(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 827 910 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
02.06.2021 Bulletin 2021/22

(21) Application number: **19841989.7**

(22) Date of filing: **26.04.2019**

(51) Int Cl.:
***B21C 37/06** (2006.01)* ***B21C 37/08** (2006.01)*
***B21D 5/12** (2006.01)*

(86) International application number:
PCT/JP2019/018006

(87) International publication number:
WO 2020/021809 (30.01.2020 Gazette 2020/05)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
KH MA MD TN

(30) Priority: **26.07.2018 JP 2018140612**

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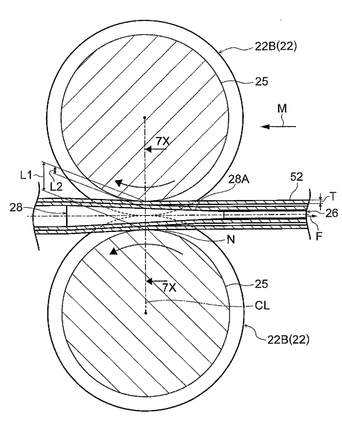
(54) MOLDING DEVICE FOR MULTI-WOUND TUBE AND MOLDING METHOD FOR MULTI-WOUND TUBE

(57) A multiple-winding pipe forming device for forming a wound pipe, the multiple-winding pipe forming device comprising: a plurality of pairs of forming rollers arranged along a feeding direction of a metal sheet that is an object of forming, each pair of forming rollers opposing one another so as to sandwich the metal sheet, and the plurality of pairs of forming rollers curling the metal sheet and winding the metal sheet into a roll shape; and a mandrel fabricated of metal, the mandrel including: a shaft that extends in the feeding direction and is disposed inside the metal sheet wound in the roll shape, one end side of the shaft being retained, which one end side is disposed upstream in the feeding direction, and a working portion provided at an opposite end side of the shaft from a side thereof at which the one end side is disposed, the working portion including a taper portion that increases in diameter from upstream to downstream in the feeding direction, wherein the taper portion of the working portion is disposed at a position at which the metal sheet wound in the roll shape is sandwiched by, of the plurality of pairs of forming rollers, a pair of the forming rollers that is disposed at a downstream side in the feeding direction.

FIG.4



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a multiple-winding pipe forming device and a multiple-winding pipe forming method.

BACKGROUND ART

[0002] Heretofore, a forming device has been known (for example, see Japanese Patent Application Laid-Open (JP-A) No. H11-342418) that uses plural pairs of forming rollers to wind a belt-shaped metal sheet into a roll shape and form a multiple-winding pipe.

[0003] In the forming device according to JP-A No. H11-342418, of the plural pairs of forming rollers, a pair of the forming rollers is disposed at the downstream side of a feeding direction of the metal sheet. A mandrel is disposed at the inner side of the metal sheet wound in the roll shape. Superposed portions of the metal sheet wound in the roll shape are compressed between this pair of forming rollers and a working portion of the mandrel, and superposed surfaces of the superposed portions are tightly contacted with one another.

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] In JP-A No. H1 1-342418, a shape of the working portion of the mandrel is a hump shape that protrudes to diametric direction outer sides. The superposed portions of the metal sheet wound in the roll shape are compressed between a maximum outer diameter portion of the working portion and the pair of forming rollers. However, thickness of the metal sheet may be inconsistent, in which case pressure forces applied by the working portion of the mandrel and the forming rollers to the superposed portions of the metal sheet wound in the roll shape may be inconsistent. When the pressure forces are inconsistent in this manner, tight contact between the superposed surfaces of the metal sheet wound in the roll shape may decline. When tight contact between the superposed surfaces declines, in a heating process after the forming process, voids (gaps) may be formed between the superposed surfaces of the metal sheet wound in the roll shape.

[0005] In consideration of the circumstances described above, an object of the present disclosure is to provide a multiple-winding pipe forming device and a multiple-winding pipe forming method that make pressure forces on superposed portions of a metal sheet wound in a roll shape more uniform even when thickness of the metal sheet is inconsistent.

SOLUTION TO PROBLEM

[0006] A multiple-winding pipe forming device according to one aspect of the present disclosure is a multiple-winding pipe forming device for forming a wound pipe, the multiple-winding pipe forming device including: plural pairs of forming rollers arranged along a feeding direction of a metal sheet that is an object of forming, each pair of forming rollers opposing one another so as to sandwich the metal sheet, and the plural pairs of forming rollers curling the metal sheet and winding the metal sheet into a roll shape; and a mandrel fabricated of metal, the mandrel including: a shaft that extends in the feeding direction and is disposed inside the metal sheet wound in the roll shape, one end side of the shaft being retained, which one end side is disposed upstream in the feeding direction, and a working portion provided at an opposite end side of the shaft from a side thereof at which the one end side is disposed, the working portion including a taper portion that increases in diameter from upstream to downstream in the feeding direction. In this multiple-winding pipe forming device, the taper portion of the working portion is disposed at a position at which the metal sheet wound in the roll shape is sandwiched by, of the plural pairs of forming rollers, a pair of the forming rollers that is disposed at a downstream side in the feeding direction.

[0007] A multiple-winding pipe forming method according to another aspect of the present disclosure uses the multiple-winding pipe forming device according to the one aspect and includes: curling the metal sheet and winding the metal sheet into the roll shape; and compressing superposed portions of the metal sheet wound in the roll shape between the taper portion of the working portion and the pair of forming rollers that is disposed at the downstream side in the feeding direction of the metal sheet.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] As described above, according to the present disclosure, a multiple-winding pipe forming device and a multiple-winding pipe forming method may be provided that make pressure forces on superposed portions of a metal sheet wound in a roll shape more uniform even when thickness of the metal sheet is inconsistent.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 is a schematic structural diagram of a multiple-winding pipe forming device according to an exemplary embodiment of the present disclosure.

Fig. 2 is a sectional diagram, cut along an axial direction of a mandrel, of a pair of forming rollers disposed furthest downstream in a feeding direction of a metal sheet in the multiple-winding pipe forming device of Fig. 1.

Fig. 3 is a schematic structural diagram depicting operation for winding the metal sheet into a roll shape in the multiple-winding pipe forming device of Fig. 1.

Fig. 4 is a sectional diagram, cut along the axial direction of the mandrel, of the pair of forming rollers disposed furthest downstream in the feeding direction of the metal sheet in the multiple-winding pipe forming device of Fig. 3.

Fig. 5 is a sectional diagram showing a state in which, from the sectional diagram shown in Fig. 4, a working portion of the mandrel is shifted downstream in the feeding direction of the metal sheet due to an increase in thickness of the metal sheet.

Fig. 6 is a sectional diagram showing a state in which, from the sectional diagram shown in Fig. 4, the working portion of the mandrel is shifted upstream in the feeding direction of the metal sheet due to a decrease in thickness of the metal sheet.

Fig. 7 is a sectional diagram cut along line 7X-7X in Fig. 4.

Fig. 8 is a sectional diagram cut along a direction orthogonal to an axial direction of a multiple-winding pipe fabricated by a multiple-winding pipe forming method according to the exemplary embodiment of the present disclosure.

Fig. 9 is a magnified sectional diagram of a metal sheet to be used in the multiple-winding pipe forming method according to the exemplary embodiment of the present disclosure.

Fig. 10 is a sectional diagram (a sectional diagram corresponding to Fig. 2) showing a variant example of the mandrel shown in Fig. 2.

Fig. 11 is a sectional diagram (a sectional diagram corresponding to Fig. 4) showing the variant example of the mandrel shown in Fig. 10.

DETAILED DESCRIPTION

[0010] Below, a multiple-winding pipe forming device and multiple-winding pipe forming method according to an exemplary embodiment relating to the present disclosure are described with reference to the drawings. An arrow M that is shown where appropriate in the drawings is a feeding direction of a metal sheet 52.

[0011] First, a multiple-winding pipe 50 that is fabricated using a multiple-winding pipe forming device (below referred to where appropriate as "the forming device") 20 is described. Then, the forming device 20 is described, after which a forming method using the forming device 20 is described.

[0012] Fig. 8 shows the multiple-winding pipe 50 according to the present exemplary embodiment. The multiple-winding pipe 50 is formed by the metal sheet 52 being wound in a roll shape and superposed surfaces of superposed portions of the metal sheet 52 being joined together. The multiple-winding pipe 50 according to the present exemplary embodiment is a two-winding pipe. The multiple-winding pipe 50 is used as, for example, a piping component of a vehicle (for example, brake piping).

