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(54) **Manufacturing method for irregular-section tubular body and axle beam for torsion beam**

Herstellungsverfahren von Rohren mit querprofilierter Wandung und Achsträger für Torsionsstab

Procédé de fabrication pour forme tubulaire de section irregulière et essieu pour axe de torsion

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to an axle beam for a torsion beam joined to a pair of trailing arms attached to a wheel side to connect the trailing arms.

Related Background Art

[0002] As a manufacturing method for manufacturing an irregular-section tubular body having a concave portion concaved in direction perpendicular to axis thereof (hereinafter simply referred "axis perpendicular direction") at least a part in an axial direction, a manufacturing method for press-forming the tubular worked body with applying pressure of a liquid sealed in an internal space thereof to an inner surface thereof, has been known.

[0003] For example, JP-A-8090097 discloses a manufacturing method for manufacturing an irregular-section tube a section shape of which varies in a longitudinal direction by usage of liquid pressure. In this manufacturing method, firstly an internal space of a circular tube as the worked body is filled with liquid, then further liquid is supplied by a pump to apply predetermined pressure P1 to an inner surface of the circular tube. In this condition, the circular tube is press-formed by a pair of upper press mold and lower press mold of predetermined shape and subjected to the bending work. Finally, further liquid is supplied into the circular tube to increase the liquid pressure up to a predetermined value P2 so that the circular tube bulges or expands along mold surfaces of the press upper and lower molds. Thus, the circular tube is formed into the final irregular-section shape to complete the formation.

[0004] On the other hand, as an article using the above irregular-section tubular body, an axle beam used for a torsion beam as a rear-wheel suspension device of a vehicle has been known.

[0005] For example, EP 0650860 B1 discloses, as shown in Fig. 20, a torsion beam comprised of a pair of trailing arms 91 attached to wheel sides, and an axle beam 92 each end of which is joined to each of trailing arm 91 respectively to the connect them integrally. This axle beam 92 is formed into a shape to have a large bending rigidity and small twisting (torsion) rigidity. That is, as shown in Fig. 21, the axle beam 92 has cross-section in the axis perpendicular direction of closed section shape including a closed space therein. The cross-section has a star shape in which three wing portions 9 2 a extending radially outwardly and equidistantly in circumferential direction are disposed.

[0006] However, the conventional manufacturing method of the irregular-section tube body needs both of the press-forming process which bends the circular tube by the press molds, and the liquid pressurizing process which pressurizes liquid in the circular tube by the liquid pressurizing device additionally provided, to obtain the final irregular-section shape of the tubular body. For this reason, the conventional manufacturing method has been suffering from a disadvantage of the manufacturing process being complex and troublesome.

[0007] In addition, since the circular tube is bulged only by the liquid pressure to follow to the mold surfaces, very large liquid pressure is needed for the bulging. For this reason, the liquid pressurizing device to make the liquid pressure high by positively pressurizing the liquid, and a large-size extra hydraulic pressing device to apply a mold fastening force to the press molds against the increasing liquid pressure become necessary. As a result, not only equipment become complexed and large-sized, but equipment cost increases.

[0008] On the other hand, in the above conventional axle beam 92, as shown in Fig. 21, three wing portion 92a of the same size and same shape and extending radially outwardly and equidistantly in the circumferential direction are disposed. As a result, it has cross-section shape in which a centroid and a shearing center are coincided. Such coincidence decreases a roll rigidity in the axle beam 92 and makes a steering character to over-steer tendency, whereby the steer stabilizing character is decreased.

SUMMARY OF THE INVENTION

[0009] The present invention intends to provide the axle beam for the torsion beam which can contribute increase of the steer stabilizing character by improvement of the section-shape in the axis perpendicular direction thereof.

[0010] The axle beam of the present invention is featured by that the axle beam has at least at axial part thereof a concave portion concaved in an axis perpendicular direction, an axis perpendicular section at the concave portion having a closed section shape including a closed and sealed space, and having a shape in which a shearing center being offset from a centroid by a predetermined amount.

[0011] Here, "the axis perpendicular direction shape at the concave portion is closed section shape having closed and sealed space" means an outer peripheral wall of the axis beam does not have circumferential ends to form a ring. In other words, it means the outer peripheral wall of the axle beam is formed by an annular wall. The outer peripheral wall formed by the annular wall can form single closed and sealed space, or plural closed and sealed spaces separated by an overlap portion where opposing inner surfaces of the outer peripheral wall are overlapped.

[0012] In the suitable mode, a circumferential part of the worked body opposing to the concave portion in the axis perpendicular direction is so shaped that the worked body has a U-shape or V-shape axis perpendicular section at the concave portion.

[0013] In the suitable mode, a rough tube comprises a large-diameter axially intermediate portion, a pair of small-diameter axially end portions having smaller diameter than the large-diameter axially intermediate portion, and a pair of diameter change portions connecting each end of the large-diameter axially intermediate portion and each of the small-diameter axially end portions integrally is, after having been formed the concave portion on the large-diameter axially intermediate portion, subjected to a bending work to form each of the trailing arms by at least each of the small-diameter axially end portions and to form the axle beam by at least the large-diameter axially intermediate portion. Here, the large-diameter axially intermediate portion, the diameter change portions and the small-diameter axially end portions are connected by a continuous surface having no radial step, due to offset of the small-diameter axially end portions from the large-diameter axially intermediate portion in the same direction of the shearing center being offset from the centroid, at a circumferential part of the small-diameter axially end portions at offset side.

[0014] In the suitable mode, each of the small-diameter axially end portions are bent in a direction orthogonal to the axial direction of the axle beam and orthogonal to a concave direction of the concave portion.

EMBODYING MODES OF INVENTION

[0015] (a) The first manufacturing method completes formation of the final irregular-section tubular body by only press-forming the worked body sealed the liquid therein, not requiring the liquid pressurizing process after the press-forming. As a result,the manufacturing process for the irregular-section tubular body becomes simple. Also, the liquid pressurizing device or the large-size extra hydraulic pressing device are not needed, which can avoid complexing and large-sizing of the equipment and avoid increase of the equipment cost.

[0016] Here, inventors has confirmed in the manufacturing method of the present invention, none of a rise speed of the liquid pressure (pressure increase speed) in the worked body, a maintained time period of the max. pressure and a pressurized state of the liquid after the liquid pressure having reached to the max. pressure affects quality of the press-formed article.

[0017] In the pressure increase process in the former half of stroke, the worked body is press-formed with the liquid pressure, increasing as decrease of the internal volume of the worked body due to formation of the concave portion, being applied on the inner peripheral surface. That is, by press-forming the tubular worked body filled with the liquid by the press upper mold and the press lower mold, a portion or part of the worked body pressed by the convex mold portion of the press mold plastically deforms to be concaved in the axis perpendicular direction.

[0018] As formation of the concave portion, the internal volume of the worked body decreases. The worked body is press-formed with the liquid gradually increasing as decrease of the internal space of the worked body being applied to the inner peripheral surface thereof. For this reason, in the pressure increase process, not only the worked body can be deformed or shaped securely following to the mold surfaces of the press molds, but the worked body can be prevented from buckle. Thus, the worked body is smoothly formed.

[0019] In the non-pressure increase process in the latter half of stroke, the worked body is press-formed without the liquid pressure under increasing stage being applied to the inner peripheral surface thereof. That is, in the non-pressure increase process, the worked body is press-formed (i) with the liquid pressure maintained in a constant being applied to the inner peripheral surface thereof, (ii) with the gradually decreasing liquid pressure being applied to the inner peripheral surface thereof, or (iii) with the gradually decreasing liquid pressure being applied to the inner peripheral surface thereof from start to midway of non-pressure increase process, and without the liquid pressure being applied to the inner peripheral surface thereof in a final stage. By press-forming the worked body without applying the liquid pressure under the increasing stage to the inner peripheral surface thereof, the liquid pressure in the worked body is prevented from excessively increasing.

[0020] One stroke process of the press-forming from the press start point to the press complete point can be comprised of only a pressure-increase process. It applies the liquid pressure gradually increasing as decrease of the internal volume of the worked body due to formation of the concave portion to the inner peripheral surface thereof.

[0021] As the concave portion formed at the axial part of the worked body, single concave portion, two or more axially separated concave portions, or long concave portion axially extended over the worked body, can be adopted. Plural concave portions separated in the axial direction can be disposed at same position or at the different (separate) positions in the circumferential direction of the worked body. Also, plural concave portions disposed at one axis perpendicular section of the worked body can be separated in the circumferential direction. There is not limit or restriction in shape and size of the concave portion. When plural concave portions are provided, they can have different shape and size.

[0022] The convex mold portion is provided on at least one of the press upper mold and the press lower mold. Shape, size, number and location of the convex mold portion can be selectively determined corresponding to that of the concave portion of the irregular-section tubular body to be formed. The mold surfaces of the press upper mold and the press lower mold other than the convex mold portion can be selectively determined corresponding to an outer surface shape of the irregular-section tubular body to be formed.

[0023] The worked body can be press-formed with restraining whole outer peripheral surface at the portion where the concave portion is formed, by the mold surfaces of the press upper mold and the press lower mold. However, press-forming the worked body without restraining the circumferential part(s) of the above portion by the press molds is preferable. In this case, the circumferential part(s) of the portion forms the restrain surface (s) which is not restrained by the mold surfaces of the press upper and lower molds.

[0024] By constructing the upper and lower molds in this way, one of them having the convex mold portion can be a convex partial mold having a width shorter than an axis perpendicular width of the worked body (diameter when the worked body is tubular). It can contribute to reduce a mold cost and a mold wear, compared to the press upper and lower molds of sealed and closed type.

[0025] Even when the worked body is press-formed with leaving the non-restrain surface(s), the excessive deformation of the worked body at the non-restrain surface can be prevented, by controlling the max. pressure of the liquid in the worked body. The max. pressure of the liquid to which the liquid may reach during the press stroke including the press complete point can be set smaller than the predetermined value, by for example removing increase of the liquid pressure in the predetermined point of the press stroke.

[0026] Also, in the first and second manufacturing methods, the liquid pressure applied to the inner surface of the worked body in the non-pressure increase process is preferably maintained in the predetermined pressure or decreased, by using a fluid-dischrge or liquid-discharge controlling device discharging the fluid or liquid from the worked body at the predetermined point. With such liquid- discharge controlling device, the liquid pressure applied to the inner surface of the worked body can be easily and accurately controlled, so that increase of the liquid pressure at the predetermined point can be easily and securely removed.

[0027] The liquid-discharge controlling device is, for example, comprised of a discharge tube and a relief value. The discharge tube is connected to a seal plug sealingly closing the end portion of the worked body and communicated with the internal space of the worked body. The relief valve is provided on the discharge valve and automatically opens when the liquid pressure in the worked body goes over the set pressure, automatically closing when it goes below the set pressure.

[0028] Another type of the liquid-discharge controlling device can be comprised of an accumulator including a cylinder member, a connect tube and a gas supply means. The cylinder member has a closed operate chamber of a predetermined capacity in which a partition member is disposed reciprocately. The partition member liquid-sealingly partitions the closed chamber into a liquid chamber and a gas chamber. The connect tube is connected at one end thereof to a water-discharge hole of a second seal plug and is connected at other end thereof to the liquid chamber of the cylinder member, to connect the internal space of the worked body and the liquid chamber of the cylinder member. The gas supply means is connected to the gas chamber of the cylinder member to supply gas of a predetermined pressure thereto.

