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(54) STRAIGHTENING MACHINE FOR METAL STRUCTURAL SHAPES

(57) Straightening machine for metal structural shapes that provides one drive side shoulder (16) and one operator side shoulder (17), supporting a plurality of shafts (12) cooperating with oscillating bearings (34a, 34b). The shafts (12) are intermediate between the shoulders (16, 17) and carrying respective groups of straightening discs (11). There are present, with the shoulders (16, 17), fixed shafts (12) lying on their lying plane and positionable shafts (12) spaced at intervals with respect to the fixed shafts (12) and at least part of the shafts (12) are cooperating with drive members (20) generating a controlled rotational motion. The positionable shafts (12) cooperate with chocks (18, 19) vertically mobile in the respective shoulders (16, 17) and positionable with hydraulic jacks (32). The operator side shoulder (17) is able to be disconnected from the straightening machine (10) in order to replace at least the groups of straightening discs (11).

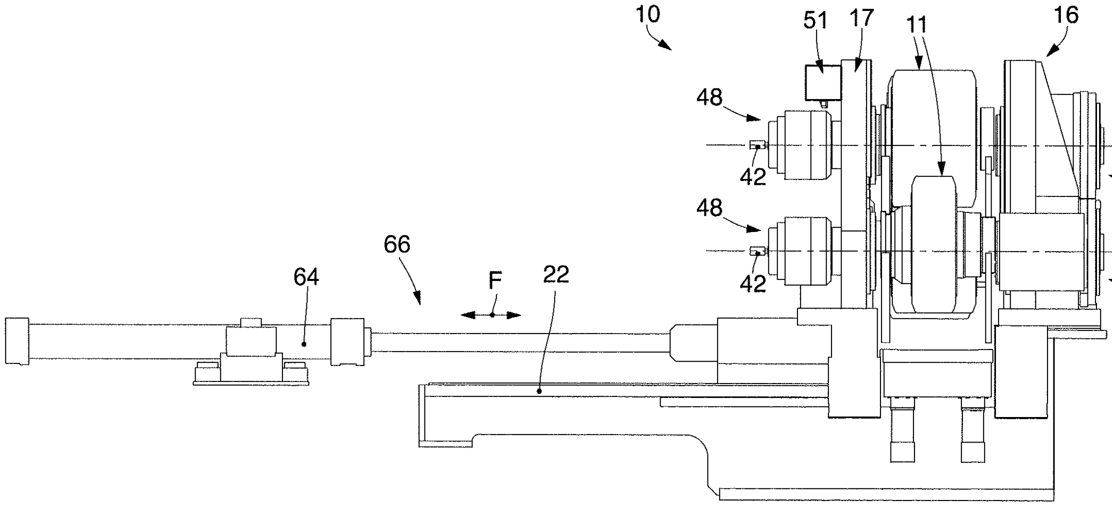

fig. 3

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Description

FIELD OF THE INVENTION

[0001] The present invention concerns a straightening machine for metal structural shapes, such as for example beams, sheet piles, tubular structural shapes, tracks, double T-shaped products, comprising a plurality of straightening rolls or discs, staggered and overlapping. In particular, but not exclusively, the machine is intended for structural shapes that are both thick and large.

[0002] The present invention concerns a straightening machine comprising two shoulders in which the straightening discs or rolls are located on a shaft and in between the shoulders.

BACKGROUND OF THE INVENTION

[0003] Metal structural shapes are obtained after a rolling process and subsequent cooling.

[0004] It is known that a structural shape after cooling has residual tensions that cause a lack of geometric uniformity in the profile, and tensions generated during the rolling cycle can also be added to these tensions.

[0005] The lack of geometric uniformity can be manifested in distortions or deflections of the structural shape, in particular geometric modifications in a direction orthogonal to the axis and/or along the longitudinal axis of the structural shape.

[0006] To overcome this disadvantage, the structural shape is made to pass in a straightening machine. By straightening we mean the joint action of a series of straightening discs or rolls, located staggered and on different planes, which induce a yield in the metal in order to obtain a structural shape with a geometrically desired and linear profile.

[0007] The straightening discs or rolls are installed on shafts, at least some of which induce motion.

[0008] A straightening machine can have from three (two straightening discs or rolls disposed above and one straightening disc or roll disposed below) to eleven (six straightening discs or rolls disposed above and five straightening discs or rolls disposed below) or even more straightening discs or rolls. In particular, one row of shafts is normally maintained in a fixed position and the other row of shafts, positioned alternate to the first row, can be adjusted with respect to the shafts in the fixed row.

[0009] The upper or lower straightening discs or rolls can be adjusted to be able to adjust the transit gap between the straightening discs or rolls to the sizes of the specific structural shape.

[0010] In the case of structural shapes, normally, straightening discs are used instead of straightening rolls, positioned on the shaft depending on the structural shape.

[0011] The shafts that carry the disc or roll cooperate, for example, with two bench bearings that in turn cooperate with the corresponding shoulder.

[0012] In correspondence with the bench bearings, the shafts mobile with respect to the fixed shafts have chocks that slide in suitable guides present in the shoulders.

[0013] It is known that, according to the requirements of production, it is necessary to replace the straightening discs in order to work structural shapes with different sizes or characteristics.

[0014] The operation to replace the straightening discs is normally carried out manually with the intervention of operators who perform the change-over operation.

[0015] Examples of straightening machines are described in WO-A-2008/025814, WO-A-01/97992, GB-A-600638 and DE-A-3616699, but in all these a manual intervention is always required by operators to change the straightening discs.

[0016] WO-A-2008/025814 describes a straightening machine provided with linear actuators associated with the support chocks of the support shaft of the straightening discs. The linear actuators allow to adjust the inclination of the rotation shaft in order to compensate the stresses to which it is subjected, and also possible play and wear.

[0017] WO-A-01/97992 also concerns a straightening machine which is provided, on the drive side, with a hydraulic system to compensate the plays between the rotation shaft, the chocks and the support bearings. The hydraulic system consists of a cylinder and a piston that slides in the cylinder and defines with it two chambers in which a pressure is generated, suitable to compensate the plays or to allow to dis-assemble the components. This solution, however, because of how it is conceived, does not supply any possibility of an automated replacement of the straightening discs.