[0013] As shown in Fig. 9, the metal sheet 52 that forms the multiple-winding pipe 50 is formed by coating a core member 54 with a coating member 56. The core member 54 is formed of a metal material, and the coating member 56 is formed of a metal material with a lower melting point than the core member 54. The metal sheet 52 is machined into a belt shape; a length direction of the metal sheet 52 matches an axial direction (a direction along an axis) of the multiple-winding pipe 50 after the multiple-winding pipe 50 is formed. A clad steel sheet and a coated steel sheet can be mentioned as examples of the metal sheet 52. Iron, aluminium or the like may be employed as the metal material forming the metal sheet 52. Copper, an aluminium alloy or the like that is used as a common brazing material may be employed as the metal material forming the coating member 56. In the present exemplary embodiment, two faces of the core member 54 are coated with the coating member 56, but structures are possible in which only one face of the core member 54 is coated with the coating member 56. In the present exemplary embodiment, after the metal sheet 52 is wound into the roll shape, superposed surfaces of superposed portions of the metal sheet 52 are joined by brazing to form the multiple-winding pipe 50.

[0014] Now, the forming device 20 according to the present exemplary embodiment is described.

= Forming Device =

[0015] As shown in Fig. 1 to Fig. 4, the forming device 20 is an apparatus that curls the metal sheet 52 and winds the metal sheet 52 into a roll shape, forming a roll in a pipe shape with a predetermined inner diameter (roll forming).

[0016] The forming device 20 is provided with plural pairs of forming rollers 22 and a mandrel 24 that is fabricated of metal. The pairs of forming rollers 22 are arranged along the feeding direction of the metal sheet 52 (below shortened where appropriate to "the feeding direction"). The mandrel 24 is arranged along the feeding direction.

- Roll forming -

[0017] As shown in Fig. 1 and Fig. 3, the plural pairs of the forming rollers 22 are disposed as plural pairs spaced apart along the feeding direction, with each pair of the forming rollers 22 opposing one another so as to sandwich the metal sheet 52, which is an object of forming. The metal sheet 52 is curled and wound into the roll shape by these forming rollers 22.

[0018] Plural pairs of assisting rollers 23 that assist in the curling of the metal sheet 52 are disposed between adjacent pairs of the forming rollers 22 along the feeding direction.

[0019] Of the plural pairs of forming rollers 22, a pair of forming rollers 22A is disposed furthest upstream in the feeding direction. The metal sheet 52 is wound on a drum 58. The forming rollers 22A function as feeding rollers that sandwich the metal sheet 52 from two sheet face sides thereof and feed the metal sheet 52 wound on the drum 58 out in the feeding direction.

[0020] Of the plural pairs of forming rollers 22, a pair of forming rollers 22B is disposed furthest downstream in the feeding direction. The forming rollers 22B function as pressure rollers that compress superposed portions of the metal sheet 52 wound in the roll shape between the forming rollers 22B and a taper portion 28A of the mandrel 24, which is described below, and put superposed surfaces 52A and 52B of the metal sheet 52 into contact without gaps. A circumferential trench 25 is formed in each of the pair of forming rollers 22B. The metal sheet 52 wound in the roll shape is inserted into each circumferential trench 25. The circumferential trench 25 is formed continuously in the circumferential direction over the whole circumference of the forming roller 22B.

[0021] Of the plural pairs of forming rollers 22, plural pairs of forming rollers 22C are disposed between the pair of forming rollers 22A and the pair of forming rollers 22B. The forming rollers 22C function as curl-forming rollers that, from an upstream side toward a downstream side in the feeding direction, progressively curl the metal sheet 52 to wind the metal sheet 52 into the roll shape.

- Mandrel -

[0022] As shown in Fig. 1 and Fig. 3, the mandrel 24 includes a shaft 26 and a working portion 28.

[0023] The shaft 26 extends along the feeding direction. More specifically, the shaft 26 extends from a space between the pair of forming rollers 22A and one pair of the forming rollers 22C to just before a nipping portion N of the pair of forming rollers 22B. According to this structure, a region of the shaft 26 (a region at the downstream side thereof in the feeding direction) is disposed inside the metal sheet 52 wound in the roll shape. The shaft 26 is formed of a metal material (for example, iron). The meaning of the term "nipping portion N" as used herein is intended to include a position at which the metal sheet 52 wound in the roll shape is sandwiched by the pair of forming rollers 22B disposed furthest downstream in the feeding direction.

[0024] One end 26A of the shaft 26 is disposed at the upstream side thereof in the feeding direction. A disc-shaped spool portion 27 is formed at the one end 26A side of the shaft 26 and protrudes to diametric direction outer sides from the shaft 26. The spool portion 27 is employed such that the shaft 26 is retained by a retention portion 32 of a moving apparatus 30, which is described below.

[0025] Another end 26B of the shaft 26 is disposed at the downstream side thereof in the feeding direction, which is an opposite side of the shaft 26 from a side thereof at which the one end 26A is disposed. The working portion 28 is provided at the another end 26B side of the shaft 26 (in the present exemplary embodiment, at the another end 26B). The working portion 28 includes the taper portion 28A, which increases in diameter from upstream to downstream in the feeding direction. The working portion 28 is formed of a metal material (for example, iron) and is joined to the another end 26B of the shaft 26 by welding.

[0026] A position of the mandrel 24 along the feeding direction is controlled by the moving apparatus 30, which is described below, such that the taper portion 28A of the working portion 28 is disposed at the nipping portion N of the pair of forming rollers 22B.

[0027] As shown in Fig. 1 and Fig. 3, the forming device 20 is further provided with the moving apparatus 30 that moves the mandrel 24 along the feeding direction.

[0028] The moving apparatus 30 includes the retention portion 32, a drive source 34, a sensor 36 and a control section 38.

[0029] The retention portion 32 is coupled to a housing 31 that retains the one end 26A side of the shaft 26 and is structured to be movable by sliding along the feeding direction. The retention portion 32 supports the one end 26A side of the shaft 26 and moves together with the housing 31 along the feeding direction. An engaging portion, which is not shown in the drawings, is provided at the retention portion 32. The engaging portion engages with the spool portion 27 of the shaft 26. Thus, the mandrel 24 moves with movement of the retention portion 32.

[0030] The drive source 34 is coupled to the housing 31 via a ball-and-screw mechanism (not shown in the drawings) for sliding the housing 31. The drive source 34 supplies driving force to move both the housing 31 and the retention portion 32 along the feeding direction. The drive source 34 that is employed may be, for example, an electric motor (a servo motor). The drive source 34 is controlled by the control section 38.

[0031] The sensor 36 is disposed in the housing. The sensor 36 detects tension acting on the shaft 26, via the retention portion 32. Information detected by the sensor 36 is sent to the control section 38.

[0032] The control section 38 controls output power (driving force) of the drive source 34, in accordance with information relating to the tension detected by the sensor 36, so as to adjust the position of the retention portion 32 in the feeding direction. Thus, the control section 38 may adjust a position of the taper portion 28A of the working portion 28 in the feeding direction.

= Forming Method =

[0033] Now, the multiple-winding pipe forming method using the forming device 20 according to the present exemplary embodiment is described.

[0034] Before formation of a multiple-winding pipe begins, a size (wall thickness, internal diameter and so forth) of the multiple-winding pipe to be formed is entered into a memory section, which is not shown in the drawings, of the control section 38 through an operation section, which is not shown in the drawings. On the basis of this size information, the control section 38 controls the drive source 34 and disposes the taper portion 28A of the working portion 28 at an optimum position of the nipping portion N of the pair of forming rollers 22B (an optimum position in the feeding direction). This optimum position is specified in advance on the basis of the size information by calculation or the like. More specifically, the control section 38 controls the drive source 34 such that a distance L2 between each forming roller 22B and the taper portion 28A (see Fig. 2) is the same as a thickness T of a peripheral wall portion of the multiple-winding pipe 50, which is entered in the size information. Thus, the taper portion 28A is disposed at the optimum position of the nipping portion N of the pair of forming rollers 22B.

[0035] Distances between the pair of forming rollers 22A, the pair of forming rollers 22B, the plural pairs of forming rollers 22C and the plural pairs of assisting rollers 23 are also altered on the basis of the entered information. For example, a distance L1 along a center line CL between floor surfaces of the circumferential trenches 25 of the pair of forming rollers 22B is altered.

[0036] Then, the metal sheet 52 is pulled out from the drum 58, and a leading end portion of the metal sheet 52 is disposed between and nipped by the pair of forming rollers 22A. The pair of forming rollers 22A turn in synchrony and feed out the nipped metal sheet 52 from upstream to downstream in the feeding direction. The metal sheet 52 fed out from the pair of forming rollers 22A is curled by the plural pairs of forming rollers 22C and the plural pairs of assisting rollers 23 and is wound into the roll shape. The metal sheet 52 is wound into the roll shape so as to encircle the shaft 26 of the mandrel 24. When the metal sheet 52 is passing through the plural pairs of forming rollers 22C, the metal sheet 52 is wound into the roll shape in a state in which gaps are formed between superposed portions of the metal sheet 52.