[0029] Still another type of the liquid-discharge controlling device can be comprised of a discharge tube and a restrict portion.

[0030] The discharge tube is connected to a seal plug sealingly closing the end portion of the worked body and communicated with the internal space of the worked body. The restrict portion is provided on the seal plug or the discharge tube and has a section-area of a flow passage so that the liquid pressure in the worked body becomes the max. pressure at the predetermined point in the press stroke.

[0031] Here, the above irregular-section tubular body is used to construct the torsion beam by bending both end portion thereof in the another step so that at least the large-diameter axially intermediate portion formed the concave portion forms the axle beam, while at least the small-diameter axially end portions form the trailing arms.

[0032] (b) The axle beam for the torsion beam of the present invention is joined to the paired trailing arms attached to the wheel side integral therewith or integrally therewith to connect them. The axle beam can be formed integral with each of the trailing arms to be joined to each end of the axle beam. Alternatively, the axle beam can be formed independent from each of the trailing arms, and then connected to them by welding for example integrally.

[0033] The axis perpendicular section at the concave portion has the closed section shape including the closed and sealed space, and has the shape the shearing center being offset from the centroid.

[0034] Here, the "centroid" of the axis perpendicular section shape means a center of gravity of a plane figure thereof. The "shear center" of the axis perpendicular section shape means a point in the section where a composed force of shearing forces acts so that the axle beam is subjected to the simple bending without generating a twisted deformation, even when the twisting force, for example resulted from the force applied to the trailing arms, is applied to the section in addition to the bending moment. The concept of "shear center" is well known in the field of material machanics. These centroid and the shear center can be determined unequivocally based on the axis perpendicular section shape by a predetermined geometrical calculation.

[0035] The concave portion of the predetermined shape and formed at the axial part of the axle beam, and the offset of the shear center from the centroid at the concave portion not only increases the roll rigidity, but makes the steering character in the under steering tendency to increase the straightly advancing character of the vehicle. Thus, the steer stabilizing character increases.

[0036] Due to cross-section shape of the concave portion, the torsion rigidity and roll rigidity of the axle beam can be adjusted by changing size or dimension of the closed and sealed space. For this reason, no additional stabilizer for the roll control is required. Also, the axle beam, having the closed cross-section shape including the closed and sealed space, does not have any shear edge portion generating fatigue crack, so that endurance character has increased.

[0037] As regard the offset amount of the shear center from the centroid in the axis perpendicular section shape, the above advantages resulted from the offset can not be rendered when it is too small. Otherwise, the straightly advancing character is affected badly when it is too large. For this reason, the offset amount of the shearing center should be determined in range so that the both requirements are satisfied. As regard the offset direction of the shear center from the centroid in the axis perpendicular section shape, the shear center is sufficiently disposed at a position at least to be above the centroid when the axle beam is mounted onto the vehicle. However, for performing effect in the steer stabilizing character resulted from the offset, the shearing center is preferably disposed at a position to be just above the centroid when the axle beam is mounted onto the vehicle.

[0038] As a concrete shape of the axis perpendicular section shape at the concave portion, various shape can be adopted as long as it has closed section shape having the closed and sealed space and the shearing center is offset from the centroid in it. The axis perpendicular section shape can be formed into a substantially U-shape, V-shape, Y-shape or laid U-shape. Among them, the U-shape or V-shape is preferable. In such shapes of the axis perpendicular section shape,size of the closed and sealed space and the offset amount of the shear center can be easily changed. As a result, the twist rigidity, roll rigidity of the axle beam, and steer character can be easily adjusted. In addition, the shear center can be effectively offset from the centroid in a limited space.

[0039] In addition, with adjustment of the twist rigidity and roll rigidity of the axle beam, the twist rigidity and roll rigidity become larger as the closed and sealed space becomes larger. For this reason,size of the closed and sealed space is suitably determined corresponding to the required twist rigidity and roll rigidity. The closed and sealed space can be formed by single closed and sealed space enclosed by an outer peripheral wall of the axle beam, or plural closed and sealed spaces separated by an overlapped portion where opposing inner surfaces of the outer peripheral wall are abutted.

[0040] As regard the feature described in the column of "Means for solving problem", in view of restriction such as setting space in the vehicle, in the axle beam for torsion beam, the trailing arms preferably have small size as thin as possible in range it has necessary rigidity. For satisfying such requirement, an axle beam shown in Fig. 18 can be adopted. For manufacturing the axle beam, a rough tube 60 is prepared. This rough tube 60 is comprised of an large-diameter intermediate portion 61 located at an axially intermediate position of the worked body, small-diameter end portions 62 located at both end positions thereof and having smaller diameter than the large-diameter intermediate portion 61, and outer diameter gradually change portions 63 connecting each end of the large-diameter intermediate portion 61 and each of the small-diameter end portions 6 2 respectively. All of the large-diameter intermediate portion 61, small-diameter end portions 62 and outer diameter gradually change portions 63 are disposed to be coaxial. By bending the rough tube 60, the torsion beam in which, at the both ends of the axle beam having the concave portion of the predetermined shape, a pair of trailing arms are joined integrally is manufactured.

[0041] That is, after having been formed the concave portion 61a on the large-diameter intermediate portion 61, the rough tube 60 is subjected to the bending work. Thus, each of the small diameter end portions 62 forms each of the trailing arms, and at least the large-diameter intermediate portion 61 and each of the outer diameter change portions 63 form the axle beam.

[0042] However, following problems arise. In the rough tube 60 having three portions 61, 62 and 63 all of which are coaxial but each of which has different diameter, each of the outer diameter gradually change portions 63 gradually decreases the outer diameter thereof from one end of the large-diameter intermediate portion 61 to one end of the small diameter end portions 62 equally in the circumferential direction. As a result, a radial step H having equal height in the circumferential direction is formed between the large-diameter intermediate portion 61 and each of the small-diameter end portions 62.

[0043] For this reason, as shown in Fig. 19, even after the concave portion 61a has been formed on the large-diameter intermediate portion 61, the radial step H remains at circumferential part between the large-diameter intermediate portion 61 and each of the small-diameter end portions 62. A compression force applied to the axle beam in an axial direction thereof may cause a buckle at a portion of the step H, so that rigidity of the axle beam against the axial input may decreases. If the steps H are existed at the both end portions of the axle beam, rigidity of the axle beam against the input from the lateral directions of the vehicle may decrease.

[0044] To the contrary, a rough tube in which each of the small-diameter axially end portions is offset from the large-diameter axially intermediate portion in the same direction as the offset direction of the shear center from the centroid can be used. In this rough tube, at a circumferential part at a side of the small-diameter axially end portions are offset, the large-diameter axially intermediate portion, outer diameter gradually change portions and small-diameter end portions are connected by a continuous surface without a radial step. By using such rough tube for manufacturing the axle beam, the continuous surface remains at the circumferential part even after the concave portion has been formed. In this way, the above step H decreasing rigidity of the axle beam against the input in the axial direction can be removed, whereby responsibility of rigidity against the input of axial direction can be increased.

BRIEF EXPLANATION OF THE DRAWINGS

[0045]

Fig. 1 is a section view showing a state prior to a press-forming according the manufacturing method for irregular section tubular body of an embodiment 1;
Fig. 2 is a section view showing a state post the press-forming according the manufacturing method of the embodiment 1;
Fig. 3 is a section view along a line A-A in Fig. 2;
Fig. 4 is a block view showing a circuit construction of a discharge control device in the manufacturing method for the embodiment 1;
Fig. 5 is a diagram showing relation between a press stroke and a liquid pressure in a worked body in the manufacturing method of the embodiment 1;
Fig. 6 is a block view showing a circuit construction of a discharge control device used in the manufacturing method for irregular section tubular body of the embodiment 2;
Fig. 7 is a diagram showing relation between a press stroke and a liquid pressure in a worked body in the manufacturing method for irregular section tubular body of an embodiment 3;
Fig. 8 is a perspective view showing a whole construction of a torsion beam of an embodiment 4;
Fig. 9 is a section view along a line B-B in Fig. 8, showing an axial perpendicular section shape at a concave portion of an axle beam of the embodiment 4;
Fig. 10 is a section view along aline C-C in Fig. 8, showing an axial perpendicular section shape of a trailing arm of a torsion beam of the embodiment 4;
Fig. 11 is a section view along aline B-B in Fig. 8, showing an axial perpendicular section shape at a concave portion of an axle beam of an embodiment 5;
Fig. 12 is a section view along aline B-B in Fig. 8, showing an axial perpendicular section shape of a trailing arm of a torsion beam of an embodiment 6;
Fig. 13 is a section view of an embodiment 7 showing a state where one end of a blank tube is diameter-reduced with being offset;
Fig. 14 is a section view along a line E-E in Fig. 13, showing a forming mold;
Fig. 15 is a front view of the embodiment 7 showing an offset and different diameter rough tube having a large-diameter intermediate portion, small-diameter end portions and outer diameter gradually change portion is diameter-reduced;
Fig. 16 is a side view viewed from direction G in Fig. 15, showing the small-diameter end portions;
Fig. 17 is front view of the embodiment 7 showing a state where the concave portion is formed on the large-diameter intermediate portion;
Fig. 18 is a front view showing an coaxial and different diameter rough tube having a large-diameter intermediate portion, small-diameter end portions and outer diameter gradually change portion;
Fig. 19 is a front view showing a step H formed between the large-diameter intermediate portion formed a concave portion thereon and small-diameter end portions;
Fig. 20 is a perspective view showing a whole construction of a conventional torsion beam; and
Fig. 21 shows an axis perpendicular section shape of the axle beam in the conventional torsion beam, corresponding to a section view along a line D-D in Fig. 13.

Preferred Embodiment of the Invention

[0046] Hereinafter, various embodiments of the present invention will be explained with reference to attached drawings.

<Embodiment 1>

[0047] An embodiment 1 of the present invention is shown in Figs. 1 to 5. A manufacturing apparatus manufactures, by press-forming a tubular worked body 1 made of metal blank tube having a true circle cross-section shape in direction perpendicular to an axis (hereinafter, simply referred as "axis perpendicular direction") of the irregular-section tubular body having a concave portion 1a concaved in the axis perpendicular direction at a part thereof.

[0048] The manufacturing apparatus includes a mold support 2, a press lower mold 3, a floating mold 5, a press upper mold 6, a first seal plug 8, a second seal plug 9 and a liquid-discharge control device 10. The press lower mold 3 is fixed on the mold support 2 at predetermined position thereof. The floating mold 5 is disposed reciprocately in upper-lower direction relative to the mold support 2, and is urged upwardly by a pneumatic cylinder (not shown) via a pair of cushion pins 4. The press upper mold 6 is supported movable in a upper-lower direction by a hydraulic cylinder (not shown). The first seal plug 8 is joined to an open portion at one end of the worked body 1 to liquid-seal it via a seal packing 7. The second seal plug 9 is joined to an open portion at other end of the worked body 1 to liquid-seal it via a seal packing 7. The liquid-discharge control device 10 is connected to the second seal plug 9.

[0049] The press lower mold 3 is a partial mold to form a concave portion 1a on a lower part of the worked body 1 at an axially intermediate portion, and has a convex mold portion 3 a corresponding to the convex portion 1a. That is, the press lower mold i.e. convex partial mold 3 has axial length shorter than that of the worked body 1, and width d smaller than diameter (diameter in the axis perpendicular direction) of the worked body 1. The worked body 1, due to above dimensional relation, is not restrained at circumferential areas (non-restrained surfaces) 1b shown by P in Fig. 3 in an axial portion where the concave portion 1 a is formed by the press upper mold 3 and the press lower mold 6.

