20) and a bottom portion of the molding dented portion (12) with 0 ≤ X ≤ X₀,

"L₀" denotes a length of the hollow cylindrical raw material (1) before the required for the expanded portion (4),

"X_p" denotes a stop position of the tip end portion of the punch (30) with respect to the bottom portion of the molding dented portion (12) obtained from a design volume of the expanded portion (4),

"X_g" denotes a stop position of the tip end portion of the guide (20) with respect to the bottom portion of the molding dented portion (12) defined by the design, and

"t₀" denotes a time lag from the moving initiation of the punch (30) to the moving initiation of the guide (20) with 0 ≤ t₀.

4. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 1, wherein the guide (20) is moved by pressing-back force acting on the guide (20) generated by press-fitting the material of the processing scheduled portion (2) of the hollow cylindrical raw material (1) into the molding dented portion (12).

5. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 1, wherein the tip end portion of the punch (30) is formed into a cross-sectional shape corresponding to a cross-sectional shape of an axial end portion of the hollow cylindrical raw material (1).

6. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 1, wherein the core bar (40) is connected to the punch (30) in such a manner that the core bar (40) extends in an axial direction of the punch (30).

7. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 6, wherein the core bar (40) is connected to the punch (30) via an extensible device (50) capable of being extended and contracted in an axial direction, and wherein the extensible device (50) is contracted with a movement of the punch (30).
8. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 1, wherein the processing scheduled portion (2) of the hollow cylindrical raw material (1) is expanded in a state in which the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially heated.
9. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 8, wherein the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially induction-heated by an induction heating means (81).
10. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 8, wherein the axial end portion of the restraining die (10) is partially induction-heated by an induction heating means (81) to thereby partially heat the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).
11. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 8, wherein the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially heated into a half-molten state.
12. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 8, wherein the processing scheduled portion (2) of the hollow cylindrical raw material (1) is expanded in a state in which the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the portion of the basal end side of the guide (20) rather than the tip end portion of the guide (20) is partially cooled by a cooling means (85).
13. An upsetting method for a hollow cylindrical raw material (1), comprising:
 - disposing a core bar (40) in hollow portions of a non-processing scheduled portion (3) of an axial intermediate portion of a hollow cylindrical raw material (1) and a processing scheduled portion (2) of both axial end portions of the hollow cylindrical raw material (1), to thereby restrain internal peripheral surfaces of the non-processing scheduled portion (3) and both the processing scheduled portions (2) by a peripheral surface of the core bar (40);
 - disposing the non-processing scheduled portion (3) of the hollow cylindrical raw material (1) in a restraining hole (11) formed in a restraining die (10) and extended in an axial direction thereof, to thereby restrain an external peripheral surface of the non-processing scheduled portion (3) with a peripheral surface of the restraining hole (11);
 - disposing both the processing scheduled portions (2) of the hollow cylindrical raw material (1) in molding dented portions (12) formed at both axial end portions of the restraining die (10);
 - disposing each processing scheduled portion (2) of the hollow cylindrical raw material (1) in an insertion hole (21) formed in a guide (20) and extended in the axial direction thereof; and
 - then, moving each guide (20) in a direction opposite to a moving direction of the punch (30) while simultaneously pressurizing each processing scheduled portion (2) of the hollow cylindrical raw material (1) with the punch (30) in an axial direction to thereby outwardly expand each processing scheduled portion (2) of the hollow cylindrical raw material (1) exposed between the tip end portion (20a) of each guide (20) and the corresponding bottom portion (12a) of the molding dented portion (12) so that a wall thickness of the hollow cylindrical raw material (1) increases within the corresponding molding dented portion (12).
14. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 13, wherein each guide (20) is moved by driving force of a corresponding guide driving apparatus (60).
15. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 13, wherein, in at least one of guides (20) and a punch (30) corresponding to the one of guides (20), "G" satisfies an equation of

$$G = (X_g - X) P / (L_0 - X_p - P t_0)$$

where

"P" denotes an average moving speed of the punch (30) from the moving initiation thereof,

"G" denotes an average moving speed of the guide (20) from the moving initiation thereof,

"X₀" denotes a buckling limit length at a cross-sectional area of the processing scheduled portion (2) of the hollow cylindrical raw material (1) before the upsetting,

"X" denotes an initial clearance between a tip end portion of the guide (20) and a bottom portion of the molding dented portion (12) with $0 \leq x \leq x_0$,

"L₀" denotes a length of the hollow cylindrical raw material (1) before the upsetting required for the expanded portion (4),

"X_p" denotes a stop position of the tip end portion of the punch (30) with respect to the bottom portion of the molding dented portion (12) obtained from a design volume of the expanded portion (4),

"X_g" denotes a stop position of the tip end portion of the guide (20) with respect to the bottom portion of the molding dented portion (12) defined by the design, and

"t₀" denotes a time lag from the moving initiation of the punch (30) to the moving initiation of the guide (20) with $0 \leq t_0$.

16. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 13, wherein each guide (20) is moved by pressing-back force acting on the guide (20) generated by press-fitting the material of the corresponding processing scheduled portion (2) of the hollow cylindrical raw material (1) into the molding dented portion (12).

17. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 13, wherein the tip end portion of each punch (30) is formed into a cross-sectional shape corresponding to a cross-sectional shape of a corresponding axial end portion of the hollow cylindrical raw material (1).

18. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 13, wherein the core bar (40) is, divided into divided core bar halves (40a) at the axial intermediate portion thereof, and wherein each core bar half (40a) is connected to a corresponding punch (30) with the divided core bar half (40a) extended in an axial direction of the punch (30).

19. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 18, wherein each core bar half (40a) is connected to the corresponding punch (30) via an extensible device (50) capable of being extended and contracted in an axial direction, and wherein each extensible device (50) is contracted with a movement of the corresponding punch (30).

20. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 13, wherein each processing scheduled portion (2) of the hollow cylindrical raw material (1) is expanded in a state, in which the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially heated.

21. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 20, wherein the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially induction-heated by an induction heating means (81).

22. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 20, wherein both the axial end portions of the restraining die (10) are partially induction-heated by induction heating means (81) to thereby partially heat the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

23. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 20, wherein the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially heated into a half-molten state.

24. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 20, wherein each processing scheduled portion (2) of the hollow cylindrical raw material (1) is expanded in a state in which the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the portion of the basal end side of the guide (20) rather than the tip end portion of the guide (20) is partially cooled by a cooling means (85).

25. An upsetting method for a hollow cylindrical raw material (1), comprising:

- preparing a core bar (40) having a core bar main body (41) and a small diameter portion (42) formed at an axial end portion of the core bar main body (41) and smaller in diameter than the core bar main body (41);
 - disposing the core bar main body (41) and the small diameter portion (42) of the core bar (40) in a hollow portion of a non-processing scheduled portion (3) of a hollow cylindrical raw material (1) and a hollow portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1), respectively, to thereby restrain the internal peripheral surface of the non-processing scheduled portion (3) by a peripheral surface of the core bar main body (41) and form a molding dented portion (12) between an internal peripheral surface of the processing scheduled portion (2) and the small diameter portion (42);
 - disposing the processing scheduled portion (2) and the non-processing scheduled portion (3) of the hollow cylindrical raw material (1) in a restraining hole (11) formed in a restraining die (10) and extended in an axial direction, to thereby restrain external peripheral surfaces of the processing scheduled portion (2) and the non-processing scheduled portion (3) by a peripheral surface of the restraining hole (11);
 - disposing a guide (20) in the hollow portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1), to thereby restrain the internal peripheral surface of the processing scheduled portion (2) by the peripheral surface of the guide (20); and then, moving the guide (20) in a direction opposite to a moving direction of the punch (30) while pressurizing the processing scheduled portion (2) of the hollow cylindrical raw material (1) with the punch (30) in an axial direction to thereby inwardly expand the processing scheduled portion (2) of the hollow cylindrical raw material (1) exposed between the tip end portion (20a) at the guide (20) and the bottom portion (12a) at the molding dented portion (12) so that a wall thickness of the hollow cylindrical raw material (1) increases within the molding dented portion (12).

26. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 25, wherein the guide (20) is moved by driving force of a guide driving apparatus (60).

27. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 25, wherein "G" satisfies an equation of

$$G = (X_g - X) P / (L_0 - X_p - P t_0)$$

where

"P" denotes an average moving speed of the punch (30) from the moving initiation thereof,

"G" denotes an average moving speed of the guide (20) from the moving initiation thereof,

"X₀" denotes a buckling limit length at a cross-sectional area of the processing scheduled portion (2) of the hollow cylindrical raw material (1) before the upsetting,

"X" denotes an initial clearance between a tip end portion of the guide (20) and a bottom portion of the molding dented portion (12) with 0 ≤ X ≤ X₀,

"L₀" denotes a length of the hollow cylindrical raw material (1) before the upsetting required for the expanded portion (4),

"X_p" denotes a stop position of the tip end portion of the punch (30) with respect to the bottom portion of the molding dented portion (12) obtained from a design volume of the expanded portion (4),

"X_g" denotes a stop position of the tip end portion of the guide (20) with respect to the bottom portion of the molding dented portion (12) defined by the design, and

"t₀" denotes a time lag from the moving initiation of the punch (30) to the moving initiation of the guide (20) with 0 ≤ t₀.

28. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 25, wherein the guide (20) is moved by pressing-back force acting on the guide (20) generated by press-fitting the material of the processing scheduled portion (2) of the hollow cylindrical raw material (1) into the molding dented portion (12).

29. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 25, wherein the tip end portion of the punch (30) is formed into a cross-sectional shape corresponding to a cross-sectional shape of an axial end portion of the hollow cylindrical raw material (1).

30. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 25, wherein the core bar (40) is connected to the guide (20) in such a manner that the core bar (40) extends in an axial direction of the guide (20).

31. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 30, wherein the core bar (40) is

connected to the guide (20) via an extensible device (50) capable of being extended and contracted in an axial direction, and
wherein the extensible device (50) is extended with a movement of the guide (20).

- 5 **32.** The upsetting method for a hollow cylindrical raw material (1) as recited in claim 25, wherein the processing scheduled portion (2) of the hollow cylindrical raw material (1) is expanded in a state in which the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially heated.
- 10 **33.** The upsetting method for a hollow cylindrical raw material (1) as recited in claim 32, wherein the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially induction-heated by an induction heating means (81).
- 15 **34.** The upsetting method for a hollow cylindrical raw material (1) as recited in claim 32, wherein the axial end portion of the restraining die (10) is partially induction-heated by an induction heating means (81) to thereby partially heat the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20)
- 20 **35.** The upsetting method for a hollow cylindrical raw material (1) as recited in claim 32, wherein the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially heated into a half-molten state.
- 25 **36.** The upsetting method for a hollow cylindrical raw material (1) as recited in claim 32, wherein the processing scheduled portion (2) of the hollow cylindrical raw material (1) is expanded in a state in which the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the portion of the basal end side of the guide (20) rather than the tip end portion of the guide (20) is partially cooled by a cooling means (85).
- 30 **37.** An upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) for outwardly expanding a processing scheduled portion (2) of the hollow cylindrical raw material (1) so that a wall thickness of the processing scheduled portion (2) increases, the upsetting apparatus (1A, 1B, 1C) comprising:
 - a core bar (40) adapted to be disposed in hollow portions of the processing scheduled portion and a non-processing scheduled portion (3) of the hollow cylindrical raw material (1);
 - a restraining die (10) having a restraining hole (11) extended in an axial direction, wherein the non-processing scheduled portion (3) of the hollow cylindrical raw material (1) is to be disposed in the restraining hole (11);
 - a molding dented portion (12) formed at an axial end portion of the restraining die (10);
 - a guide (20) having an insertion hole (21) extended in an axial direction, wherein the processing scheduled portion (2) of the hollow cylindrical raw material (1) is to be disposed in the insertion hole (21); and
 - a punch (30) for pressurizing the processing scheduled portion (2) of the hollow cylindrical raw material (1) in the axial direction,
 - wherein the guide (20) is movable in a direction, opposite to a moving direction of the punch (30), whereby in use the processing scheduled portion (2) at the hollow cylindrical raw material (1) exposed between the tip end portion (20a) of the guide (20) and the bottom portion (12a) of the molding dented portion (12) is outwardly expanded within the molding dented portion (12).
- 45 **38.** The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 37, further comprising a guide driving apparatus (60) for moving the guide (20) in a direction opposite to the moving direction of the punch (30).
- 50 **39.** The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 37, wherein the tip end portion of the punch (30) is formed into a cross-sectional shape corresponding to a cross-sectional shape of an axial end portion of the hollow cylindrical raw material (1).
- 55 **40.** The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 37, wherein the core bar (40) is connected to the punch (30) in such a manner that the core bar (40) extends in an axial direction of the punch (30).
- 41.** The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 40, wherein the

core bar (40) is connected to the punch (30) via an extensible device (50) capable of being extended and contracted in an axial direction.

42. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 41, wherein the punch (30) is equipped with the extensible device (50) therein.

43. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 41, wherein the extensible device (50) has a fluid pressure cylinder (51) or a spring (52) capable of being extended and contracted in an axial direction.

44. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 37, wherein chamfering work is given to the insertion hole opening edge portion of the tip end portion of the guide (20).

45. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 37, further comprising a heating means (80) for partially heating the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

46. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 45, wherein the heating means (80) is an induction heating means (81) configured to partially induction-heat the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

47. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 45, wherein the heating means (80) is an induction heating means (81) configured to partially induction-heat the axial end portion of the restraining die (10) to thereby partially heat the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

48. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 45, wherein the heating means (80) is capable of partially heating the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) into a half-molten state.

49. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 45, further comprising a cooling means (85) configured to partially cool the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the portion of the basal end side of the guide (20) rather than the tip end portion of the guide (20).

50. An upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) for outwardly expanding processing scheduled portions (2) of both axial end portions of the hollow cylindrical raw material (1) so that a wall thickness of each processing scheduled portion (2) increases, the upsetting apparatus (1A, 1B, 1C) comprising;

- a core bar (40) adapted to be disposed in hollow portions of a non-processing scheduled portion of an axial intermediate portion of the hollow cylindrical raw material (1) and the processing scheduled portion (2) of both axial end portions of the hollow cylindrical raw material (1);
- a restraining die (10) having a restraining hole (11) extended in an axial direction, wherein the non-processing scheduled portion (3) of the hollow cylindrical raw material (1) is to be disposed in the restraining hole (11);
- two molding dented portions (12) formed at axial both end portions of the restraining die (10);
- two guides (20) each having an insertion hole (21) extended in an axial direction, wherein each processing scheduled portion (21) of the hollow cylindrical raw material (1) is to be disposed in the insertion hole (21); and
- two punches (30) each for pressurizing each processing scheduled portion (2) of the hollow cylindrical raw material (1) in the axial direction,
- wherein each guide (20) is movable in a direction opposite to a moving direction of the punch (30), whereby in use each processing scheduled portion (2) of the hollow cylindrical raw material (1) exposed between the tip end portion (20a) of each guide (20) and the corresponding bottom portion (12a) of the molding dented portion (12) is outwardly expanded with in the molding dented portion (12).

51. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 50, further comprising two guide driving apparatuses (60) each for moving the corresponding guide (20) in a direction opposite to the moving direction of the punch (30).

52. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 50, wherein the tip end portion of each punch (30) is formed into a cross-sectional shape corresponding to a cross-sectional shape of a corresponding axial end portion of the hollow cylindrical raw material (1).

53. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 50, wherein the core bar (40) is divided into divided core bar halves (40a) at the axial intermediate portion thereof, and wherein each core bar half (40a) is connected to a corresponding punch (30) with the divided core bar half (40a) extended in an axial direction of the punch (30).

54. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 53, wherein each core bar half (40a) is connected to the corresponding punch (30) via an extensible device (50) capable of being extended and contracted in an axial direction.

55. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 54, wherein each punch (30) is equipped with the corresponding extensible device (50) therein.

56. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 54, wherein the extensible device (50) has a fluid pressure cylinder (51) or a spring (52) capable of being extended and contracted in an axial direction.

57. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 50, wherein chamfering work is given to the insertion hole opening edge portion of the tip end portion of each guide (20).

58. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 50, further comprising two heating means (80) each for partially heating the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

59. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 58, wherein each heating means (80) is an induction heating means (81) configured to partially induction-heat the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

60. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 58, wherein each heating means (80) is an induction heating means (81) configured to partially induction-heat both the axial end portions of the restraining die (10) to thereby partially heat the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

61. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 58, wherein each heating means (80) is capable of partially heating the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) into a half-molten state.

62. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 58, further comprising two cooling means (85) each configured to partially cool the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the portion of the basal end side of the guide (20) rather than the tip end portion of the guide (20).

63. An upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) for inwardly expanding a processing scheduled portion (2) of a hollow cylindrical raw material (1) so that a wall thickness increases, the upsetting apparatus (1A, 1B, 1C) comprising:

- a core bar (40) having a core bar main body (41) and a small diameter portion (42) formed at an axial end portion of the core bar main body (41) and smaller in diameter than the core bar main body (41), wherein the core bar main body (41) and the small diameter portion (42) are adapted to be disposed in a hollow portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) and a hollow portion of a non-processing scheduled portion (3) of the hollow cylindrical raw material (1), respectively, to thereby form a molding dented portion (12) between an internal peripheral surface of the non-processing scheduled portion (3) and the small diameter portion (42);
- a restraining die (10) having a restraining hole (11) extended in an axial direction, wherein the processing

scheduled portion (2) and the non-processing scheduled portion (3) of the hollow cylindrical raw material (1) are to be disposed in the restraining hole (11);

- a guide (20) to be disposed in the hollow portion of the processing scheduled portion (2) of the hollow cylindrical raw material, (1); and

- a punch (30) configured to pressurize the processing scheduled portion (2) of the hollow cylindrical raw material (1) in an axial direction,

- wherein the guide (20) is movable in a direction opposite to a moving direction of the punch (30), whereby in use the processing scheduled portion (2) of the hollow cylindrical raw material (1) exposed between the tip end portion (20a) of the guide (20) and the bottom portion (12a) of the molding dented portion (12) is inwardly expanded within the molding portion (12).

64. The upsetting apparatus (1A, 1B, 1C) for a hollow, cylindrical raw material (1) as recited in claim 63, further comprising a guide deriving apparatus (60) for moving the guide (20) in a direction apposite to the moving direction of the punch (30).

65. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 63, wherein the tip end portion of the punch (30) is forced into a cross-sectional shape corresponding to a cross-sectional shape of an axial end portion of the hollow cylindrical raw material (1).

66. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 63, wherein the guide (20) is disposed in a hollow portion formed in the punch (30) and extended in an axial direction in a manner such that the guide (20) is movable in an axial direction of the punch (30).

67. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 63, wherein the core bar (40) is connected to the guide (20) in such a manner that the core bar (40) extends in an axial direction of the guide (20).

68. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 67, wherein the core bar (40) is connected to the guide (20) via an extensible device (50) capable of being extended and contracted in an axial direction.

69. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 68, wherein the guide (20) is equipped with the extensible device (50) therein.

70. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 68, wherein the extensible device (50) has a fluid pressure cylinder (51) or a spring (52) capable of being extended and contracted in an axial direction.

71. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 63, wherein chamfering work is given to a peripheral edge portion of a tip end portion of the guide (20).

72. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 63, further comprising a heating means (80) for partially heating the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

73. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1), as recited in claim 72, wherein the heating means (80) is an induction heating means (81) configured to partially induction-heat the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) .

74. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 72, wherein the heating means (80) is an induction heating means (81) configured to partially induction-heat the axial end portion of the restraining die (10) to thereby partially heat the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

75. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 72, wherein the heating means (80) is capable of partially heating the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) into a half-molten state.

76. The upsetting apparatus (1A, 1B, 1C) for a hollow, cylindrical raw material (1) as recited in claim 72, further comprising a cooling means (85) configured to partially cool the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the portion of the basal end side of the guide (20) rather than the tip end portion of the guide (20).

77. An upsetting method for a hollow cylindrical raw material (1), comprising:

- filling hollow portions of a processing scheduled portion (2) and a non-processing scheduled portion (3) of a hollow cylindrical raw material (1) with pressure fluid, to thereby pressurize and restrain internal peripheral surfaces of the processing scheduled portion (2) and the non-processing scheduled portion (3) with the fluid pressure;
- disposing the non-processing scheduled portion (3) of the hollow cylindrical raw material (1) in a restraining hole (11) formed in a restraining die (10) and extended in an axial direction, to thereby restrain an external peripheral surface of the non-processing scheduled portion (3) with a peripheral surface of the restraining hole (11);
- disposing the processing scheduled portion (2) of the hollow cylindrical raw material (1) in a molding dented portion (12) formed at an axial end portion of the restraining die (10);
- disposing the processing scheduled portion (2) of the hollow cylindrical raw material (1) in an insertion hole (21) formed in a guide (20) and extended in an axial direction;
- then, moving the guide (20) in a direction opposite to a moving direction of the punch (30) while pressurizing the processing scheduled portion (2) of the hollow cylindrical raw material (1) with the punch (30) in an axial direction to thereby outwardly expand the processing scheduled portion (2) of the hollow cylindrical raw material (1) exposed between the tip end portion (20a) of the guide (20) and the bottom portion (12a) of the molding dented portion (12) so that a wall thickness of the hollow cylindrical raw material (1) increases within the molding dented portion (12).

78. An upsetting method for a hollow cylindrical raw material (1) as recited in claim 77, wherein the guide (20) is moved by driving force of a guide driving apparatus (60).

79. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 77, wherein "G" satisfies an equation of

$$G = (X_g - X) P / (L_0 - X_p - P t_0)$$

where

"P" denotes an average moving speed of the punch (30) from the moving initiation thereof,

"G" denotes an average moving speed of the guide (20) from the moving initiation thereof,

"X₀" denotes a buckling limit length at a cross-sectional area of the processing scheduled portion (2) of the hollow cylindrical raw material (1) before the upsetting,

"X" denotes an initial clearance between a tip end portion of the guide (20) and a bottom portion of the molding dented portion (12) with 0 ≤ X ≤ X₀,

"L₀" denotes a length of the hollow cylindrical raw material (1) before the upsetting required for the expanded portion (4),

"X_p" denotes a stop position of the tip end portion of the punch (30) with respect to the bottom portion of the molding dented portion (12) obtained from a design volume of the expanded portion (4),

"X_g" denotes a stop position of the tip end portion of the guide (20) with respect to the bottom portion of the molding dented portion (12) defined by the design, and

"t₀" denotes a time lag from the moving initiation of the punch (30) to the moving initiation of the guide (20) with 0 ≤ t₀.

80. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 77, wherein the guide (20) is moved by pressing-back force acting on the guide (20) generated by press-fitting the material of the processing scheduled portion (2) of the hollow cylindrical raw material (1) into the molding dented portion (12).

81. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 77, wherein the tip end portion of the punch (30) is formed into a cross-sectional shape corresponding to a cross-sectional, shape of an axial end portion of the hollow cylindrical raw material (1).

82. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 77, wherein the processing scheduled portion (2) of the hollow cylindrical raw material (1) is expanded in a state in which the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially heated.

83. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 82, wherein the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially induction-heated by an induction heating means (81).

84. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 82, wherein the axial end portion of the restraining die (10) is partially induction-heated by an induction heating means (81) to thereby partially heat the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

85. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 82, wherein the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially heated into a half-molten state.

86. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 82, wherein the processing scheduled portion (2) of the hollow cylindrical raw material (1) is expanded in a state in which the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the portion of the basal end side of the guide (20) rather than the tip end portion of the guide (20) is partially cooled by a cooling means (85).

