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[54] **DEVICE FOR HELICALLY DEFORMING A BAND TO FORM A TUBE**

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Oct. 30, 1970 Germany .... P 20 53 266.5

[52] **U.S. Cl.** **72/12,** 29/477.3, 72/173
[51] **Int. Cl.** **B21b 37/00,** B21d 5/14
[58] **Field of Search** 72/49, 142, 173, 72/12; 29/477.3, 477.7

[56] **References Cited**

UNITED STATES PATENTS

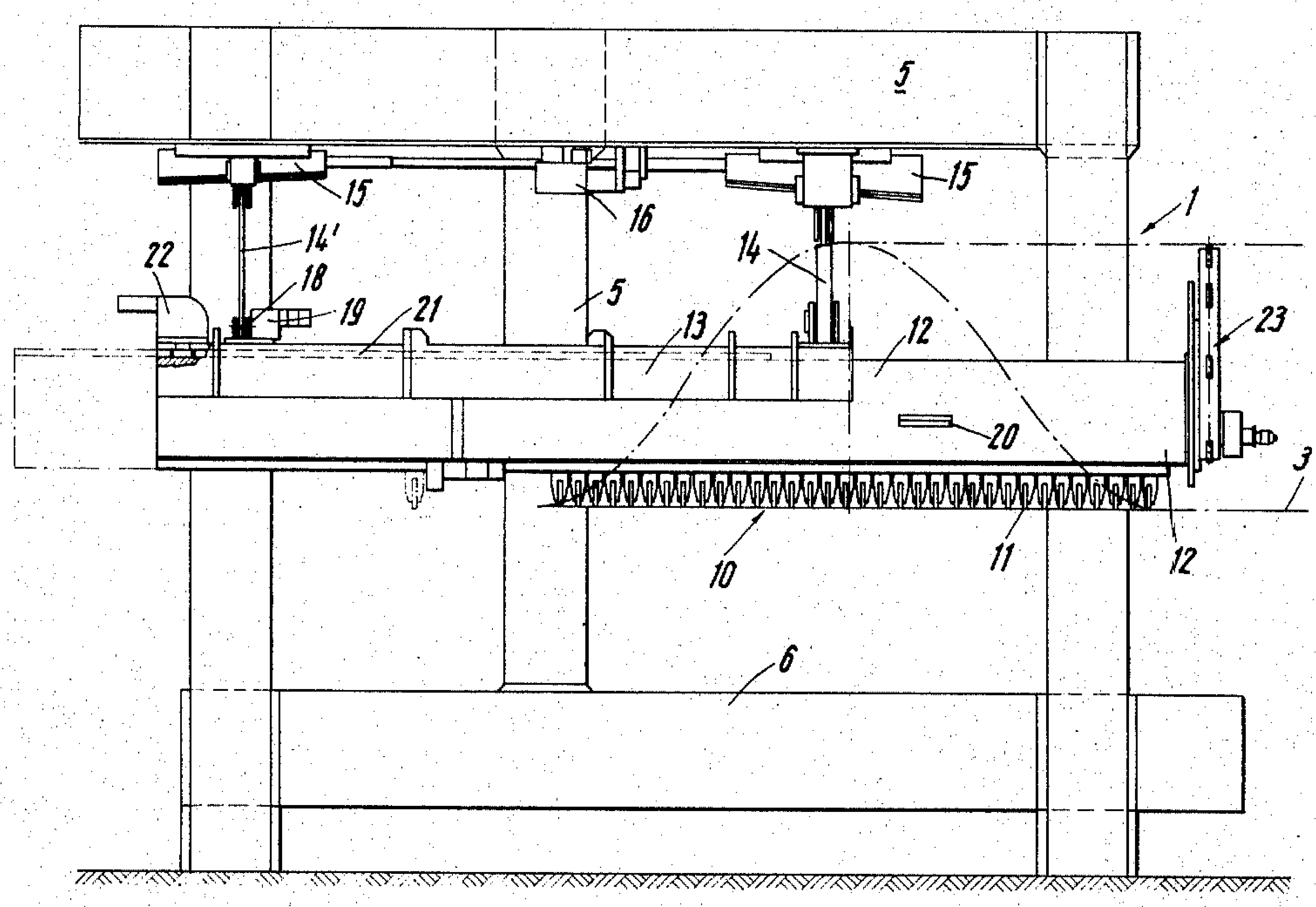
3,650,015 3/1972 Davis 29/477.3

Primary Examiner—Charles W. Lanham
Assistant Examiner—Robert M. Rogers
Attorney—Benjamin H. Sherman et al.

[57] **ABSTRACT**

A device for helically deforming a sheet metal band into the form of a tube comprising an inner bending roll and two outer bending rolls, the axes of all of which during the deformation procedure of the sheet metal band may be displaced axially and parallel to each other. In addition, the inner bending roll is vertically adjustable and the two outer bending rolls are each individually vertically and laterally adjustable, and the curvature of the tube while being formed is measured by a scanning device which upon deviations of the tube curvature from a predetermined dimension produces electric impulses which effect an adjustment of the vertical position of the inner bending roll.