[0050] The press upper mold 6 forms an upper part of the worked body 1, and has on a lower side thereof a concave mold surface 6a of which axial length is slightly smaller than that of the worked body 1 and which extends a whole axial length thereof. Axial length of the press upper mold 6 is longer than that of the press lower mold 3, and the press lower mold 3 is disposed at an approximately axially intermediate portion of the press upper mold 6. The concave mold surface 6a of the press upper mold 6 is concaved into U-shape in an axially intermediate area corresponding to the axial length of the convex mold surface 3a of the press lower mold 3. Axially end areas of the concave mold surface 6a are concaved into a semi-circular shape corresponding to an outer surface shape of the worked body 1 to have same diameter as that of the worked body 1.

[0051] The first seal plug 8 is formed a water supply hole 8a to which a water supply tube (not shown) is connected. Water W is supplied to an internal space of the worked body 1 by a water supply pump (not shown) through the water supply tube and the water supply hole 8a. An oil can be supplied into the worked body 1 instead of the water.

[0052] The second seal plug 9 is formed a water-discharge hole 9a to which a liquid-discharge control device 10 is connected. The liquid-discharge control device 10 is comprised of, as shown in Fig. 4,a water-discharge tube 11, a high pressure coupler 12, a digital pressure meter 13, a variable relief valve 15, a drain tank 16, a drain tube 17, and an air relief valve 18. The water-discharge tube 11 is connected at one end thereof to the water-discharge hole 9a and is connected at other end thereof to the train tank 16. On the water-discharge tube 11 the high-pressure coupler 12 is disposed near to the second sealing plug 9, the digital pressure meter 13 is disposed downstream of the high-pressure coupler 12, and the variable relief valve 15 with an anologue pressure meter 14 is disposed downstream of the digital pressure meter 13. The air relief valve 18 is disposed on the drain tube 17 branched from the water-discharge tube 11 at portion between the high-pressure coupler 12 and the digital pressure meter 13 and is connected to the drain tank 16.

[0053] The variable relief valve 15 automatically opens when liquid pressure within the worked body 1 exceeds a set pressure, and automatically closes when it becomes less than the set pressure. On account of such operation of the variable relief valve 15, liquid pressure within the worked body 1, after having reached to the set pressure in the press-forming process, is maintained in the set pressure. Value of set pressure is selected within range so that pressure liquid in the worked body 1 does not excessively deform the non-restrain surfaces 1b. The air relief valve 18 relieves air within the worked body 1 when the water is supplied into the worked body 1.

[0054] Next, the manufacturing method for manufacturing, by using the above manufacturing apparatus, the irregular-section tubular body from the worked body 1 having the concave portion 1a will be explained.

(Dispose process of worked body)

[0055] In the first, as shown in Fig. 1 the first seal plug 8 to which the water supply tube is connected, and the second seal plug 9 to which the water-discharge control device 10 is connected are connected to one open portion and other open portion of the worked body 1. The worked body 1 is set on the floating mold 5 held at the ascended position by the pneumatic cylinder via the cushion pins 4. Simultaneously, the press upper mold 6 is descended by the hydraulic cylinder to be set above the worked body 1. In this condition, the concave mold surface 6a of the press upper mold 6 and the press lower mold 3 do not abut to the worked body 1.

(Liquid fill process to worked body)

[0056] With the air relief valve 18 being released, air within the worked body 1 is relieved and water W is supplied into the worked body 1to fill it by operating the water supply pump. Then, the air relief valve 18 is closed. Fig. 1 shows this state.

(Pressure increase process in press-forming process)

[0057] The pressure upper mold 6 is descended by the hydraulic cylinder to abut at the concave mold surface 6a thereof to the worked body 1, so that the worked body 1 descends together with the floating mold 5. As a result, the worked body 1 abuts to the press lower mold 3 to be concaved at the concave portion 1a in the axis perpendicular direction by the convex mold portion 3a. Thus, formation of the concave portion 1a starts. Decrease of the internal volume of the worked body 1 due to deformation thereof increases liquid pressure within the worked body 1.

(Non-pressure increase (constant pressure) process in press-forming process)

[0058] When liquid pressure within the worked body 1 exceeds the set pressure preset, the variable relief valve 15 automatically opens. Water W within the worked body 1 is discharged with decrease of the internal volume thereof by amount corresponding to opened degree of the variable relief valve 15. In this way, the liquid pressure after having reached to the preset pressure is maintained in the preset pressure.

[0059] Under condition the liquid pressure within the worked body 1 being maintained in the preset pressure, the press-forming for forming the concave portion 1a by descending of the press upper mold 6 continues. It is completed at the time when the floating mold 5 abuts to the mold support 2. Fig. 2 shows this state.

(De-mold process)

[0060] When the press-forming is completed, after discharging the water W within the work body 1, the press upper mold 6 is ascended by the hydraulic cylinder to demold the irregular-section tubular body having been pressed formed. In this way, the irregular-section tubular body having the concave portion 1a concaved in the axis perpendicular direction at axially intermediate portion has been manufactured.

[0061] As mentioned above, according to the manufacturing method of the embodiment 1, the final irregular-section tubular body can be obtained by only press-forming the worked body 1 sealingly filled with liquid therein, without any liquid pressure process after the press-forming process. As a result, the manufacturing process becomes simplified. In addition, the liquid pressurize device and the large-size extra hydraulic cylinder become unnecessary, which can not only avoid complexing and large-sizing of the equipment but avoid increase of equipment cost.

[0062] In the pressure increase process in the former half of the press stroke, the worked body 1 is press-formed with the liquid pressure, which increases as decrease of the internal volume of the worked body 1, being applied to the inner peripheral surface thereof. As a result, the worked body 1 is deformed following to the convex mold portion 3a of the press lower mold 3 and the concave mold surface 6a of the press upper mold 6 securely, without generating any bend or buckle. Thus, the worked body 1 can be smoothly worked.

[0063] In the non-pressure increase process in the latter half of th press stroke, liquid pressure in the worked body 1, being prevented from excessive increase, is maintained at constant pressure. For this reason, although the press lower mold 3 (partial mold) and the press upper mold 6 do not restrain the circumferential part of the worked body 1 at portion P where the concave portion 1 a is formed in the press-forming, the non-restrain surfaces 1b of the worked body 1 is prevented from excessive deformation and are suitably deformed. The press lower mold 3 i.e. the partial mold having the convex mold portion 3a contributes to reduce manufacturing cost for the mold and wear of the mold, compared in case where both of the upper mold and the lower mold have closed construction.

[0064] In addition, the liquid-discharge control device 10 having the variable relief valve 15 discharges liquid in the worked body 1 at the predetermined timing of the press stroke, to thereby securely maintain liquid pressure in the worked body 1 in the constant pressure. Thus, liquid pressure applied to the inner surface of the worked body 1 is accurately controlled. As a result, increase of the liquid pressure at the predetermined timing is securely removed, so that the liquid pressure after the predetermined timing can be easily and securely maintained in the constant pressure.

<Embodiment 2>

[0065] An embodiment 2 of the present invention is shown in Fig. 6. A manufacturing apparatus of the embodiment 2 uses a liquid-discharge controlling device (accumulator) 20 instead of the liquid-discharge control device 10 in the embodiment 1, having different construction therefrom. Construction of the embodiment 2 other than the liquid-discharge control device 20 is same as that of the embodiment 1.

[0066] This liquid pressure control device 20 is comprised of a cylinder member 21, a connect tube 22 and a gas supply means 23. The cylinder member 21 has a closed operate chamber of a predetermined capacity in which a partition member 21c is disposed reciprocately. The partition member 2 1 c liquid-sealingly partitions the closed chamber into a liquid chamber 21a and a gas chamber 21b. The connect tube 22 is connected at one end thereof to a water-discharge hole 9a of a second seal plug 9 and is connected at other end thereof to the liquid chamber 21a of the cylinder member 21, to connect the internal space of the worked body 1 and the liquid chamber 21a of the cylinder member 21. The gas supply means 23 is connected to the gas chamber 21b of the cylinder member 21 to supply gas of a predetermined pressure thereto.

[0067] On the connect tube 22, a high-pressure coupler 24 is disposed near to the second seal plug 9, and a restrict portion 25 is disposed downstream thereof. Liquid of high-pressure discharged from the internal space of the worked body 1 is introduced into the liquid chamber 21a after having been decreased pressure thereof at the restrict portion 25. As a result, gas pressure of the gas chamber 21b balancing with liquid pressure in the liquid chamber 21a can be decreased. Thus, an air compressor as an air supply source (to be explained later) supplying pressure gas to the gas chamber 21b can be compacted.

[0068] The gas supply means 23 includes the air compressor 23a, an air supply tube 23b, and an air regulator 23d provided with a check valve 23c and is disposed on the air supply tube 23b. The air supply tube 23b is connected at one end thereof to the gas chamber 21b and is connected to at other end thereof to the air compressor 23a.

[0069] Next, the manufacturing method for manufacturing, by the above manufacturing apparatus with the liquid-discharge control device 20, the irregular-section tubular body from the worked body 1 having the concave portion 1a will be explained.

[0070] The worked body 1 is disposed in the same manner as the above embodiment 1. Then, water W is supplied by a water supply pump (not shown) to fill an internal space of the worked body 1, and gas of predetermined pressure is supplied into the gas chamber 21b of the cylinder member 21 by the air compressor 23a. Here, the pressure of gas supplied to the gas chamber 21b is preset in the predetermined value,corresponding to the max. pressure (set pressure) of the liquid pressure in the worked body 1 and restricted degree at the restrict portion 25.

[0071] In this way, in the embodiment 2, the press-forming process same as that of the embodiment 1 is performed with the worked body being filled with the water W and the gas chamber 21b of the cylinder body 21 being with the gas. As long as pressure of the liquid supplied from the worked body 1 to the liquid chamber 21a via the restrict portion 25 is lower than gas pressure in the gas chamber 21b, the partition member 21c stays without being lifted at the lowermost position to make volume of the gas chamber 21b maximum. For this reason, as volume decrease of the worked body 1 corresponding to deformation thereof, the liquid pressure in the worked body 1 gradually increases. At the time when pressure of the liquid supplied from the worked body 1 to the liquid chamber 21 a becomes higher than the preset gas pressure in the gas chamber 21 b, the partition member 21c is lifted up. Volume of the liquid chamber 21a increases and the water W in the worked body 1 is discharged therefrom by the predetermined amount, as decrease of the internal volume of the worked body 1. Thus, after having reached to the set value, the liquid pressure in the worked body 1 is maintained in the predetermined value.

[0072] With liquid pressure in the worked body 1 being maintained, the worked body 1 is press-formed the concave portion 1a by the descending press upper mold 6. The press-forming is completed at the time when the floating mold 5 abuts to the mold support 2.

[0073] The manufacturing method of the embodiment 2 can render the same advantages as that of the embodiment 1.

<Embodiment 3>

[0074] An embodiment 3 of the present invention is shown in Fig. 7. A manufacturing apparatus of this embodiment 3 uses, instead of the liquid-discharge controlling device 10, a liquid-discharge controlling device in which hole diameter of the water-discharge hole 9a of the second seal plug 9 is selected in predetermined value (3mm) and a discharge tube is connected to the discharge hole 9a. Remaining construction of manufacturing apparatus of the embodiment 3 is same as that of the embodiment 1.

