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(54) APPARATUS FOR MANUFACTURING WELDED STEEL PIPE

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Description

INDUSTRIAL FIELD

The present invention relates to a machine for manufacturing welded steel pipes.

BACKGROUND ART

(A) Line constitution

It is well known to form welded steel pipe by roll forming a steel strip so that it is pipe shaped with its edges butted together to form a seam and welding the seam. Nowadays electrically seamed steel pipe manufactured by the electrical (resistance) welding of the seam is mainly produced.

One of the roll forming methods used is a whole width reduction bending method in which a strip is bent as a whole, while gradually reducing its width, so as to make the whole of the pipe round. As to the forming machines using this method, there are known the one shown in Fig.11 and Fig.12 of the accompanying drawings, supplied by Yoda Co. in U.S.A. (disclosed in Japanese Patent Application Laid-open No. 29,896/1970) and the one shown in Fig.13 to Fig.15 of the accompanying drawings, supplied by Thorans Co. in U.S.A. (Japanese Utility Model Publication No. 28,897/1971). In these figures, the reference numeral 100 represents a pre-forming roll; numerals 102, 104, 106 and 108 represent break-down rolls; 110 . . . represent inner rolls; EF represents an edge forming roll; CR represents cage rolls; 1F, 2F and 3F represent fin pass rolls; and SQ represents a squeezing roll, respectively.

However, these machines have defects as follows:

- i) the number of forming rolls is large,
- ii) the constraining force on strip is weak so that the strip is apt to roll.
- iii) the applicability of the rolls when the size of the pipe to be produced changed, is limited,
- iv) the contour of the formed pipe readily adopts a discontinuous polygonal form due to the influence of the rolls (See: Fig.16), and
- v) there is large load in the final stage of fin pass forming, because the tending work can not be satisfactorily carried out in the rough and intermediate forming courses, and in practice, it is required to provide at least three stages of fin pass rolls.

In order to improve these defects, such a forming machine as shown in Fig. 17 and Fig. 18 of the accompanying drawings has developed (Japanese Patent Application Laid-open No. 135,428/1986). This machine comprises an edge bending roll EB, first to fourth center bending rolls 1CB, 2CB, 3CB and 4CB and a large number of cage rolls CR . . . arranged on both sides of the center bending rolls, a plurality of fin pass rolls 1F, 2F and 3F, and a squeezing roll SQ, arranged in order

from the upstream side to the downstream side, wherein the edge bending roll EB serves to bend the pipe edge-defining portions of the strip (Fig.18 a), the first to the third center bending rolls 1CB, 2CB and 3CB and the cage rolls CR . . . serve to bend the boundaries between the pipe side-defining portions of the strip and the pipe bottom-defining portion thereof (Figs. 18 b, c and d), the fourth center bending roll 4CB and the cage rolls CR . . . serve to bend the pipe bottom-defining portion (Fig.18 e) so that a member U-shaped in cross section is formed (Fig.18 f), and the fin pass rolls 1F, 2F and 3F serve to further form the strip under pressure so that the pipe side-defining portions protruded, and the pipe edge-defining portions, the boundaries between the pipe edge-defining portions and the pipe side-defining portions and the boundaries between the pipe side-defining portions and the pipe bottom-defining portion are bent and unbent. A welder serves to weld the resulting seam and the squeezing roll SQ serve to upset bond the said seam.

In this case also there are defects as follows:

① Since the first to the fourth center bending rolls 1CB, 2CB, 3CB and 4CB serve to bend only the boundaries between the pipe side-defining portions and the pipe bottom-defining portion and the pipe bottom-defining portion and they are therefor arranged at the center of the strip within a range as wide as one-third of its width (Figs. 18 b to d), and since the first to the third center bending rolls 1CB, 2CB and 3CB each comprises a twin type split roll, the contact area of these rolls with the strip is small. Even if all the center bending rolls are driven, accordingly, the transmission of feed torque from the rolls to the strip can not be carried out satisfactorily and, as a result, the strip can not be made to progress smoothly through the machine

In order to drive all the center bending rolls, it is necessary to make the machine larger and it is difficult to ensure that there is space for the cage rolls to be installed which leads to increased expense.

② Since each of the second and the third center bending rolls 2CB and 3CB is a twin type split roll (See : Fig.19 and Fig. 20 of the accompanying drawings, wherein Fig.19 shows a small size of pipe being produced and Fig.20 shows a larger one), the formation of dents and roll flaws on the strip by the corners of the rolls, and in particular the down rolls, tends to occur.

③ Since the first to the fourth center bending rolls 1CB, 2CB 3CB and 4CB each has an independent stand structure, there are required much labor and a long time when exchanging these rolls.

④ As to the down rolls of the second and third center bending rolls 2CB and 3CB, their roll space must be changed, in spite of the presence of the cage rolls on both the sides thereof, every time the size of the pipe to be produced is changed, and hence much

labor and a long time are required for the adjustment of the rolls.

⑤ Since it is necessary to provide at least three stages of fin pass rolls 1F, 2F and 3F, much labor and a long time are required when exchanging these rolls.

It is an object of the present invention to provide a machine for manufacturing welded steel pipes where these disadvantages are reduced.

In conventional machines for manufacturing electrically seamed steel pipes, there are used several stages of forming stands for the breakdown roll system or center bending roll system in the rough and intermediate forming processes. These respective stands are independent of one another, and in each of these stands, upper and down rolls are incorporated in a common housing by way of chocks. Accordingly, the exchange of rolls in each forming stand is carried out one by one using the stand side drawing-out system or the chock top drawing-out system.

In these roll exchange techniques, however, there are required much labor and a long time particularly when most rolls have to be exchanged, for instance when the size of the pipe to be produced is changed.

It is an object of an embodiment of the present invention to ameliorate such problems and to improve the rate of operation.

In a conventional welded pipe forming machine, however, the pipe is curved down by the force applied thereto from the cage rolls in the last zone L of the cage roll forming zone. Hence, in the sledding of the strip, the end does not proceed smoothly into the first fin pass roll 1F, and it may get out of the pass line so that pipe forming becomes impossible. Even if the pipe end gets into the fin pass roll, the contact of the pipe with the down roll of the first fin pass roll 1F may be too strong, leading to the ready formation of roll flaws on the pipe. Furthermore, when the strip is subjected to width-reduction forming by right and left cage rolls, its pipe bottom-defining portion may be deformed, namely folded partly so that the pipe formation is deleteriously affected.

It is an object of an embodiment of the present invention to ameliorate such defects and to achieve the stable forming of pipes.

(B) Edge bending roll

A known edge bending roll for bending the edges of a steel strip in a forming machine which bends the strip continuously, is disclosed in Japanese Patent Application Laid-open No. 167,025/1983 (Fig. 34 of the accompanying drawings). According to this document, the upper roll 36 of the edge bending rolls is in the form of a pair of right and left split rolls 36a and 36b mounted on one shaft. These split rolls 36a and 36b are such that the radius of curvature of the split roll surfaces on the mutually opposite face sides thereof, i.e. on the inner surface sides and the radius of curvature of the roll surfaces on

the non-opposite face sides thereof, i.e. on the outer surface sides are made different. These split rolls 36a, 36b are made to be changeable for each other in their mounting position with respect to shaft 37 so that both the inner and outer face sides of these split rolls 36a, 36b can be reversed in position. It is, therefore, possible to form strip edges for two sizes of pipes to be produced, by use of a pair of these split upper rolls 36a, 36b together with down rolls 1.

A strip edge forming roll for a welded steel pipe serves to pass the strip while it is held between both the upper and down rolls, thereby forming on the edges of the strip a curved portion corresponding to the size of the pipe to be produced. It is, therefore, necessary to exchange the said rolls, every time the size of the pipe to be produced is changed. Such roll exchange requires much labor and a number of rolls in proportion to the sizes of the pipes to be produced.

An object of an embodiment of the present invention is to provide an edge bending roll for welded steel pipes, in which the above problems are ameliorated.

(C) Split forming roll adjusting device

A roll forming machine in a welded steel pipe manufacturing line for working a steel strip continuously comprises upper rolls and down rolls as the forming rolls in which machine the steel strip is passed between the rolls so as to be bent in the so-called flower form. If the forming roll has to be exchanged every time the size of pipe to be produced is changed, there are required a large number of forming rolls different in size, and their exchange is not easy, leading to an increase of cost. Recently, a split roll system has been, therefore, mainly used.

This split roll system is such that the forming roll is composed of split members divided right and left into two parts, i.e. split rolls, wherein the size of a pipe to be produced can be changed by adjusting the space between the split rolls. As to an adjustment means therefor, there are known, for instance one having a helical adjustment mechanism, disclosed in Japanese Patent Application Laid-open No. 28,627/1982 and another of exchanging a spacer between the split rolls, disclosed in Japanese Patent Application Laid-open No. 209,722/1982.

However, the former adjustment means is composed such that the horizontal main shaft thereof is a screw in itself and a pair of nuts are screw-engaged with the said screw. In this case the pair of split rolls movably mounted on the main shaft are moved in the axial directions, respectively, by screw-moving the said nuts so that the space between the split rolls can be adjusted. Accordingly, there is a large possibility that the main shaft may be damaged due to the concentration of stress, when any large load is applied to the split rolls. Furthermore, the former adjustment means is not suitable in the case of manufacturing pipes from a thin sheet, in which high accuracy is required, because it has no backlash adjustment mechanism.

The latter adjustment means is such that a spacer is made to intervene between a pair of right and left split rolls and the said spacer is exchanged for one of different size as desired. Every time the spacer is exchanged, accordingly, there are required so much labor and long time, because it is necessary to detach the main shaft from the machine and to detach the split rolls and the spacer from the main shaft, and then to assemble the split rolls and another spacer different in size in place of the old one and incorporate them into the machine.

It is an object of an embodiment of the present invention ameliorate such problems and to stabilize the quality of the product.

(D) Upper roll actuating apparatus

An upper roll which serves to cause the strip to progress as the strip is held between it and down rolls whereby the strip is gradually shaped into a tubular form, is provided so as to be adjustable in its vertical position, in order that the roll surface of the said upper roll is made to accord with the pass line for strips of different thickness and the strips are pressed down. The upper roll actuating apparatus therefor usually comprises screw shafts provided standingly from chocks at both the ends of the upper roll shaft, and these screw shafts are incorporated in worm jucks at both the right and left portions of a worm shaft supported on a stand, whereby the upper roll can be moved up and down, by rotation of the worm shaft in both the normal and reverse directions. The elimination of backlash in this apparatus is carried out by the use of a special oil-hydraulic jack provided between the chocks at both the ends of a down roll shaft and the chocks of the upper roll shaft.

As to the elimination of backlash in such a conventional apparatus as mentioned above, there are such defects that it is difficult to carry out the elimination of backlash, because the space between both the upper roll shaft and the down roll shaft is narrow, and it is necessary to detach and attach the oil pipings of the said oil-hydraulic jack, when a stand on the movable side is taken off or mounted on the roll shafts to exchange the rolls.

It is an object of an embodiment of the invention to ameliorate such defects as mentioned above, and to carry out properly the elimination of backlash.

(E) Cage rolls

In general, for the cage roll forming of an electrically seamed steel pipe, there has been hitherto used such a forming machine as shown in Fig. 47 and Fig. 48 of the accompanying drawings. This machine is composed so that a plurality of inner rolls 110 . . . , whose roll widths are smaller in order, are arranged from the upstream side to the downstream side, and a large number of outer rolls, i.e. cage rolls CR . . . , CR . . . are arranged on both the sides of the said inner rolls, at heights and directions appropriate to the forming situations, wherein the strip fed therein is gradually bent into a U-shaped form,

and further into a circular form by applying force to the strip from the inside and the outside by these rolls.

As to the cage rolls CR . . . , CR . . . of the prior arts, by the way, there are two types, as shown in Fig. 49 to Fig. 50 of the accompanying drawings, one whose roll surface is a flat face (for example, disclosed in Japanese Utility Model Publication No. 19,371/1987 and Japanese Patent Application Laid-open No. 174,216/1985) and the other whose roll surface is a convexly curved face (for example, in Japanese Patent Application Laid-open No. 202,122/1984). Both of them can be applicable to various sizes of pipes to be produced.

In these cage rolls, however, there are such defects as making the roll-contacted portion of the formed steel pipe flat in a stripe-pattern so that its good appearance is strikingly ruined and its commercial value is decreased. In particular, the latter of the two types of cage rolls is excessively defective.

The present invention is intended to eliminate these defects in the prior arts.

DISCLOSURE OF THE INVENTION

The invention is concerned to a machine according to the preamble of claim 1 as known from JP-A-62-114729.

(A) Line constitution

According to the present invention, there is provided a machine for manufacturing a welded steel pipe by continuously roll forming a strip so that it is pipe shaped with its edges butted together to form a seam and welding the seam wherein the apparatus comprises a sequence of forming rolls extending along the strip as it passes through the apparatus, characterised in that the apparatus includes, in order from the upstream side of the apparatus to the downstream side of the apparatus, an edge bending roll for constraining the strip under pressure from its edge portions to the boundaries between its edge portions and its pipe side-defining portions to bend the strip, a first centre bending roll for constraining the pipe side-defining portions under pressure to bend the pipe side-defining portions, second to fourth centre bending rolls for constraining under pressure the strip from the boundaries between the pipe side-defining portions and the pipe bottom-defining portion to the pipe bottom-defining portion and for applying lateral pressure to the strip from both sides to bend the boundaries and the pipe bottom-defining portion, and first and second fin pass rolls for further forming the strip under pressure, and additionally includes a plurality of cage rolls arranged on both sides of the centre bending rolls, wherein at least the edge bending roll, the first centre bending roll and the first and second fin pass rolls each has a driving means provided thereon; all the upper rolls of the first to the fourth centre bending rolls are mounted in one housing, and all the down rolls of the first to the fourth centre bending rolls or all the down rolls of the sec-

ond to fourth centre bending rolls are mounted on one common sub-base plate.

In a preferred embodiment, both the upper roll and the down roll of the edge bending roll and of the first centre bending roll are split rolls adjustable in width; the down roll of each of the second to fourth centre bending rolls is a calliper-shaped one-part roll appropriate to the maximum pipe diameter to be produced; the upper roll of each of the second and third centre bending rolls is a split roll adjustable in width; the upper roll of the fourth centre bending roll is a one-part roll; and the cage rolls are mounted so as to be adjustable for slant advance and retreat.

In another preferred embodiment, the housing is detachable whereby all the upper rolls of the first to the fourth centre bending rolls can be replaced at a stroke by exchanging said housing.

In a further preferred embodiment, the common sub-base plate is detachable whereby all the down rolls of the first to the fourth centre bending rolls or all the down rolls of the second to the fourth centre bending rolls can be replaced at a stroke by exchanging said common sub-base plate.

The upper roll of the edge bending roll may be driven or not and only each down roll of the second to the fourth centre bending rolls may be driven.

In use of a machine constituted as above, a strip of a predetermined size is fed from the upstream side to the downstream side and formed into a steel pipe. The strip is dealt with as follows:

I. By the edge bending roll, the strip, from its pipe edge-defining portions to the boundaries between the pipe edge-defining portions and the pipe side-defining portions is constrained under pressure so as to be bent. The bending in this stage may be such that the pipe edge-defining portions and the boundaries are bent almost equally to a finally formed circle.

II. By the first center bending roll, the pipe side-defining portions are constrained under pressure so as to be bent. The bending in this stage may be slight.

III. By the second to the third center bending rolls, the boundaries between the pipe side-defining portions and the pipe bottom-defining portion are constrained under pressure, and at the same time, by the plurality of cage rolls arranged on both sides thereof, lateral force is applied to both sides of the pipe so that the same boundaries are bent. The bending in this stage may be in excess of that for providing the finally formed circle.

IV. By the fourth center bending roll, the pipe bottom-defining portion is constrained under pressure, and at the same time, by the plurality of cage rolls arranged on both sides thereof, lateral force is applied to both sides of the pipe so that the pipe bottom-defining portion is bent. The bending in this stage may be to the extent of providing the finally formed circle or in excess.

V. By the first and second fin pass rolls, the pipe (which has become oval-shaped in cross section, by the bending work in the above step IV) is further formed under pressure so that the pipe side-defining portions are protruded sideways, and the respective boundaries and pipe edge-defining portions are properly bent and unbent so that the pipe becomes nearly a circle,

VI. Then, the resulting seam is properly welded and the shape of the pipe is corrected, thereby obtaining a welded steel pipe.

In an embodiment, in the first to the fourth centre bending rolls, each upper roll is mounted on an upper roll common stand frame and each down roll is mounted on a down roll common stand frame and the rolls are individually vertically adjustable with respect to their respective frames.

In another embodiment, the housing is in the form of a horizontal frame forming part of an upper roll common stand frame having a positioning means and a clamping means provided thereon, the clamping means being releasable to disengage the horizontal frame during the upper roll replacement and the positioning means being operable to locate a new horizontal frame at a predetermined position in which it can be fixed by the clamping means.

In a further embodiment, the common sub-base is in the form of a down roll common stand frame for the first to the fourth centre bending rolls and having a positioning means and a clamping means provided thereon, the clamping means being releasable to disengage the common stand frame during the down roll replacement and the positioning means being operable to locate a new common stand frame at a predetermined position in which it can be fixed by the clamping means.

Due to the abovementioned construction, the exchange of each upper roll and the exchange of each down roll may be carried out together with a common stand frame at a stroke. In addition, the vertical adjustment of each upper roll and each down roll may be carried out individually.

In a still further embodiment of the present invention a bottom guide roll for receiving the pipe is arranged in a section between the fourth centre bending roll and the first fin pass roll.

Due to the abovementioned construction, the bottom guide roll serves to support the pipe bottom-defining portion at the final stage of the cage roll forming step thereby preventing the pipe from being curved down. Thus the pipe can be made to keep on a normal pass line and it can be properly guided to the fin pass roll of the next stage.

(B) Edge bending roll

In a yet further embodiment of the present invention, the edge bending roll comprises a down roll and an upper roll each in the form of split rolls symmetrical right and

left, wherein said down roll is a stepped roll having a plurality of steps of different outside diameter with the inner side having the smaller diameter whereby concavely curved portions having different radii of curvatures are provided respectively for location opposite to the edges of the strip, and said upper roll has an outer peripheral profile of a contour such that only the outer face side of the roll has a convexly curved form, wherein the upper roll is journaled in a holder so that its position can be changed to a position opposite to each step of the said stepped roll and so that the upper roll can be inclined in the breadth direction of the strip, the convexly curved form of the upper roll comprising a combination of sectors having different radii of curvature.

In another embodiment of the present invention, the center of inclination of the upper roll of the edge bending roll is set on a line normal to the end of the convexly curved face of the upper roll.

In a further embodiment, the upper roll of the edge bending roll has an upper roll supporting apparatus which comprises a lift frame supported liftably in a housing, an upper roll supporting frame supported on the lift frame movably in the breadth direction of the upper roll, the upper roll holder inclinably supported on the upper roll supporting frame, a jack device provided between the upper roll supporting frame and the upper roll holder for inclining the upper roll holder, a cylinder device for pressing the lift frame in the direction of the forming reaction force, and a cylinder device for pressing the upper roll holder in the direction of the forming reaction force.

In a machine of the above construction, the down rolls 1a, 1b and upper rolls 36a, 36b (Fig.28 of the accompanying drawings) are such that space adjustment between the upper and down rolls can be carried out appropriate to the width of the strip 4. In order that the roll surface height is made to accord with the pass line height, furthermore, the down and upper rolls are adjustable in position in the vertical direction.

The down roll is a stepped roll having a plurality of steps different in outside diameter wherein the inner side has the smaller diameter and concavely curved portions different in radius of curvature are provided respectively in the portion of each step opposite to the edge of the strip. As a result, the down roll can be used for various kinds of strips.

In the upper roll, the contour of its outer peripheral profile in a plane including the roll center axis is such that only the outer face side of the upper roll has a convexly curved form and such is omitted on the inner side thereof. Thus, the upper roll can be made thin in roll thickness, and the roll holder thereof can be made thick and high in rigidity.

The upper roll is journaled in this holder, and the upper roll can be positioned opposite to each of the caliper steps of the stepped down roll by being drawn out of its bearings. Accordingly, the upper roll can be fitted to various strips having different width and thickness.

By virtue of this roll, the rigidity of the mill will be increased and the bending of the strip edges will be

sharply improved as compared with the prior art, without ruining the usability of the roll.

The convexly curved portion of the upper roll is shaped in the form comprising a combination of sectors of different radius of curvature, and on the other hand, the roll surface of the upper roll is made capable of being inclined in the direction shown at the angle of α in the breadth direction of the strip, as shown in Fig. 30 of the accompanying drawings.

Due to this inclination, it becomes possible to use the different radii of curvature of the upper roll instead of having to change the roll.

(C) Split form roll adjusting device

In yet another embodiment of the present invention, the machine has an adjusting device for one of the driven forming rolls wherein the driven forming roll, such as the down roll of the edge bonding roll and the upper and down rolls of the first centre bending roll, comprises left and right split rolls and the adjusting device includes a hollow main shaft journaled at both its ends; a pair of left and right cylindrical roll holders slidably mounted in the axial direction on the outer periphery of the middle portion of said hollow main shaft and holding the left and right split rolls at their inner ends, respectively; position retaining means provided for retaining the roll holders at an optional position; a gear, for mechanically engaging the hollow main shaft to a driving unit, fixed at one end of the main shaft; a rotatably mounted adjustment shaft running through the hollow main shaft; a pair of threaded portions having different thread directions provided at the ends of the adjustment shaft; screw-movers engaged for screw-advance and retreat with said threaded portions; transmission mechanisms for transmitting the said screw-advance and retreat provided between each screw-mover and roll holder; and a handle for rotation provided on the said adjustment shaft.

If the handle is rotated clockwise or counterclockwise, after the position retaining means is released to make the roll holder slidable, due to the abovementioned construction, the adjustment shaft follows so that the screw-movers on both sides are screw-advanced or retreated mutually in the reverse directions and both the holders follow therewith by way of the transmission mechanism, whereby the split rolls approach or move away from each other.

After the spacing of the split forming rolls is adjusted in such a manner as mentioned above, the position retaining means is caused to work again, thereby constraining the position of both the roll holders, i.e. the position of the split rolls.

To the split rolls whose space has been adjusted, a rotating force is supplied from a driving apparatus. This rotating force is transmitted to gears and then transmitted to the split rolls by way of the main shaft and both the holders.

In a further embodiment of the present invention, the machine includes an adjusting device for one of the non-

driven forming rolls wherein the non-driven forming roll, such as each upper roll of the second to the third centre bending rolls, comprises left and right split rolls and the adjusting device includes a main shaft formed by rotatably mounting an outer cylinder shaft on the outer periphery of a core shaft and having its ends fixed on supporting plates; a pair of left and right sliding sleeves having a positioning mechanism and mounted on the middle portion of the main shaft so as to be slidable in the axial direction and having the left and right split rolls rotatably mounted on their outer peripheries, respectively; screw shafts which are mutually in a reverse screw relation provided projectingly from the ends of the said core shaft, respectively; nuts screw-engaged with the screw shafts; rods connecting said sliding sleeves with each other; and a core shaft-rotating means attached to the end of one of said screw shafts.

By rotating handle 506 in the right direction from the situation illustrated in Fig.41 and Fig.42 of the accompanying drawings, core shaft 502 is rotated with respect to outer cylinder shaft 503 fixedly supported at both its ends on supporting plates 510, 510. Then, nuts 505, 505, connected with sliding sleeves 515, 515 which do not rotate with respect to the outer cylinder shaft because of rods 530, 530, are screw-advanced toward the supporting plates 510, 510, because their screw shafts 504, 504 are mutually in reverse screw relation. Accordingly, the sliding sleeves 515, 515 are pushed by the rods 530, 530 so as to move together with split rolls 520, 520 in such a direction that they approach each other. And, reversely rotating the handle 506, the nuts 505, 505 are screw-related to separate the split rolls from each other. The outer cylinder shaft 503 and the sliding sleeves 515, 515 can be fixed by actuating a positioning mechanism at a position where the space between the split rolls is appropriate to the width of the strip to be shaped into a tubular form. If the strip is held between the upper and down split rolls at the same position, it is deformed into a tubular form, as it is caused to progress.

(D) Upper roll actuating apparatus

In a still further embodiment of the present invention, the machine includes an upper roll actuating apparatus, having a backlash eliminating means, for the edge bending roll, center bending rolls and fin pass rolls, the apparatus comprising a shaft on which the upper roll is mounted; shocks supporting both ends of the upper roll shaft; a screw shaft upstanding from each of the shocks; the screw shafts being incorporated in worm jacks provided at both end portions of a worm shaft supported on a stand whereby the upper roll can be moved up and down by means of said screw shafts by rotation of said worm shaft in both the normal and reverse directions; the apparatus also including a fluid-hydraulic cylinder provided above each of said screw shafts respectively and having piston rods connected to the upper ends of the screw shafts whereby the upper roll can be pulled up.

In Fig. 43, of the accompanying drawings the up and down movements of upper roll 605 are carried out by the rotation of worm shaft 613 caused by reversible motor 616 in both the normal and reverse directions. When the worm shaft is rotated in the normal direction, screw shafts 608, 608 are caused to go down by the actuation of worm jacks 614, 614, thereby causing the upper roll 605 to go down, and reversely when the worm shaft is rotated in the reverse direction, the worm jacks are actuated in the reverse direction, thereby causing the upper roll to go up by way of the screw shafts. The backlash elimination of the work jacks is carried out by pulling up the said screw shafts 608, 608 by the actuation of fluid-hydraulic cylinders 617, 617.

The pulling-up force of the said fluid-hydraulic cylinders may be preferably set to be the sum of the tare of the pulling-up portions, i.e. the screw shaft 608, the second chock 607, the upper roll put-on shaft 606 and the upper roll 605 in the embodiment shown in Fig.43, or the screw shaft 608, the suspension base plate 628, the arms 629, 629, the upper roll put-on shaft 606 and the upper roll 605 in the embodiment shown in Fig.43, or the screw shaft 608, the suspension base plate 628, the arms 629, 629, the upper roll put-on shaft 606 and the upper roll 605 in the embodiment shown in Fig.3 of the accompanying drawings, and 10% ~ 20% of the strip forming load.

(E) Cage rolls

According to another embodiment of the present invention, the roll surface of the cage rolls is in the form of a concavely curved face having a larger radius of curvature than that of the pipe to be formed.

Due to the abovementioned construction, the roll surface shaped in the form of a concavely curved face serves to form under pressure the strip to be bent. Namely, this roll surface is suitably fitted to the convexly curved face of a forming flower, so that the roll-contacted portion of the strip is not made flat in a stripe-pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is an illustrative view of the construction of a welded steel pipe manufacturing machine according to the present invention.

Fig.2 to Fig.10 show embodiments of the present invention wherein Fig.2 is a side view of the machine in the roll forming process, Fig.3 is a front view of the first center bending roll, Fig.4 is a front view of the third center bending roll, Fig.5 is a front view of the fourth center bending roll, Fig.6 is a plan view of the cage roll, Fig.7 is an enlarged front view of the main part of the first center bending roll, Fig.8 and Fig.9 are enlarged front views of the main parts of the second to fourth center bending rolls, for a small size of a pipe to be produced and for a large size, and Fig. 10 is a graph.

Fig.11 to Fig.20 show prior art machines wherein Fig.11 is a plan view of the essentials of a first prior art

machine, Fig.12 is an enlarged cutaway front view of the main part of the same machine, Fig.13 is a perspective view of a second prior art machine, Fig.14 is a sectional view taken along the line XIV-XIV of Fig.13, Fig.15 is a sectional view taken along the line XV-XV of Fig.13, Fig.16 is an illustrative view of the main parts of the first and second prior art machines, Fig.17 is a plan view of the essentials of a third prior art machine, Fig.18 a, b . . . and f are views of the main parts taken along the lines a-a, b-b, . . . and f-f of Fig.17, and Fig.19 and Fig.20 each is an enlarged front view of the main part of the center bending roll of the same machine.

Fig.21 is a front view of a bottom guide roll of a machine according to the invention; Fig.22 is a side view, Fig.23 is a plan view, Fig.24 is a rear elevational view of the main part, Fig.25 is a plan view of the main part, Fig.26 is an enlarged side view of the main part, and Fig.27 is an enlarged cutaway rear elevational view of the machine.

Fig.28 is an illustrative view taken from the front of a machine in accordance with the present invention having a strip edge forming roll capable of different forming sizes.

Fig.29 is an illustrative view showing the setting situation of the upper and down rolls in the forming of a thick strip in a machine of the present invention.

Fig.30 is an illustrative view of the part shown in Fig 29 showing the setting situation of the upper roll inclined for the forming of a thin strip.

Fig.31 is a front view of one embodiment of the present invention is shown.

Fig.32 is a cross sectional view of a portion of the machine shown in Fig.31 wherein the upper roll is incorporated.

Fig.33 is a graph for comparing the bending curvatures of strip edges.

Fig.34 is an illustrative view of one of the prior art forming methods.

Fig.35 is a cutaway front view of a further machine in accordance with the invention; Fig.36 is a side elevational view, Fig.37 is a cutaway plan view, taken along the line A-A of Fig.35, Fig.38 is a semi-cutaway plan view, taken along the line B-B of Fig.36, Fig.39 is a side view of the main parts, and Fig.40 is a cutaway plan view of the main parts, taken along the line C-C of Fig.35.

Fig. 41 is a plan view of another machine according to the present invention, and Fig.42 is a cross-sectional view thereof, taken from the front.

Fig.43 is a partially cutaway front view of a part of a machine according to the present invention.

Fig.44 is an enlarged elevational view in section of the main parts of Fig.1, and Fig.45 and Fig.46 are views illustrative of the operation. Fig.47 to Fig.52 show a prior art machine, wherein Fig.47 is a plan view illustrative of the constitutional essentials of a forming machine, Fig.48 is a sectional view taken along the line VI-VI of Fig.47, and Fig.49 to Fig.52 are views illustrative of the operation.

BEST MODE FOR CARRYING OUT THE INVENTION

(A) Line constitution

A machine according to the present invention is shown in Fig.1 to Fig.9.