87. An upsetting method for a hollow cylindrical raw material (1), comprising:

- filling hollow portions of a non-processing scheduled portion of an axial intermediate portion of the hollow cylindrical raw material (1) and a processing scheduled portion (2) of both axial end portions of the hollow cylindrical raw material (1) with pressure fluid, to thereby pressurize and restrain internal peripheral surfaces of both the processing scheduled portion (2) and the non-processing scheduled portion (3) with the fluid pressure;
- disposing the non-processing scheduled portion (3) of the hollow cylindrical raw material (1) in a restraining hole (11) formed in a restraining die (10) and extended in an axial direction, to thereby restrain an external peripheral surface of the non-processing scheduled portion (3) with a peripheral surface of the restraining hole (11);
- disposing both the processing scheduled portions (2) of the hollow cylindrical raw material (1) in molding dented portions (12) formed at both axial end portions of the restraining die (10);
- disposing each processing scheduled portion (2) of the hollow cylindrical raw material (1) in an insertion hole (21) formed in a guide (20) and extended in an axial direction;
- then, moving each guide (20) in a direction opposite to a moving direction of the punch (30) while simultaneously pressurizing each processing scheduled portion (2) of the hollow cylindrical raw material (1) with the punch (30) in an axial direction to thereby outwardly expand each processing scheduled portion (2) of the hollow cylindrical raw material (1) exposed between the tip end portion (20a) of each guide (20) and the corresponding bottom portion (12a) of the molding dented portion (12) so that a wall thickness of the hollow cylindrical raw material (1) increases within the corresponding molding dented portion (12).

88. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 87, wherein each guide (20) is moved by driving force of a corresponding guide driving apparatus (60).

89. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 87, wherein, in at least one of guides (20) and a punch (30) corresponding to the one of guides (20), "G" satisfies an equation of

$$G = (X_g - X) P / (L_0 - X_p - P t_0)$$

where

"P" denotes an average moving speed of the punch (30) from the moving initiation thereof,

"G" denotes an average moving speed of the guide (20) from the moving initiation thereof,

"X₀" denotes a buckling limit length at a cross-sectional area of the processing scheduled portion (2) of the hollow

cylindrical raw material (1) before the upsetting,

"X" denotes an initial clearance between a tip end portion of the guide (20) and a bottom portion of the molding dented portion (12) with $0 \leq X \leq X_0$,

"L₀" denotes a length of the hollow cylindrical raw material (1) before the upsetting required for the expanded portion (4),

"X_p" denotes a stop position of the tip end portion of the punch (30) with respect to the bottom portion of the molding dented portion (12) obtained from a design volume of the expanded portion (4),

"X_g" denotes a stop position of the tip end portion of the guide (20) with respect to the bottom portion of the molding dented portion (12) defined by the design, and

"t₀" denotes a time lag from the moving initiation of the punch (30) to the moving initiation of the guide (20) with $0 \leq t_0$.

90. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 87, wherein each guide (20) is moved by pressing-back force acting on the guide (20) generated by press-fitting the material of the corresponding processing scheduled portion (2) of the hollow cylindrical raw material (1) into the molding dented portion (12).

91. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 87, wherein the tip end portion of each punch (30) is formed into a cross-sectional shape corresponding to a cross-sectional shape of a corresponding axial end portion of the hollow cylindrical raw material (1).

92. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 87, wherein each processing scheduled portion (2) of the hollow cylindrical raw material (1) is expanded in a state in which the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially heated.

93. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 92, wherein the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially induction-heated by an induction heating means (81).

94. The upsetting method for a hollow cylindrical raw material (1) as recited in claim wherein both the axial end portions of the restraining die (10) are partially induction-heated by induction heating means (81) to thereby partially heat the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

95. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 92, wherein the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) is partially heated into a half-molten state.

96. The upsetting method for a hollow cylindrical raw material (1) as recited in claim 92, wherein each processing scheduled portion (2) of the hollow cylindrical raw material (1) is expanded in a state in which the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the portion of the basal end side of the guide (20) rather than the tip end portion of the guide (20) is partially cooled by a cooling means (85).

97. An upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) for outwardly expanding a processing scheduled portion (2) of the hollow cylindrical raw material (1) so that a wall thickness of the processing scheduled portion (2) increases, the upsetting apparatus (1A, 1B, 1C) comprising:

- a pressure fluid filling means (90) configured to fill hollow portions of a processing scheduled portion (2) and a non-processing scheduled portion (3) of the hollow cylindrical raw material (1) with pressure fluid;
- a restraining die (10) having a restraining hole (11) extended in an axial direction, wherein the non-processing scheduled portion (3) of the hollow cylindrical raw material (1) is to be disposed in the restraining hole (11);
- a molding dented portion (12) formed in an axial, end portion of the restraining die (10);
- a guide (20) having an insertion hole (21) extended in an axial direction, wherein the processing scheduled portion (2) of the hollow cylindrical raw material (1) is to be disposed in the insertion hole (21); and
- a punch (30) for pressurizing the processing scheduled portion (2) of the hollow cylindrical raw material (1) in the axial direction,
- wherein the guide (20) is movable in a direction opposite to a moving direction of the punch (30), whereby in use the processing scheduled portion (2) of the hollow cylindrical raw material (1) exposed between the tip end portion (20a) of the guide (20) and the bottom portion (12a) of the molding dented portion (12) is outwardly

expanded within the molding dented portion (12).

5 98. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 97, further comprising a guide driving apparatus (60) for moving the guide (20) in a direction opposite to the moving direction of the punch (30).

10 99. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 97, wherein the tip end portion of the punch (30) is formed into a cross-sectional shape corresponding to a cross-sectional shape of an axial end portion of the hollow cylindrical raw material (1).

100. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 97, therein chamfering work is given to the insertion hole opening edge portion of the tip end portion of the guide (20).

15 101. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 97, further comprising a heating means (80) for partially heating the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

20 102. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 101; wherein the heating means (80) is an induction heating means (81) configured to partially induction-heat the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

25 103. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 101, wherein the heating means (80) is an induction heating means (81) configured to partially induction-heat the axial end portion of the restraining die (10) to thereby partially heat the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

30 104. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 101, wherein the heating means (80) is capable of partially heating the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) into a half-molten state.

35 105. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 101, further comprising a cooling means (85) configured to partially cool the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the portion of the basal end side of the guide (20) rather than the tip end portion of the guide (20).

40 106. An upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) for outwardly expanding processing scheduled portions (2) of both axial end portions of the hollow cylindrical raw material (1) so that a wall thickness of each processing scheduled portion (2) increases, the upsetting apparatus (1A, 1B, 1C) comprising:

- a pressure fluid filling means (90) configured to fill hollow portions of a non-processing scheduled portion (3) of an axial intermediate portion of the hollow cylindrical raw material (1) and processing scheduled portions (2) of both axial end portions of the hollow cylindrical raw material (1) with pressure fluid;
- a restraining die (10) having a restraining hole (11) extended in an axial direction, wherein the non-processing scheduled portion (3) of the hollow cylindrical raw material (1) is to be disposed in the restraining hole (11);
- two molding dented portions (12) formed at both axial end portions of the restraining die (10);
- two guides (20) each having an insertion hole (21) extended in an axial direction, wherein each processing scheduled portion (2) of the hollow cylindrical raw material (1) is to be disposed in the insertion hole (21); and
- two punches (30) each for pressurizing each processing scheduled portion (2) of the hollow cylindrical raw material (1) in the axial direction,
- wherein each guide (20) is movable in a direction opposite to a moving direction of the punch (30), whereby in use each processing scheduled portion (2) of the hollow cylindrical raw material (1) exposed between the tip end portion (20a) of each guide (20) and the corresponding bottom portion (12a) of the molding dented portion (12) is outwardly expanded within the molding dented portion (12).

55 107. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 106, further comprising two guide driving apparatuses (60) each for moving the corresponding guide (20) in a direction opposite to the moving direction of the punch (30).

108. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 106, wherein the tip end portion of each punch (30) is formed into a cross-sectional shape corresponding to a cross-sectional shape of a corresponding axial end portion of the hollow cylindrical raw material (1).

109. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 106, wherein chamfering work is given to the insertion hole opening edge portion of the tip end portion of each guide (20).

110. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 106, further comprising two heating means (80) each for partially heating the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

111. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 110, wherein each heating means (80) is an induction heating means (81) configured to partially induction-heat the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

112. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 110, wherein each heating means (80) is an induction heating means (81) configured to partially induction-heat both the axial end portions of the restraining die (10) to thereby partially heat the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20).

113. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 110, wherein each heating means (80) is capable of partially heating the portion of the processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the tip end portion of the guide (20) into a half-molten state.

114. The upsetting apparatus (1A, 1B, 1C) for a hollow cylindrical raw material (1) as recited in claim 110, further comprising two cooling means (85) each configured to partially cool the portion of each processing scheduled portion (2) of the hollow cylindrical raw material (1) corresponding to the portion of the basal end side of the guide (20) rather than the tip end portion of the guide (20).

Patentansprüche

1. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1), aufweisend:

- Anordnen einer Kernstange (40) in hohlen Abschnitten eines zur Bearbeitung vorgesehenen Abschnitts (2) und eines nicht zur Bearbeitung vorgesehenen Abschnitts (3) des hohlzylindrischen Rohmaterials (1), um **dadurch** die Innenumfangsflächen des zur Bearbeitung vorgesehenen Abschnitts (2) und des nicht zur Bearbeitung vorgesehenen Abschnitts (3) durch eine Umfangsfläche der Kernstange (40) zurückzuhalten;
- Anordnen des nicht zur Bearbeitung vorgesehenen Abschnitts (3) des hohlzylindrischen Rohmaterials (1) in einer Rückhalteöffnung (11), die in einer Rückhalteform (10) ausgebildet ist und sich in deren Axialrichtung erstreckt, um **dadurch** eine Außenumfangsfläche des nicht zur Bearbeitung vorgesehenen Abschnitts (3) mit einer Umfangsfläche der Rückhalteöffnung (11) zurückzuhalten;
- Anordnen des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einem Buckelformabschnitt (12), der an einem axialen Endabschnitt der Rückhalteform (10) ausgebildet ist;
- Anordnen des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einer Einsetzöffnung (21), die in einer Führung (20) ausgebildet ist und sich in deren Axialrichtung erstreckt; und
- dann Bewegen der Führung (20) in einer Richtung entgegengesetzt zu einer Bewegungsrichtung eines Stempels (30), während der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) mit dem Stempel (30) in einer Axialrichtung unter Druck gesetzt wird, um **dadurch** den zur Bearbeitung vorgesehenen Abschnitt (2) des hohlzylindrischen Rohmaterials (1), der zwischen dem oberen Endabschnitt (20a) der Führung (20) und dem unteren Abschnitt (12a) des Buckelformabschnitts (12) freigelegt ist, nach außen zu expandieren, so dass eine Wanddicke des hohlzylindrischen Rohmaterials (1) innerhalb des Buckelformabschnitts (12) zunimmt.

2. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 1, wobei die Führung (20) durch die Antriebskraft einer Führungsantriebsvorrichtung (60) bewegt wird.

3. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 1, wobei "G" eine Gleichung $G=(X_g-X)/P/(L_0-X_p-Pt_0)$ erfüllt,
wobei
"P" eine durchschnittliche Bewegungsgeschwindigkeit des Stempels (30) von dessen Bewegungsbeginn bezeichnet,
"G" eine durchschnittliche Bewegungsgeschwindigkeit der Führung (20) von deren Bewegungsbeginn bezeichnet,
"X₀" eine Stauchungsbegrenzungslänge an einer Querschnittsfläche des zur Bearbeitung vorgesehenen Abschnitts
(2) des hohlzylindrischen Rohmaterials (1) vor dem Stauchen bezeichnet,
"X" einen Anfangsabstand zwischen einem oberen Endabschnitt der Führung (20) und einem unteren Abschnitt
des Buckelformabschnitts (12) mit $0 \leq X \leq X_0$ bezeichnet,
"L₀" eine für den expandierten Abschnitt (4) vor dem Stauchen benötigte Länge des hohlzylindrischen Rohmaterials
(1) bezeichnet,
"X_p" eine aus einem Gestaltungsvolumen des expandierten Abschnitts (4) erlangte Endposition des oberen End-
abschnitts des Stempels (30) in Bezug auf den unteren Abschnitt des Buckelformabschnitts (12) bezeichnet,
"X_g" eine durch die Gestaltung definierte Endposition des oberen Endabschnitts der Führung (20) in Bezug auf den
unteren Abschnitt des Buckelformabschnitts (12) bezeichnet, und
"t₀" eine Zeitverschiebung von dem Bewegungsbeginn des Stempels (30) bis zu dem Bewegungsbeginn der Führung
(20) mit $0 \leq t_0$ bezeichnet.
4. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 1, wobei die Führung (20) durch die auf
die Führung (20) wirkende Rückpresskraft bewegt wird, die durch Einpressen des Materials des zur Bearbeitung
vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in den Buckelformabschnitt (12) erzeugt wird.
5. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 1, wobei der obere Endabschnitt des
Stempels (30) in einer Querschnittsform gestaltet ist, die einer Querschnittsform eines axialen Endabschnitts des
hohlzylindrischen Rohmaterials (1) entspricht.
6. Stauchverfahren für ein hohlzylindrisches Material (1) nach Anspruch 1, wobei die Kernstange (40) mit dem Stempel
(30) derart verbunden ist, dass sich die Kernstange (40) in einer Axialrichtung des Stempels (30) erstreckt.
7. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 6, wobei die Kernstange (40) über eine
dehnbare Vorrichtung (50), die geeignet ist, in einer Axialrichtung auseinander- und zusammengezogen zu werden,
mit dem Stempel (30) verbunden ist, und wobei die dehnbare Vorrichtung (50) mit einer Bewegung des Stempels
(30) zusammengezogen wird.
8. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 1, wobei der zur Bearbeitung vorgesehene
Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einem Zustand expandiert wird, in welchem der dem oberen
Endabschnitt der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des
hohlzylindrischen Rohmaterials (1) teilweise erwärmt wird.
9. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 8, wobei der dem oberen Endabschnitt
der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen
Rohmaterials (1) durch ein Induktionserwärmungsmittel (81) teilweise induktionserwärmt wird.
10. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 8, wobei der axiale Endabschnitt der
Rückhalteform (10) durch ein Induktionserwärmungsmittel (81) teilweise induktionserwärmt wird, um **dadurch** den
dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts
(2) des hohlzylindrischen Rohmaterials (1) teilweise zu erwärmen.
11. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 8, wobei der dem oberen Endabschnitt
der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen
Rohmaterials (1) in einen halbgeschmolzenen Zustand teilweise erwärmt wird.
12. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 8, wobei der zur Bearbeitung vorgesehene
Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einem Zustand expandiert wird, in welchem der dem Abschnitt
der basalen Endseite der Führung (20) anstatt dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt
des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) durch ein Kühlmittel
(85) teilweise gekühlt wird.

13. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1), aufweisend:

- Anordnen einer Kernstange (40) in hohlen Abschnitten eines nicht zur Bearbeitung vorgesehenen Abschnitts (3) eines axialen Zwischenabschnitts eines hohlzylindrischen Rohmaterials (1) und eines zur Bearbeitung vorgesehenen Abschnitts (2) beider axialer Endabschnitte des hohlzylindrischen Rohmaterials (1), um **dadurch** die Innenumfangsflächen des nicht zur Bearbeitung vorgesehenen Abschnitts (3) und der beiden zur Bearbeitung vorgesehenen Abschnitte (2) durch eine Umfangsfläche der Kernstange (40) zurückzuhalten;
- Anordnen des nicht zur Bearbeitung vorgesehenen Abschnitts (3) des hohlzylindrischen Rohmaterials (1) in einer Rückhalteöffnung (11), die in einer Rückhalteform (10) ausgebildet ist und sich in deren Axialrichtung erstreckt, um **dadurch** eine Außenumfangsfläche des nicht zur Bearbeitung vorgesehenen Abschnitts (3) mit einer Umfangsfläche der Rückhalteöffnung (11) zurückzuhalten;
- Anordnen der beiden zur Bearbeitung vorgesehenen Abschnitte (2) des hohlzylindrischen Rohmaterials (1) in Buckelformabschnitten (12), die an beiden axialen Endabschnitten der Rückhalteform (10) ausgebildet sind;
- Anordnen jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einer Einsetzöffnung (21), die in einer Führung (20) ausgebildet ist und sich in deren Axialrichtung erstreckt; und
- dann Bewegen jeder Führung (20) in einer Richtung entgegengesetzt zu einer Bewegungsrichtung des Stempels (30), während jeder zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) mit dem Stempel (30) in einer Axialrichtung gleichzeitig unter Druck gesetzt wird, um **dadurch** jeden zur Bearbeitung vorgesehenen Abschnitt (2) des hohlzylindrischen Rohmaterials (1), der zwischen dem oberen Endabschnitt (20a) jeder Führung (20) und dem entsprechenden unteren Abschnitt (12a) des Buckelformabschnitts (12) freigelegt ist, nach außen zu expandieren, so dass eine Wanddicke des hohlzylindrischen Rohmaterials (1) innerhalb des entsprechenden Buckelformabschnitts (12) zunimmt.

14. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 13, wobei jede Führung (20) durch die Antriebskraft einer entsprechenden Führungsantriebsvorrichtung (60) bewegt wird.

15. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 13, wobei bei wenigstens einer der Führungen (20) und einem der einen der Führungen (20) entsprechenden Stempel (30) "G" eine Gleichung $G = (X_g - X)P / (L_0 - X_p - Pt_0)$ erfüllt,

wobei

"P" eine durchschnittliche Bewegungsgeschwindigkeit des Stempels (30) von dessen Bewegungsbeginn bezeichnet, "G" eine durchschnittliche Bewegungsgeschwindigkeit der Führung (20) von deren Bewegungsbeginn bezeichnet, " X_0 " eine Stauchungsbegrenzungslänge an einer Querschnittsfläche des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) vor dem Stauchen bezeichnet,

"X" einen Anfangsabstand zwischen einem oberen Endabschnitt der Führung (20) und einem unteren Abschnitt des Buckelformabschnitts (12) mit $0 \leq X \leq X_0$ bezeichnet,

" L_0 " eine für den expandierten Abschnitt (4) vor dem Stauchen benötigte Länge des hohlzylindrischen Rohmaterials (1) bezeichnet,

" X_p " eine aus einem Gestaltungsvolumen des expandierten Abschnitts (4) erlangte Endposition des oberen Endabschnitts des Stempels (30) in Bezug auf den unteren Abschnitt des Buckelformabschnitts (12) bezeichnet,

" X_g " eine durch die Gestaltung definierte Endposition des oberen Endabschnitts der Führung (20) in Bezug auf den unteren Abschnitt des Buckelformabschnitts (12) bezeichnet, und

" t_0 " eine Zeitverschiebung von dem Bewegungsbeginn des Stempels (30) bis zu dem Bewegungsbeginn der Führung (20) mit $0 \leq t_0$ bezeichnet.

16. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 13, wobei jede Führung (20) durch die auf die Führung (20) wirkende Rückpresskraft bewegt wird, die durch Einpressen des Materials des entsprechenden zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in den Buckelformabschnitt (12) erzeugt wird.

17. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 13, wobei der obere Endabschnitt jedes Stempels (30) in einer Querschnittsform gestaltet ist, die einer Querschnittsform eines entsprechenden axialen Endabschnitts des hohlzylindrischen Rohmaterials (1) entspricht.

18. Stauchverfahren für ein hohlzylindrisches Material (1) nach Anspruch 13, wobei die Kernstange (40) an deren axialen Zwischenabschnitt in getrennte Kernstangenhälften (40a) geteilt ist, und wobei jede Kernstangenhälfte (40a) mit einem entsprechenden Stempel (30) verbunden ist, wobei sich die getrennte Kernstangenhälfte (40a) in einer Axialrichtung des Stempels (30) erstreckt.

19. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 18, wobei jede Kernstangenhälfte (40a) über eine dehnbare Vorrichtung (50), die geeignet ist, in einer Axialrichtung auseinander- und zusammengezogen zu werden, mit dem entsprechenden Stempel (30) verbunden ist, und wobei jede dehnbare Vorrichtung (50) mit einer Bewegung des entsprechenden Stempels (30) zusammengezogen wird.

20. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 13, wobei jeder zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einem Zustand expandiert wird, in welchem der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise erwärmt wird.

21. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 20, wobei der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) durch ein Induktionserwärmungsmittel (81) teilweise induktionserwärmt wird.

22. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 20, wobei die beiden axialen Endabschnitte der Rückhalteform (10) durch ein Induktionserwärmungsmittel (81) teilweise induktionserwärmt werden, um **dadurch** den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise zu erwärmen.

23. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 20, wobei der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einen halbgeschmolzenen Zustand teilweise erwärmt wird.

24. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 20, wobei jeder zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einem Zustand expandiert wird, in welchem der dem Abschnitt der basalen Endseite der Führung (20) anstatt dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) durch ein Kühlmittel (85) teilweise gekühlt wird.

25. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1), aufweisend:

- Bereitstellen einer Kernstange (40) mit einem Kernstangenhauptkörper (41) und einem Abschnitt mit kleinem Durchmesser (42), der an einem axialen Endabschnitt des Kernstangenhauptkörpers (41) ausgebildet ist und einen kleineren Durchmesser als der Kernstangenhauptkörper (41) hat;

- Anordnen des Kernstangenhauptkörpers (41) und des Abschnitts mit kleinem Durchmesser (42) der Kernstange (40) in einem hohlen Abschnitt eines nicht zur Bearbeitung vorgesehenen Abschnitts (3) eines hohlzylindrischen Rohmaterials (1) bzw. einem hohlen Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1), um **dadurch** die Innenumfangsfläche des nicht zur Bearbeitung vorgesehenen Abschnitts (3) durch eine Umfangsfläche des Kernstangenhauptkörpers (41) zurückzuhalten und einen Buckelformabschnitt (12) zwischen einer Innenumfangsfläche des zur Bearbeitung vorgesehenen Abschnitts (2) und dem Abschnitt mit kleinem Durchmesser (42) zu bilden;

- Anordnen des zur Bearbeitung vorgesehenen Abschnitts (2) und des nicht zur Bearbeitung vorgesehenen Abschnitts (3) des hohlzylindrischen Rohmaterials (1) in einer Rückhalteöffnung (11), die in einer Rückhalteform (10) ausgebildet ist und sich in deren Axialrichtung erstreckt, um **dadurch** Außenumfangsflächen des zur Bearbeitung vorgesehenen Abschnitts (2) und des nicht zur Bearbeitung vorgesehenen Abschnitts (3) mit einer Umfangsfläche der Rückhalteöffnung (11) zurückzuhalten;

- Anordnen einer Führung (20) in dem hohlen Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1), um **dadurch** die Innenumfangsfläche des zur Bearbeitung vorgesehenen Abschnitts (2) mit der Umfangsfläche der Führung (20) zurückzuhalten; und

- dann Bewegen der Führung (20) in einer Richtung entgegengesetzt zu einer Bewegungsrichtung des Stempels (30), während der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) mit dem Stempel (30) in einer Axialrichtung unter Druck gesetzt wird, um **dadurch** den zur Bearbeitung vorgesehenen Abschnitt (2) des hohlzylindrischen Rohmaterials (1), der zwischen dem oberen Endabschnitt (20a) jeder Führung (20) und dem unteren Abschnitt (12a) des Buckelformabschnitts (12) freigelegt ist, nach innen zu expandieren, so dass eine Wanddicke des hohlzylindrischen Rohmaterials (1) innerhalb des Buckelformabschnitts (12) zunimmt.

26. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 25, wobei die Führung (20) durch die

Antriebskraft einer Führungsantriebsvorrichtung (60) bewegt wird.

27. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 25, wobei "G" eine Gleichung $G = (X_g - X) / (L_0 - X_p - Pt_0)$ erfüllt,
wobei
"P" eine durchschnittliche Bewegungsgeschwindigkeit des Stempels (30) von dessen Bewegungsbeginn bezeichnet,
"G" eine durchschnittliche Bewegungsgeschwindigkeit der Führung (20) von deren Bewegungsbeginn bezeichnet,
" X_0 " eine Stauchungsbegrenzungslänge an einer Querschnittsfläche des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) vor dem Stauchen bezeichnet,
" X " einen Anfangsabstand zwischen einem oberen Endabschnitt der Führung (20) und einem unteren Abschnitt des Buckelformabschnitts (12) mit $0 \leq X \leq X_0$ bezeichnet,
" L_0 " eine für den expandierten Abschnitt (4) vor dem Stauchen benötigte Länge des hohlzylindrischen Rohmaterials (1) bezeichnet,
" X_p " eine aus einem Gestaltungsvolumen des expandierten Abschnitts (4) erlangte Endposition des oberen Endabschnitts des Stempels (30) in Bezug auf den unteren Abschnitt des Buckelformabschnitts (12) bezeichnet,
" X_g " eine durch die Gestaltung definierte Endposition des oberen Endabschnitts der Führung (20) in Bezug auf den unteren Abschnitt des Buckelformabschnitts (12) bezeichnet, und
" t_0 " eine Zeitverschiebung von dem Bewegungsbeginn des Stempels (30) bis zu dem Bewegungsbeginn der Führung (20) mit $0 \leq t_0$ bezeichnet.
28. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 25, wobei die Führung (20) durch die auf die Führung (20) wirkende Rückpresskraft bewegt wird, die durch Einpressen des Materials des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in den Buckelformabschnitt (12) erzeugt wird.
29. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 25, wobei der obere Endabschnitt des Stempels (30) in einer Querschnittsform gestaltet ist, die einer Querschnittsform eines axialen Endabschnitts des hohlzylindrischen Rohmaterials (1) entspricht.
30. Stauchverfahren für ein hohlzylindrisches Material (1) nach Anspruch 25, wobei die Kernstange (40) mit der Führung (20) derart verbunden ist, dass sich die Kernstange (40) in einer Axialrichtung der Führung (20) erstreckt.
31. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 30, wobei die Kernstange (40) über eine dehbare Vorrichtung (50), die geeignet ist, in einer Axialrichtung auseinander- und zusammengezogen zu werden, mit der Führung (20) verbunden ist, und wobei die dehbare Vorrichtung (50) mit einer Bewegung der Führung (20) auseinandergezogen wird.
32. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 25, wobei der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einem Zustand expandiert wird, in welchem der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise erwärmt wird.
33. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 32, wobei der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) durch ein Induktionserwärmungsmittel (81) teilweise induktionserwärmt wird.
34. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 32, wobei der axiale Endabschnitt der Rückhalteform (10) durch ein Induktionserwärmungsmittel (81) teilweise induktionserwärmt wird, um **dadurch** den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise zu erwärmen.
35. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 32, wobei der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einen halbgeschmolzenen Zustand teilweise erwärmt wird.
36. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 32, wobei der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einem Zustand expandiert wird, in welchem der dem Abschnitt der basalen Endseite der Führung (20) anstatt dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) durch ein Küh-

lungsmittel (85) teilweise gekühlt wird.

37. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) zum Expandieren eines zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) nach außen derart, dass eine Wanddicke des zur Bearbeitung vorgesehenen Abschnitts (2) zunimmt, wobei die Stauchvorrichtung (1A, 1B, 1C) aufweist:

- eine Kernstange (40), die geeignet ist, in hohlen Abschnitten des zur Bearbeitung vorgesehenen Abschnitts (2) und eines nicht zur Bearbeitung vorgesehenen Abschnitts (3) des hohlzylindrischen Rohmaterials (1) angeordnet zu sein;
- eine Rückhalteform (10) mit einer sich in einer Axialrichtung erstreckenden Rückhalteöffnung (11), wobei der nicht zur Bearbeitung vorgesehene Abschnitt (3) des hohlzylindrischen Rohmaterials (1) in der Rückhalteöffnung (11) anzuordnen ist;
- einen Buckelformabschnitt (12), der an einem axialen Endabschnitt der Rückhalteform (10) ausgebildet ist;
- eine Führung (20) mit einer sich in einer Axialrichtung erstreckenden Einsetzöffnung (21), wobei der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in der Einsetzöffnung (21) anzuordnen ist; und
- einen Stempel (30) zum Druckbeaufschlagen des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in der Axialrichtung,
- wobei die Führung (20) in einer Richtung entgegengesetzt zu einer Bewegungsrichtung des Stempels (30) bewegbar ist, wodurch bei der Benutzung der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1), der zwischen dem oberen Endabschnitt (20a) der Führung (20) und dem unteren Abschnitt (12a) des Buckelformabschnitts (12) freigelegt ist, innerhalb des Buckelformabschnitts (12) nach außen expandiert wird.

38. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 37, ferner aufweisend eine Führungsantriebsvorrichtung (60) zum Bewegen der Führung (20) in einer Richtung entgegengesetzt zu der Bewegungsrichtung des Stempels (30).

39. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 37, wobei der obere Endabschnitt des Stempels (30) in einer Querschnittsform gestaltet ist, die einer Querschnittsform eines axialen Endabschnitts des hohlzylindrischen Rohmaterials (1) entspricht.

40. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Material (1) nach Anspruch 37, wobei die Kernstange (40) mit dem Stempel (30) derart verbunden ist, dass sich die Kernstange (40) in einer Axialrichtung des Stempels (30) erstreckt.

41. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 40, wobei die Kernstange (40) über eine dehnbare Vorrichtung (50), die geeignet ist, in einer Axialrichtung auseinander- und zusammengezogen zu werden, mit dem Stempel (30) verbunden ist.

42. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 41, wobei der Stempel (30) darin mit der dehnbaren Vorrichtung (50) versehen ist.

43. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 41, wobei die dehnbare Vorrichtung (50) einen Fluiddruckzylinder (51) oder eine Feder (52) aufweist, der/die geeignet ist, in einer Axialrichtung auseinander- und zusammengezogen zu werden.

44. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 37, wobei eine Abfasbearbeitung an dem Öffnungsrandabschnitt der Einsetzöffnung des oberen Endabschnitts der Führung (20) vorgenommen wird.

45. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 37, ferner aufweisend ein Erwärmungsmittel (80) zum teilweisen Erwärmen des dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitts des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1).

46. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 45, wobei das Erwärmungsmittel (80) ein Induktionserwärmungsmittel (81) ist, das derart konfiguriert ist, dass es den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen

Rohmaterials (1) teilweise induktionserwärmt.

47. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 45, wobei das Erwärmungsmittel (80) ein Induktionserwärmungsmittel (81) ist, das derart konfiguriert ist, dass es den axialen Endabschnitt der Rückhalteform (10) teilweise induktionserwärmt, um **dadurch** den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise zu erwärmen.

48. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 45, wobei das Erwärmungsmittel (80) geeignet ist, den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einen halbgeschmolzenen Zustand teilweise zu erwärmen.

49. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 45, ferner aufweisend ein Kühlmittel (85), das derart konfiguriert ist, dass es den dem Abschnitt der basalen Endseite der Führung (20) anstatt dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise kühlt.

50. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) zum Expandieren von zur Bearbeitung vorgesehenen Abschnitten (2) beider axialer Endabschnitte des hohlzylindrischen Rohmaterials (1) nach außen derart, dass eine Wanddicke jedes zur Bearbeitung vorgesehenen Abschnitts (2) zunimmt, wobei die Stauchvorrichtung (1A, 1B, 1C) aufweist:

- eine Kernstange (40), die geeignet ist, in hohlen Abschnitten eines nicht zur Bearbeitung vorgesehenen Abschnitts eines axialen Zwischenabschnitts des hohlzylindrischen Rohmaterials (1) und des zur Bearbeitung vorgesehenen Abschnitts (2) beider axialer Endabschnitte des hohlzylindrischen Rohmaterials (1) angeordnet zu sein;

- eine Rückhalteform (10) mit einer sich in einer Axialrichtung erstreckenden Rückhalteöffnung (11), wobei der nicht zur Bearbeitung vorgesehene Abschnitt (3) des hohlzylindrischen Rohmaterials (1) in der Rückhalteöffnung (11) anzuordnen ist;

- zwei Buckelformabschnitte (12), die an beiden axialen Endabschnitten der Rückhalteform (10) ausgebildet sind;
- zwei Führungen (20) mit jeweils einer sich in einer Axialrichtung erstreckenden Einsetzöffnung (21), wobei jeder zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in der Einsetzöffnung (21) anzuordnen ist; und

- zwei Stempel (30) jeweils zum Druckbeaufschlagen jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in der Axialrichtung,

- wobei jede Führung (20) in einer Richtung entgegengesetzt zu einer Bewegungsrichtung des Stempels (30) bewegbar ist, wodurch bei der Benutzung jeder zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1), der zwischen dem oberen Endabschnitt (20a) jeder Führung (20) und dem entsprechenden unteren Abschnitt (12a) des Buckelformabschnitts (12) freigelegt ist, innerhalb des Buckelformabschnitts (12) nach außen expandiert wird.

51. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 50, ferner aufweisend zwei Führungsantriebsvorrichtungen (60) jeweils zum Bewegen der entsprechenden Führung (20) in einer Richtung entgegengesetzt zu der Bewegungsrichtung des Stempels (30).

52. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 50, wobei der obere Endabschnitt jedes Stempels (30) in einer Querschnittsform gestaltet ist, die einer Querschnittsform eines entsprechenden axialen Endabschnitts des hohlzylindrischen Rohmaterials (1) entspricht.

53. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 50, wobei die Kernstange (40) an deren axialen Zwischenabschnitt in getrennte Kernstangenhälften (40a) geteilt ist, und wobei jede Kernstangenhälfte (40a) mit einem entsprechenden Stempel (30) verbunden ist, wobei sich die getrennte Kernstangenhälfte (40a) in einer Axialrichtung des Stempels (30) erstreckt.

54. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 53, wobei jede Kernstangenhälfte (40a) über eine dehnbare Vorrichtung (50), die geeignet ist, in einer Axialrichtung auseinander- und zusammengezogen zu werden, mit dem entsprechenden Stempel (30) verbunden ist.

55. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Material (1) nach Anspruch 54, wobei jeder Stempel (30) darin mit der entsprechenden dehnbaren Vorrichtung (50) versehen ist.
56. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 54, wobei die dehnbare Vorrichtung (50) einen Fluiddruckzylinder (51) oder eine Feder (52) aufweist, der/die geeignet ist, in einer Axialrichtung auseinander- und zusammengezogen zu werden.
57. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 50, wobei eine Abfasbearbeitung an dem Öffnungsrandabschnitt der Einsetzöffnung des oberen Endabschnitts jeder Führung (20) vorgenommen wird.
58. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 50, ferner aufweisend zwei Erwärmungsmittel (80) jeweils zum teilweisen Erwärmen des dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitts jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1).
59. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 58, wobei jedes Erwärmungsmittel (80) ein Induktionserwärmungsmittel (81) ist, das derart konfiguriert ist, dass es den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise induktionserwärmt.
60. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 58, wobei jedes Erwärmungsmittel (80) ein Induktionserwärmungsmittel (81) ist, das derart konfiguriert ist, dass es die beiden axialen Endabschnitte der Rückhalteform (10) teilweise induktionserwärmt, um **dadurch** den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise zu erwärmen.
61. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 58, wobei jedes Erwärmungsmittel (80) geeignet ist, den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einen halbgeschmolzenen Zustand teilweise zu erwärmen.
62. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 58, ferner aufweisend zwei Kühlmittel (85), die jeweils derart konfiguriert sind, dass sie den dem Abschnitt der basalen Endseite der Führung (20) anstatt dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise kühlt.
63. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) zum Expandieren eines zur Bearbeitung vorgesehenen Abschnitts (2) eines hohlzylindrischen Rohmaterials (1) nach innen derart, dass eine Wanddicke zunimmt, wobei die Stauchvorrichtung (1A, 1B, 1C) aufweist:
- eine Kernstange (40) mit einem Kernstangenhauptkörper (41) und einem Abschnitt mit kleinem Durchmesser (42), der an einem axialen Endabschnitt des Kernstangenhauptkörpers (41) ausgebildet ist und einen kleineren Durchmesser als der Kernstangenhauptkörper (41) hat, wobei der Kernstangenhauptkörper (41) und der Abschnitt mit kleinem Durchmesser (42) geeignet sind, in einem hohlen Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) bzw. einem hohlen Abschnitt eines nicht zur Bearbeitung vorgesehenen Abschnitts (3) des hohlzylindrischen Rohmaterials (1) angeordnet zu sein, um **dadurch** einen Buckelformabschnitt (12) zwischen einer Innenumfangsfläche des nicht zur Bearbeitung vorgesehenen Abschnitts (3) und dem Abschnitt mit kleinem Durchmesser (42) zu bilden;
 - eine Rückhalteform (10) mit einer sich in einer Axialrichtung erstreckenden Rückhalteöffnung (11), wobei der zur Bearbeitung vorgesehene Abschnitt (2) und der nicht zur Bearbeitung vorgesehene Abschnitt (3) des hohlzylindrischen Rohmaterials (1) in der Rückhalteöffnung (11) anzuordnen ist;
 - eine Führung (20), die in dem hohlen Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) anzuordnen ist; und
 - einen Stempel (30), der derart konfiguriert ist, dass er den zur Bearbeitung vorgesehenen Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einer Axialrichtung unter Druck setzt,
 - wobei die Führung (20) in einer Richtung entgegengesetzt zu einer Bewegungsrichtung des Stempels (30) bewegbar ist, wodurch bei der Benutzung der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1), der zwischen dem oberen Endabschnitt (20a) der Führung (20) und dem unteren Abschnitt

(12a) des Buckelformabschnitts (12) freigelegt ist, innerhalb des Buckelformabschnitts (12) nach innen expandiert wird.

- 5 64. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 63, ferner aufweisend eine Führungsantriebsvorrichtung (60) zum Bewegen der Führung (20) in einer Richtung entgegengesetzt zu der Bewegungsrichtung des Stempels (30).
- 10 65. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 63, wobei der obere Endabschnitt des Stempels (30) in einer Querschnittsform gestaltet ist, die einer Querschnittsform eines axialen Endabschnitts des hohlzylindrischen Rohmaterials (1) entspricht.
- 15 66. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 63, wobei die Führung (20) in einem hohlen Abschnitt angeordnet ist, der in dem Stempel (30) ausgebildet ist und sich in einer Axialrichtung derart erstreckt, dass die Führung (20) in einer Axialrichtung des Stempels (30) bewegbar ist.
- 20 67. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Material (1) nach Anspruch 63, wobei die Kernstange (40) mit der Führung (20) derart verbunden ist, dass sich die Kernstange (40) in einer Axialrichtung der Führung (20) erstreckt.
- 25 68. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 67, wobei die Kernstange (40) über eine dehnbare Vorrichtung (50), die geeignet ist, in einer Axialrichtung auseinander- und zusammengezogen zu werden, mit der Führung (20) verbunden ist.
- 30 69. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 68, wobei die Führung (20) darin mit der dehnbaren Vorrichtung (50) versehen ist.
- 35 70. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 68, wobei die dehnbare Vorrichtung (50) einen Fluiddruckzylinder (51) oder eine Feder (52) aufweist, der/die geeignet ist, in einer Axialrichtung auseinander- und zusammengezogen zu werden.
- 40 71. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 63, wobei eine Abfasbearbeitung an einem Umfangsrandabschnitt eines oberen Endabschnitts der Führung (20) vorgenommen wird.
- 45 72. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 63, ferner aufweisend ein Erwärmungsmittel (80) zum teilweisen Erwärmen des dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitts des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1).
- 50 73. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 72, wobei das Erwärmungsmittel (80) ein Induktionserwärmungsmittel (81) ist, das derart konfiguriert ist, dass es den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise induktionserwärmt.
- 55 74. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 72, wobei das Erwärmungsmittel (80) ein Induktionserwärmungsmittel (81) ist, das derart konfiguriert ist, dass es den axialen Endabschnitt der Rückhalteform (10) teilweise induktionserwärmt, um **dadurch** den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise zu erwärmen.
75. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 72, wobei das Erwärmungsmittel (80) geeignet ist, den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einen halbgeschmolzenen Zustand teilweise zu erwärmen.
76. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 72, ferner aufweisend ein Kühlmittel (85), das derart konfiguriert ist, dass es den dem Abschnitt der basalen Endseite der Führung (20) anstatt dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise kühlt.

77. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1), aufweisend:

- Füllen hohler Abschnitte eines zur Bearbeitung vorgesehenen Abschnitts (2) und eines nicht zur Bearbeitung vorgesehenen Abschnitts (3) eines hohlzylindrischen Rohmaterials (1) mit Druckfluid, um **dadurch** die Innenumfangsflächen des zur Bearbeitung vorgesehenen Abschnitts (2) und des nicht zur Bearbeitung vorgesehenen Abschnitts (3) mit dem Fluidruck unter Druck zu setzen und zurückzuhalten;
- Anordnen des nicht zur Bearbeitung vorgesehenen Abschnitts (3) des hohlzylindrischen Rohmaterials (1) in einer Rückhalteöffnung (11), die in einer Rückhalteform (10) ausgebildet ist und sich in einer Axialrichtung erstreckt, um **dadurch** eine Außenumfangsfläche des nicht zur Bearbeitung vorgesehenen Abschnitts (3) mit einer Umfangsfläche der Rückhalteöffnung (11) zurückzuhalten;
- Anordnen des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einem Buckelformabschnitt (12), der an einem axialen Endabschnitt der Rückhalteform (10) ausgebildet ist;
- Anordnen des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einer Einsetzöffnung (21), die in einer Führung (20) ausgebildet ist und sich in einer Axialrichtung erstreckt;
- dann Bewegen der Führung (20) in einer Richtung entgegengesetzt zu einer Bewegungsrichtung des Stempels (30), während der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) mit dem Stempel (30) in einer Axialrichtung unter Druck gesetzt wird, um **dadurch** den zur Bearbeitung vorgesehenen Abschnitt (2) des hohlzylindrischen Rohmaterials (1), der zwischen dem oberen Endabschnitt (20a) der Führung (20) und dem unteren Abschnitt (12a) des Buckelformabschnitts (12) freigelegt ist, nach außen zu expandieren, so dass eine Wanddicke des hohlzylindrischen Rohmaterials (1) innerhalb des Buckelformabschnitts (12) zunimmt.

78. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 77, wobei die Führung (20) durch die Antriebskraft einer Führungsantriebsvorrichtung (60) bewegt wird.

79. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 77, wobei "G" eine Gleichung $G = (X_g - X)P / (L_0 - X_p - Pt_0)$ erfüllt, wobei

- "P" eine durchschnittliche Bewegungsgeschwindigkeit des Stempels (30) von dessen Bewegungsbeginn bezeichnet,
- "G" eine durchschnittliche Bewegungsgeschwindigkeit der Führung (20) von deren Bewegungsbeginn bezeichnet,
- "X₀" eine Stauchungsbegrenzungslänge an einer Querschnittsfläche des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) vor dem Stauchen bezeichnet,
- "X" einen Anfangsabstand zwischen einem oberen Endabschnitt der Führung (20) und einem unteren Abschnitt des Buckelformabschnitts (12) mit $0 \leq X \leq X_0$ bezeichnet,
- "L₀" eine für den expandierten Abschnitt (4) vor dem Stauchen benötigte Länge des hohlzylindrischen Rohmaterials (1) bezeichnet,
- "X_p" eine aus einem Gestaltungsvolumen des expandierten Abschnitts (4) erlangte Endposition des oberen Endabschnitts des Stempels (30) in Bezug auf den unteren Abschnitt des Buckelformabschnitts (12) bezeichnet,
- "X_g" eine durch die Gestaltung definierte Endposition des oberen Endabschnitts der Führung (20) in Bezug auf den unteren Abschnitt des Buckelformabschnitts (12) bezeichnet, und
- "t₀" eine Zeitverschiebung von dem Bewegungsbeginn des Stempels (30) bis zu dem Bewegungsbeginn der Führung (20) mit $0 \leq t_0$ bezeichnet.

80. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 77, wobei die Führung (20) durch die auf die Führung (20) wirkende Rückpresskraft bewegt wird, die durch Einpressen des Materials des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in den Buckelformabschnitt (12) erzeugt wird.

81. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 77, wobei der obere Endabschnitt des Stempels (30) in einer Querschnittsform gestaltet ist, die einer Querschnittsform eines axialen Endabschnitts des hohlzylindrischen Rohmaterials (1) entspricht.

82. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 77, wobei der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einem Zustand expandiert wird, in welchem der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise erwärmt wird.

83. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 82, wobei der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen

Rohmaterials (1) durch ein Induktionserwärmungsmittel (81) teilweise induktionserwärmt wird.

84. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 82, wobei der axiale Endabschnitt der Rückhalteform (10) durch ein Induktionserwärmungsmittel (81) teilweise induktionserwärmt wird, um **dadurch** den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise zu erwärmen.

85. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 82, wobei der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einen halbgeschmolzenen Zustand teilweise erwärmt wird.

86. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 82, wobei der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einem Zustand expandiert wird, in welchem der dem Abschnitt der basalen Endseite der Führung (20) anstatt dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) durch ein Kühlmittel (85) teilweise gekühlt wird.

87. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1), aufweisend:

- Füllen hohler Abschnitte eines nicht zur Bearbeitung vorgesehenen Abschnitts eines axialen Zwischenabschnitts des hohlzylindrischen Rohmaterials (1) und eines zur Bearbeitung vorgesehenen Abschnitts (2) beider axialer Endabschnitte des hohlzylindrischen Rohmaterials (1) mit Druckfluid, um **dadurch** die Innenumfangsflächen der beiden zur Bearbeitung vorgesehenen Abschnitte (2) und des nicht zur Bearbeitung vorgesehenen Abschnitts (3) mit dem Fluidruck unter Druck zu setzen und zurückzuhalten;

- Anordnen des nicht zur Bearbeitung vorgesehenen Abschnitts (3) des hohlzylindrischen Rohmaterials (1) in einer Rückhalteöffnung (11), die in einer Rückhalteform (10) ausgebildet ist und sich in deren Axialrichtung erstreckt, um **dadurch** eine Außenumfangsfläche des nicht zur Bearbeitung vorgesehenen Abschnitts (3) mit einer Umfangsfläche der Rückhalteöffnung (11) zurückzuhalten;

- Anordnen der beiden zur Bearbeitung vorgesehenen Abschnitte (2) des hohlzylindrischen Rohmaterials (1) in Buckelformabschnitten (12), die an beiden axialen Endabschnitten der Rückhalteform (10) ausgebildet sind;

- Anordnen jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einer Einsetzöffnung (21), die in einer Führung (20) ausgebildet ist und sich in einer Axialrichtung erstreckt;

- dann Bewegen jeder Führung (20) in einer Richtung entgegengesetzt zu einer Bewegungsrichtung des Stempels (30), während jeder zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) mit dem Stempel (30) in einer Axialrichtung gleichzeitig unter Druck gesetzt wird, um **dadurch** jeden zur Bearbeitung vorgesehenen Abschnitt (2) des hohlzylindrischen Rohmaterials (1), der zwischen dem oberen Endabschnitt (20a) jeder Führung (20) und dem entsprechenden unteren Abschnitt (12a) des Buckelformabschnitts (12) freigelegt ist, nach außen zu expandieren, so dass eine Wanddicke des hohlzylindrischen Rohmaterials (1) innerhalb des entsprechenden Buckelformabschnitts (12) zunimmt.

88. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 87, wobei jede Führung (20) durch die Antriebskraft einer entsprechenden Führungsantriebsvorrichtung (60) bewegt wird.

89. Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 87, wobei bei wenigstens einer der Führungen (20) und einem der einen der Führungen (20) entsprechenden Stempel (30) "G" eine Gleichung $G = (X_g - X) P / (L_0 - X_p - P t_0)$ erfüllt,

wobei

"P" eine durchschnittliche Bewegungsgeschwindigkeit des Stempels (30) von dessen Bewegungsbeginn bezeichnet,

"G" eine durchschnittliche Bewegungsgeschwindigkeit der Führung (20) von deren Bewegungsbeginn bezeichnet,

"X₀" eine Stauchungsbegrenzungslänge an einer Querschnittsfläche des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) vor dem Stauchen bezeichnet,

"X" einen Anfangsabstand zwischen einem oberen Endabschnitt der Führung (20) und einem unteren Abschnitt des Buckelformabschnitts (12) mit $0 \leq X \leq X_0$ bezeichnet,

"L₀" eine für den expandierten Abschnitt (4) vor dem Stauchen benötigte Länge des hohlzylindrischen Rohmaterials (1) bezeichnet,

"X_p" eine aus einem Gestaltungsvolumen des expandierten Abschnitts (4) erlangte Endposition des oberen Endabschnitts des Stempels (30) in Bezug auf den unteren Abschnitt des Buckelformabschnitts (12) bezeichnet,

"X_g" eine durch die Gestaltung definierte Endposition des oberen Endabschnitts der Führung (20) in Bezug auf den

unteren Abschnitt des Buckelformabschnitts (12) bezeichnet, und
 "t₀" eine Zeitverschiebung von dem Bewegungsbeginn des Stempels (30) bis zu dem Bewegungsbeginn der Führung (20) mit 0 ≤ t₀ bezeichnet.

- 5 **90.** Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 87, wobei jede Führung (20) durch die auf die Führung (20) wirkende Rückpresskraft bewegt wird, die durch Einpressen des Materials des entsprechenden zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in den Buckelformabschnitt (12) erzeugt wird.
- 10 **91.** Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 87, wobei der obere Endabschnitt jedes Stempels (30) in einer Querschnittsform gestaltet ist, die einer Querschnittsform eines entsprechenden axialen Endabschnitts des hohlzylindrischen Rohmaterials (1) entspricht.
- 15 **92.** Stauchverfahren für ein hohlzylindrisches Material (1) nach Anspruch 87, wobei jeder zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einem Zustand expandiert wird, in welchem der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise erwärmt wird.
- 20 **93.** Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 92, wobei der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) durch ein Induktionserwärmungsmittel (81) teilweise induktionserwärmt wird.
- 25 **94.** Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 92, wobei die beiden axialen Endabschnitte der Rückhalteform (10) durch ein Induktionserwärmungsmittel (81) teilweise induktionserwärmt werden, um **dadurch** den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise zu erwärmen.
- 30 **95.** Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 92, wobei der dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einen halbgeschmolzenen Zustand teilweise erwärmt wird.
- 35 **96.** Stauchverfahren für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 92, wobei jeder zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in einem Zustand expandiert wird, in welchem der dem Abschnitt der basalen Endseite der Führung (20) anstatt dem oberen Endabschnitt der Führung (20) entsprechende Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) durch ein Kühlmittel (85) teilweise gekühlt wird.
- 40 **97.** Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) zum Expandieren eines zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) nach außen derart, dass eine Wanddicke des zur Bearbeitung vorgesehenen Abschnitts (2) zunimmt, wobei die Stauchvorrichtung (1A, 1B, 1C) aufweist:
 - ein Druckfluidfüllmittel (90), das derart konfiguriert ist, dass es hohle Abschnitte eines zur Bearbeitung vorgesehenen Abschnitts (2) und eines nicht zur Bearbeitung vorgesehenen Abschnitts (3) des hohlzylindrischen Rohmaterials (1) mit Druckfluid füllt;
 - 45 - eine Rückhalteform (10) mit einer sich in einer Axialrichtung erstreckenden Rückhalteöffnung (11), wobei der nicht zur Bearbeitung vorgesehene Abschnitt (3) des hohlzylindrischen Rohmaterials (1) in der Rückhalteöffnung (11) anzuordnen ist;
 - einen Buckelformabschnitt (12), der an einem axialen Endabschnitt der Rückhalteform (10) ausgebildet ist;
 - eine Führung (20) mit einer sich in einer Axialrichtung erstreckenden Einsetzöffnung (21), wobei der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in der Einsetzöffnung (21) anzuordnen ist; und
 - 50 - einen Stempel (30) zum Druckbeaufschlagen des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in der Axialrichtung,
 - wobei die Führung (20) in einer Richtung entgegengesetzt zu einer Bewegungsrichtung des Stempels (30) bewegbar ist, wodurch bei der Benutzung der zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1), der zwischen dem oberen Endabschnitt (20a) der Führung (20) und dem unteren Abschnitt (12a) des Buckelformabschnitts (12) freigelegt ist, innerhalb des Buckelformabschnitts (12) nach außen expandiert wird.
 - 55

98. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 97, ferner aufweisend eine Führungsantriebsvorrichtung (60) zum Bewegen der Führung (20) in einer Richtung entgegengesetzt zu der Bewegungsrichtung des Stempels (30).

99. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 97, wobei der obere Endabschnitt des Stempels (30) in einer Querschnittsform gestaltet ist, die einer Querschnittsform eines axialen Endabschnitts des hohlzylindrischen Rohmaterials (1) entspricht.

100. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Material (1) nach Anspruch 97, wobei eine Abfasbearbeitung an dem Öffnungsrandabschnitt der Einsetzöffnung des oberen Endabschnitts der Führung (20) vorgenommen wird.

101. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 97, ferner aufweisend ein Erwärmungsmittel (80) zum teilweisen Erwärmen des dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitts des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1).

102. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 101, wobei das Erwärmungsmittel (80) ein Induktionserwärmungsmittel (81) ist, das derart konfiguriert ist, dass es den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise induktionserwärmt.

103. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 101, wobei das Erwärmungsmittel (80) ein Induktionserwärmungsmittel (81) ist, das derart konfiguriert ist, dass es den axialen Endabschnitt der Rückhalteform (10) teilweise induktionserwärmt, um **dadurch** den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise zu erwärmen.

104. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 101, wobei das Erwärmungsmittel (80) geeignet ist, den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einen halbgeschmolzenen Zustand teilweise zu erwärmen.

105. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 101, ferner aufweisend ein Kühlmittel (85), das derart konfiguriert ist, dass es den dem Abschnitt der basalen Endseite der Führung (20) anstatt dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise kühlt.

106. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) zum Expandieren von zur Bearbeitung vorgesehenen Abschnitten (2) beider axialer Endabschnitte des hohlzylindrischen Rohmaterials (1) nach außen derart, dass eine Wanddicke jedes zur Bearbeitung vorgesehenen Abschnitts (2) zunimmt, wobei die Stauchvorrichtung (1A, 1B, 1C) aufweist:

- ein Druckfluidfüllmittel (90), das derart konfiguriert ist, dass es hohle Abschnitte eines nicht zur Bearbeitung vorgesehenen Abschnitts (3) eines axialen Zwischenabschnitts des hohlzylindrischen Rohmaterials (1) und der zur Bearbeitung vorgesehenen Abschnitte (2) beider axialer Endabschnitte des hohlzylindrischen Rohmaterials (1) mit Druckfluid füllt;
- eine Rückhalteform (10) mit einer sich in einer Axialrichtung erstreckenden Rückhalteöffnung (11), wobei der nicht zur Bearbeitung vorgesehene Abschnitt (3) des hohlzylindrischen Rohmaterials (1) in der Rückhalteöffnung (11) anzuordnen ist;
- zwei Buckelformabschnitte (12), die an beiden axialen Endabschnitten der Rückhalteform (10) ausgebildet sind;
- zwei Führungen (20) mit jeweils einer sich in einer Axialrichtung erstreckenden Einsetzöffnung (21), wobei jeder zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1) in der Einsetzöffnung (21) anzuordnen ist; und
- zwei Stempel (30) jeweils zum Druckbeaufschlagen jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in der Axialrichtung,
- wobei jede Führung (20) in einer Richtung entgegengesetzt zu einer Bewegungsrichtung des Stempels (30) bewegbar ist, wodurch bei der Benutzung jeder zur Bearbeitung vorgesehene Abschnitt (2) des hohlzylindrischen Rohmaterials (1), der zwischen dem oberen Endabschnitt (20a) jeder Führung (20) und dem entsprechenden unteren Abschnitt (12a) des Buckelformabschnitts (12) freigelegt ist, innerhalb des Buckelformabschnitts (12)

nach außen expandiert wird.

107. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 106, ferner aufweisend zwei Führungsantriebsvorrichtungen (60) jeweils zum Bewegen der entsprechenden Führung (20) in einer Richtung entgegengesetzt zu der Bewegungsrichtung des Stempels (30).

108. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 106, wobei der obere Endabschnitt jedes Stempels (30) in einer Querschnittsform gestaltet ist, die einer Querschnittsform eines entsprechenden axialen Endabschnitts des hohlzylindrischen Rohmaterials (1) entspricht.

109. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 106, wobei eine Abfasbearbeitung an dem Öffnungsrandabschnitt der Einsetzöffnung des oberen Endabschnitts jeder Führung (20) vorgenommen wird.

110. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 106, ferner aufweisend zwei Erwärmungsmittel (80) jeweils zum teilweisen Erwärmen des dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitts jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1).

111. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 110, wobei jedes Erwärmungsmittel (80) ein Induktionserwärmungsmittel (81) ist, das derart konfiguriert ist, dass es den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise induktionserwärmt.

112. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 110, wobei jedes Erwärmungsmittel (80) ein Induktionserwärmungsmittel (81) ist, das derart konfiguriert ist, dass es die beiden axialen Endabschnitte der Rückhalteform (10) teilweise induktionserwärmt, um **dadurch** den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise zu erwärmen.

113. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 110, wobei jedes Erwärmungsmittel (80) geeignet ist, den dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt des zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) in einen halbgeschmolzenen Zustand teilweise zu erwärmen.

114. Stauchvorrichtung (1A, 1B, 1C) für ein hohlzylindrisches Rohmaterial (1) nach Anspruch 110, ferner aufweisend zwei Kühlmittel (85), die jeweils derart konfiguriert sind, dass sie den dem Abschnitt der basalen Endseite der Führung (20) anstatt dem oberen Endabschnitt der Führung (20) entsprechenden Abschnitt jedes zur Bearbeitung vorgesehenen Abschnitts (2) des hohlzylindrischen Rohmaterials (1) teilweise kühlt.

Revendications

1. Procédé de refoulement pour un matériel cylindrique creux brut (1), comprenant:

- disposer une âme-noyau (40) dans des portions creuses d'une portion (2) programmée pour un traitement et d'une portion (3) non programmée pour un traitement du matériel brut cylindrique creux (1), pour ainsi maintenir des surfaces périphériques internes de la portion (2) programmée pour un traitement et de la portion (3) non programmée pour un traitement par une surface périphérique de l'âme-noyau (40) ;

- disposer la portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) dans un trou de maintien (11) formé dans une matrice de maintien (10) et déployé dans sa direction axiale pour ainsi maintenir une surface périphérique externe de la portion non-programmée pour un traitement (3) par une surface périphérique externe du trou de maintien (11) ;

- disposer la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans une portion dentée de moulage (12) formée dans une portion d'extrémité axiale de la matrice de maintien (10) ;

- disposer la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans un trou d'insertion (21) formé dans un guide (20) et déployé dans sa direction axiale ; et

- ensuite, déplacer le guide (20) dans un sens opposé à un sens de déplacement d'un poinçon (30) tout en

pressant la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) avec le poinçon (30) dans une direction axiale pour ainsi dilater vers l'extérieur la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) exposée entre la portion d'extrémité de pointe (20a) du guide (20) et la portion inférieure (12a) de la portion dentée de moulage (12) de sorte qu'une épaisseur de paroi du matériel cylindrique creux brut (1) augmente dans la portion dentée de moulage (12).

2. Procédé de refoulement pour un matériel cylindrique creux brut (1) selon la revendication 1, dans lequel le guide (20) est déplacé par la force d'entraînement d'un appareil d'entraînement de guide (60).
3. Procédé de refoulement pour un matériel cylindrique creux brut (1) selon la revendication 1, dans lequel "G" répond à l'équation suivante :

$$G = (X_g - X) P / (L_0 - X_p - P t_0)$$

où:

"P" désigne une vitesse de déplacement moyenne du poinçon (30) depuis son départ en déplacement,
 "G" désigne une vitesse de déplacement moyenne du guide (20) depuis son départ en déplacement,
 "X₀" désigne une longueur limite de flambage dans une surface en section transversale de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) avant le refoulement,
 "X" désigne un jeu initial entre une portion d'extrémité de pointe du guide (20) et une portion inférieure de la portion dentée de moulage (12) avec $0 \leq X \leq X_0$,
 "L₀" désigne une longueur du matériau cylindrique creux brut (1) avant le refoulement nécessaire à la portion dilatée (4),
 "X_p" désigne une position d'arrêt de la portion d'extrémité de pointe du poinçon (30) par rapport à la portion inférieure de la portion dentée de moulage (12) obtenue à partir d'un volume théorique de la portion dilatée (4),
 "X_g" désigne une position d'arrêt de la portion d'extrémité de pointe du guide (20) par rapport à la portion inférieure de la portion dentée de moulage (12) définie par le modèle, et
 "t₀" désigne un retard entre le départ en déplacement du poinçon (30) et le départ en déplacement du guide (20) avec $0 \leq t_0$

4. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 1, dans lequel le guide (20) est déplacé par une force de rappel agissant sur le guide (20) générée par ajustement sous pression du matériau de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans la portion dentée de moulage (12).
5. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 1, dans lequel la portion d'extrémité de pointe du poinçon (30) est formée en section transversale correspondant à une section transversale d'une portion d'extrémité axiale du matériau cylindrique creux brut (1).
6. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 1, dans lequel l'âme-noyau (40) est raccordée au poinçon (30) de manière que l'âme-noyau (40) se déploie dans une direction axiale du poinçon (30).
7. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 6, dans lequel l'âme-noyau (40) est raccordée au poinçon (30) via un dispositif extensible (50) capable de se déployer et de se contracter dans une direction axiale, et dans lequel le dispositif extensible (50) est contracté par un déplacement du poinçon (30).
8. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 1, dans lequel la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) est dilatée dans un état dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée.
9. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 8, dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée par induction avec un moyen de chauffage par

induction (81).

10. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 8, dans lequel la portion d'extrémité axiale de la matrice de maintien (10) est partiellement chauffée par induction avec un moyen de chauffage à induction (81) pour ainsi chauffer partiellement la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

11. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 8, dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée à l'état semi-fondu.

12. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 8, dans lequel la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) est dilatée dans un état dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion du côté d'extrémité de base du guide (20) plutôt qu'à la portion d'extrémité de pointe du guide (20) est partiellement refroidie par un moyen de refroidissement (85).

13. Procédé de refoulement pour un matériel cylindrique creux brut (1), comprenant :

- disposer une âme-noyau (40) dans des portions creuses d'une portion (3) non programmée pour un traitement d'une portion intermédiaire axiale d'un matériel cylindrique creux brut (1) et d'une portion (2) programmée pour un traitement des deux portions d'extrémité axiales du matériel brut cylindrique creux (1), pour ainsi maintenir des surfaces périphériques internes de la portion (3) non programmée pour un traitement et des deux portions (2) programmées pour un traitement par une surface périphérique de l'âme-noyau (40) ;

- disposer la portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) dans un trou de maintien (11) formé dans une matrice de maintien (10) et déployé dans sa direction axiale pour ainsi maintenir une surface périphérique externe de la portion (3) non programmée pour un traitement par une surface périphérique du trou de maintien (11) ;

- disposer les deux portions (2) programmées pour un traitement du matériel cylindrique creux brut (1) dans des portions dentées de moulage (12) formées dans les deux portions d'extrémité axiales de la matrice de maintien (10) ;

- disposer chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans un trou d'insertion (21) formé dans un guide (20) et déployé dans sa direction axiale ; et

- ensuite, déplacer chaque guide (20) dans un sens opposé à un sens de déplacement du poinçon (30) tout en pressant simultanément chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) avec le poinçon (30) dans une direction axiale pour ainsi dilater vers l'extérieur chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) exposée entre la portion d'extrémité de pointe (20a) de chaque guide (20) et la portion inférieure correspondante (12a) de la portion dentée de moulage (12) de sorte qu'une épaisseur de paroi du matériel cylindrique creux brut (1) augmente dans la portion dentée de moulage correspondante (12).

14. Procédé de refoulement pour un matériel cylindrique creux brut (1) selon la revendication 13, dans lequel chaque guide (20) est déplacé par la force d'entraînement d'un appareil d'entraînement de guide correspondant (60).

15. Procédé de refoulement pour un matériel cylindrique creux brut (1) selon la revendication 13, dans lequel, dans au moins l'un des guides (20) et un poinçon (30) correspondant à l'un des guides (20), "G" répond à l'équation suivante :

$$G = (X_g - X) P / (L_0 - X_p - P t_0)$$

où:

"P" désigne une vitesse de déplacement moyenne du poinçon (30) depuis son départ en déplacement,

"G" désigne une vitesse de déplacement moyenne du guide (20) depuis son départ en déplacement,

"X₀" désigne une longueur limite de flambage dans une surface en section transversale de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) avant le refoulement,

"X" désigne un jeu initial entre une portion d'extrémité de pointe du guide (20) et une portion inférieure de la

portion dentée de moulage (12) avec $0 \leq X \leq X_0$,

" L_0 " désigne une longueur du matériau cylindrique creux brut (1) avant le refoulement nécessaire à la portion dilatée (4),

" X_p " désigne une position d'arrêt de la portion d'extrémité de pointe du poinçon (30) par rapport à la portion inférieure de la portion dentée de moulage (12) obtenue à partir d'un volume théorique de la portion dilatée (4),

" X_g " désigne une position d'arrêt de la portion d'extrémité de pointe du guide (20) par rapport à la portion inférieure de la portion dentée de moulage (12) définie par le modèle, et

" t_0 " désigne un retard entre le départ en déplacement du poinçon (30) et le départ en déplacement du guide (20) avec $0 \leq t_0$.

16. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 13, dans lequel chaque guide (20) est déplacé par une force de rappel agissant sur le guide (20) générée par ajustement sous pression du matériau de la portion (2) programmée pour un traitement correspondante (2) du matériel cylindrique creux brut (1) dans la portion dentée de moulage (12).

17. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 13, dans lequel la portion d'extrémité de pointe de chaque poinçon (30) est formée en section transversale correspondant à une section transversale d'une portion d'extrémité axiale correspondante du matériau cylindrique creux brut (1).

18. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 13, dans lequel l'âme-noyau (40) est divisée en moitiés d'âme-noyau divisées (40a) dans sa portion axiale intermédiaire et dans lequel chaque moitié d'âme-noyau (40a) est raccordée à un poinçon correspondant (30) avec la moitié d'âme-noyau divisée (40a) déployée dans une direction axiale du poinçon (30).

19. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 18, dans lequel chaque moitié d'âme-noyau (40a) est raccordée au poinçon correspondant (30) via un dispositif extensible (50) capable de se déployer et de se contracter dans une direction axiale, et dans lequel chaque dispositif extensible (50) est contracté par un déplacement du poinçon correspondant (30).

20. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 13, dans lequel chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) est dilatée dans un état dans lequel la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée.

21. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 20, dans lequel la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée par induction avec un moyen de chauffage par induction (81).

22. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 20, dans lequel les deux portions d'extrémité axiales de la matrice de maintien (10) sont partiellement chauffées par induction avec un moyen de chauffage à induction (81) pour ainsi chauffer partiellement la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

23. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 20, dans lequel la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée à l'état semi-fondu.

24. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 20, dans lequel chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) est dilatée dans un état dans lequel la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion du côté d'extrémité de base du guide (20) plutôt qu'à la portion d'extrémité de pointe du guide (20) est partiellement refroidie par un moyen de refroidissement (85).

25. Procédé de refoulement pour un matériel cylindrique creux brut (1), comprenant:

- préparer une âme-noyau (40) ayant un corps principal d'âme-noyau (41) et une portion de petit diamètre (42) formée dans une portion d'extrémité axiale du corps principal d'âme-noyau (41) et de diamètre plus petit que

celui du corps principal d'âme-noyau (41) ;

- disposer le corps principal d'âme-noyau (41) et la portion de petit diamètre (42) de l'âme-noyau (40) dans une portion creuse d'une portion (3) non programmée pour un traitement d'un matériel cylindrique creux brut (1) et dans une portion creuse de la portion (2) programmée pour un traitement du matériel brut cylindrique creux (1), respectivement, pour ainsi maintenir la surface périphérique interne de la portion (3) non programmée pour un traitement par une surface périphérique du corps principal d'âme-noyau (41) et former une portion dentée de moulage (12) entre une surface périphérique interne de la portion (2) programmée pour un traitement et la portion de petit diamètre (42) ;

- disposer la portion (2) programmée pour un traitement et la portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) dans un trou de maintien (11) formé dans une matrice de maintien (10) et déployé dans une direction axiale pour ainsi maintenir les surfaces périphériques externes de la portion (2) programmée pour un traitement et de la portion (3) non programmée pour un traitement par une surface périphérique du trou de maintien (11) ;

- disposer un guide (20) dans la portion creuse de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) pour ainsi maintenir la surface périphérique interne de la portion (2) programmée pour un traitement par la surface périphérique du guide (20) ; et

- ensuite, déplacer le guide (20) dans un sens opposé à un sens de déplacement du poinçon (30) tout en pressant la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) avec le poinçon (30) dans une direction axiale pour ainsi dilater vers l'intérieur la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) exposée entre la portion d'extrémité de pointe (20a) du guide (20) et la portion inférieure (12a) de la portion dentée de moulage (12) de sorte qu'une épaisseur de paroi du matériel cylindrique creux brut (1) augmente dans la portion dentée de moulage (12).

26. Procédé de refoulement pour un matériel cylindrique creux brut (1) selon la revendication 25, dans lequel le guide (20) est déplacé par la force d'entraînement d'un appareil d'entraînement de guide (60).

27. Procédé de refoulement pour un matériel cylindrique creux brut (1) selon la revendication 25, dans lequel "G" répond à l'équation suivante :

$$G=(X_g-X) P / (L_0-X_p-Pt_0)$$

où :

"P" désigne une vitesse de déplacement moyenne du poinçon (30) depuis son départ en déplacement,

"G" désigne une vitesse de déplacement moyenne du guide (20) depuis son départ en déplacement,

"X₀" désigne une longueur limite de flambage dans une surface en section transversale de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) avant le refoulement,

"X" désigne un jeu initial entre une portion d'extrémité de pointe du guide (20) et une portion inférieure de la portion dentée de moulage (12) avec $0 \leq X \leq X_0$,

"L₀" désigne une longueur du matériau cylindrique creux brut (1) avant le refoulement nécessaire à la portion dilatée (4),

"X_p" désigne une position d'arrêt de la portion d'extrémité de pointe du poinçon (30) par rapport à la portion inférieure de la portion dentée de moulage (12) obtenue à partir d'un volume théorique de la portion dilatée (4),

"X_g" désigne une position d'arrêt de la portion d'extrémité de pointe du guide (20) par rapport à la portion inférieure de la portion dentée de moulage (12) définie par le modèle, et

"t₀" désigne un retard entre le départ en déplacement du poinçon (30) et le départ en déplacement du guide (20) avec $0 \leq t_0$

28. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 25, dans lequel le guide (20) est déplacé par une force de rappel agissant sur le guide (20) générée par ajustement sous pression du matériau de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans la portion dentée de moulage (12).

29. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 25, dans lequel la portion d'extrémité de pointe du poinçon (30) est formée en section transversale correspondant à une section transversale d'une portion d'extrémité axiale du matériau cylindrique creux brut (1).

30. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 25, dans lequel l'âme-noyau (40) est raccordée au guide (20) de manière que l'âme-noyau (40) se déploie dans une direction axiale du guide (20).
- 5 31. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 30, dans lequel l'âme-noyau (40) est raccordée au guide (20) via un dispositif extensible (50) capable de se déployer et de se contracter dans une direction axiale, et dans lequel le dispositif extensible (50) est déployé par un déplacement du guide (20).
- 10 32. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 25, dans lequel la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) est dilatée dans un état dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée.
- 15 33. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 32, dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée par induction avec un moyen de chauffage à induction (81).
- 20 34. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 32, dans lequel la portion d'extrémité axiale de la matrice de maintien (10) est partiellement chauffée par induction avec un moyen de chauffage à induction (81) pour ainsi chauffer partiellement la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).
- 25 35. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 32, dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée à l'état semi-fondu.
- 30 36. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 32, dans lequel la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) est dilatée dans un état dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion du côté d'extrémité de base du guide (20) plutôt qu'à la portion d'extrémité de pointe du guide (20) est partiellement refroidie par un moyen de refroidissement (85).
- 35 37. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) pour dilater vers l'extérieur une portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) de sorte qu'une épaisseur de paroi de la portion (2) programmée pour un traitement augmente, l'appareil de refoulement (1A, 1B, 1C) comprenant :
- 40 - une âme-noyau (40) adaptée pour être disposée dans des portions creuses de la portion (2) programmée pour un traitement et d'une portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) ;
- une matrice de maintien (10) ayant un trou de maintien (11) déployé dans une direction axiale, où la portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) doit être disposée dans le trou de maintien (11) ;
- 45 - une portion dentée de moulage (12) formée dans une portion d'extrémité axiale de la matrice de maintien (10) ;
- un guide (20) ayant un trou d'insertion (21) déployé dans une direction axiale, où la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) doit être disposée dans le trou d'insertion (21) ; et
- 50 - un poinçon (30) pour presser la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans la direction axiale,
- dans lequel le guide (20) peut être déplacé dans un sens opposé à un sens de déplacement du poinçon (30), si bien qu'en service, la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) exposée entre la portion d'extrémité de pointe (20a) du guide (20) et la portion inférieure (12a) de la portion dentée de moulage (12) est dilatée vers l'extérieur dans la portion dentée de moulage (12).
- 55 38. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 37, comprenant par ailleurs un appareil d'entraînement de guide (60) pour déplacer le guide (20) dans un sens opposé au sens de déplacement du poinçon (30).
39. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 37, dans lequel la portion d'extrémité de pointe du poinçon (30) est formée en section transversale correspondant à une

section transversale d'une portion d'extrémité axiale du matériau cylindrique creux brut (1).

40. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 37, dans lequel l'âme-noyau (40) est raccordée au poinçon (30) de manière que l'âme-noyau (40) se déploie dans une direction axiale du poinçon (30).

41. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 40, dans lequel l'âme-noyau (40) est raccordée au poinçon (30) via un dispositif extensible (50) capable de se déployer et de se contracter dans une direction axiale.

42. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 41, dans lequel le poinçon (30) est équipé du dispositif extensible (50) incorporé.

43. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 41, dans lequel le dispositif extensible (50) a un cylindre de pression de fluide (51) ou un ressort (52) capable d'être déployé et contracté dans une direction axiale.

44. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 37, dans lequel un travail de biseautage est appliqué à la portion de bord de l'ouverture du trou d'insertion de la portion d'extrémité de pointe du guide (20).

45. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 37, comprenant en outre un moyen de chauffage (80) pour chauffer partiellement la portion de la portion (2) programmée pour un traitement du matériau cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

46. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 45, dans lequel le moyen de chauffage (80) est un moyen de chauffage à induction (81) configuré pour chauffer partiellement par induction la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

47. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 45, dans lequel le moyen de chauffage (80) est un moyen de chauffage à induction (81) configuré pour chauffer partiellement par induction la portion d'extrémité axiale de la matrice de maintien (10) pour chauffer ainsi partiellement la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

48. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 45, dans lequel le moyen de chauffage (80) est capable de chauffer partiellement à l'état semi-fondu la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

49. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 45, comprenant en outre un moyen de refroidissement (85) configuré pour refroidir partiellement la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion du côté d'extrémité de base du guide (20) plutôt qu'à la portion d'extrémité de pointe du guide (20).

50. Appareil de refoulement (1A, 1 B, 1 C) pour un matériel cylindrique creux brut (1) pour dilater vers l'extérieur des portions (2) programmées pour un traitement des deux portions d'extrémité axiales du matériel cylindrique creux brut (1) de sorte qu'une épaisseur de paroi de chaque portion (2) programmée pour un traitement augmente, l'appareil de refoulement (1A, 1B, 1C) comprenant :

- une âme-noyau (40) adaptée pour être disposée dans des portions creuses d'une portion non-programmée pour un traitement d'une portion axiale intermédiaire du matériel cylindrique creux brut (1) et de la portion (2) programmée pour un traitement des deux portions d'extrémité axiales du matériel cylindrique creux brut (1) ;
- une matrice de maintien (10) ayant un trou de maintien (11) déployé dans une direction axiale, où la portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) doit être disposée dans le trou de maintien (11) ;
- deux portions dentées de moulage (12) formées dans les deux portions d'extrémité axiales de la matrice de

maintien (10) ;

- deux guides (20) ayant chacun un trou d'insertion (21) déployé dans une direction axiale, où chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) doit être disposée dans le trou d'insertion (21) ; et

- deux poinçons (30) chacun pour presser chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans la direction axiale,

- dans lequel chaque guide (20) peut être déplacé dans un sens opposé à un sens de déplacement du poinçon (30), si bien qu'en service, chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) exposée entre la portion d'extrémité de pointe (20a) de chaque guide (20) et la portion inférieure correspondante (12a) de la portion dentée de moulage (12) est dilatée vers l'extérieur dans la portion dentée de moulage (12).

51. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 50, comprenant par ailleurs deux appareils d'entraînement de guide (60) chacun pour déplacer le guide correspondant (20) dans un sens opposé au sens de déplacement du poinçon (30).

52. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 50, dans lequel la portion d'extrémité de pointe de chaque poinçon (30) est formée en section transversale correspondant à une section transversale d'une portion d'extrémité axiale correspondante du matériau cylindrique creux brut (1).

53. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 50, dans lequel l'âme-noyau (40) est divisée en moitiés d'âme-noyau divisées (40a) dans sa portion axiale intermédiaire, et dans lequel chaque moitié d'âme-noyau (40a) est raccordée à un poinçon correspondant (30) avec la moitié d'âme-noyau déployée dans une direction axiale du poinçon (30).

54. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 53, dans lequel chaque moitié d'âme-noyau (40a) est raccordée au poinçon correspondant (30) via un dispositif extensible (50) capable de se déployer et de se contracter dans une direction axiale.

55. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 54, dans lequel chaque poinçon (30) est équipé du dispositif extensible correspondant (50) incorporé.

56. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 54, dans lequel le dispositif extensible (50) a un cylindre de pression de fluide (51) ou un ressort (52) capable d'être déployé et contracté dans une direction axiale.

57. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 50, dans lequel un travail de biseautage est appliqué à la portion de bord de l'ouverture du trou d'insertion de la portion d'extrémité de pointe du guide (20).

58. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 50, comprenant en outre deux moyens de chauffage (80) chacun pour chauffer partiellement la portion de chaque portion (2) programmée pour un traitement du matériau cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

59. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 58, dans lequel chaque moyen de chauffage (80) est un moyen de chauffage à induction (81) configuré pour chauffer partiellement par induction la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

60. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 58, dans lequel chaque moyen de chauffage (80) est un moyen de chauffage à induction (81) configuré pour chauffer partiellement par induction les deux portions d'extrémité axiales de la matrice de maintien (10) afin de chauffer ainsi partiellement la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

61. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 58, dans lequel chaque moyen de chauffage (80) est capable de chauffer partiellement à l'état semi-fondu la portion de la

portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

5 62. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 58, comprenant en outre deux moyens de refroidissement (85) chacun configurés pour refroidir partiellement la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion du côté d'extrémité de base du guide (20) plutôt qu'à la portion d'extrémité de pointe du guide (20).

10 63. Appareil de refoulement (1A, 1B, 1 C) pour un matériel cylindrique creux brut (1) pour dilater vers l'extérieur une portion (2) programmée pour un traitement d'un matériel cylindrique creux brut (1) de sorte qu'une épaisseur de la paroi augmente, l'appareil de refoulement (1A, 1 B, 1 C) comprenant :

15 - une âme-noyau (40) ayant un corps principal d'âme-noyau (41) et une portion de petit diamètre (42) formée dans une portion d'extrémité axiale du corps principal d'âme-noyau (41) et de plus petit diamètre que le corps principal d'âme-noyau (41), dans lequel le corps principal d'âme-noyau (41) et la portion de petit diamètre (42) sont adaptés pour être disposés dans une portion creuse de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) et dans une portion creuse d'une portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1), respectivement, pour former ainsi une portion dentée de moulage (12) entre une surface périphérique interne de la portion (3) non programmée pour un traitement et la portion de petit diamètre (42) ;

20 - une matrice de maintien (10) ayant un trou de maintien (11) déployé dans une direction axiale, où la portion (2) programmée pour un traitement et la portion non programmée pour un traitement du matériel cylindrique creux brut (1) doivent être disposées dans le trou de maintien (11) ;

25 - un guide (20) qui doit être disposée dans la portion creuse de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) ; et

- un poinçon (30) configuré pour presser la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans une direction axiale,

30 - dans lequel le guide (20) peut être déplacé dans un sens opposé à un sens de déplacement du poinçon (30), si bien qu'en service, la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) exposée entre la portion d'extrémité de pointe (20a) du guide (20) et la portion inférieure (12a) de la portion dentée de moulage (12) est dilatée vers l'intérieur dans la portion dentée de moulage (12).

35 64. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 63, comprenant par ailleurs un appareil d'entraînement de guide (60) pour déplacer le guide (20) dans un sens opposé au sens de déplacement du poinçon (30).

40 65. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 63, dans lequel la portion d'extrémité de pointe du poinçon (30) est formée en section transversale correspondant à une section transversale d'une portion d'extrémité axiale du matériau cylindrique creux brut (1).

45 66. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 63, dans lequel le guide (20) est disposé dans une portion creuse formée dans le poinçon (30) et déployée dans une direction axiale de manière que le guide (20) puisse se déplacer dans une direction axiale du poinçon (30).

50 67. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 63, dans lequel l'âme-noyau (40) est raccordée au guide (20) de manière que l'âme-noyau (40) se déploie dans une direction axiale du guide (20).

55 68. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 67, dans lequel l'âme-noyau (40) est raccordée au guide (20) via un dispositif extensible (50) capable de se déployer et de se contracter dans une direction axiale.

69. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 68, dans lequel le guide (20) est équipé du dispositif extensible (50) incorporé.

70. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 68, dans lequel le dispositif extensible (50) a un cylindre de pression de fluide (51) ou un ressort (52) capable d'être déployé et contracté dans une direction axiale.

71. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 63, dans lequel un travail de biseautage est appliqué à la portion de bord périphérique d'une portion d'extrémité de pointe du guide (20).
- 5 72. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 63, comprenant en outre un moyen de chauffage (80) pour chauffer partiellement la portion de la portion (2) programmée pour un traitement du matériau cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).
- 10 73. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 72, dans lequel le moyen de chauffage (80) est un moyen de chauffage à induction (81) configuré pour chauffer partiellement par induction la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).
- 15 74. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 72, dans lequel le moyen de chauffage (80) est un moyen de chauffage à induction (81) configuré pour chauffer partiellement par induction la portion d'extrémité axiale de la matrice de maintien (10) afin de chauffer ainsi partiellement la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).
- 20 75. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 72, dans lequel le moyen de chauffage (80) est capable de chauffer partiellement à l'état semi-fondu la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).
- 25 76. Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 72, comprenant en outre un moyen de refroidissement (85) configuré pour refroidir partiellement la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion du côté d'extrémité de base du guide (20) plutôt qu'à la portion d'extrémité de pointe du guide (20).
- 30 77. Procédé de refoulement pour un matériel cylindrique creux brut (1), comprenant:
- remplir des portions creuses d'une portion (2) programmée pour un traitement et d'une portion (3) non programmée pour un traitement d'un matériel cylindrique creux brut (1) avec un fluide sous pression pour ainsi presser et maintenir des surfaces périphériques internes de la portion (2) programmée pour un traitement et
 - 35 de la portion (3) non programmée pour un traitement avec la pression du fluide ;
 - disposer la portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) dans un trou de maintien (11) formé dans une matrice de maintien (10) et déployé dans une direction axiale pour ainsi maintenir une surface périphérique externe de la portion (3) non programmée pour un traitement par une surface périphérique du trou de maintien (11) ;
 - 40 - disposer la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans une portion dentée de moulage (12) formée dans une portion d'extrémité axiale de la matrice de maintien (10) ;
 - disposer la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans un trou d'insertion (21) formé dans un guide (20) et déployé dans une direction axiale ; et
 - 45 - ensuite, déplacer le guide (20) dans un sens opposé à un sens de déplacement du poinçon (30) tout en pressant la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) avec le poinçon (30) dans une direction axiale pour ainsi dilater vers l'extérieur la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) exposée entre la portion d'extrémité de pointe (20a) du guide (20) et la portion inférieure (12a) de la portion dentée de moulage (12) de sorte qu'une épaisseur de paroi du matériel cylindrique creux brut (1) augmente dans la portion dentée de moulage (12).
 - 50
78. Procédé de refoulement pour un matériel cylindrique creux brut (1) selon la revendication 77, dans lequel le guide (20) est déplacé par la force d'entraînement d'un appareil d'entraînement de guide (60).
- 55 79. Procédé de refoulement pour un matériel cylindrique creux brut (1) selon la revendication 77, dans lequel "G" répond à l'équation suivante :

$$G=(X_g-X) P/ (L_0-X_p-Pt_0)$$

où :

"P" désigne une vitesse de déplacement moyenne du poinçon (30) depuis son départ en déplacement,
 "G" désigne une vitesse de déplacement moyenne du guide (20) depuis son départ en déplacement,
 "X₀" désigne une longueur limite de flambage dans une surface en section transversale de la portion (2) pro-
 grammée pour un traitement du matériel cylindrique creux brut (1) avant le refoulement,
 "X" désigne un jeu initial entre une portion d'extrémité de pointe du guide (20) et une portion inférieure de la
 portion dentée de moulage (12) avec $0 \leq X \leq X_0$,
 "L₀" désigne une longueur du matériau cylindrique creux brut (1) avant le refoulement nécessaire à la portion
 dilatée (4),
 "X_p" désigne une position d'arrêt de la portion d'extrémité de pointe du poinçon (30) par rapport à la portion
 inférieure de la portion dentée de moulage (12) obtenue à partir d'un volume théorique de la portion dilatée (4),
 "X_g" désigne une position d'arrêt de la portion d'extrémité de pointe du guide (20) par rapport à la portion
 inférieure de la portion dentée de moulage (12) définie par le modèle, et
 "t₀" désigne un retard entre le départ en déplacement du poinçon (30) et le départ en déplacement du guide
 (20) avec $0 \leq t_0$

80. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 77, dans lequel le guide (20) est déplacé par une force de rappel agissant sur le guide (20) générée par ajustement sous pression du matériau de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans la portion dentée de moulage (12).

81. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 77, dans lequel la portion d'extrémité de pointe du poinçon (30) est formée en section transversale correspondant à une section transversale d'une portion d'extrémité axiale du matériau cylindrique creux brut (1).

82. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 77, dans lequel la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) est dilatée dans un état dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée.

83. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 82, dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée par induction avec un moyen de chauffage à induction (81).

84. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 82, dans lequel la portion d'extrémité axiale de la matrice de maintien (10) est partiellement chauffée par induction avec un moyen de chauffage à induction (81) pour ainsi chauffer partiellement la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

85. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 82, dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée à l'état semi-fondu.

86. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 82, dans lequel la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) est dilatée dans un état dans lequel la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion du côté d'extrémité de base du guide (20) plutôt qu'à la portion d'extrémité de pointe du guide (20) est partiellement refroidie par un moyen de refroidissement (85).

87. Procédé de refoulement pour un matériel cylindrique creux brut (1), comprenant:

- remplir des portions creuses d'une portion non programmée pour un traitement d'une portion axiale intermé-

diaire du matériel cylindrique creux brut (1) et d'une portion (2) programmée pour un traitement des deux portions d'extrémité axiales du matériel cylindrique creux brut (1) avec un fluide sous pression pour ainsi presser et maintenir des surfaces périphériques internes les deux portions (2) programmées pour un traitement et de la portion (3) non programmée pour un traitement avec la pression du fluide ;

- disposer la portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) dans un trou de maintien (11) formé dans une matrice de maintien (10) et déployé dans une direction axiale pour ainsi maintenir une surface périphérique externe de la portion (3) non programmée pour un traitement par une surface périphérique du trou de maintien (11) ;

- disposer les deux portions (2) programmées pour un traitement du matériel cylindrique creux brut (1) dans des portions dentées de moulage (12) formées dans les deux portions d'extrémité axiales de la matrice de maintien (10) ;

- disposer chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans un trou d'insertion (21) formé dans un guide (20) et déployé dans une direction axiale ; et

- ensuite, déplacer chaque guide (20) dans un sens opposé à un sens de déplacement du poinçon (30) tout en pressant simultanément chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) avec le poinçon (30) dans une direction axiale pour ainsi dilater vers l'extérieur chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) exposée entre la portion d'extrémité de pointe (20a) de chaque guide (20) et la portion inférieure correspondante (12a) de la portion dentée de moulage (12) de sorte qu'une épaisseur de paroi du matériel cylindrique creux brut (1) augmente dans la portion dentée de moulage correspondante (12).

88. Procédé de refoulement pour un matériel cylindrique creux brut (1) selon la revendication 87, dans lequel chaque guide (20) est déplacé par la force d'entraînement d'un appareil d'entraînement de guide correspondant (60).

89. Procédé de refoulement pour un matériel cylindrique creux brut (1) selon la revendication 87, dans lequel, dans au moins l'un des guides (20) et un poinçon (30) correspondant à l'un des guides, "G" répond à l'équation suivante :

$$G = (X_g - X) P / (L_0 - X_p - P t_0)$$

où :

"P" désigne une vitesse de déplacement moyenne du poinçon (30) depuis son départ en déplacement,

"G" désigne une vitesse de déplacement moyenne du guide (20) depuis son départ en déplacement,

"X₀" désigne une longueur limite de flambage dans une surface en section transversale de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) avant le refoulement,

"X" désigne un jeu initial entre une portion d'extrémité de pointe du guide (20) et une portion inférieure de la portion dentée de moulage (12) avec $0 \leq X \leq X_0$,

"L₀" désigne une longueur du matériau cylindrique creux brut (1) avant le refoulement nécessaire à la portion dilatée (4),

"X_p" désigne une position d'arrêt de la portion d'extrémité de pointe du poinçon (30) par rapport à la portion inférieure de la portion dentée de moulage (12) obtenue à partir d'un volume théorique de la portion dilatée (4),

"X_g" désigne une position d'arrêt de la portion d'extrémité de pointe du guide (20) par rapport à la portion inférieure de la portion dentée de moulage (12) définie par le modèle, et

"t₀" désigne un retard entre le départ en déplacement du poinçon (30) et le départ en déplacement du guide (20) avec $0 \leq t_0$

90. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 87, dans lequel chaque guide (20) est déplacé par une force de rappel agissant sur le guide (20) générée par ajustement sous pression du matériau de la portion (2) programmée pour un traitement correspondante du matériel cylindrique creux brut (1) dans la portion dentée de moulage (12).

91. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 87, dans lequel la portion d'extrémité de pointe de chaque poinçon (30) est formée en section transversale correspondant à une section transversale d'une portion d'extrémité axiale correspondante du matériau cylindrique creux brut (1).

92. Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 87, dans lequel chaque

portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) est dilatée dans un état dans lequel la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée.

- 5 **93.** Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 92, dans lequel la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée par induction avec un moyen de chauffage à induction (81).
- 10 **94.** Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 92, dans lequel les deux portions d'extrémité axiales de la matrice de maintien (10) sont partiellement chauffées par induction avec un moyen de chauffage à induction (81) pour ainsi chauffer partiellement la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).
- 15 **95.** Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 92, dans lequel la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20) est partiellement chauffée à l'état semi-fondu.
- 20 **96.** Procédé de refoulement pour un matériau cylindrique creux brut (1) selon la revendication 92, dans lequel chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) est dilatée dans un état dans lequel la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion du côté d'extrémité de base du guide (20) plutôt qu'à la portion d'extrémité de pointe du guide (20) est partiellement refroidie par un moyen de refroidissement (85).
- 25 **97.** Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) pour dilater vers l'extérieur une portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) de sorte qu'une épaisseur de paroi de la portion (2) programmée pour un traitement augmente, l'appareil de refoulement (1A, 1B, 1 C) comprenant :
 - 30 - un moyen de remplissage de fluide sous pression (90) configuré pour remplir des portions creuses d'une portion (2) programmée pour un traitement et d'une portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) avec du fluide sous pression ;
 - une matrice de maintien (10) ayant un trou de maintien (11) déployé dans une direction axiale, où la portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) doit être disposée dans le trou de maintien (11) ;
 - 35 - une portion dentée de moulage (12) formée dans la portion d'extrémité axiale de la matrice de maintien (10) ;
 - un guide (20) ayant un trou d'insertion (21) déployé dans une direction axiale, où la portion programmée pour un traitement (2) du matériel cylindrique creux brut (1) doit être disposée dans le trou d'insertion (21) ; et
 - un poinçon (30) configuré pour presser la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans la direction axiale,
 - 40 - dans lequel le guide (20) peut être déplacé dans un sens opposé à un sens de déplacement du poinçon (30), si bien qu'en service, la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) exposée entre la portion d'extrémité de pointe (20a) du guide (20) et la portion inférieure (12a) de la portion dentée de moulage (12) est dilatée vers l'extérieur dans la portion dentée de moulage (12).
- 45 **98.** Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 97, comprenant par ailleurs un appareil d'entraînement de guide (60) pour déplacer le guide (20) dans un sens opposé au sens de déplacement du poinçon (30).
- 50 **99.** Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 97, dans lequel la portion d'extrémité de pointe du poinçon (30) est formée en section transversale correspondant à une section transversale d'une portion d'extrémité axiale du matériau cylindrique creux brut (1).
- 55 **100.** Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 97, dans lequel un travail de biseautage est appliqué à la portion de bord de l'ouverture du trou d'insertion de la portion d'extrémité de pointe du guide (20).
- 101.** Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 97, comprenant en outre un moyen de chauffage (80) pour chauffer partiellement la portion de la portion (2) programmée pour un

traitement du matériau cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

5 102.Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 101, dans lequel le moyen de chauffage (80) est un moyen de chauffage à induction (81) configuré pour chauffer partiellement par induction la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

10 103.Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 101, dans lequel le moyen de chauffage (80) est un moyen de chauffage à induction (81) configuré pour chauffer partiellement par induction la portion d'extrémité axiale de la matrice de maintien (10) afin de chauffer ainsi partiellement la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

15 104.Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 101, dans lequel le moyen de chauffage (80) est capable de chauffer partiellement à l'état semi-fondu la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

20 105.Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 101, comprenant en outre un moyen de refroidissement (85) configuré pour refroidir partiellement la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion du côté d'extrémité de base du guide (20) plutôt qu'à la portion d'extrémité de pointe du guide (20).

25 106.Appareil de refoulement (1A, 1B, 1 C) pour un matériel cylindrique creux brut (1) pour dilater vers l'extérieur des portions (2) programmées pour un traitement des deux portions d'extrémité axiales du matériel cylindrique creux brut (1) de sorte qu'une épaisseur de paroi chaque portion (2) programmée pour un traitement augmente, l'appareil de refoulement (1A, 1B, 1 C) comprenant :

- 30 - un moyen de remplissage de fluide sous pression (90) configuré pour remplir des portions creuses d'une portion (3) non programmée pour un traitement d'une portion axiale intermédiaire du matériel cylindrique creux brut (1) et de portions (2) programmées pour un traitement des deux portions d'extrémité axiales du matériel cylindrique creux brut (1) avec du fluide sous pression ;
- une matrice de maintien (10) ayant un trou de maintien (11) déployé dans une direction axiale, où la portion (3) non programmée pour un traitement du matériel cylindrique creux brut (1) doit être disposée dans le trou de maintien (11);
- 35 - deux portions dentées de moulage (12) formées dans les deux portions d'extrémité axiales de la matrice de maintien (10) ;
- deux guides (20) ayant chacun un trou d'insertion (21) déployé dans une direction axiale, où chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) doit être disposée dans le trou d'insertion (21) ; et
- 40 - deux poinçons (30) chacun pour presser chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) dans la direction axiale,
- dans lequel chaque guide (20) peut être déplacé dans un sens opposé à un sens de déplacement du poinçon (30), si bien qu'en service, chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) exposée entre la portion d'extrémité de pointe (20a) de chaque guide (20) et la portion inférieure correspondante (12a) de la portion dentée de moulage (12) est dilatée vers l'extérieur dans la portion dentée de moulage (12).
- 45

50 107.Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 106, comprenant par ailleurs deux appareils d'entraînement de guide (60) chacun pour déplacer le guide correspondant (20) dans un sens opposé au sens de déplacement du poinçon (30).