[0075] Hole diameter i.e. section-area of a flow passage of the water-discharge hole 9a is so selected that liquid pressure in the worked body 1 reaches to the max. point at a press complete point where the floating mold 5 abuts to the mold support 2 and the press upper mold 6 decreases to the lowermost position. Here, the water-discharge hole 9a operates as the restrict portion. The max. pressure of the liquid at the press complete point is set within range capable of preventing excessive deformation of the non-restrain surfaces 1b of the worked body 1.

[0076] When the irregular-section tubular body is manufactured by the manufacturing apparatus having the discharge control device, the worked body 1 is press-formed with the water W being filled therein. With restricted discharge amount of the water-discharged from the worked body 1 through the discharge hole 9a as the restrict portion, as volume decrease of the worked body 1 due to deformation thereof, the liquid pressure in the internal space gradually increases. Rise speed of the liquid pressure is moderate compared to that of the embodiments 1 and 2, since the predetermined amount of the water W is discharged through the water-discharge hole 9a.

[0077] Liquid pressure in the internal space of the worked body 1 reaches to the max. value when the floating mold 5 abuts to the mold support 2 and the press upper mold 6 descends to the lowermost position, i.e. in the press complete position. Then, it gradually decreases as the water W is gradually discharged from the worked body 1.

[0078] Thus, in the manufacturing method of the embodiment 3, the worked body 1 filled with liquid is sufficiently press-formed to be formed into the final irregular-section tubular body, without requiring the liquid pressure process after the press-forming process.Thus, the manufacturing process becomes simple. In addition, the liquid pressurizing device or the large-size extra hydraulic pressing device is not required, and the discharge control device is simplified.As a result, complex and large-size of the equipment and rise of equipment cost are reduced

[0079] Also, as shown in Fig. 7, in the manufacturing method of the embodiment 3 one stroke of the press-forming from the press start point to the press complete point is comprised of only a pressure increase process. The pressure increase stroke press-forms the worked body 1 by applying gradually increasing liquid pressure to the inner periphery surface thereof as decrease of the internal volume of the worked body 1. As a result, not only the worked body 1 can be deformed following to the convex mold portion 3a of the press lower mold 3 and the concave mold surface 6a of the press upper mold 6 securely, but the worked body 1 is prevented from the buckle. Thus, the worked body 1 is press-formed smoothly.

[0080] Further, hole diameter of the discharge hole 9a as the restrict portion is selected in the predetermined value in connection with the max. liquid pressure. For this reason, the non-restrain portions 1b, prevented from excessive deformation by liquid pressure, are formed into desired shape. The press lower mold 3 having the convex mold portion 3a is constructed as the partial mold can reduce cost for the mold and wear of the mold, compared to the closed type upper and lower molds.

[0081] In the embodiment 3, since the liquid pressure in the worked body 1 is set to become the max. value at the press complete point, one stroke of the press-forming is comprised of only pressure increase process. However, it can be set to become the max. value in midway of the press stroke as mentioned in the embodiments 1 and 2. In this case,one stroke is comprised of the pressure increase process and the non-pressure increase process. This can be performed by reducing the descending speed of the press upper mold 6 below the predetermined value at the predetermined position.

[0082] Also, in the embodiment 3, the discharge hole 9a is used as the restrict portion by controlling hole diameter thereof. However, a restrict portion having predetermined section-area of the flow passage can be provided in midway on the water-discharge tube, instead of the discharge hole 9a.

(Evaluation)

[0083] All of the irregular section tube bodies of the embodiments 1 to 3 are excellent as the press-formed articles. As a result, pressure rise speed in the pressure increase process, maintained time period of the max. value and pressurized state after the max. pressure state do not badly affect quality of the press-formed article.

<Embodiment 4>

[0084] Figs. 8 to 10 show an axle beam 31 for torsion beam of an embodiment 4 according to the present invention. The axle beam 31 is joined to each of one ends of a pair of trailing arms 30 attached to wheels to connect them.

[0085] The torsion beam is used in a suspension device of a vehicle rear wheel, and is comprised of the paired trailing arms 30, the axle beam 31, a pair of axle carriers 32, a pair of arms 33, and a pair of brackets 34. The paired axle carriers 32 are joined to the trailing arms 30 by welding, and the paired arms 33 are joined by welding to extend horizontally from both ends of the axle beam 31 toward front side when the torsion beam is mounted on the vehicle. The paired brackets 34 are joined to both ends of the axle beam 31 by welding to be disposed at rear side thereof when the torsion beam is mounted on the vehicle.

[0086] Among them, each of the trailing beams 30, as shown in Fig. 10, has cross-section of a true circle shape. An inner pipe 30a is inserted into and joined to the trailing arm 30 to increase rigidity of the trailing arm 30 against an input force applied thereto from the wheel upon turning of the vehicle. Both trailing arms 30 are bent orthogonal to both of the axial direction of the axle beam 31 and the concave direction of the concave portion 31a.

[0087] The axle beam 31, as shown in Fig. 9, has a concave portion 3 1a concaved in an axis perpendicular direction thereof, and extended over substantially whole axial length thereof. The concave portion 31a has a cross-section of closed U-shape defining single sealingly closed space 31b therein. In the cross section, a shearing center C is offset from a centroid O by predetermined distance L to be positioned just above the centroid O, when the torsion beam is mounted on the vehicle. A pair of extend portions 3 1c divergently extend at both sides of the concave portion 31a. Thus, an outer periphery wall of the whole concave portion 31a is comprised of only curved portions.

[0088] Each of the paired axle carriers 32 supporting a wheel rotatably has an insert hole 32a into which a wheel shaft is inserted. Each of the paired arms 33 has a connect hole 33a at which it is connected to the vehicle body rockably in upper and lower directions.

[0089] The torsion beam of the embodiment 4 having the above construction can be manufactured in following manner.

[0090] In the first, the cylindrical worked body made of metal blank tube of which cross-section is true circle is subjected to the press forming, in the same manner as that of the embodiment 1. The concave portion 31a concaved in the axis perpendicular direction is press-formed at axially intermediate portion. Then, both ends of the worked body 1 is bent to form the axle beam 31 and the paired trailing arms 30 integrally. Then, the inner pipes 30 coated with an adhere agent on an outer peripheral surface thereof are inserted into and joined to the trailing arms 30, respectively. Next, the paired axle carriers 32, the arms 33 and the brackets 34 respectively formed into predetermined shape are joined to predetermined positions of the integrated axle beam 31 and trailing arms 30.

[0091] The axle beam 31 of the embodiment 4 has the concave portion 31a having the cross-section shape in which the shearing center C is offset upwardly from the centroid O by predetermined amount L. As a result, not only the roll rigidity increases, but the steering stability increases due to under-steer tendency of the steering character.

[0092] Due to cross-section shape of the concave portion 31a above-mentioned, the torsion rigidity and roll rigidity of the axle beam 31 can be adjusted by changing size or dimension of the closed space 31b. For this reason, no additional stabilizer for the roll control is required. Also, the axle beam 31, having the closed cross-section shape including the closed space 31b, does not have any shear edge portion where fatigue crack may occur, so that endurance character has increased.

[0093] The offset amount of the shearing center C from the centroid O is selected so that the steer-stabilizing character resulted from offset increases sufficiently and straightly advancing character is not influenced badly. Since the shearing center C is offset from the centroid O to be located just above it when the torsion beam is mounted on the vehicle, the steering-stabilize character resulted from offset is effectively performed. Further, the concave portion 31a has cross-section shape of substantially U-shape, size of the closed space 31b and offset amount of the sheering center C from the centroid O can be easily changed. Accordingly, the torsion rigidity, rolling rigidity and steering character of the axle beam 31 can be easily adjusted. Also, the shearing center C can be offset from the centroid O more effectively even in the limited space.

<Embodiment 5>

[0094] A Torsion beam of an embodiment 5 disclosed in Fig. 11 differs from that of the embodiment 4 only in a cross-section shape of a concave portion 31d of the axle beam 31, and remaining construction is same as that of the embodiment 4.

[0095] A concave portion 31d of the axle beam 31 forms one closed space 31e and has a closed cross-section of substantially V-shape in which the shearing center C is offset from the centroid O by a predetermined amount L. An outer periphery wall of the concave portion 31d is comprised of a pair of straight hypotenuse portions 31f, and a pair of expand portions 31g expanded inwardly at tip ends of the hypotenuse portions 31f. The closed space 31e has larger size at a center top portion thereof than a remaining portion. The shearing center C is offset from the centroid O to be located just above it when the torsion beam is mounted on the vehicle.

[0096] The axle beam 31 of the embodiment 5 operates in the same manner as that of the embodiment 4, and can render the same advantages as that of the embodiment 4. In addition, local large-size of the closed space 31e at the expand portions 31g (the tip ends) and at bottom portion of v-shape can increase the torsion rigidity at these portions locally.

<Embodiment 6>

[0097] A Torsion beam of an embodiment 6 disclosed in Fig. 12 differs from that of the embodiment 4 only in a cross-section shape of a concave portion 31h of the axle beam 31, and remaining construction is same as that of the embodiment 4.

[0098] A concave portion 31h of the axle beam 31 forms two closed spaces 31j separated by an overlapped portion 31i where outer peripheral walls are overlapped. It has a closed cross-section of substantially V-shape in which shearing center C is offset from the centroid O by a predetermined amount L. The outer periphery wall of the concave portion 31h is comprised of a pair of curved hypotenuse portions 31k. The shearing center C is offset from the centroid O to be located just above it when the torsion beam is mounted on the vehicle.

[0099] The axle beam 31 of the embodiment 6 operates in the same manner as that of the embodiment 4, and can render the same advantages as that of the embodiment 4.

<Embodiment 7>

[0100] A torsion beam of an embodiment 7 is manufactured from an irregular and offset rough tube, and a cross section shape of an axle beam 31 at a concave portion 31a is changed into a shape same as that of the embodiment 5. Remaining construction of the torsion beam is same as that of the embodiment 4.

[0101] In the first, a metal blank tube Q having a cross-section of true circle shape and even thickness is prepared similar to the embodiment 4. Also, as shown in Figs. 13 and 14 a forming mold 40 including a first opening 41, a second opening 42, an axial hole 43, and a sloped guide surface 44 is prepared. The first opening 41 is opened on one end surface of the forming mold 40 and has true circle shape. The second opening 42 of true circle shape and opened on other surface has smaller diameter than that of the first opening 41, and is offset from the first opening 41 by a predetermined amount F. The axial hole 43 is formed succeeding to the second opening 42 coaxially therewith and has inner diameter equivalent to outer diameter of a small-diameter end portion (to be explained later). The sloped guide surface 44 of circular shape is formed succeeding to the axial hole 43 at side of the first opening 41 so that an opened periphery is coaxial with the first opening 41.

[0102] As shown in Figs. 13 and 14, the sloped guide surface 44 of which a part of the cross-section (upper part in the axis perpendicular direction in Figs. 13 and 14) coincided with a corresponding part of the axial hole 43 gradually enlarges inner diameter thereof toward the first opening 41. Also, the blank tube Q disposed coaxially with the first opening 41 and the sloped guide surface 44 coincides at one part of the axis hole 43 (upper part in the axis perpendicular direction in Figs. 13 and 14) with an inner peripheral surface of the axis hole 43 and an outer peripheral edge of the sloped guide surface 44.