As shown in Fig.1, this machine is composed so that an edge bending roll EB, first to fourth center bending rolls 1CB, 2CB, 3CB and 4CB, a plurality of cage rolls CR.. arranged on both the sides from the second center bending roll to the downstream side of the fourth center bending roll, first and second fin pass rolls 1F and 2F, a rotary seam guide roll RSG, a high frequency welder HFW and a squeezing roll SQ, are arranged in order from the upperstream side to the downstream side.

Of these rolls, in further detail as shown in Fig.2 to Fig.9, the edge bending roll EB, the first to fourth center bending roll 1CB, 2CB, 3CB and 4CB and the first and second fin pass rolls 1F and 2F, each comprises an upper roll U and a down roll D, and the plurality of the cage rolls CR.. and the squeezing roll SQ each comprises a pair of right and left rolls. Each of the first to fourth center bending rolls 1CB, 2CB, 3CB and 4CB is given a predetermined range of use. Providing that steel pipes, 22.22 mm ~ 60.5 mm in outer diameter, are manufactured, for instance, as shown in Fig. 10, three sets of roll groups ①, ② and ③ will be provided which have the following applicable ranges of use:

- ① 22.22 mm ~ 31.03 mm,
- ② 31.03 mm ~ 43.33 mm,
- ③ 43.33 mm ~ 60.5 mm.

In addition, although a side roll SD is arranged between the first and second fin pass rolls, it may be omitted.

Of these rolls, the down roll D of the edge bending roll EB, the upper and down rolls U and D of the first center bending roll 1CB, the upper and down rolls U and D of each of the first and second fin pass rolls 1F and 2F, each has a driving means 27 provided thereon. More particularly, their roll shaft is mechanically connected with a driving source by way of a universal joint. If necessary, the upper roll U of the edge bending roll EB, the down roll D . . . of each of the second to fourth center bending rolls 2CB, 3CB and 4CB, and the squeezing roll SQ can be driven.

Both the upper and down rolls of the edge bending roll EB are in the form of a split roll and adjustable in width in accordance with the size of pipe to be produced. The edge bending roll EB serves to constrain under pressure the strip from its pipe edge-defining portions to the boundaries between the pipe edge-defining portions and its pipe side-defining portions so that the strip is fed, and at the same time, the pipe edge-defining portions and the boundaries are bent almost equally to a finally formed circle whilst anticipating the spring-back.

As to the first center bending roll 1CB, as shown in Fig. 3 and Fig.7, its down roll D is in the form of a split

roll comprising three parts, i.e. comparatively wide right and left members 12 and 13 and a comparatively narrow intermediate member 11, and its upper roll U is in the form of a split roll comprising two parts, right and left members 14 and 15, wherein the upper and down rolls each has a width-adjusting means 22, 22, so as to be adjustable in width in accordance with the size of pipe to be produced. The first center bending roll 1CB serves to constrain under pressure the pipe side-defining portions of the strip so that the strip is fed, and at the same time it is bent slightly. The bending extent in this stage may be such that the caliper radius at an intermediate point within the range of pipe size (the outside diameter of a pipe) applicable for this roll is about 2.5 times the caliper radius of the squeezing roll SQ appropriate thereto.

As to the second to fourth center bending rolls 2CB, 3CB and 4CB, as shown in Fig.4, Fig.5 and Fig.8 (Fig.9), their down rolls D each is made to be a one-part roll 16, which is used for a predetermined size range of pipe to be produced. Providing that there are three use ranges, ① 22.22 mm ~ 31.03 mm, ② 31.03 mm ~ 43.33 mm and ③ 43.33 mm ~ 60.5 mm, as mentioned above, three one-part rolls for the use ranges ①, ② and ③ will be provided. The first one-part roll for the range ① is of caliper-shaped form appropriate to 31.03 mm, the second for the range ② is of caliper-shaped form appropriate 43.33 mm, and the third for the range ③ is of caliper-shaped form appropriate to 60.5 mm, respectively. Namely, each of them is shaped in a caliper-shaped form suitable for the maximum outside diameter of an applicable common range of use.

In the second and third center bending rolls 2CB and 3CB, as shown in Fig.4 and Fig.8 (Fig.9), their upper rolls U, U each is in the form of a split roll comprising two parts, right and left members 17 and 18, and adjustable in width in accordance with the size of pipe to be produced (Fig.8 shows the case of a smaller size of pipe to be produced and Fig.9 shows the case of a larger one). The upper roll U of the fourth center bending roll 4CB is in the form of a one-part roll 28, as shown in Fig.5.

The second and third center bending rolls 2CB and 3CB serve to constrain under pressure the pipe side-defining portions of the strip and the boundaries between the pipe side-defining portions and the pipe bottom-defining portion and the fourth center bending roll 4CB serves to constrain under pressure the pipe bottom-defining portion, and these center bending rolls bend the above boundaries in excess of the bending extent for providing the finally formed circle and the pipe bottom-defining portion to an extent equal to that for providing the finally formed circle, or in excess, together with the plurality of cage rolls CR . . . , CR . . . arranged on both sides thereof.

As to the cage rolls CR . . . , CR . . . , as shown in Fig.2 and Fig.4 to Fig.6, there are arranged a total of twelve rolls in four zones, three rolls in each zone, on both sides from the upperstream position of the second center bending roll 2CB to the downstream position of the fourth center bending roll 4CB, and these cage rolls

apply lateral pressure to the pipe from both sides, together with the second to fourth center bending rolls, whereby the strip from the boundaries between the pipe side-defining portions and the pipe bottom-defining portion to the pipe bottom-defining portion is bent in order, as mentioned above.

The first and second fin pass rolls 1F and 2F each comprises a finned upper roll and a finless down roll. The first fin pass roll 1F serves to form under pressure the pipe which has become oval-shaped in cross section at the previous step so that the boundaries between the pipe edge-defining portions and the pipe side-defining portions and the boundaries between the pipe side-defining portions and the pipe bottom-defining portion are further bent in excess and the pipe edge-defining portions are bent to a proper degree, and then the second fin pass roll 2F serves to form under pressure the pipe successively so that the pipe side-defining portions are protruded outwards and bent almost equally to the finally formed circle and at the same time, each of the said boundaries is unbent nearly to the finally formed circle.

The rotary seam guide roll RSG comprises a finned upper roll and a finless down roll, which rolls are adjustable in position and angle, and it serves to arrange the pipe in a normal welding attitude.

The high frequency welder HFW is one kind of resistance welder, whereby a welding current is caused to pass through the resulting seam of the pipe to heat and melt the seam.

The squeezing roll SQ (Fig.1) comprises a pair of right and left rolls which press the pipe from both sides so that the melted seam is upset-bonded and the thus-bonded pipe is corrected in shape into the form of a circle.

In the abovementioned edge bending roll EB, first and second fin pass rolls 1F and 2F, rotary seam guide roll RSG, as shown in Fig.1 and Fig.2, their upper and down rolls U . . . , D . . . are mounted, for exchange of the rolls, on an independent roll stand 19, respectively, and in the squeezing roll SQ, its right and left rolls are mounted, for exchange of the rolls, on a roll stand 20.

In the first to the fourth center bending rolls 1CB, 2CB, 3CB and 4CB, as shown in Fig.1 and Fig.2, only their down roll D..is mounted on an independent roll stand 21, and the second to fourth center bending roll stands 21 . . . are fixed on one common sub-base plate 50, whereby the down rolls can be exchanged together with the common sub-base plate at a stroke. Their upper rolls U . . . are also mounted, for exchange of the rolls, in one detachable housing 23 common to these four rolls. In the exchange of the upper and down rolls U . . . and D . . . , accordingly, four upper rolls or three down rolls can be exchanged at a stroke by exchanging the said housing 23 or the said common sub-base plate 50.

In each zone, as shown in Fig.2 and Fig.4 to Fig.6, the three cage rolls CR . . . are mounted in one roll stand 24 . . . , and each roll stand has a slant advance and retreat control means 25 common to the three cage

rolls. The control in this case may be carried out mainly on the intermediate roll. By virtue of the control means, the cage rolls can be applied to all sizes of pipes to be produced. The angle of the cage rolls may be satisfactorily set previously in accordance with their positions. 5

Experiments relating to the abovementioned machine will now be described.

(1) Pipes manufactured for trial (See: Fig.10): 10

Outer Diameter: 22.22 mm ~ 60.5 mm

(2) Strips used:

Thickness: 0.8 ~ 3.0 mm 15

Materials:

① corresponding to ordinary steel SS41

② Stainless steel SUS 304 20

(3) The applicable range of use for the first to fourth center bending rolls 1CB, 2CB, 3CB and 4CB (See: Fig.10) 25

① Pipe outside diameter 22.22~ 31.03 mm

② Pipe outside diameter 31.03~ 43.33 mm

③ Pipe outside diameter 43.33~ 60.5 mm

(Three types of rolls ① to ③ were provided.) 30

In this experiment, the desired purposes could be achieved with no trouble. For the change of the size of pipe to be produced and for the exchange of the rolls, in particular, it was confirmed that they could be carried out with the half of the labor and time required by the prior art or less. 35

The present invention has the following effects.

(a) Since all the upper rolls of the first to fourth center bending rolls can be exchanged at a stroke, by setting these upper rolls in one housing, it is possible to reduce the labor and time necessary for the exchange of these rolls to a large extent, thereby enabling the rate of operation to be improved. 40 45

(b) Since all the down rolls of the second to fourth center bending rolls can be exchanged at a stroke by setting the down roll stands on one common sub-base plate, it is possible to reduce the labor and time necessary for the exchange of these rolls to a large extent, thereby enabling the rate of operation to be improved. 50

(c) Since the strip is bent, in order, from its pipe edge-defining portions to the boundaries between the pipe edge-defining portions and its pipe side-defining portions by the edge bending roll, on the pipe side-defining portions by the first center bending roll, from the boundaries between the pipe side-defining portions and pipe bottom-defining portion 55

to the pipe side-defining portions by the second to fourth center bending rolls and a number of the cage rolls arranged on both sides thereof, it is possible to shape the pipe in an oval-shaped form in cross section, before it reaches the fin pass rolls, and since the oval-shaped pipe is formed under pressure so that the pipe side-defining portions are protruded sideways, it is possible to carry out the bending work of the strip precisely, while it does not assume a polygonal form. Furthermore, two stages of fin pass rolls will be sufficient, because the load in the fin pass roll forming step is smaller, and as a result, it is possible to reduce the number of rolls as a whole and to compact the machine.

(d) Since the strip is constrained from the pipe edge-defining portions to the boundaries between the pipe edge-defining portions and the pipe side-defining portions by the edge bending roll, on the pipe side-defining portions by the first center bending roll, from the boundaries between the pipe side-defining portions and the pipe bottom-defining portion to the pipe bottom-defining portion by the second to fourth center bending rolls, and from the pipe edge-defining portions to the pipe side-defining portions by the cage rolls, and hence the strip is sufficiently constrained almost in the whole area in the breadth direction, it is possible to stabilize the roll forming work and to improve the quality of the pipes produced, while the strip is prevented from getting out of the center and rolling, with no formation of edge waves.

(e) Since a driving means is provided on the edge bending roll for constraining the pipe edge-defining portions and the boundaries adjacent thereto, the first center bending roll for constraining the pipe side-defining portions, and the first and second fin pass rolls for constraining the top and bottom-defining portions of the pipe, respectively, the strip is given the transmission of torque over a wide range in the breadth direction. It is, therefore, possible to make the strip progress smoothly. Since the upper rolls of the second to the fourth center bending rolls are not driven, it is possible to make the machine small-scaled and to ensure that there is space where the cage rolls are installed, without any trouble, leading to a decrease in installing expense.

(f) Since each of the down rolls of the second to fourth center bending rolls is in the form of a caliper-shaped one-part roll appropriate to the maximum pipe size of the applicable common range of use, it is possible to eliminate the formation of dents or roll flaws on the strip by the roll corners. If the size of the steel pipe is in a predetermined range, it is not necessary to adjust the roll space, even when the size of pipe to be produced is changed, and there is no need for the labor and time for roll adjustment.

(g) Since the cage rolls are mounted so as to be controllable for slant advance and retreat, they are applicable to all the sizes of pipes to be produced and the

control of the cage rolls can be carried out only by one element. Thus, it is possible to control the cage rolls easily and quickly, and to simplify the structure of the machine.

The modification shown in Fig.22 to Fig. 27 will now be described.

In Fig.22 to Fig 27, the first to the fourth center bending rolls 1CB, 2CB, 3CB and 4CB each comprises an upper roll U . . . and a down roll D . . . which stand opposite to each other, wherein each down roll D . . . and each upper roll U . . . are mounted on a sub-base plate in the form of a common stand frame 202 for the down rolls, arranged on a base plate 201, and a common stand frame 203 for the upper rolls, respectively. In addition, the upper roll U and down roll D of the first center bending roll 1CB is each a driving roll connected to a driving means and each of all the other rolls is a non-driven roll.

The down roll common stand frame 202 is composed so that four pairs of chocks 223, 223, each pair consisting of a right chock and a left chock, are arranged in order on both the sides of a groove-shaped frame 221 extending longitudinally in the line direction, and the down rolls D . . . of the first to the fourth center bending rolls 1CB, 2CB, 3CB and 4CB are journaled in these chocks. But, the portion of the frame 221 for the first center bending roll 1CB is made broader in width so as to be suitable for driving, because its down roll D is a driving roll.

Under the chocks 223, 223 . . . in which the down roll D . . . of the second to the fourth center bending rolls 2CB, 3CB and 4CB are journaled, there are arranged oil-hydraulic jacks 224, 224 . . . , whereby the chocks 223 . . . and the down rolls D . . . are made adjustable in height, and further all the down rolls D . . . of the first to the fourth center bending rolls 1CB, 2CB, 3CB and 4CB are made adjustable in height by their shim adjustment.

The down roll common stand frame 202 is arranged detachably on a base plate 201, and positioned at a predetermined position by a positioning means 204 and a clamping means 205.

The positioning means 204 is composed so that on both the sides of the down roll common stand frame 202, two pairs of breadth fittings 241, 241, 242, 242 are arranged against the front and rear and a butt fitting 243 is arranged against the rear end, each of these fittings being fixed on the base plate 201, and an oil-hydraulic cylinder 244 for pressing backward the down roll common stand frame 202 is arranged against the front and fixed on the base plate. Thus, the down roll common stand frame 202 will be positioned by inserting the same stand frame 202 between the breadth fittings 241, 241, 242, 242 and actuating the oil-hydraulic cylinder 244 to press the same stand frame 202 against the butt fitting 243.

The clamping means 205 is composed so that a semi-circular engaging projection 251 . . . is arranged

respectively at the front and rear on both sides of the down roll common stand frame 202, and an oil-hydraulic clamp 252 . . . is arranged against each of these engaging projections 251 . . . and mounted on the base plate 201. Thus, these oil-hydraulic clamps 252 . . . will be engaged with each of the engaging projections 251 by oil pressure.

In addition, reference numeral 206 represents a suspension ring provided at the front and rear of the down roll common stand frame 202 respectively.

The upper roll common stand frame 203 is supported on cylindrical legs 231, 232 arranged at the front and rear and fixed on the base plate 201, and includes a housing in the form of a horizontal frame 233 detachably mounted on the said legs. The upper rolls U . . . of the first to fourth center bending rolls 1CB, 2CB, 3CB and 4CB are mounted movably up and down on the said horizontal frame.

Each of the upper rolls U . . . is journaled on a lifting frame 235 which is lifted by a worm jack 234 . . . , and these lifting frames are engaged liftably and slidably on a pair of vertical sliding guides 236, 236 . . . , arranged on the horizontal frame 233 .

Two worm jacks 234 . . . are arranged for the upper roll U of the first center bending roll and one worm jack 234 for the upper rolls U . . . of the other center bending rolls, respectively on the horizontal frame 233, because the upper roll U of the first center bending roll 1CB is a driving roll and the lifting frame 235 is given a large load. These worm jacks 234 . . . will be driven by reversible reduction motors 237

On the horizontal frame 233, there are arranged one oil-hydraulic cylinder 238 for the lifting frame 235 of the first center bending roll 1CB, and two air cylinders 239 . . . for each of the other lifting frames 235, respectively, wherein upward force is applied to the lifting frames, thereby eliminating play of the worm jacks 234.

A positioning means 207 and a clamping means 208 are further installed between the legs 231, 232 and the horizontal frame 233.

The positioning means 207 is composed so that butt fittings 271 . . . are provided at the right end of the top surfaces of both the front and rear legs 231, 232 and at the right and left rears of the top surfaces of the rear legs 232, and oil-hydraulic cylinders 272, 272 for pressing the horizontal frame 233 right are provided at the left end of the top surfaces of both the front and rear legs 231, 232, and oil-hydraulic cylinders 273, 273 for pressing the horizontal frame 232 backward at the right and left front ends of the top surfaces of the rear legs 232, respectively. Thus, the horizontal frame 233 will be set at a predetermined position by pressing the same frame 233 into contact with the butt fittings 271 . . . by these oil-hydraulic cylinders.

The clamping means 208 comprises fastening bolts 281 . . . , each directed backward, which are mounted at the right and left front ends of the top surfaces of both the front and rear legs 231, 232, respectively, whereby

the horizontal frame 233 set at the predetermined position can be fastened and fixed.

Due to the above mentioned construction, the following procedure may be preferably taken for the exchange of rolls in the first to the fourth center bending rolls 1CB, 2CB, 3CB and 4CB.

I. In the upper roll common stand frame 203, all the fastening bolts 281 . . . which constitute the clamping means 208, are loosened, all the oil-hydraulic cylinder 272, 272, 273, 273 of the positioning means 207 are retreated, and the horizontal frame 233 is removed together with all the upper rolls U . . . by a crane.

II. In the down roll common stand frame 202, all the oil-hydraulic clamps 252 . . . of the clamping means 205 are retreated for disengagement, the oil-hydraulic cylinder 244 of the positioning means 204 is retreated, and the down roll common stand frame 202 is removed together with all the down rolls D . . . by a crane.

III. A down roll common stand frame 202 in which new down rolls D . . . are mounted is incorporated by a crane so as to be inserted between the breadth fittings 241, 241, 242, 242 of the positioning means 204, and pressed against the butt fitting 243 by elongating the oil-hydraulic cylinder 244, and then it is engaged with the engaging projections 251 . . . by advancing all the oil-hydraulic clamps 252 . . . which constitute the clamping means 205. At that time, each of the down rolls D . . . is adjusted in height by the shim adjustment and the control of the oil-hydraulic jacks 223, 223 . . .

IV. The horizontal frame 233 of an upper roll common stand frame 203 in which new upper rolls U . . . are mounted is incorporated by a crane so as to be placed on the legs 231, 232, all the oil-hydraulic cylinders 272, 272, 273, 273 of the positioning means 207 are advanced to press the horizontal frame 233 into contact with all the butt fittings 271 . . ., and then all the fastening bolts 281 . . . of the clamping means 208 are fastened to fix the horizontal frame 233 at a predetermined position. Furthermore, each of the worm jacks 234 . . . is actuated by the reversible reduction motors 237 . . . to adjust the height of each lifting frame 235 . . . and each upper roll U . . ., and at the same time, the oil-hydraulic cylinder 238 and air cylinders 239 . . . are actuated to eliminate play thereof.

Experiments were carried out and the following results were obtained.

(1) Size of a pipe to be produced, changed:
the outside diameter of pipe 60.5 mm → 31.8 mm

(2) Forming rolls subjected to the roll exchange:
the first to fourth center bending rolls

(3) Experimental results (compared with the prior art):

① Exchanging time of the stand:

Prior art:	including the adjusting time: 15(min/set) x 4 (set) = 60 (min)
Present invention:	Adjustment can be pre-set in off-line
Upper roll :	5 (min)
Down roll :	5 (min) Total: 10 (min)

② Fitting accuracy:

Prior art:	Accuracy in the center inserting direction less than ± 0.2 (min)
Present invention:	Accuracy in the center inserting direction less than ± 0.05 (min)

According to the present invention, it is possible to exchange several stages of forming rolls at a stroke by the exchange of the common stand frame in either case of the upper or down rolls, and to decrease the labor and time required for the roll exchange remarkably so that the suspension time of the line can be shortened sharply, leading to a reduction of cost.

Furthermore, it is possible to improve the fitting accuracy and to carry out adjustment easily and precisely so that the quality of the products can be improved.

The bottom guide roll arranged in the last zone of the cage roll forming zone between the fourth centre bending roll and the first fin pass roll as shown in Fig.6 and Fig.21, will be described.

A bottom guide roll stand 60 is arranged midway between the right and left cage roll stands 24, 24 placed on a base plate.

In the right and left cage roll stands 24, 24, three cage rolls CR . . . are arranged above each of the stand bodies placed on the base plate.

The bottom guide roll stand 60 is made up by a stand body between the stand bodies of the said right and left cage roll stands 24, 24, and by further arranging, above the said base plate, two bottom guide rolls BGR . . . in order along the line (See : Fig.6) and journaling each of these bottom guide rolls on a pair of bearings placed on the base plate.

(B) Edge bending roll

The construction of the edge bending roll EB will now be described.

At first, Fig.28 to Fig.30 will be described. Down roll 1 is split right and left, (1a, 1b) and is mounted on the outer periphery of a shaft 2 so that the space 7 between both these split down rolls (1a, 1b) is adjustable. Each of

the right and left split down rolls 1a, 1b is in the form of a stepped roll having two large and small steps in which the inner face side has the smaller outer diameter and the outer face side has the larger outer diameter, wherein on these respective steps of different outer diameter, concavely curved peripheral surfaces 3a, 3b having radii of curvature RB-1 and RB-2 different from each other are provided on the portions thereof opposite to the edge of the strip, respectively. In the illustrated example, RB-1 is for a small-diametered pipe and RB-2 is for a large-diametered one.

The forming of the strip 4 will be carried out at a predetermined pass line height. Since the respective steps of the said down roll are different in outside diameter, the shaft 2 is provided so that its height is adjustable, in order that the roll surface at each step can be accorded to its pass line height. When the down roll is driven, a transmission gear must be attached in order that the speed of the roll surface can be kept constant in spite of the difference in outside diameter of the respective steps.

The upper roll 36 is also in the form of upper rolls split right and left (36a, 36b) and each split roll is journaled by a roll holder 16 (See: Fig.31). The space between the roll holders is also adjustable. In such a manner as shown in Fig.28, wherein the upper roll 36a is inclined in the position 36c shown by a dotted line and the upper roll 36b is in the position 36d shown by a dotted line, respectively, the upper roll is made to be capable of being inclined in the breadth direction of the strip 4 by way of the upper roll holder, whereby the operation face of the roll surface of the upper roll can be changed, and hence the upper roll can be set inclinedly, as shown in Fig.30.

In the convexly curved face portion of the upper roll, its cross-sectional profile is shaped in such a way that two sectors having a radius of curvature RU-1 used for forming a thin strip (small in thickness) and a radius of curvature RU-2 used for forming a thick strip (large in thickness) are provided adjacently as shown in Fig.29 and Fig.30. The roll surface portion with the radius of curvature RU-1 may be used for strips of minimum thickness to the middle thickness, and the roll surface portion with the radius of curvature RU-2 may be used for strips of the middle thickness to the maximum thickness, respectively.

When a thin strip is formed, the roll surface portion with the radius of curvature RU-1 will be used by inclining the upper roll 36 by an inclining mechanism, as shown in Fig.30.

In addition, the center of inclination of the upper roll 36 will be set on a line normal to the end of the convexly curved face of the upper roll 36 (for instance, on the dotted line of Fig.29). This can facilitate the setting of the upper roll 36 and decrease the change in the gap between the upper and down rolls, even when the upper roll 36 is inclined.

When a thick strip is formed, the roll surface portion with the radius of curvature RU-2 will be used by erecting the upper roll 36 vertically, as shown in Fig.29. In the

case of a strip with a middle thickness, the upper roll 36 may be used by setting the angle of inclination α thereof at a proper value within a range which can be set. The upper roll can be drawn out for exchange from the roll holder when the RB-1 face portion for small outside diameter size and the RB-2 face portion for the large outside diameter size of the stepped down roll is used. As to the upper roll, in conclusion, there will be provided two rolls, one for the small outside diameter size, covering the minimum outside diameter to the middle outside diameter, and another for the large outside diameter size, covering the middle outside diameter to the maximum outside diameter.

Providing that steel pipes 22.22 mm ~ 60.5 mm in outside diameter are manufactured, for instance, the applicable ranges of use for the upper and down rolls in the edge bending roll EB will be divided into three ranges, ① 22.22 mm ~ 31.03 mm, ② 31.03 mm ~ 43.33 mm and ③ 43.33 mm ~ 60.5 mm, and in each of the upper roll and down roll, three sets of roll groups ①, ② and ③ will be provided. At that time, the down roll for ① has RB-1 of 22.22 mm ~ 26.63 mm and RB-2 of 26.64 mm ~ 31.03 mm, the down roll for ② has RB-1 of 31.04 mm ~ 37.18 mm and RB-2 of 37.19 mm ~ 43.33 mm, and the down roll for ③ has RB-1 of 43.34 mm ~ 51.92 mm and RB-2 of 51.93 mm ~ 60.5 mm.

It is a matter of course to provide a space-adjusting function between the abovementioned down roll and upper rolls.

For instance, the down rolls 1a, 1b and upper rolls 36a, 36b may be incorporated in such a machine as shown in Fig.31. Both ends of the down roll shaft 2 are supported in down roll journaling portions 50.

In the housing 40, a beam 6 is supported as a lift frame which is lifted by a worm jack 42 driven by a press motor 41, and the said beam 6 is pressed by an air cylinder 43 in the same direction as the direction of the forming reaction force.

Above the down rolls 1a, 1b, slide rails 5 are installed up and down in a direction meeting at right angles with the progressing direction of the strip 4. These slide rails are fixed on beam 6 as a lifting frame which is supported at both its right and left ends by the housing 40. The said beam 6 is movable up and down with respect to the housing 40 so that the clearance for holding the strip between the said down rolls and the upper rolls, hereinafter mentioned, can be adjusted.

A pair of right and left main apparatus bodies 10a and 10b are mounted on the slide rails 5. These main apparatus bodies 10a, 10b are mounted for sliding movement on the slide rails 5, and upper roll supporting frames 14 are hung at a given interval from the middle portion of the beam 6 in the longitudinal direction between the slide rails and the beams. Both the right and left ends of the upper roll supporting frame 14 have a threaded portion, and a shaft 13 having a screw-threaded portion engaged with the said threaded portion of the upper roll supporting frame 14 is journaled by the

fixing plate portions provided at both the right and left ends between both beams.

The shaft 13 is connected to a reversible motor 15 fixed on the fixing plate portion so that movement of the upper roll in the breadth direction is made possible.

The upper roll supporting frame has shafts 22, 26 provided in parallel to the progressing direction of the strip and the upper roll holder 16a also has similar shafts 24 provided thereon, and worm jacks 28 for giving a turning function for the upper roll and an AC reversible motor 33 for driving the same worm jacks are mounted on the said shaft 26. The rectilinear motion of the worm jacks 28 will be changed to the turning motion for the upper roll holder 16a and upper roll 36 by use of the said three shafts 22, 24 and 26 as fulcrums.

An air cylinder 30 is provided between the upper roll holder 16a and upper roll supporting frame 14, so that backlash existing in the upper roll and upper roll holder can be eliminated.

In addition, it is effective to support the strip 4 by a semi-split type of roll 1c arranged at the center of the down roll, in particular when the strip width is larger. This center roll 1c will be changed in accordance with the used step of the down roll.

Thus, the upper roll supporting apparatus of the edge bending roll EB shown in Fig.31 comprises having the beam 6 as a lifting frame which is supported liftably in the housing 40, an upper roll supporting frame 14 supported on the beam 6 movably in the breadth direction of the upper roll, upper roll holder 16a supported for inclination on the upper roll supporting frame 14, worm jack 28 provided between the upper roll supporting frame 14 and the upper roll holder 16a for inclining the upper roll holder 16a, an air cylinder 43 for pressing the beam 6 in the direction of the forming reaction force, and air cylinder 30 for pressing the upper roll holder 16a in the direction of the forming reaction force.

An assembly of the upper roll 36 and upper roll holder 16a is shown in Fig.32. The upper roll in this embodiment is incorporated in the upper roll holder 16a in such a structure as shown in Fig.32, in which the roll change will be carried out by releasing the fastening nuts 38, 39 on the outer face side, drawing out the roll shaft 34, and removing the roll shaft 34 from the upper roll 36.

According to the present invention, since a set of upper and down strip edge forming rolls is each made to be a pair of right and left split rolls and plural roll surface portions different in radius of curvature are provided respectively on these upper and down rolls, the edge forming of strips for different sizes of pipe can be carried out, in spite of the presence of one set of rolls, whereby the number of rolls required can be decreased and the labor for roll exchange can be reduced.

Since the upper roll holder is given the function of inclining the upper roll in the breadth direction of the strip and the roll surface of the upper roll is divided into two or more portions of different radius of curvature, furthermore, the accuracy and performance of the strip edge forming can be improved by positioning these portions

opposite to the roll surfaces of the down roll, whereby the outer peripheral surface of the upper roll can be effectively utilized as plural upper roll surface portions.

Since the roll surface of the upper roll is provided on one side only, thereby increasing the thickness of the upper roll holder frame, the rigidity of the holder can be increased and the reversing mechanism of the upper roll holder can be placed therein. In addition, since the mill rigidity of the whole of the upper rolls is increased, the turning fulcrums of the upper roll are as near to the pressing point of the rolls as possible and the elimination of backlash is realized, the accuracy of setting the upper roll can be improved and the accuracy and performance of forming the strip edges can be sharply improved, with the mill rigidity improved.