[0037] Then, at the nipping portion N of the pair of forming rollers 22B, the superposed portions of the metal sheet 52 wound in the roll shape are compressed by the pair of forming rollers 22B and the taper portion 28A of the working portion 28. More specifically, in the forming device 20 as shown in Fig. 4, a roll inner side portion of the metal sheet 52 wound in the roll shape increases in diameter while riding over the taper portion 28A of the working portion 28. As shown in Fig. 7, in a state in which the superposed surfaces 52A and 52B of the superposed portions of the metal sheet 52 wound in the roll shape touch without gaps (that is, a tightly contacted state), the superposed portions of the metal sheet 52 wound in the roll shape are compressed from inside and outside the roll by the pair of forming rollers 22B and the taper portion 28A of the working portion 28. After the superposed portions are compressed but before the superposed portions are joined, as shown in Fig. 4 and Fig. 5, the diameter of the metal sheet 52 wound in the roll shape increases after the compression while passing beyond a maximum diameter portion of the taper portion 28A.

[0038] When there is inconsistency in the thickness of the metal sheet 52 and, as illustrated in Fig. 5, the thickness T of the metal sheet 52 is greater than a standard sheet thickness (in the present exemplary embodiment, half of the entered wall thickness), frictional forces that are produced when the roll inner side portion of the metal sheet 52 wound in the roll shape rides over the taper portion 28A of the working portion 28 increase. Thus, a tension F acting on the shaft acting on the shaft 26 of which the one end 26A side is retained increases. When the tension F acting on the shaft 26 is greater, axial direction elongation (resilient elongation) of the shaft 26 fabricated of metal is greater, and the position of the taper portion 28A shifts downstream in the feeding direction relative to when the thickness of the metal sheet 52 is the standard sheet thickness (that is, relative to when the taper portion 28A is disposed at the optimum position of the nipping portion N mentioned above). When the position of the taper portion 28A shifts downstream in this manner, the distance L2 between each forming roller 22B and the taper portion 28A increases. As a result, an increase in pressure forces acting on the superposed portions of the metal sheet 52 wound in the roll shape between the pair of forming rollers 22B and the taper portion 28A is suppressed.

[0039] Alternatively, as illustrated in Fig. 6, when the thickness T of the metal sheet 52 is smaller than the standard sheet thickness, the frictional forces that are produced when the roll inner side portion of the metal sheet 52 wound in the roll shape rides over the taper portion 28A of the working portion 28 decrease. Thus, the tension F acting on the shaft 26 acting on the shaft 26 of which the one end 26A side is retained decreases. When the tension F acting on the shaft 26 is smaller, axial direction elongation (resilient elongation) of the shaft 26 fabricated of metal is smaller than when the thickness of the metal sheet 52 is the standard sheet thickness, and the position of the taper portion 28A shifts upstream in the feeding direction. When the position of the taper portion 28A shifts upstream in this manner, the distance L2 between each forming roller 22B and the taper portion 28A decreases. As a result, a decrease in the pressure forces acting on the superposed portions of the metal sheet 52 wound in the roll shape between the pair of forming rollers 22B and the taper portion 28A is suppressed.

[0040] In the forming device 20 as described above, even when the thickness T of the metal sheet 52 is inconsistent, pressure forces on the superposed portions of the metal sheet 52 wound in the roll shape may be made more uniform.

[0041] The meaning of the term "inconsistency in the thickness of the metal sheet" as used herein is intended to include inconsistencies in thickness caused by fabrication errors, inconsistencies in thickness when a metal sheet that is used is specified to change in thickness along the length direction thereof, and so forth.

[0042] In the present exemplary embodiment, the moving apparatus 30 is employed. The tension F acting on the shaft 26 is detected by the sensor 36, the drive source 34 is controlled by the control section 38 in accordance with the tension F detected by the sensor 36, and the position in the feeding direction of the retention portion 32 that supports the shaft 26 is adjusted. More specifically, when the taper portion 28A may not be disposed at the optimum position of the nipping portion N of the pair of forming rollers 22B by resilient elongation of the shaft 26 alone, the taper portion 28A is disposed at the optimum position of the nipping portion N of the forming rollers 22B by the moving apparatus 30, taking account of the resilient elongation of the shaft 26. Therefore, in addition to the effects described above caused by resilient elongation of the shaft 26 fabricated of metal, pressure forces on the superposed portions of the metal sheet wound in the roll shape may be made even more uniform.

[0043] The metal sheet 52 wound in the roll shape passes through the pair of forming rollers 22B and is heated in a heating step of a subsequent process. As a result of this heating, the superposed portions of the metal sheet 52 wound in the roll shape are joined by brazing. Thus, the multiple-winding pipe 50 is fabricated. Because the multiple-winding pipe 50 that is fabricated in this manner has been heated in a state in which the superposed surfaces 52A and 52B of the superposed portions of the metal sheet 52 wound in the roll shape are touching without gaps (that is, the tightly contacted state), the formation of voids (gaps) between the superposed surfaces 52A and 52B is suppressed.

[0044] Now, operational effects of the multiple-winding pipe 20 according to the present exemplary embodiment are described.

[0045] In the forming device 20 as described above, pressure forces on the superposed portions of the metal sheet 52 wound in the roll shape may be made more uniform even when the thickness of the metal sheet 52 is inconsistent.

[0046] In the forming device 20, because the taper portion 28A is disposed at the optimum position of the nipping portion N of the pair of forming rollers 22B, one type of the mandrel 24 may be applied to metal sheets of plural sizes (sheet thicknesses). Therefore, a number of types of the mandrel 24 may be reduced. Hence, because the number of types of the mandrel 24 is reduced, the labor of setting a different mandrel in the forming device for each size of metal sheet may be reduced.

[0047] In the forming device 20, because the moving apparatus 30 is also provided, positions in the feeding direction of the pairs of forming rollers 22C and the taper portion 28A of the working portion 28 may be adjusted automatically prior to the forming of the metal sheet 52. Thus, the taper portion 28A may be disposed at the optimum position of the nipping portion N of the pair of forming rollers 22B.

[0048] In the forming device 20 as described above, the taper portion 28A is disposed by the moving apparatus 30 at the optimum position of the nipping portion N of the pair of forming rollers 22B taking account of resilient elongation of the shaft 26. Therefore, in addition to the effects described above caused by resilient elongation of the shaft 26 fabricated of metal, pressure forces on the superposed portions of the metal sheet 52 wound in the roll shape may be made even more uniform.

[0049] In the forming device 20 according to the exemplary embodiment described above, the working portion 28 of the mandrel 24 includes the taper portion 28A, but the present disclosure is not limited by this structure. For example, as with a mandrel 60 shown in Fig. 10 and Fig. 11, a working portion 62 may include a circular rod portion 62B that protrudes from an end of a taper portion 62A and is equal in diameter to the end of the taper portion 62A. The circular rod portion 62B protrudes to an opposite side of the working portion 62 from a side thereof at which the shaft 26 is disposed. In this structure, compared to, for example, a structure in which the circular rod portion 62B is not provided and a terminal end of a taper portion has sharp angles, pressure forces acting on the end of the taper portion 62A are dispersed and abrasion of the mandrel 24 associated with the working of the metal sheet 52 is suppressed.

[0050] In the exemplary embodiment described above, the forming device 20 includes the moving apparatus 30, but the present disclosure is not limited by this structure. The forming device 20 need not include the moving apparatus 30, in which case the taper portion 28A is disposed at the optimum position of the nipping portion N only by the effects of resilient elongation of the shaft 26.

[0051] In the exemplary embodiment described above, the taper portion 28A of the working portion 28 is disposed at the nipping portion N of the pair of forming rollers 22B that are disposed furthest downstream in the feeding direction, but the present disclosure is not limited by this structure. For example, structures are possible in which the taper portion 28A of the working portion 28 is disposed at a nipping portion N of a pair of the forming rollers 22C that is disposed at the downstream side in the feeding direction and is the first pair upstream from the pair of forming rollers 22B (i.e., the pair of forming rollers 22C that is second furthest downstream). In this structure, the metal sheet 52 wound in the roll shape may be compressed at the pair of forming rollers 22C that is second furthest downstream, and fine adjustments of pipe diameter may be implemented at the pair of forming rollers 22B that is furthest downstream.

[0052] In the foregoing, an exemplary embodiment of the present disclosure has been illustrated and the exemplary embodiment has been described. However, this embodiment is an example; numerous modifications may be embodied within a scope not departing from the gist of the disclosure. It will be clear that the technical scope of the present disclosure is not to be limited by the exemplary embodiment.

[0053] The following notes are disclosed in relation to the exemplary embodiment described above.