[0103] The blank tube Q is pressed into the axial hole 43 from the first opening 41 so that an axial one end (right end in Fig. 13) thereof is worked (reduced outer diameter thereof) by the sloped guide surface 44 and inner surface of the axial hole 43. In the diameter-reducing work, the blank tube Q is reduced outer diameter thereof from the one part where the outer diameter is not reduced to other part (lower part in the axis perpendicular direction in Fig. 13) so that the outer diameter reduced rate increases gradually. As a result, the other part is diameter-reduced to the maximum. Other axial end (left end in Fig. 13) is subjected to the diameter-reducing work similarly.

[0104] As a result, as shown in Fig. 15, the rough tube 50 comprised of a large-diameter intermediate portion 51 located at an axially intermediate portion, a pair of small-diameter end portions 52 having smaller outer diameter than that of the inter mediate portion 51, and a pair of diameter change portions 53 each connecting each end of the intermediate portion 51 and the end portion 52 has been manufactured. Both small-diameter end portions 52 are offset form the large-diameter intermediate portion 51 by a predetermined amount F toward one part (upper part in the axis perpendicular direction in Fig. 15). At a peripheral part located at the offset side, the large-diameter intermediate portion 51, outer diameter change portion 5 3 and the small-diameter end portions

52 are connected by a continuous surface without radial step to be flush with each other

[0105] As shown in Fig. 16, the small-diameter end portion 52 has the smallest thickness d1 at one part (upper part in the axis perpendicular direction in Fig. 16), the largest thickness d3 at other part (lower part in Fig. 16). Thickness gradually increases from the smallest thickness d1 to the largest thickness d3 via an intermediate thickness d2 (d1<d2<d3) The smallest diameter d1 is equal to thickness of the large-diameter intermediate portion 5 1 not having been subjected to the diameter reducing work which is in turn equal to thickness of the blank tube Q.

[0106] On the large-diameter intermediate portion 51 a concave portion 51a concaved in the axis perpendicular direction is press-formed similar to the embodiment 4 by manner same as that of the embodiment 1.

[0107] In a cross-section shape of the concave portion 51a, a shearing center C is offset from the centroid O in the same direction where the small-diameter portion 52 are offset from the large-diameter intermediate portion 51. As apparent from Fig. 17 showing condition the concave portion 51a having been formed, the large-diameter intermediate portion 51 and the small-diameter end portions 52 are connected by a continuous surface without any steps, at one part (upper part in the axis perpendicular direction in Fig. 17) and other part (lower part in Fig. 17)

[0108] Then, similar to the embodiment 4, the axle beam and the paired trailing arms are formed integrally by the bending work, and the inner pipe, axle carrier, arm and bracket are joined, whereby the torsion beam is completed.

[0109] In the torsion beam, the large-diameter intermediate portion 51 and the sloped diameter change portion 53 of the rough tube 50 form the axle beam, while each small-diameter portion 52 form each trailing arm, respectively. Instead of it, the axle beam can be formed by the large-diameter intermediate portion 51 and one part of the sloped diameter change portion 53, while each of the trailing arms can be formed by the other part of the sloped diameter change portion 53 and each of the small-diameter portions 52, respectively. Also, the axle beam can be formed by only the large-diameter intermediate portion 51, while each of the trailing arms can be formed by each of the sloped diameter change portions 53 and each of the small-diameter portion 5 2 , respectively.

[0110] The torsion beam of the embodiment 7 can render, in addition to the operation and advantage of the embodiment 4, following operation and advantages. That is, the axle beam portion do not have any radial step at one part and other part thereof in the axis perpendicular direction, so that responsibility for rigidity against axial input i.e. input in lateral direction of the vehicle increases. Also, not only each of the trailing arm portions has varied thickness d1, d2 , and d3 in the circumferential direction, but diameter-reduced rate i.e. work hardened degree increases from the portion of smallest diameter d1to the portion of largest diameter d3. As a result, in the trailing arm portions, the rigidity and strength increases from the portion of smallest diameter d1 to the portion of largest diameter d3.

[0111] As mentioned above, according to the manufacturing method for irregular-section tubular body of the present invention, the manufacturing process can be simplified, the liquid pressurize device and large-size hydraulic press device become unnecessary, and complex and large-size of the equipment and increase of the equipment cost can be avoided.

Claims

1. An axle beam (31) for torsion beam joined to a pair of trailing arms (30) attached to a wheel side to connect the trailing arms (30),
   characterized by that said axle beam (31) has at least at axial part thereof a concave portion (31a) concaved in an axis perpendicular direction, an axis perpendicular section at said concave portion (31a) having a closed section shape including a closed and sealed space (31b) and having a shape in which a shearing center (C) is offset from a centroid (O) by a predetermined amount (L).

2. An axle beam (31) for torsion beam according to claim 1, wherein a circumferential part of said worked body opposing to said concave portion (31a) in the axis perpendicular direction is so shaped that said worked body has a U-shape or V-shape axis perpendicular section at said concave portion (31a).

3. An axle beam (31) for torsion beam according to claim 1, wherein a rough tube comprises a large-diameter axially intermediate portion, a pair of small-diameter axially end portions having smaller diameter than said large-diameter axially intermediate portion, and a pair of diameter change portions connecting each end of said large-diameter axially intermediate portion and each of said small-diameter axially end portions integrally is, after having been formed said concave portion (31a) on said large-diameter axially intermediate portion, subjected to a bending work to form each of said trailing arms (30) by at least each of said small-diameter axially end portions and to form said axle beam (31) by at least said large-diameter axially intermediate portion, and
   said large-diameter axially intermediate portion, said diameter change portions and said small-diameter axially end portions are connected by a continuous surface having no radial step, due to offset of said small-diameter axially end portions from said large-diameter axially intermediate portion in the same direction as said shearing center is offset from said centroid (O), at a circumferential part of said small-diameter axially end portions at offset side.

4. An axle beam (31) for torsion beam according to claim 2 or 3, wherein each of said small-diameter axially end portions are bent in a direction orthogonal to the axial direction of said axle beam (31) and orthogonal to a concave direction of said concave portion (31a).

Patentansprüche

1. Achsenträger (31) für Torsionsachse, der mit einem Paar von nach hinten gerichteten Armen (30) verbunden ist, die an einer Radseite befestigt sind, um mit den nach hinten gerichteten Armen (30) verbunden zu sein, **dadurch gekennzeichnet, dass** der Achsenträger wenigstens in einem axialen Teil (31) davon einen konkaven Abschnitt (31a) besitzt, der in einer zur Achse senkrechten Richtung konkav ausgebildet ist, wobei ein zur Achse senkrechter Abschnitt bei dem konkaven Abschnitt (31a) einen geschlossen ausgebildeten Abschnitt aufweist, der einen geschlossenen und abgedichteten Raum (31b) enthält, und eine Form aufweist, bei der ein Scherzentrum (C) um einen vorbestimmten Betrag (L) gegenüber einem Schwerpunkt (O) versetzt ist.

2. Achsenträger (31) nach Anspruch 1, wobei ein Umfangsteil des bearbeiteten Körpers, der dem konkaven Abschnitt (31a) in der zu der Achse senkrechten Richtung gegenüberliegt, so geformt ist, dass der bearbeitete Körper einen zur Achse senkrechten Abschnitt bei dem konkaven Abschnitt (31a) aufweist, der U-förmig oder V-förmig ist.

3. Achsenträger (31) nach Anspruch 1, wobei ein unebenes Rohr einen axial mittleren Abschnitt mit einem großen Durchmesser, ein Paar axialer Endabschnitte mit kleinem Durchmesser, die einen kleineren Durchmesser als der axial mittlere Abschnitt aufweisen, und ein Paar von Durchmesseränderungsabschnitten, die jedes Ende des axial mittleren Abschnitts und jedes der axialen Endabschnitte mit kleinerem Durchmesser einstückig verbindet, umfasst und, nachdem der konkave Abschnitt (31a) an dem axial mittleren Abschnitt ausgebildet ist, einer Biegebearbeitung unterzogen wird, um jeden der nach hinten gerichteten Arme (30) durch wenigstens jeden der axialen Endabschnitte kleinen Durchmessers zu bilden und den Achsenträger (31) durch wenigstens den axial mittleren Abschnitt großen Durchmessers zu bilden, und wobei der axial mittlere Abschnitt großen Durchmessers, die Durchmesseränderungsabschnitte und die axialen Endabschnitte kleinen Durchmessers durch eine kontinuierliche Oberfläche ohne radiale Stufe verbunden sind, und zwar aufgrund einer Versetzung der axialen Endabschnitte kleinen Durchmessers gegenüber dem axial mittleren Abschnitt großen Durchmessers in derselben Richtung wie das Scherzentrum von dem Schwerpunkt (O) versetzt ist, und zwar bei einem Umfangsteil der axialen Endabschnitte kleinen Durchmessers auf der Versetzungsseite.

4. Achsenträger (31) für Torsionsachse nach Anspruch 2 oder 3, wobei jeder der axialen Endabschnitte kleinen Durchmessers in einer zu der axialen Richtung des Achsenträgers (31) senkrechten Richtung und zu einer konkaven Richtung des konkaven Abschnitts (31a) senkrechnten Richtung gebogen ist.

Revendications

1. Poutre d'essieu (31) pour longeron de torsion reliée à une paire de bras oscillants (30) fixée à un côté de roue pour connecter les bras oscillants (30), **caractérisée par le fait que** ladite poutre d'essieu (31) a au moins à une partie axiale de celle-ci une portion concave (31a) dont la concavité est établie dans une direction perpendiculaire axiale, une section perpendiculaire axiale à ladite portion concave (31a) ayant une forme de section fermée incluant un espace fermé et scellé (31 b) et ayant une forme dans laquelle un centre de cisaillement (c) est décalé depuis un centroïde (o) par une grandeur prédéterminée.

2. Poutre d'essieu (31) pour longeron de torsion selon la revendication 1, dans laquelle une partie circonférentielle dudit corps travaillé s'opposant à ladite portion concave (31a) dans la direction perpendiculaire axiale est façonnée de sorte que ledit corps travaillé a une section perpendiculaire axiale en forme de U ou en forme de V à ladite portion concave (31a).

3. Poutre d'essieu (31) pour longeron de torsion selon la revendication 1, dans laquelle un tube grossier comprend une portion axialement intermédiaire à grand diamètre, une paire de portions axialement d'extrémité à petit diamètre ayant un plus petit diamètre que ladite portion axialement intermédiaire à grand diamètre, et une paire de portions de changement de diamètre connectant chaque extrémité de ladite portion axialement intermédiaire à grand diamètre et chacune desdites portions axialement d'extrémité à petit diamètre intégralement est, après avoir formé ladite portion concave (31a) sur ladite portion axialement intermédiaire à grand diamètre, soumis à un travail de pliage pour former chacun desdits bras oscillants (30) par au moins chacune desdites portions d'extrémité axiales à petit diamètre et pour former ladite poutre d'essieu (31) par au moins ladite portion axialement intermédiaire à grand diamètre, et
ladite portion axialement intermédiaire à grand dia-

mètre, lesdites portions de changement de diamètre et lesdites portions axialement d'extrémité à petit diamètre sont connectées par une surface continue n'ayant pas de palier radial, à cause du décalage desdites portions axialement d'extrémité à petit diamètre de ladite portion axialement intermédiaire à grand diamètre dans la même direction dans laquelle le centre de cisaillement est décalé dudit centroïde (0), à une partie circonférentielle desdites portions axialement d'extrémité à petit diamètre au côté de décalage.

