



(11)

EP 3 248 706 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
29.11.2017 Bulletin 2017/48

(51) Int Cl.:
B21H 3/04 (2006.01)

(21) Application number: **17172587.2**

(22) Date of filing: **23.05.2017**

(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
Designated Validation States:
MA MD

(71) Applicant: **Mico S.r.l.**
20122 Milano (IT)

(72) Inventor: **FARINA, Simone**
I-26013 Crema (CR) (IT)

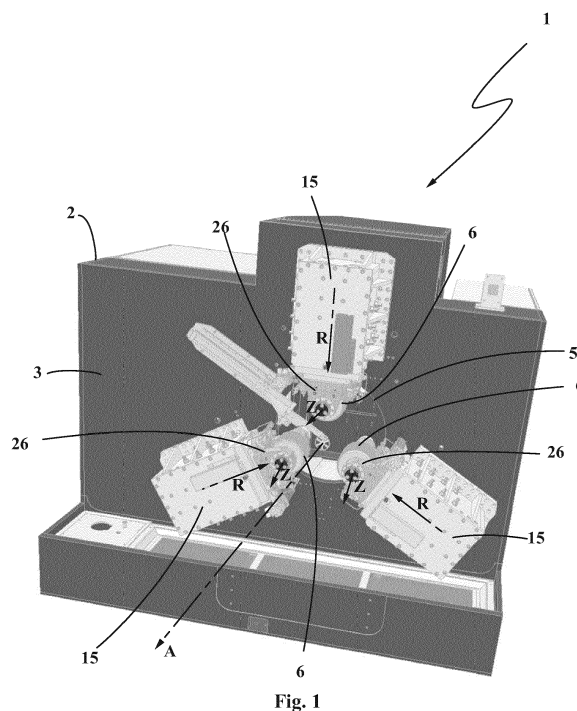
(74) Representative: **Gallo, Luca**
Gallo & Partners S.r.l.
Via Rezzonico, 6
35131 Padova (IT)

(30) Priority: **24.05.2016 IT UA20163757**

(54) **ROLLING MACHINE FOR FORMING IMPRESSIONS ON CYLINDRICAL BODIES AND METHOD FOR SUBSTITUTING A FORMING ROLLER OF SUCH ROLLING MACHINE**

(57) Rolling machine (1) for making impressions on cylindrical bodies, which comprises a support structure (2) mechanically connected to two or more forming rollers (6), each fit on a respective rotary transmission member (21) and provided with a shaped profile susceptible of rotating on a cylindrical body to be formed, placeable along a central work axis (A) of the machine (1). The machine (1) also comprises two or more hydraulic actuators (15), each of which mechanically associated with the support structure (2) and rotatably supporting a corresponding rotary transmission member (21) in order to move the forming roller (6) along a respective first transverse axis (R) perpendicular to the central work axis (A), and comprises two or more motors (16), each of which mechanically connected to a corresponding rotary transmission member (21) in order to actuate the corresponding forming roller (6) in rotation around the rotation axis (Z) thereof.

In particular, such rolling machine (1) comprises two or more actuator means (22), each mechanically associated with a corresponding rotary transmission member (21) in order to move the latter between a forward position, in which it is fit with the relative forming roller (6), supporting it on the corresponding hydraulic actuator (15), and a retracted position, in which it is removed and free from said relative forming roller (6). In addition, each rotary transmission member (21) is telescopically extensible in order to compensate for the movement between the forward and retracted positions.



Description

Field of application

[0001] The present invention regards a rolling machine and a method for substituting a forming roller of such forming machine, according to the preamble of the respective independent claims.

[0002] The rolling machine and the present method are inserted in the industrial field of precision mechanical machining obtained by means of cold plastic deformation and capable of conferring high mechanical performances to the machined metal components, in particular toughness and fatigue strength.

[0003] The machine and the method, object of the invention, are advantageously intended to be employed for plunge or through feed rolling, obtaining threads, teeth, rings or other machining, on metal cylindrical bodies such as shafts, bars, rods etc.

State of the art

[0004] The rolling machines of known type, and currently available on the market, usually comprise two or more forming rollers mounted on a support structure, each of which provided with a shaped profile, such as a thread for making an impression on a cylindrical body to be formed.

[0005] Rolling machines are known, for example from the documents CN 104942190, EP 0894555, DE 19710730 and US 5,916,318, that are conventionally provided with multiple forming rollers connected to corresponding rotary transmission members, and one or more motors connected to the rotary transmission members in order to drive the forming rollers in rotation.

[0006] The surface machining of the rollers cooperate with each other in succession in order to plastically deform the surface of the cylindrical body placed along a central work axis and for making the desired profile thereon.

[0007] Hereinbelow, the expression "cylindrical body" indicates the mechanical piece or member to be formed, whether a shaft, a bar, a rod or another cylindrical metal body, on which it is desired to make the impression by means of cold plastic deformation.

[0008] As is known, the forming by means of cold plastic deformation allows obtaining mechanically machined cylindrical bodies that are particularly strong, since the metal fibers of the body subjected to machining are not cut as in a normal milling process.

[0009] During the rolling process, the desired machining receives work-hardening properties that contribute to considerably increasing the fatigue strength of the material.

[0010] More in detail, each forming roller is mounted on a tool holder shaft or mandrel and is driven to rotate by a corresponding motor; in addition, each forming roller is also driven to be moved by a corresponding actuator

along a transverse axis substantially perpendicular to the work axis in order to impart, by means of compression, the desired impression on the metal body to be formed.

[0011] The cylindrical body to be formed is supported at the center of the work axis by a suitable support and is cold deformed by the surface machining of the forming rollers which compress it by rotating thereon.

[0012] The single forming rollers are adapted to form in succession the desired treatment on the metal body to be machined and for such purpose the shaped profile of each roller must follow, in an extremely precise manner, the impression made on the metal body by the shaped profile of the preceding forming roller.

[0013] The formation operations are controlled by means of a logic control unit, preferably of numeric control type directed by an external computer (CNC).

[0014] The logic control unit receives the instructions from the operator by means of a work program that uses, for example, a standardized ISO code language.

[0015] Since the radial compression stresses and the axial cutting stresses that affect both the cylindrical body and the shaped profile of the forming roller are very high, two or more forming rollers are generally used in a manner such to equally distribute the stresses and avoid risks of breakage.

[0016] As is known, the hydraulic actuators are driven through an oil hydraulic system to be moved close to and away from the cylindrical body to be formed.

[0017] More in detail, a first approaching or moving away travel is provided, in which the hydraulic actuators move the forming rollers with respect to the cylindrical body without however subjecting it to machining, and a second work travel is provided, in which the hydraulic actuators move the forming rollers on the cylindrical body to be formed, exerting the necessary pressure to obtain the cold deformation of the cylindrical body.

[0018] In particular, the first approaching/moving away travel has a greater length than the second work travel.

[0019] The forming of the cylindrical bodies to be machined, obtained through the above-reported operations, is of course undertaken as a function of the type of impression that one wishes to obtain and of the sizes of the cylindrical bodies to be machined.

[0020] It follows that in order to vary the type of impression or even to make a same impression type but with different geometric parameters, such as the pitch of a thread, it is necessary to substitute the roller in use with a forming roller having the desired shaped profile.

[0021] In addition, for example if it is desired to impart the same impression on cylindrical bodies of different size, it is still necessary to substitute the forming rollers so that the machining of a forming roller perfectly follows the machining completed by the contiguous forming roller.

[0022] Therefore, in accordance with the impression that one wishes to impart on the cylindrical body, such as threads of different shape or pitch, or teeth, rings or still other machining, it is necessary to use different form-

ing rollers.

[0023] In addition, each time that one must change the format of the cylindrical bodies to be machined or the type of cylindrical body (e.g. with solid or tubular body) or often even only the material (not all steels have the same mechanical response to deformations), it is necessary to substitute the set of forming rollers with others with different characteristics.

[0024] The need to substitute one set of forming rollers with another new set also occurs in the case of normal wear of the rollers.

[0025] Such forming rollers are made of metal and have considerable size and mass, adapted to support the reaction thrust exerted by the piece on the roller itself during machining.

[0026] The operations of substitution of the forming rollers in the rolling machines currently present on the market are therefore long and difficult.

[0027] Indeed, the rolling machines of known type only allow this substitution operation by disassembling a plurality of mechanical components in order to free the forming roller and be able to extract it from the shaft. Once the forming roller has been substituted with another with different characteristics, the same mechanical components must be reassembled so to clamp the new forming roller.

[0028] Generally, such mechanical components comprise a front casing, which is fixed by means of a tie rod to the top of the tool-holder shaft due to a bush fit on the head of the tool-holder shaft itself. The latter is supported by two shoulders on the corresponding hydraulic actuator by means of a plurality of bearings. The front shoulder must be completely disassembled in order to remove the forming roller. Finally, a series of spacers are mounted on the shaft, between the two shoulders, and due to the tie rod such spacers pack together the set of the above-described components, preventing axial movements thereof.

[0029] Following the removal of the aforesaid components, the tool-holder shaft is accessible to an operator who is able to remove, through the free end of the shaft, the forming roller in use and fit a new forming roller necessary for the subsequent machining.

[0030] As anticipated, the masses of the forming rollers are considerable, in some cases coming to exceed a weight of hundreds of kilos, requiring the intervention of a bridge crane for lifting and moving the forming rollers themselves.

[0031] As is clear from the preceding brief description, these rolling machines have a series of drawbacks.

[0032] A first drawback is the time required for executing the operation of substitution of one forming roller with another with new or different characteristics.

[0033] A second drawback is the specialized labor required for disassembling and reassembling the components of the machine with each forming roller change.

[0034] A third drawback is the high production cost connected to the low output of the machine, due to the

machine stops for the substitutions of the forming rollers.

Presentation of the invention

[0035] In this situation, the problem underlying the present invention is therefore that of overcoming the drawbacks manifested by the abovementioned solutions of known type, by providing a rolling machine and a method for substituting forming rollers for forming machines, which allow reducing the time for the substitution of each forming roller.

[0036] A further object of the present invention is to provide a rolling machine which allows reducing the costs tied to the substitution of each forming roller.

[0037] A further object of the present invention is to provide a rolling machine which allows reducing the labor necessary for the substitution of each forming roller.