As one example of the abovementioned effects, in Table 1, there are shown the frequency of roll exchange in the prior art example 1 (Fig.34), the prior art example 2 (Japanese Patent Application No.317289/1989) and according to the present invention, in the forming of strips for pipes of outside diameters in a range of 31 ϕ mm~ 44 ϕ mm. Furthermore, the comparison of the strip edge bending characteristics in the case of Standard SUS 430 strips, 38.1 ϕ mm x 1.2 t mm and 2.5 t mm, are shown in Figs.33(a) and (b). From these results, it is obvious that in the frequency of roll exchange, the present invention stands comparison with the prior art example 2, and in the bending of strip edges, the present invention is much superior to the prior art examples in both the cases of thin strip 1.2 mmt and thick strip 2.5 mmt.

Table 1

	Frequency of Roll Exchange	
	upper roll	down roll
Prior Art 1	5	5
Prior Art 2	0	0
The Invention	1	0

(C) Split forming roll adjusting device

(C-1) A driven split forming roll adjusting device for the down roll of the edge bending roll, the upper and down rolls of the first center bending roll or the like.

The drawings in Fig.35 to Fig.40 show a center bending roll of the driving type according to the present invention.

In the drawings in Fig.35 to Fig.40, the designation UR represents an upper roll, and DR a down roll, respectively. These rolls are the same, except that the contours of the roll bodies (split forming rolls) are essentially different and their supporting frames are different. Both of these rolls will be described together.

The reference numeral 301 represents a main hollow shaft journaled at both its ends on supporting frames 302a and 302b, 303a, 303b : a pair of right

and left cylindrical roll holders put on the outer periphery of the middle portion of the said main shaft 301 so as to be slidable in the axial direction, 304a, 304b : position retaining means provided in the said roll holders, which will be stopped at an optional position, and 305a, 305b : a pair of right and left split forming rolls fixed at the inner ends of the said roll holders, respectively. In addition, the split forming rolls of the down roll have an auxiliary roll 305c for receiving a strip, midway between them.

The reference numeral 306 represents a gear fixed at one end of the main shaft, and 307 : a driving shaft journaled on the supporting frame 302a in the vicinity of one end of the main shaft, and having a gear 308 fixed on its middle portion for engagement with the said gear 306, whose end is to be mechanically connected with a universal joint (not shown) of a driving unit, respectively.

The reference numeral 309 represents an adjustment shaft mounted running through the inner hollow portion of the main shaft, 310a, 310b : a pair of threaded portions provided on both the ends of the said adjustment shafts, different in the threading direction, 311a, 311b : screw-movers screw-engaged on both the threaded portions so as to be capable of being screw-advanced or retreated thereon, respectively, 312a, 312b : transmission mechanisms placed between one screw-mover and one roll holder and between the other screw-mover and the other roll holder, respectively, 313 : a handle for manual rotation fixed at the other end of the adjustment shaft, and 314a, 314b : moving quantity indicating digital gauges provided between the supporting frames and the said transmission mechanisms, respectively.

The position retaining means 304a, 304b provided in the roll holders 303a, 303b each comprises an oil-hydraulic reduction mechanism for reducing their inner periphery, in which an annular oil pressure cell 341a, 341b running along the inner periphery of the roll holder 303a, 303b is provided in the inside of the peripheral wall of the roll holder very nearly to its inner peripheral surface, and composed so as to be supplied with an oil pressure from the outside, wherein by the same oil pressure, the thin reduction portion 342a, 342b constituting the inner wall of the oil pressure cell is expanded toward the main shaft 301 so as to be pressed against the periphery of the main shaft 301.

Each of the roll holders 303a, 303b has a flange 331a, 331b provided at its inner end, and the annular split forming rolls 305a, 305b are fixed on the said flanges by screws.

The adjustment shaft 309 is mounted at both ends of the main shaft 301 by way of bearings 391a, 391b so as to be rotatable, but immobile in the axial direction. In addition, precision screws may be preferably used for the screw-engagement of the

threaded portions 310a, 310b of the adjustment shaft 309 with the screw-movers 311a, 311b.

The transmission mechanisms 312a, 312b are composed so that cylindrical rotary joint 422a, 422b is mounted on the outer periphery of the outer end of each roll holder 303a, 303b by way of bearing 421a, 421b, so as to be rotatable, but immobile in the direction of the cylinder. A bar 423a, 423b projecting inward is put and fixed on the outer periphery of the screw-mover 311a, 311b, and a pair of supporting cylinders 321a, 321a, 321b, 321b are provided in parallel to the main shaft 301 on both the wings of each of the supporting frames 302a, 302b, and rods 424a, 424a, 424b, 424b are slidably provided running through each of these supporting cylinders, and one end of each of these rods is connected with both ends of the said bars 423a, 423a, 423b, 423b and the other end thereof with both wings of the said rotary joints 422a, 422a, 422b, 422b, respectively.

The rotary joints 422a, 422a, 422b, 422b have an oil passage 343a, 343b leading to the oil pressure cell 341a, 341b of the said oil-hydraulic reduction mechanism, and the said oil passages are connected with an oil hose (not shown) leading to an external oil-hydraulic device.

When the space between the split forming rolls 305a, 305b is adjusted, due to the abovementioned construction, the handle 313 may be rotated clockwise or counterclockwise, while watching the digital gauges 314a, 314b, after the oil pressure supplied to the position retaining means 304a, 304b, i.e., the oil-hydraulic reduction mechanisms is shut down. Then, the adjustment shaft 309 is rotated so that two screw-movers 311a, 311b screw-engaged with the threaded portions at both ends of the said adjustment shaft are screw-advanced or retreated mutually in the reverse directions. This screw-advance and retreat is transmitted to the roll holders 303a, 303b by way of the transmission mechanisms 312a, 312b, whereby the split forming rolls 305a, 305b approach or move away from each other.

After the space between the split forming rolls has been thus adjusted, oil pressure is supplied to the oil pressure cells 341a, 341b of the oil-hydraulic reduction mechanisms that are the position retaining means 304a, 304b, and by the same oil pressure, the thin reduction portions 342a, 342b are reduced so as to be constrained in position with respect to the main shaft 301.

In addition, the rotating force from the driving unit is transmitted to the driving shaft 307 by way of a universal joint (not shown), and further transmitted to the main shaft 301 by way of the gears 308, 306 and to the split forming rolls 305a, 305b by way of the roll holders 303a, 303b.

The following effects are obtained:

① Since a driving shaft connected with a driving unit is mounted in the vicinity of one end of a main shaft and a rotating force can be transmitted from the gear provided on the said driving shaft to the gear of the main shaft, it is possible to simplify the driving means, and to make its width (length) in the direction of the main shaft narrow (short) so that the driving means can be made more compact.

② It is possible not only to drive the main shaft and the split forming rolls, without any troubles, but also to adjust the roll space optionally, and further it is possible to make the whole of the forming roll more compact externally.

③ Since a position retaining means is provided between the main shaft and the roll holder, it is possible to restrict the runout of the outside diameter of the forming rolls, and as a result, these forming rolls are optimum for use in the manufacture of pipes from thin strip. Furthermore, since no load is transmitted to the threaded portion of the adjustment shaft by actuating the position retaining means, the same threaded portion is not damaged.

④ Since the adjustment of the roll space can be carried out very easily and in a short time only by operating the position retaining means and the handle, it is possible to decrease the suspension time of the pipe manufacturing line so that it is as short as possible.

⑤ It is possible to carry out the adjustment of the roll space highly accurately in the order of 1/100 mm, by using precision screws for the screw-engagement of the threaded portion of the adjustment shaft with the screw-movers and by detecting the moving quantity of the split forming rolls by the digital gauges.

⑥ It is possible to stabilize the quality of products.

(C-2) A non-driven split forming roll adjusting device for each upper roll of the second to the third center bending rolls or the like

The split roll of the illustrated example in Fig.41 and Fig.42 is an upper roll. The said upper roll and a down roll are merely different in the contour of their roll periphery, and the adjusting device can be applied to either of the upper and down split rolls.

The adjusting device will be further described with reference to the drawings.

The reference numeral 501 represents a main shaft, and this main shaft is formed by putting an outer cylinder shaft 503 rotatably on the outer periphery of a core shaft 502. Screw shafts 504, 504 which are mutually in a reverse screw relation are provided projectingly in the direction of their elongation from the centers of both the right and left end surfaces of the said core shaft 502. Nuts 505, 505 are screw-engaged on both these screw shafts 504,

504, and a handle 506 for rotation of the core shaft is attached on one of the screw shafts.

Both the right and left portions of the main shaft 501 are fixed on supporting plates 510, 510. In the case of an adjusting device for the down roll, as mentioned above, each supporting plate is constituted by a portion of a stand thereof, and for the upper roll, by a suspension plate hung down from a stand thereof, respectively.

A pair of right and left sliding sleeves 515, 515 are put on the middle portion of the main shaft between the supporting plates 510, 510 so as to be slidable in the axial direction. These sliding sleeves are made to be positionable at an optional position with respect to the outer cylinder shaft 503. In the illustrated example, namely, there are used oil-hydraulic reducible sleeves, wherein the oil pressure cell 516 provided on the inner peripheral side of each sleeve is pressurized to reduce the bore portion thereof so that the outer cylinder shaft 503 is clamped and fixed, or the oil pressure is decreased to restore the sleeve bore portion so that the sleeve becomes slidable again. For such a positioning mechanism, there can be adopted various other kinds of means.

The said sliding sleeves 515, 515 have split rolls 520, 520 put rotatably on their outer peripheries, respectively. A bearing 525 is made to intervene between the split roll and the sliding sleeve.

The said sliding sleeves 515, 515 and the abovementioned nuts 505, 505 are connected with each other by rods 530... Engaging plates 531, 532 protrude from the outer ends of the sliding sleeves and from the portions of the nuts, respectively, and the said rods are connected running through the supporting plates 510, 510 by way of these engaging plates.

The reference numerals 535, 535 represent linear sensors attached on the right and left supporting plates 510, 510, which serve to measure the lateral sliding quantity of the split rolls.

Precision screws such as ball screws may be preferably adopted for the said screw shafts and nuts, thereby eliminating backlash.

This embodiment has the abovementioned construction in which main shaft 501 is formed by putting outer cylinder shaft 503 rotatably on the outer periphery of core shaft 502, both the right and left portions of the main shaft 501 are fixed on supporting plates 510, 510, and screw shafts 504, 504 which are mutually in a reverse screw relation are provided projectingly from the centers of both the end surfaces of the said core shaft 502 and nuts 505, 505 are screw-engaged with the said screw shafts 504, 504, and the said nuts and a pair of right and left sliding sleeves 515, 515 put on the middle portion of the main shaft 501 so as to be slidable in the axial direction are connected with each other by rods 530. Merely by rotating handle 506 or the like attached

on the outer end of one of the screw shafts to approach or separate split rolls 520, 520 put on the said sliding sleeves the space between them can be easily adjusted. Furthermore, since a positioning mechanism is provided on the sliding sleeves 515, 515, respectively, the sliding sleeves and the split rolls put on the said sliding sleeves can be prevented from moving axially with respect to the main shaft 501.

(D) Upper roll actuating apparatus

Fig. 43 shows the upper roll actuating apparatus of the first and second fin pass rolls 1F and 2F, to which the backlash eliminating means is applied.

In Fig 43, the reference numeral 601 represents a pair of right and left stands, wherein first chocks 604, 604 supporting both the ends of a shaft 603 on which a down roll 602 is put are inserted in the lower portions of both these stands. Long holes are vertically provided in the upper portions of the stands above these first chocks, and second chocks 607, 607 supporting both the ends of a shaft 606 on which an upper roll 605 is put are inserted movably up and down in the lower portions of these long holes. Screw shafts 608, 608 are provided standingly through the insides of the stands from the top surfaces of the second chocks, and screw pipes 609, 609 are screw-engaged with the upper portions of the said screw shafts. The said screw pipe runs through the inside of the upper portion of the stand, with its upper portion projected upward out of the stand. A worm wheel 610 is put and fixed on the outer periphery of the lower portion of the said upward projected portion. The said worm wheel is surrounded by a box 611, and a retaining ring 612 put and fixed on the outer periphery of the upper portion of the screw pipe above the worm wheel is mounted on the box.

Worms (not shown) put on both sides of a worm shaft 613 are engaged with the said worm wheel, and they constitute worm jacks 614, 614. On the other hand, the worm jacks are made operable by a reversible motor 616 fixed on an arm 615 projected from the side portion of the stand.

Fluid-hydraulic cylinders 617, 617 are provided standingly from the said boxes 611, 611, and the lower ends of the piston rods 618, 618 of the said cylinders are connected with the upper ends of the screw shafts, whereby the upper roll 605 can be pulled up by way of the screw shafts 608, 608, with the lift of the pistons 619, 619.

Fig. 3 shows the upper roll actuating apparatus of the center bending rolls, to which the backlash eliminating means is applied. In this embodiment, there are separately provided down roll stands 21, 21 and upper roll stands (not shown). Brackets 626, 626 are provided standingly from the beams 23, 23 of the upper roll stand so as to bear a worm shaft 613, and one of the said brackets supports a reversible motor 616 so that the worm shaft is rotatable thereby. A worm jack 614 is provided

on the middle portion of the worm shaft 613, and placed on a bed plate 627 installed between the beams. A suspension base plate 628 is hung at the lower end of the screw shaft 608, and both ends of a shaft 606 on which upper rolls 14, 15 are put are journaled in the lower portions of arms 629, 629 hung down from both the right and left sides of the said base plate. The lower ends of fluid-hydraulic cylinders 617, 617 are fixed on both the right and left sides of the said bed plate 627, and the lower ends of the piston rods 618, 618 of the said cylinders are connected to both the right and left sides of the suspension base plate 628 so as to be capable of being pulled up.

Thus, in the case of Fig.43 the fluid-hydraulic cylinders 617, 617 are provided above the screw shaft 608, 608 for moving the upper roll put-on shaft 606 up and down, and the lower ends of the piston rods 618, 618 of the said cylinders are connected to the upper ends of the said screw shafts 608, 608, so that the upper roll 605 can be pulled up. Accordingly, there is no need of labor at the time when the stand on the movable side is pulled out for exchange of the upper roll as in the prior art.

In the case of Fig.3, both ends of the upper roll put-on shaft 606 are journaled in the arms 629, 629 of the suspension base plate 628, the suspension base plate is made movably up and down by the worm jack 614 and the same suspension base plate is made to be capable of being pulled up by the fluid-hydraulic cylinders separately provided. Accordingly, the fluid-hydraulic cylinders are not any obstacle to the exchange of the upper roll.

In the case where the pulling-up force of the fluid-hydraulic cylinder is set to be the tare of the pulling-up portions of the said cylinder + the strip forming load $\times 10 \sim 20 \%$, it is possible to carry out the elimination of backlash with a proper force.

(E) Cage rolls

Fig.44 to Fig.46 are illustrative views showing modifications of the cage rolls.

The cage rolls CR . . . , CR . . . serve to apply lateral pressure to the pipe edge-defining portions and pipe side-defining portions from both sides so that the boundaries between the pipe side-defining portions and pipe bottom-defining portion are gradually bent in excess of the finally formed circle and the pipe bottom-defining portion is gradually bent almost equally to the finally formed circle or slightly in excess. Accordingly, the pipe which has passed this bending step becomes oval in cross section.

As to the cage rolls CR . . . , however, a total of twelve rolls are arranged on both sides in four zones, three rolls in each zone, and as shown in Fig.44, they serve to properly apply forces to the pipe edge-defining portions and pipe side-defining portions from the out-sides so that the boundaries between the pipe side-defining portions and pipe bottom-defining portion and the pipe bottom-defining portion are bent in order, while restraining the spring-back. The three cage rolls in each

zone are mounted in one roll stand 723 . . . and in each of these roll stands, each cage roll has an advance and retreat control means 724, a lift control means 725 and an angle adjustment means 726 provided individually therein.

In the respective cage rolls CR . . . , CR . . . , their roll surface is shaped in the form of a concavely curved face whose radius of curvature is made 1.0 ~ 2.0 times as large as the maximum outside diameter of various sizes of pipe to be produced, to which these rolls are applicable.

By the abovementioned machine, welded steel pipes, 22.22~ 60.5 mm in outer diameter, were manufactured using strips, 0.8~ 3.0 mm in thickness. It was not found at all that the pipes were made flat in a stripe-pattern by the cage rolls CR . . . , CR

Since the roll surface of the cage roll is shaped in the form of a concavely curved face having a larger radius of curvature than that of a forming flower at its own position, the roll surface can be suitably fitted to the convexly curved face of the forming flower. Accordingly, it is possible to prevent the surface of the welded pipe from being made flat in a stripe-pattern, and it is further possible to make its appearance good, and to improve its quantity.

INDUSTRIAL APPLICABILITY

Using the welded steel pipe manufacturing machine and method for handling the same machine according to the present invention, as described above, it is possible to form strips stably and manufacture welded steel pipes superior in quality, with improved rate of operation, by virtue of the compact construction of the machine.

Claims

1. A machine for manufacturing a welded steel pipe by continuously roll forming a strip so that it is pipe shaped with its edges butted together to form a seam and welding the seam wherein the apparatus comprises a sequence of forming rolls extending along the strip as it passes through the apparatus, characterised in that the apparatus includes, in order from the upstream side of the apparatus to the downstream side of the apparatus, an edge bending roll (EB) for constraining the strip under pressure from its edge portions to the boundaries between its edge portions and its pipe side-defining portions to bend the strip, a first centre bending roll (1CB) for constraining the pipe side-defining portions under pressure to bend the pipe side-defining portions, second to fourth centre bending rolls (2CB, 3CB, 4CB) for constraining under pressure the strip from the boundaries between the pipe side-defining portions and the pipe bottom-defining portion to the pipe bottom-defining portion and for applying lateral pressure to the strip from both sides to bend the boundaries and the pipe bottom-defining portion,

and first and second fin pass rolls (1F, 2F) for further forming the strip under pressure, and additionally includes a plurality of cage rolls (CR) arranged on both sides of the centre bending rolls, wherein at least the edge bending roll (EB), the first centre bending roll (1CB) and the first and second fin pass rolls (1F, 2F) each has a driving means (27) provided thereon; all the upper rolls (U) of the first to the fourth centre bending rolls (1CB to 4CB) are mounted in one housing (23) (233), and all the down rolls (D) of the first to the fourth centre bending rolls or all the down rolls (D) of the second to fourth centre bending rolls are mounted on one common sub-base plate (50)(202).

2. A machine for manufacturing a welded steel pipe, as claimed in claim 1, in which both the upper roll (U) and the down roll (D) of the edge bending roll (EB) and of the first centre bending roll (1CB) are split rolls adjustable in width; the down roll (D) of each of the second to fourth centre bending rolls (2CB to 4CB) is a caliper-shaped one-part roll (16) appropriate to the maximum pipe diameter to be produced; the upper roll (U) of each of the second and third centre bending rolls (2CB, 3CB) is a split roll (17, 18) adjustable in width; the upper roll (U) of the fourth centre bending roll (4CB) is a one-part roll (28); and the cage rolls (CR) are mounted so as to be adjustable for slant advance and retreat.
3. A machine for manufacturing a welded steel pipe as claimed in claim 1 or 2 in which the housing (23)(233) is detachable whereby all the upper rolls of the first to the fourth centre bending rolls (1CB to 4CB) can be replaced at a stroke by exchanging said housing (23)(233).
4. A machine for manufacturing a welded steel pipe as claimed in claim 3, in which the housing is in the form of a horizontal frame (233) forming part of an upper roll common stand frame (203) having a positioning means (207) and a clamping means (208) provided thereon, the clamping means (208) being releasable to disengage the horizontal frame 233 during the upper roll replacement and the positioning means (207) being operable to locate a new horizontal frame at a predetermined position in which it can be fixed by the clamping means.
5. A machine for manufacturing a welded steel pipe as claimed in any preceding claim in which the common sub-base plate (50)(202) is detachable whereby all the down rolls (D) of the first to the fourth centre bending rolls or all the down rolls (D) of the second to the fourth centre bending rolls can be replaced at a stroke by exchanging said common sub-base plate (50)(202).

6. A machine for manufacturing a welded steel pipe, as claimed in claim 5, in which the common sub-base is in the form of a down roll common stand frame (202) for the first to the fourth centre bending rolls and having a positioning means (204) and a clamping means (205) provided thereon, the clamping means (205) being releasable to disengage the common stand frame during the down roll replacement and the positioning means (204) being operable to locate a new common stand frame at a predetermined position in which it can be fixed by the clamping means (205). 5 10
7. A machine for manufacturing a welded steel pipe, as claimed in any preceding claim in which in the first to the fourth centre bending rolls, each upper roll (U) is mounted on an upper roll common stand frame (203) and each down roll (D) is mounted on a down roll common stand frame (202) and the rolls are individually vertically adjustable with respect to their respective frames. 15 20
8. A machine for manufacturing a welded steel pipe as claimed in any preceding claim in which a bottom guide roll (BGR) for receiving the pipe is arranged in a section between the fourth centre bending roll and the first fin pass roll. 25
9. A machine for manufacturing a welded steel pipe as claimed in any preceding claim in which the edge bending roll (EB) comprises a down roll and an upper roll each in the form of split rolls symmetrical right and left, wherein said down roll (1a,1b) is a stepped roll having a plurality of steps of different outside diameter with the inner side having the smaller diameter whereby concavely curved portions having different radii of curvatures (RB-1, RB-2) are provided respectively for location opposite to the edges of the strip, and said upper roll (36a, 36b) has an outer peripheral profile of a contour such that only the outer face side of the roll has a convexly curved form, wherein the upper roll is journaled in a holder (16) so that its position can be changed to a position opposite to each step of the said stepped roll and so that the upper roll can be inclined in the breadth direction of the strip, the convexly curved form of the upper roll comprising a combination of sectors having different radii of curvature. 30 35 40 45
10. A machine for manufacturing a welded steel pipe as claimed in claim 9, in which the centre of inclination of the upper roll of the edge bending roll is set on a line normal to the end of the convexly curved face of the upper roll. 50
11. A machine for manufacturing a welded steel pipe, as claimed in claim 9 or 10 in which the upper roll of the edge bending roll has a supporting apparatus, which comprises a lift frame (6) supported liftably in a housing (40), an upper roll supporting frame (14) supported on the lift frame (6) movably in the breadth direction of the upper roll, the upper roll holder (16) inclinably supported on the upper roll supporting frame, a jack device (28) provided between the upper roll supporting frame and the upper roll holder for inclining the upper roll holder, a cylinder device (43) for pressing the lift frame (6) in the direction of the forming reaction force, and a cylinder device (30) for pressing the upper roll holder in the direction of the forming reaction force. 55
12. A machine for manufacturing a welded steel pipe as claimed in any preceding claim which has an adjusting device for one of the driven forming rolls wherein the driven forming roll, such as the down roll of the edge bonding roll and the upper and down rolls of the first centre bending roll, comprises left and right split rolls (305a, 305b) and the adjusting device includes a hollow main shaft (301) journaled at both its ends; a pair of left and right cylindrical roll holders (303a, 303b) slidably mounted in the axial direction on the outer periphery of the middle portion of said hollow main shaft and holding the left and right split rolls at their inner ends, respectively; position retaining means (304a, 304b) provided for retaining the roll holders at an optional position; a gear (306), for mechanically engaging the hollow main shaft to a driving unit, fixed at one end of the main shaft; a rotatably mounted adjustment shaft (309) running through the hollow main shaft; a pair of threaded portions (310a, 310b) having different thread directions provided at the ends of the adjustment shaft; screw-movers (311a, 311b) engaged for screw-advance and retreat with said threaded portions; transmission mechanisms (312a, 312b) for transmitting the said screw-advance and retreat provided between each screw-mover and roll holder; and a handle (313) for rotation provided on the said adjustment shaft.
13. A machine for manufacturing a welded steel pipe as claimed in any preceding claim which has an adjusting device for one of the non-driven forming rolls wherein the non-driven forming roll, such as each upper roll of the second to third centre bending rolls, comprises left and right split rolls (520) and the adjusting device includes a main shaft (501) formed by rotatably mounting an outer cylinder shaft (503) on the outer periphery of a core shaft (502) and having its ends fixed on supporting plates (510); a pair of left and right sliding sleeves (515) having a positioning mechanism and mounted on the middle portion of the main shaft (501) so as to be slidable in the axial direction and having the left and right split rolls rotatably mounted on their outer peripheries, respectively; screw shafts (504) which are mutually in a reverse screw relation provided projectingly from the ends of the said core shaft (502), respec-

tively; nuts (505) screw-engaged with the screw shafts; rods (530) connecting said sliding sleeves with each other; and a core shaft-rotating means (506) attached to the end of one of said screw shafts.

14. A machine for manufacturing a welded steel pipe as claimed in any preceding claim which includes an upper roll actuating apparatus, having a backlash eliminating means, for the edge bending roll, the centre bending rolls and the fin pass rolls, the apparatus comprising a shaft (606) on which the upper roll (605) is mounted; shocks (607) supporting both ends of the upper roll shaft (606); a screw shaft (608) upstanding from each of the shocks (607); the screw shafts being incorporated in worm jacks (614) provided at both end portions of a worm shaft (613) supported on a stand (601) whereby the upper roll can be moved up and down by means of said screw shafts (608) by rotation of said worm shaft (613) in both the normal and reverse directions; the apparatus also including a fluid-hydraulic cylinder (617) provided above each of said screw shafts (608) respectively and having piston rods (618) connected to the upper ends of the screw shafts (608) whereby the upper roll can be pulled up.
15. A machine for manufacturing a welded steel pipe as claimed in any preceding claim wherein the roll surface of the cage rolls is in the form of a concavely curved face having a larger radius of curvature than that of the pipe to be formed.

Patentansprüche

1. Maschine zum Herstellen eines geschweißten Stahlrohres durch kontinuierliches Bearbeiten eines Streifens mit Walzen, um ihm eine rohrförmige Gestalt zu geben, wobei seine Ränder zur Bildung einer Naht aneinander zur Anlage gebracht werden und die Naht verschweißt wird und wobei die Anordnung eine Serie von Verformungswalzen umfaßt, die sich entlang des sich durch die Anordnung bewegendes Streifens erstrecken, **dadurch gekennzeichnet, daß** die Anordnung in der Reihenfolge von der Zufuhrseite der Anordnung zur Ausgangsseite der Anordnung eine Randbiegewalze [EB] zum Zusammenpressen des Streifens unter Druck von seinen Randbereichen zu den Grenzen zwischen seinen Randbereichen und seinen die Rohrseiten definierenden Bereichen zum Biegen des Streifens, sowie eine erste Zentralbiegewalze [1CB] zum Zusammenpressen der die Rohrseiten definierenden Bereiche unter Druck zum Biegen der die Rohrseiten definierenden Bereiche, sowie zweite bis vierte Zentralbiegewalzen [2CB, 3CB, 4CB] zum Pressen des Streifens von den Grenzen zwischen den die Rohrseiten definierenden Bereichen und dem den Rohrboden definierenden Bereich zum den Rohrboden definierenden Bereich unter Druck

und zum Ausüben von seitlichem Druck auf den Streifen von beiden Seiten, um die Grenzen und den den Rohrboden definierenden Bereich zu biegen, und erste und zweite Finnenpassierwalzen [1F, 2F] zum weiteren Verformen des Streifens unter Druck umfaßt und daß die Anordnung überdies zusätzlich mehrere auf beiden Seiten der Zentralbiegewalzen angeordnete Käfigrollen [CR] umfaßt, wobei wenigstens die Randbiegewalze [EB], die erste Zentralbiegewalze [1CB] und die erste und zweite Finnenpassierwalzen [1F, 2F] jeweils eine daran angeordnete Antriebseinrichtung [27] aufweisen, alle oberen Walzen [U] der ersten bis vierten Zentralbiegewalzen [1CB-4CB] in einem Gehäuse [23][233] montiert sind, und alle unteren Walzen [D] der ersten bis vierten Zentralbiegewalzen oder alle unteren Walzen [D] der zweiten bis vierten Zentralbiegewalzen auf einer gemeinsamen Unter-Basis-Platte [50][202] montiert sind.

2. Maschine zum Herstellen eines geschweißten Stahlrohres nach Anspruch 1, **dadurch gekennzeichnet, daß** sowohl die obere Walze [U] wie auch die untere Walze [D] der Randbiegewalze [EB] und der ersten Zentralbiegewalze [1CB] in der Breite verstellbare geteilte Walzen sind, und daß die untere Walze [D] jeder der zweiten bis vierten Zentralbiegewalzen [2CB-4CB] eine angepaßte, einteilige Walze [16] ist, die für den maximal zu erzeugenden Rohrdurchmesser ausgebildet ist, daß die obere Walze [U] jeder der zweiten und dritten Zentralbiegewalzen [2CB, 3CB] eine geteilte, in der Breite verstellbare Walze [17, 18] ist, daß die obere Walze [U] der vierten Zentralbiegerolle [4CB] eine einteilige Walze [28] ist und daß die Käfigwalzen [CR] in einer für schräge Vorwärtsbewegung und Zurückbewegung angepaßten Weise montiert sind.
3. Maschine zum Herstellen eines geschweißten Stahlrohres nach einem der Ansprüche 1 oder 2, **dadurch gekennzeichnet, daß** das Gehäuse [23][233] abnehmbar ist, wodurch alle oberen Walzen der ersten bis vierten Zentralbiegewalzen [1CB-4CB] auf einmal durch Austausch besagten Gehäuses [23][233] ersetzt werden können.
4. Maschine zur Herstellung eines geschweißten Stahlrohres nach Anspruch 3, **dadurch gekennzeichnet, daß** das Gehäuse als horizontaler Rahmen [233] ausgebildet ist, der den oberen Teil eines gemeinsamen Standrahmens [203] für die oberen Walzen bildet, der eine Positioniereinrichtung [207] und eine darauf angeordnete Klemmeinrichtung [208] aufweist, wobei die Klemmeinrichtung [208] abnehmbar ist, um den horizontalen Rahmen [233] während des Ersetzens der oberen Walze zu lösen und daß durch die Positioniereinrichtung [207] ein neuer horizontaler Rahmen an einer vorgegebenen

Position positionierbar ist, in welcher er durch die Klemmeinrichtung fixierbar ist.