[0018] GB-A-600638 and DE-A-3616699 also describe straightening machines which do not however supply any teaching regarding the possibility of an automated replacement of the relative straightening discs.

[0019] One disadvantage of the known solutions described above is therefore that the operation to replace the straightening discs, or the shaft bearing the discs, cannot be performed in the state of the art with a great degree of automation.

[0020] Furthermore, in the current state of the art, the change-over operation entails long replacement times.

[0021] Moreover, for problems of safety and cost, it is better if the straightening machine requires a minimum intervention by the operator during the replacement of the discs.

[0022] It is also necessary that the straightening machine contributes, with its own means, to speed up the change-over operations and at the same time guarantees that once the change-over has been made, the machine is stable and efficient.

[0023] Another requirement is that the machine should be as simplified as possible, possibly preventing the continuous functioning of position detectors and/or automatisms that create blockages, problems in the storage of spare parts, extraordinary maintenance downtimes, continuous controls on the functioning, etc.

[0024] The Applicant has devised, tested and embodied a straightening machine according to the present invention to overcome these problems.

[0025] The present invention has a plurality of purposes.

[0026] One purpose is to prevent, during the straightening step, that is, while the structural shape is in transit, dependent and desired correction processes having to be used, on an instrumental basis, of the positioning and/or lay-out of the straightening discs.

[0027] Another purpose is to prevent the straightening step from requiring the continuous controlled and managed repositioning of the straightening discs.

[0028] Another aspect is to simplify the operation of replacing the group of shafts and/or corresponding straightening discs or rolls, at the same time making it quicker and safer.

[0029] Another aspect is to simplify the clamping of the shaft in a reciprocal desired position to the operator side shoulder.

[0030] Another aspect is to simplify the operation to install-disinstall the shaft on the operator side shoulder.

[0031] Another purpose of the present invention is to simplify the reciprocal adjustment of the straightening discs of one shaft with the discs of the mating shafts.

[0032] The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

[0033] The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

[0034] In accordance with the above purposes, a straightening machine for metal structural shapes according to the present invention comprises:

- at least one rotation shaft supported by a first bearing and a second bearing associated with respective chocks;
- a group of straightening discs installed on the shaft between the chocks;
- one drive side shoulder and one operator side shoulder on each of which one of the chocks is installed;
- drive members associated with the drive side shoulder to make the shaft rotate;
- a movement unit configured to move the operator side shoulder with respect to the drive side shoulder to allow to replace the group of straightening discs;
- a clamping unit installed on the operator side shoulder and configured to selectively constrain the second bearing to the shaft and to the respective chock.

[0035] According to one aspect of the present invention, the clamping unit comprises:

- a support tube installed on the chock, supporting the second bearing and associated with the shaft;
- a mobile tube installed in the support tube and selectively able to be coupled/decoupled with an abutment portion of the shaft to prevent or respectively allow the movement of the operator side shoulder, and
- a drive device configured to move the mobile tube with respect to the support tube and to define a condition of constraint or release between the support tube and the shaft.

[0036] Hereafter we will refer only to a shaft which with its chocks is adjustable vertically or sub-vertically in the respective shoulders.

[0037] According to the invention, all the shafts bearing the straightening discs are motorized.

[0038] According to a variant, only the adjustable shafts are motorized that cooperate with the respective chocks.

[0039] The motorizations can be electric or oil-dynamic.

[0040] According to a variant, at least some of the shafts have a positioning member which allows to position them axially so as to align the straightening discs or rolls of the various shafts.

[0041] According to a variant, only one row of shafts are equipped with said drive.

[0042] The shafts according to the invention are mounted with oscillating bearings, advantageously barrel roller bearings or suchlike.

[0043] The positionable shafts have said bearings located in the respective chocks. Moreover, in the drive side chock there is also advantageously at least a thrust bearing or similar means.

[0044] According to another variant, the operator side shoulder is associated with constraint means that allow to clamp the straightening discs on the shaft in the desired axial position.

[0045] According to a variant of the invention, the operator side shoulder not only has the constraint means but also a clamping unit that allows to clamp-unclamp the shaft with respect to the shoulder or the chock. This is in order to keep, during the straightening step, at least part of the mobile structure toward the drive side under the desired mechanical stress without using other mechanical constraints.

[0046] According to another variant, the shaft has the two median axes of the oscillating bearings around 1.8 - 2.5 times the maximum distance between the straightening discs.

[0047] Another variant of the invention is that, under the maximum straightening load provided for the biggest structural shape that has to be straightened, the shaft is sized so that it bends in the center line by a maximum of between 0.16mm and 0.35mm.

[0048] As a consequence, with a flexion for example of 0.26mm, when the distance between the axes of the bearings is 1200mm and the straightening discs are 600mm distant, the inflexion, that is, the maximum displacement to which the straightening discs will be subjected, will be only 0.20mm.

[0049] This condition keeps the straightening discs in the correct position and allows them to move by a value that has no effect, in terms of tolerance, on the result, given the large sizes of the structural shape.

[0050] Another variant is that the deformations generated by the maximum straightening force are absorbed by the elasticity of the structure. According to this variant, the maximum deformation that entails a reciprocal movement between the two chocks is between 0.030mm and 0.070mm. These values do not entail any problems, given the size of the structural shape.

[0051] According to the invention, for their vertical or sub-vertical positioning, the chocks cooperate with hydraulic jacks.

[0052] According to a variant, the hydraulic jacks have a power, that is, a thrust-drawing capacity, which with respect to the maximum yield force that the straightening machine has to support, is comprised between 1.6 and 3.0 times. This implies that the hydraulic jacks do not move, because their power is redundant.

[0053] Once the chocks have been positioned, according to the invention, the hydraulic jacks, given that their power is redundant, keep their position during the transit of the structural shape for which the straightening machine has been prepared.

[0054] With this system, the reciprocal displacement of the chocks is not compensated by the hydraulic jacks but by the calculated elasticity of the structure, so that said reciprocal displacement remains inside minimum values much lower than a tenth of a millimeter in the event of the greatest straightening force.