[0038] A further object of the present invention is to provide a rolling machine which allows the substitution of each forming roller without requiring the disassembly of any component of the rolling machine.

[0039] A further object of the present invention is to provide a rolling machine which is simple and inexpensive to make.

[0040] These and still other objects are all attained by the machine and by the methods, object of the present invention, according to the enclosed claims.

Brief description of the drawings

[0041] The technical characteristics of the present invention, according to the aforesaid objects, can be seen in the contents of the below-reported claims and the advantages thereof will be clearer in the following detailed description, made with reference to the enclosed figures, which represent a merely exemplifying and non-limiting embodiment of the invention, in which:

- figure 1 shows a front perspective view of the rolling machine, object of the present invention;
- figure 2 shows a detail of the machine, object of the present invention, relative to the arrangement of the forming rollers;
- figure 3 shows a side view of a detail of the machine, object of the present invention, relative to a transmission member in extended position;
- figure 4 shows a top view of a detail of the machine, object of the present invention, relative to a linear actuator connected to a transmission member in extended position;
- figure 5 shows an enlarged view of a detail of the machine, object of the present invention, relative to a forming roller in operating condition;
- figure 6 shows a side view of a detail of the machine, object of the present invention, relative to a transmission member in retracted position;
- figure 7 shows a top view of a detail of the machine, object of the present invention, relative to a linear

actuator connected to a transmission member in retracted position;

- figure 8 shows an enlarged view of a detail of the machine, object of the present invention, relative to a linear actuator connected to a transmission member in retracted position;
- figure 9 shows an enlarged view of a detail of the machine, object of the present invention, relative to a forming roller in abutment against suitable support means.

Detailed description of some preferred embodiments

[0042] With reference to the enclosed drawings, reference number 1 overall indicates a rolling machine for making an impression on cylindrical bodies to be formed in accordance with the present invention.

[0043] This is generally intended to be employed to carry out treatments for making threads, teeth, rings or other impressions on cylindrical bodies of mechanical members such as shafts, bars, rods etc. for many different applications.

[0044] The aforesaid treatments are obtained, in a *per se* known and conventional manner, by means of cold plastic deformation of the surface of the cylindrical body to be formed, by compressing it between multiple forming rollers placed peripherally with respect to the cylindrical body itself.

[0045] More in detail, the rolling machine 1 is provided with a support structure 2 intended to be abutted against the ground, which is mechanically associated with two or more forming rollers 6 provided with a shaped profile. The forming rollers 6, as described in detail hereinbelow, operate with their shaped profile against the peripheral surface of the body to be formed, being driven to machine by rotating substantially parallel to each other in a common rotation direction, and compressed on the surface of the cylindrical body to be formed.

[0046] Preferably the support structure 2 is obtained by means of a metal framework, closed with paneling that confer it a box-like appearance. In such support structure 2, one can identify a longitudinal extension parallel to a central work axis A at which the cylindrical body to be formed can be coaxially arranged.

[0047] In accordance with the embodiment of the enclosed figures, the support structure 2 is longitudinally extended between a front wall 3 and a rear wall opposite the front wall 3, each provided with a central opening 5, for example of circular shape.

[0048] The central work axis A is arranged orthogonally to the front walls 3 and to the rear wall and passes through the center of the aforesaid openings 5, which are then traversed by the cylindrical body to be machined.

[0049] Each forming roller 6 is constituted by a cylindrical body, preferably made of steel, provided with a central symmetry axis that corresponds with its rotation axis Z, and is provided with the abovementioned shaped profile on its external peripheral surface.

[0050] The shaped profile is therefore extended on the external peripheral surface of the roller 6 and around the rotation axis Z with shape and pitch characteristics that vary in accordance with the application requirements of the cylindrical body to be formed.

[0051] In accordance with the embodiment illustrated in the enclosed figures, the machine 1 provides for three forming rollers 6, placed at 120 degrees from each other, which are adapted to plastically deform under cold conditions the cylindrical body to be formed arranged along the central work axis A of the machine and supported in such position by a suitable support structure (not illustrated). The latter structure is constituted for example by a plate with V-shaped concavity directed upward and fixed to the support structure 2 of the machine 1.

[0052] The machine 1 also comprises two or more hydraulic actuators 15 mechanically associated with the support structure 2, each mechanically connected to a corresponding forming roller 6 in order to move it along a respective first transverse axis R substantially perpendicular to the work axis A.

[0053] The forming rollers 6 are positioned around the central work axis A with their extension axes Z preferably substantially parallel to the central work axis A and at an adjustable radial distance due to the driving of the hydraulic actuators 15.

[0054] Due to the aforesaid hydraulic actuators 15, the forming rollers 6 are able to achieve at least one first approaching/moving away travel in which the forming roller 6 is moved from a position that is distal with respect to the central work axis A to a position proximal to the central work axis A. The forming rollers 6 are also able to achieve at least one second work travel, placed in succession after the first and in which the forming roller 6 operates in compression on the cylindrical body to be formed in order to plastically deform it according to its shaped profile.

[0055] In particular the distal position of the forming rollers 6 is defined on the corresponding transverse axis R at a distance with respect to the maximum or end stop work axis A or at least such to allow an operator to maneuver and substitute the cylindrical bodies to be machined without being obstructed in operation by the size of the forming rollers 6; in such distal position, the forming rollers 6 are therefore not in contact with the cylindrical body to be formed.

[0056] The proximal position of the forming rollers 6 is still defined on the corresponding transverse axis R but in this case the shaped profile of the forming roller 6 is proximal to the cylindrical body to be machined, i.e. it is in contact therewith.

[0057] Motor means 16 are further provided, arranged on the support structure 2, mechanically connected to the forming rollers 6 in order to drive them in rotation at least while they are in abutment against the cylindrical body to be formed, so as to impart a cold plastic deformation on the external surface thereof due to their shaped profile.

[0058] For such purpose, a rotary transmission member 21 is provided that is adapted to transmit the torque generated by each of the motor means 16 to the respective forming roller 6. More in detail, each of such transmission members 21 comprises a support shaft 23 and a transmission shaft 28 mechanically connected to each other in succession. The support shaft 23 is adapted to support one of the forming rollers 6 suitably provided with an axial through hole along its longitudinal extension axis Z, in which the support shaft 23 is inserted in a coupling relationship. The support shaft 23 has a first free end 24, directed towards the front wall 3, and a second end 25, directed towards the rear wall of the rolling machine 1 and mechanically connected to the transmission shaft 28, which is placed following the support shaft 23 and together with the latter forms the rotary transmission member 21.

[0059] The transmission shaft 28 is in turn provided with a first portion 29 mechanically connected to the support shaft 23, and with a second portion 30 mechanically connected to the motor means 16.

[0060] More in detail, the mechanical connections between the support shaft 23 and the transmission shaft 28 as well as between the transmission shaft 28 and the motor means 16 are made with homokinetic joints 13.

[0061] More in detail, such first and second portion 29, 30 of the transmission shaft 28 are telescopically associated with each other, and therefore susceptible of a relative axial sliding with respect to each other, in a manner so as to compensate for the axial component of the movements of the hydraulic actuators 15 of the machine 1 during the operation thereof, such as the movements between the first and the second travel of the hydraulic actuators 15.

[0062] The motor means 16 which are advantageously electric motors, in particular of brushless type, are capable of precisely controlling the rotation speed of their shafts and their angular position (and hence of the forming roller 6 that they drive in rotation) with respect to a reference angular position.

[0063] The Cardan joints 13 interposed to connect the components of the transmission member 21 allow the transmission of the rotation without the necessary condition of alignment of the shafts of the motor means 16 with the axes of the forming rollers 6, which can therefore rotate at different distances from the central work axis A, and they can also have a tilt with respect to the rotation axes of the shafts of the motor means 16.

[0064] The rotation axes Z of the support shafts 23 (or support mandrels) are susceptible of being adjusted, in a known manner, regarding the tilt thereof with respect to the central work axis A, even if they can approximately be considered substantially parallel to the work axis A itself of the cylindrical body to be machined.

[0065] In particular, each support shaft 23 carrying a forming roller 6 fitted thereon is connected to the support structure 2 through a pair of shoulders 26, 27 mechanically connected to the hydraulic actuator 15 in a manner

such that the travel of the actuator 15 closer to or further away from work axis A leads to a consequent decrease or increase of the distance between work axis A and rotation axis Z, thus coming to adjust the magnitude of the deformation that the forming roller 6 exerts on the surface of the cylindrical body to be formed.

[0066] More in detail, the pair of shoulders 26, 27 which supports the support shaft 23 comprises a front shoulder 26 in proximity to the front wall 3 of the forming machine 1, and a rear shoulder 27 in proximity to the rear wall of the forming machine 1. The shoulders 26, 27 are provided with through holes aligned with each other along the axis of the support shaft 23, such that the latter can be inserted or extracted from such holes with a movement respectively from the rear wall to the front wall 3 and vice versa, advantageously horizontal. More in detail, the front shoulder 26 is susceptible of receiving the first free end 24 of the support shaft 23 while the rear shoulder 27 is susceptible of receiving an intermediate portion of the support shaft 23. The forming roller 6 is therefore positioned in the space comprised between the two shoulders 26, 27 and traversed by the support shaft 23, which in turn is supported by the shoulders 26, 27 mounted on the head of the hydraulic actuator 15.

[0067] As anticipated, the combination of the transverse compression action due to the hydraulic actuators 15 which compress the forming rollers 6 on the cylindrical body to be formed, and the rotation motion of the forming rollers 6 around their rotation axis Z due to the motor means 16 allows plastically deforming the cylindrical body placed along the central work axis A, obtaining progressive impressions on its peripheral external surface until the desired shape is attained.

[0068] Advantageously, in accordance with the embodiment of the machine 1 illustrated in the enclosed figures, in particular in figures 1 and 2, three forming rollers 6 are provided, arranged at 120° from each other with respect to the work axis A, in a manner such to equally distribute the stresses on the cylindrical body to be formed.