5. Maschine zum Herstellen eines geschweißten Stahlrohres nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** die gemeinsame Unter-Basis-Platte [50][202] abnehmbar ist, wodurch alle unteren Walzen [D] der ersten bis vierten Zentralbiegewalzen oder alle unteren Rollen [D] der zweiten bis vierten Zentralbiegewalzen auf einmal gemeinsam durch Auswechseln besagter Unter-Basis-Platte [50][202] ausgewechselt werden können. 5 10
6. Maschine zum Herstellen eines geschweißten Stahlrohres nach Anspruch 5, **dadurch gekennzeichnet, daß** die gemeinsame Unterbasis in Form eines Standrahmens für die unteren Rollen für die ersten bis vierten Zentralbiegewalzen ausgebildet ist und eine Positionseinrichtung [204] und eine daran angeordnete Klemmeinrichtung [205] vorgesehen ist, wobei die Klemmeinrichtung [205] zum Außereingriffbringen des gemeinsamen Standrahmens während des Ersetzens der unteren Rollen lösbar ist und durch die Positioniereinrichtung [204] ein neuer gemeinsamer Standrahmen an einer vorgegebenen Position positionierbar ist, in welcher er durch die Klemmeinrichtung [205] befestigbar ist. 15 20 25
7. Maschine zum Herstellen eines geschweißten Stahlrohres nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** in den ersten bis vierten Zentralbiegewalzen jede obere Walze [U] an einem gemeinsamen Standrahmen [203] für die oberen Walzen montiert ist und jede untere Walze [D] an einem gemeinsamen Standrahmen [202] für die unteren Walzen montiert ist und die Walzen einzeln bezüglich ihrer jeweiligen Rahmen vertikal justierbar sind. 30 35 40
8. Maschine zum Herstellen eines geschweißten Stahlrohres nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** eine untere Führungsrolle [BGR] zur Aufnahme des Rohres in einem Bereich zwischen der vierten Zentralbiegewalze und der ersten Finnenpassierwalze angeordnet ist. 45
9. Maschine zum Herstellen eines geschweißten Stahlrohres nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** die Randbiegewalze [EB] eine untere Walze und eine obere Walze umfaßt, die jeweils als geteilte Walzen ausgebildet sind, und deren rechter und linker Teil symmetrisch sind, und daß besagte untere Walze [1a, 1b] eine Stufenwalze ist, die mehrere Stufen verschiedenen Außendurchmessers aufweist, wobei die innere Seite den geringeren Durchmesser aufweist, wodurch konkav gekrümmte Teilstücke mit verschiedenen Krümmungsradien [RB-1, RB-2] jeweils in Positionen gegenüber den Rändern des Streifens angeordnet sind, daß besagte obere Walze [36a, 36b] ein äußeres Umfangsprofil mit einer derartigen Kontur aufweist, daß nur die äußere Seite der Walze eine konvex gekrümmte Form aufweist, wobei die obere Walze mit ihren Lagerzapfen in einer Halteeinrichtung [16] aufgenommen ist, so daß ihre Position gegen eine jeder Stufe der besagten Stufenwalze gegenüberliegende Position getauscht werden kann und so daß die obere Walze in Richtung der Breite des Streifens geneigt sein kann, wobei die konvex gekrümmte Form der oberen Walze eine Kombination von Sektoren mit verschiedenen Krümmungsradien umfaßt. 50 55
10. Maschine zur Herstellung eines geschweißten Stahlrohres nach Anspruch 9, **dadurch gekennzeichnet, daß** das Zentrum der Neigung der oberen Walze der Randbiegewalze sich auf einer Linie befindet, die normal zum Ende der konvex gekrümmten Fläche der oberen Walze ist.
11. Maschine zur Herstellung eines geschweißten Stahlrohres nach Anspruch 9 oder 10, **dadurch gekennzeichnet, daß** die obere Walze der Randbiegewalze eine Stützordnung aufweist, welche einen Heberahmen [6] aufweist, der anhebbar in einem Gehäuse [40] gelagert ist, sowie einen Tragrahmen [14] für die oberen Rollen, welcher am in Richtung der Breite der oberen Walze beweglichen Heberahmen [6] gelagert ist, wobei die Halterung [16] der oberen Walzen neigbar an dem die oberen Walzen tragenden Rahmen gelagert ist, wobei ein Niederhalter [28] zwischen dem die obere Walze tragenden Rahmen und dem Halter der oberen Walze zum Neigen des Halters der oberen Walze vorgesehen ist, wobei eine Zylinderanordnung [43] zum Drücken des Heberahmens [6] in Richtung der Verformungsreaktionskraft vorgesehen ist, sowie eine Zylinderanordnung [30] zum Anpressen des Halters der oberen Walze in Richtung der Verformungsreaktionskraft.
12. Maschine zur Herstellung eines geschweißten Stahlrohres nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** sie eine Justiereinrichtung für eine der angetriebenen Verformwalzen aufweist, wobei die angetriebene Verformwalze, wie die untere Walze der Randbiegewalze und die obere und unteren Walzen der ersten Zentralbiegewalze linke und rechte geteilte Walzen [305a, 305b] aufweisen und die Justiereinrichtung eine hohle Hauptwelle [301] umfaßt, die über Lagerzapfen an ihren Enden gelagert ist; ein Paar linker und rechter Halter [303a, 303b] für zylindrische Walzen, die in axialer Richtung auf dem äußeren Umfang des mittleren Teils der besagten hohlen Hauptwelle verschiebbar sind und die die linken und

rechten geteilten Walzen jeweils an ihren inneren Enden stützen, sowie Positionsfixiereinrichtungen [304a,304b], die vorgesehen sind, um die Walzenhalter an einer optionalen Position zu halten, ein Getriebe [306] zum mechanischen Ineingriffbringen der hohlen Hauptwelle mit einer Antriebseinheit, welches an einem Ende der Hauptwelle befestigt ist, eine rotierbar montierte Justierwelle [309], die sich durch die hohle Hauptwelle dreht; ein Paar Gewindeelemente [310a,310b] mit unterschiedlichen Gewinderichtungen, die an den Enden der Justierwelle angeordnet sind; Schraubenbewegungseinrichtungen [311a, 311b], die zum Vorwärts- und Rückwärtsbewegen besagter Schraubenelemente mit diesen in Eingriff sind; Übertragungsmechanismen [312a,312b] zum Übertragen der besagten Schraubenvorwärts- und -rückwärtsbewegung, welche zwischen jeder Schraubenbewegungseinrichtung und einem Walzenhalter vorgesehen sind; und ein zum Drehen an besagter Justierwelle vorgesehener Griff [313].

13. Maschine zur Herstellung eines geschweißten Stahlrohres nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** sie eine Justiereinrichtung für eine der nichtangetriebenen Verformwalzen aufweist, wobei die nichtangetriebene Verformwalze, wie jede obere Walze der zweiten bis dritten Zentralbiegewalzen, linke und rechte geteilte Walzen [520] umfaßt und die Justiereinrichtung eine Hauptwelle [501] umfaßt, die dadurch gebildet ist, daß eine äußere Zylinderwelle [503] am äußeren Umfang einer kegelförmigen Welle [502] montiert ist und ihre beiden Enden an tragenden Platten [510] fixiert sind; ein Paar linker und rechter Verschiebehülsen [515] mit einem Positioniermechanismus, die im mittleren Teil der Hauptwelle [501] montiert sind, sodaß sie in axialer Richtung verschiebbar sind und die jeweils linke und rechte geteilte, rotierbar an ihren äußeren Umfängen montierte Walzen aufweisen; Schraubenwellen [504], die bezüglich zueinander in einer entgegengesetzten Schraubrichtung von den Enden besagter Kegelwelle [502] hervorstehen, Nüsse [505], die in besagte Schraubenwellen eingeschraubt sind, Stangen [530], die besagte Verschiebehülsen miteinander verbinden, und eine für die Kegelwelle vorgesehene Rotationseinrichtung [506], die am Ende einer der besagten Schraubenwellen festgelegt ist.

14. Maschine zur Herstellung eines geschweißten Stahlrohres nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** sie für die Randbiegewalze, die Zentralbiegewalzen und die Finnenpassierwalzen eine Einrichtung zur Betätigung der oberen Welle mit einer Einrichtung zur Eliminierung von Spiel aufweist, wobei die Anordnung eine Welle [606] umfaßt, auf welcher die obere Welle [605] montiert ist, sowie Lagerungen [607], die beide

Enden der Welle [606] der oberen Walze tragen; eine Schraubenwelle [608], die von jedem der Lager [607] absteht, daß die Schraubenwellen in Niederhaltern [614] mit Schnecken aufgenommen sind, welche an beiden Endteilen einer Schneckenwelle [613] vorgesehen sind, die an einem Ständer [601] gelagert ist, wodurch die obere Walze durch besagte Schraubenwelle [608] durch Drehung besagter Schneckenwelle [613] in sowohl die normale wie auch die gegengesetzte Richtungen nach oben und nach unten bewegt werden kann, und daß die Anordnung auch einen Fluid-Hydraulik-Zylinder [617] umfaßt, der jeweils über den besagten Schraubenwellen [608] angeordnet ist und Kolbenstangen [618] umfaßt, die mit den oberen Enden der Schraubenwellen [608] verbunden sind, wodurch die obere Walze nach oben gezogen werden kann.

15. Maschine zur Herstellung eines geschweißten Stahlrohres nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** die Walzenoberfläche der Käfigrollen mit einer konkav gekrümmten Oberfläche ausgebildet ist, die einen größeren Krümmungsradius als das herzustellende Rohr aufweist.

Revendications

1. Une machine de fabrication d'un tube soudé en acier en formant par laminage en continu une bande afin qu'elle soit mise en forme de tube avec ses bords aboutés l'un avec l'autre pour former une jonction et en soudant la jonction, dans laquelle l'appareil comprend une séquence de cylindres de formage s'étendant le long de la bande alors qu'elle passe à travers l'appareil, caractérisé en ce que l'appareil comprend, dans l'ordre depuis le côté en amont de l'appareil jusqu'au côté en aval de l'appareil, un cylindre de cintrage de bord (EB) pour contraindre sous pression la bande à partir de ses parties de bord jusqu'aux limites entre ses parties de bord et ses parties de définition latérale de tube pour cintrer la bande, un premier cylindre de cintrage de centre (1CB) pour contraindre sous pression les parties de définition latérale de tube à cintrer les parties de définition latérale de tube, des second à quatrième cylindres de cintrage de centre (2CB, 3CB, 4CB) pour contraindre sous pression la bande à partir des limites entre les parties de définition latérale de tube et la partie de définition de fond de tube jusqu'à la partie de définition de fond de tube et pour appliquer une pression latérale à la bande à partir des deux côtés pour cintrer les limites et la partie de définition de fond de tube, et des premier et second cylindres de passe fine (1F, 2F) pour davantage former la bande sous pression, et comprend en plus une pluralité de cylindres de cage (CR) agencés sur les deux côtés des cylindres de cintrage de centre, dans lequel au moins le cylindre de cintrage de bord (EB),

le premier cylindre de cintrage de centre (1CB) et les premier et second cylindres de passe fine (1F, 2F) comportent chacun des moyens d'entraînement (27) prévus sur ces cylindres; tous les cylindres supérieurs (U) du premier au quatrième cylindres de cintrage de centre (1CB à 4CB) sont montés dans une cage (23) (233) et tous les cylindres inférieurs (D) du premier au quatrième cylindres de cintrage de centre ou tous les cylindres inférieurs (D) du second au quatrième cylindres de cintrage de centre sont montés sur une plaque d'embase commune (50) (202).

2. Une machine de fabrication d'un tube soudé en acier, selon la revendication 1, dans lequel le cylindre supérieur (U) et le cylindre inférieur (D) du cylindre de cintrage de bord (EB) et du premier cylindre de cintrage de centre (1CB) sont tous deux des cylindres fractionnés réglables en largeur; le cylindre inférieur (D) de chacun des second au quatrième cylindres de cintrage de centre (2CB à 4CB) est un cylindre simple en forme d'étrier (16) approprié au diamètre de tube maximum à fabriquer; le cylindre supérieur (U) de chacun des second et troisième cylindres de cintrage de centre (2CB, 3CB) est un cylindre fractionné (17, 18) réglable en largeur; le cylindre supérieur (U) du quatrième cylindre de cintrage de centre (4CB) est un cylindre simple (28); et les cylindres de cage (CR) sont montés de façon à être réglables pour une avance et un retrait inclinés.

3. Une machine de fabrication d'un tube soudé en acier selon la revendication 1 ou 2, dans lequel la cage (23) (233) est amovible de telle manière que tous les cylindres supérieurs des premier au quatrième cylindres de cintrage de centre (1CB à 4CB) puissent être remplacés d'un coup en échangeant ladite cage (23) (233).

4. Une machine de fabrication d'un tube soudé en acier selon la revendication 3, dans lequel la cage a la forme d'un cadre horizontal (233) faisant partie d'un bâti de support commun (203) des cylindres supérieurs ayant des moyens de positionnement (207) et des moyens de serrage (208) prévus sur ce cadre, les moyens de serrage (208) étant détachables pour dégager le cadre horizontal (233) pendant le remplacement des cylindres supérieurs et les moyens de positionnement (207) étant susceptibles d'être actionnés pour placer un nouveau cadre horizontal à une position prédéterminée dans laquelle il peut être fixé par les moyens de serrage.

5. Une machine de fabrication d'un tube soudé en acier selon l'une quelconque des revendications précédentes, dans lequel la plaque d'embase commune (50) (202) est détachable de telle manière que tous les cylindres inférieurs (D) des premier au quatrième

cylindres de cintrage de centre ou tous les cylindres inférieurs (D) des second à quatrième cylindres de cintrage de centre puissent être remplacés d'un coup en échangeant ladite plaque d'embase commune (50) (202).

6. Une machine de fabrication d'un tube soudé en acier, selon la revendication 5, dans lequel l'embase commune a la forme d'un bâti de support commun (202) des cylindres inférieurs pour les premier à quatrième cylindres de cintrage de centre et comporte des moyens de positionnement (204) et des moyens de serrage (205) prévus sur ce bâti, les moyens de serrage (205) étant détachables pour dégager le bâti de support commun pendant le remplacement des cylindres inférieurs et les moyens de positionnement (204) étant susceptibles d'être actionnés pour placer un nouveau bâti de support commun à une position prédéterminée dans laquelle il peut être fixé par les moyens de serrage (205).

7. Une machine de fabrication d'un tube soudé en acier, selon l'une quelconque des revendications précédentes dans lequel, dans les premier à quatrième cylindres de cintrage de centre, chaque cylindre supérieur (U) est monté sur un bâti de support commun (203) des cylindres supérieurs et chaque cylindre inférieur (D) est monté sur un bâti de support commun (202) des cylindres inférieurs et les cylindres sont réglables verticalement individuellement par rapport à leurs bâtis respectifs.

8. Une machine de fabrication d'un tube soudé en acier selon l'une quelconque des revendications précédentes, dans lequel un cylindre de guidage inférieur (BGR) pour recevoir le tube est agencé dans une section entre le quatrième cylindre de cintrage de centre et le premier cylindre de passe fine.

9. Une machine de fabrication d'un tube soudé en acier selon l'une quelconque des revendications précédentes, dans lequel le cylindre de cintrage de bord (EB) comprend un cylindre inférieur et un cylindre supérieur, chacun sous la forme de cylindres fractionnés symétriques droit et gauche, dans lequel ledit cylindre inférieur (1a, 1b) est un cylindre à gradins ayant une pluralité de gradins de diamètre extérieur différent, le côté intérieur ayant le plus petit diamètre de telle manière que des parties incurvées de manière concave ayant différents rayons de courbures (RB-1, RB-2) soient prévues respectivement pour être disposées en face des bords de la bande et que ledit cylindre supérieur (36a, 36b) présente un profil périphérique extérieur d'un contour tel que seul le côté extérieur de surface du cylindre ait une forme courbée de manière convexe, dans lequel le cylindre supérieur est tourilloné dans un support (16) afin que sa position puisse être modifiée vers

une position opposée à chaque gradin dudit cylindre à gradins et afin que le cylindre supérieur puisse être incliné dans la direction de la largeur de la bande, la forme incurvée de manière convexe du cylindre supérieur comprenant une combinaison de secteurs ayant différents rayons de courbure.

10. Une machine de fabrication d'un tube soudé en acier selon la revendication 9, dans lequel le centre d'inclinaison du cylindre supérieur du cylindre de cintrage de bord est fixé sur une ligne normale à l'extrémité de la surface incurvée de manière convexe du cylindre supérieur.

11. Une machine de fabrication d'un tube soudé en acier, selon la revendication 9 ou 10, dans lequel le cylindre supérieur du cylindre de cintrage de bord comporte un appareil de support, qui comprend un cadre de levage (6) supporté de manière susceptible d'être soulevée dans une cage (40), un bâti de support (14) de cylindre supérieur supporté sur le cadre de levage (6) de manière mobile dans la direction de la largeur du cylindre supérieur, le support (16) de cylindre supérieur supporté de manière inclinable sur le bâti de support de cylindre supérieur, un appareil de cric (28) prévu entre le bâti de support de cylindre supérieur et le support de cylindre supérieur pour incliner le support de cylindre supérieur, un vérin (43) pour presser le cadre de levage (6) dans la direction de la force de réaction de formage et un vérin (30) pour presser le support de cylindre supérieur dans la direction de la force de réaction de formage.

12. Une machine de fabrication d'un tube soudé en acier selon l'une quelconque des revendications précédentes, qui comporte un appareil de réglage pour l'un des cylindres de formage entraîné dans lequel le cylindre de formage entraîné, tel que le cylindre inférieur du cylindre de cintrage de bord et les cylindres inférieur et supérieur du premier cylindre de cintrage de centre, comprend des cylindres fractionnés gauche et droit (305a, 305b) et l'appareil de réglage comprend un arbre creux principal (301) tourillonné à ses deux extrémités; deux supports cylindriques de cylindre gauche et droit (303a, 303b) montés coulissants dans la direction axiale sur la périphérie extérieure de la partie centrale dudit arbre creux principal et maintenant respectivement les cylindres fractionnés gauche et droit à leurs extrémités intérieures; des moyens de retenue en position (304a, 304b) prévus pour retenir les supports de cylindres à une position optionnelle; une roue d'engrenage (306), pour mettre en prise mécaniquement l'arbre creux principal avec une unité motrice, fixée à une extrémité de l'arbre principal; un arbre de réglage (309) monté à rotation et passant à travers l'arbre creux principal; deux parties filetées (310a, 310b) ayant des sens de filetage différents et

prévues aux extrémités de l'arbre de réglage; des organes de déplacement à vis (311a, 311b) vissés pour une avance et un retrait à vis sur lesdites parties filetées; des mécanismes de transmission (312a, 312b) pour transmettre lesdits avance et retrait à vis prévus entre chaque organe de déplacement à vis et support de cylindre; et une poignée (313) de rotation prévue sur ledit arbre de réglage.

13. Une machine de fabrication d'un tube soudé en acier selon l'une quelconque des revendications précédentes, qui comporte un appareil de réglage pour l'un des cylindres de formage non entraînés, dans lequel le cylindre de formage non entraîné, tel que chaque cylindre supérieur des second à troisième cylindres de cintrage de centre, comprend des cylindres fractionnés gauche et droit (520) et l'appareil de réglage comprend un arbre principal (501) formé en montant de manière rotative un arbre extérieur de cylindre (503) sur la périphérie extérieure d'un arbre intérieur (502) et ayant ses extrémités fixées sur des plaques de support (510); deux manchons coulissants gauche et droite (515) ayant un mécanisme de positionnement et montés sur la partie médiane de l'arbre principal (501) afin d'être susceptible de coulisser dans la direction axiale et ayant les cylindres fractionnés gauche et droit montés respectivement à rotation sur leurs périphéries extérieures, des arbres ou tiges fileté(e)s (504) qui sont mutuellement dans une relation de pas inverse, prévus respectivement en saillie à partir des extrémités dudit arbre intérieur (502); des écrous (505) vissés sur les arbres ou tiges fileté(e)s; des barres (530) reliant l'un avec l'autre lesdits manchons coulissants; et des moyens d'entraînement (506) en rotation d'arbre intérieur fixés à l'extrémité de l'un desdits arbres ou tiges fileté(e)s.

14. Une machine de fabrication d'un tube soudé en acier selon l'une quelconque des revendications précédentes, qui comprend un appareil d'actionnement de cylindres supérieurs, ayant des moyens de suppression de jeu, pour le cylindre de cintrage de bord, pour les cylindres de cintrage de centre et pour les cylindres de passe fine, la machine comprenant un arbre (606) sur lequel le cylindre supérieur (605) est monté; des amortisseurs (607) supportant les deux extrémités de l'arbre (606) de cylindre supérieur; un arbre fileté (608) partant verticalement de chacun des amortisseurs (607); les arbres filetés étant incorporés dans des crics à vis (614) prévus aux deux parties d'extrémité d'un arbre de vis (613) supporté sur un support (601) de telle manière que le cylindre supérieur puisse être déplacé vers le haut et vers le bas au moyen desdits arbres filetés (608) par la rotation dudit arbre fileté (613) à la fois dans les directions normale et inverse; la machine comprenant également un vérin hydraulique à fluide (617) prévu respectivement au-dessus de chacun

desdits arbres filetés (608) et ayant des tiges de piston (618) reliées aux extrémités supérieures des arbres filetés (608) de telle manière que le cylindre supérieur puisse être tiré vers le haut.

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15. Une machine de fabrication d'un tube soudé en acier selon l'une quelconque des revendications précédentes, dans lequel la surface de cylindre des cylindres de cage a la forme d'une surface incurvée de manière concave présentant un plus grand rayon de courbure que celui du tube à former.