[0055] Another variant is that during the displacement of the chocks for the new position of the shaft (straightening rolls), or to correct the straightening capacity after the transit of a not completely straightened structural shape, or for the initial positioning for that type of structural shape, the chocks work in tandem so as to keep a horizontal position. Therefore, the hydraulic jacks are controlled so that the possible misalignment between one oscillating bearing and the other remains confined in a field comprised between 0.07mm and 0.16mm. This allows to prevent the shaft, when the chocks are positioned, from having a non-horizontal state such as to prevent a correct straightening.

[0056] According to the invention, the shafts complete with straightening discs are replaced.

[0057] According to a variant, the shafts remain in position on the operator side shoulder and only the groups of straightening discs are replaced.

[0058] If the groups of straightening discs are replaced, having disconnected the operator side chock hydraulically, the operator side shoulder is displaced in an axial direction to the shafts.

[0059] In this condition the shaft and the groups of straightening discs are supported by the drive side chock and subsequently the groups of straightening discs are removed, leaving the shaft in position on the drive side chock.

[0060] According to a possible variant solution, the operator side shoulder carries the shafts with it, or in the case of a variant the groups of straightening discs.

[0061] According to some variants, the shafts remain solid with the drive side shoulder, that is, the shafts and the corresponding groups of straightening discs remain solid with the drive side shoulder.

[0062] According to another variant, the groups of straightening discs are taken away by the operator side shoulder.

[0063] To replace the groups of straightening discs, the invention provides to use a bridge crane carrying a tool that already supports the new set of pre-adjusted groups of straightening discs, and a tool that is able to attach the groups of straightening discs to be replaced.

[0064] According to a variant, two tools are provided, possibly independent, one carrying the pre-adjusted groups of straightening discs, and the other able to remove the groups of straightening discs to be replaced.

[0065] According to another variant, the straightening discs to be replaced are made to cooperate with a support frame that slides on rails while another frame, carrying the groups of straightening discs, is able to position itself.

[0066] According to another variant, the groups of straightening discs cooperate with a replacement frame that remains in the straightening machine while it is straightening.

[0067] With a replacement frame it is possible to perform the replacement operation both with cranes and with pathways that slide orthogonal to the axes of the shafts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0068] These and other characteristics of the present invention will become apparent from the following description of some embodiments, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a front view of a straightening machine for metal structural shapes according to a variant;
- fig. 2 is a plan view of a straightening machine for metal structural shapes according to another variant;
- fig. 3 is a front view of a straightening machine for metal structural shapes according to a variant;
- fig. 4 is a front view of a straightening machine for metal structural shapes according to another variant;
- fig. 5 is a lateral section of a straightening machine for metal structural shapes according to a variant;
- fig. 6 is a diagram showing the distribution of the inflection;
- fig. 7 is a front section of a part of a straightening

machine for metal structural shapes;
- fig. 8 is a partial lateral section of a part of a shaft;
- fig. 9 is a partial lateral section of a rotary joint;
- fig. 10 is an enlarged view of fig. 7.

[0069] To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one embodiment can conveniently be incorporated into other embodiments without further clarifications.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

[0070] We shall now refer in detail to the various embodiments of the present invention, of which one or more examples are shown in the attached drawings. Each example is supplied by way of illustration of the invention and shall not be understood as a limitation thereof. For example, the characteristics shown or described insomuch as they are part of one embodiment can be adopted on, or in association with, other embodiments to produce another embodiment. It is understood that the present invention shall include all such modifications and variants.

[0071] According to the present description, the invention concerns a straightening machine 10 for metal structural shapes 35.

[0072] By metal structural shapes 35 we mean for example beams, sheet piles, V- or double T-shaped structural shapes, or tracks.

[0073] The machine according to the invention is particularly suitable for thick or large size structural shapes 35, for example HE type from 100mm to 400mm and more, or IPE type from 200mm to 1100mm and more.

[0074] With reference to figs. 1, 3, 4 and 7, the straightening machine 10 comprises two shoulders, that is, a drive side shoulder 16 and an operator side shoulder 17 located facing the drive side shoulder 16.

[0075] The straightening machine 10 comprises a plurality of groups of straightening discs 11 each installed on a respective shaft 12 and conformed and positioned depending on the structural shape 35 (fig. 7) to be straightened.

[0076] Although the present invention refers to groups of straightening discs 11, an analogous application to straightening cylinders is not excluded, with different conformations depending on the structural shapes to be straightened.

[0077] According to possible embodiments, the group of straightening discs 11 can comprise a pair of discs 50a disposed facing and distanced from each other, and a distancing core 50b interposed between the pair of discs 50a. The group of straightening discs 11 can be made in a single body, or, according to the solution shown in figs. 7-10, made with separate components connected with each other.

[0078] The axes of rotation of the shafts 12 of the straightening machine 10 are located substantially parallel to each other.

[0079] According to a possible solution, the straightening machine 10 comprises a plurality of mobile straightening discs 11 a, in this case the upper ones, and a plurality of fixed straightening discs 11b, in this case the lower ones.

[0080] The mobile straightening discs 11 a are mobile toward/away from the fixed straightening discs 11b as will be described hereafter.

[0081] The mobile straightening discs 11 a have their axes of rotation located on a common lying plane, parallel to the direction of feed of the structural shape 35.

[0082] The fixed straightening discs 11b have their axes of rotation located on a common lying plane which is parallel to that of the mobile straightening discs 11a.

[0083] The fixed straightening discs 11b are disposed so that between each pair of mobile straightening discs 11a a fixed straightening disc 11b is positioned. In this way, a looped straightening path is defined for the structural shape 35.

[0084] Hereafter, where not specified, we will refer to a group of straightening discs 11, with the description being valid for mobile 11a and fixed straightening discs 11b.

[0085] The group of straightening discs 11 is installed solid on the shaft 12 by means of a bushing 38 which guarantees the correct assembly.

[0086] According to the embodiment shown in fig. 7, the bushing 38 is attached or keyed onto the shaft 12 with kinematic connection members 13, such as keys, tongues or flanges, for example inserted into a hollow 15 made in the shaft 12. In the same way, the straightening discs 11 can be keyed onto the bushing 38 with similar kinematic connection members.

[0087] Each shaft 12 is supported by a drive side chock 18 and an operator side chock 19.