[0069] In accordance with the idea underlying the present invention, the rolling machine 1 comprises two or more actuator means 22, each mechanically associated with a corresponding rotary transmission member 21 in order to move it between a forward position, in which the support shaft 23 is inserted in both support shoulders 26, 27 and sustains the forming roller 6, traversing it in the suitable seat, and a retracted position, in which the support shaft 23 is removed from the seat of the forming roller 6, by uncoupling it from the rotary transmission member 21. In particular, when the transmission member 21 is situated in the aforesaid retracted position, the support shaft 23 has (it too in retracted position as part of the transmission member 21) the first free end 24 arranged in proximity to the rear shoulder 27 and projecting from its seat in the direction of the front shoulder 26. In addition, according to the invention, the rotary transmission member 21 is telescopically modifiable in order to

compensate for the movement that the actuator means 22 impart to the support shaft 23 between the forward position and the retracted position, and for such purpose is advantageously provided with a telescopic part, defined by the first portion 29 and by the second portion 30 of the transmission shaft 28 which are telescopically coupled together.

[0070] In accordance with the preferred embodiment of the present invention, the actuator means 22, associated with the corresponding rotary transmission member 21, comprise a first annular body 31, rotatably traversed by the support shaft 23 and axially constrained thereto, and at least one linear actuator 32 provided with two mechanically coupled members, movable relative to each other along a linear main extension direction, of which a first member 33 is integral with a shoulder 26, 27 of the hydraulic actuator 15 and a second member 34 is integral with the annular body 31.

[0071] More in detail, the first annular body 31 is rotatably traversed by the support shaft 23 and axially constrained thereto by means of the use of an axial bearing 49. Such axial bearing 49 comprises a first and a second sliding jacket with annular shape that face each other, and a plurality of rolling bodies interposed between the two sliding jackets. The first sliding jacket is fixed to the first annular body 31 while the second sliding jacket is fixed to the support shaft 23, obtaining an axial constraint between the first annular body 31 and the support shaft 23. In addition, the rolling bodies interposed between the sliding jackets allow the relative motion between the two sliding jackets and therefore the rotation of the support shaft 23 with respect to the first annular body 31.

[0072] In particular, according to the preferred embodiment of the present invention, a pair of axial bearings 49 is present that is associated with the first annular body 31. In particular, the first annular body 31 has, on both faces orthogonal to the axis of the support shaft 23, a seat with annular concave shape coaxial with the substantially central hole of the annular body itself. Such seats are each adapted to house an axial bearing 49. More in detail, each axial bearing 49 comprises a first and a second sliding jacket with annular shape that face each other, and a plurality of rolling bodies interposed between the two sliding jackets.

[0073] Each seat with annular concave shape made in the first annular body 31 has size sufficient for allowing the embedding of an axial bearing 49 at its interior, in particular with the central holes arranged aligned and coaxial. When the two axial bearings 49 are each in position in the corresponding seat, they are separated from each other by a portion of the first annular body 31 and each axial bearing 49 has a sliding jacket directed towards said portion of the first annular body 31 and a sliding jacket directed in the opposite direction. In particular, the sliding jackets directed towards the portion of the first annular body 31 are mechanically fixed thereto, while the sliding jackets directed in the opposite direction are mechanically connected to the support shaft 23.

[0074] The rolling bodies comprised in each bearing allow a relative sliding between the first and the second sliding jacket by freeing the first annular body 31 from the rotation of the support shaft 23 even while maintaining the axial translation constraint as previously described.

[0075] An alternative embodiment of the present invention provides for constraining the jackets outside the first annular body 31 and the jackets inside the support shaft 23, by rotatably freeing the first annular body 31 from the support shaft 23 even while maintaining the axial constraint.

[0076] According to the preferred but non-limiting embodiment of the present invention, the actuator means 22 advantageously provide for two linear actuators 32, each associated with the annular body 31 and with a shoulder 26, 27 of the hydraulic actuator 15, as described above, and advantageously arranged in a diametrically opposite position from each other with respect to the rotation axis Z of the relative support shaft 23.

[0077] Such configuration allows orienting the thrust of the actuator 32 in a centered manner on the support shaft 23, i.e. along a direction substantially coaxial thereto, preventing the onset of moments which could lead to jamming or make it difficult to move the support shaft 23 with respect to the shoulders 26, 27. For the same purpose, the actuator means 22 advantageously also comprise at least one axial sliding guide 12 and preferably two axial sliding guides 12, each associated with the first annular body 31 and with a shoulder 26, 27 of the hydraulic actuator 15. The two axial sliding guides 12 are preferably mounted in diametrically opposite position with respect to the support shaft 23.

[0078] According to an alternative embodiment of the present rolling machine, the actuator means 22 comprise at least one linear actuator 32 provided with a first member 33 mechanically connected to the first portion of the transmission shaft 29 and a second member 34 mechanically connected to the second portion 30 of the transmission shaft 28. According to this embodiment, the movement of the rotary transmission member 21 and hence of the support shaft 23 from the forward position to the retracted position and vice versa is coordinated by the linear actuator 32 which selectively controls, in extension or retraction, the telescopic sliding of the two portions 29, 30 of the transmission shaft 28. Consequently the support shaft 23 is driven or thrust between the two forward and retracted positions of the rotary transmission member 21.

[0079] Preferably, the linear actuator 32 has the first member 33 mechanically connected to an annular body that is rotatably uncoupled and axially constrained to the first portion 29 of the transmission shaft 28 due to a pair of axial bearings 49 mounted as previously described. The second member 34 of the same linear actuator 32 is instead mechanically connected to an annular body that is rotatably uncoupled and axially constrained to the second portion 30 of the transmission shaft 28 due to a pair of axial bearings 49 mounted as previously de-

scribed.

[0080] In accordance with a further embodiment of the rolling machine 1 according to the present invention, the actuator means 22 comprise a linear actuator 32 provided with two mechanical members formed by the portions 29, 30 of the transmission shaft 28, actuated to be moved with respect to each other by a hydraulic circuit connected to the portions 29, 30 themselves.

[0081] According to this embodiment, the telescopic connection of the first and second portion 29, 30 of the transmission shaft 28 is integrated with a hydraulic circuit and used as linear actuator 32 in order to drive or push the support shaft 23 between the abovementioned forward and retracted positions of the rotary transmission member 21.

[0082] As anticipated, the forming roller 6 is provided with a longitudinal extension axis that allows defining a third end 35 thereof and a fourth end 36 thereof. In the course of the present description, with third end 35, it is indicated the end directed towards the rear shoulder 27, while with fourth end 36, it is indicated the end directed towards the front shoulder 26.

[0083] The forming roller 6 also comprises a first key 41 fixed with fixing means to the internal surface of the forming roller 6. The fixing of the first key 41 to the forming roller 6 occurs by means of movable or irremovable fixing means such as screws or a welding. The fixing can be obtained during the production of the forming roller 6, given that the key is integrally made with the remaining body of the roller 6. The first key 41 comprises a first portion 42 and a second portion 43 axially projecting with respect to the extension length of the forming roller 6 from the opposite ends thereof. In accordance with the embodiments of the enclosed figures, the first portion 42 indicates the end placed at the third end 35 of the forming roller 6 and the second portion 43 indicates the end placed at the fourth end 36 of the forming roller 6.

[0084] The rolling machine 1 comprises first support means 37 of the forming roller 6 in order to support the forming roller 6 at the third end 35 on the first free end 24 of the support shaft 23 when the rotary transmission member 21 and hence the same shaft 23 are in retracted position.

[0085] More in detail, the first support means 37 of the forming roller 6 comprise the first portion 42 of the first key 41 axially projecting beyond the third end 35 of the forming roller 6 and susceptible of abutting against the first free end 24 of the support shaft 23 with the rotary transmission member 21 and hence the same shaft 23 in retracted position.

[0086] The rolling machine 1 advantageously also comprises a first bush 38 rotatably mounted in the seat of the front shoulder 26 and fit starting from the first free end 24 of the support shaft 23 by means of a second key 39, which is fixed with fixing means, movable or irremovable, to the internal surface of the first bush 38.

[0087] In particular the second key 39 comprises second support means 40 for the forming roller 6 in order to

support the fourth end 36 of the forming roller 6 on the first bush 38, for supporting the support shaft 23 with the latter in retracted position. The second support means 40 comprise a third portion 11 of the second key 39 axially projecting several tens of millimeters beyond the first bush 38 and the second portion 43 of the first key 41 axially projecting beyond the fourth end 36 of the forming roller 6 and susceptible of abutting against the third portion 11 of the second key 39 of the first bush 38 with the rotary transmission member 21 and hence the same shaft 23 in retracted position.

[0088] More in detail, the third portion 11 of the second key 39 is provided with a step-like seat that constitutes a part of said second support means 40. Analogously, the second portion 43 of the first key 41 has a step-like shape complementary to the step-like shape of the hollow seat on the third portion 11 of the second key 39.

[0089] For the purpose of receiving the first key 41 and the second key 39, the support shaft 23 is provided with a groove 44 obtained longitudinally on the lateral surface thereof and axially extended between the first free end 24 of the support shaft 23 and an intermediate section of the shaft 23 indicated with X - X in figure 5 at which the groove 44 terminates with a bottom wall 45. The groove 44 is extended for a length at least sufficient for receiving both the first key 41 and the second key 39, i. e. in order to fit the first bush 38 and the forming roller 6 on the support shaft 23, so as to rotatably constrain the support shaft 23 to the first bush 38 and to the forming roller 6.

[0090] The initial portion of such groove 44 starting from the free end 24 of the support shaft 23 is comprised in the first support means 37, since it is susceptible of receiving in abutment the first portion 42 of the first key 41 with the rotary transmission member 21 and hence the same shaft 23 in retracted position.

[0091] Advantageously, according to the preferred embodiment of the present invention, the length of the groove 44 is equal to the sum of the lengths of the first key 41 and of the second key 39. This condition allows the bottom wall 45 of the groove 44, in the step of inserting the support shaft 23, i.e. of advancing from the retracted position to the forward position, to thrustingly engage the first key 41, which in turn pushes the second key 39. In this condition, the linear actuator 32 of the previously-described actuator means 22 exerts a pressure sufficient for maintaining packed the aforesaid components of the rolling machine 1 as described, without requiring mechanical tie rods that must be assembled and disassembled by an operator during the roller change step.