4. Poutre d'essieu (31) pour longeron de torsion selon la revendication 2 ou 3, dans laquelle chacune desdites portions axialement d'extrémité à petit diamètre sont pliées dans une direction orthogonale à la direction axiale de ladite poutre d'essieu (31) et orthogonale à une direction concave de ladite portion concave (31a).

FIG. 1

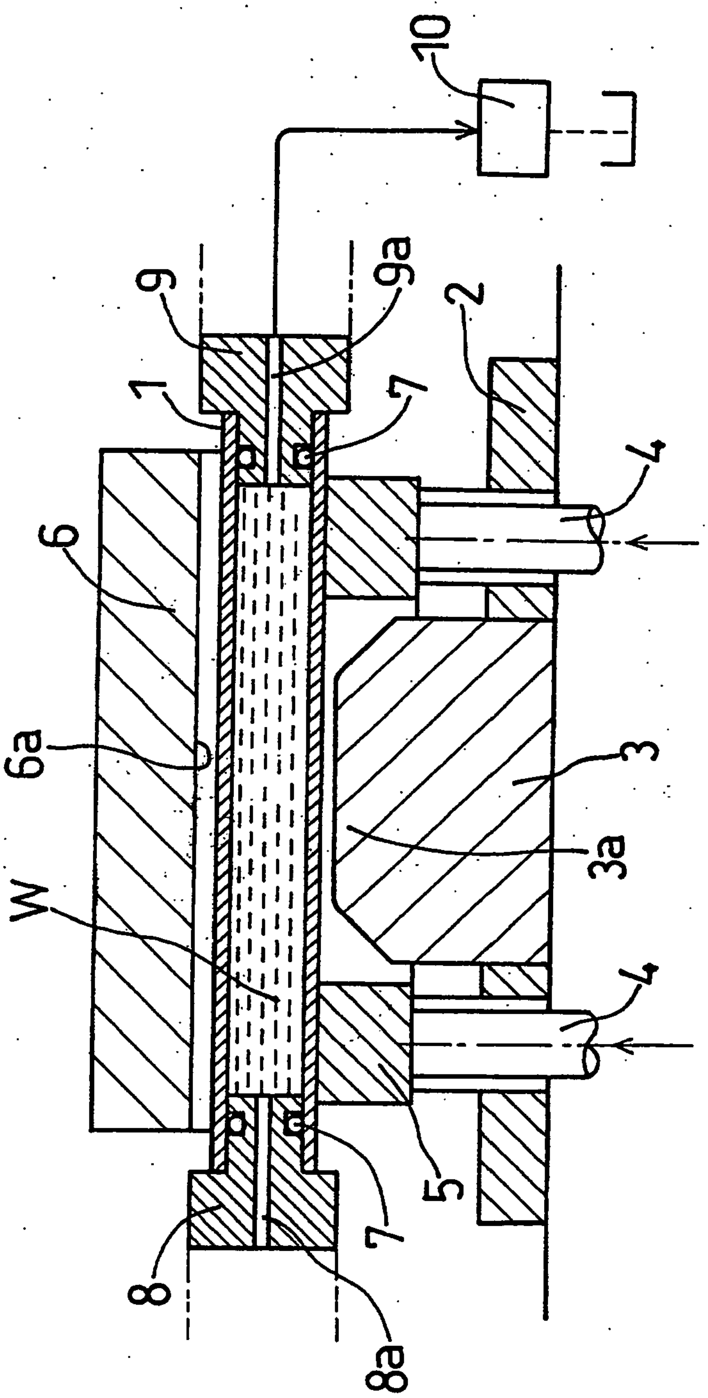


FIG. 2

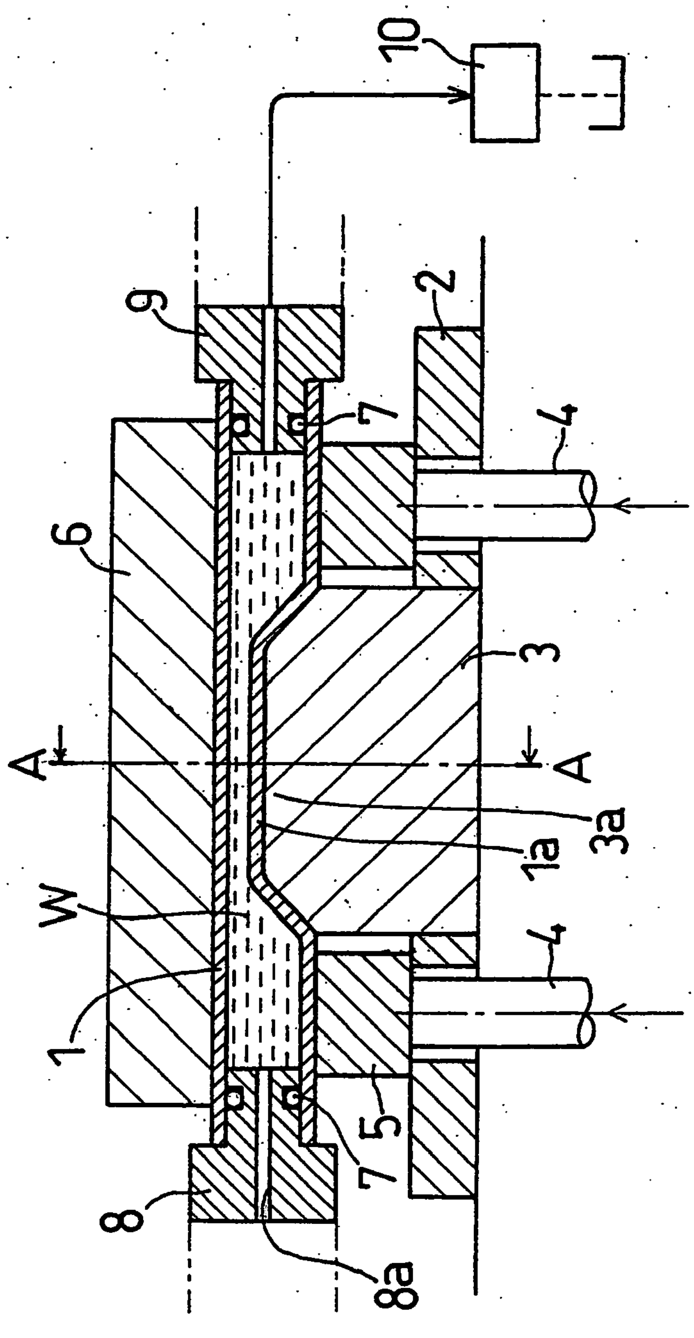


FIG. 3

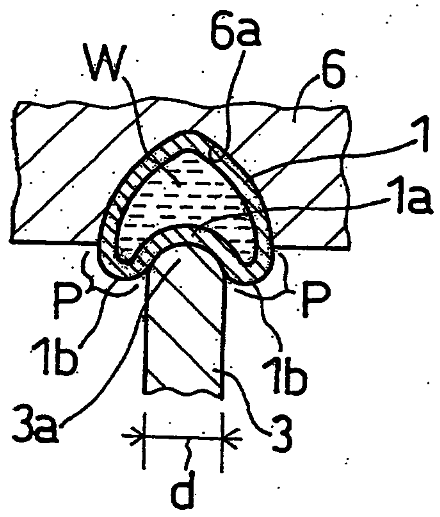


FIG. 4

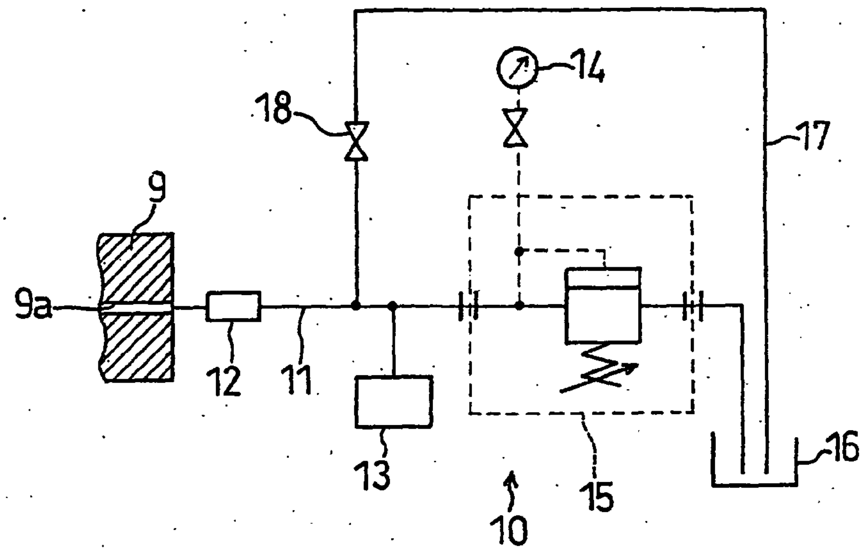

14
18
17
9
9a
12
11
13
10
15
16

FIG. 5

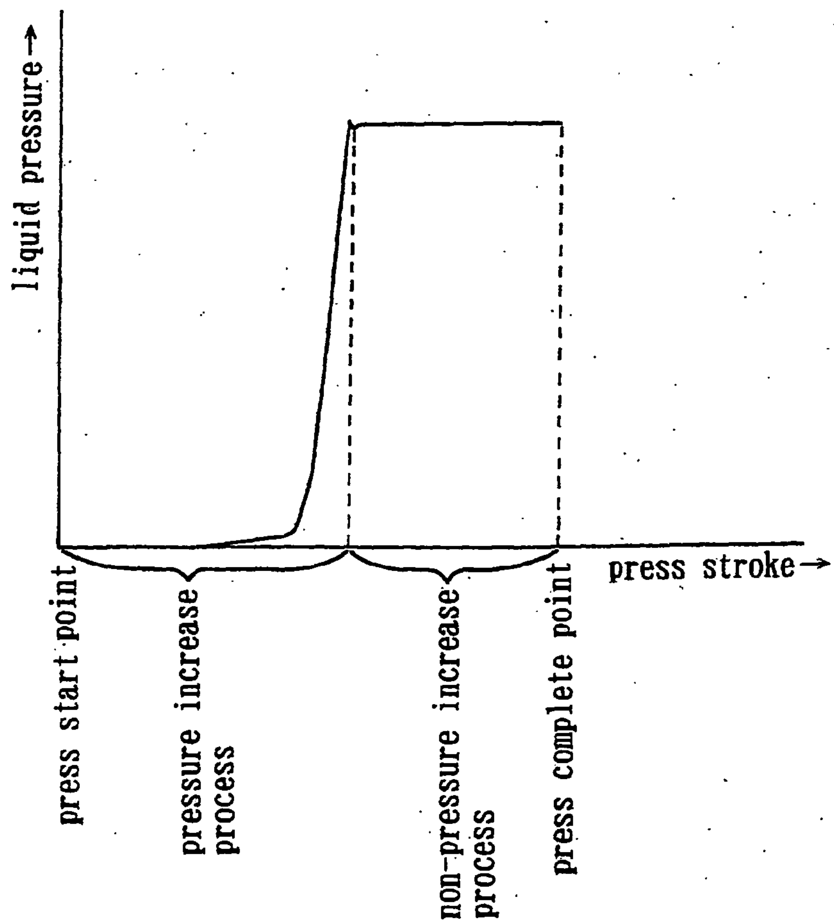

liquid pressure→
press stroke→
press start point
pressure increase process
non-pressure increase process
press complete point