[0088] Each drive side chock 18 is installed on the drive side shoulder 16 and each operator side chock 19 is installed on the operator side shoulder 17.

[0089] With reference to figs. 6 and 7, each drive side chock 18 and each operator side chock 19 is provided respectively with at least one first bearing 34a and at least one second bearing 34b configured to support the respective shaft 12.

[0090] The first bearing 34a and the second bearing 34b can be the oscillating type, for example barrel bearings or suchlike.

[0091] According to the present invention, the first bearing 34a and the second bearing 34b are installed on two support portions 12a and respectively 12b of the shaft 12, axially distanced from each other. The group of straightening discs 11 is installed between the support portions 12a and 12b of the shaft 12.

[0092] According to a possible solution, the first bearing 34a and the second bearing 34b are distanced, along the axis of the shaft 12, by a bearing interaxis 39a.

[0093] The discs 50a of the groups of straightening discs 11 are reciprocally distanced by a straightening discs interaxis 39b.

[0094] According to a possible solution, the bearing interaxis 39a is about 1.8 and 2.5 times the straightening discs interaxis 39b, so as to be able to contain the flexion of the shaft 12.

[0095] The particular configuration of the present invention allows to contain the amplitude of flexion of the shaft 12 to very limited values. Merely by way of example, the shaft 12 is configured to assume a range of flexion comprised between 0.16mm and 0.35mm, advantageously between 0.24mm and 0.28mm in correspondence with its center line and in the condition of maximum straightening load. According to the load diagram shown in fig. 6, the shaft 12 is subjected to an inflexion of about 0.27mm.

[0096] According to a possible embodiment, the drive side chock 18 can comprise at least one bearing 33 of the thrust type to contain the axial thrusts that are discharged onto the shaft 12. According to the solution shown in figs. 6 and 7, two thrust bearings 33 are associated with the shaft 12 and the drive side chock 18 and are configured to contain the axial thrusts in both axial directions of the shaft 12.

[0097] According to a possible solution, at least the first support bearing 34a, in this case also the thrust bearings 33, are installed on a bearing carrier ring 61 which is in turn installed on the drive side chock 18. According to a possible solution, the second bearing 34b is installed on a support body 74 attached to the operator side chock 19.

[0098] According to a possible embodiment, at least some of the chocks, whether operator side chock 19 or drive side chock 18, can be installed mobile, in a direction orthogonal to the axis of the shaft 12 and to the direction of feed of the structural shape 35, in rigid guides 31 between shoulders 60 (see fig. 5).

[0099] The rigid guides 31 are provided on the drive side shoulders 16 and the operator side shoulders 17, while the shoulders 60 are each installed on one of the operator side chocks 19 and drive side chocks 18 and are sliding on the rigid guides 31.

[0100] The ratios in size of the rigid guides 31 and the chocks 18, 19 in any case cause the misalignment, according to the present invention, of the two chocks 18, 19, and hence the non-horizontal condition of the shaft 12, to be maintained within values much lower than 0.1 mm.

[0101] The adjustment of the positioning of each shaft 12 with respect to the others is allowed by the simultaneous displacement of the drive side chock 18 and the operator side chock 19, the misalignment being maintained within values much lower than 0.1 mm.

[0102] The positioning of the groups of mobile straightening discs 11 a, in this case the upper ones (see fig. 5), with respect to the groups of fixed straightening discs 11b takes place by means of hydraulic jacks 32 that operate in synchrony.

[0103] The hydraulic jacks 32 allow to position the drive side chock 18 and the operator side chock 19 in a vertical or subvertical direction along the rigid guides 31.

[0104] In particular, the hydraulic jacks 32 are configured to move each shaft 12, at least of the groups of mobile straightening discs 11a, in a direction orthogonal to the axis of rotation of the latter and to the axis of feed of the structural shape 35.

[0105] Moreover, it is provided that for each movable shaft 12 there is a hydraulic jack 32 associated with the drive side chock 18 and a hydraulic jack 32 associated with the operator side chock 19.

[0106] The hydraulic jacks 32 are configured so that they exert a thrust-drawing capacity applied on the shaft 12 comprised between about 1.6 times to about 3.0 times the maximum yield force provided for the straightening machine 10.

[0107] The drive side chock 18 and the operator side chock 19 work in tandem, that is, they are moved vertically and in synchrony, and are configured so as to keep the shaft 12 horizontal during the straightening step comprised within a minimum error.

[0108] The horizontal position of the chocks 18, 19 is adjusted, for positioning the shaft 12 and therefore the straightening discs 11, only when the reciprocal position of the straightening discs 11 has to be adjusted for a new type or size of structural shape, that is, when it is necessary, for example after a replacement of the worn groups of straightening discs 11.

[0109] Another adjustment, for example a precision adjustment, of the chocks 18, 19 can be made following the straightening of a first structural shape 35, if the results obtained are not those expected.

[0110] Consequently, the hydraulic jacks 32 allow to keep the position of the drive side chock 18 and the operator side chock 19 stable until the maximum yield point of the structural shape 35 has been passed.

[0111] Furthermore, the hydraulic jacks 32 are configured to contain any possible misalignment of the first bearing 34a and the second bearing 34b to very low values, merely by way of example comprised in a range between 0.007mm and 0.16mm, which are insignificant given the sizes of the structural shapes 35.

[0112] In a variant, the straightening machine 10 can have at least some of the shafts 12 positioned axially to correctly dispose the various groups of straightening discs 11.

[0113] According to this variant, the shafts 12 that support the groups of straightening discs 11 can also be adjusted axially by means of an axial positioning member 21, configured to move the shaft 12 in a direction parallel to its axis of rotation Z.

[0114] According to a possible solution, the axial positioning member 21 comprises a toothed wheel 21a or pinion (see fig. 7) which engages on a driven toothed wheel 21b which can be selectively rotated around its axis of rotation and is constrained in its displacement in an axial direction.

[0115] The driven toothed wheel 21b is installed coaxial with the rotation shaft and on the bearing-carrier ring 61.

[0116] The driven toothed wheel 21b is installed, with a threading 65, on a mating threading 65 of the bearing-carrier ring 61.