[0092] Advantageously, moreover, the first key 41 of the forming roller 6, when it is in abutment against first 37 and against second 40 support means, aligns the rotation axis of the forming roller 6 with the rotation axis of the support shaft 23. In addition, in the aforesaid condition, the first key 41 is aligned with the second key 39 and the first portion 43 of the first key 41 is inserted in the groove 44 in proximity to the first free end 24 of the

support shaft 23.

[0093] Therefore, according to the preferred embodiment of the present invention, the first support means 37 are obtained with the groove 44 portion made in proximity to the first free end 24 of the support shaft 23, which receives the first portion 43 of the first key 41.

[0094] In the step of advancing the rotary transmission member 21 and hence the same support shaft 23 from the retracted position to the forward position, the first key 41 and the second key 39 are moved to slide within the groove 44 up to contact against the bottom wall 45 of the groove 44 itself.

[0095] For the purpose of withstanding the thrusts at play during the operating step and during the step of substitution of the rollers, a series of bearings are necessary.

[0096] More in detail, preferably, the rolling machine 1 comprises at least one radial bearing 46 at the front shoulder 26 and at least one radial bearing 47 at the rear shoulder 27. Such radial bearings are adapted to withstand the thrusts in radial direction with respect to the rotation axis Z of the forming roller 6 and of the support shaft 23, generated during the machining on the cylindrical piece to be formed, i.e. when the hydraulic actuators 15 push the forming roller 6 against the cylindrical piece in order to obtain the surface plastic deformation of the cylindrical piece.

[0097] The radial bearings each comprise a first and a second sliding jacket constituted by two concentric cylindrical shells. A plurality of rolling bodies are interposed between said jackets, such bodies allowing the relative sliding of the two sliding jackets.

[0098] More in detail, in accordance with the preferred embodiment of the present invention, the first radial bearings 46 advantageously comprise a first external sliding jacket, having the external surface in contact with the housing seat of the front shoulder 26, a first internal sliding jacket constituted by the first bush 38 fit on the support shaft 23 and a plurality of rolling elements interposed between the first internal sliding jacket and the first external sliding jacket. The use of the first bush 38 as internal jacket of the first radial bearings 46 is preferable with respect to the direct insertion of the first free end 24 of the support shaft 23 since it allows using wider tolerances between the internal diameter of the first bush 38 and the external diameter of the support shaft 23, facilitating the steps of insertion and extraction during the roller change. The direct insertion without use of the first bush 38 is equally valid but requires very low tolerances between the diameters, therefore it complicates the steps of insertion and extraction of the support shaft 23.

[0099] Analogously, the second radial bearings 47 comprise a second external sliding jacket, having the external surface in contact with the rear shoulder 27, a second internal sliding jacket constituted by a second bush 50 mounted on the support shaft 23, a plurality of rolling elements interposed between the second internal sliding jacket and the second external sliding jacket.

[0100] More in detail, the second bush 50 is provided,

on the external surface of the external sliding jacket, with a radial projection adapted to abut against a suitable guide made in the seat of the rear shoulder 27. Such radial projection is susceptible of preventing the axial sliding of the second bush 50, preventing the second bush 50 from being driven out of the seat by the friction connection with the support shaft 23 during the steps of insertion and extraction of the support shaft 23 itself.

[0101] The rolling machine 1 is also subjected to the forces that arise during the roller change operations. In order to withstand the axial thrusts that are generated during the extraction and insertion of the first free end 24 of the support shaft 23 in the seats made in the front 26 and rear 27 shoulders of the hydraulic actuators 15, a plurality of axial bearings are arranged. Such bearings allow the rotation of the system even when it is subjected to forces aligned with the rotation axis Z, allowing a possible operation of adjustment and alignment of the first bush 38, of the forming roller 6 and of the groove 44 of the support shaft 23.

[0102] Advantageously, according to the preferred embodiment of the present invention, a second annular body 10 is provided, inserted on the head of the first bush 38 and integral with the first shoulder 26.

[0103] In particular, the second annular body 10 is rotatably traversed by the first support bush 38 but integral with the front shoulder 26. This is made possible by a first pair of axial bearings 48 associated with the second annular body 10. In particular, the second annular body 10 has, on both faces orthogonal to the axis of the support shaft 23, a seat with annular concave shape coaxial with the substantially central hole of the second annular body 10 itself. Each of such seats are adapted to house an axial bearing 48. More in detail, each axial bearing 48 comprises a first and a second sliding jacket with annular shape that face each other, and a plurality of rolling bodies interposed between the two sliding jackets.

[0104] Each seat with concave annular shape obtained in the second annular body 10 has size sufficient for allowing the embedding of an axial bearing 48 at its interior, in particular with the central holes arranged aligned and coaxial. When the two axial bearings 48 are each in position in the corresponding seat, they are separated from each other by a portion of the second annular body 10 and each axial bearing 48 has a sliding jacket directed towards said portion of the second annular body 10 and a sliding jacket directed in the opposite direction. In particular, the sliding jackets directed towards the portion of the second annular body 10 are mechanically fixed thereto, while the sliding jackets directed in the opposite direction are mechanically connected to the support bush 38 on which they are inserted.

[0105] The rolling bodies comprised in each bearing allow a relative sliding between the first and the second sliding jacket by freeing the second annular body 10 from the rotation of the support shaft 23 even while maintaining it constrained to the front shoulder 26.

[0106] According to this configuration, the axial bear-

ing 48 arranged at the front supports the thrust during the extraction of the support shaft 23, i.e. during the movement from the forward position to the retracted position. In order to prevent the friction between the first bush 38 and the support shaft 23 during this extraction step from driving the first bush 38 itself out of the seat obtained in the front shoulder 26, a casing 19 is provided, advantageously axial-symmetric and T-shaped, i.e. provided with a threaded shank and with a projecting head. Such casing 19 is fixed, by means of the threaded shank, to the first bush 38 given that it is engaged via screwing in a relative nut screw, while the projecting head is in abutment against the lower face of the second annular body 10, preventing the first bush 38 from being removed together with the support shaft 23.

[0107] The axial bearing 48 arranged at the rear, with respect to the preceding, supports the thrust exerted by the linear actuator 32 during the insertion of the support shaft 23, i.e. during the movement from the retracted position to the forward position. In addition, as previously anticipated, the linear actuator 32 exerts a pressure also during the operation of the rolling machine 1 in order to maintain packed the components fit on the support shaft 23. Therefore, the rear axial bearing 48 is adapted to support the thrust and allow the rotation of the first bush 38 with respect to the front shoulder 26 also during the operation of the rolling machine 1.

[0108] In an entirely analogous manner and therefore within the scope of the present patent, the role of the front and rear axial bearings can be interchanged, by suitably varying the mechanical connections between the jackets of the bearings, the second annular body 10 and the first bush 38. More in detail, in an alternative embodiment of the present invention, the axial bearing 48 arranged at the front supports the thrust exerted by the linear actuator 32 during the insertion of the support shaft 23, i.e. during the movement from the retracted position to the forward position and during the operation of the rolling machine 1. The axial bearing 48 arranged at the rear instead supports the thrust during the extraction of the support shaft 23, i.e. during the movement from the forward position to the retracted position.

[0109] As previously described, also in proximity to the first annular body 31, a second pair of axial bearings 49 arranged facing is provided. Such configuration, in addition to having the function of rotatably freeing the first annular body 31 from the support shaft 23, maintaining the axial constraint, also has the object of supporting the thrusts during the normal operation of the rolling machine 1. In particular, with reference to the preferred embodiment described herein, the front axial bearing 49 supports the thrust in the extraction step for the support shaft 23 while the rear axial bearing 49 supports the thrust during the insertion of the support shaft 23 and during the entire operating period of the rolling machine 1.

[0110] Also forming an object of the present invention is a method for substituting a forming roller 6, which is advantageously executed with the rolling machine 1 de-

scribed up to now, and regarding which the reference numbers already indicated will be maintained for the sake of simplicity.

[0111] The method underlying the present invention for substituting a forming roller 6 of the rolling machine 1, as previously described, comprises a first step of actuating the actuator means 22 in order to move the rotary transmission member 21 from the forward position to the retracted position, in which the transmission shaft 23 is free to axially slide. In particular, in accordance with the preferred embodiment, the linear actuator 32 associated with each support shaft 23 is driven into extended position in order to remove the support shaft 23 from the forming roller 6, by exerting a thrust between the shoulder, with which the first member 33 of the linear actuator 32 is connected, and the first annular body 31, with which the second member 34 of the actuator 32 is connected.

[0112] In particular, according to the preferred embodiment of the present invention, two linear actuators 32 and one or more sliding guides 12 associated with each support shaft 23 are provided for. The overall thrust delivered by the actuators is centered with respect to the axis of the shaft 23 itself, in a manner so as to facilitate the sliding and prevent tensions or jamming that could damage the support shaft 23 or facilitate the onset of frictions between the moving parts.

[0113] In accordance with an alternative embodiment of the present invention, the actuator means 22 are associated with the transmission shaft 28, in particular with the first member 33 of the linear actuator 32 connected to the annular body associated with the first portion 29 of the transmission shaft 28 and with the second member 34 of the linear actuator 32 connected to the annular body associated with the second portion 30 of the transmission shaft 28. In such case, the linear actuator 32 is driven into retracted position in a manner so as to force the transmission shaft 28, having telescopic structure, into restricted configuration. The transmission shaft 28 in turn drives the support shaft 23 from the forward position to the retracted position.

[0114] In a further embodiment, the actuator means 22 comprise a linear actuator 32 formed by the portions 29, 30 of the transmission shaft 28 actuated by a hydraulic circuit connected to the portions 29, 30 themselves. According to this embodiment, the telescopic connection of the first portion 29 and of the second portion 30 of the transmission shaft 28 allows the hydraulic circuit connected for such purpose to both portions 29 and 30 to slidably move them together, making the linear actuator 32 in order to drive or push the support shaft 23 between the forward position and the retracted position defined for the rotary transmission member 21 that they constitute.

[0115] Subsequently, a step is provided for extracting a first forming roller 6 from the shoulders, followed by a step of inserting a second forming roller 6' (i.e. a new roller or a roller with different characteristics) with the extension axis aligned with the axis of said support shaft

23. Such steps for maneuvering the forming rollers 6 can be manually carried out by operators in the case of small-size rollers. More frequently, given the size and weight of the forming rollers 6 generally used, the extraction and insertion steps will be executed by an operator with the aid of a bridge crane for lifting and moving the forming rollers 6, 6' themselves.