22 Claims, 7 Drawing Figures



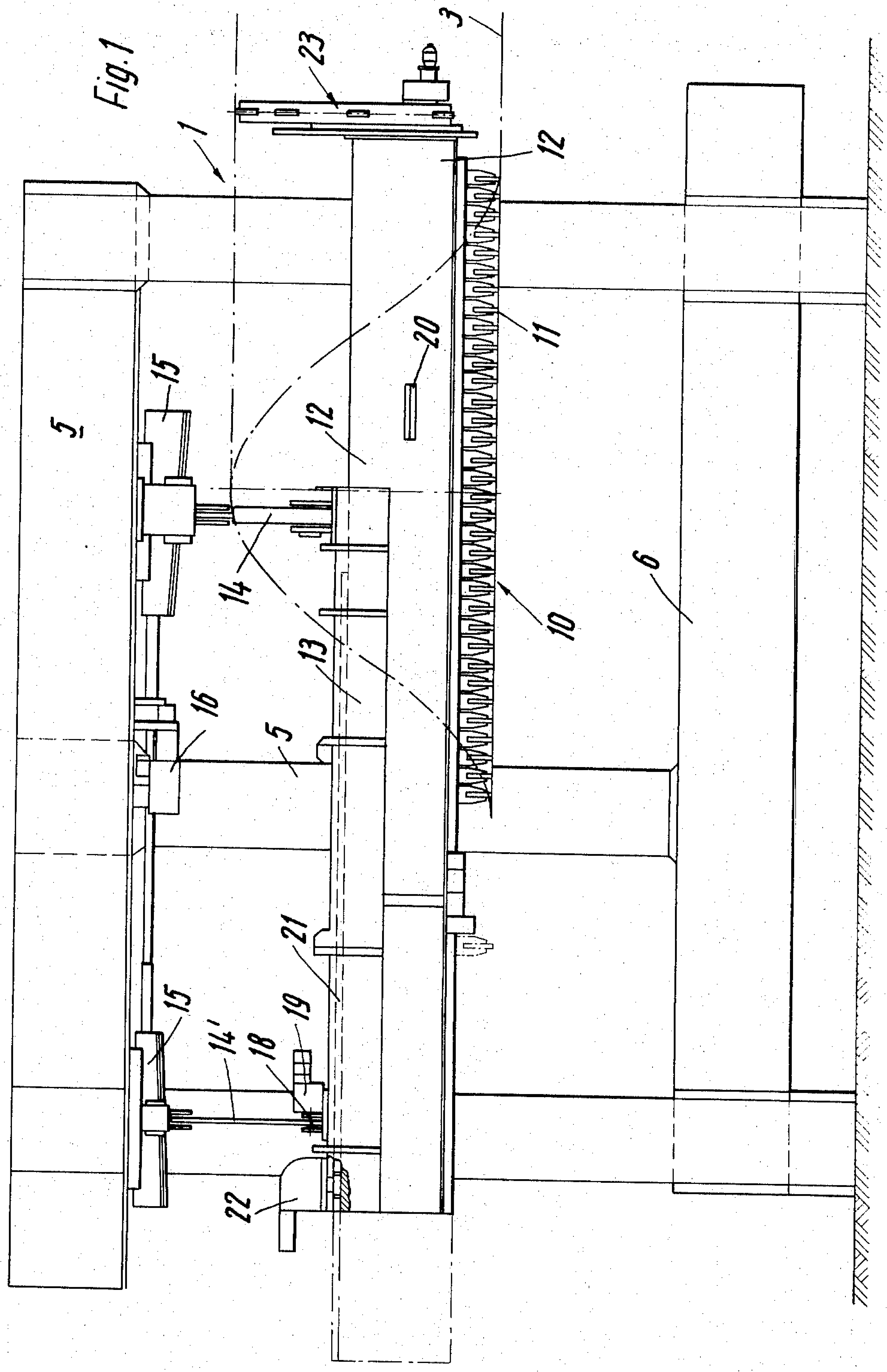


Fig.1

Fig.2

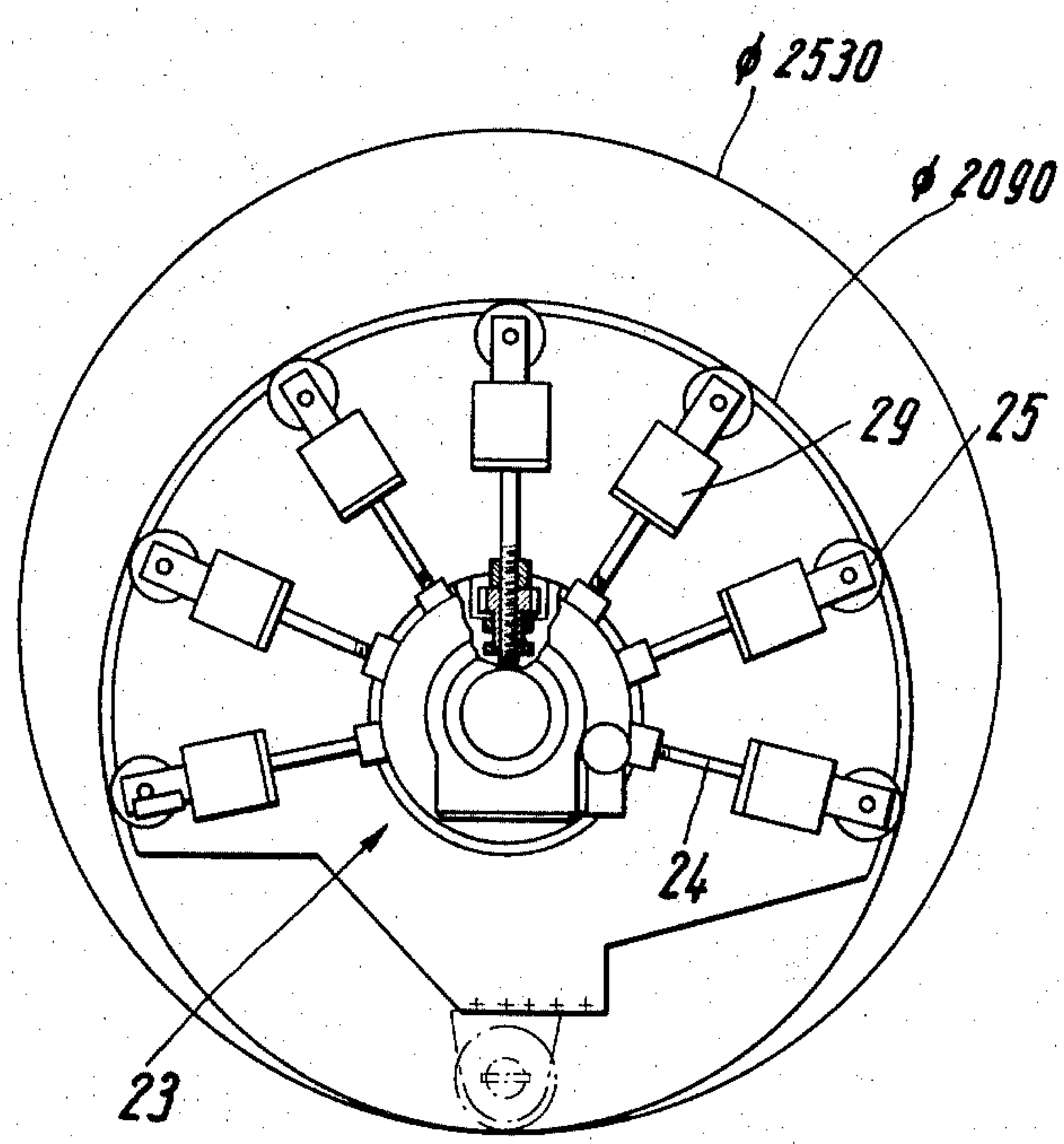
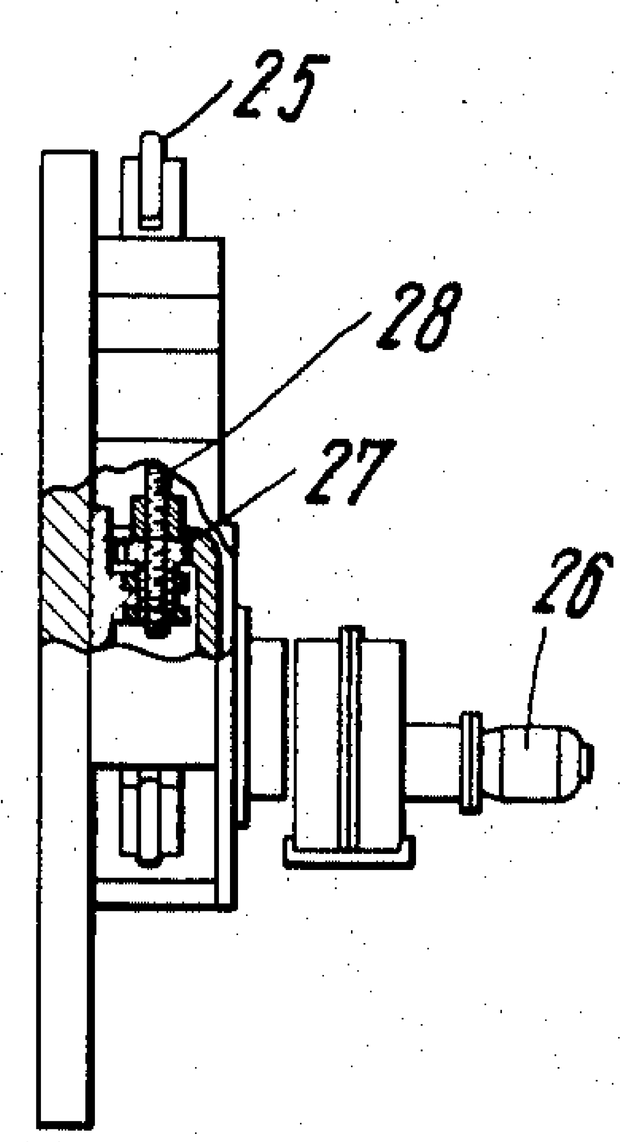