FIG. 6

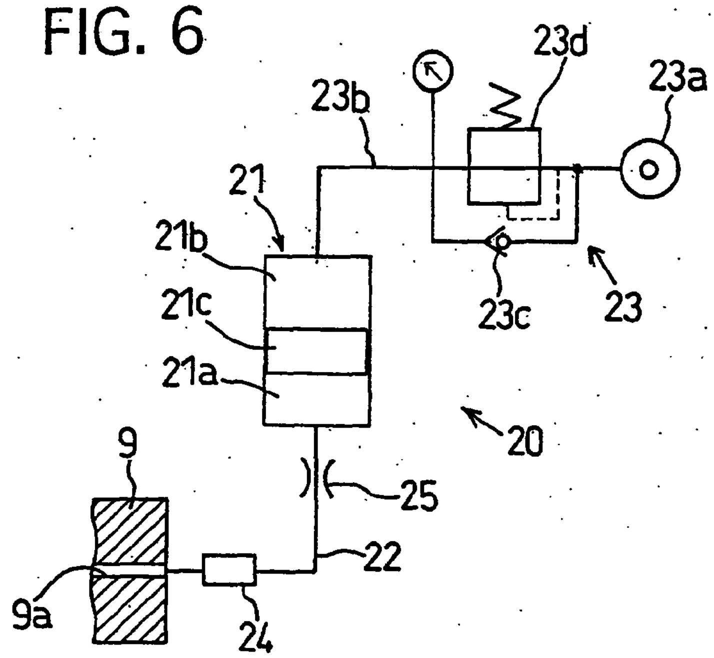

23d
23a
23b
21
21b
21c
21a
23c
23
20
9
25
22
9a
24

FIG. 7

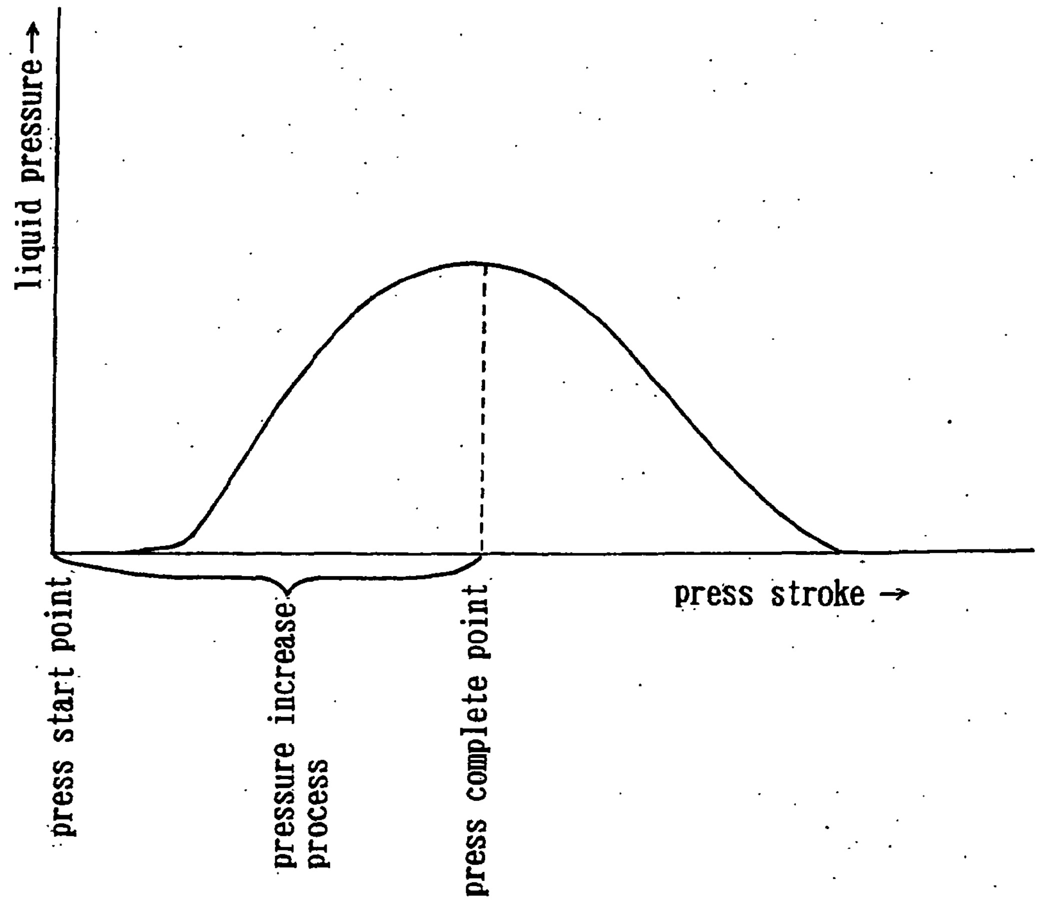

liquid pressure →
press stroke →
press start point
pressure increase process
press complete point