- Note 1 -

[0054] A multiple-winding pipe forming device for forming a wound pipe, the multiple-winding pipe forming device comprising:

a plurality of pairs of forming rollers arranged along a feeding direction of a metal sheet that is an object of forming, each pair of forming rollers opposing one another so as to sandwich the metal sheet, and the plurality of pairs of forming rollers curling the metal sheet and winding the metal sheet into a roll shape; and

a mandrel fabricated of metal, the mandrel including:

a shaft that extends in the feeding direction and is disposed inside the metal sheet wound in the roll shape, one end side of the shaft being retained, which one end side is disposed upstream in the feeding direction, and

a working portion provided at an opposite end side of the shaft from a side thereof at which the one end side is disposed, the working portion including a taper portion that increases in diameter from upstream to downstream in the feeding direction,

wherein the taper portion of the working portion is disposed at a position at which the metal sheet wound in the roll shape is sandwiched by, of the plurality of pairs of forming rollers, a pair of the forming rollers that is disposed at a downstream side in the feeding direction.

[0055] In the multiple-winding pipe forming device according to note 1, a wound pipe in which a metal sheet is curled and wound in a roll shape is formed by plural pairs of forming rollers. At the position at which the metal sheet wound in the roll shape is sandwiched by, of the plural pairs of forming rollers, the pair of forming rollers that is disposed at the downstream side in the feeding direction of the metal sheet, the superposed portions of the metal sheet wound in the roll shape are compressed by this pair of the forming rollers and the taper portion of the working portion. More specifically, in this forming device, a roll inner side portion of the metal sheet wound in the roll shape increases in diameter while riding over the taper portion of the working portion. In a state in which superposed surfaces of the superposed portions of the metal sheet wound in the roll shape are in contact without gaps (that is, a tightly contacted state), these superimposed portions of the metal sheet wound in the roll shape are compressed from inside and outside the roll by the pair of forming rollers and the taper portion of the working portion. When there is inconsistency in the thickness of the metal sheet and the thickness of the metal sheet is thicker than a standard sheet thickness, friction that occurs when the roll inner side portion of the metal sheet wound in the roll shape rides over the taper portion of the working portion increases, and tension acting on the shaft of which the one end side is retained increases. When the tension acting on the shaft is greater, axial direction elongation (resilient elongation) of the shaft fabricated of metal is greater, and a position of the taper portion shifts downstream in the feeding direction of the metal sheet (below shortened where appropriate to "the feeding direction") relative to when the thickness of the metal sheet is the standard sheet thickness. When the position of the taper portion shifts downstream in the feeding direction in this manner, distances between the forming rollers and the taper portion increase. As a result, an increase in pressure forces acting on the superposed portions of the metal sheet wound in the roll shape between the forming rollers and the taper portion is suppressed. On the other hand, when the thickness of the metal sheet is smaller than the standard sheet thickness, friction that occurs when the roll inner side portion of the metal sheet wound in the roll shape rides over the taper portion of the working portion decreases, and the tension acting on the shaft decreases. When the tension acting on the shaft is smaller, axial direction elongation (resilient elongation) of the shaft fabricated of metal is smaller than when the thickness of the metal sheet is the standard sheet thickness, and the position of the taper portion shifts upstream in the feeding direction. When the position of the taper portion shifts upstream in this manner, the distances between the forming rollers and the taper portion decrease. As a result, a reduction in pressure forces acting on the superposed portions of the metal sheet wound in the roll shape between the forming rollers and the taper portion is suppressed.

[0056] Thus, in the multiple-winding pipe forming device according to note 1 as described above, pressure forces on superposed portions of the metal sheet wound in the roll shape may be made more uniform even when there is inconsistency in the thickness of the metal sheet.

-Note 2 -

[0057] The multiple-winding pipe forming device according to note 1, wherein the working portion includes a circular rod portion protruding from an end of the taper portion to an opposite side of the taper portion from a side thereof at which the shaft is disposed, the circular rod portion being equal in diameter to the end of the taper portion.

[0058] In the multiple-winding pipe forming device according to note 2, the working portion includes the circular rod portion that protrudes from the end of the taper portion, to the opposite side of the taper portion from the side thereof at which the shaft is disposed, with the same diameter as the taper portion. As a result, pressure forces acting on the end of the taper portion are dispersed compared to a structure in which the circular rod portion is not provided and the terminal end of the taper portion has sharp angles. Thus, abrasion of the mandrel associated with working of the metal sheet is suppressed.

- Note 3 -

[0059] The multiple-winding pipe forming device according to note 1 or note 2, further comprising a moving apparatus that moves the mandrel along the feeding direction, the moving apparatus including:

a retention portion that retains the one end side of the shaft and is movable to an upstream side and the downstream side in the feeding direction, and
a drive source that moves the retention portion.

[0060] Because the multiple-winding pipe forming device according to note 3 is further provided with the moving device that moves the mandrel along the feeding direction, a position of the taper portion along the feeding direction may be adjusted in accordance with a standard sheet thickness of the metal sheet. For example, by appropriate control of the drive source, adjustment of a positional relationship between the pair of forming rollers and the working portion prior to the forming of the metal sheet may be automated.

- Note 4 -

[0061] The multiple-winding pipe forming device according to note 3, wherein the moving apparatus further includes:

a sensor that, via the retention portion, detects tension acting on the shaft; and
a control section that, in accordance with a tension detected by the sensor, controls the drive source and adjusts a position of the retention portion along the feeding direction.

[0062] In the multiple-winding pipe forming device according to note 4, tension acting on the shaft is detected by the sensor, the drive source is controlled by the control section in accordance with the tension detected by the sensor, and the position along the feeding direction of the retention portion that retains the shaft is adjusted. Thus, the positional relationship between the pair of forming rollers and the working portion is automatically adjusted during the forming of the metal sheet. As a result, in addition to the effects caused by resilient elongation of the shaft fabricated of metal described above, pressure forces acting on superposed portions of the metal sheet wound in the roll shape may be made even more uniform.

- Note 5 -

[0063] A multiple-winding pipe forming method using the multiple-winding pipe forming device according to any one of notes 1 to 4, the multiple-winding pipe forming method comprising:

curling the metal sheet and winding the metal sheet into the roll shape; and
compressing superposed portions of the metal sheet wound in the roll shape between the taper portion of the working portion and the pair of forming rollers that is disposed at the downstream side in the feeding direction of the metal sheet.

[0064] In the multiple-winding pipe forming method according to note 5, because the multiple-winding pipe forming device according to any one of notes 1 to 4 is employed, pressure forces from inside and outside the roll on superposed portions of the metal sheet wound in the roll shape may be made more uniform even when there is inconsistency in the thickness of the metal sheet.

[0065] The disclosures of Japanese Patent Application No. 2018-140612 filed July 26, 2018 are incorporated into the present specification by reference in their entirety.

[0066] All references, patent applications and technical specifications cited in the present specification are incorporated by reference into the present specification to the same extent as if the individual references, patent applications and technical specifications were specifically and individually recited as being incorporated by reference.

Claims

1. A multiple-winding pipe forming device for forming a wound pipe, the multiple-winding pipe forming device comprising:

a plurality of pairs of forming rollers arranged along a feeding direction of a metal sheet that is an object of forming, each pair of forming rollers opposing one another so as to sandwich the metal sheet, and the plurality of pairs of forming rollers curling the metal sheet and winding the metal sheet into a roll shape; and
a mandrel fabricated of metal, the mandrel including:

a shaft that extends in the feeding direction and is disposed inside the metal sheet wound in the roll shape, one end side of the shaft being retained, which one end side is disposed upstream in the feeding direction, and
a working portion provided at an opposite end side of the shaft from a side thereof at which the one end side is disposed, the working portion including a taper portion that increases in diameter from upstream to

downstream in the feeding direction,
wherein the taper portion of the working portion is disposed at a position at which the metal sheet wound in the roll shape is sandwiched by, of the plurality of pairs of forming rollers, a pair of the forming rollers that is disposed at a downstream side in the feeding direction.

2. The multiple-winding pipe forming device according to claim 1, wherein the working portion includes a circular rod portion protruding from an end of the taper portion to an opposite side of the taper portion from a side thereof at which the shaft is disposed, the circular rod portion being equal in diameter to the end of the taper portion.

3. The multiple-winding pipe forming device according to claim 1 or claim 2, further comprising a moving apparatus that moves the mandrel along the feeding direction, the moving apparatus including:

a retention portion that retains the one end side of the shaft and is movable to an upstream side and the downstream side in the feeding direction, and
a drive source that moves the retention portion.

4. The multiple-winding pipe forming device according to claim 3, wherein the moving apparatus further includes:

a sensor that, via the retention portion, detects tension acting on the shaft; and
a control section that, in accordance with a tension detected by the sensor, controls the drive source and adjusts a position of the retention portion along the feeding direction.

5. A multiple-winding pipe forming method using the multiple-winding pipe forming device according to any one of claims 1 to 4, the multiple-winding pipe forming method comprising:

curling the metal sheet and winding the metal sheet into the roll shape; and
compressing superposed portions of the metal sheet wound in the roll shape between the taper portion of the working portion and the pair of forming rollers that is disposed at the downstream side in the feeding direction of the metal sheet.