[0116] After having substituted the first forming roller 6 with the second roller 6', a second step is provided for actuating the actuator means 22 in order to move the rotary transmission member 21 from the retracted position to the forward position in which the support shaft 23 is rotatably engaged with the second forming roller 6'. In particular, such step provides for the actuation of the actuator means 22 in the direction opposite the first actuation step, with reference to each of the three previously-described embodiments.

[0117] More in detail, the extraction step comprises an abutment step for the first forming roller 6, in which the latter is supported by the first and second support means 37, 40. In particular, the first portion 42 of the first key 41 placed at the third end 35 of the forming roller 6 is engaged with the first support means 37 placed at the first free end 24 of the support shaft 23 with the latter in said retracted position. The second portion 43 of the first key 41 placed at the fourth end 36 of the forming roller 6 is engaged with the second support means 40 at the third projecting portion 11 of the second key 39 of the first bush 38, with the support shaft 23 in retracted position. This allows executing the extraction operations, preventing the fall of the forming roller 6 when the support shaft 23 is completely removed from the forming roller 6 itself.

[0118] The insertion step also comprises a step of aligning the second forming roller 6' with the axis of the support shaft 23 in which the first portion 42 of the first key 41 placed at the third end 35 of the second forming roller 6' is engaged with the first support means 37 placed at the first free end 24 of the support shaft 23 with the latter in said retracted position. The second portion 43 of the first key 41 placed at the fourth end 36 of the second forming roller 6' is engaged with the second support means 40 at the third projecting portion 11 of the second key 39 of the first bush 38, with the support shaft 23 in retracted position. The alignment step assisted by the first and second support means 37, 40, during which the second forming roller 6' is in abutment against the support means 37, 40, allows an easy and simple insertion of the support shaft 23 within the second forming roller 6', preventing problems of friction, deformation or fitting during sliding. In addition, the use of the first and second support means 37, 40 in the alignment step, as they have been conceived, allow the quick and simple engagement of the first key 41 and of the second key 39 with the groove 44 obtained on the support shaft 23, rotatably constraining the support shaft 23 with the first bush 38 and the second forming roller 6'.

[0119] The invention thus conceived therefore attains the pre-established objects.

Claims

1. Rolling machine (1) for making impressions on cylindrical bodies, which comprises:

- a support structure (2);
- two or more forming rollers (6), each being:
 - fit on a respective rotary transmission member (21);
 - provided with a shaped profile susceptible of rotating on a cylindrical body to be formed, placeable along a central work axis (A) of said machine (1);

- two or more hydraulic actuators (15), each of which mechanically connected to said support structure (2) and rotatably supporting a corresponding rotary transmission member (21) in order to move said forming roller (6) along a respective first transverse axis (R) perpendicular to said central work axis (A);
- two or more motors (16), each of which mechanically connected to a corresponding said rotary transmission member (21) in order to actuate said corresponding forming roller (6) in rotation around its rotation axis (Z);

characterized in that it comprises:

- two or more actuator means (22), each mechanically associated with a corresponding rotary transmission member (21) in order to move the latter between a forward position, in which said rotary transmission member (21) is fit with the relative forming roller (6), supporting it on the corresponding hydraulic actuator (15), and a retracted position, in which said rotary transmission member (21) is removed and free from said relative forming roller (6);
- each said rotary transmission member (21) being telescopically modifiable between said forward and retracted positions.

2. Rolling machine according to claim 1, **characterized in that** each said rotary transmission member (21) comprises a support shaft (23) and a transmission shaft (28) mechanically connected to each other in succession;

- said support shaft (23):
 - having a first free end (24) and a second end (25) mechanically connected to said transmission shaft;
 - carrying said forming roller (6) fitted thereon and
 - being mechanically supported by a front

- shoulder (26), which houses said first free end (24), and by a rear shoulder (27), which houses said second end (25); both shoulders (26, 27) being fixed to said hydraulic actuator (15), said forming roller (6) being interposed therebetween;
- said transmission shaft (28) being provided with a first portion (29) mechanically connected to said support shaft (23), and with a second portion (30) mechanically connected to said motor (16);
 - said first and second portion (29, 30) of said transmission shaft (28) being telescopically connected to each other in order to compensate for the movement between said forward and retracted positions of said rotary transmission member (21).
3. Rolling machine according to claim 2, **characterized in that** said actuator means (22) comprise:
 - at least one annular body (31) rotatably traversed by said support shaft (23) and axially constrained thereto;
 - at least one linear actuator (32) provided with two mechanically coupled members, movable relative to each other along a main extension line, of which a first member (33) is integral with a shoulder (26, 27) of said hydraulic actuator (15) and a second member (34) is integral with said annular body (31).
 4. Rolling machine according to claim 2, **characterized in that** said actuator means (22) comprise a linear actuator (32) provided with two mechanically coupled members, movable relative to each other along a main extension line, of which a first member (33) is mechanically connected to said first portion (29) of said transmission shaft (28) and said second member (34) is mechanically connected to said second portion (30) of said transmission shaft (28).
 5. Rolling machine according to claim 2, **characterized in that** said actuator means (22) comprise a linear actuator (32) provided with two mechanically coupled members, movable relative to each other along a main extension line; said members being formed by a first and second portion (29, 30) of said transmission shaft (28), which are actuated to be moved with respect to each other by means of a hydraulic circuit connected to said first and second portion (29, 30).
 6. Rolling machine according to claim 2, **characterized in that** said forming roller (6) is provided along its extension axis with a third end (35) directed towards the second end (25) of
 - said support shaft (23), and with a fourth end (36) directed towards the first free end (24) of said support shaft (23);
 - said machine (1) comprising first support means (37) for said forming roller (6) in order to support the third end (35) of said forming roller (6) on the first free end (24) of said support shaft (23) with the latter in said retracted position;
 - said forming roller (6) comprises a first key (41) fixed with fixing means to the internal surface of said forming roller (6);
 - said first support means (37) comprising a first portion (42) of said first key (41) axially projecting beyond the third end (35) of said forming roller (6) and susceptible of abutting against the first free end (24) of said support shaft (23) with the latter in said retracted position.
 7. Rolling machine according to claim 2, **characterized in that** it comprises a first bush (38) for supporting the support shaft (23) rotatably mounted in the seat of the front shoulder (26) and fit starting from said first free end (24) of said support shaft (23) by means of a second key (39), which is fixed with fixing means to the internal surface of said first bush (38).
 8. Rolling machine according to claims 2 and 7, **characterized in that** said forming roller (6) is provided along its extension axis with a third end (35) directed towards the second end (25) of said support shaft (23), and with a fourth end (36) directed towards the first free end (24) of said support shaft (23) with the latter in said forward position;
 - said machine (1) comprising second support means (40) for said forming roller (6) in order to support the fourth end (36) of said forming roller (6) on the first bush (38) for supporting the support shaft (23) with the latter in said retracted position;
 - said second support means (40) for said forming roller (6) comprising: a third portion (11) of said second key (39) axially projecting beyond said first bush (38) and a second portion (43) of said first key (41) axially projecting beyond the fourth end (36) of said forming roller (6) and susceptible of abutting against the third portion (11) of the second key (39) of said first bush (38) with said support shaft (23) in said retracted position.
 9. Rolling machine according to claim 8, **characterized in that** said support shaft (23) is provided with a groove (44) obtained on its lateral surface and axially extended between said first free end (24) of said support shaft (23) and a bottom wall (45) provided at an intermediate section (XX) thereof; said groove (44) having length at least sufficient for receiving said first (41) and second (39) key in order to fit said first bush (38) and said forming roller (6) on said support shaft (23).

10. Rolling machine according to claims 2 and 8, **characterized in that** said first key (41) of said forming roller (6) in abutment against said first (37) and second (40) support means aligns said forming roller (6) with said support shaft (23). 5
11. Rolling machine according to claim 2, **characterized in that** it comprises at least one first radial bearing (46) at said front shoulder (26) and at least one second radial bearing (47) at said rear shoulder (27). 10
12. Rolling machine according to claim 2, **characterized in that** it comprises at least one first axial bearing (48) at said front shoulder (26) and at least one second axial bearing (49) at said annular body (31). 15
13. Method for substituting a forming roller in a rolling machine according to claim 2, **characterized in that** it comprises: 20
- a first step of actuating said actuator means (22) in order to move said rotary transmission member (21) from said forward position to said retracted position, in which said support shaft (23) is free to axially slide; 25
 - a step of extracting a first forming roller (6) from said front (26) and rear (27) shoulders with movement transverse to the rotation axis (Z) of said forming roller (6); 30
 - a step of inserting a second forming roller (6) with the extension axis aligned with the axis of said support shaft (23) with movement transverse to the rotation axis (Z) of said support shaft (23); 35
 - a second step of actuating said actuator means (22) in order to move said transmission member (21) from said retracted position to said forward position, in which it is rotatably engaged with said second forming roller (6). 40
14. Method for substituting a forming roller in a rolling machine according to claim 13, **characterized in that** said extraction step comprises an abutment step for said first forming roller (6) in which the latter is supported by said first (37) and second (40) support means, wherein: 45
- said first portion (42) of said first key (41) placed at said third end (35) of said forming roller (6) is engaged with said first support means (37) placed at said first free end (24) of said support shaft (23) with the latter in said retracted position; 50
 - said second portion (43) of said first key (41) placed at said fourth end (36) of said forming roller (6) is engaged with said second support means (40) placed at said second key (39) of said first bush (38) with said support shaft (23) 55

in said retracted position.

15. Method for substituting a forming roller in a rolling machine according to claim 13, **characterized in that** said step of inserting said second forming roller (6) comprises a step of aligning said second forming roller (6) with the axis of said support shaft (23), wherein:

- said first portion (42) of said first key (41) placed at said third end (35) of said forming roller (6) is engaged with said first support means (37) placed at said first free end (24) of said support shaft (23) with the latter in said retracted position;
- said second portion (43) of said first key (41) placed at said fourth end (36) of said forming roller (6) is engaged with said second support means (40) at said second key (39) of said first bush (38) with said support shaft (23) in said retracted position.