Fig.2a



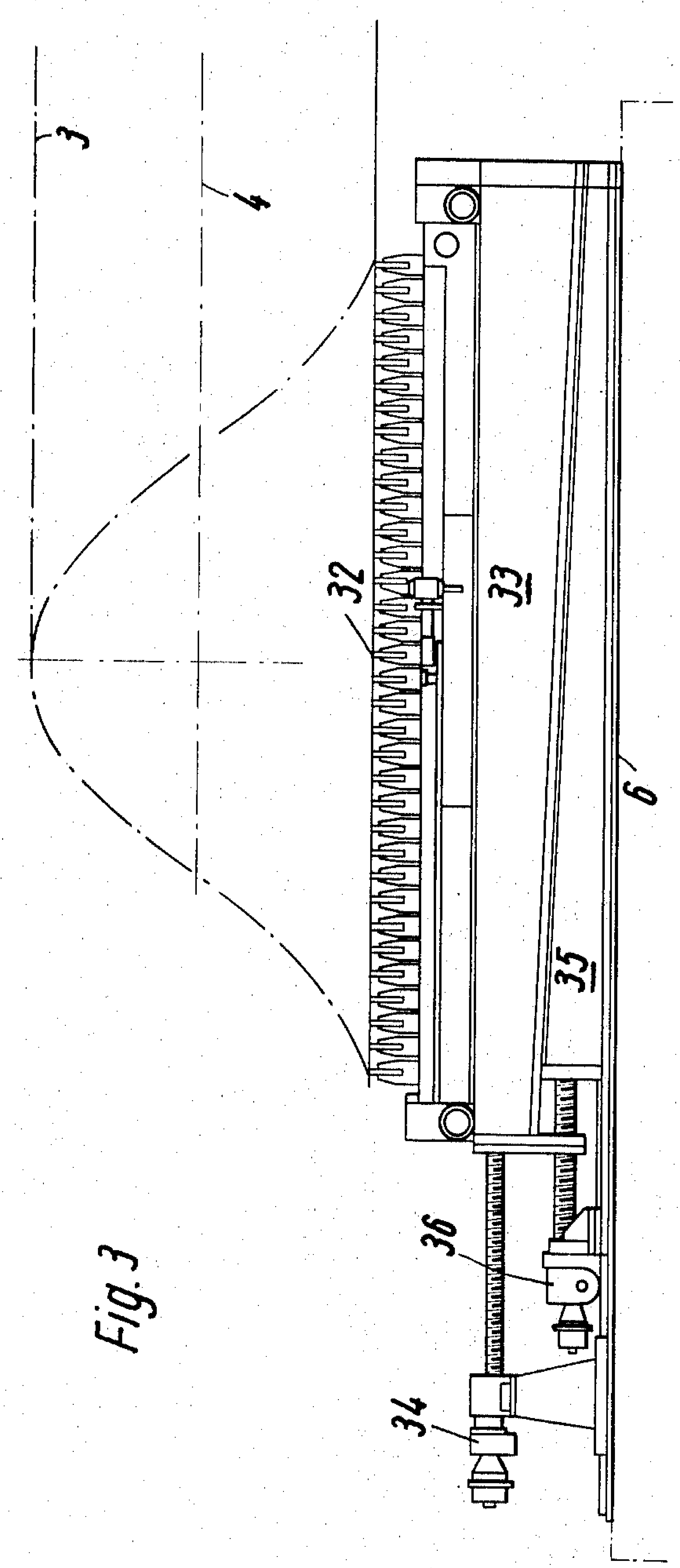


Fig.3

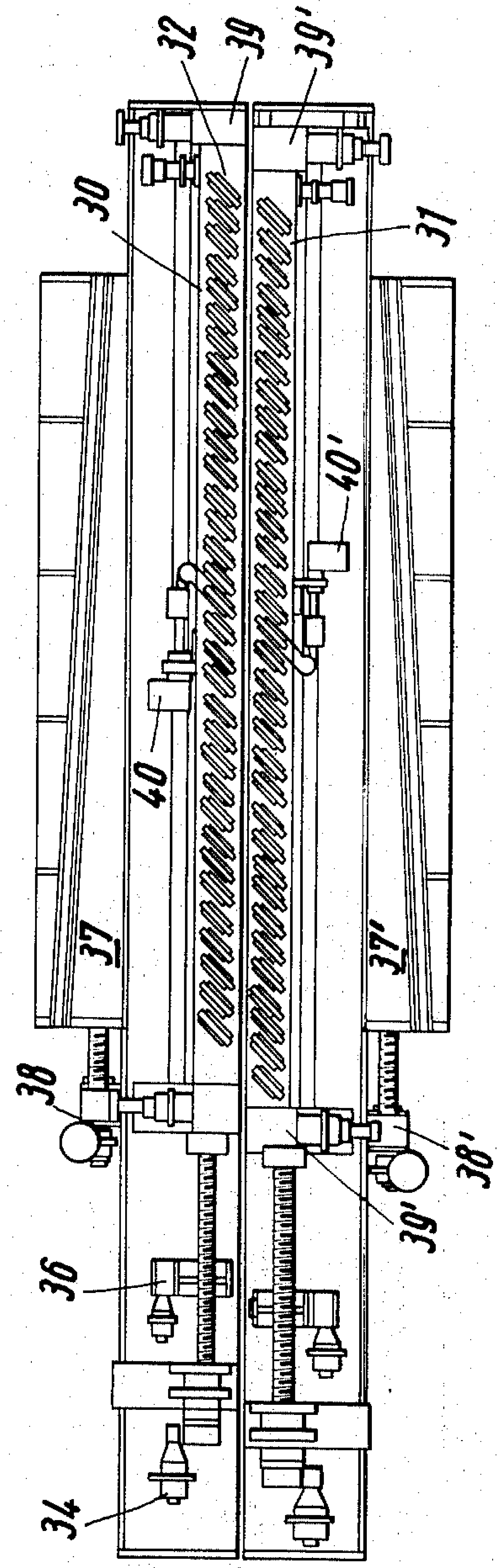