FIG.1

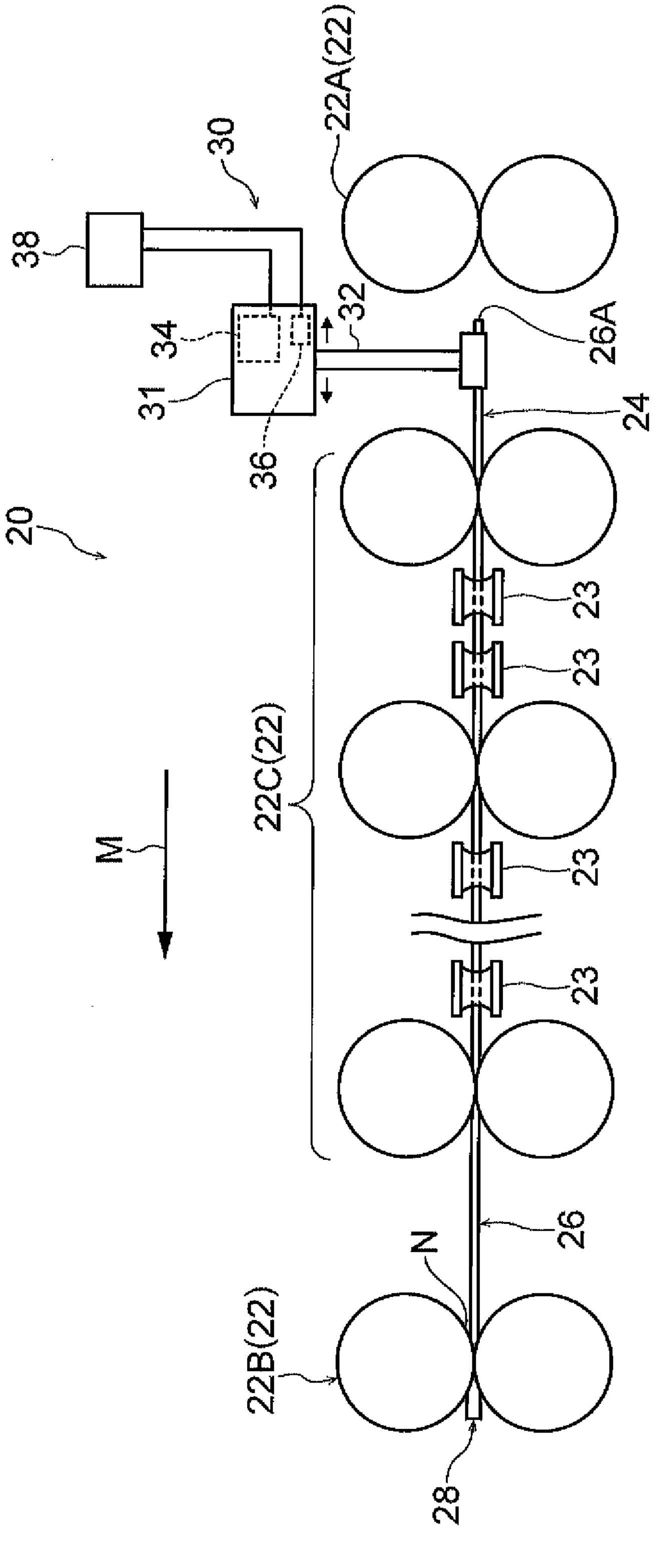


FIG.2

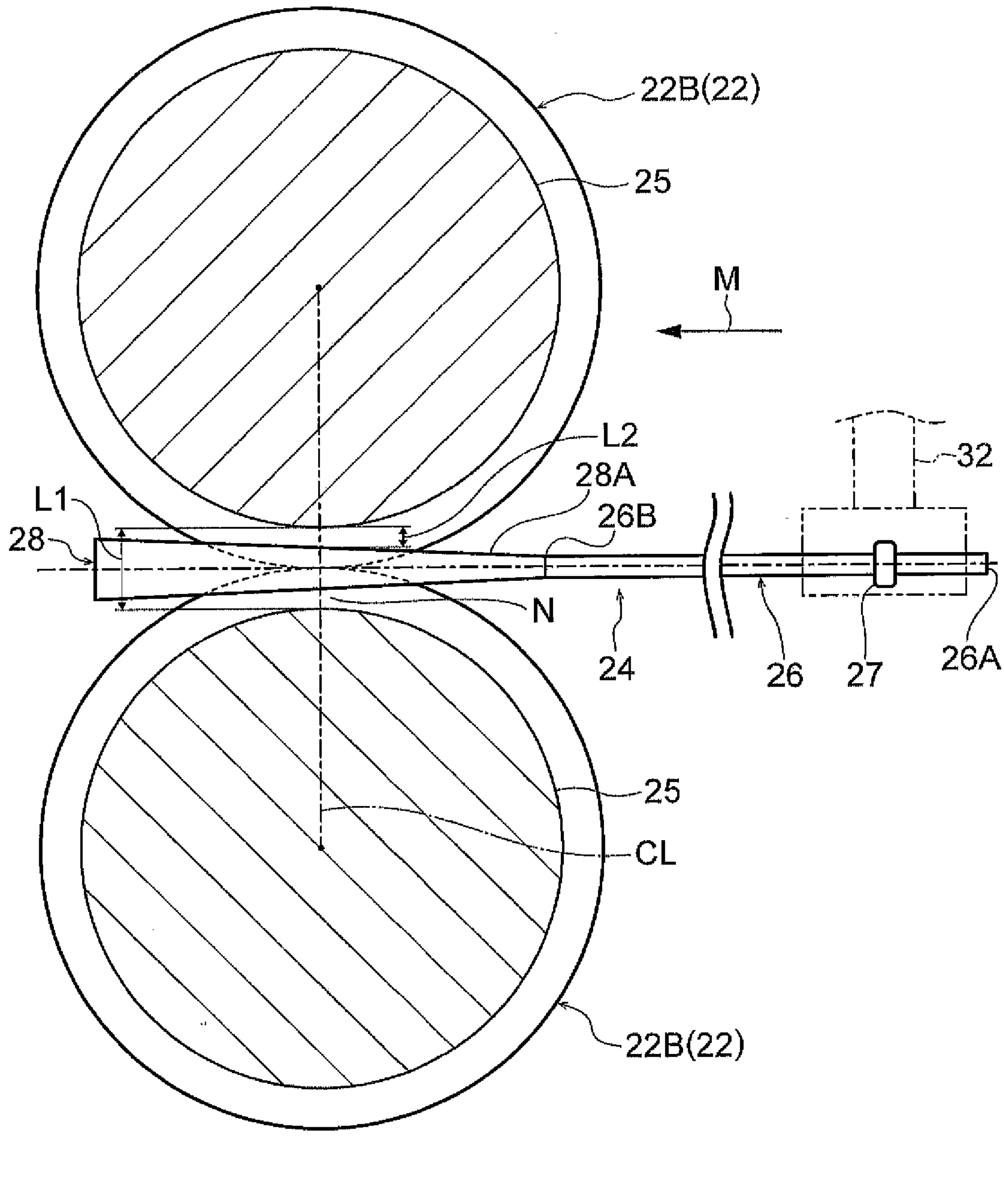


FIG.3

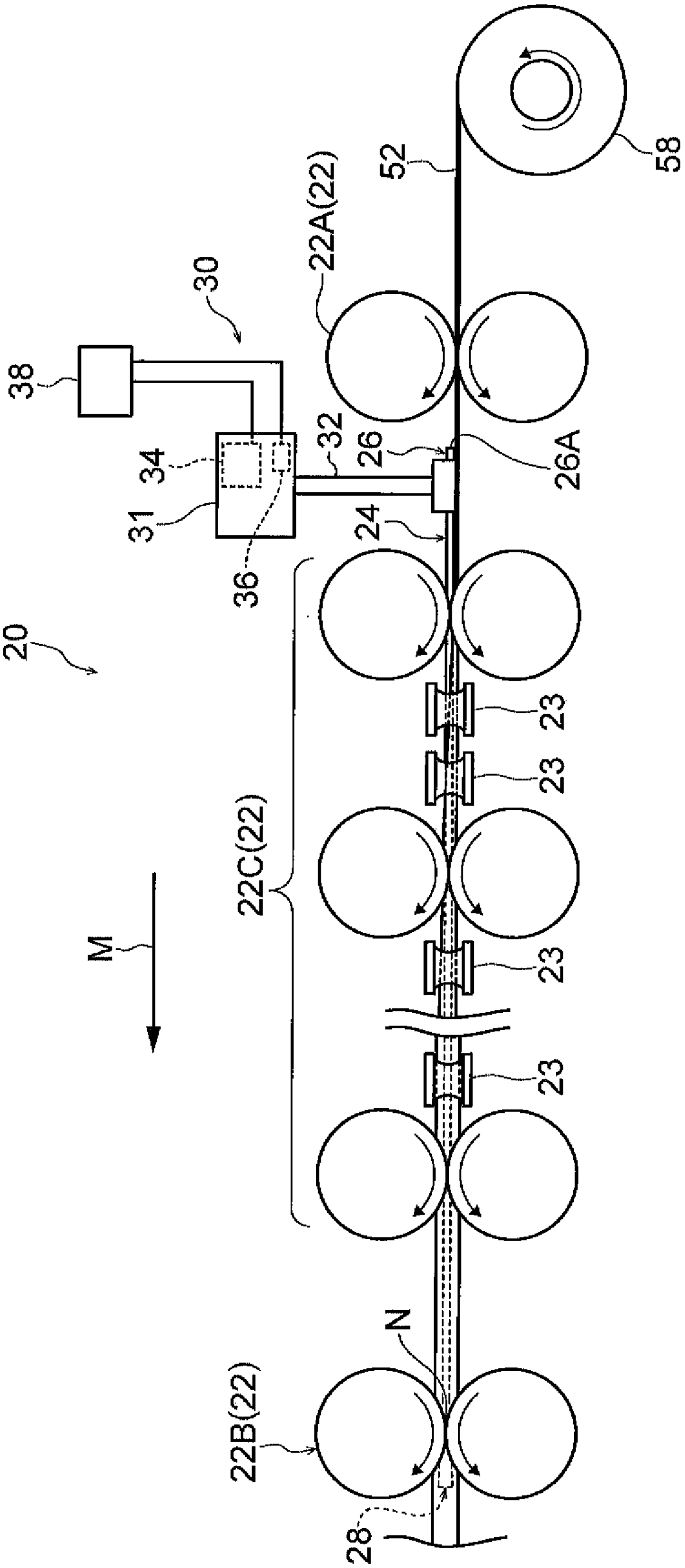


FIG.4

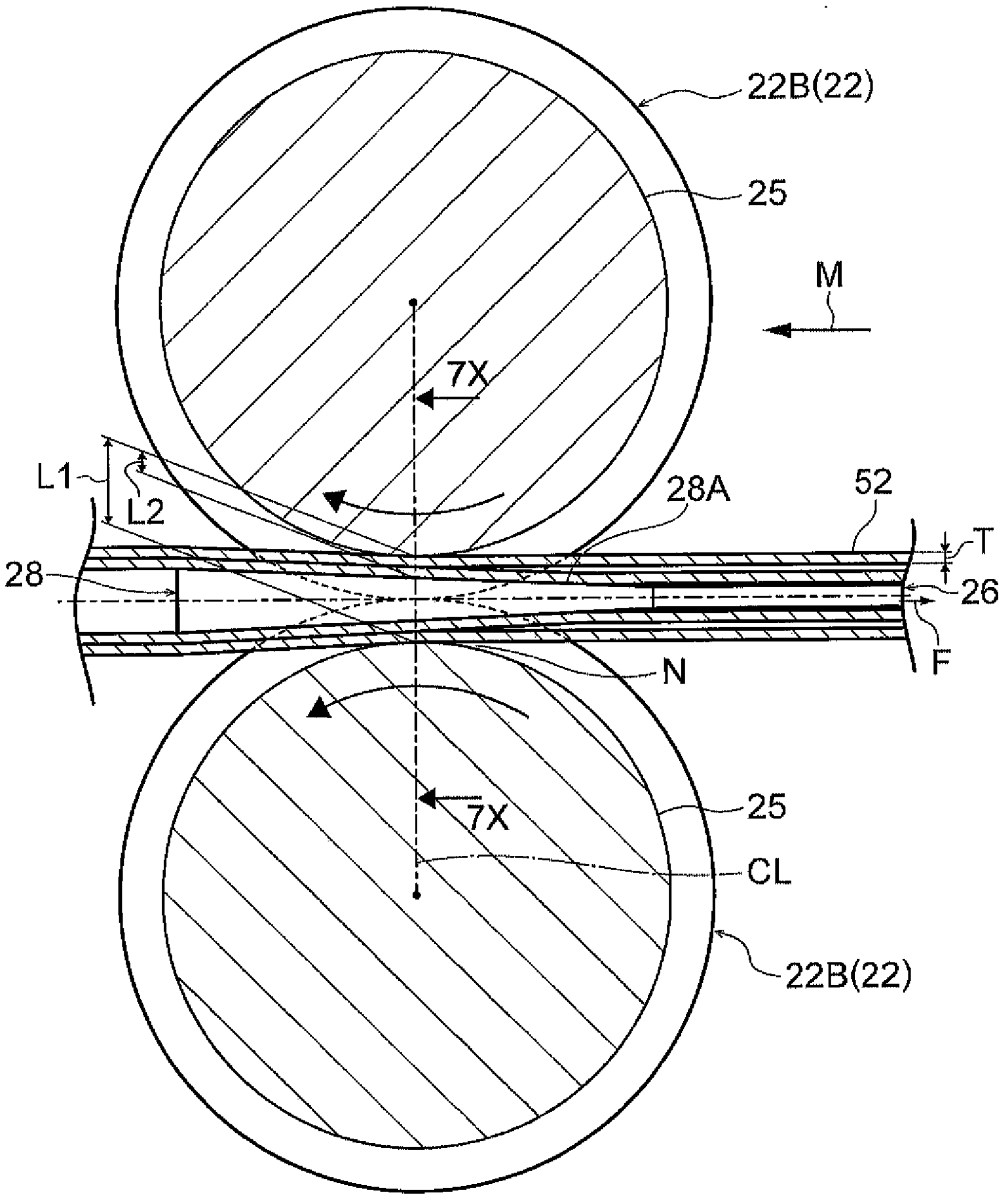


FIG.5

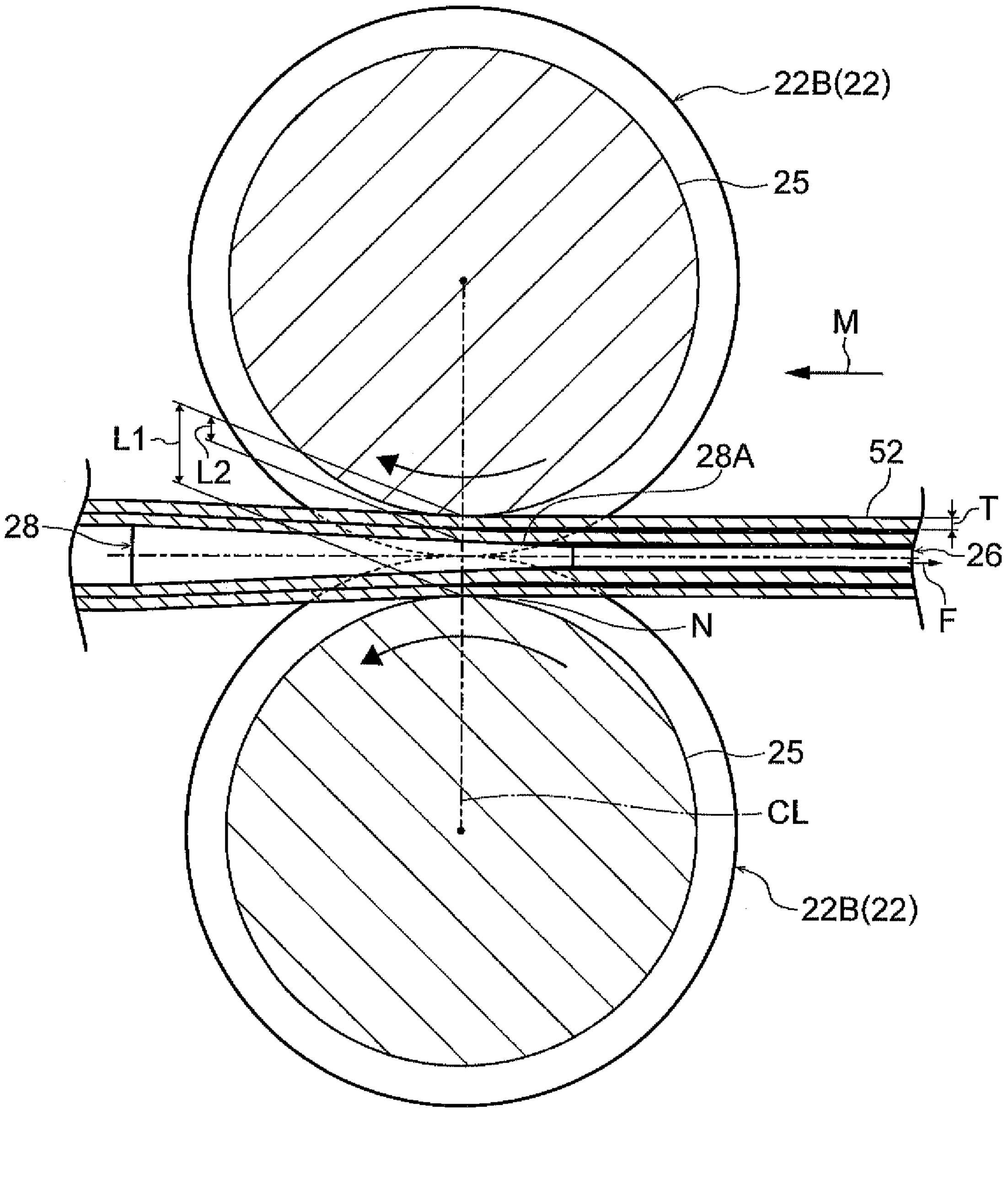


FIG.6

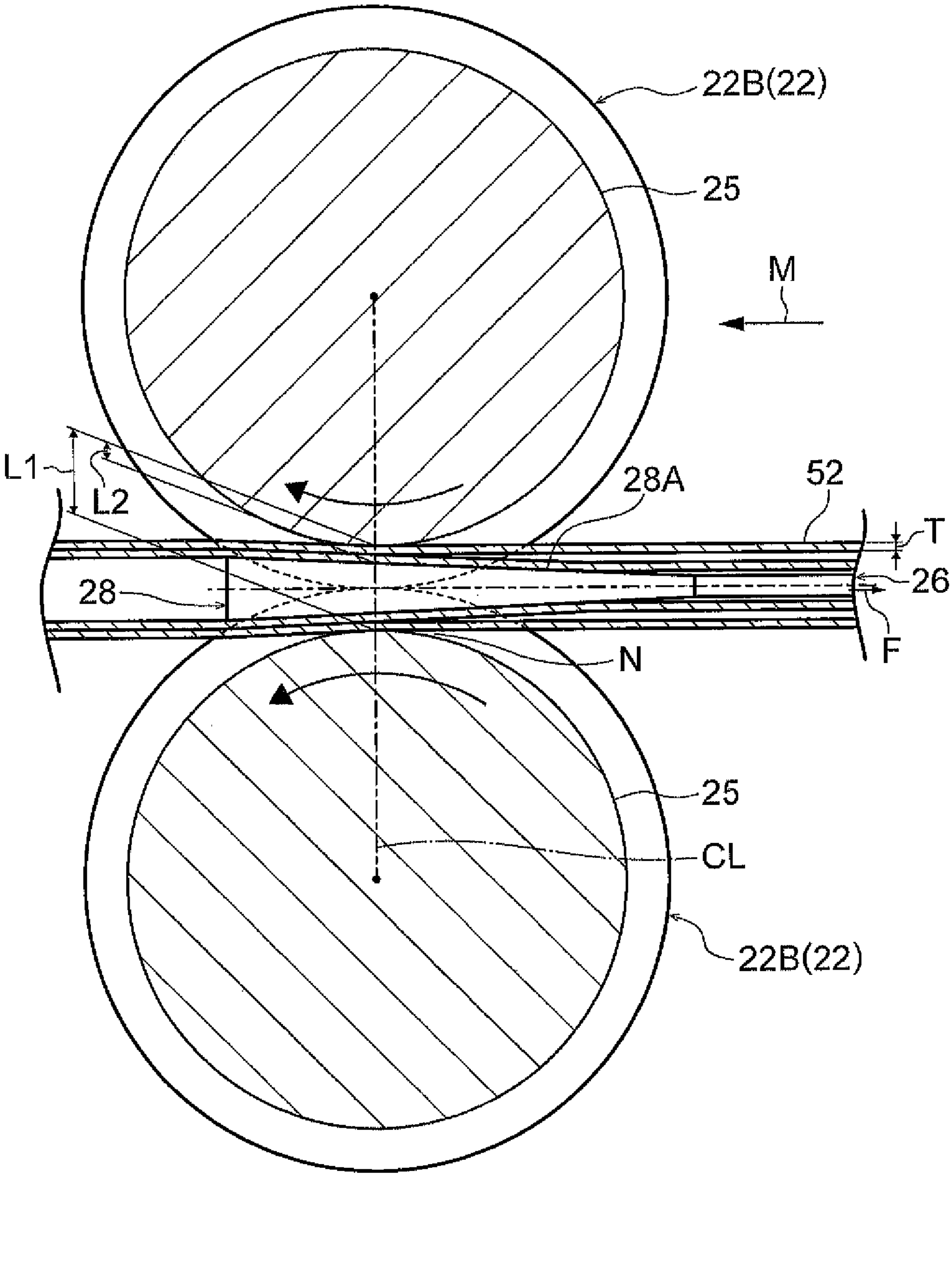


FIG.7