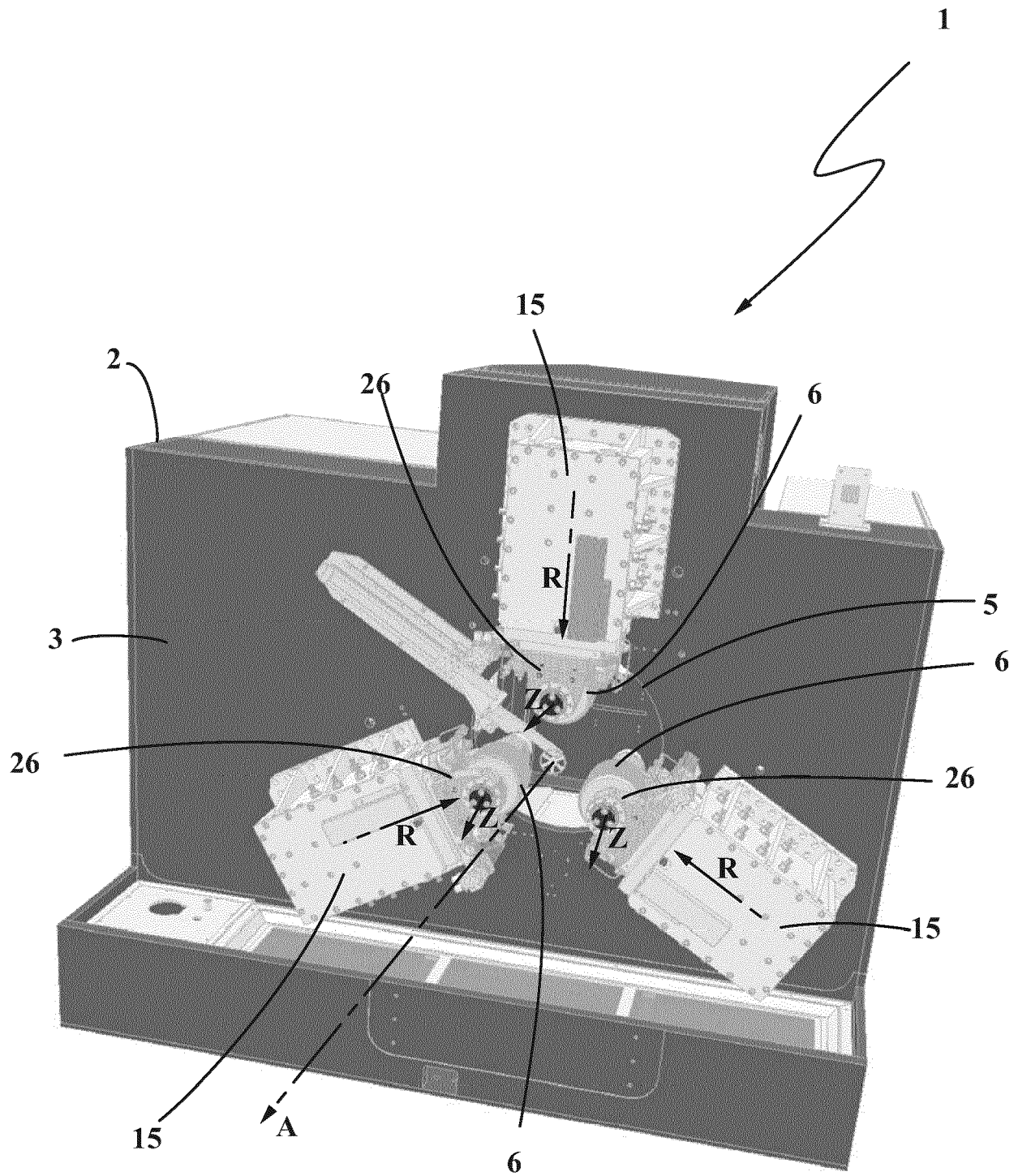


Fig. 1

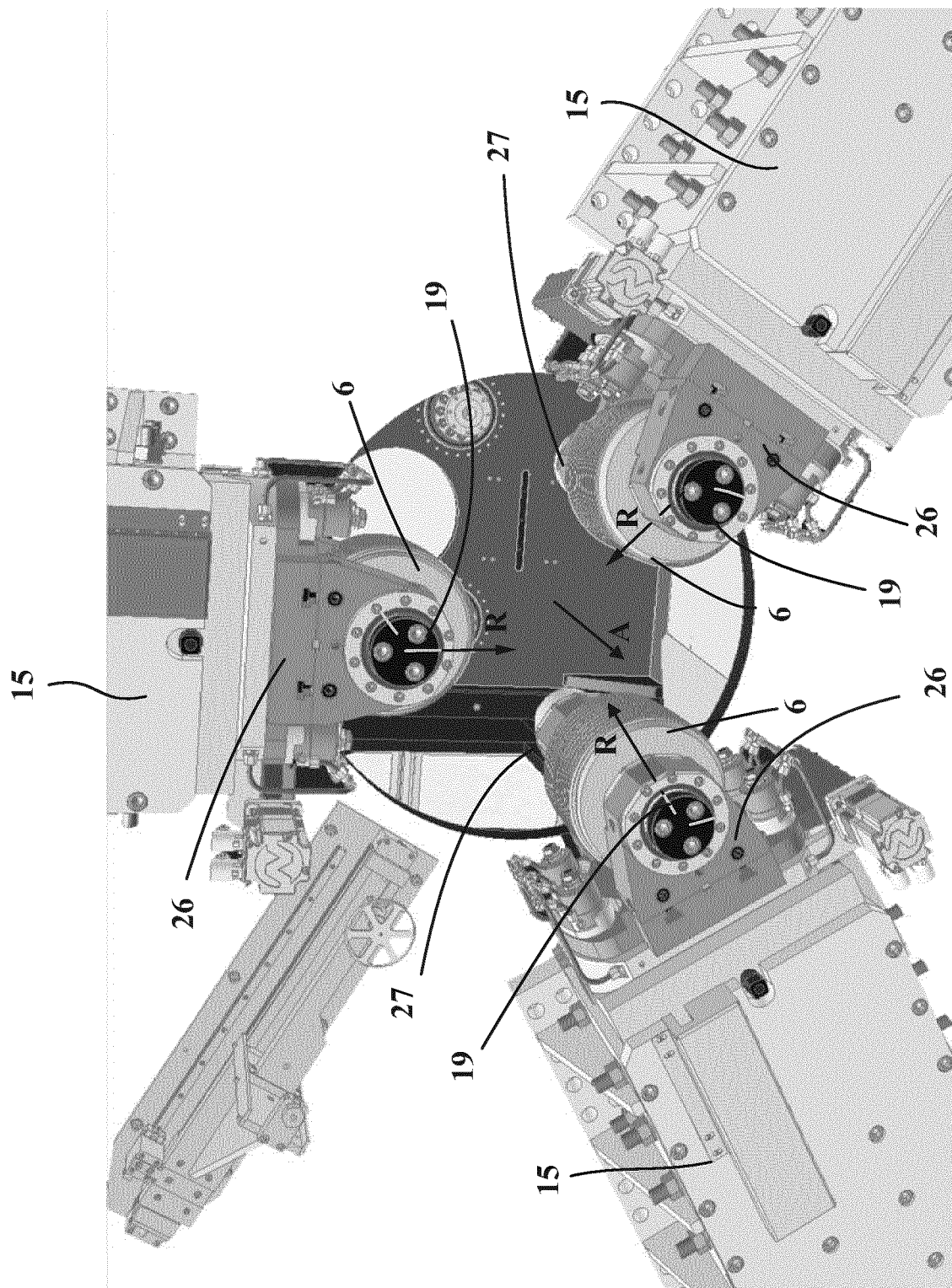
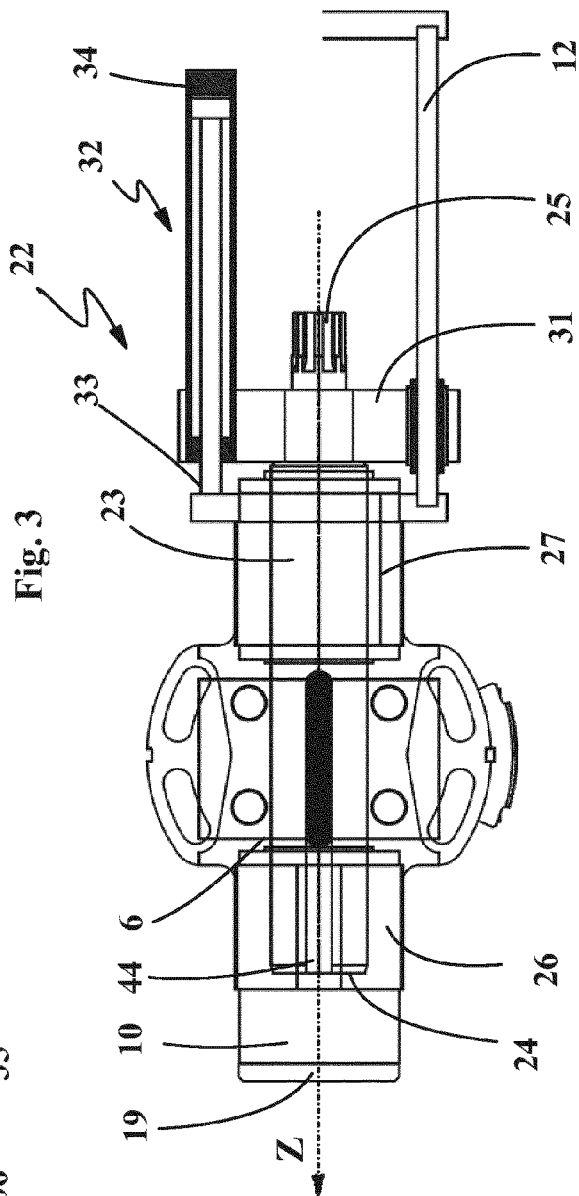
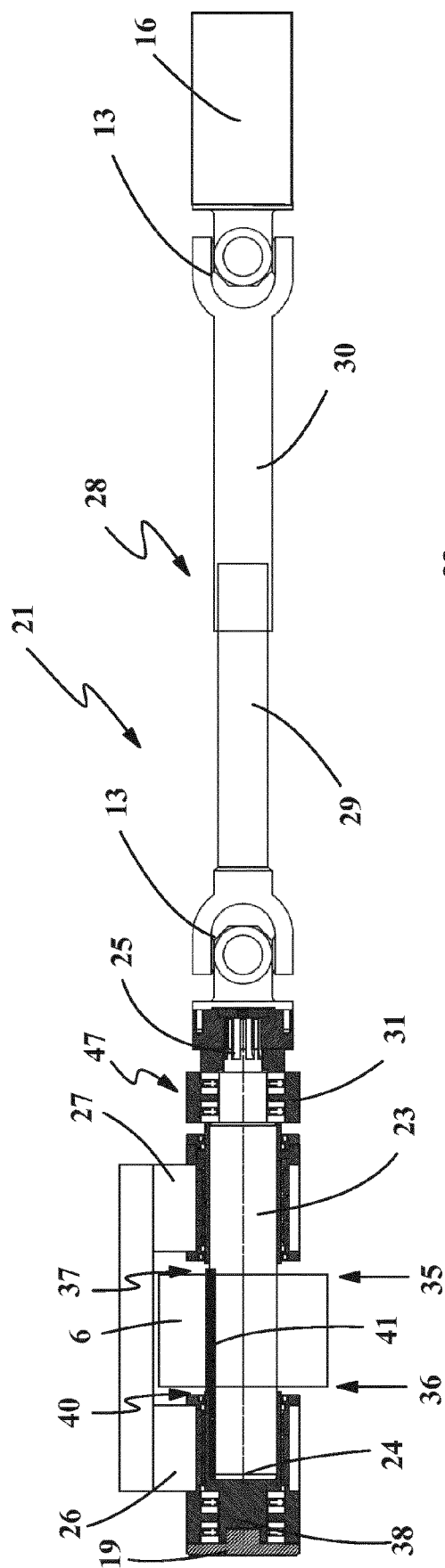