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FIG. 1

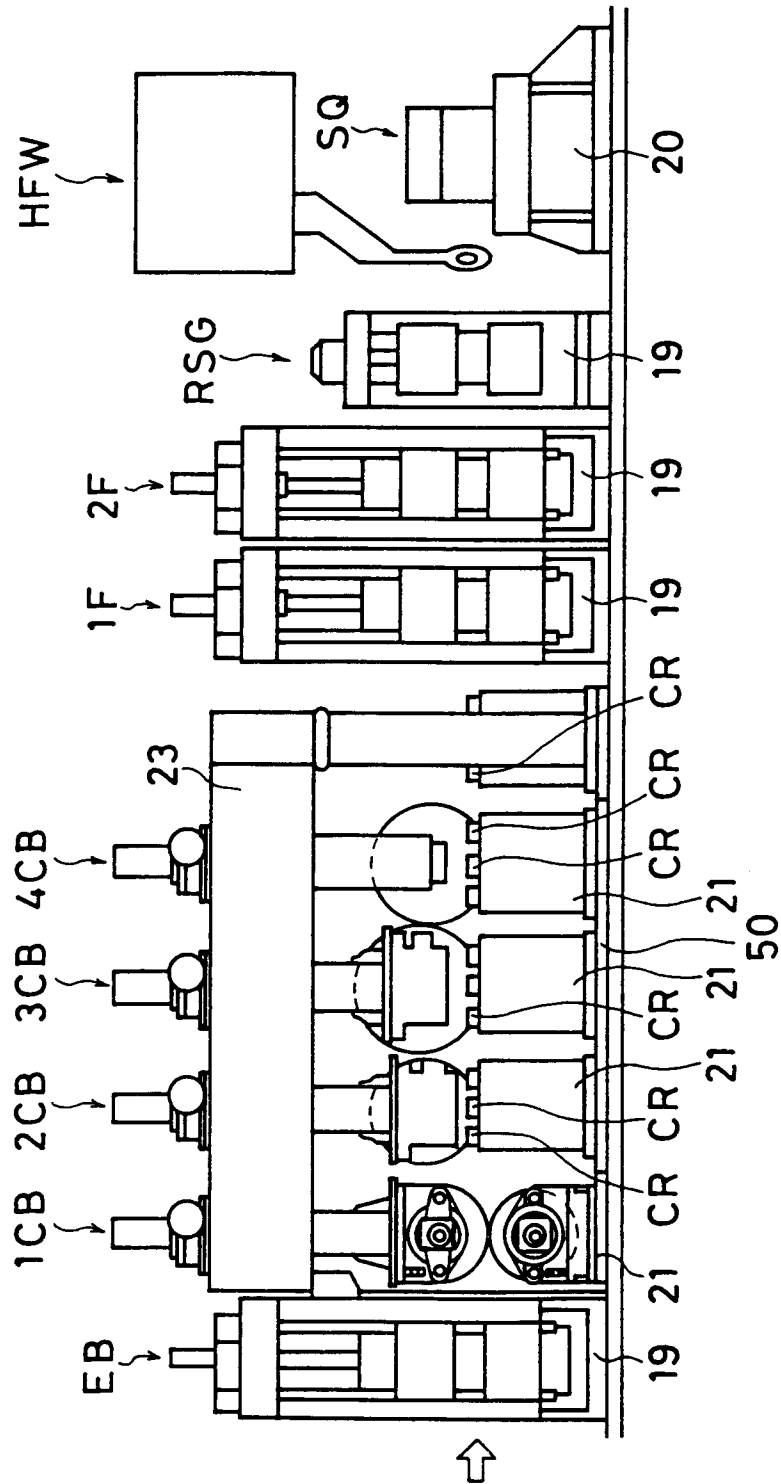


FIG. 2

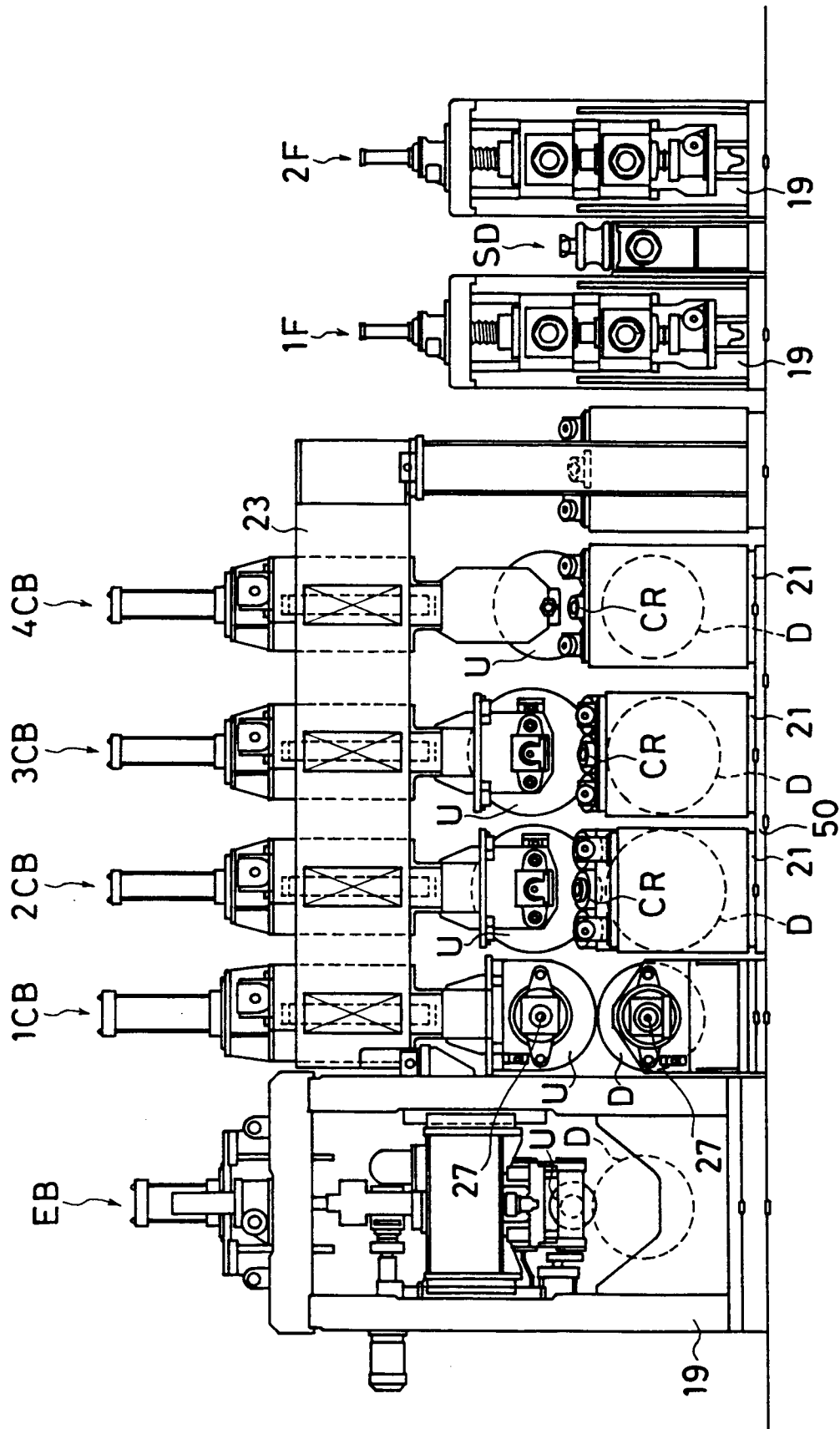


FIG. 3

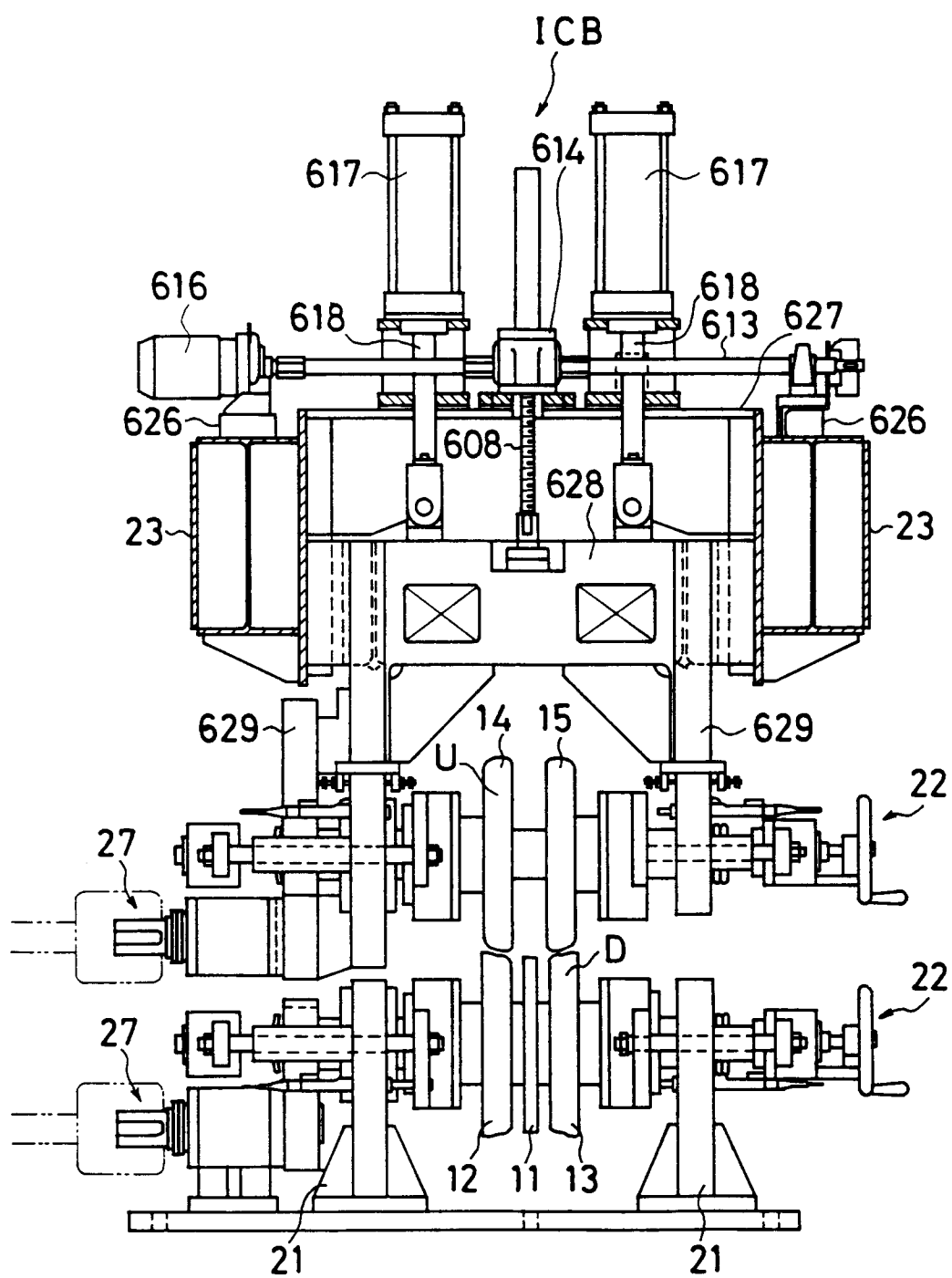


FIG. 4

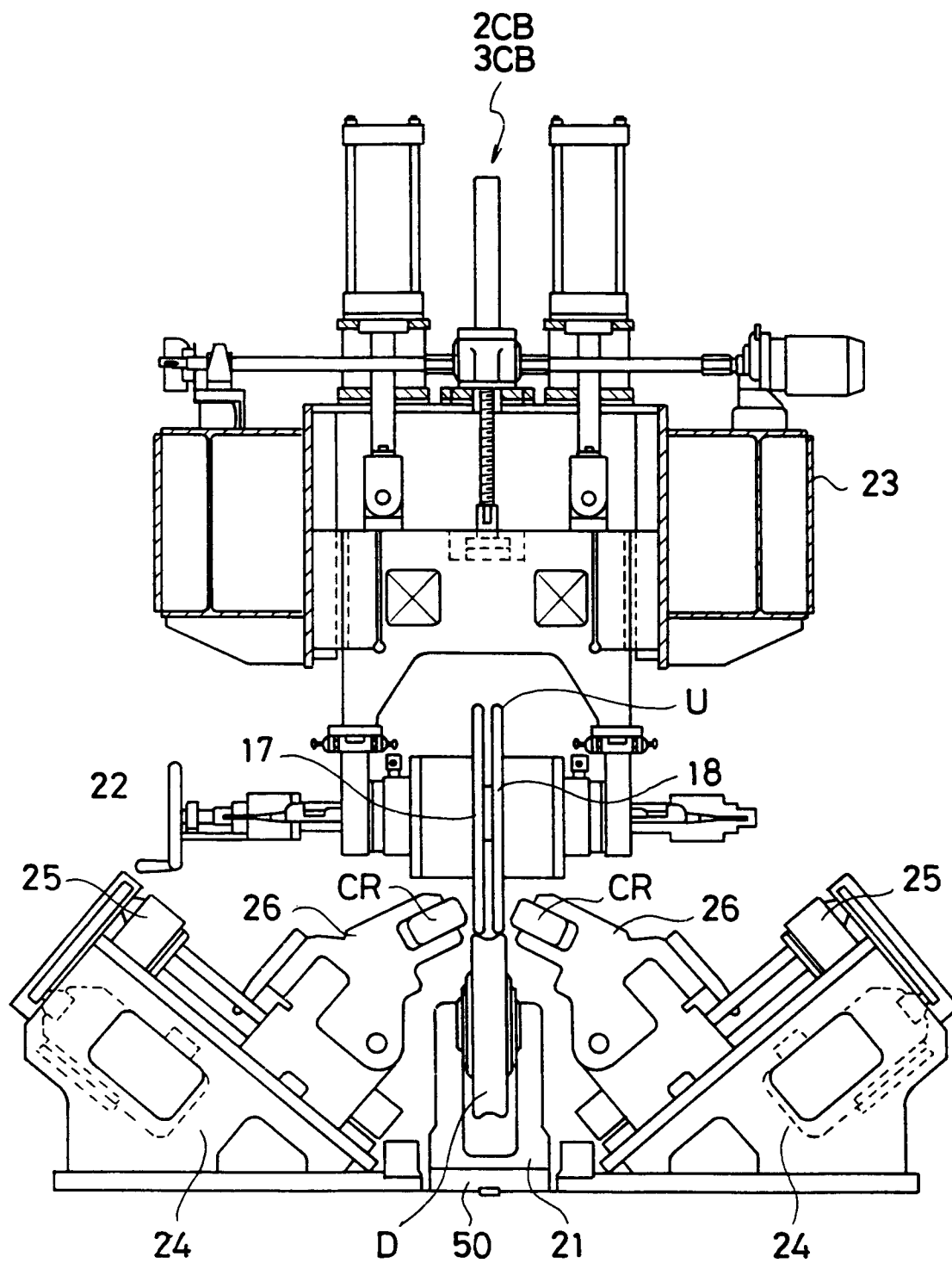


FIG. 5

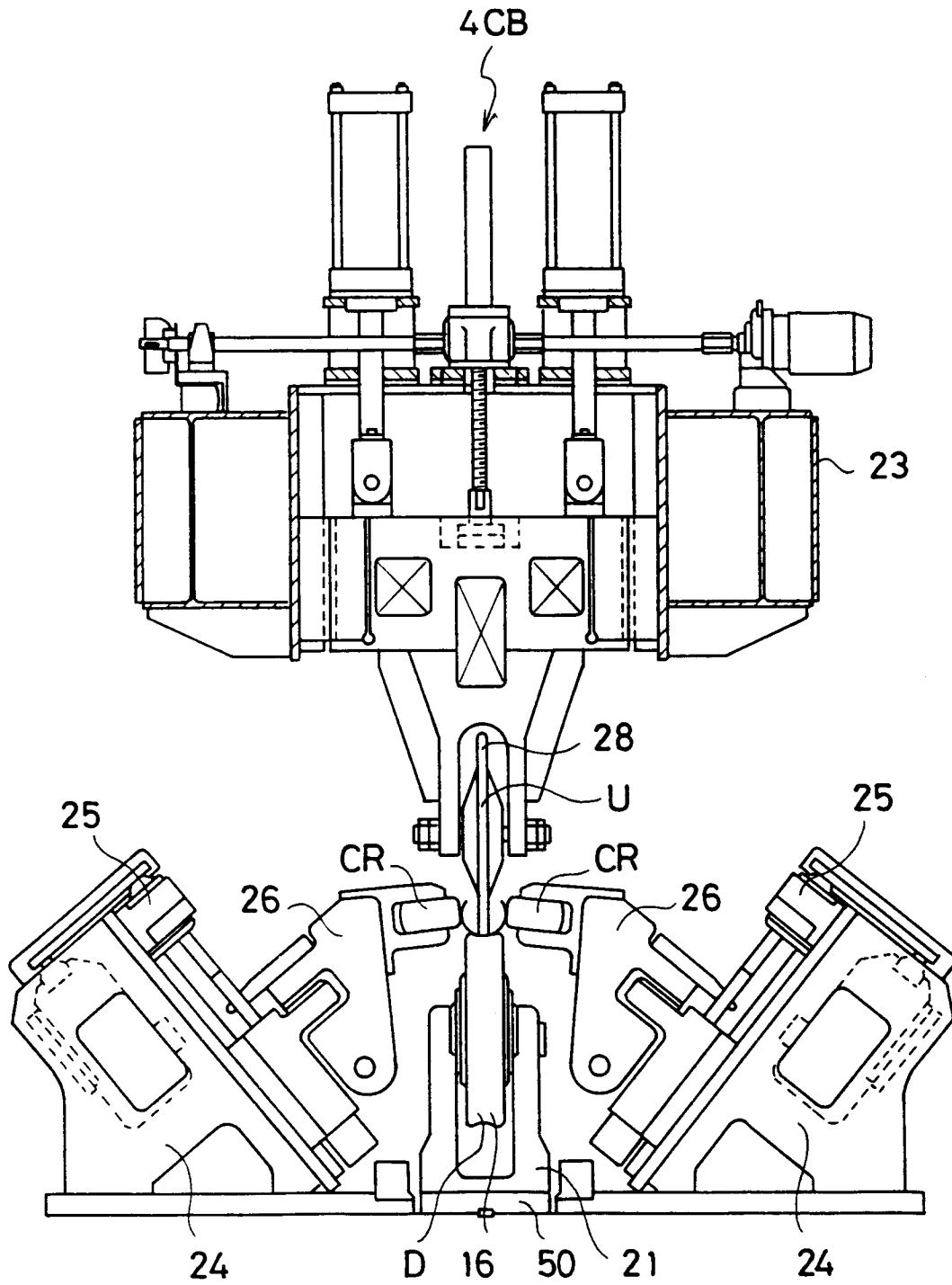


FIG. 6

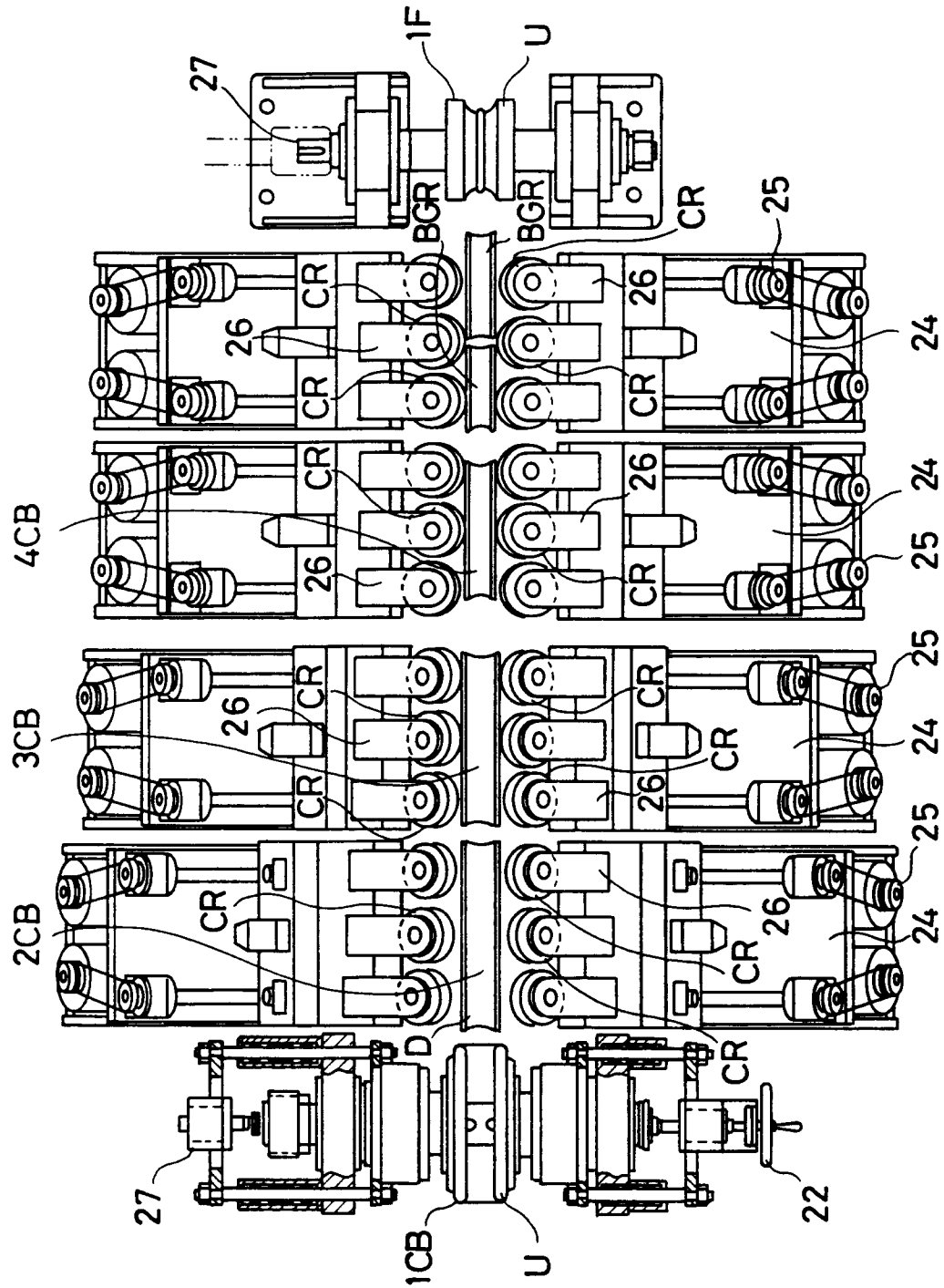


FIG. 7

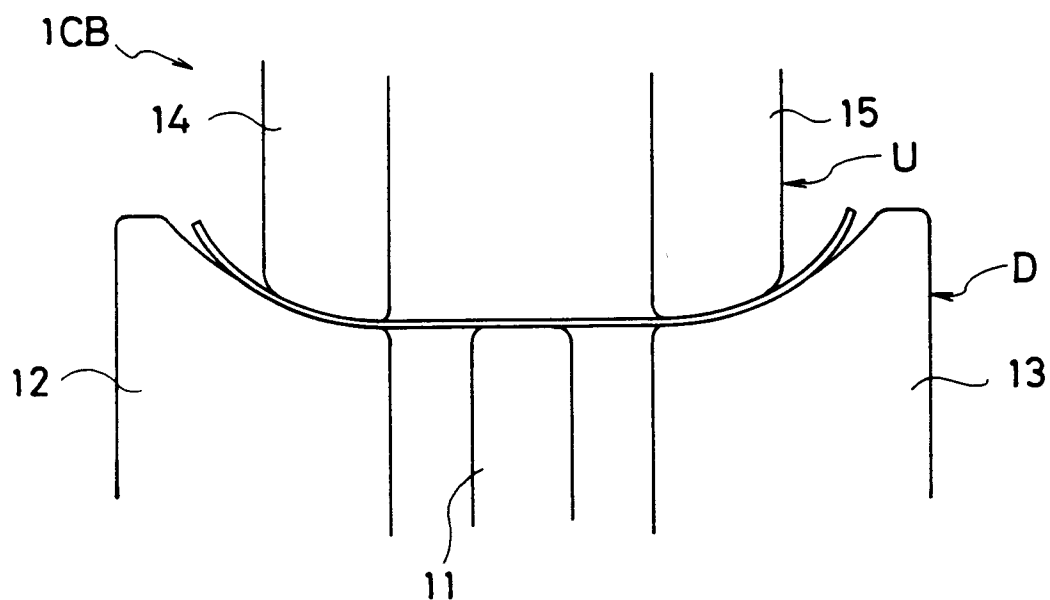


FIG. 8

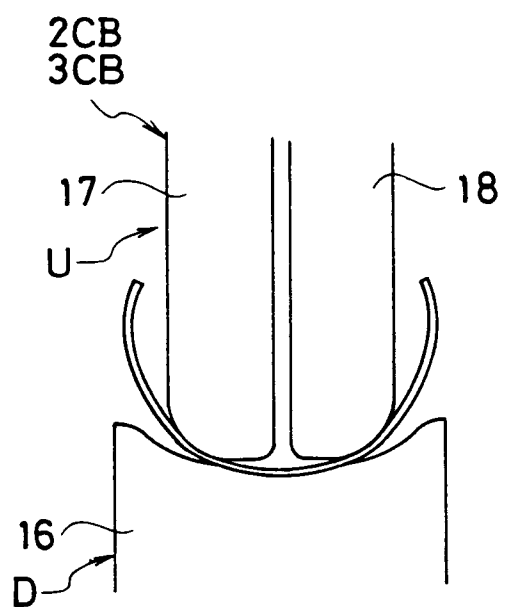


FIG. 9

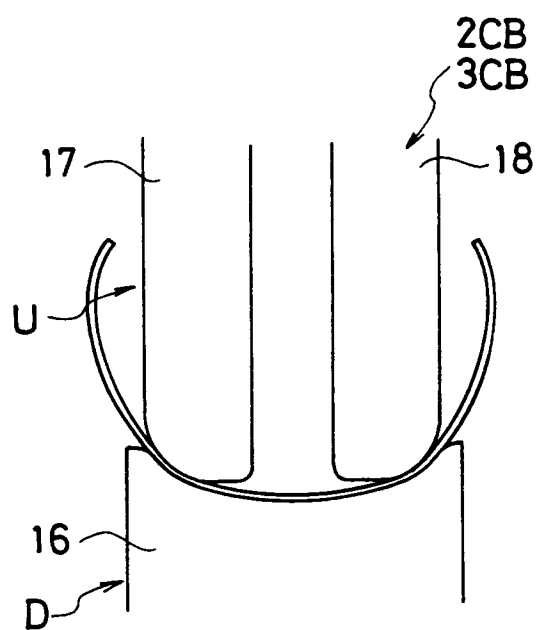


FIG.10

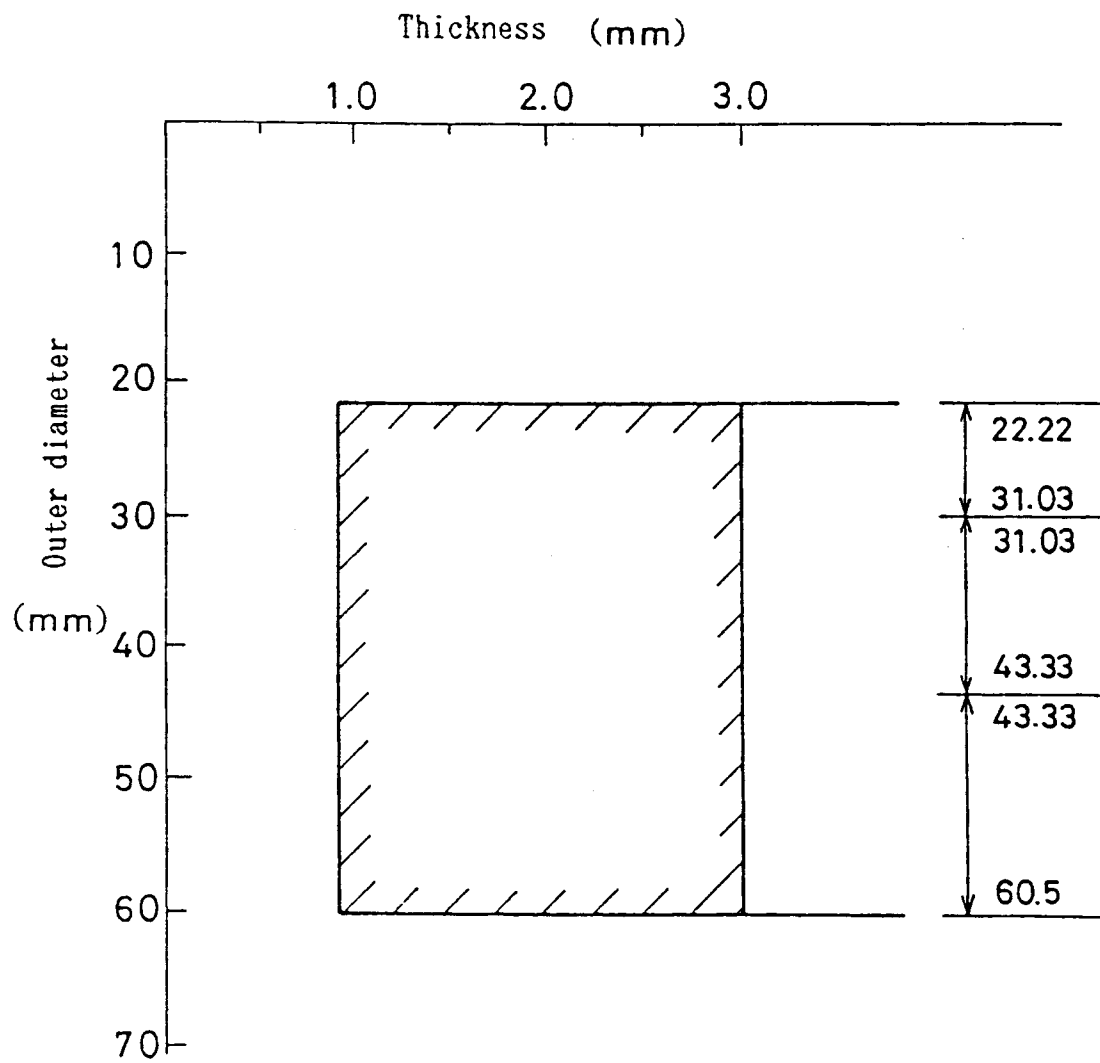


FIG. 11

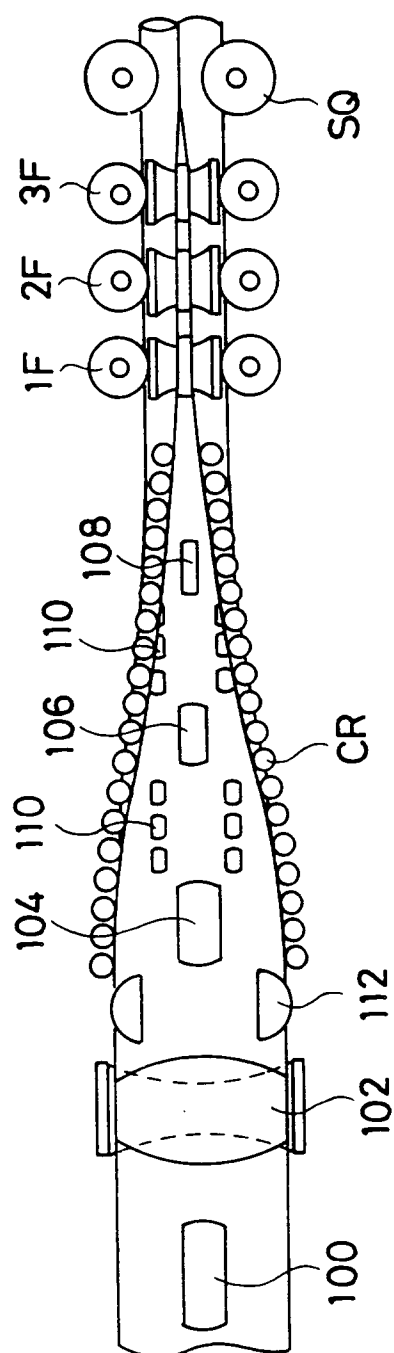