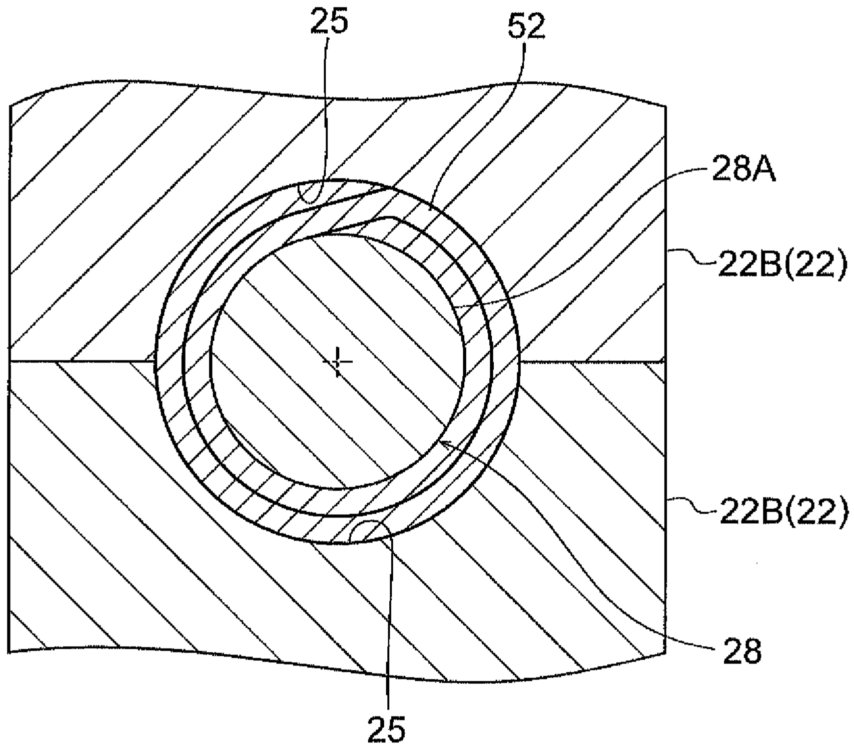


FIG.8

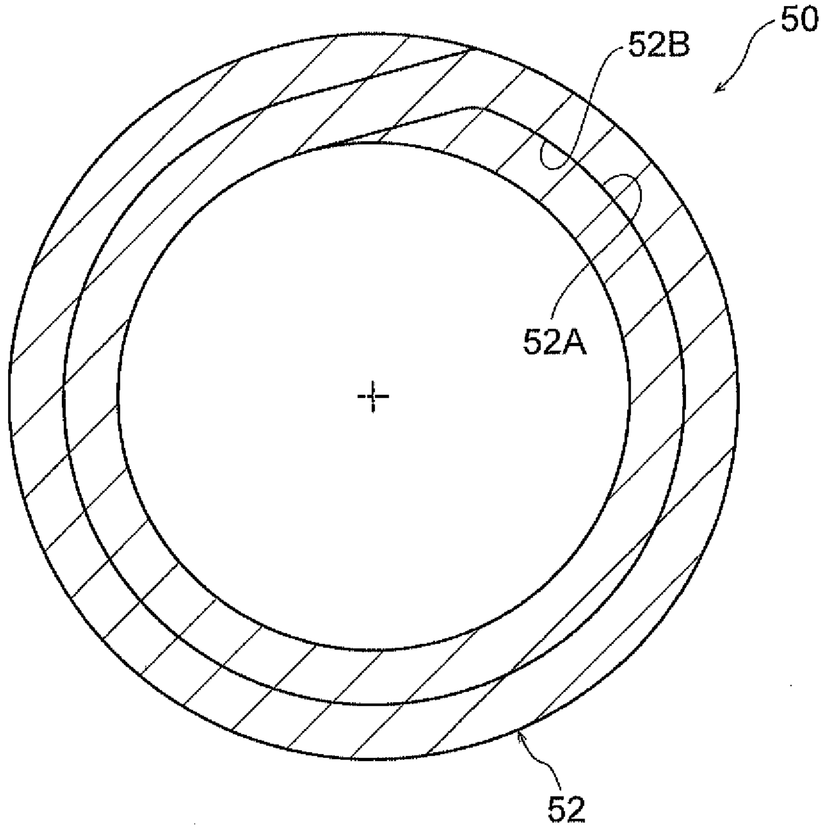


FIG.9

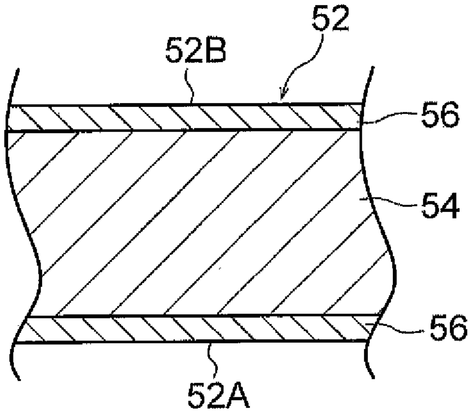


FIG.10

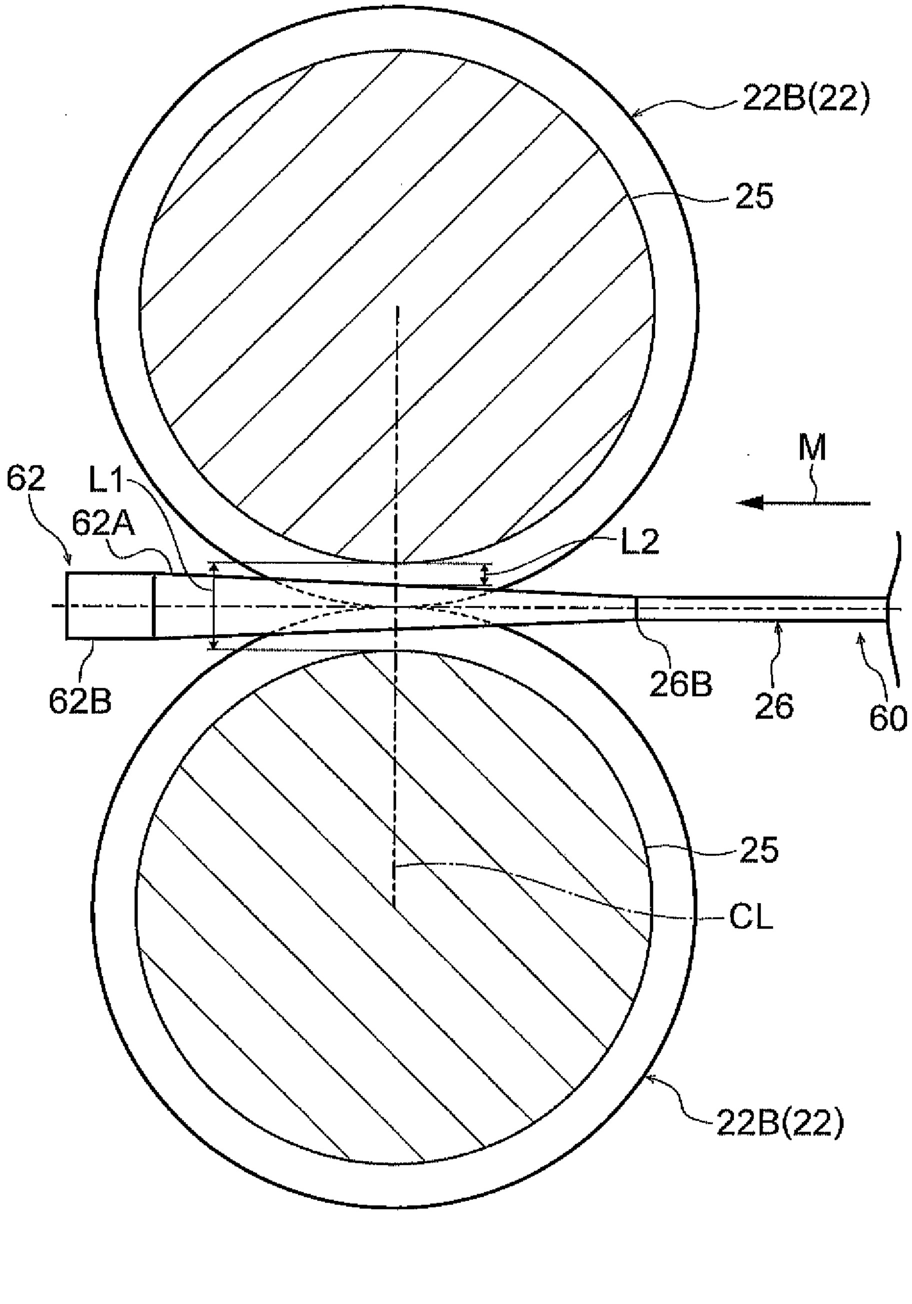
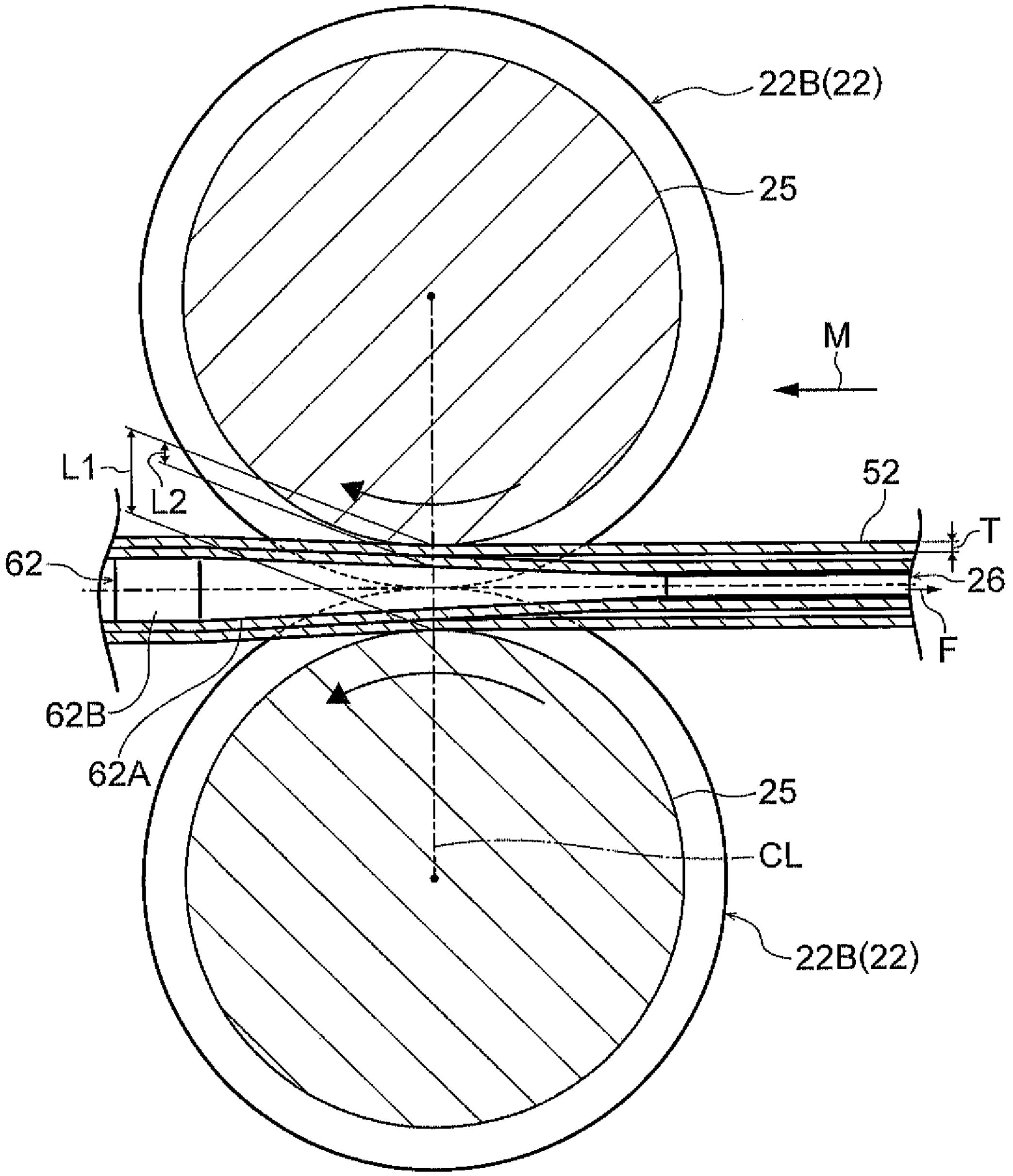


FIG.11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/018006

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. B21C37/06(2006.01)i, B21C37/08(2006.01)i, B21D5/12(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. B21C37/06, B21C37/08, B21D5/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2015-139811 A (SANOH INDUSTRIAL CO., LTD.) 03 August 2015 & US 2016/0361749 A1 & WO 2015/114888 A1 & CN 105939797 A	1-5
A	JP 11-342418 A (USUI CO., LTD.) 14 December 1999 (Family: none)	1-5

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 July 2019 (08.07.2019)	16 July 2019 (16.07.2019)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H11342418 A **[0002] [0003] [0004]**
- JP 2018140612 A **[0065]**