Fig.3a

Fig. 4

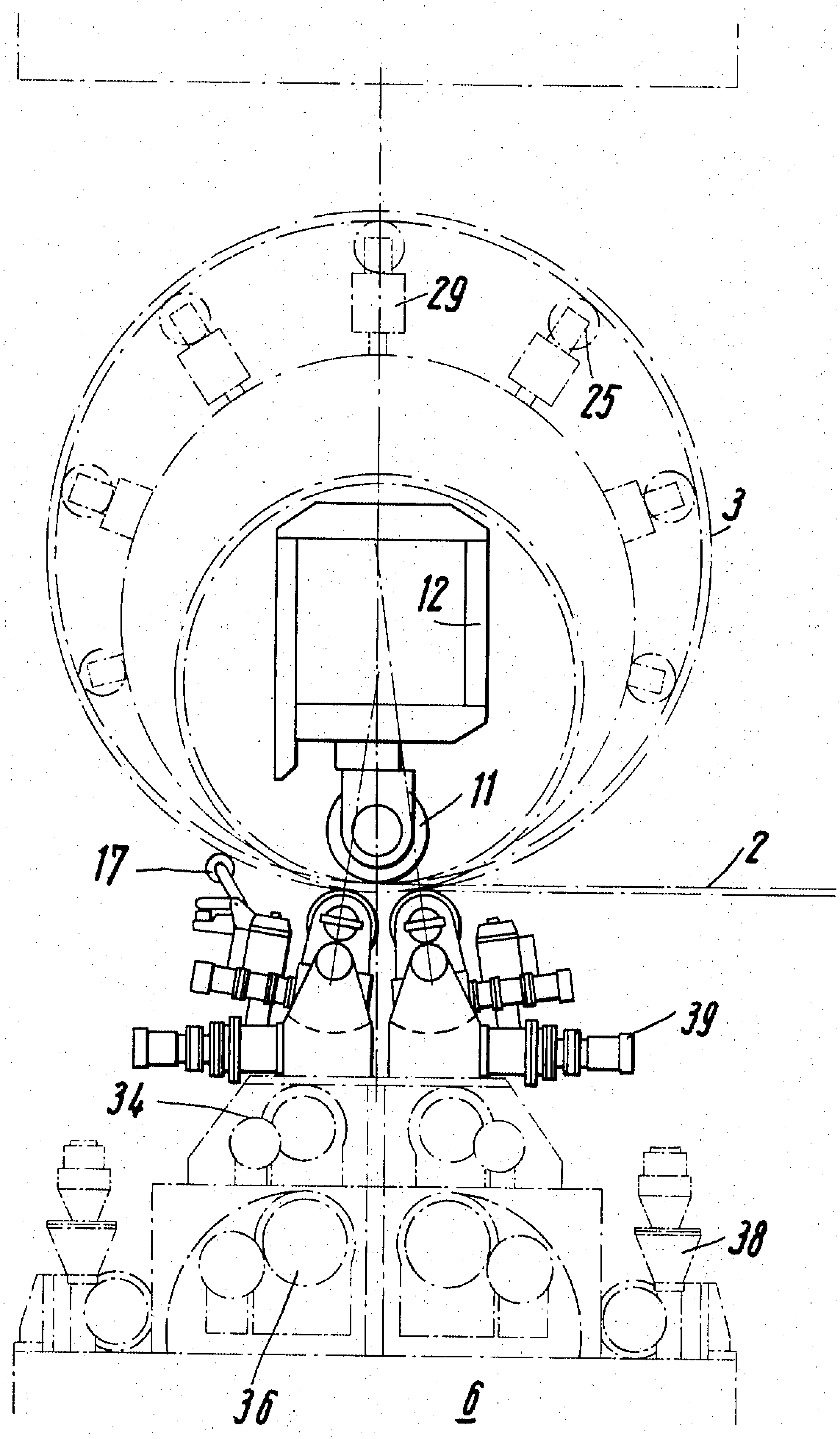
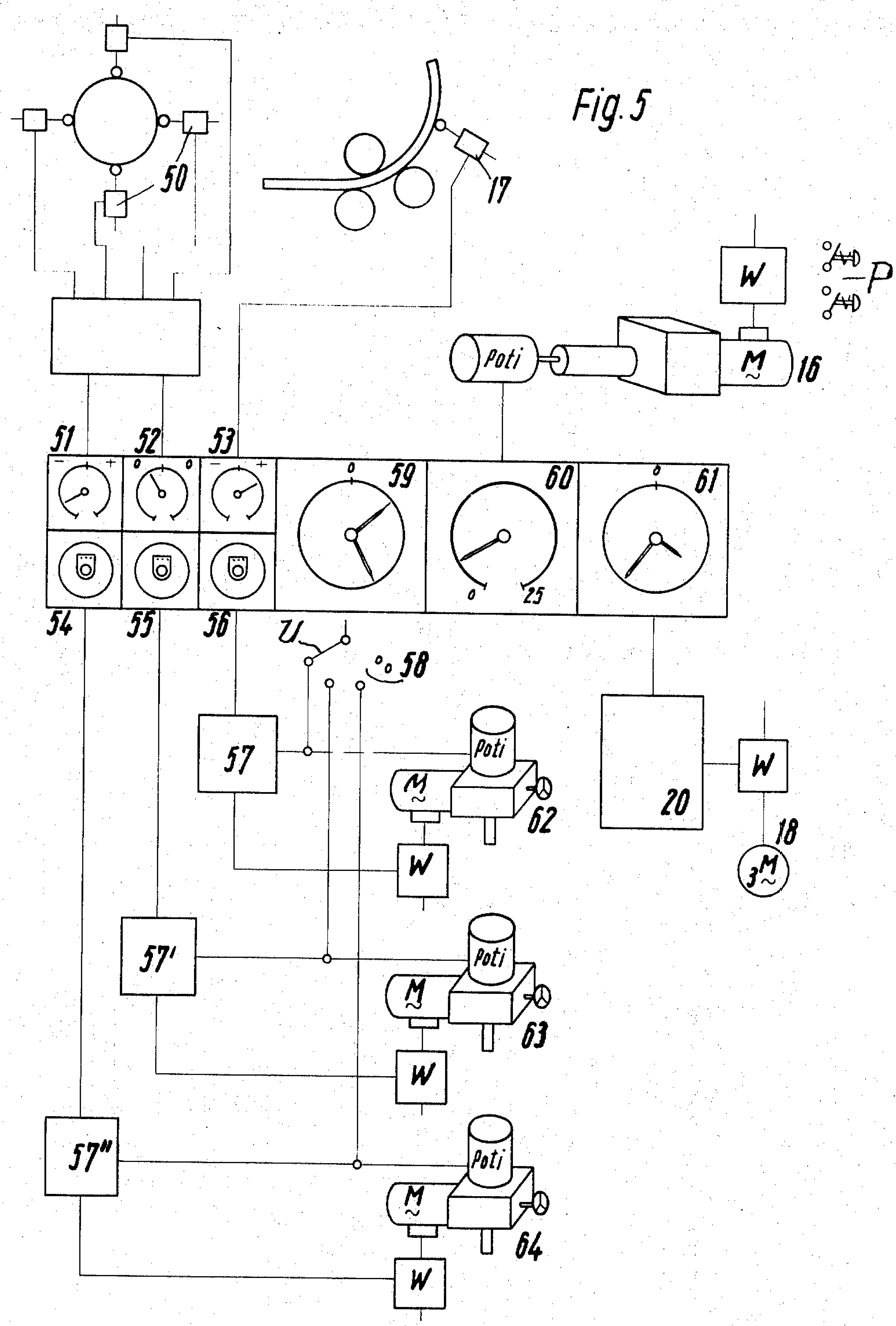