FIG.12

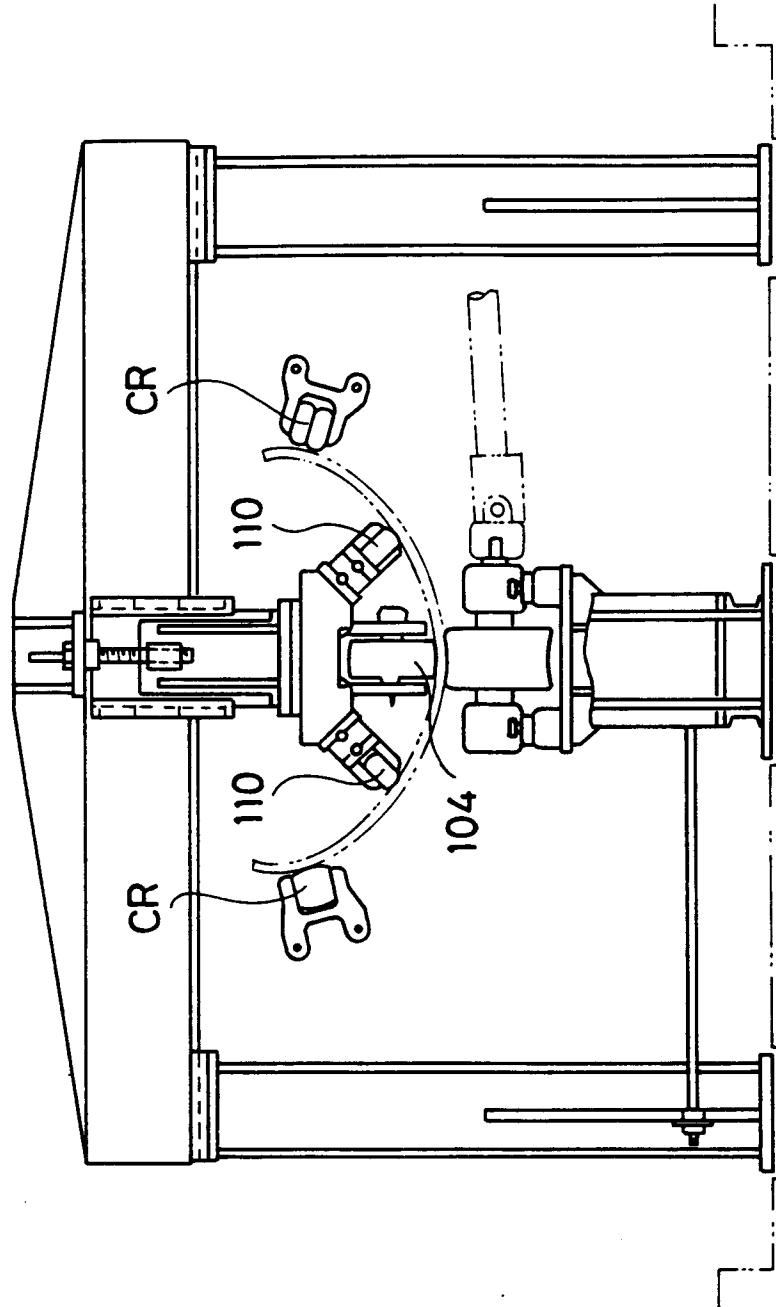


FIG. 13

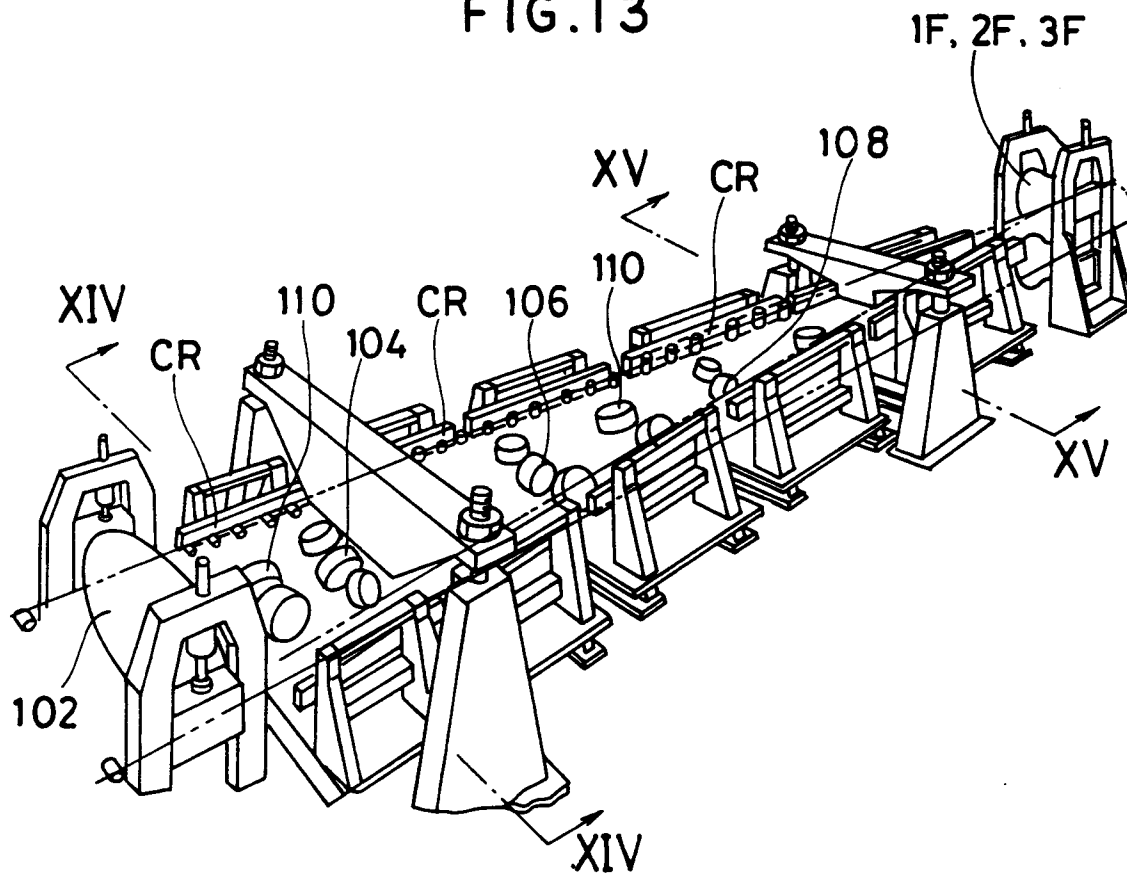


FIG. 14

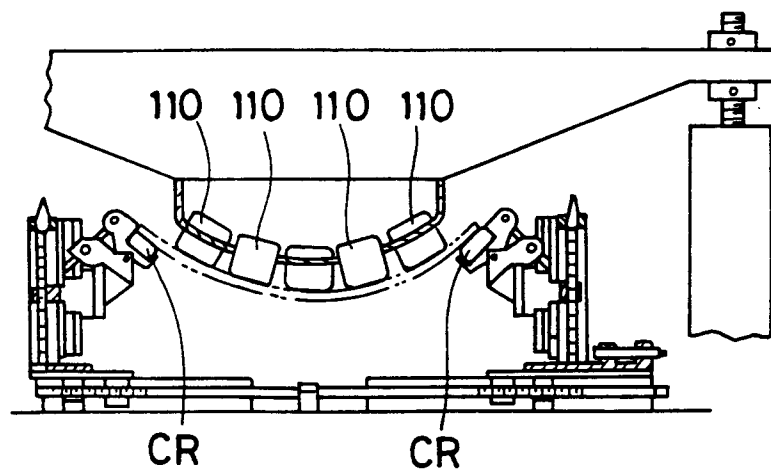


FIG.15

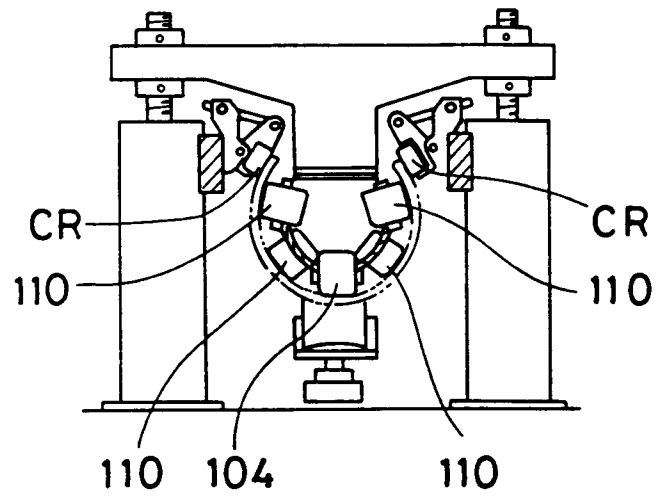


FIG.16

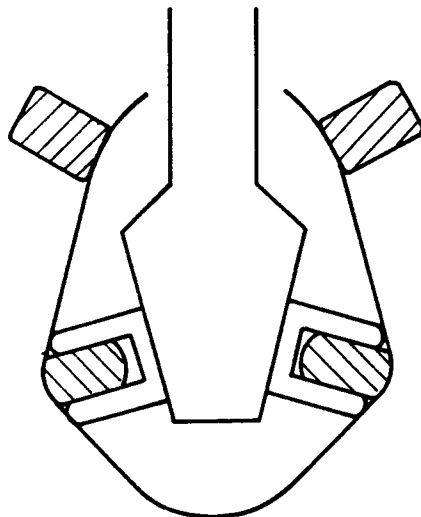


FIG.17

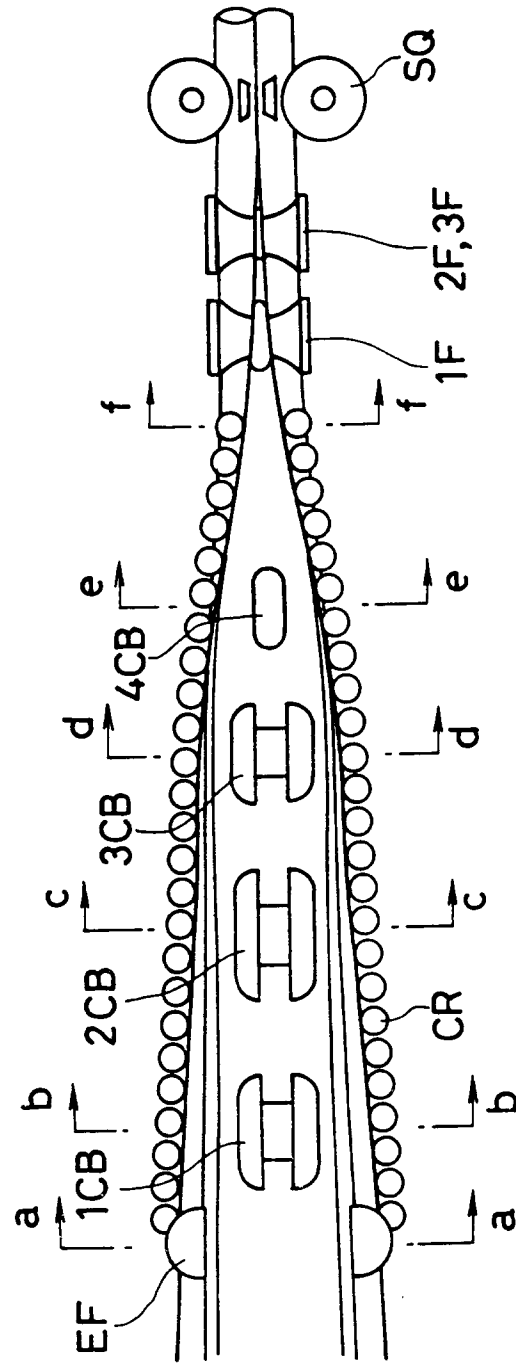


FIG.18

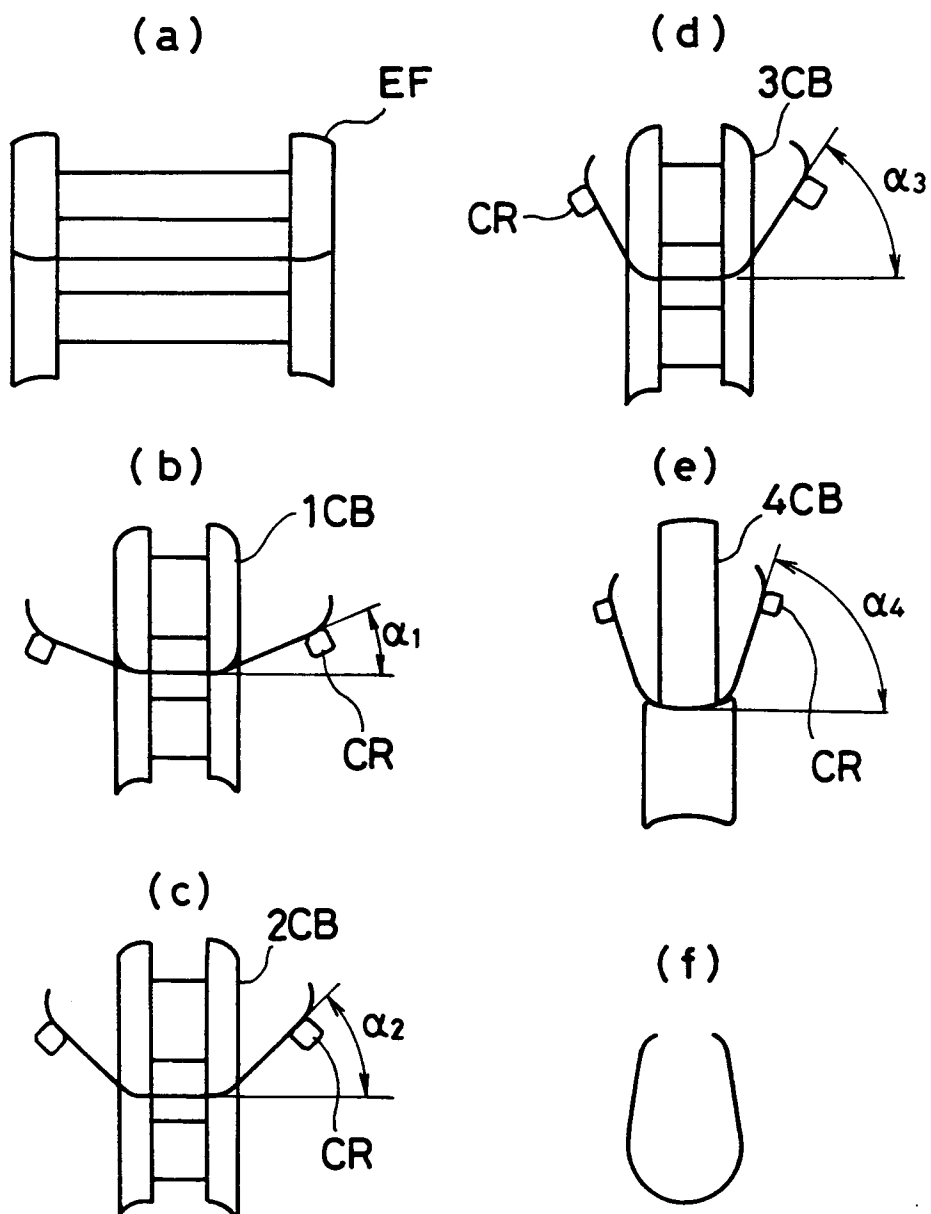


FIG. 20

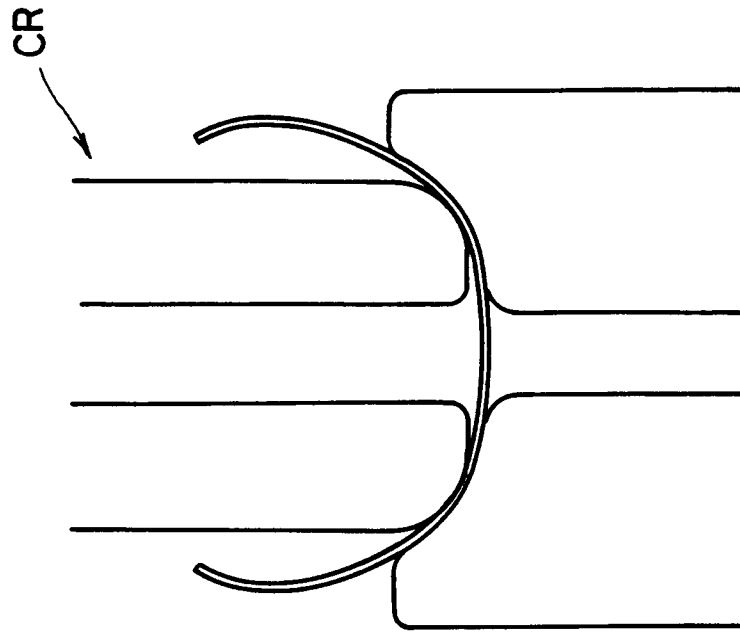


FIG. 19

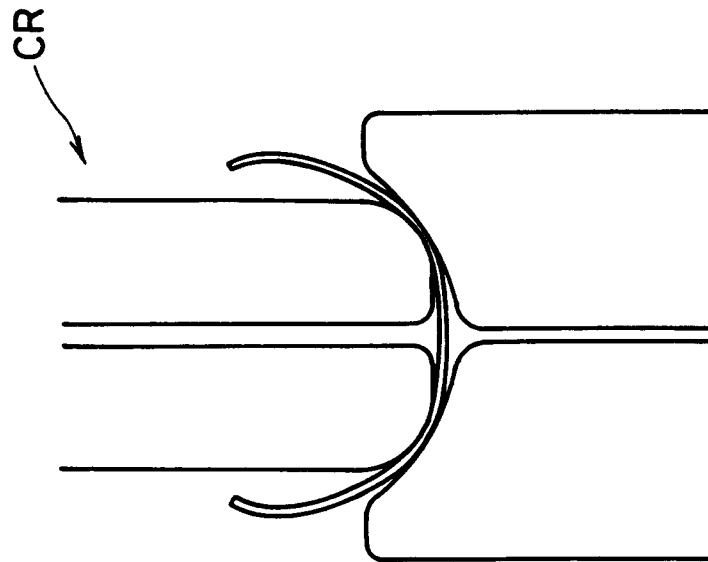


FIG.21

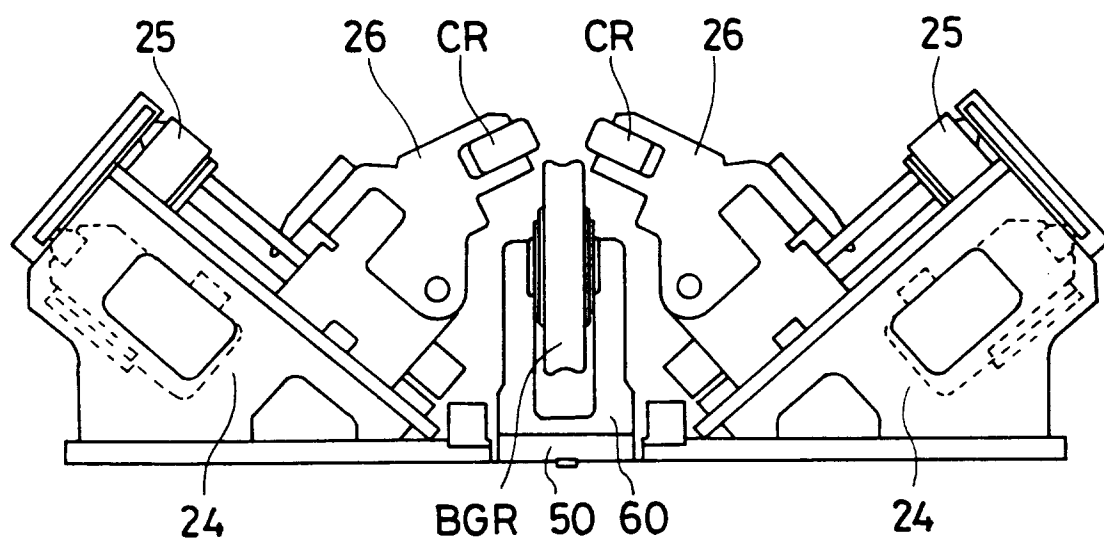


FIG.22

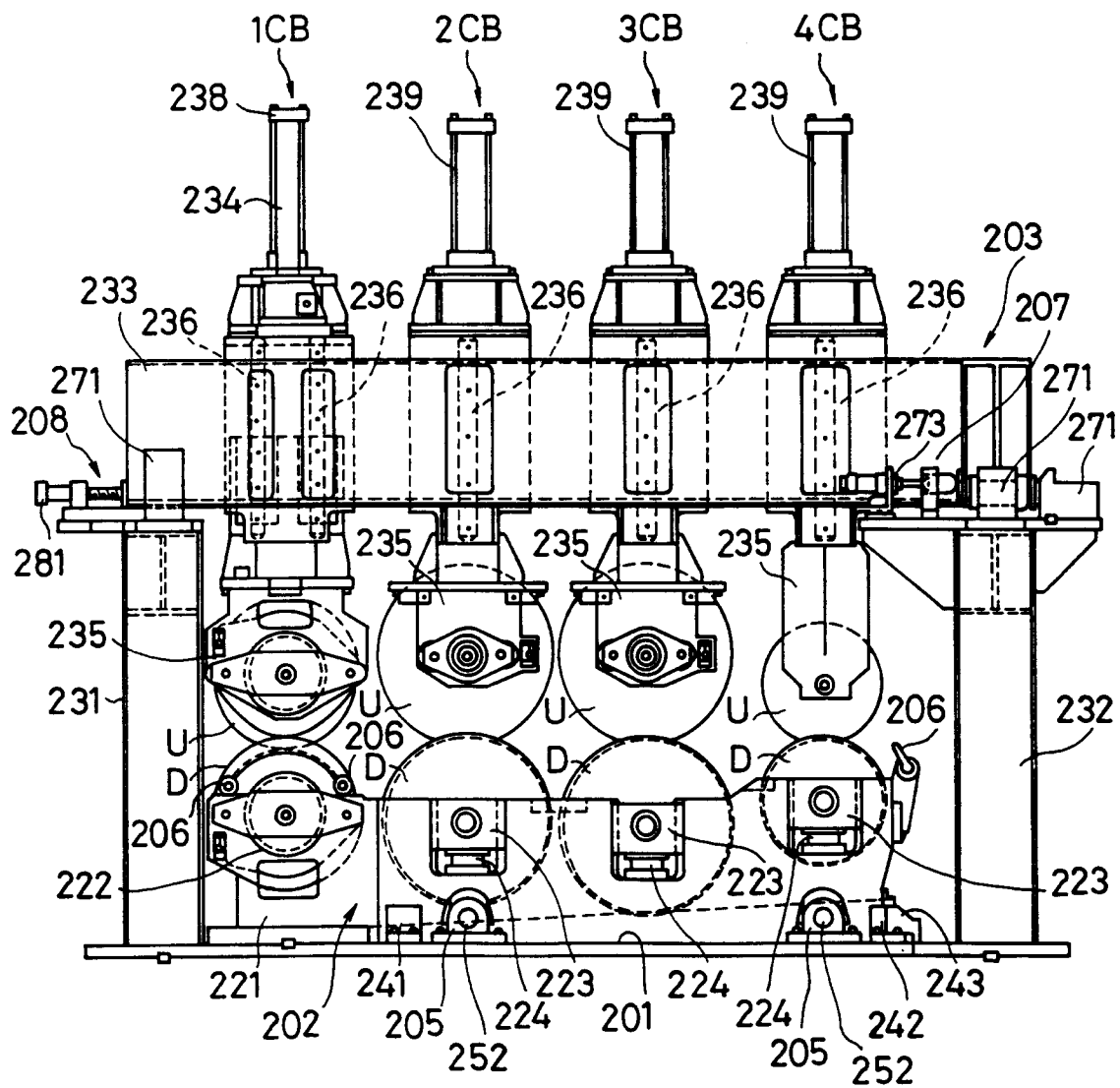


FIG. 23

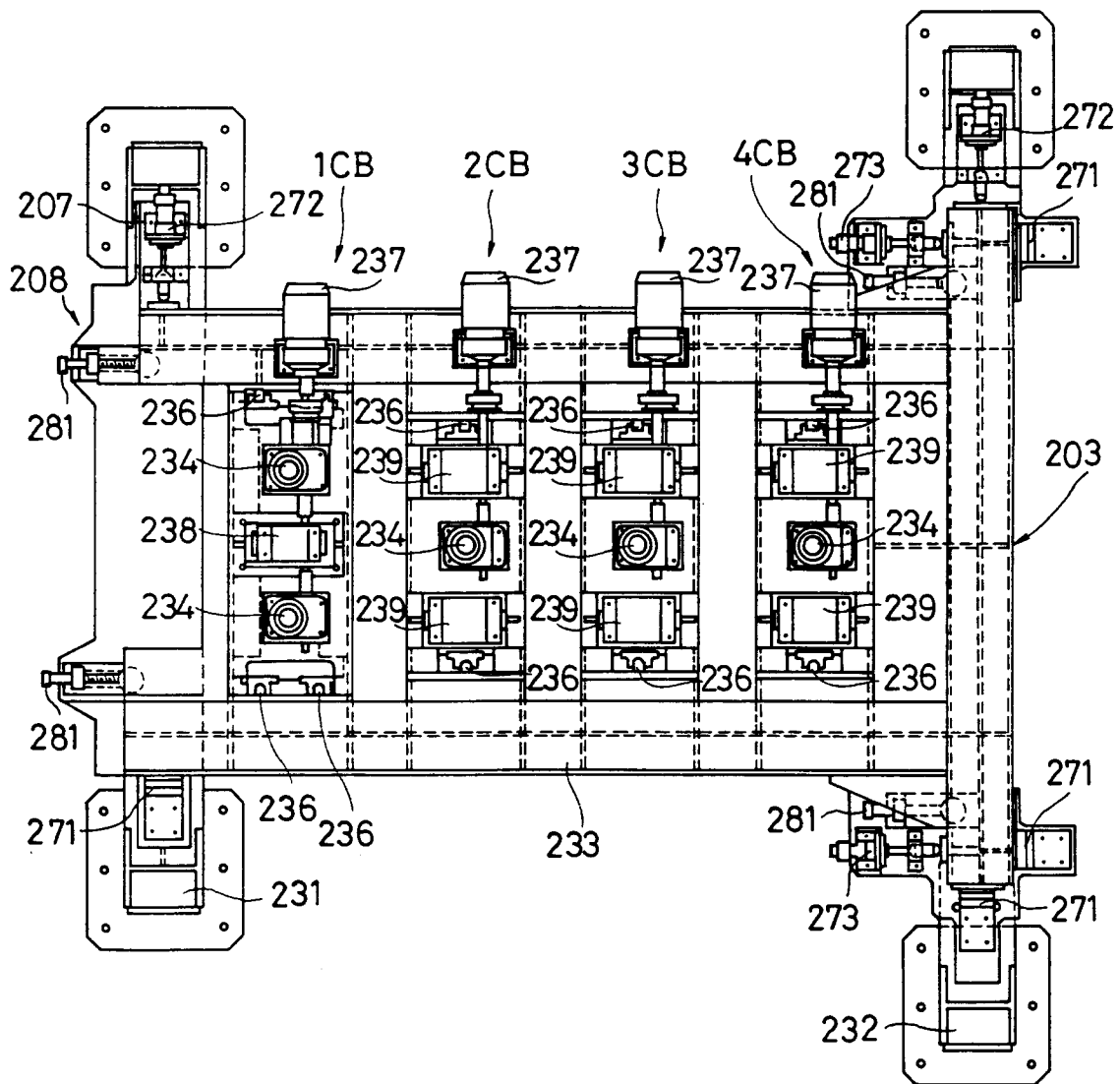