[0117] In this way, by making the driven toothed wheel 21b rotate, it is possible to determine an axial movement of the whole rotation shaft 12 and therefore of the group of straightening discs 11 associated with it.

[0118] An encoder 67 allows to control or manage, also automatically and in the adjustment step, the correct axial positioning of the shaft 12 and therefore of the respective group of straightening discs 11.

[0119] All the support shafts 12 of the group of straightening discs 11 are connected to a drive member 20, i.e. they are motorized. The drive member 20 can be an electric or oil-dynamic motor and can be provided with reduction and/or motion control members 68, such as encoders.

[0120] The drive member 20 is associated with the drive side shoulder 16 and is connected to the shaft 12 in correspondence with a first end. The connection between the drive member 20 and the shaft 12 can be obtained by joints, clutch joints, flanges or similar and comparable connection elements.

[0121] The operator side shoulder 17 is associated with a movement unit 66 configured to move the operator side shoulder 17 with respect to the drive side shoulder 16 and allow in this way to replace the group of straightening discs 11.

[0122] The movement unit 66 can comprise longitudinal guides 22 which are parallel to the axis of rotation Z and on which the operator side shoulder 17 is installed.

[0123] The cooperation of the operator side shoulder 17 with the longitudinal guides 22 allows to translate the operator side shoulder 17 in a longitudinal direction of translation F parallel to the axis of the shafts 12.

[0124] In a particular variant shown in figs. 1, 3 and 4, the movement unit 66 comprises a linear actuator 64, or any other mean that supplies the desired and controlled motion. The linear actuator 64 is configured to move the operator side shoulder 17 parallel to the axis of the shafts 12 and along the longitudinal guides 22.

[0125] The linear actuator 64 is able to selectively determine the movement of the operator side shoulder 17 toward/away from the drive side shoulder 16 to allow to replace the group of straightening discs 11.

[0126] In a variant, not shown, the operator side shoulder 17 can carry the shafts 12 and/or the groups of straightening discs 11 with it, during its movement.

[0127] In another variant, the shafts 12 can remain installed on the drive side shoulder 16 possibly with the groups of straightening discs 11.

[0128] According to the embodiment shown in fig. 4, when the operator side shoulder 17 is moved away from the drive side shoulder 16, the shaft 12 remains supported cantilevered by the drive side shoulder 16.

[0129] With reference to figs. 7, 8 and 10, the operator side shoulder 17 comprises a clamping unit 48 configured to selectively constrain the second bearing 34b to the shaft 12 and to the respective operator side chock 19.

[0130] During the operations to change the shaft 12, or the groups of straightening discs 11, the clamping unit 48 remains solid with the operator side shoulder 17.

[0131] According to the present invention, the clamping unit 48 comprises a support tube 36 installed on the chock 19, supporting the second bearing 34b and associated with the shaft 12.

[0132] In particular, the support tube 36 is installed coaxially with the shaft 12. The second bearing 34b is in turn installed, coaxial, on the support tube 36.

[0133] The support tube 36 can be made in one or more components, in this case three, which can be separated from each other, in order to allow to assemble the second bearing 34b.

[0134] The clamping unit 48 comprises a mobile tube 55 installed in the support tube 36 and able to be selectively coupled/uncoupled to/from at least an abutment portion 47 of the shaft 12, to prevent or respectively allow the movement of the operator side shoulder 17.

[0135] The abutment portion 47 can be provided on a second end of the shaft 12, opposite the first end. The abutment portion 47 can be defined by a component connected solidly with the shaft 12.

[0136] In this way, when the mobile tube 55 is coupled with the abutment portion 47, an axial constraint is obtained between the operator side shoulder 17 and the shaft 12, thus constraining the axial positioning of the second bearing 34b with respect to the shaft 12. In this condition, the shaft 12 can be made to rotate around its axis to perform the straightening operations on the structural shapes 35.

[0137] When it is necessary to replace the group of straightening discs 11, the abutment portion 47 is released from the mobile tube 55. In this way, the operator side shoulder 17, or the operator side chock 19 associated therewith, is no longer constrained axially with respect to the shaft 12, and therefore it is possible to perform an axial translation of the operator side shoulder 17. During the axial translation the operator side shoulder 17 takes with it the support tube 36 and the second bearing 34b, leaving the shaft 12 supported cantilevered on the drive side shoulder 16.

[0138] According to the embodiment shown in figs. 7, 8 and 10, the mobile tube 55 is provided with an axial seating 71 configured so as to define a bayonet type coupling with the abutment portion 47 of the shaft 12. At least part of the shaft 12 is installed through in the axial seating 71.

[0139] According to a possible solution, the axial seating 71 is defined by a plurality of insertion seatings 59, separated from each other circumferentially by striker portions 70 cooperating during use with at least one of the abutment portions 47 of the shaft 12. In particular, the striker portions 70 protrude radially toward the center of the axial seating 71 with respect to the insertion seatings 59.

[0140] During the operations to couple the shaft 12 to the mobile tube 55, the operator side shoulder 17 is moved toward the drive side shoulder 16.

[0141] In this step the abutment portions 47 of the shaft 12 are substantially aligned with the insertion seatings 59 of the mobile tube 55 to insert the abutment portions 47 through the insertion seatings 59.

[0142] Subsequently it is provided to rotate the shaft 12 so as to define a coupling between the abutment portion 47 of the shaft 12 and the striker portions 70 of the mobile tube 55 so as to define an axial constraint of the mobile tube 55 and the shaft 12. The rotation of the shaft 12 takes place in a controlled manner by means of the reduction and/or motion control members 68 associated with the drive member 20.

[0143] Therefore, the abutment portion 47 and the striker portion 70 together define a bayonet type connection.

[0144] According to another aspect of the present invention, it is provided that the clamping unit 48 comprises a drive device 42 configured to move the mobile tube 55 with respect to the support tube 36 and to define a constraint or release condition of the support tube 36 and the shaft 12.

[0145] According to possible solutions, the drive device 42 can be the mechanical type, for example comprising threaded connection members, mechanical interference members, articulated mechanisms or suchlike.

[0146] According to variants shown in figs. 7 and 10, the drive device 42 is the hydraulic type.

[0147] According to this latter variant, the support tube 36 and the mobile tube 55 can define between them a hydraulic type actuator in which the fixed part, or jacket, is defined by the support tube 36, while the mobile part or piston is defined by the mobile tube 55.