Fig. 5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DEVICE FOR HELICALLY DEFORMING A BAND TO FORM A TUBE

The invention relates to a device for helically deforming a sheet metal band to form a tube by means of inner and outer bending rolls.

When producing sheets and bands, as they are employed, for instance, in the production of helical seam tubes, it is of known importance that certain production tolerances have to be maintained. These production tolerances relate to the maintenance of dimensions of angularity of the material to be worked upon. Also required are tensile values and elongation values which are tested by means of random samples and have to be within predetermined tolerances. It has been discovered, however, that even such sheet metal bands which in each case lie within the permissible tolerances, that the same are not all alike. In addition thereto, the elastic elongation or the modulus of elasticity does not have the same value at all points of a band or a sheet metal strip. This situation makes the deformation of sheets or bands, respectively, to a tube very troublesome and leads to diversified, mostly permanently remaining curvatures of the band after the same leaves the bending rolls, so that non-circular tube shapes and other difficulties occur during the welding of the helical seam.

These disadvantages are the more serious and consequential, the thicker the band, namely the greater the differences in the forces which oppose the deformation of the band and the larger the diameter of the tube, then the smaller is the curvature to be produced.

The object of the invention is a device for producing helically formed tubes and which compensates for all of the above-mentioned differences in the material.

In accordance with the invention, the axes of all bending rolls during the deformation of the band are arranged at least in one direction parallel slidable in the device. This means that the axes of the inner and of the outer bending rolls are controlled partly automatically or partly programmatically or manually, axially, horizontally and vertically independently of each other during their deforming operation and may subsequently be displaced parallel to one another.

This arrangement makes it possible that for each quality of sheet metal and for each thickness of the sheet metal the correct position of the axes of the bending rolls to each other is determined in relation to sheet metal values ascertained from a previous bending test during the adjustment to a predetermined tube diameter and for different tube diameters.

Such an adjustment is preferably accomplished at relatively low expense with a device in which during the deformating operation the axes of the inner bending rolls are vertically adjustable and also laterally displaceable.

Such a construction has the advantage that for the compensation of the differences in the sheet metal thickness and of the quality of the sheet metal, the bending rolls are adjusted only in the mentioned manner in order to take into consideration at once and continuously without interruption of the deformation operation.

Even though one determines the values of the sheet metal prior to the entrance of the sheet metal band into the deformation machine and characterizes the same, for instance, by color markings, and by a manually vertical adjustment of the inner bending rolls, an automatic operation of the entire procedure is still to be preferred.

This automatic procedure in accordance with the invention is attained in that the tube curvature at the outlet of the bending rollers is measured by a scanning device, whereby the deviations from the desired curvature of the tube diameter in the form of impulses are used for the operation of the vertical adjusting device of the inner bending roller.

The bending rolls do not have a cylindrical form but in accordance with the invention are constructed as bend-resistant supports which carry individual disc-shaped deforming rolls.

It is advisable to arrange the disc-shaped deforming rolls of the inner bending roll on a roll support which is supported at least at two points along the direction of the axis of the tube vertically slidable with respect to pedestal-like frames. In such an arrangement, the frames may be in direct force-transmitting connection with the supports for the exterior bending rolls in order to receive the deformation forces in a closed frame structure.

The vertically adjustable supports of the roll carrier may also be flexible and constructed in the form of a sliding key mechanism whose slidable key is actuated by a motor which is controlled by the tube curvature scanning device.

Such a vertical adjusting device operates continuously and fully automatically and has a good efficiency. This device is not very expensive and any too high frictional forces may be taken up by anti-friction bearings.

A further advantageous construction of the device of the invention comprises an arrangement in which the roll support is mounted in a bearing box which is supported by the frame and is movable in the direction of the axis of the tube.

This arrangement makes it possible to move the inner bending rolls in accordance with the inlet angle of the sheet metal band into the deformation device, namely, in the direction of the axis of the tube. This means the arrangement may accommodate a material having a smaller width with a shorter stressed length of the inner bending roll. This arrangement also makes it possible to move the roll carrier with the highly stressed rolls outwardly from the tube, for instance, for the purpose of exchanging without difficulty any damaged or jammed rolls.

Owing to the deformation pressures taken up by the inner roll, the roll carrier will be subject to a very small bending or flexure. The shape of this flexure changes with the position of the inner bending roll and of the roll support in axial direction, namely, with the position of the axially non-slidable supports of the roll support and the bearing box, respectively, with respect to the frame. In order to obtain with reference to the width of the band a symmetrically extending bending line, namely, a symmetrical bending stress of the band over its width, it is necessary to "balance out" the roll support.