FIG. 24

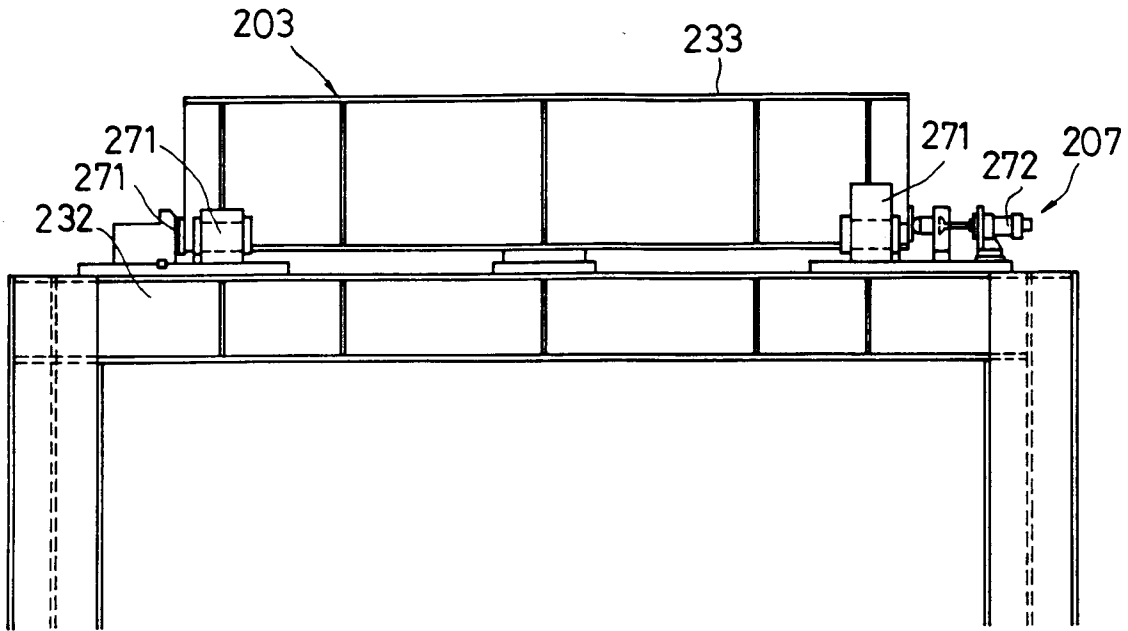


FIG. 25

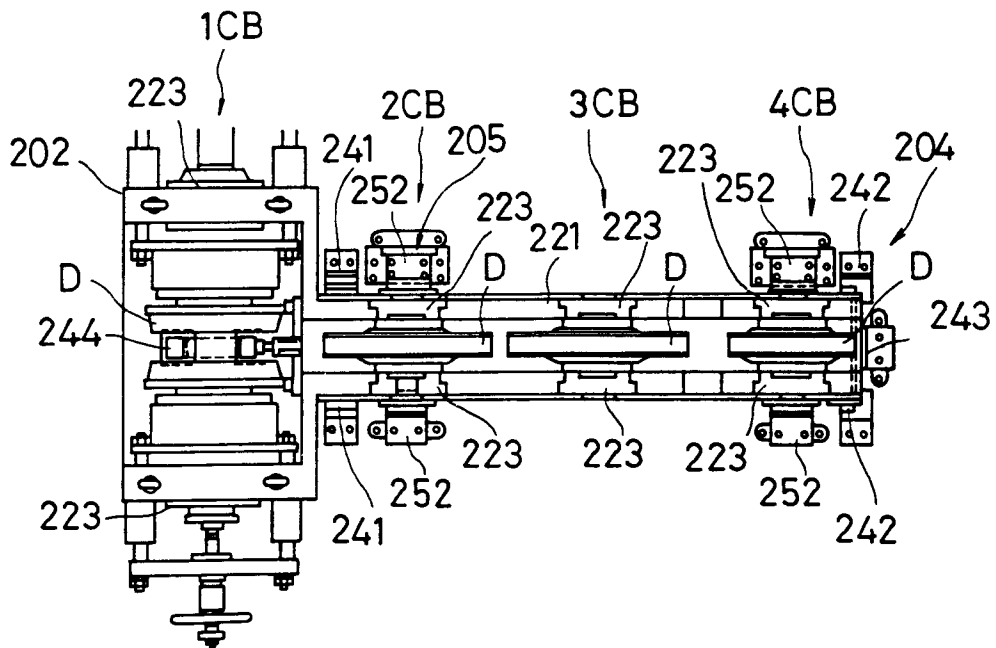


FIG. 26

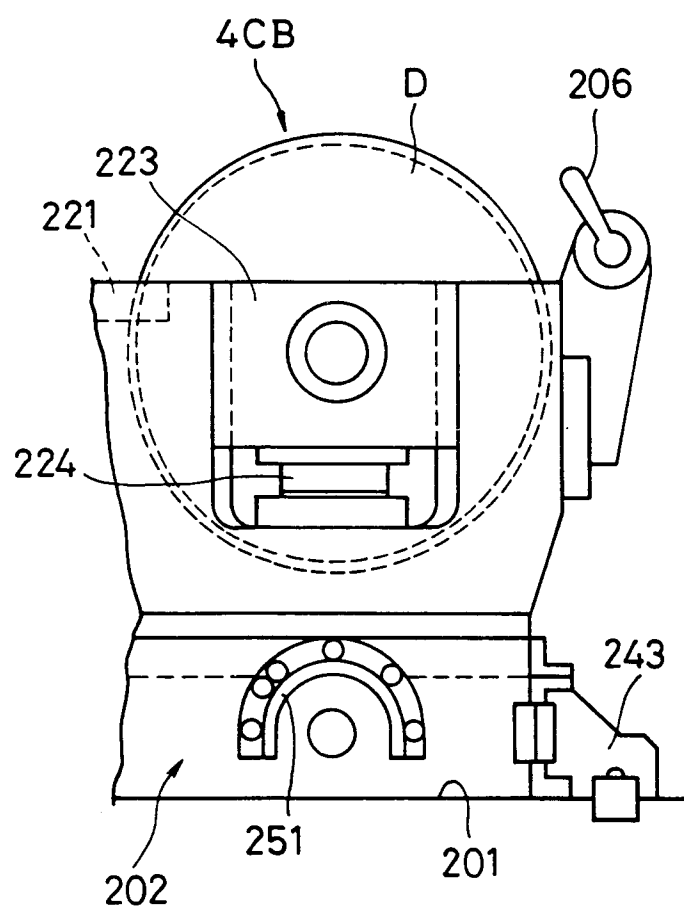


FIG.27

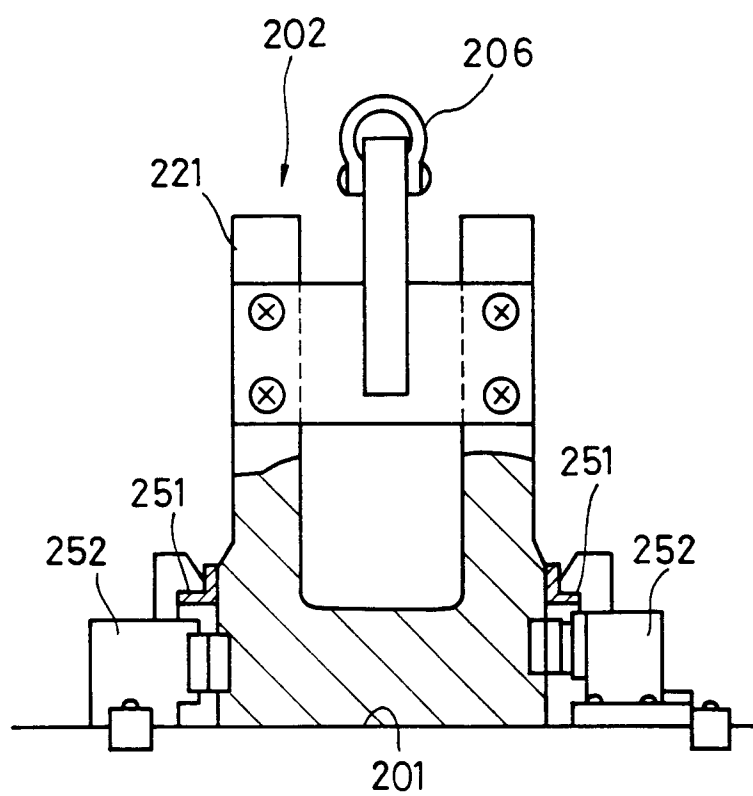


FIG. 28

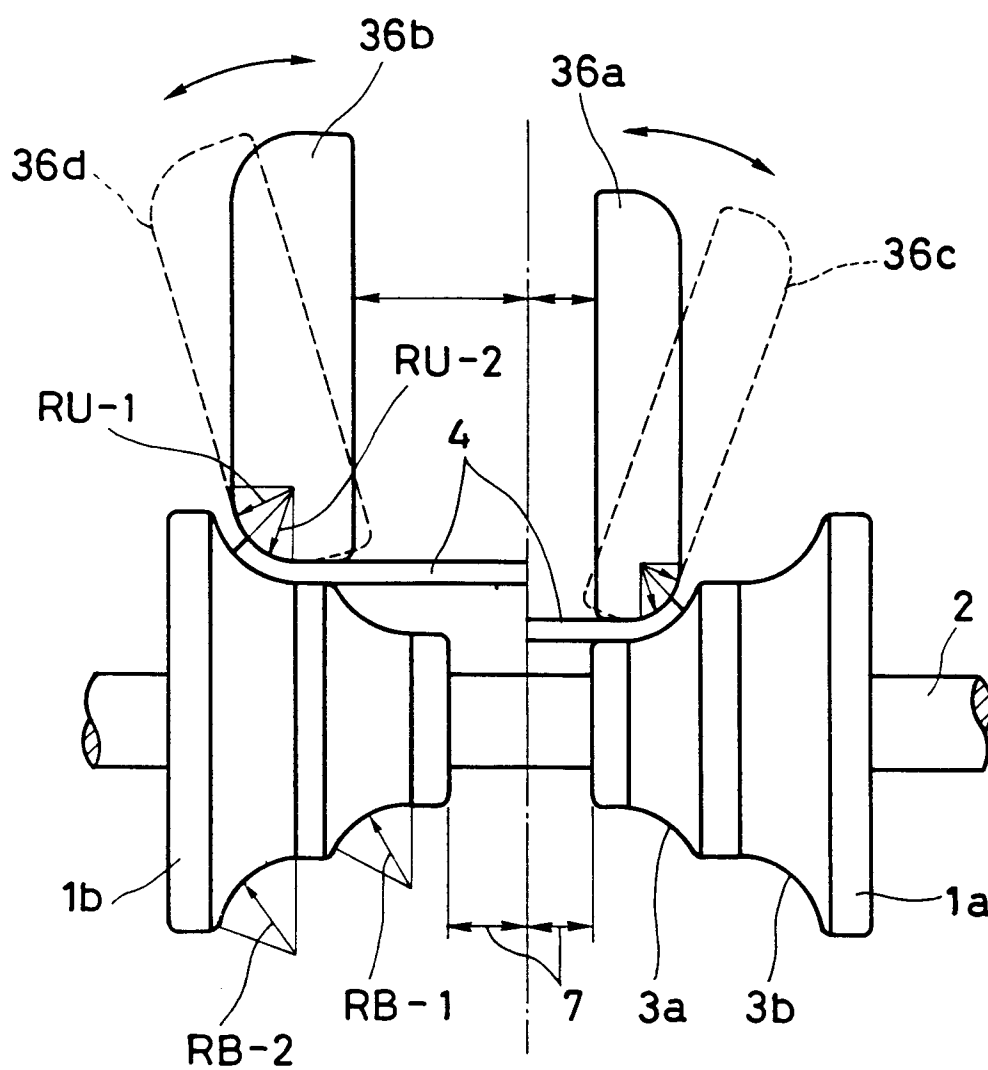


FIG.29

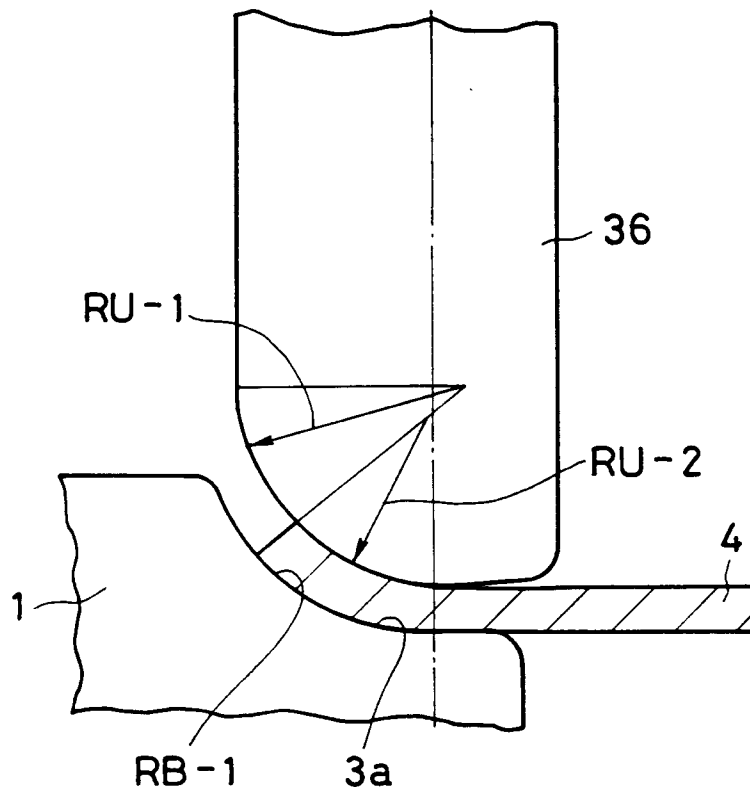
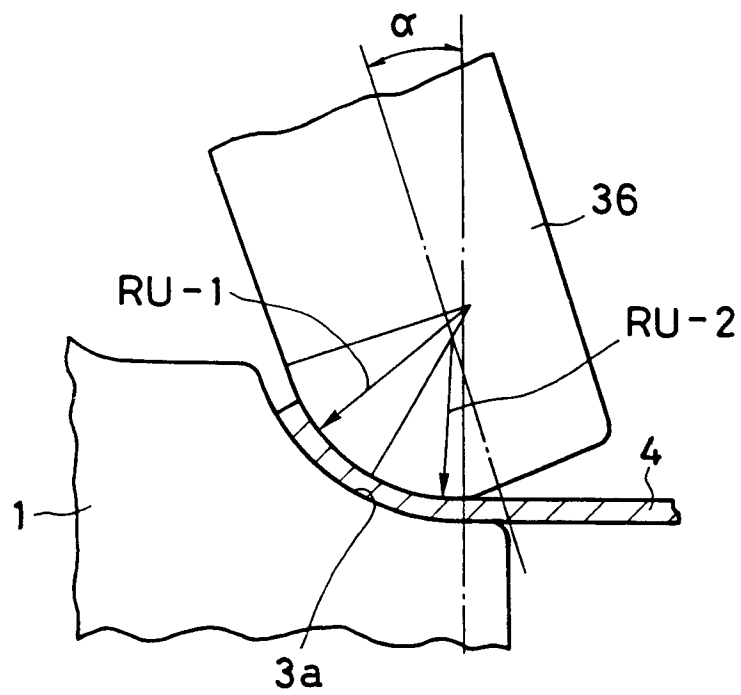


FIG.30



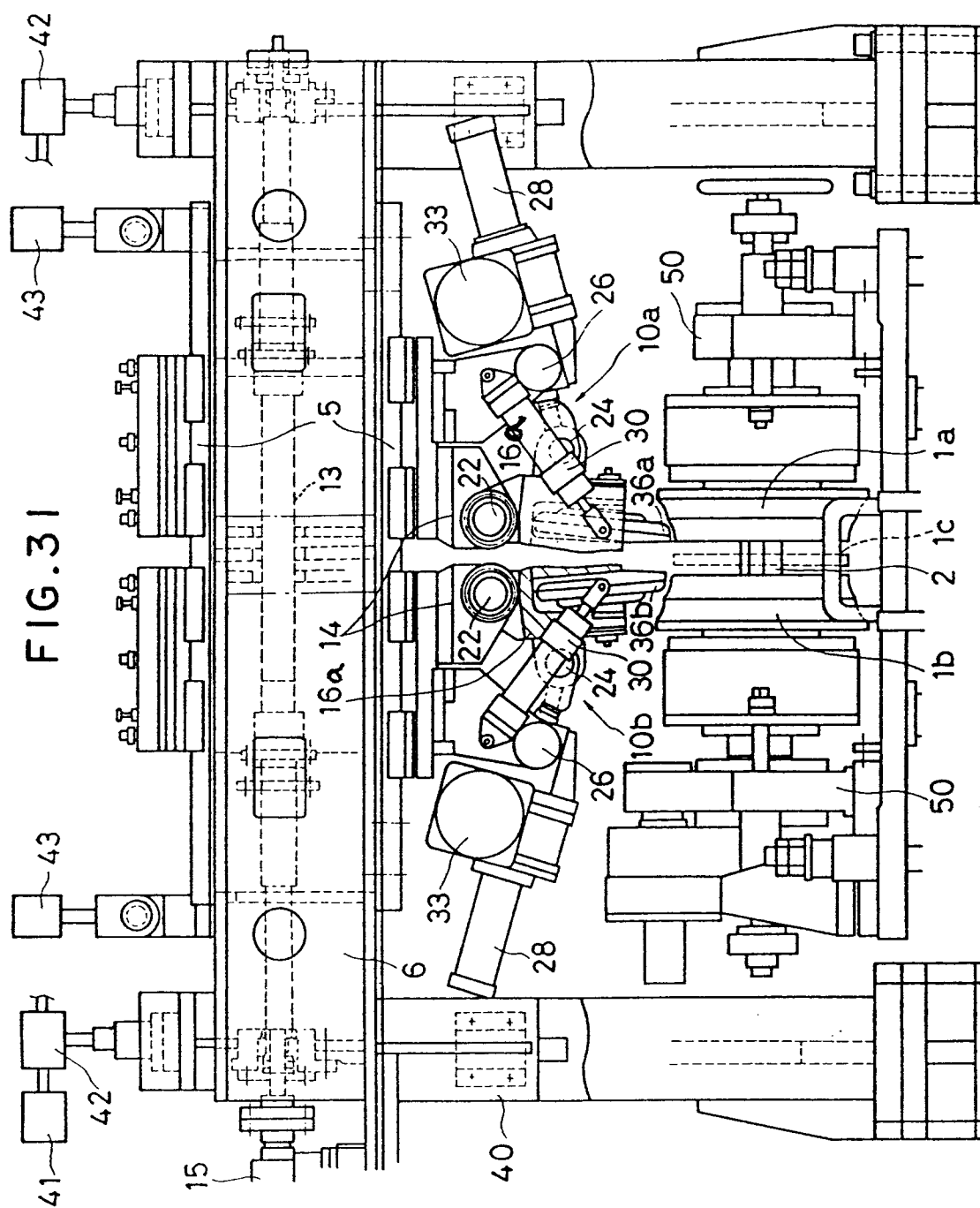


FIG. 32

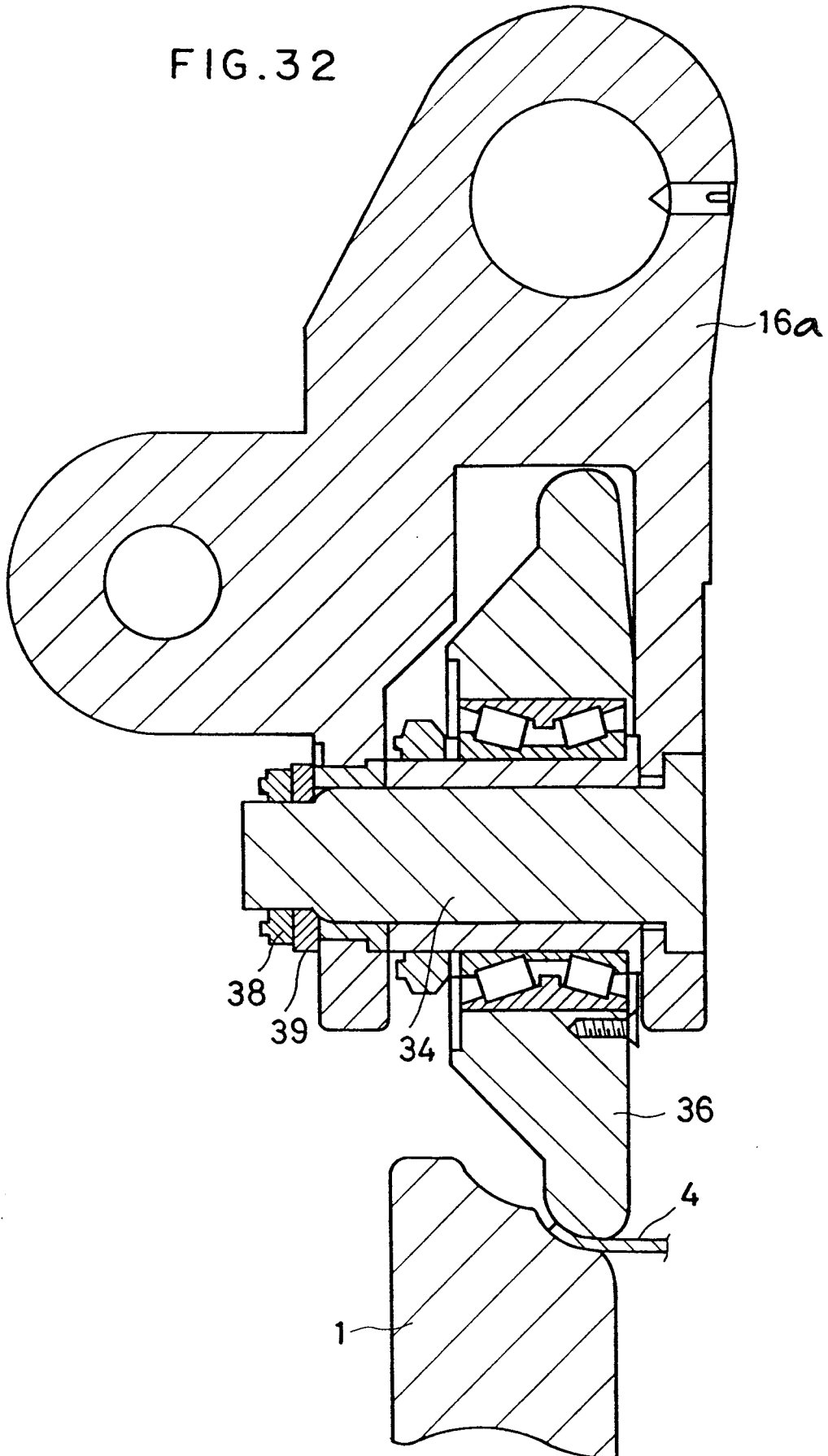


FIG.33(a)

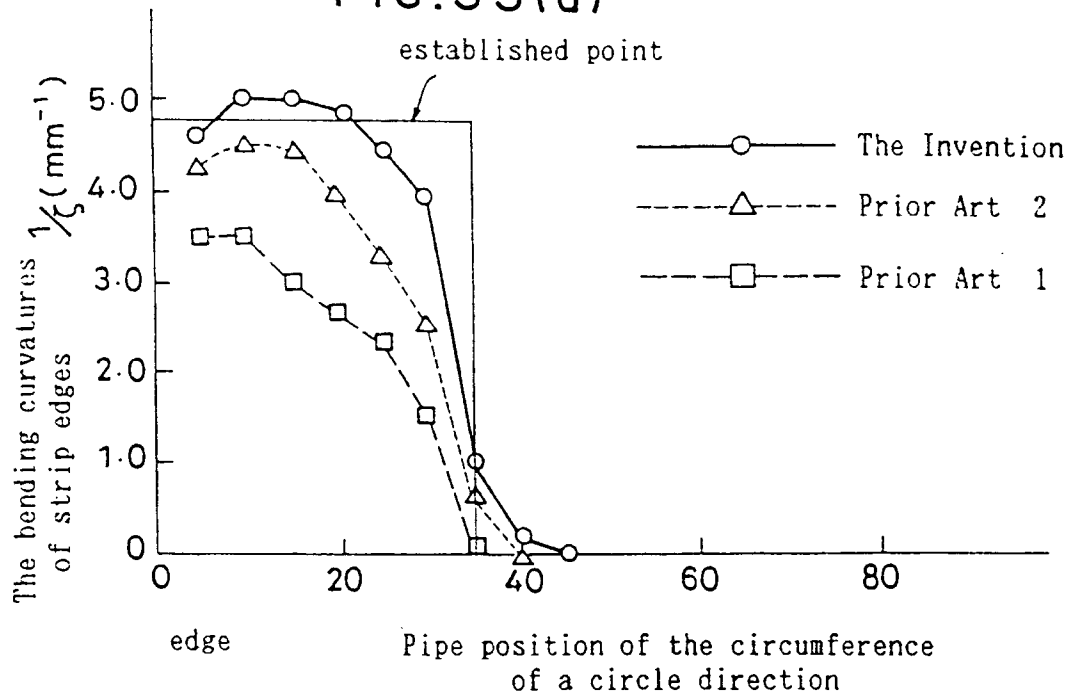


FIG.33(b)

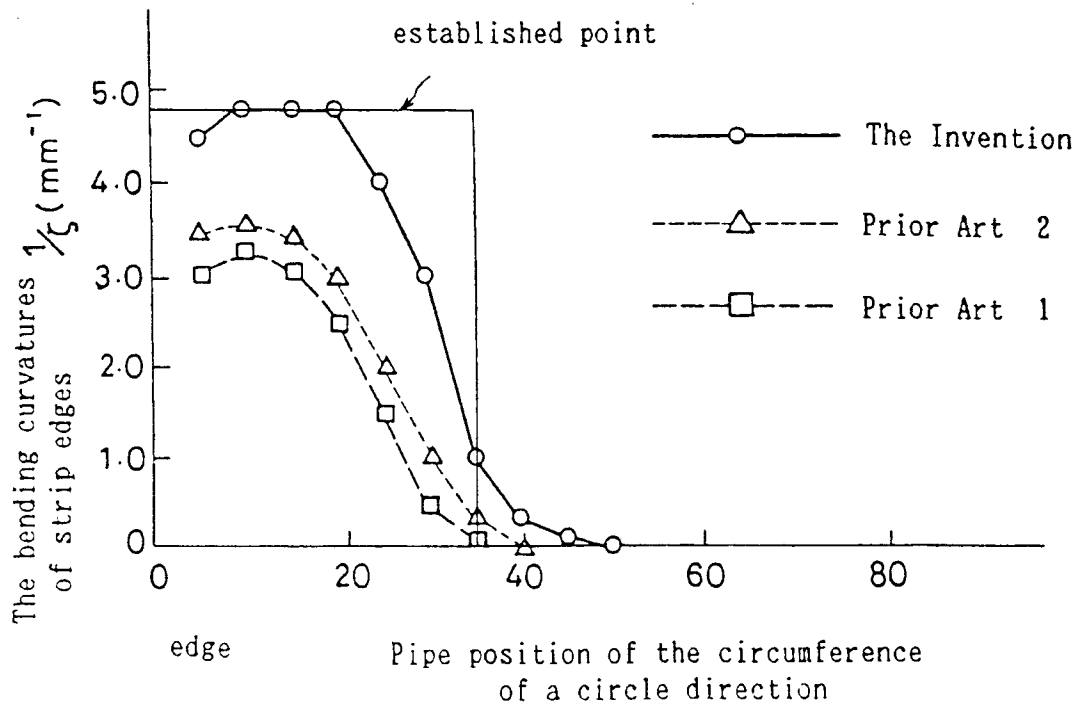
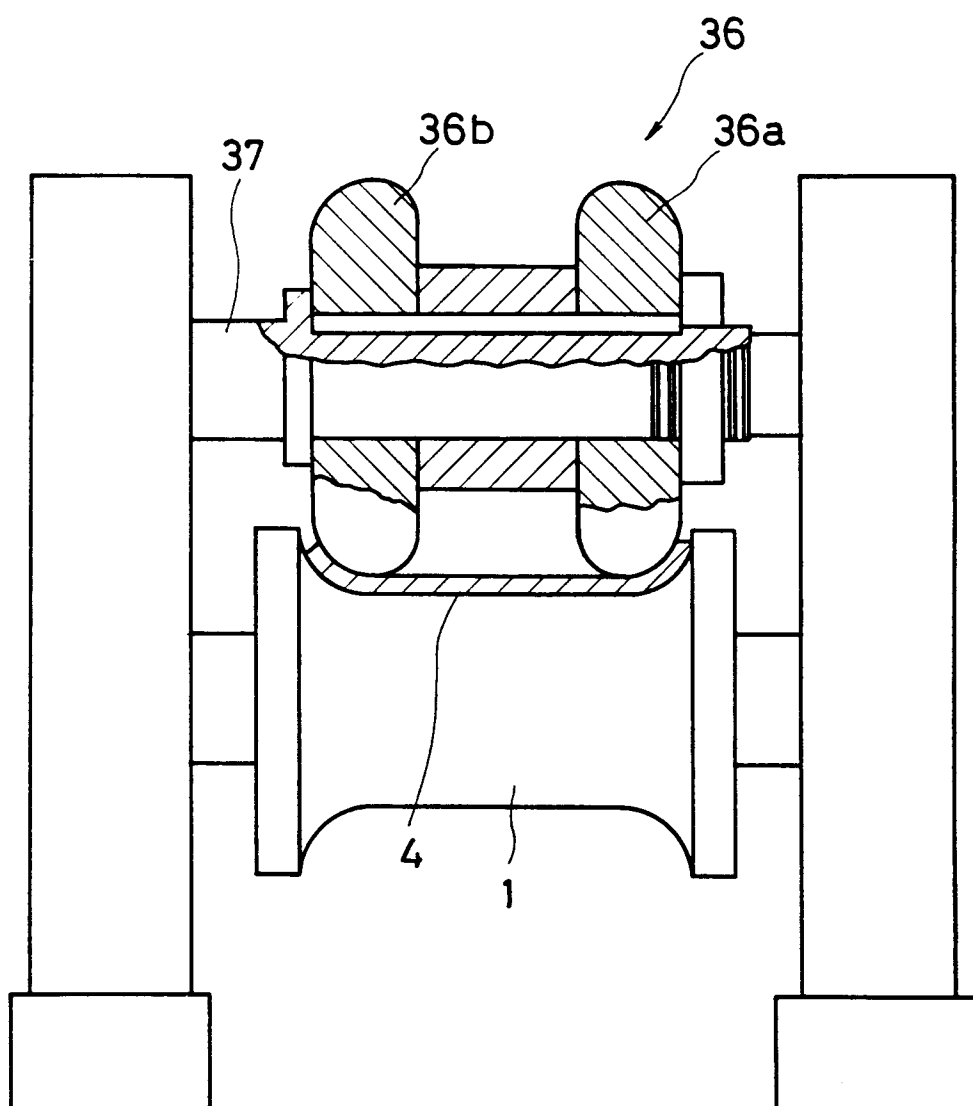