55 108.Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 106, dans lequel la portion d'extrémité de pointe de chaque poinçon (30) est formée en section transversale correspondant à une section transversale d'une portion d'extrémité axiale correspondante du matériau cylindrique creux brut (1).

109.Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 106, dans lequel un travail de biseautage est appliqué à la portion de bord de l'ouverture du trou d'insertion de la portion

d'extrémité de pointe de chaque guide (20).

5 **110.**Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 106, comprenant en outre deux moyens de chauffage (80) chacun pour chauffer partiellement la portion de chaque portion (2) programmée pour un traitement du matériau cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

10 **111.**Appareil de refoulement (1A, 1B, 1 C) pour un matériel cylindrique creux brut (1) selon la revendication 110, dans lequel chaque moyen de chauffage (80) est un moyen de chauffage à induction (81) configuré pour chauffer partiellement par induction la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

15 **112.**Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 110, dans lequel chaque moyen de chauffage (80) est un moyen de chauffage à induction (81) configuré pour chauffer partiellement par induction les deux portions d'extrémité axiales de la matrice de maintien (10) afin de chauffer ainsi partiellement la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

20 **113.**Appareil de refoulement (1A, 1B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 110, dans lequel chaque moyen de chauffage (80) est capable de chauffer partiellement à l'état semi-fondu la portion de la portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion d'extrémité de pointe du guide (20).

25 **114.**Appareil de refoulement (1A, 1 B, 1C) pour un matériel cylindrique creux brut (1) selon la revendication 110, comprenant en outre deux moyens de refroidissement (85) configurés pour refroidir partiellement la portion de chaque portion (2) programmée pour un traitement du matériel cylindrique creux brut (1) correspondant à la portion du côté d'extrémité de base du guide (20) plutôt qu'à la portion d'extrémité de pointe du guide (20).