[0148] In particular, in the solution shown in figs. 7 and 10, the support tube 36 defines a compartment 69 in which the mobile tube 55 is installed, axially sliding.

[0149] In the compartment 69, between the support tube 36 and the mobile tube 55, a compression chamber 40 and a release chamber 49 are defined, into/from which a work fluid is selectively introduced or discharged in order to determine the axial sliding of the mobile tube 55 with respect to the support tube 36, in one direction or the other.

[0150] The axial movement of the mobile tube 55 allows to selectively define a coupling condition thereof through interference with the shaft 12.

[0151] In particular, by moving the mobile tube 55 axially it is possible to generate a coupling through mechanical interference between the abutment portions 47 of the shaft 12 and the striker portions 70 of the mobile tube 55.

[0152] In this condition, the mobile tube 55 and the support tube 36 are constrained both axially and circumferentially to the shaft 12. By making the shaft 12 rotate, during the straightening operations, it is therefore possible to make the mobile tube 55 and the support tube 36 also rotate at the same time.

[0153] The hydraulic pressure of the work fluid present in the compression chamber 40 allows to clamp/unclamp the operator side chock 19 with respect to the shaft 12 and to keep under mechanical stress the reciprocal coupling of the operator side chock 19 and the shaft 12 during the work steps, without requiring mechanical constraints, such as ring-nuts, as required in known solutions.

[0154] This solution allows to automate the operations of replacing the groups of straightening discs 11, also allowing to considerably reduce the replacement times.

[0155] According to the solution shown in figs. 7 and 10, the drive device 42 comprises a feed circuit 72 configured to selectively feed a work fluid to the compression chamber 40 or the release chamber 49, to define the coupling or respectively the decoupling of the shaft 12 and mobile tube 55.

[0156] The feed circuit 72 can be made at least partly in the mobile tube 55.

[0157] The drive device 42 can also comprise a distribution member 73 fluidically connected to the feed circuit 72 to feed the work fluid. The distribution member 73 (see fig. 9) can have two entrances 45 and 57 connected to respective pipes to feed and/or discharge (not shown) the work fluid.

[0158] The entrances 45 and 57 feed respective pipes 46 and 58 of the distribution member 73 connected respectively to the compression chamber 40 and the release chamber 49.

[0159] The distribution member 73 can comprise a mobile body 43 solid with the mobile tube 55 and an external body 44 with respect to the mobile body 43. The mobile body 43, during use, is selectively made to rotate by the shaft 12 while the external body 44, to which the feed and/or discharge pipes are connected, is fixed.

[0160] Packings 37 are installed between the mobile body 43 and the external body 44. The packings 37 allow to separate the stream of oil that feeds the compression chamber 40 from the stream of oil that feeds the release chamber 49.

[0161] According to a possible embodiment of the present invention, the operator side shoulder 17 is provided with a constraint member 51 configured to constrain the rotation of the support tube 36 with respect to the shaft 12.

[0162] The constraint member 51 can comprise an interference element 52a, for example a shaped tooth, selectively drivable by a drive member 52b.

[0163] The constraint member 51 can also comprise a recess 53 made externally on the support tube 36 and configured to cooperate with the interference element 52a.

[0164] When it is required to decouple the shaft 12 and the operator side shoulder 17, the constraint member 51 is driven to prevent the rotation of the support tube 36.

[0165] In this condition, by rotating the shaft 12 by a predefined angular amplitude, it is possible to release it from the mobile tube 55, axially decoupling the abutment portion 47 from the striker portion 70. The structure of the straightening machine 10 is able to absorb elastic deformations generated in a condition of maximum straightening force.

[0166] As shown in fig, 1, the straightening machine 10 comprises at least one replacement unit 23, in the case shown here two replacement units 23, configured to automatically replace the groups of straightening discs 11 installed on the shafts 12.

[0167] The replacement unit 23 can be installed on a bridge crane structure 24 and is configured to support a set of groups of pre-adjusted straightening discs 11.

[0168] By groups of "pre-adjusted" straightening discs 11 we mean the plurality of groups of straightening discs 11 to be installed on the straightening machine 10 to straighten a new structural shape 35.

[0169] The replacement units 23 can be installed on respective movement sliders 25, which allow the movement of each replacement unit 23 from one point to another, for example of the bridge crane structure 24, allowing them to cooperate with the straightening machine 10 and with the section dedicated to preparing/maintaining the groups of straightening discs 11.

[0170] In a variant embodiment, the movement slider 25 can be selectively moved in the same direction of longitudinal translation F and in a direction transverse to the longitudinal guides 22.

[0171] Furthermore, the movement slider 25 can also allow to move the replacement unit 23 in a vertical direction upward or downward.

[0172] In the solution where at least two replacement units 23 are provided, a first replacement unit 23 is configured to remove the groups of straightening discs 11 to be replaced from the straightening machine 10, while a second replacement unit 23 is configured to deliver the groups of pre-adjusted straightening discs 11 to the straightening machine 10.

[0173] In particular, the replacement unit 23 can be moved toward/away from a removal station 27, toward/away from a delivery station 28, toward/away from the straightening machine 10.

[0174] In a variant embodiment, one replacement unit 23 corresponds to the removal station 27 and the delivery station 28.

[0175] During the replacement of the groups of straightening discs 11, the replacement unit 23 of the removal station 27 removes the groups of straightening discs 11 from the straightening machine 10 and transports them to the removal station 27.

[0176] The replacement unit 23 of the delivery station 28 transports the groups of pre-adjusted straightening discs 11 toward the straightening machine 10 for installation.

[0177] The replacement unit 23 can comprise at least one support body 26 for the groups of straightening discs 11, and/or installation or displacement means 29.

[0178] The support bodies 26 comprise means (not shown) which allow to remove and install a set of groups of straightening discs 11 from and respectively onto the shaft 12.

[0179] The displacement means 29 (shown here only in fig. 1) allow to move and correctly locate the groups of straightening discs 11 from the support body 26 on the straightening machine 10.

[0180] Furthermore, the displacement means 29 allow to dis-insert the groups of straightening discs 11 and position them on the support body 26.