FIG. 34



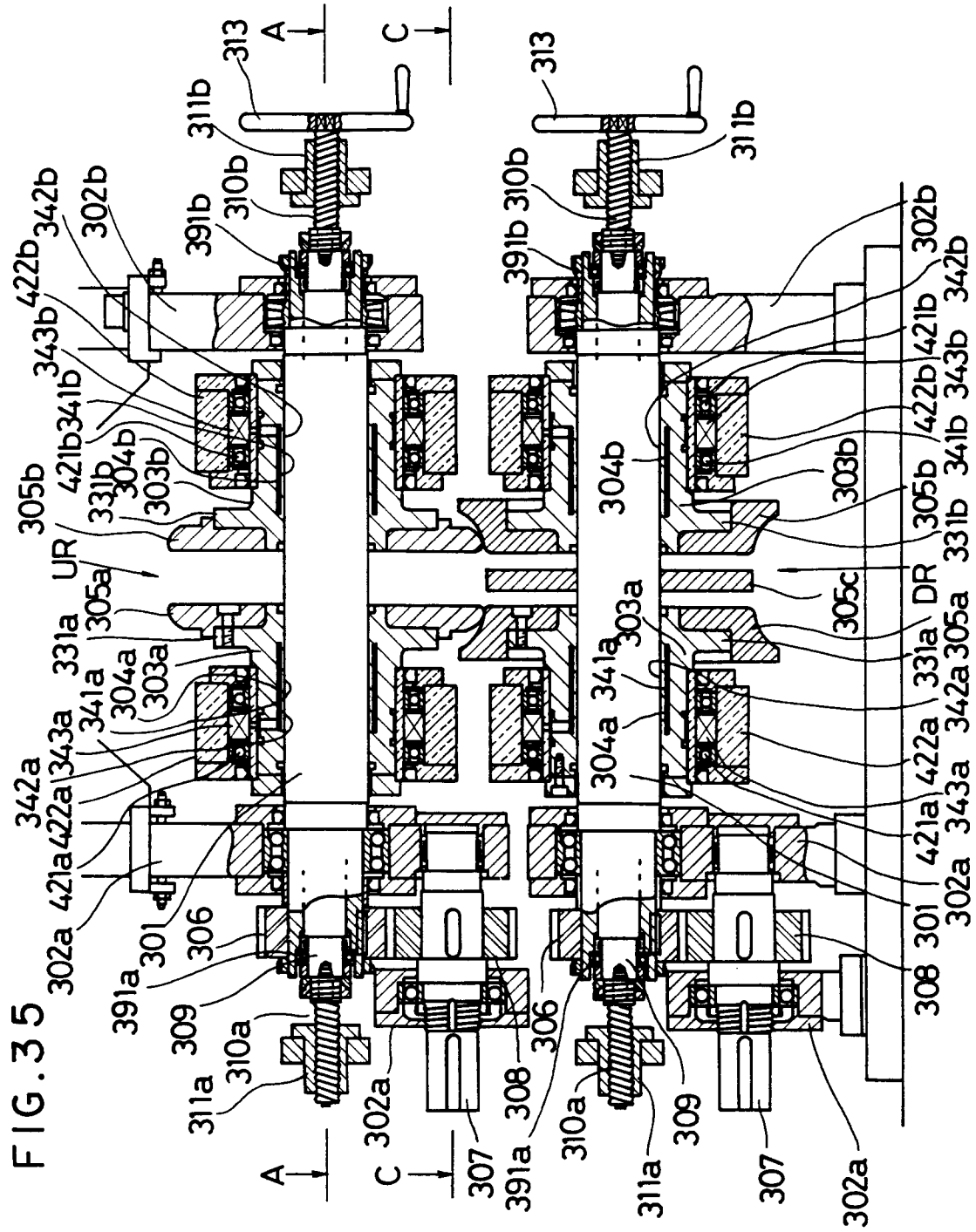


FIG. 36

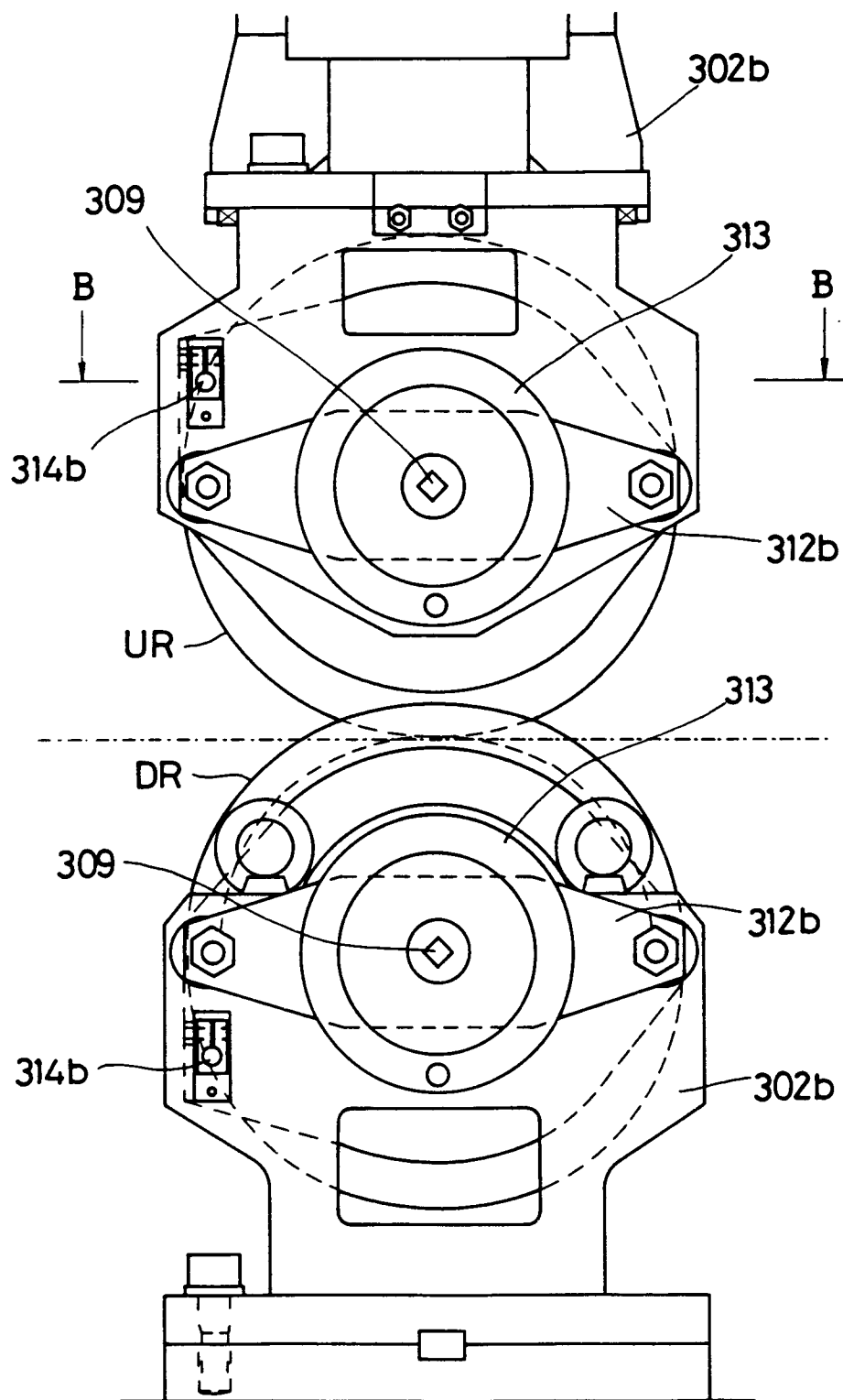


FIG. 37

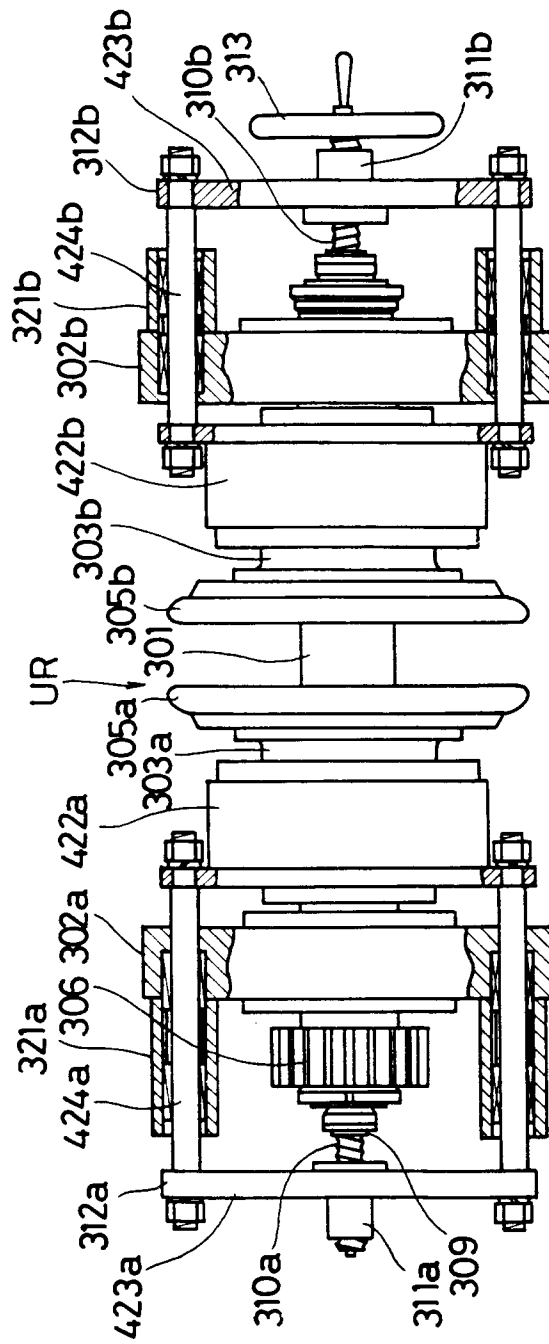


FIG. 38

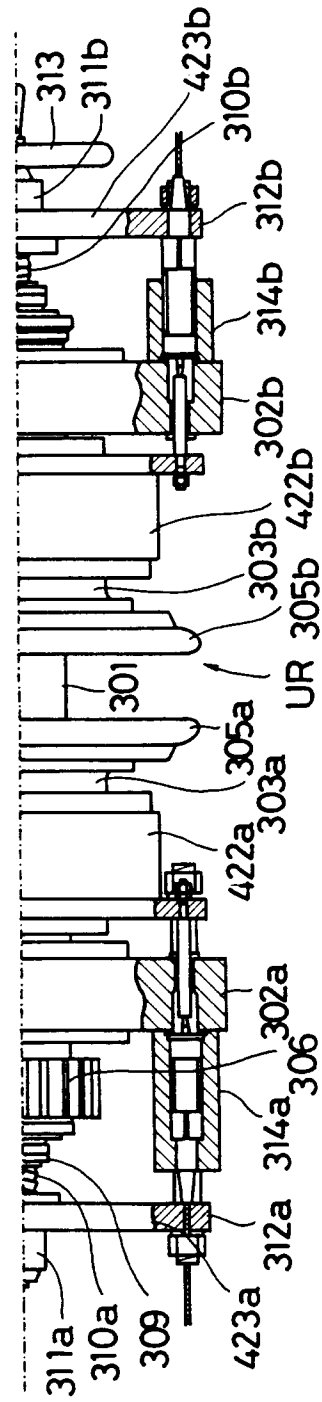


FIG. 39

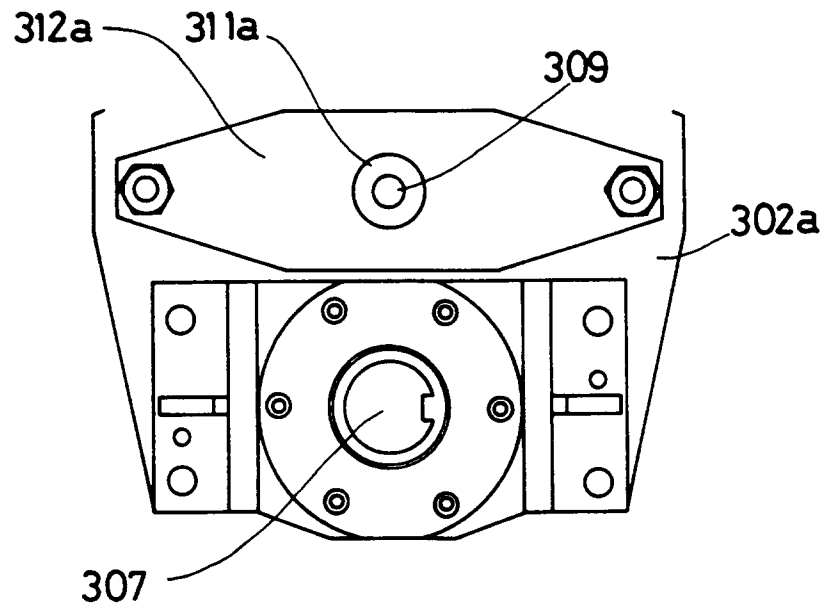


FIG. 40

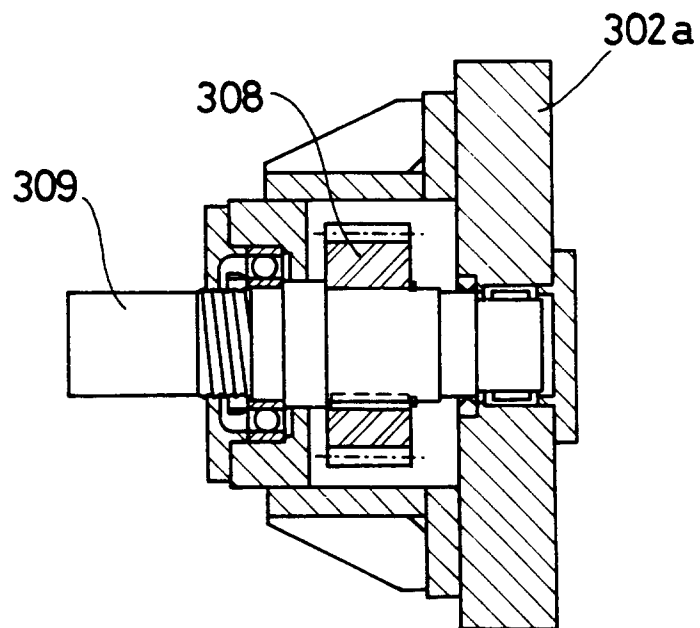


FIG. 41

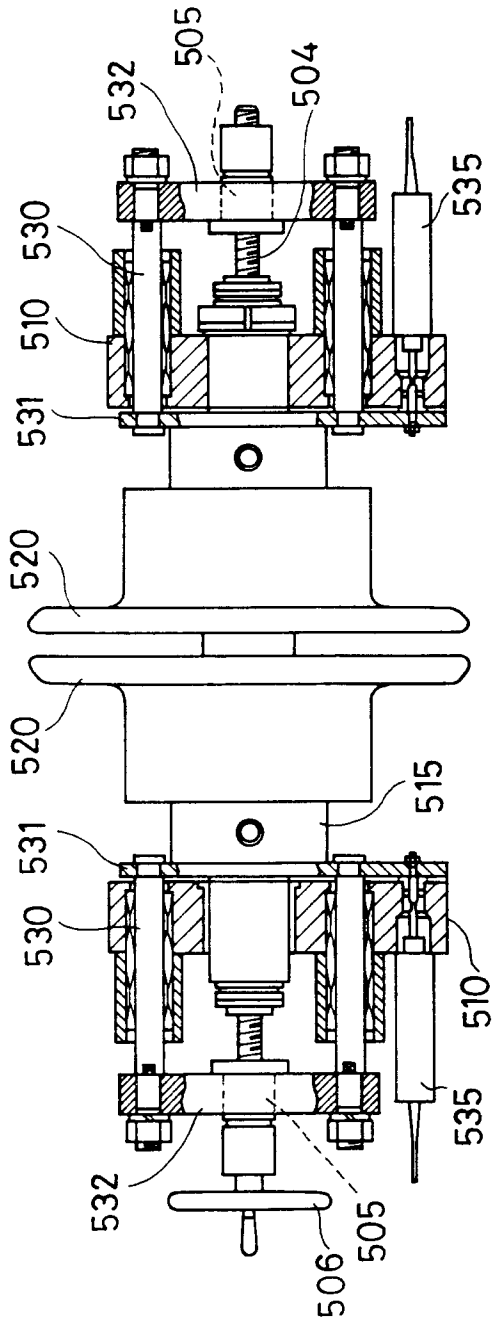


FIG. 42

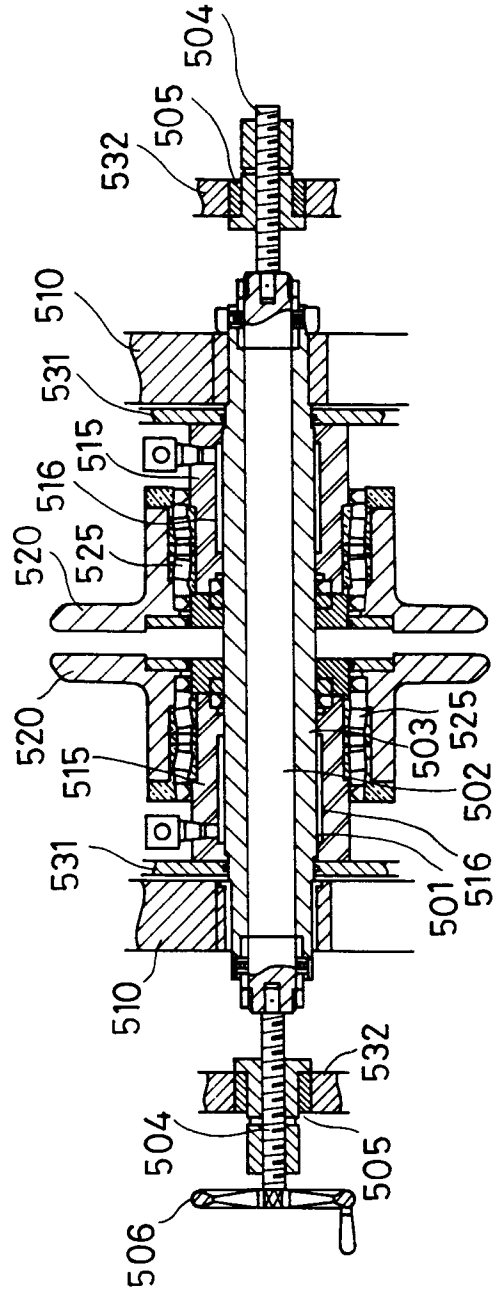


FIG. 43

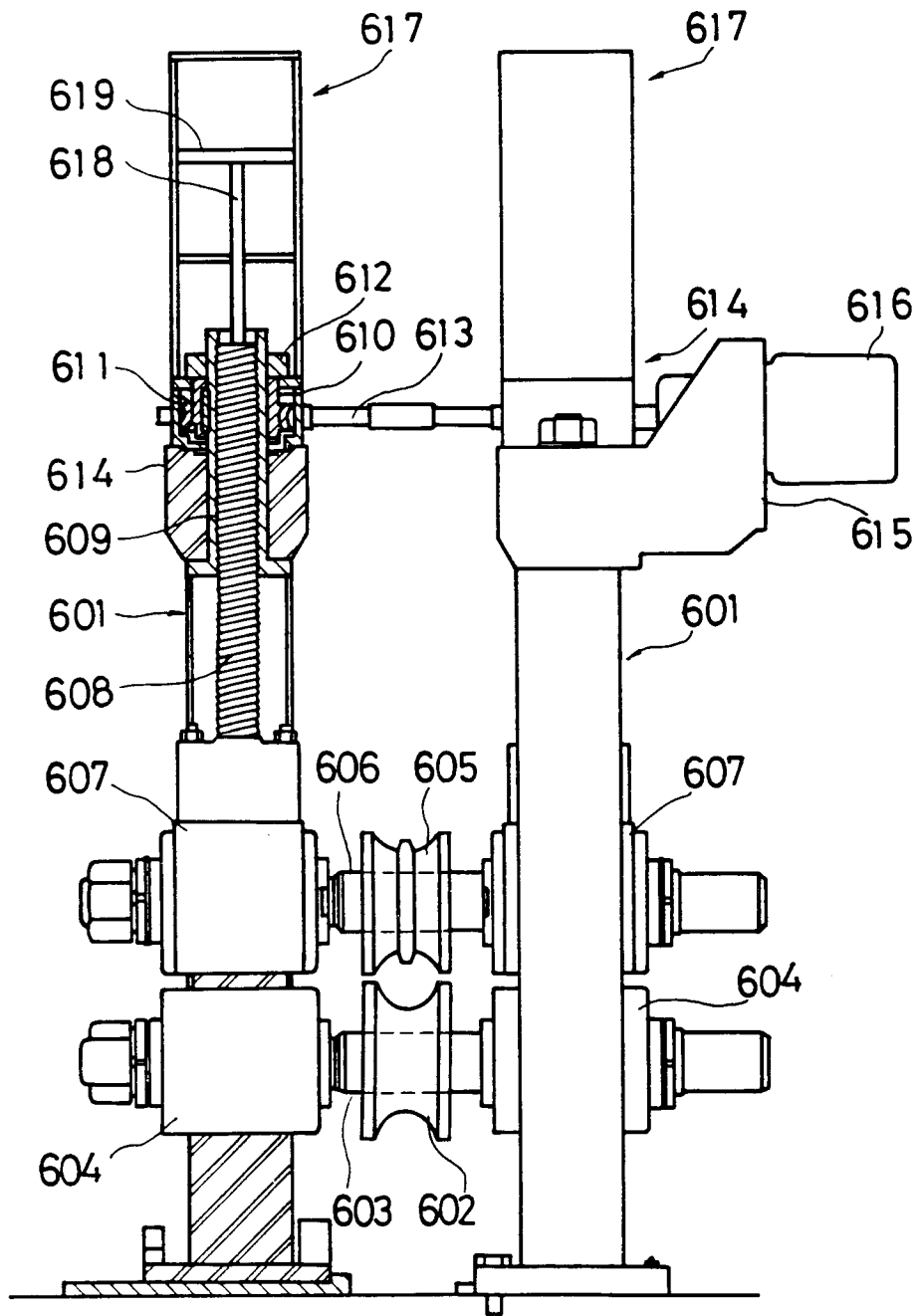


FIG. 44

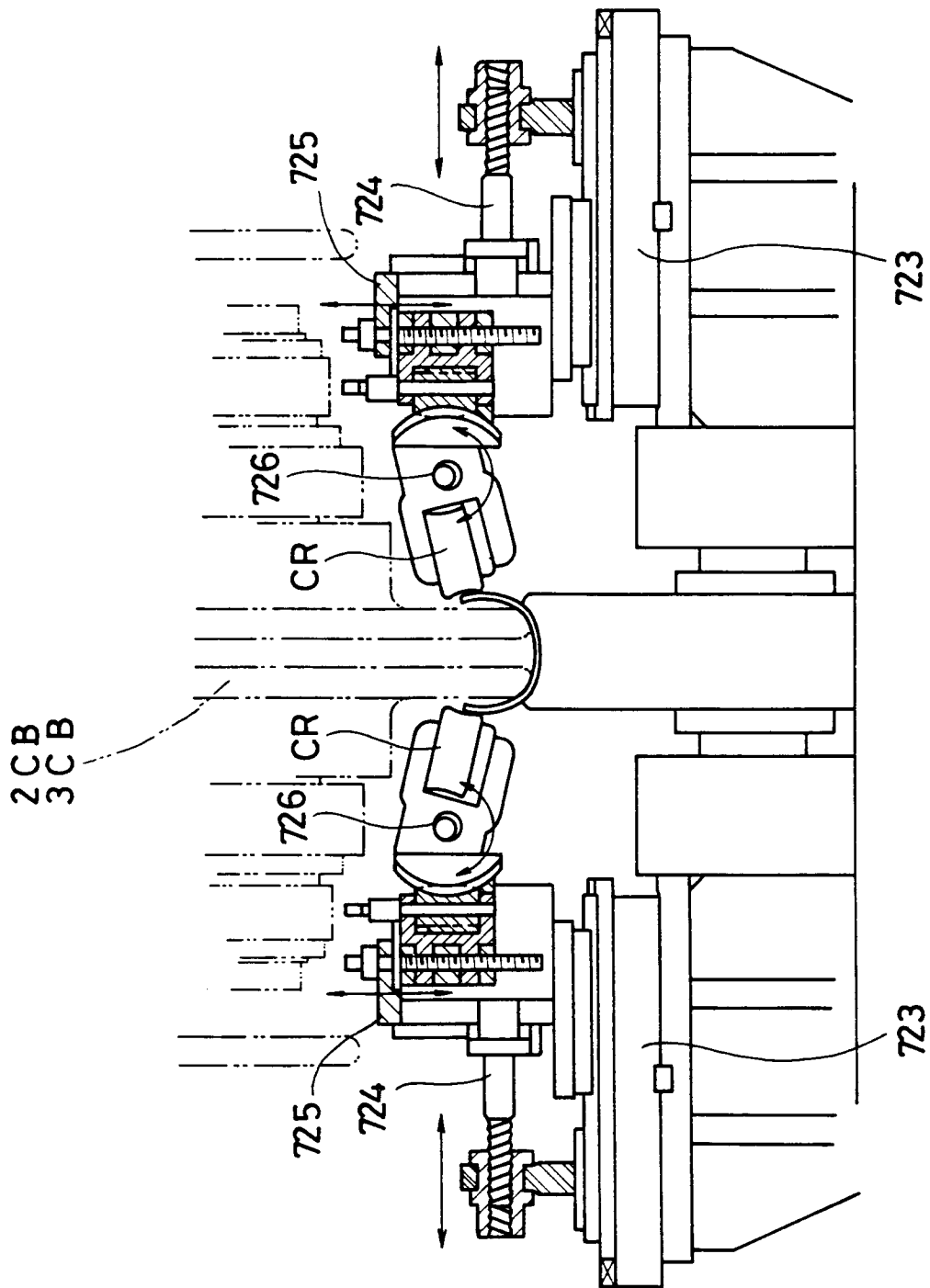


FIG. 45

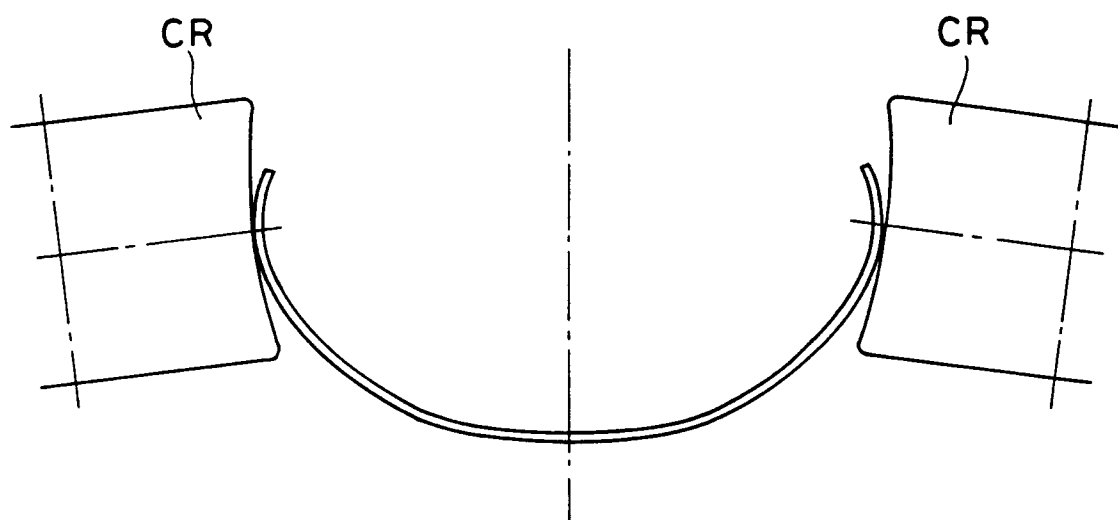


FIG. 46

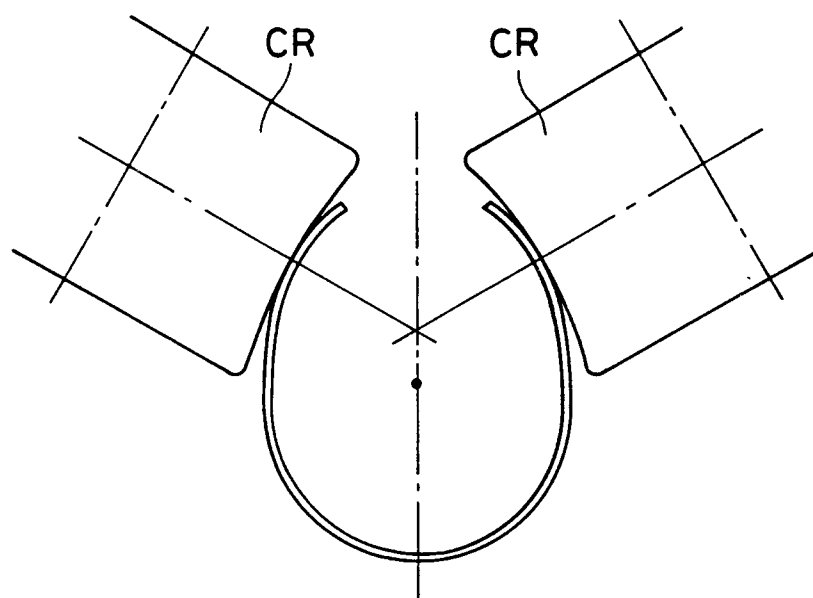


FIG. 47

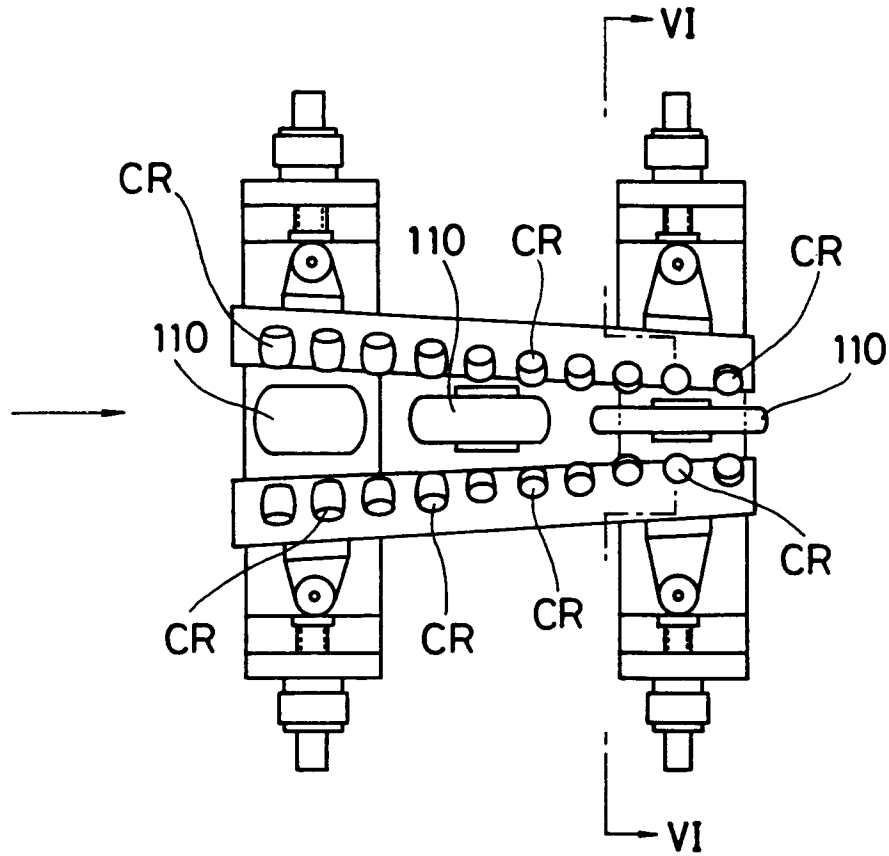


FIG. 48

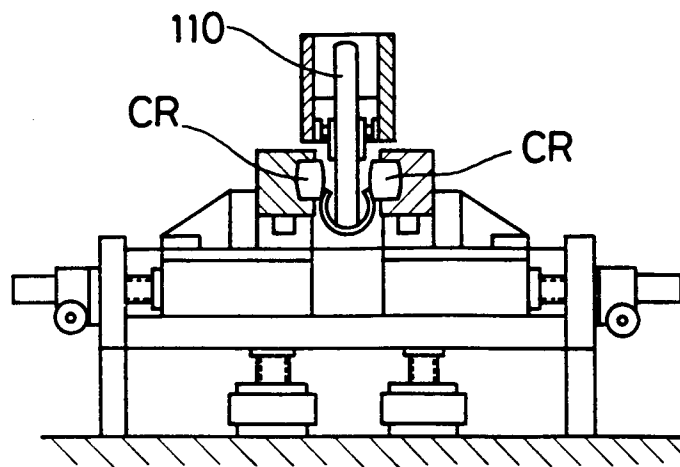


FIG.49

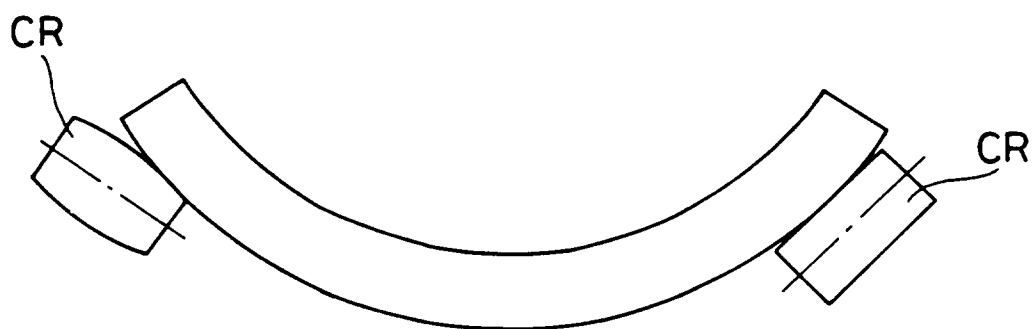


FIG.50

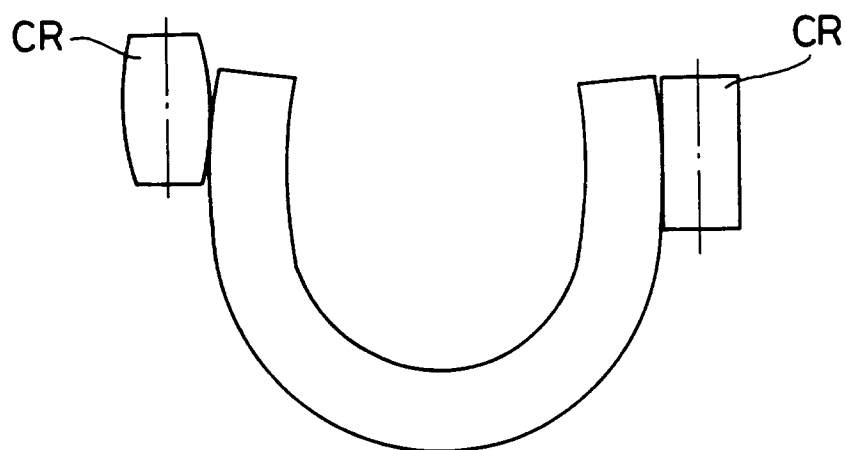


FIG.51

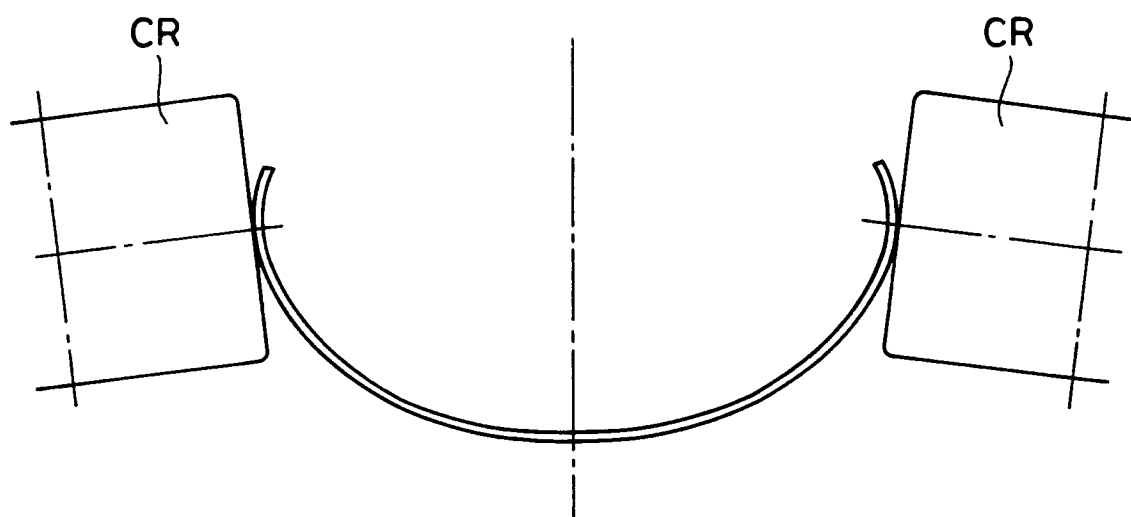


FIG.52