This is accomplished in that the outer vertically adjustable supports of the roll support or the bearing box, respectively, are for instance made vertically adjustable with the assistance of a motor-driven eccentric shaft independently of the scanning device which measures the tube curvature. The motor drive of the eccentric shaft may be controlled by a water balance or another suitable inclination measuring device.

Finally the roll support may have at its inner end facing the tube an inner tube support which is provided with rollers on arms, whereby all of the rollers at the same time are adjustable in radial direction and subject the inner wall of the tube to pressure.

Furthermore, during the deformation operation, the tube diameter—if desired—in cooperation with a small change of the inlet angle, may be increased or decreased within narrow limits. The possibility of making the entire calibration of the inner surface of the tube centric is important for the reason, that only the roll support with the assistance of the above-mentioned gear drive or any other means may be removed from the tube.

While the devices used for the adjustment of the inner bending roll during the operation of the deformation machine operate substantially automatically, the outer bending rolls, as soon as the inner bending roll reaches the limit range of its operativeness by means of suitable drives, which also operate during the operation of the deformation either manually or programmatically, i.e. in relation to the effectiveness of the vertical adjustment of the inner bending roll, are adjusted. The invention makes use of the knowledge that the influencing of the radius of curvature of the tube by solely adjusting the vertical position of the inner bending roll only in the range of certain positions of the outer bending rolls yields a maximum result.

The devices for the adjustment of the outer bending rolls are actuated by electrical, hydraulical or electrohydraulical drive means. In this manner, the axes of the outer bending rolls may be adjusted in the axial, horizontal and in the vertical direction in such a manner that at the average thickness of the sheet metal and the average quality of the sheet metal under due consideration of the size of the still available operating range of the automatic adjusting means, the inner bending roll produces the desired curvature of the tube diameter. If then the average values of the thickness of the sheet metal and quality or thickness of the sheet metal are not obtained during the deformation operation, i.e. when at certain parts the desired tube curvature cannot be obtained, then there will come into operation first of all the tube curvature scanning device which controls the vertical adjusting device of the inner bending roll, so that the previously adjusted tube curve is increased or decreased.

In addition to the horizontal, vertical and axial adjustability of the axes of the outer bending rolls, the invention provides that the bearings of the outer bending rolls, which take up pressure may be pivoted by drive means about axes which extend parallel to the axes of the rolls. In this manner, these bearings are not eccentrically stressed when the tube diameters are different, so that the lubrication of the bearing and the attachment of the bearing are not in danger, because the pivotal adjustment which is possible has the result that the center line of the bearings and the direction of the force on the bearings are substantially in coincidence.

Finally, the invention also provides a device for the adjustment of the attack angle of the deformation rolls in correspondence with the inlet angle of the sheet metal band into the deformation machine.

All of these described adjusting devices for the outer bending rolls are provided in an embodiment for each of the two outer bending rolls, so that each axis of the two outer bending rolls is independently adjustable from the outer in the described manner.

An embodiment of the device of the invention is diagrammatically illustrated in the accompanying drawings in which:

FIG. 1 illustrates the arrangement of the inner bending roll in side elevation.

FIG. 2 illustrates an end view of the inner tube support.

FIG. 2*a* illustrates in a partial section a detail of the inner tube support.

FIG. 3 illustrates in a side elevation view the arrangement of the outer bending rolls.

FIG. 3*a* is a top view of the arrangement shown in FIG. 3.

FIG. 4 illustrates an end view of the device from the left-hand side of the FIGS. 3 or 3*a*.

FIG. 5 is a diagrammatic illustration of the automatic control of the attack angle of the deformation rolls as determined by the desired dimensions of the tube to be produced.

Referring to the drawings, the device **1** which deforms a sheet metal band **2** into a helical seam tube **3** having the longitudinal axis **4** comprises basically a plurality of frames **5** which together with a foundation **6** constitute a closed structure for resisting the bending forces which occur during the deformation of the band **2**.

An inner bending roll **10** comprises a series of individual deforming rolls **11** which are mounted one next to each other on a common roll support or shaft **12** which is axially movable within a bearing box **13**, whereby the axial movement is accomplished by a toothed rack **21** which is actuated to be axially movable by a drive **22**.

The bearing box **13** is supported by means of vertically adjustable supports **14** and **14'** within the frame **5**. Each of the vertically adjustable supports **14** and **14'** consist of a sliding key mechanism **15**, both of which are operated by a common drive **16** which in turn is controlled by a tube curvature scanning device **17**. (FIG. **5**).

The roll support **12** and the bearing box **13**, respectively, are pivotally supported in the two vertically adjustable supports **14** and **14'**, namely in such a manner that a tilting movement of a roll support **12** from the horizontal is possible. Viewed from above (FIG. 3*a*) the pivot axis extends at right angles to the longitudinal axis of the tube to be produced. This arrangement is not very apparent from the drawing because one has to deal with shoulder bearings which permit minor pendulum movements.

The roll support **12** and the bearing box **13**, respectively, are guided in the parts of the frame **5** of the device by parallelogram guides which, for instance, may have the form of articulated lever systems, so that a twisting of the roll supports during vertical movements is not possible.

Between the outer vertically adjustable support **14'** and the bearing box **13** is arranged an ecentric shaft **18** whose position effect is one-sided vertical adjustment of the bearing box **13** and therewith an adjustment of the roll support **12**, which however is independent of the tube curvature scanning device **17**. The eccentric shaft **18** is rotated by a motor **19** by means of a gearing and this motor **19** may be controlled by an inclination measuring device **20** (FIG. **5**).

With the assistance of a toothed rack **21** provided on the roll support **12** and a drive **22** on the bearing box **13**, the roll support **12** may be moved relatively to the bearing box **13** in the direction of the horizontal axis **4** of the tube.

At the inner end of the roll support **12** is arranged an inner tube support **23** (FIGS. **1** and **2**) which is provided with radially extending arms **24** at the outer end of which are mounted rollers **25** which by means of a central drive **26** and a gear **27** (FIG. **2a**) and shafts **28** and an elastic intermediate member **29** are pressed against the inner wall of the tube **3**.

For the vertical and axial adjustment of the outer bending rolls **30** and **31** and their deformation rollers **32** and for each of the two outer bending rolls **32**, are provided two adjusting devices with relatively to each other slidable adjusting wedges **33** and **35**. The latter are associated with drive means **34** and **36** and furthermore for the horizontal adjustment each one of the outer bending rolls is provided with a lateral adjustment device having adjusting wedges **37** and **37'** operated by drive means **38** and **38'**. In the same manner as the roll supports **12**, the two outer bending rolls **30** and **31** have to be movable along the axis of the tube, but by maintaining the preselected vertical adjustment. This is done in that the slidable wedges **33** and **35** are moved together in axial direction.