[0181] In another variant shown in fig. 2, the replacement unit 23 can be installed on longitudinal rails, for example the same longitudinal guides 22 on which the operator side shoulders 17 also slide.

[0182] In this case, transverse rails 30 can also be provided, positioned transverse with respect to the longitudinal rails, which serve to move the replacement unit 23 laterally.

[0183] The transverse rails 30 allow to move replacement units 23 in a transverse direction of translation T, disposed transverse to the direction of longitudinal translation F.

[0184] The replacement unit 23 can comprise at least a support frame 62 selectively movable along the longitudinal guides 22 and the transverse rails 30.

[0185] The support frame 62 allows to remove the groups of straightening discs 11 to be replaced from the straightening machine 10. Moreover, the support frame 62 transports the groups of straightening discs 11 to be replaced to the delivery station 28.

[0186] In this way the groups of straightening discs 11 can be replaced with a single positioning of the replacement unit 23 in correspondence with the straightening machine 10.

[0187] According to a variant, the groups of straightening discs 11 can cooperate with a replacement frame (not shown in the drawings) which remains in the straightening machine 10 while it is straightening. In this case, it is possible to replace the shafts 12, or the straightening discs 11, with a crane and/or with sliders and pathways orthogonal to the axis of rotation Z.

[0188] With reference to figs. 1-10, we will now describe a possible method to change the groups of straightening discs 11 which comprises at least one and/or the other of the following steps:

- stopping the drive members 20 that make the shafts 12 rotate;
- axially aligning the shafts 12 with respect to the drive side shoulders 16 and the operator side shoulders 17;
- moving the shafts 12 vertically to position them at a predefined extraction height;
- activating the constraint member 51 to prevent the rotation of the support tube 36 and the mobile tube 55 with the shaft 12;
- releasing the pressure of the work fluid in the compression chamber 40 introducing work fluid into the

release chamber 49 and in this way generating a decoupling and play between the abutment portion 47 of the shaft 12 and the striker portion 70 of the mobile tube 55;

- partly rotating the shaft 12 with respect to the support tube 36 and the mobile tube 55 to dispose the abutment portions 47 of the shaft 12 in correspondence with the insertion seatings 59 of the mobile tube 55;
- moving the operator side shoulder 17, using the movement unit 66, away from the drive side shoulder 16;
- removing the groups of straightening discs 11 installed on the shafts 12 using the replacement unit 23 and repositioning the groups of pre-adjusted straightening discs 11 on the shaft 12.

[0189] Once the groups of straightening discs 11 have been replaced, the operation to attach the operator side chocks 19 to the shafts 12 takes place in a specular manner with respect to the sequence described above. According to some embodiments of the present invention, at least the clamping unit 48, the drive members 20, the constraint member 51, the movement unit 66 and the replacement unit 23 are connected to a control and command unit, not shown, configured to control and command the drive of each component to allow to automate the process of replacing the groups of straightening discs 11.

[0190] The method described above, which can also provide modifications in the sequence, or the introduction of other sequences, obtains a process for replacing the groups of straightening discs 11 which lasts from 10 to 20 minutes.

[0191] It is clear that modifications and/or additions of parts may be made to the straightening machine 10 for metal structural shapes as described heretofore, without departing from the field and scope of the present invention.

[0192] It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art shall certainly be able to achieve many other equivalent forms of straightening machine 10 for metal structural shapes, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.

Claims

1. Straightening machine for metal structural shapes comprising:

   - at least one rotation shaft (12) supported by a first bearing (34a) and a second bearing (34b) associated with respective chocks (18, 19);
   - a group of straightening discs (11) installed on said shaft (12) between said chocks (18, 19);
   - one drive side shoulder (16) and one operator side shoulder (17) on each of which one of said chocks (18, 19) is installed;
   - drive members (20) associated with said drive side shoulder (16) to make said shaft (12) rotate;
   - a movement unit (66) configured to move said operator side shoulder (17) with respect to said drive side shoulder (16) to allow to replace said group of straightening discs (11);
   - a clamping unit (48) installed on said operator side shoulder (17) and configured to selectively constrain said second bearing (34b) to said shaft (12) and to the respective chock (19);

   characterized in that said clamping unit (48) comprises:

   - a support tube (36) associated with said shaft (12) and installed on the chock (19) supporting said second bearing (34b);
   - a mobile tube (55) installed in said support tube (36) and selectively able to be coupled/decoupled with an abutment portion (47) of said shaft (12) to prevent or respectively allow the movement of said operator side shoulder (17), and
   - a drive device (42) configured to move said mobile tube (55) with respect to said support tube (36) and to define a condition of constraint or release between said support tube (36) and said shaft (12).

2. Machine as in claim 1, **characterized in that** said mobile tube (55) is provided with an axial seating (71) configured so as to define a bayonet coupling with said abutment portion (47) of said shaft (12).

3. Machine as in claim 1 or 2, **characterized in that** said support tube (36) and said mobile tube (55) define between them an actuator of the hydraulic type, in which the fixed part is defined by said support tube (36) and the mobile part is defined by said mobile tube (55).

4. Machine as in claim 3, **characterized in that** between said support tube (36) and said mobile tube (55) a compression chamber (40) and a release chamber (49) are defined in which a work fluid is selectively introduced or discharged to determine the axial sliding of said mobile tube (55) with respect to said support tube (36), said sliding defining the coupling/decoupling with said abutment portion (47).

5. Machine as in any claim hereinbefore, **characterized in that** said operator side shoulder (17) is provided with a constraint member (51) configured to constrain the rotation of said support tube (36) with respect to said shaft (12).

6. Machine as in any claim hereinbefore, **character-**

ized in that said chocks (19, 18) are associated with hydraulic jacks (32) configured to move said chocks (18, 19) in a direction orthogonal to the axis of said shaft (12).

7. Machine as in any claim hereinbefore, **characterized in that** said shaft (12) is axially adjustable by means of an axial positioning member (21), configured to move the shaft (12) in a direction parallel to its axis of rotation (Z).