Fig. 2



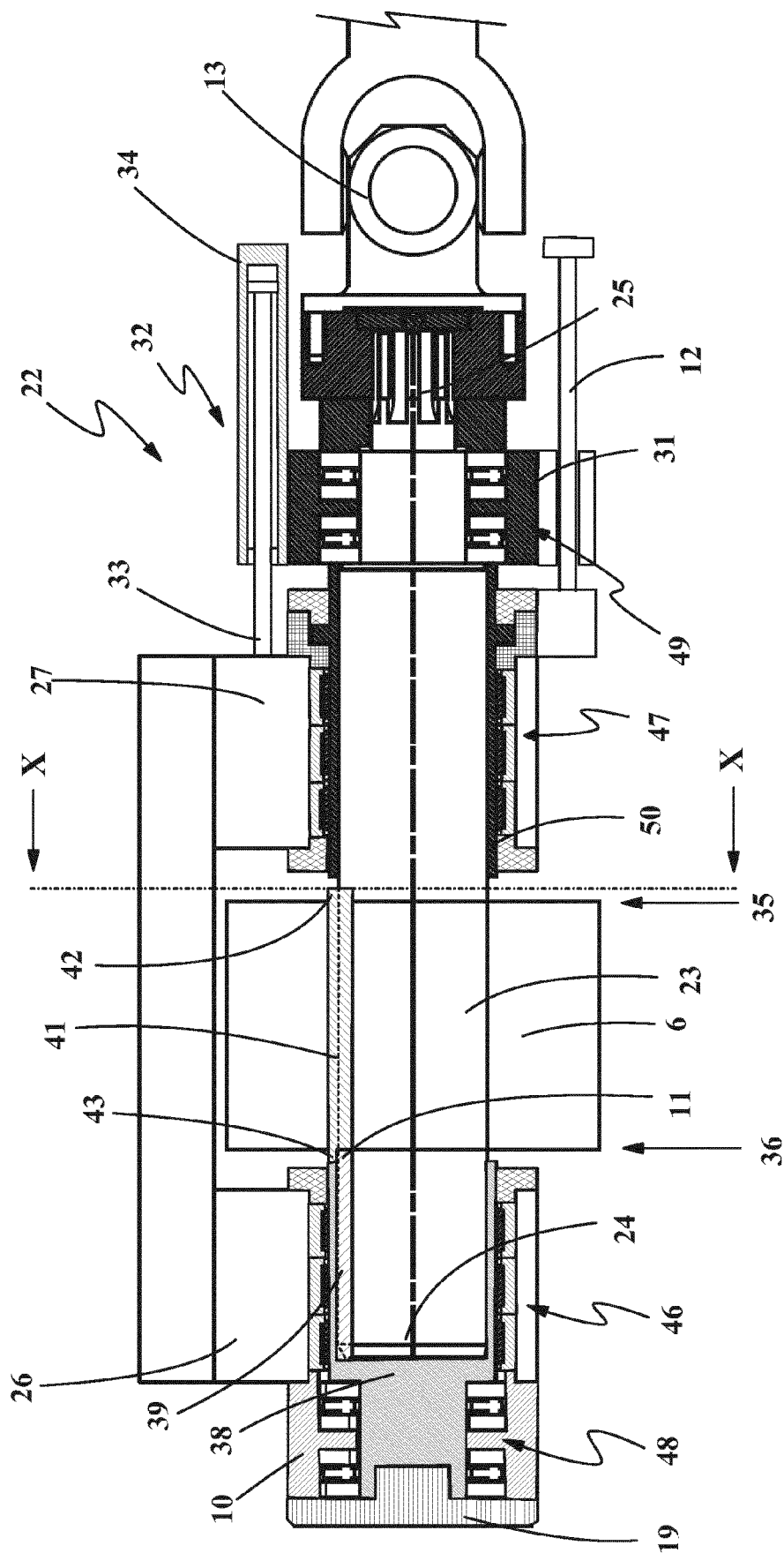
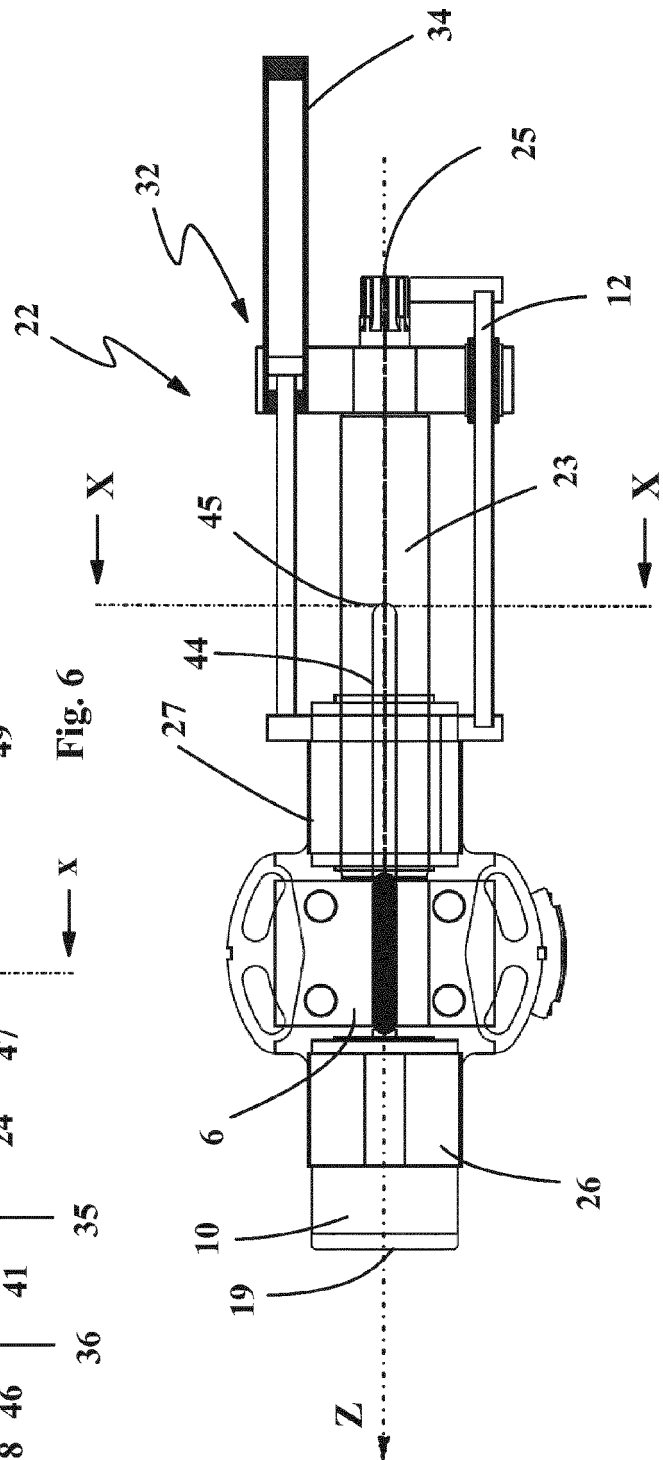
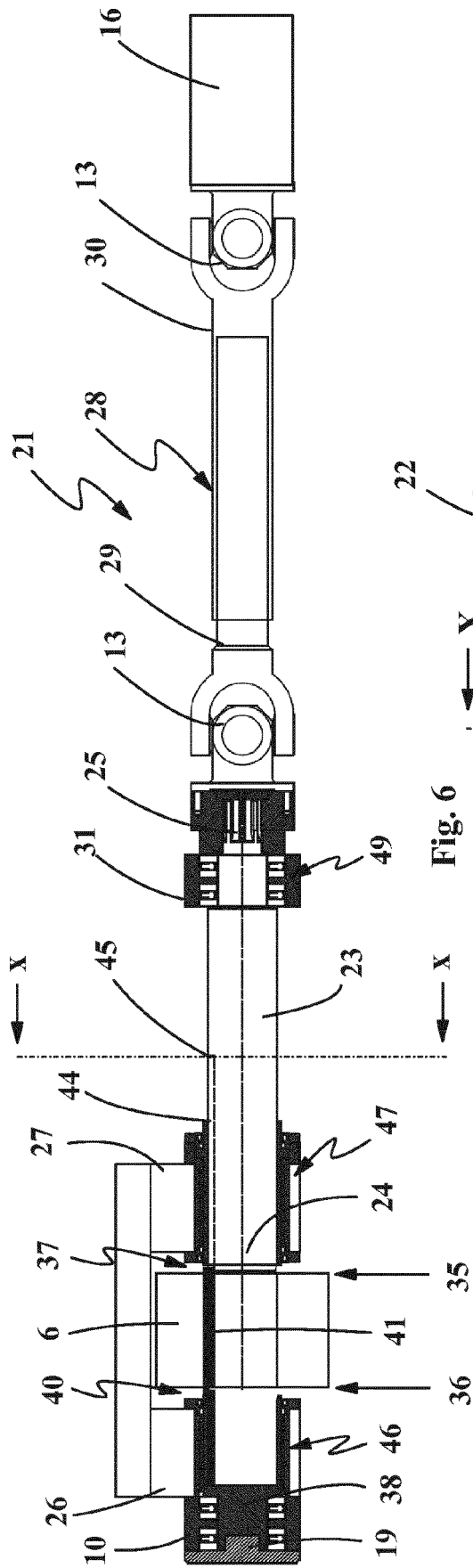