If one desires solely an adjustment in vertical direction, the wedge **33** remains stationary. The outer wedge **35** is then introduced or removed and when this is done, the vertical adjustment is changed. The slidable wedges **37** and **37'** are arranged in the wedge member **33**.

For the swinging movement of the bearings each one of the same is provided with a separate drive **39** and **39'**, respectively. These bearings swing the bending rolls **30, 31** in relation to the center point of the tube in which or nearby thereto the symmetry lines of the bearings of the two outer bending rolls **30** and **31** should intersect.

The axis for the swinging movement of the bearings toward the center point of the tube may be selected as desired. Preferably, this axis is arranged in the plane in which the bending roll engages the tube. The bearings for the lower bending rolls are therefore swung more when a tube of a smaller diameter is being made and is swung to a smaller degree when a tube of a larger diameter is being made.

The three bending rolls **10, 30** and **31** are each provided with a series of deformation rolls **11** and **32**, respectively, which are disc-shaped and by themselves, with respect to the axis of the respective bending roll, are adjustable about a vertical axis in such a manner that the planes of the disc-shaped deformation rolls **11** and **32** with respect to the axis of the associated roll may assume an attack angle deviating from 90°. A change of the attack angle of the deformation rolls is necessary when a change of the inlet angle of the sheet metal band into the deformation device takes place. The change in the attack angle is effected in this case for the outer bending rolls **30** and **31** by the drives **40** and **40'** and for the inner bending roll **10** with the assistance of a similar drive not illustrated.

In accordance with the invention, the change of the attack angle of the deformation rolls **11** and **32**, respectively, of the three bending rolls is also employed for the purpose of accomplishing a continuous control of the tube by making corrections resulting from the tube bending operation so as to protect the deformation rolls against excessive lateral forces which could lead to a destruction of these rolls, when on one hand the inlet angle of the band changes constantly within certain limits, and when on the other hand the attack angle of the deformation rolls is not in agreement therewith. For this purpose the control system illustrated in FIG. **5** is employed This control system comprises the already mentioned tube curvature scanning device **17** and in addition thereto four measuring instruments **50** which are circularly arranged so as to be each 90° apart from each other and which continuously measure the oval shape and the diameter of the finished welded tube. The measured values are transferred as actual values to the actual value potentiometers **51** and **52**, of which the potentiometer **51** measures the oval shape and the potentiometer **52** measures diameter values, while the tube curvature actual values measured by the scanning device **17** are indicated at **53**.

These actual value potentiometers are arranged for the sake of comparison opposite of the desired value potentiometers **54, 55** and **56**. The differences between the said desired values and the measured actual values are amplified in their electrical values which are converted in order to operate by means of control devices **62, 63**, and **64** associated drive means (such as **40** and **40'**) which adjust the deformation rolls of the three bending rolls. For the amplification and conversion of the differential values determined from the desired values and the actual values potentiometer are provided the devices **57, 57'** and **57''**. **59** indicates an indicating instrument for the attack angle of the three deformation roll units. This indicating instrument may be selectively switched at **58** to either one of the roll units. The indicating instrument **60** indicates the vertical position of the inner deformation roll unit. The adjustment in vertical direction is accomplished by the adjusting drive **16** and indicated by the potentiometer connected thereto. The operating member for the vertical adjustment drive may consist, as indicated in the drawing, of a push-button P or another automatically actuating adjustment member. The indicating instrument **61** indicates the inclination of the roll support **12** of the inner bending roll **10** on which are arranged the individual disc-shaped deformation rolls **11**. An inclination measuring instrument **20** effects an automatic operation of the drive **19** of the eccentric shaft **18**, both of which are arranged on the outer end of the roll support **12**.

$\underset{\sim}{M}$ in FIG. **5** indicates alternating current motors, $\underset{3\sim}{M}$ indicates a three-phase alternating current motor, W indicates switching means for the automatic adjustment of the adjusting means in relation to the desired value potentiometers **54, 55** and **56**. U indicates a manually operable changeover switch at **58**, and Poti indicates potentiometers.

It has been discovered that the change of the attack angle of the deformation rolls, particularly in deformation devices for tubes having a large diameter and a very thick wall has a deciding alleviation effect during a change of the inlet angle of the sheet metal band and that in such a case a swingable arrangement of the deformation station with respect to the sheet metal band is not necessary.

However, the deformation procedure is also then considerably alleviated, for instance, by the arrangement of the adjustable deformation rolls because the inlet direction of the band always is in the direction of the plane of the direction of the deformation rolls.

The invention permits the practice of a production method for making helical seam tubes which is based on a careful testing of the material to be deformed as a starting product and/or of the dimensions of the tube as end product, and comprises a suitable device and also a control of this device which permits the continuous automatic production of tubes having a large diameter and a thick wall.

What I claim is:

1. Device for helically deforming a sheet metal band to form a tube therefrom, comprising inner and outer bending rolls for engaging the inner wall and the outer wall of the tube to be formed, shaft means on which said rolls are mounted, and means for so supporting said shaft means during the deforming operation on said sheet metal band that said shaft means at least in one direction are slidably displaceable along their axes, and mounting means for said rolls so that said rolls are slidable parallel in at least one direction and are also vertically adjustable during the forming operation responsive to variations in the coefficient of elasticity in the sheet metal band for enabling the rolls to adjust to the desired diameter of the tubing.

2. Device according to claim **1**, including means for vertically adjusting the shaft means of said inner bending rolls during said deforming operation and means for vertically and laterally adjusting the shaft means of said outer bending rolls during said deforming operation.

3. Device according to claim **1**, in which said inner bending roll comprises a plurality of serially arranged deformation rollers mounted on a common shaft (**12**), the latter being rotatably supported for vertical adjustment at least on two places within the frame of the device.

4. Device for helically deforming a sheet metal band to form a tube therefrom, comprising inner and outer bending rolls for engaging the inner wall and the outer wall of the tube to be formed, shaft means on which said rolls are mounted, means for so supporting said shaft means during the deforming operation on said sheet metal band that said shaft means at least in one direction are slidably displaceable along their axes, said inner bending roll comprises a plurality of serially arranged deformation rollers mounted on a common shaft, the latter being rotatably supported for vertical adjustment at least on two places within the frame of the device, means comprising slidable wedge gearing for flexibly supporting said common shaft, an electric motor for operating said wedge gearing, and a scanning means for measuring the curvature of said tube, said scanning means controlling the operation of said electric motor.

5. Device according to claim **4**, including a bearing box for said common shaft mounted displaceable in direction of said tube in the frame of the device.

6. Device according to claim **4**, including a tube support (**23**) for the inner end of said common shaft (**12**), said tube support comprising substantially radially disposed arms provided each with a roller at their outer ends which engage the inner wall of the tube, and means for radially urging all of said arms and rollers thereon into engagement with the inner wall of the tube.