FIG. 8

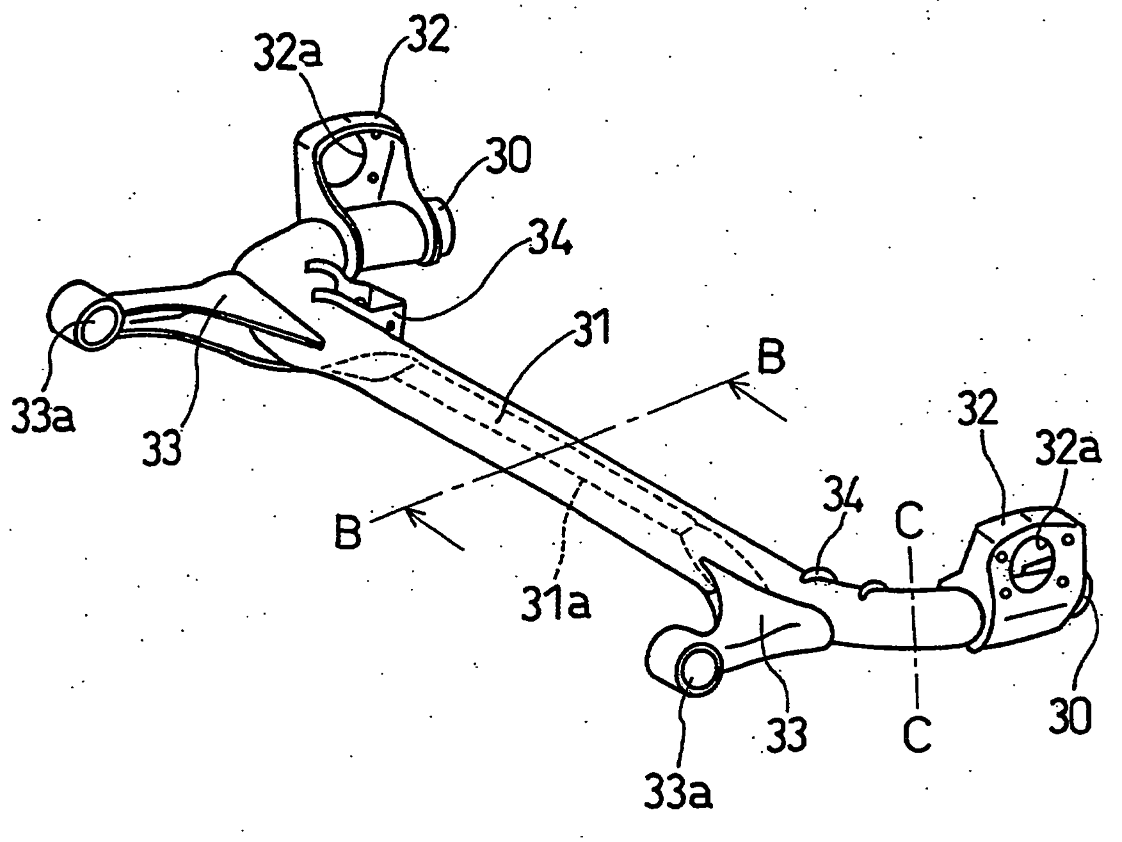


FIG. 9

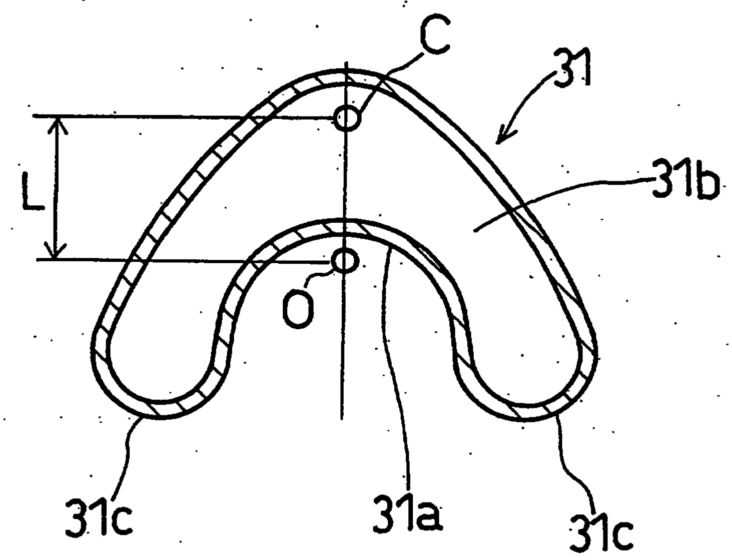


FIG. 10

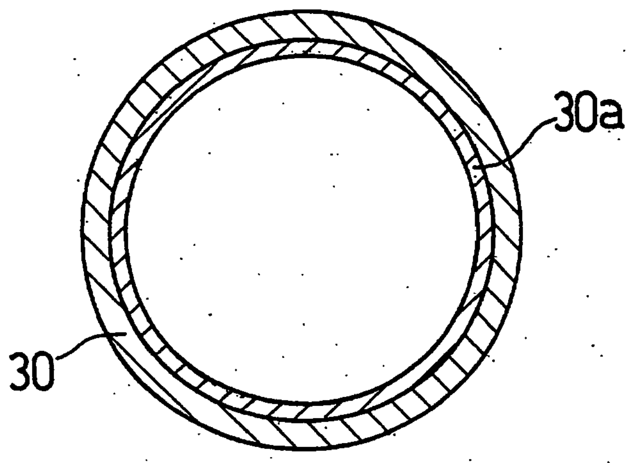


FIG. 11

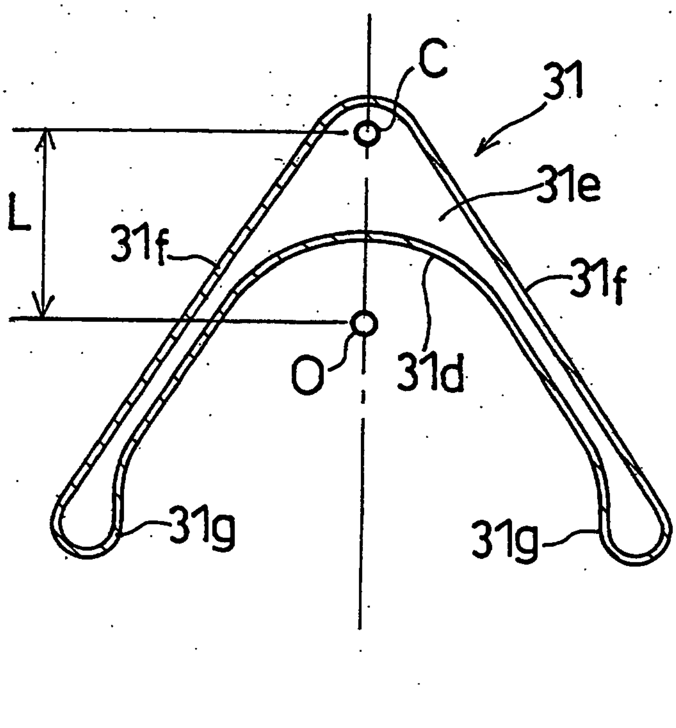


FIG. 12

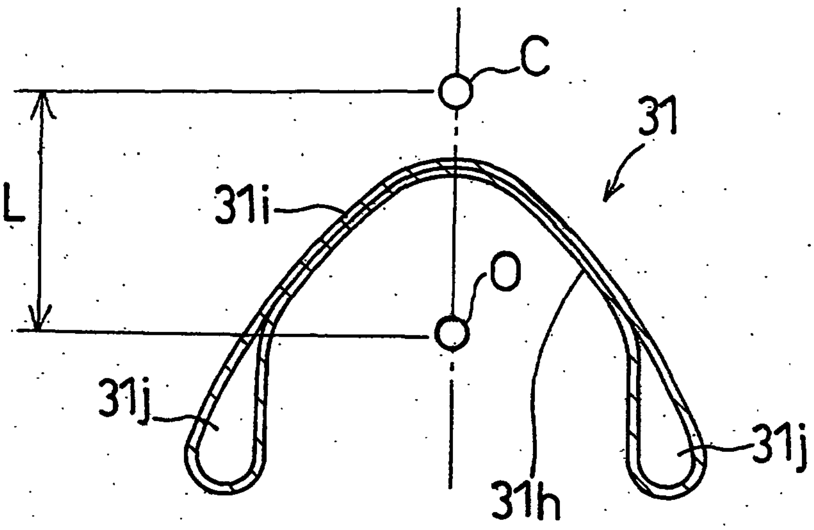


FIG. 13

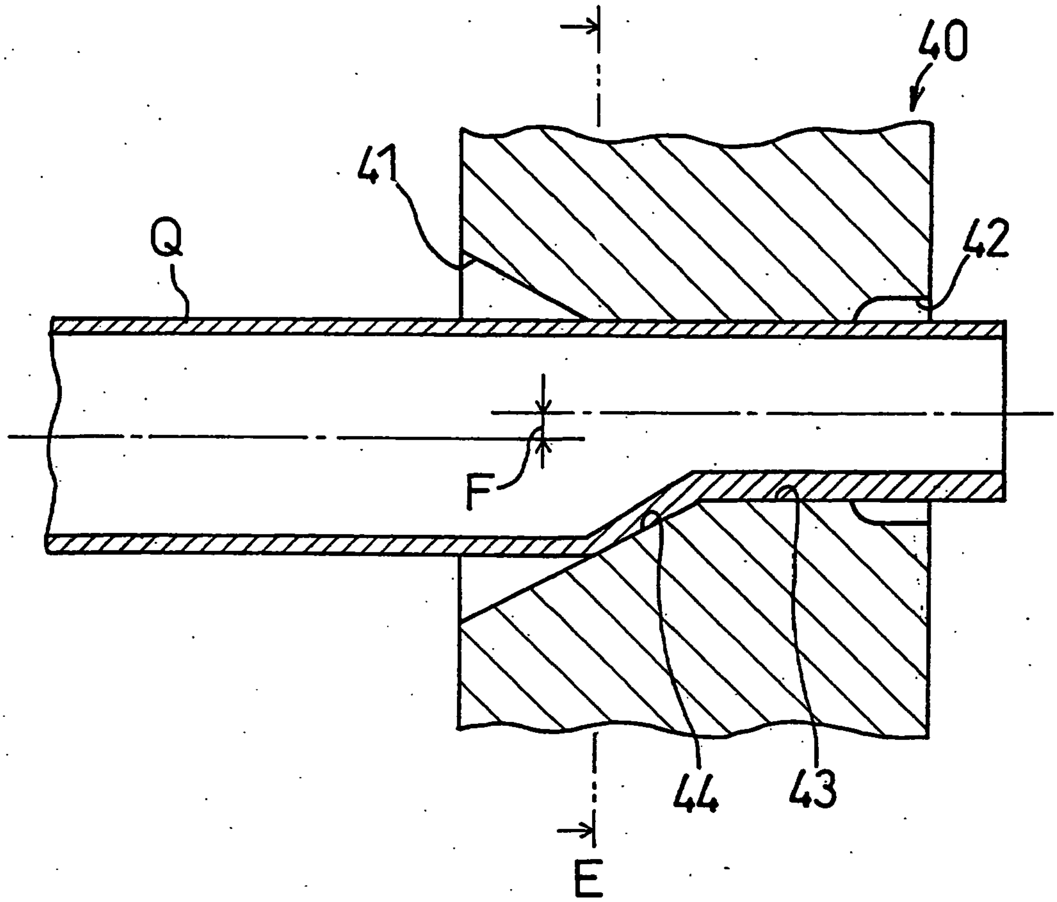


FIG. 14

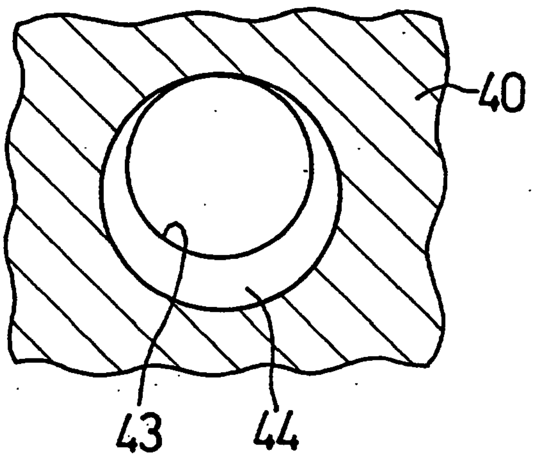


FIG. 15

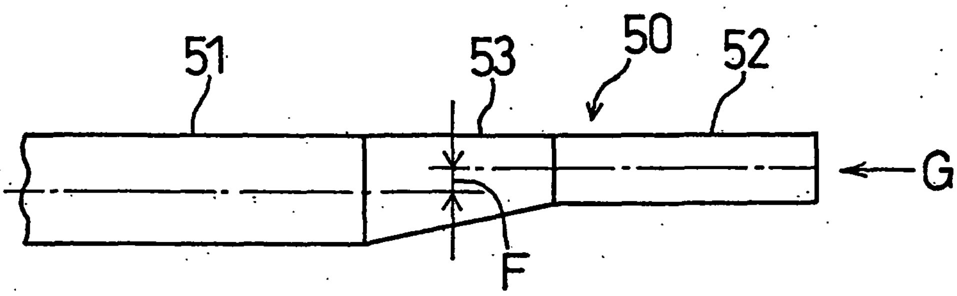


FIG. 16

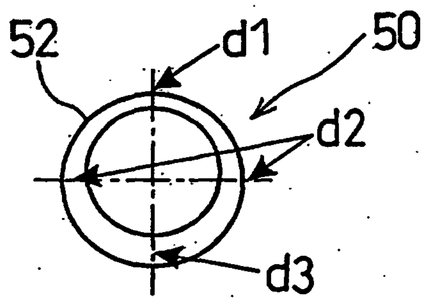


FIG. 17

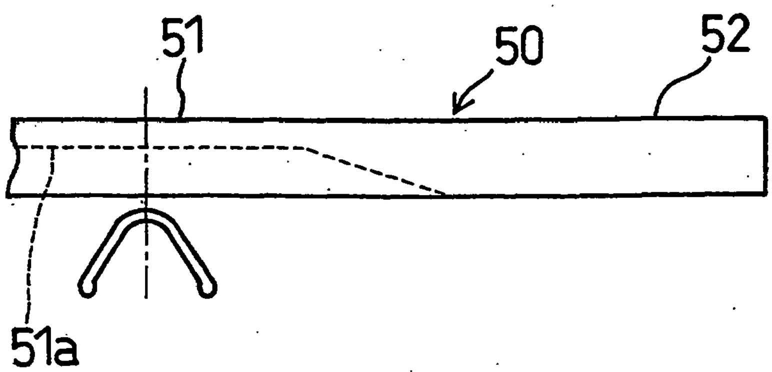
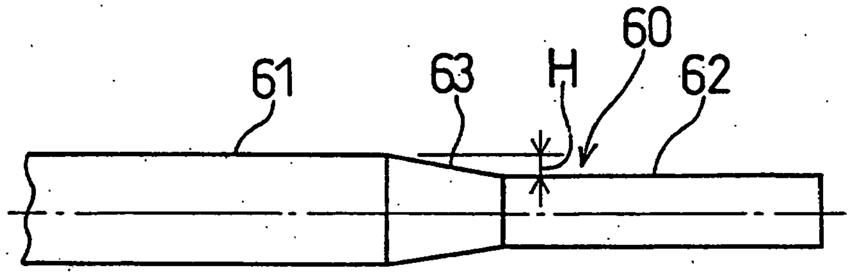


FIG. 18



19FIG.

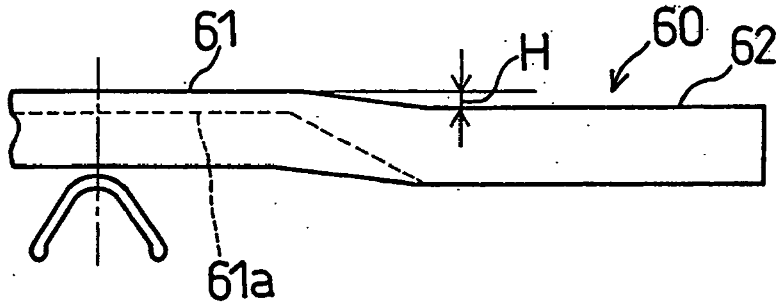


FIG. 20

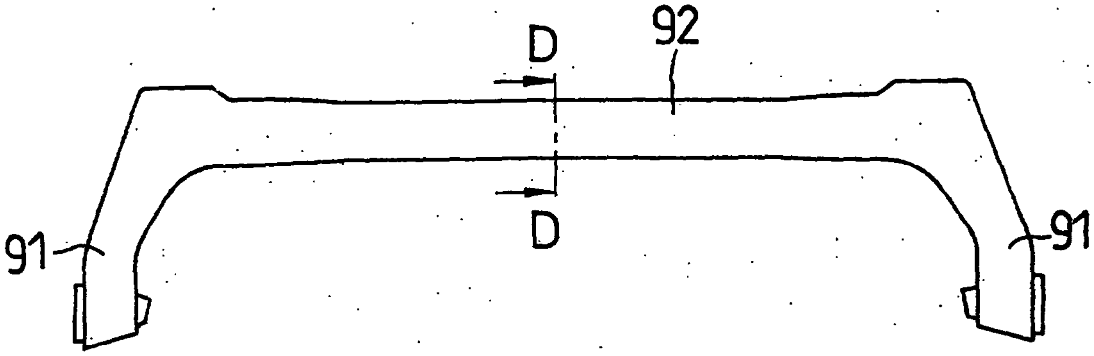
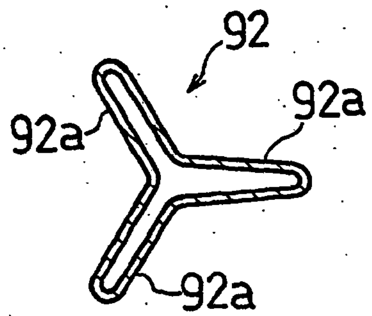


FIG. 21



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Patent documents cited in the description

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- EP 0650860 B1 **[0005]**