Fig. 5



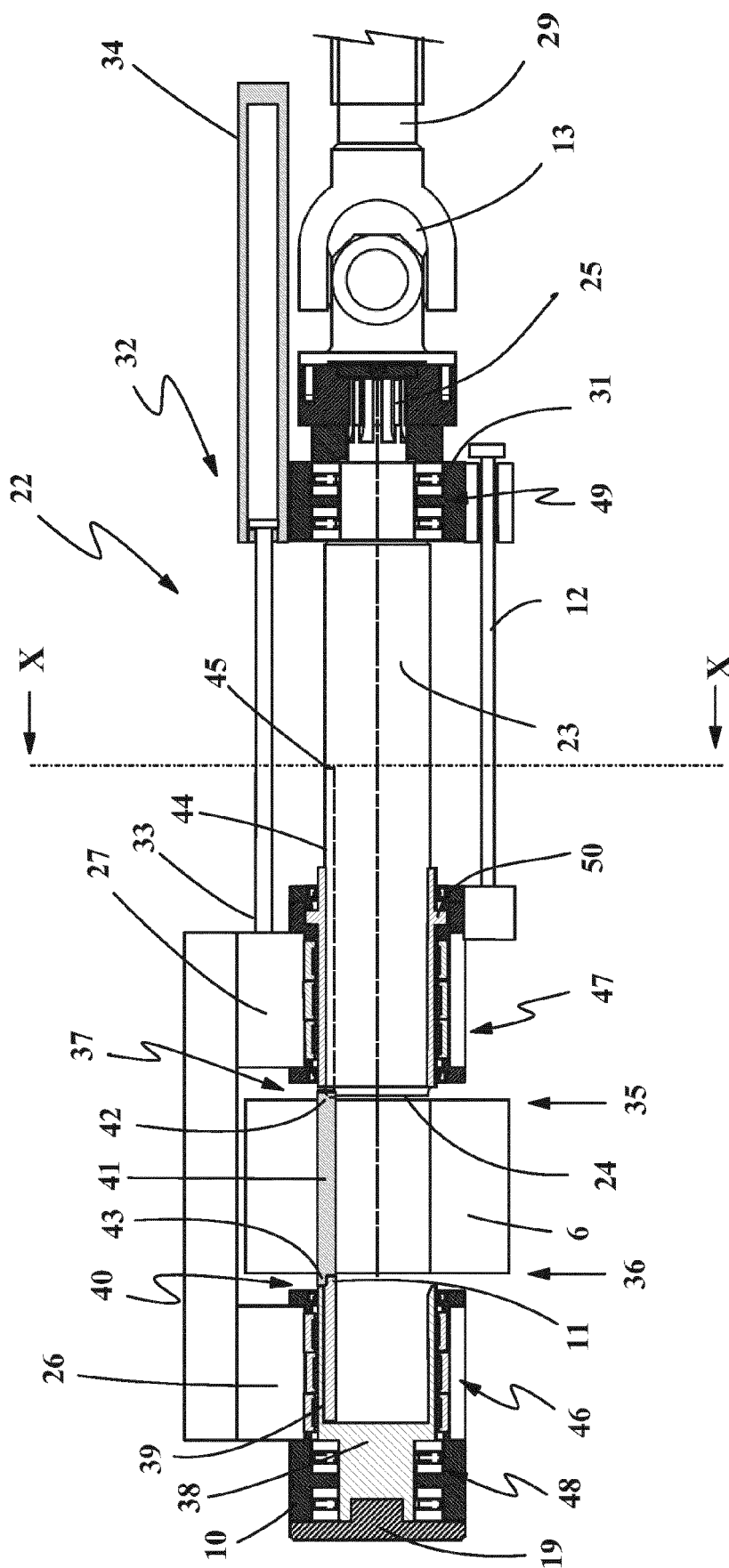


Fig. 8

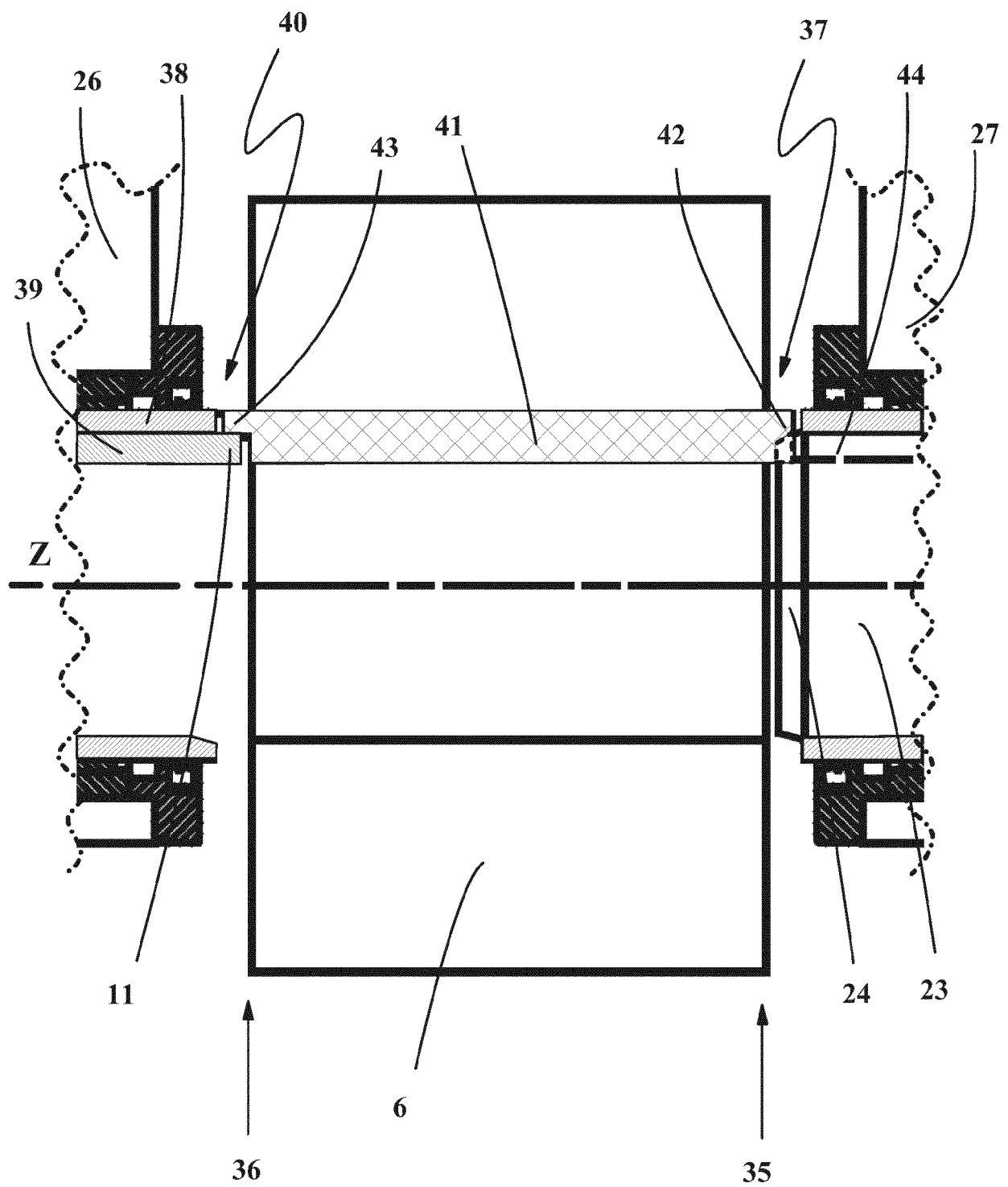


Fig. 9



EUROPEAN SEARCH REPORT

Application Number
EP 17 17 2587

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	CN 104 942 190 A (SHANDONG QINGDAO SHENGJIAN MACHINERY FACTORY) 30 September 2015 (2015-09-30) * paragraphs [0022], [0025]; figures 1,2 *	1-15	INV. B21H3/04
A	----- EP 0 894 555 A2 (REVUE THOMMEN AG [CH]) 3 February 1999 (1999-02-03) * paragraphs [0018], [0021], [0022], [0025]; figure 1 *	1-15	
A	----- DE 197 10 730 A1 (FRAUNHOFER GES FORSCHUNG [DE]) 24 September 1998 (1998-09-24) * column 3, line 63 - column 4, line 23; figure 1 *	1-15	
A	----- US 5 916 318 A (ANDERSON RAY C [US]) 29 June 1999 (1999-06-29) * column 3, line 55 - column 4, line 8; figures *	1-15	
	-----		TECHNICAL FIELDS SEARCHED (IPC)
			B21H
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 October 2017	Examiner Charvet, Pierre
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 17 2587

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

10-10-2017

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 104942190 A	30-09-2015	NONE	
EP 0894555 A2	03-02-1999	CH 692382 A5 EP 0894555 A2	31-05-2002 03-02-1999
DE 19710730 A1	24-09-1998	NONE	
US 5916318 A	29-06-1999	NONE	

15

20

25

30

35

40

45

50

55

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- CN 104942190 [0005]
- EP 0894555 A [0005]
- DE 19710730 [0005]
- US 5916318 A [0005]