7. Device according to claim **1**, including bearings for said outer bending rolls, and drive means (**39**) for pivotally adjusting said bearings about axes extending parallel to axes of said rolls.

8. Device according to claim **1**, in which said bending rolls comprise each a plurality of disc-shaped deformation rollers (**11, 32**) which are mounted on shafts rotatable about parallel axes.

9. Device according to claim **1**, in which said bending rolls comprise each a plurality of disc-shaped deformation rollers (**11, 32**) which are mounted on shafts rotatable about parallel axes, and including means for adjusting the attack angle of the disc-shaped deformation rollers about vertical axes.

10. Device according to claim **1**, in which said bending rolls comprise each a plurality of disc-shaped deformation rollers (**11, 32**) which are mounted on shafts rotatable about parallel axes, and including means for adjusting the attack angle of the disc-shaped deformation rollers about vertical axes, the attack angle of said disc-shaped deformation roller being adjusted during the deformation operation in correspondence with the deviations of the tube curvature from the desired dimensions of the tube being formed.

11. Device for helically deforming a sheet metal band to form a tube therefrom, comprising inner and outer bending rolls for engaging the inner wall and the outer wall of the tube to be formed, shaft means on which said rolls are mounted, means for so supporting said shaft means during the deforming operation on said sheet metal band that said shaft means at least in one direction are slidably displaceable along their axes, scanning means for measuring the curvature of the tube at the outlet end of said bending rolls, means for vertically adjusting the shafts for said inner bending rolls, means for operating said vertically adjusting means, and means for producing electric signals from the measurement deviations between the measurements made by said scanning means and the desired dimension of the tube diameter, and means for causing said signals to operate said operating means for said vertically adjusting means.

12. Device according to claim **11**, including measuring instruments (**50**) in addition to said scanning means for determining the diameter of the ovality of the tube.

13. Device for helically deforming a sheet metal band to form a tube therefrom, comprising inner and outer bending rolls for engaging the inner wall and the outer wall of the tube to be formed, shaft means on which said rolls are mounted, means for so supporting said shaft means during the deforming operation on said sheet metal band that said shaft means at least in one direction are slidably displaceable along their axes, vertically adjustable means for supporting the outer bending rollers, and a motor-operated eccentric drive shaft connected with said supporting means for operating said vertically adjustable means.

14. Device for helically deforming a sheet metal band to form a tube therefrom, comprising inner and outer bending rolls for engaging the inner wall and the outer wall of the tube to be formed, shaft means on which said rolls are mounted, means for so supporting said shaft means during the deforming operation on said sheet metal band that said shaft means at least in one direction are slidably displaceable along their axes, said inner and outer rolls including two outer bending rolls mounted on separate shafts arranged in horizontal spaced relationship, and driven slidable wedge gearings for adjusting the distance between said shafts.

15. Device for helically deforming a sheet metal band to form a tube therefrom, comprising inner and outer bending rolls for engaging the inner wall and the outer wall of the tube to be formed, shaft means on which said rolls are mounted, means for so supporting said shaft means during the deforming operation on said sheet metal band that said shaft means at least in one direction are slidably displaceable along their axes, the aforesaid rolls including two outer bending rolls (**30, 31**) mounted on separate shafts arranged in horizontal spaced relationship, and driven slidable wedge gearings (**37**) for adjusting the distance between said shafts, and additional driven slidable wedge gearings (**33, 35**) for adjusting the shafts of said bending rolls (**30, 31**) in axial and vertical directions.

16. Device for helically deforming a sheet metal band to form a tube therefrom, comprising inner and outer bending rolls for engaging the inner wall and the outer wall of the tube to be formed, shaft means on which said rolls are mounted, means for so supporting said shaft means during the deforming operation on said sheet metal band that said shaft means at least in one direction are slidably displaceable along their axes, and including, in combination, scanning means and measuring instruments for determining the actual dimensions of the tube in relation to adjusted desired dimensions of the same, said combination forming an automatic control means for drive means which adjust the attack angles of the deformation rollers constituting parts of said bending rolls.

17. Device for helically deforming a sheet metal band to form a tube therefrom, comprising inner and outer bending rolls for engaging the inner wall and the outer wall of the tube to be formed, shaft means on which said rolls are mounted, and means for so supporting said shaft means during the deforming operation on said sheet metal band that said shaft means at least in one direction are slidably displaceable along their axes, and mounting means for said rolls so that said rolls are slidable parallel in at least one direction during the forming operation responsive to variations in the coefficient of elasticity in the sheet metal band for enabling the rolls to adjust to the desired diameter of the tubing.

18. A method of helically deforming a sheet metal band comprising the steps of relatively moving the band with respect to a series of inner and outer bending rolls, and while relatively moving the sheet metal band causing the rolls to slide parallel in at least one direction responsive to variations in the coefficient of elasticity in the sheet metal band for enabling the rolls to adjust to the desired diameter of the tubing and thereby controlling the radius of curvature of the thus helically deformed sheet metal band.

19. A method of helically deforming a sheet metal band comprising the steps of relatively moving the band with respect to a series of inner and outer bending rolls, and while relatively moving the sheet metal band causing the rolls to slide parallel in at least one direction and also vertically responsive to variations in the coefficient of elasticity in the sheet metal band for enabling the rolls to adjust to the desired diameter of the tubing and thereby controlling the radius of curvature of the thus helically deformed sheet metal band.

20. A method of helically deforming a sheet metal band comprising the steps of welding together a series of sheet metal pieces to form a sheet metal band, relatively moving the band with respect to a series of inner and outer bending rolls, and while relatively moving the sheet metal band causing the rolls to slide parallel in at least one direction responsive to variations in the coefficient of elasticity in the sheet metal band for enabling the rolls to adjust to the desired diameter of the tubing and thereby controlling the radius of curvature of the thus helically deformed sheet metal band.

21. A method of helically deforming a sheet metal band comprising the steps of relatively moving the band with respect to a series of inner and outer bending rolls, while relatively moving the sheet metal band causing the rolls to slide parallel in at least one direction responsive to variations in the coefficient of elasticity in the sheet metal band for enabling the rolls to adjust to the desired diameter of the tubing and thereby controlling the radius of curvature of the thus helically deformed sheet metal band, measuring the thickness of the band during the helical deformation thereof and causing relative movement of the rolls where the measurements indicate that a vertical adjustment of the rolls is required, and vertically causing relative movement of the rolls in response to the aforesaid measurement step where required.

22. The device of claim **17** further characterized as including a scanning device for ascertaining deviations of the tube curvature from a predetermined dimension and means responsive to said scanning means for vertically moving the centermost bending roll in response to the sensed deviations.

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