Fig.1

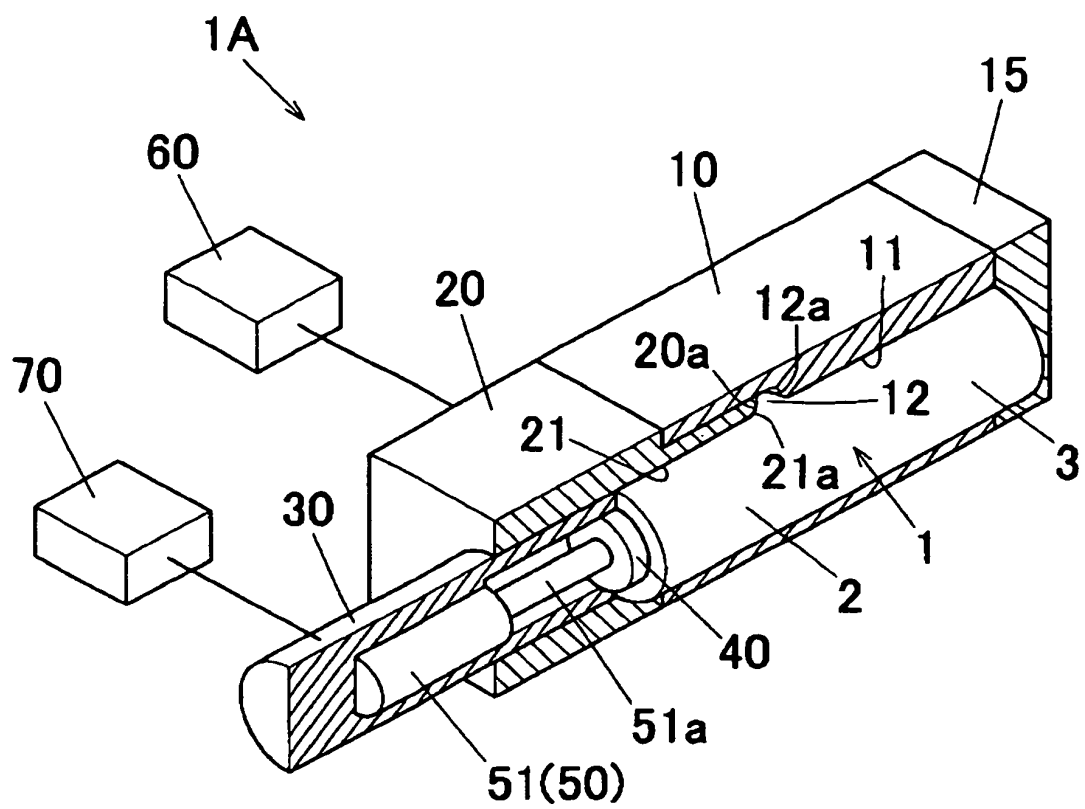


Fig.2

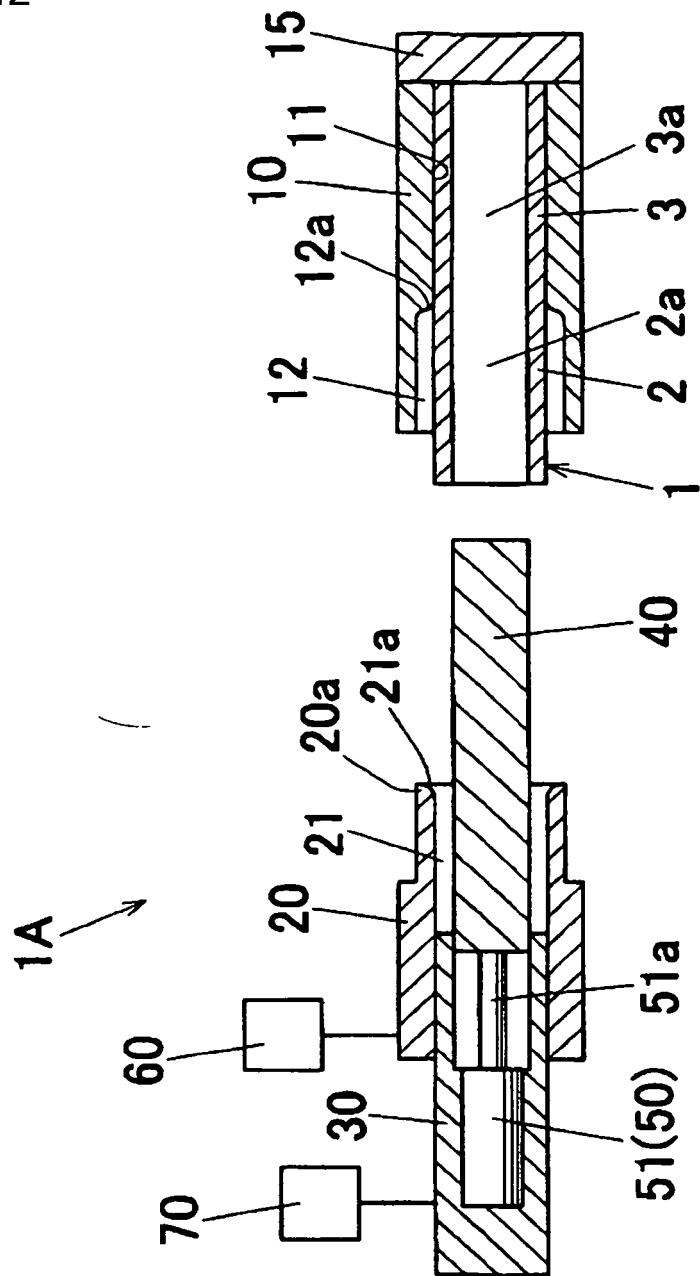


Fig.3

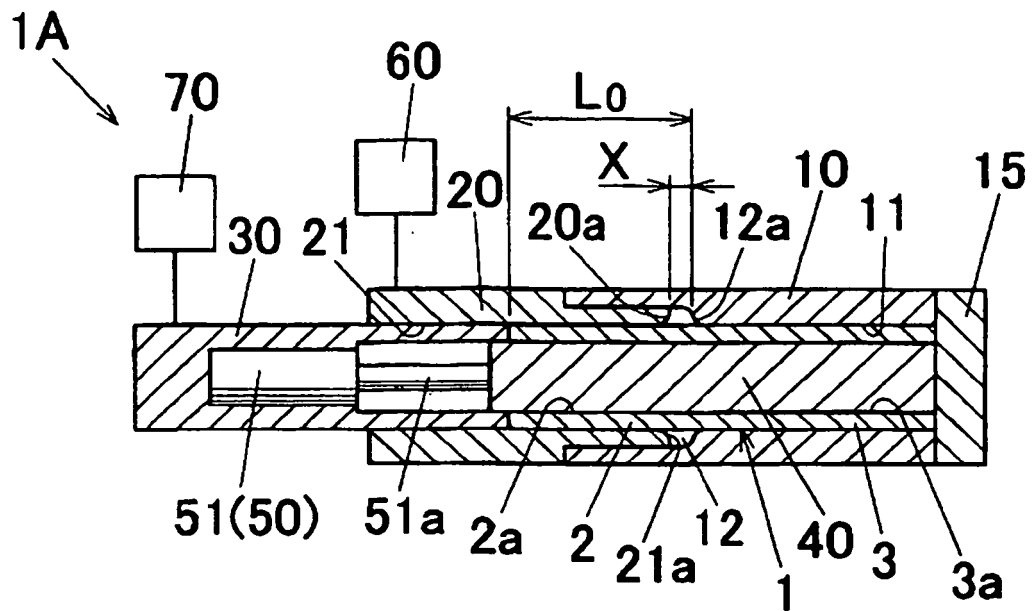


Fig.4

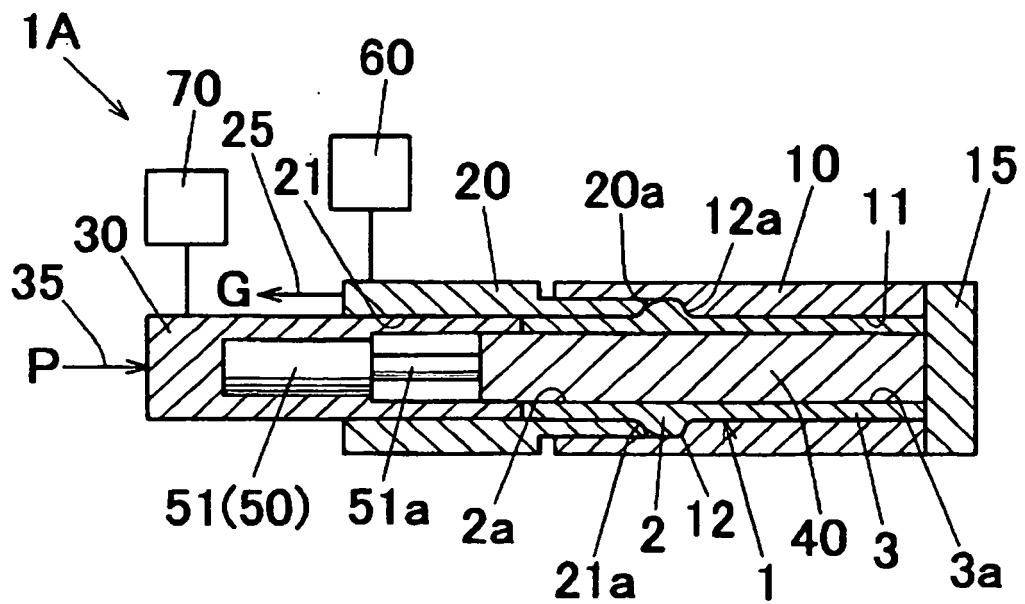


Fig.5

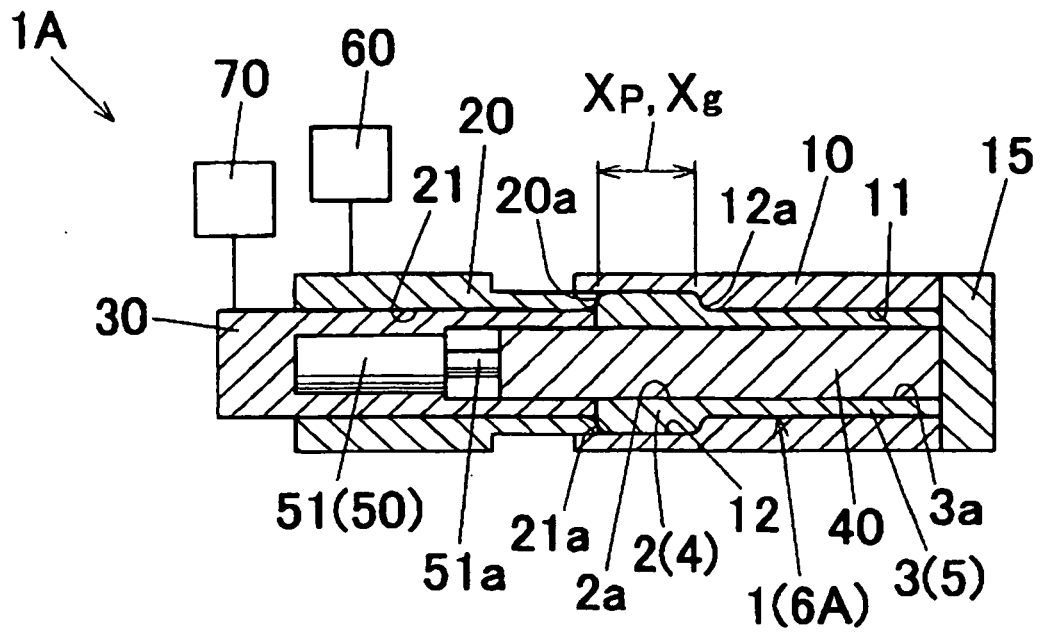


Fig.6

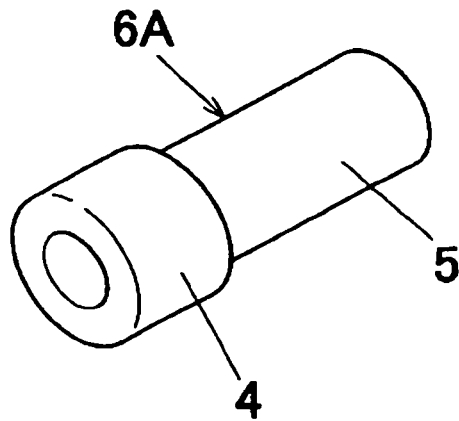


Fig.7

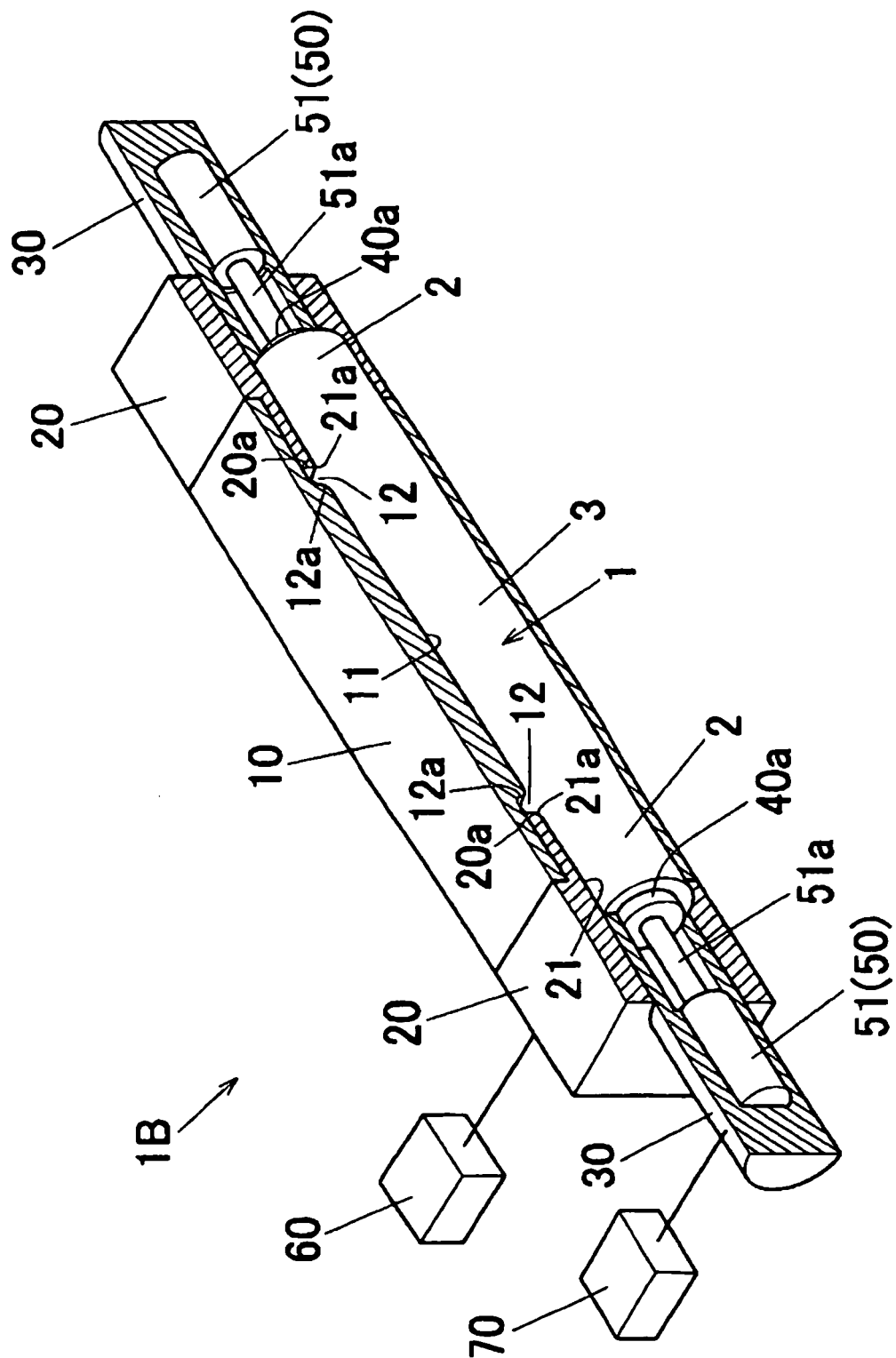


Fig.8

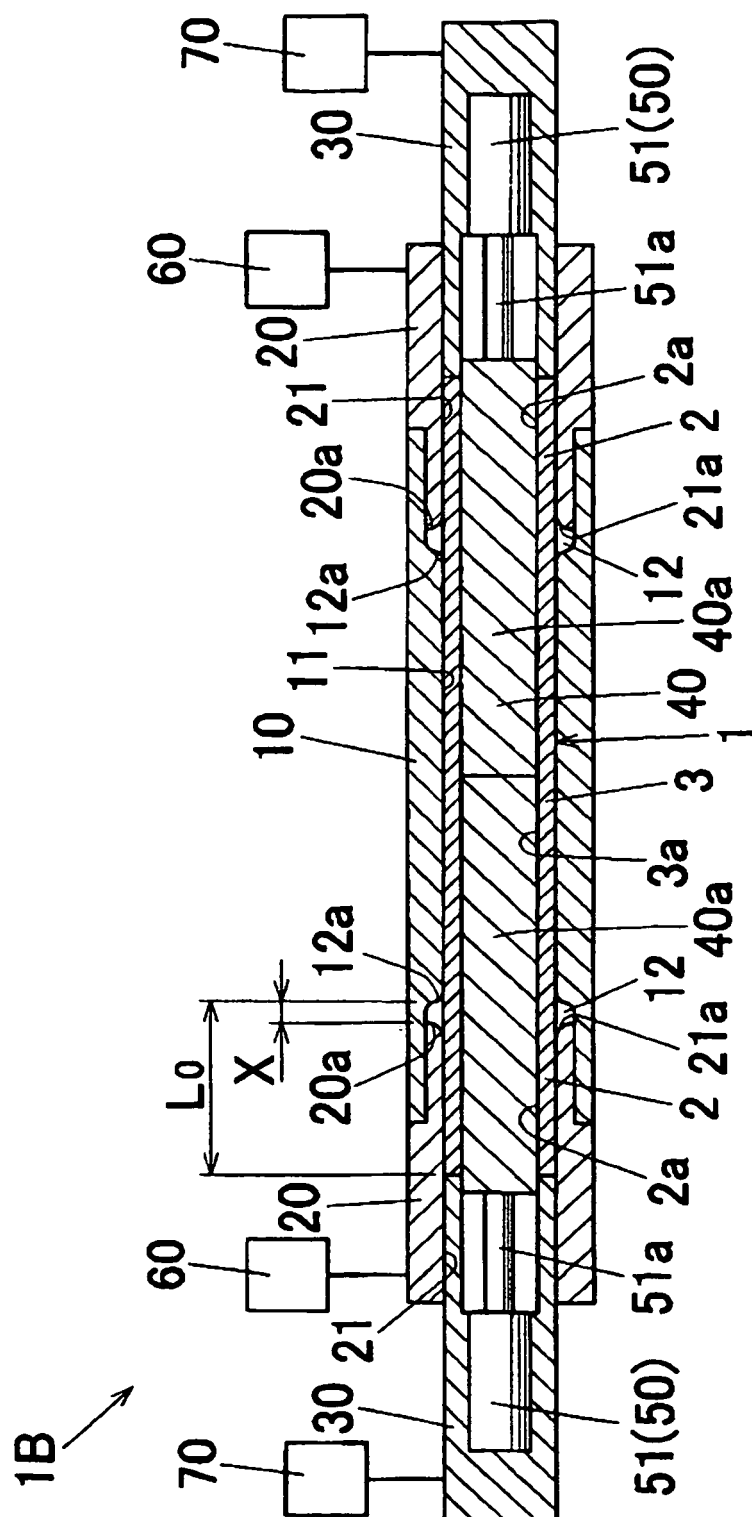


Fig.9

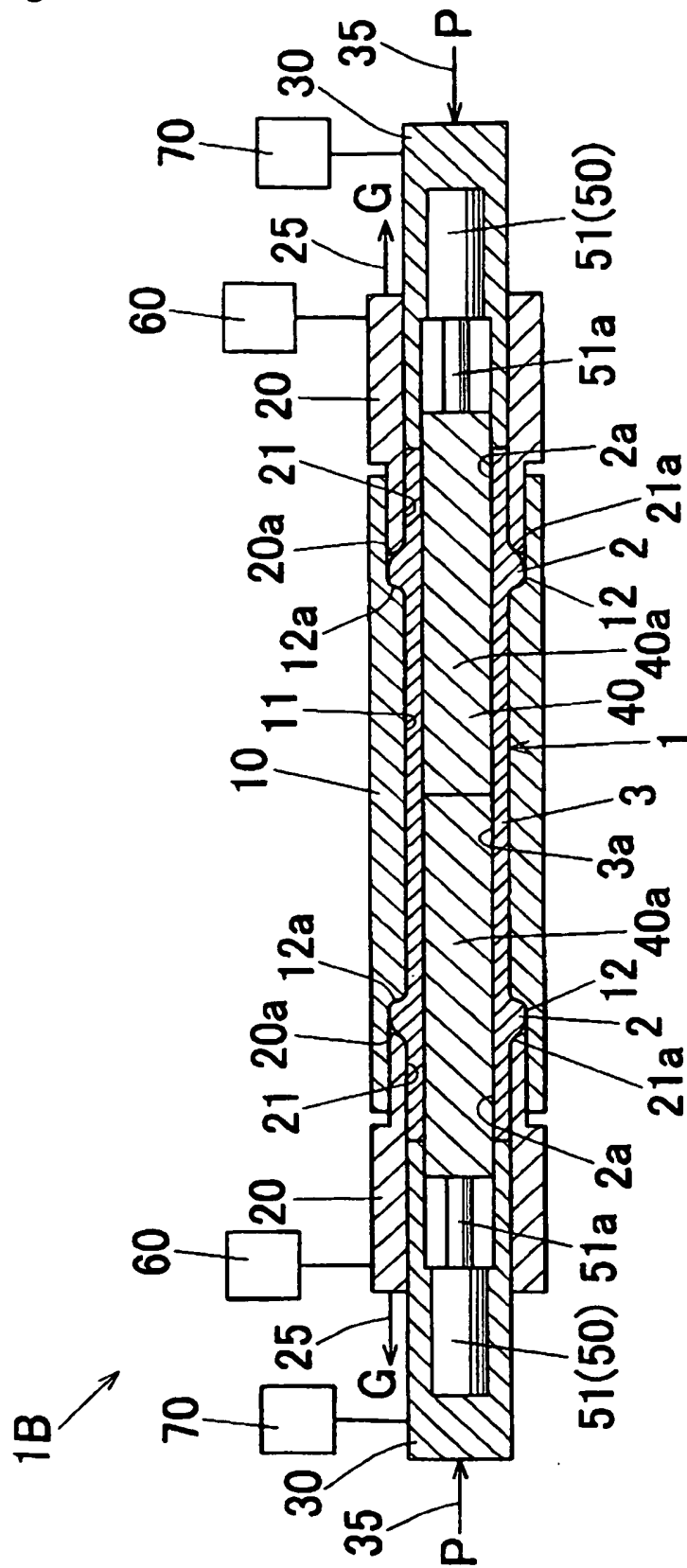


Fig.10

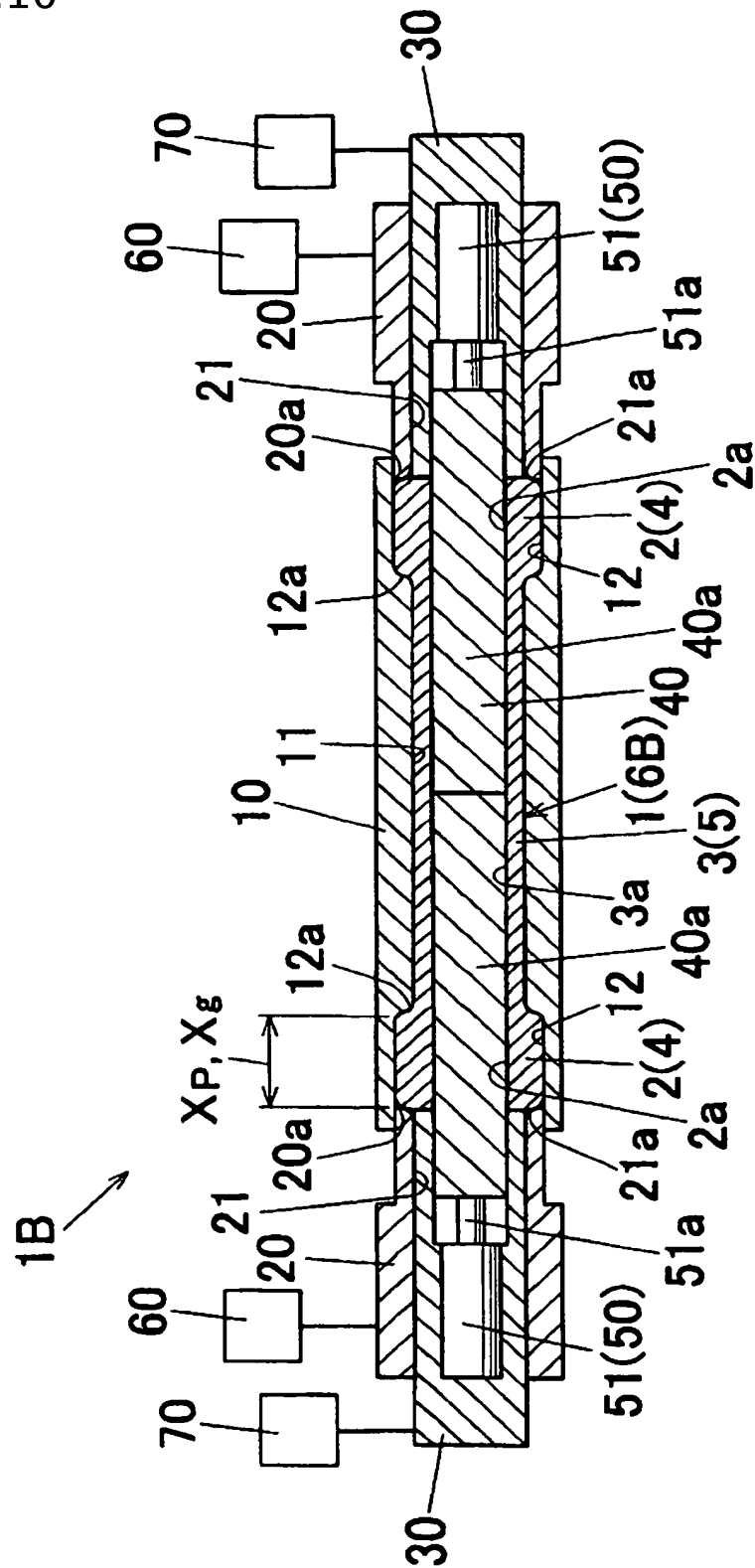


Fig.11

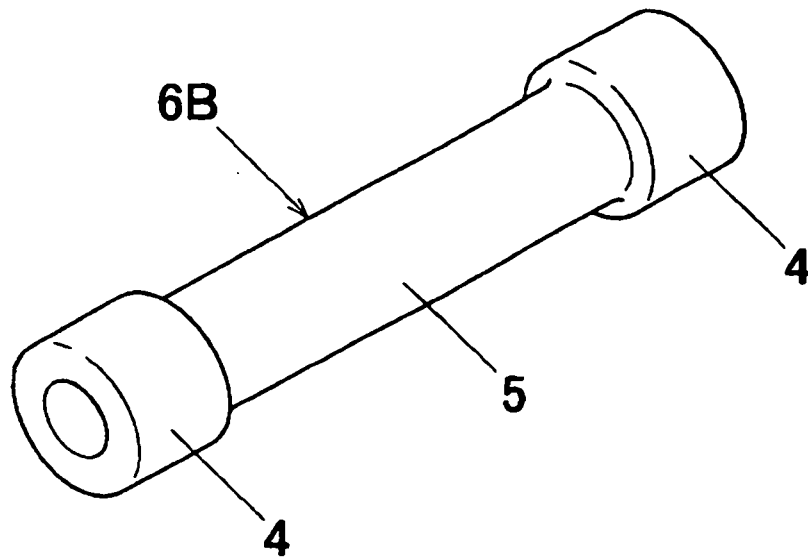


Fig.12

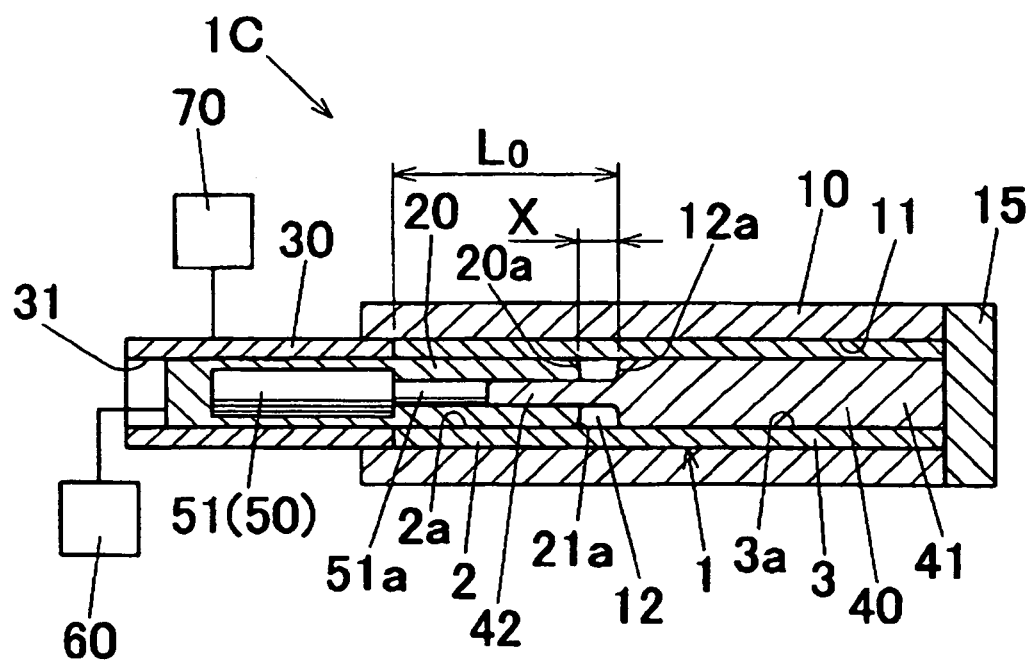


Fig.13

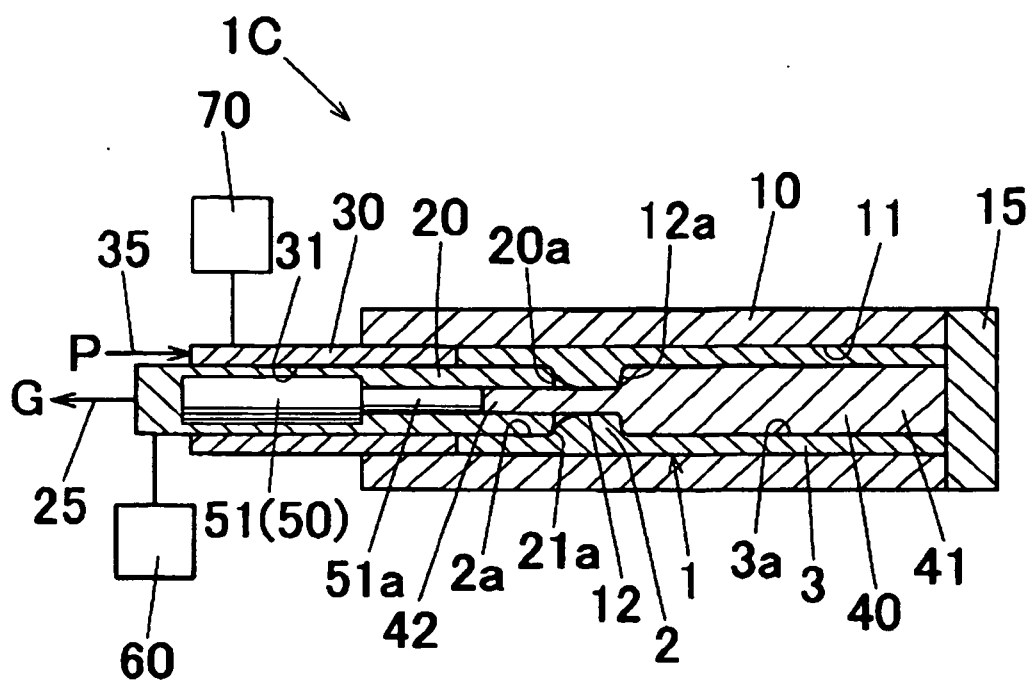


Fig.14

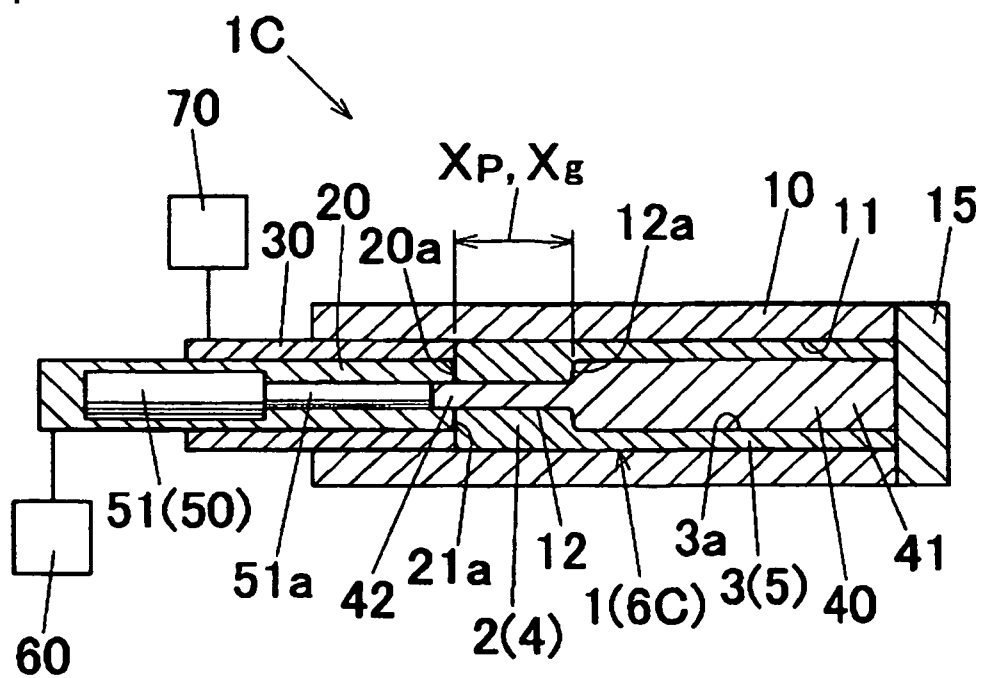


Fig.15

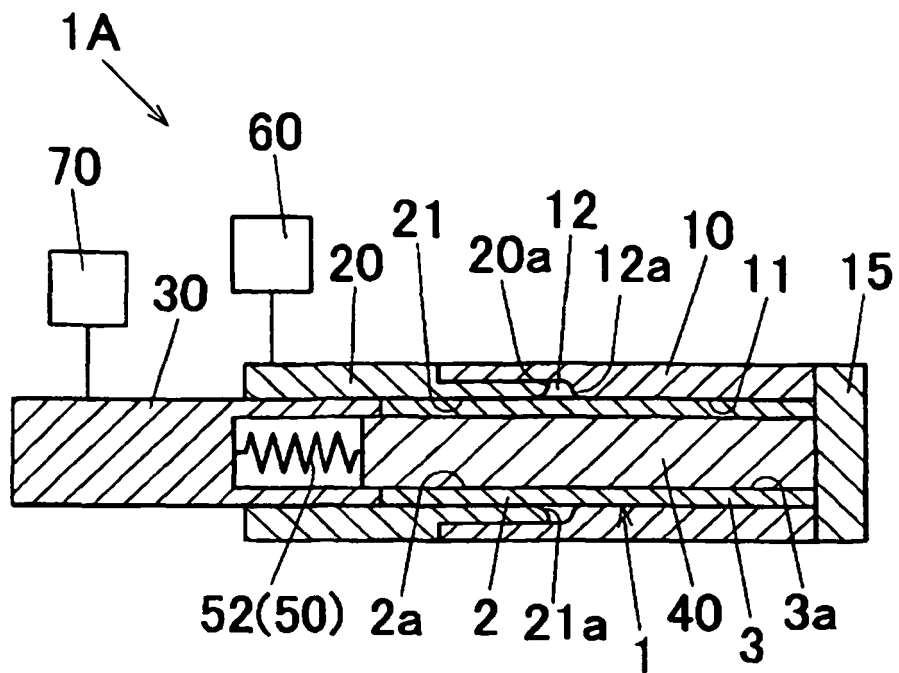


Fig.16

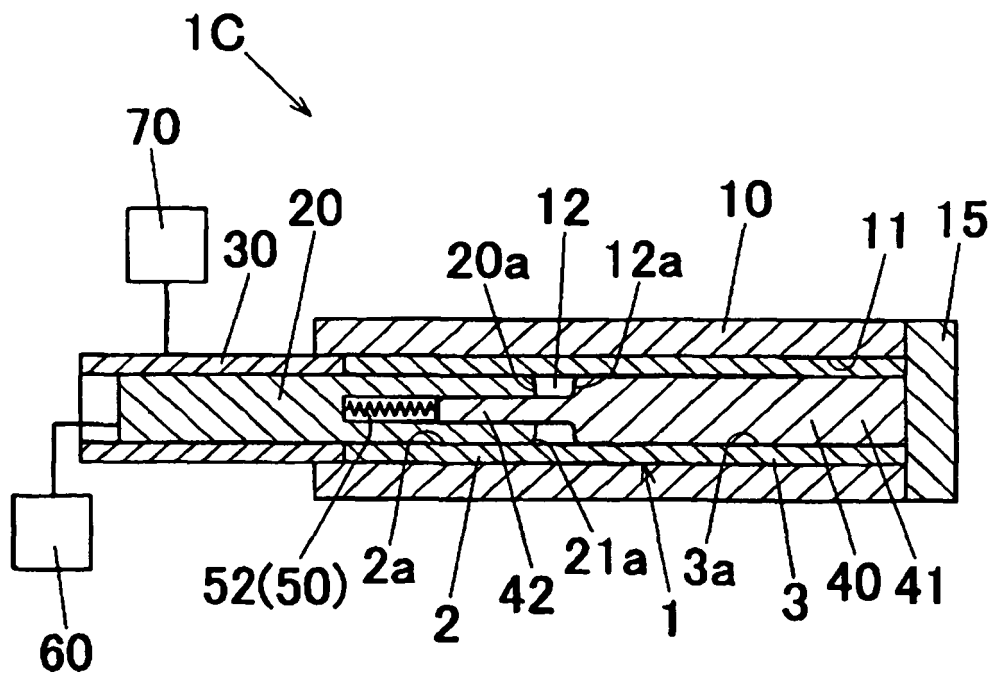


Fig.17

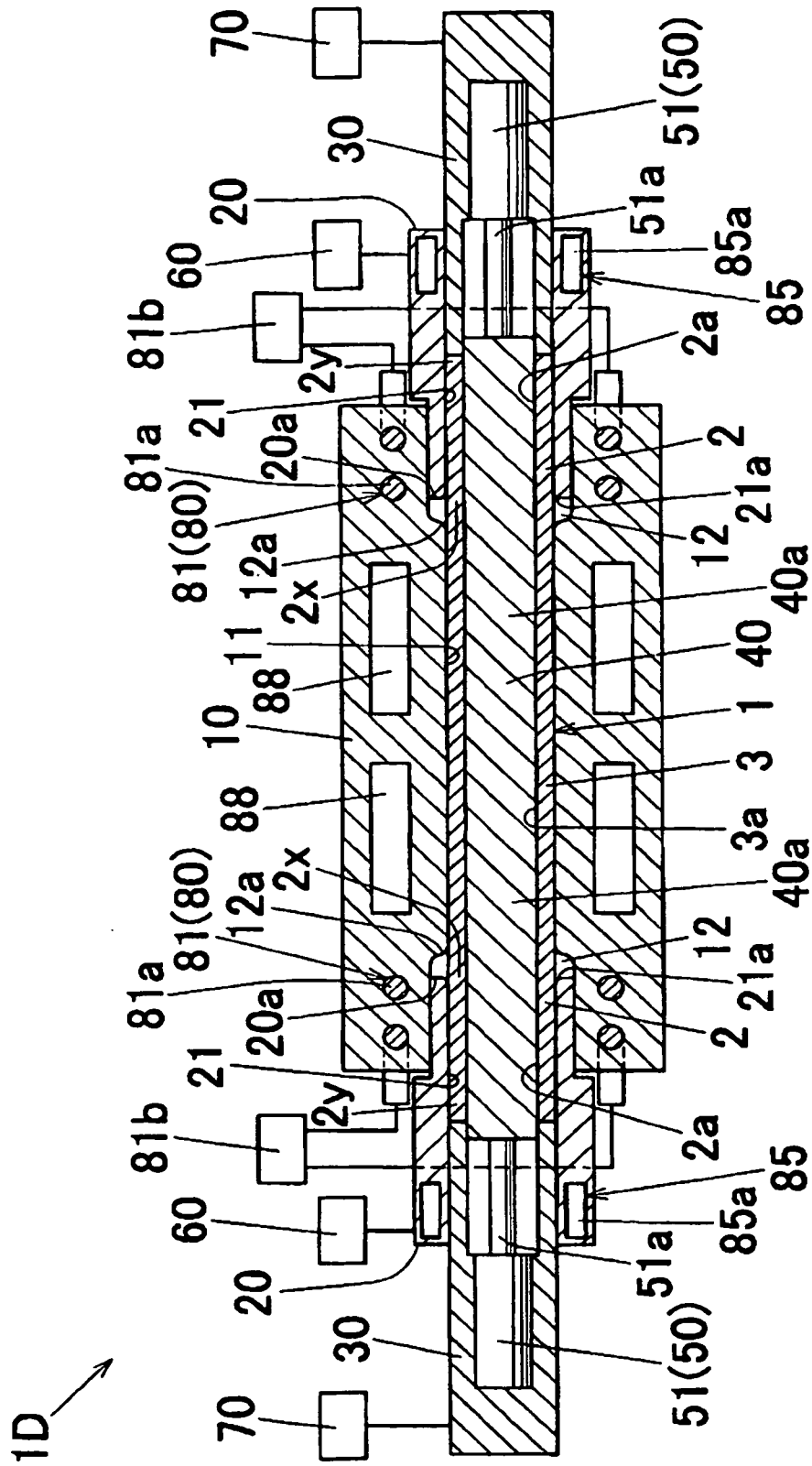


Fig.18

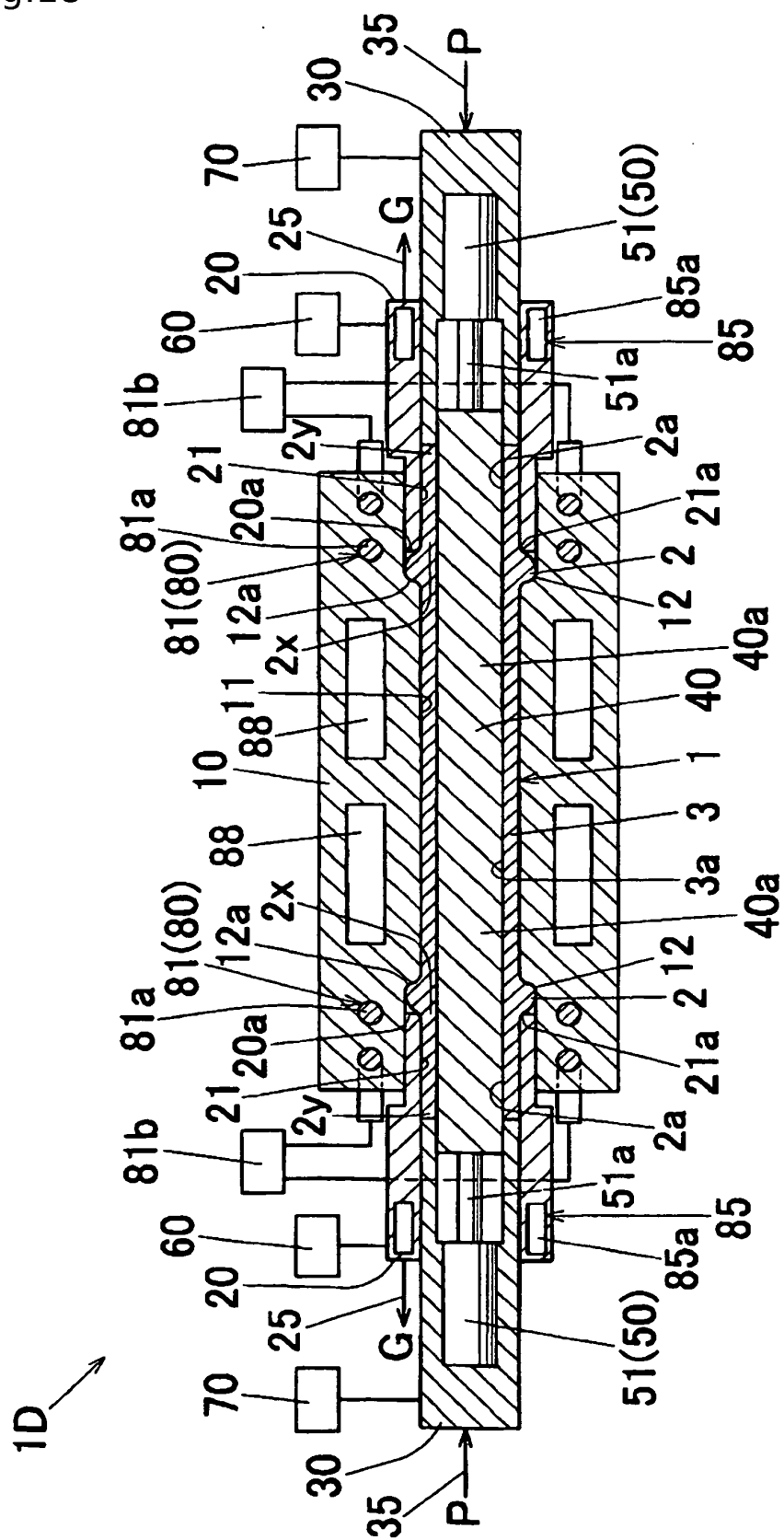


Fig.19

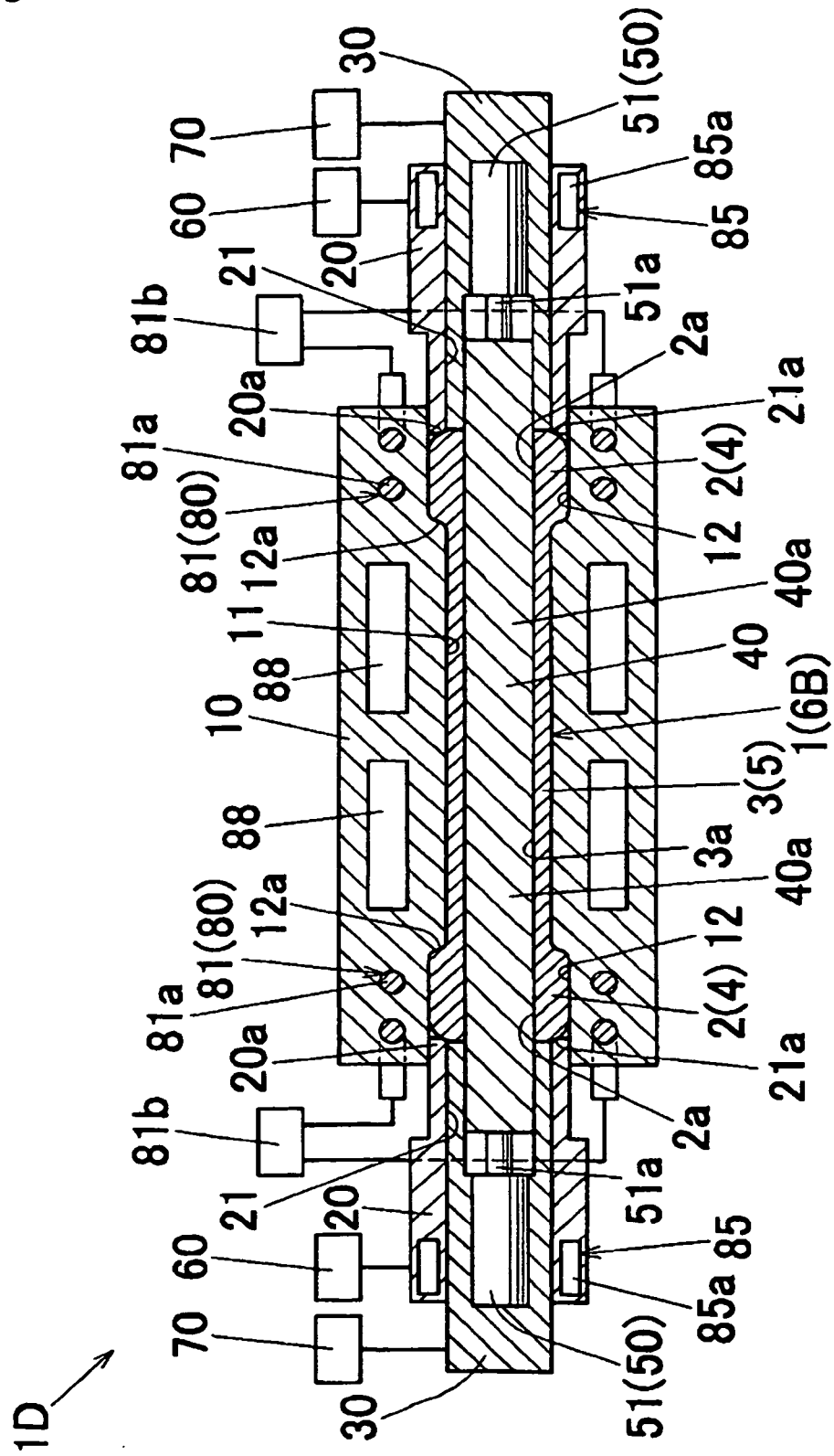


Fig.20

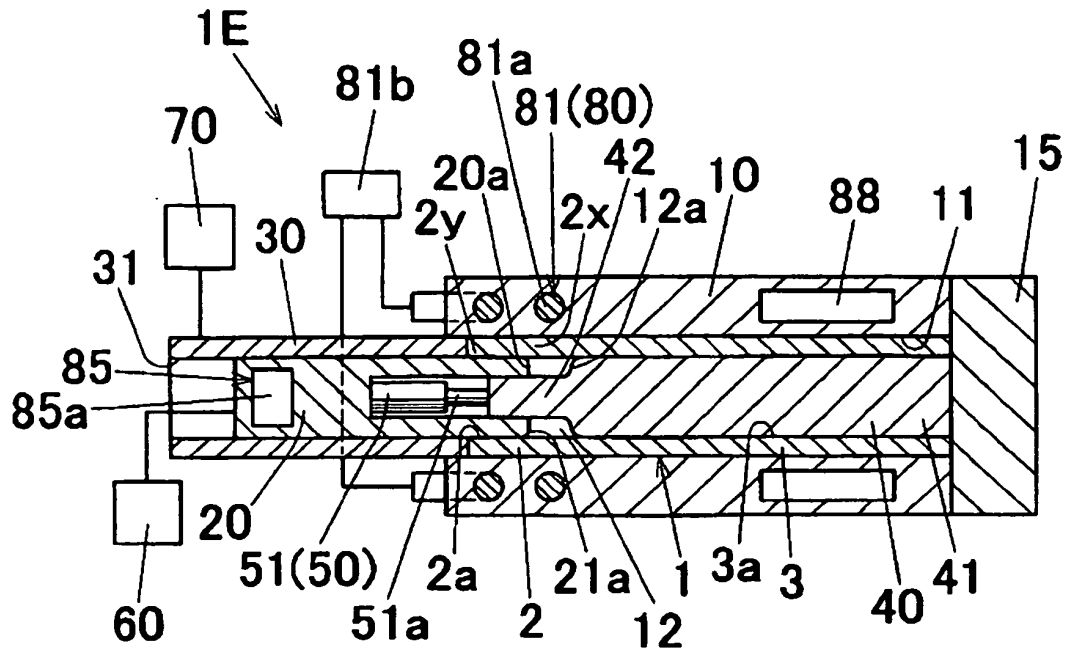


Fig.21

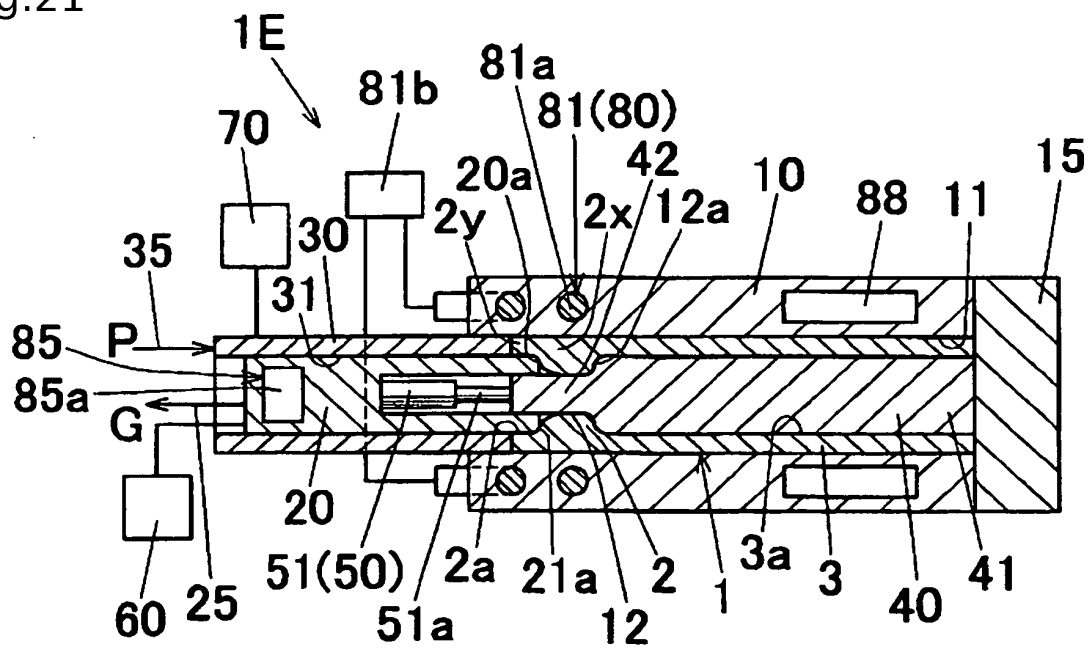


Fig.22

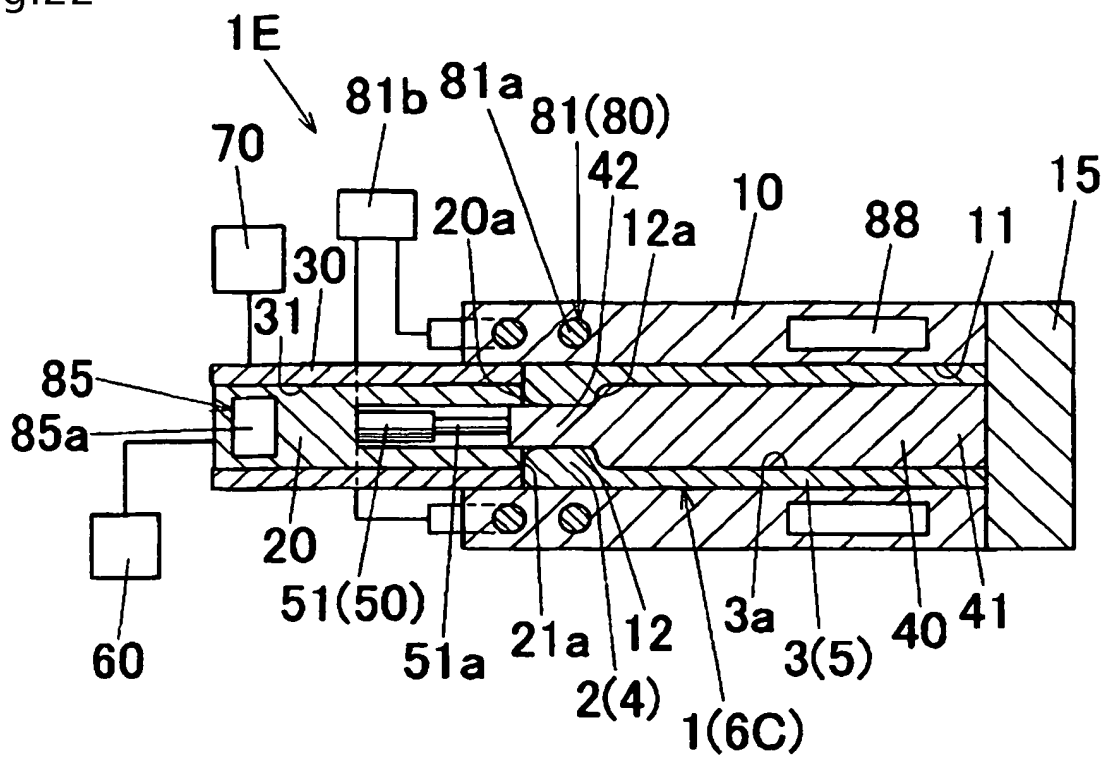


Fig.23

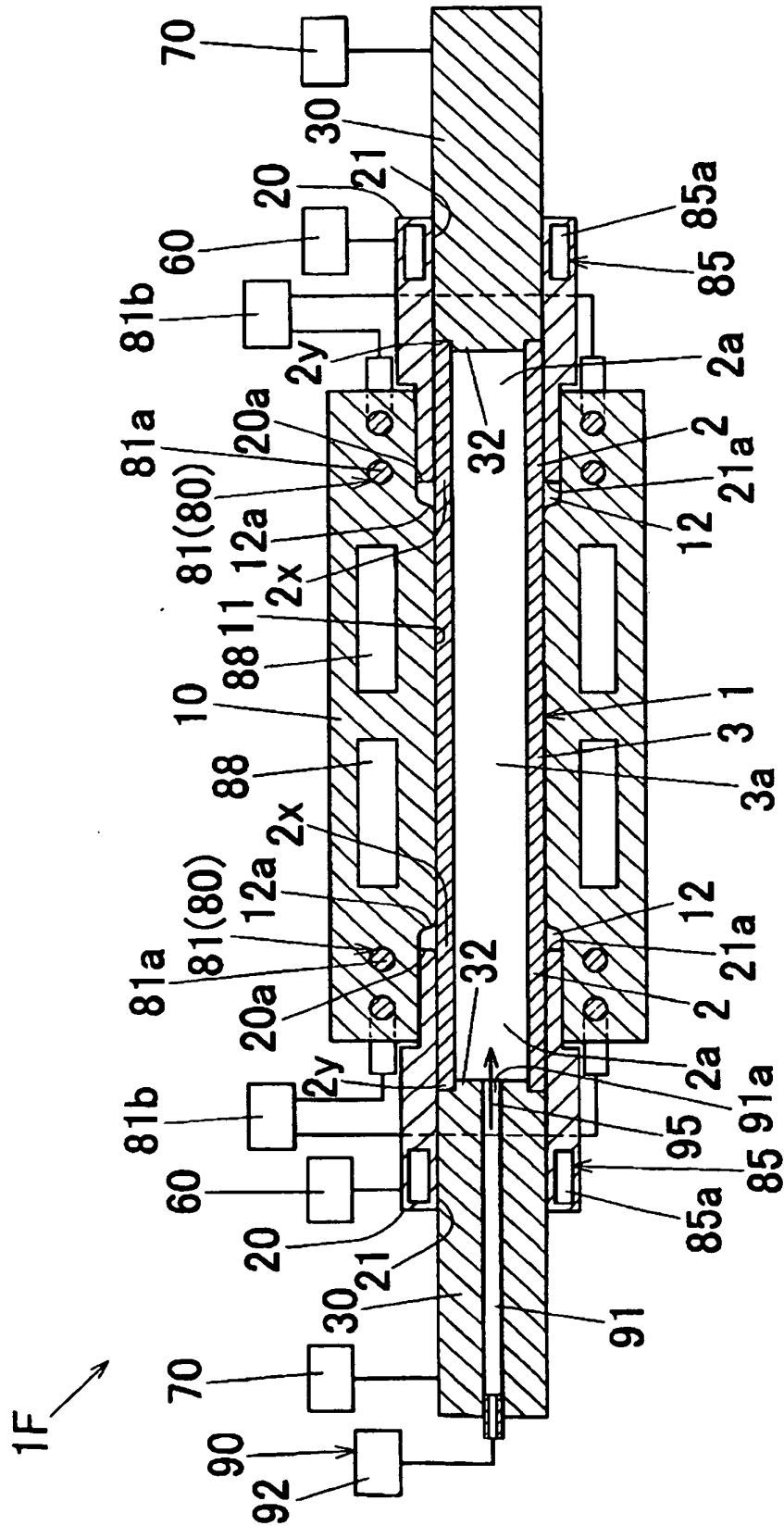


Fig.24

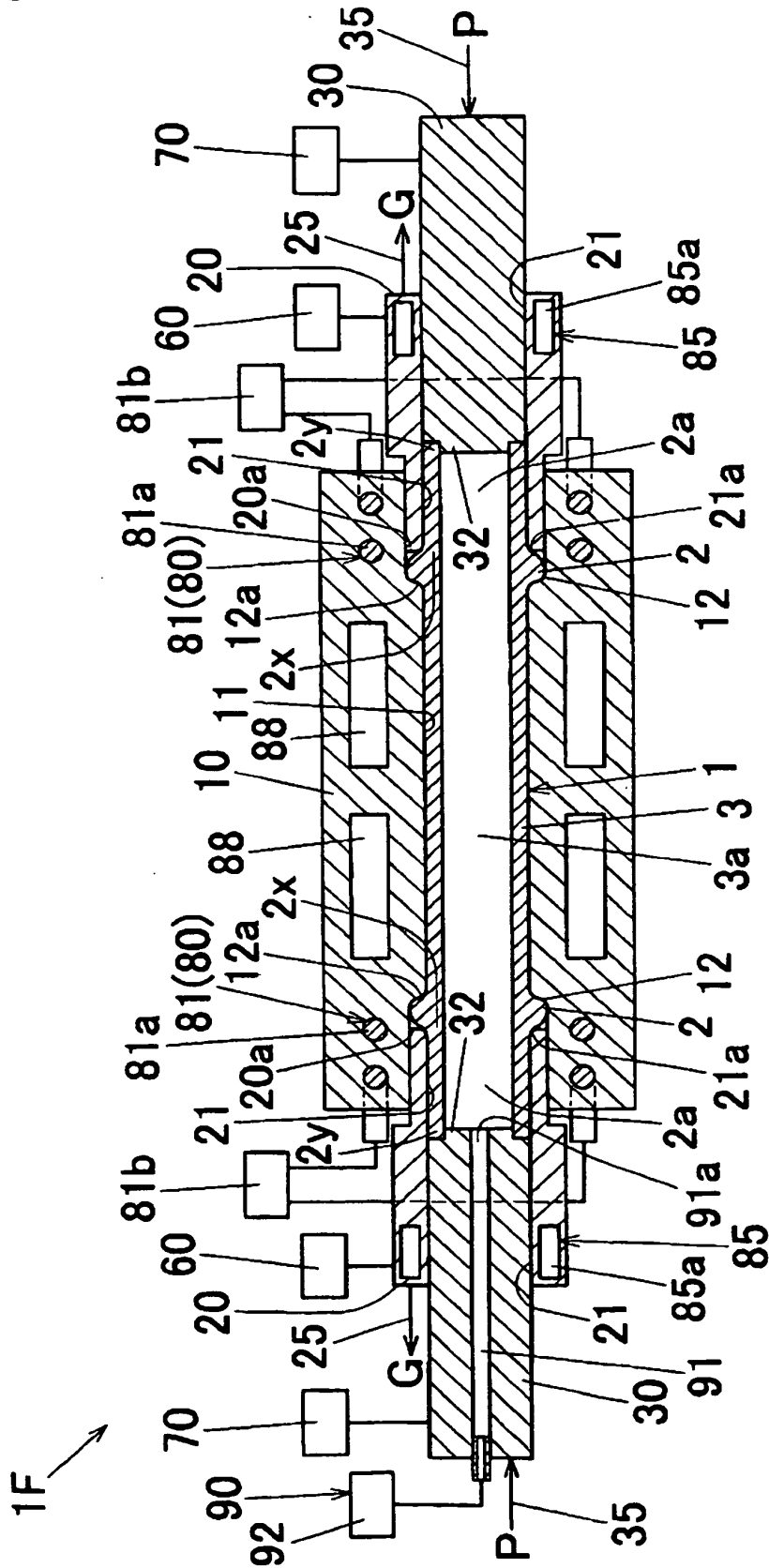
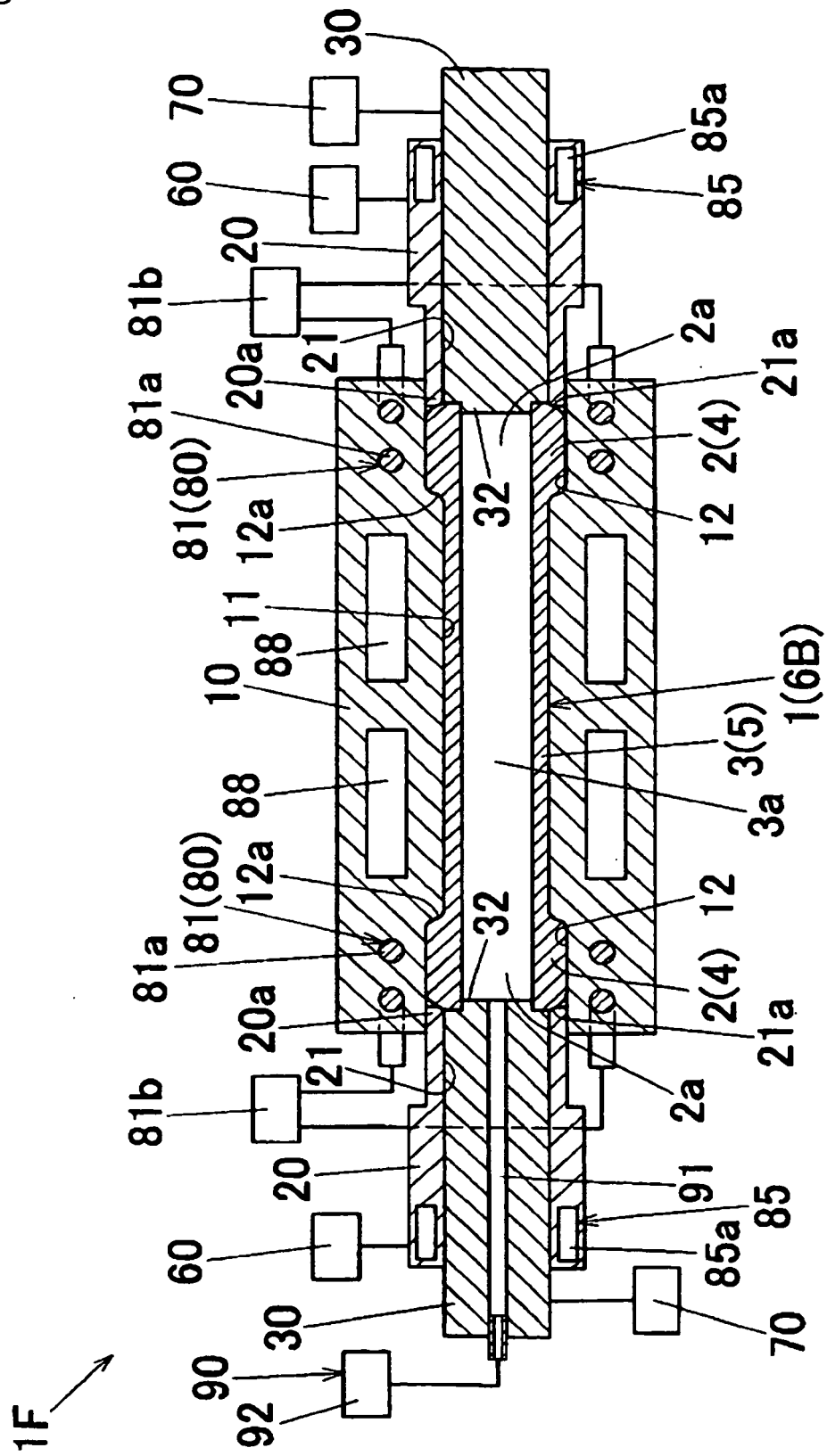


Fig.25



REFERENCES CITED IN THE DESCRIPTION

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