8. Machine as in any claim hereinbefore, **characterized in that** said group of straightening discs (11) comprises a pair of discs (50a) disposed facing and distanced from each other and a distancing core (50b) interposed between said pair of discs (50a), **in that** said first bearing (34a) and said second bearing (34b) are distanced by a bearing interaxis (39a), **in that** said discs (50a) of said groups of straightening discs (11) are reciprocally distanced by a straightening discs interaxis (39b), and **in that** said bearing interaxis (39a) is comprised between 1.8 and 2.5 times the straightening discs interaxis (39b).

9. Machine as in any claim hereinbefore, **characterized in that** it comprises at least a replacement unit (23) configured to automatically replace said group of straightening discs (11).

10. Machine as in claim 9, **characterized in that** said replacement unit (23) is installed on a respective movement slider (25)

11. Machine as in claim 9 or 10, **characterized in that** it comprises a removal station (27) and a delivery station (28) of said group of straightening discs (11), and **in that** said replacement unit (23) is movable from/toward said removal station (27), from/toward said delivery station (28), and from/toward said straightening machine (10).

12. Machine as in claim 5 and 9, 10 or 11, **characterized in that** at least said clamping unit (48), said drive members (20), said constraint member (51), said movement unit (66) and said replacement unit (23) are connected to a control and command unit configured to control and command the drive of each component to allow an automation of the replacement process of the group of straightening discs (11).

13. Straightening method with a straightening machine (10) that provides to:

- support at least one rotation shaft (12) on chocks (18, 19), using a first bearing (34a) and a second bearing (34b);
- install a group of straightening discs (11) on said shaft (12) between said chocks (18, 19);
- install said chocks (18, 19) on a drive side shoulder (16) and an operator side shoulder (17);
- associate drive members (20) with said drive side shoulder (16) to make said shaft (12) rotate;
- move, with a movement unit (66), said operator side shoulder (17) with respect to said drive side shoulder (16) to allow to replace said group of straightening discs (11);
- selectively constrain said second bearing (34b) to said shaft (12) and to the respective chock (19) with a clamping unit (48) installed on said operator side shoulder (17);

characterized in that it comprises:

- associating a support tube (36) with said shaft (12), installing it on the chock (19) supporting said second bearing (34b);
- installing a mobile tube (55) in said support tube (36), selectively able to be coupled/decoupled with an abutment portion (47) of said shaft (12) in order to prevent or respectively allow the movement of said operator side shoulder (17); and
- moving said mobile tube (55) with respect to said support tube (36) with a drive device (42) and defining a condition of constraint or release between said support tube (36) and said shaft (12).

14. Method as in claim 13, **characterized in that** it comprises activating a constraint member (51) to prevent the rotation of said support tube (36) and said mobile tube (55) with said shaft (12).

15. Method as in claim 13 or 14, **characterized in that** it comprises the automatic replacement of said group of straightening discs (11) with a replacement unit (23) mobile between a removal station (27), a delivery station (28) and a straightening machine (10) on which said group of straightening discs (11) is installed.

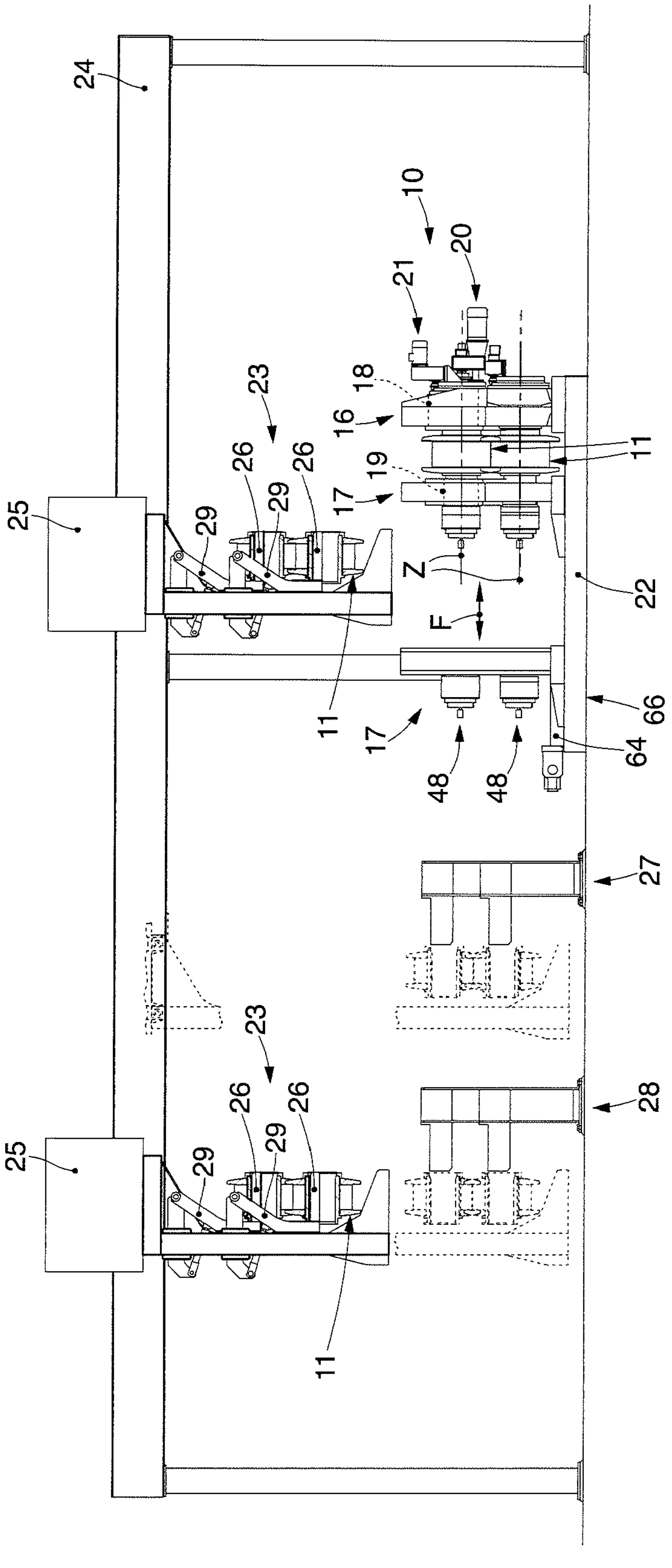


fig. 1

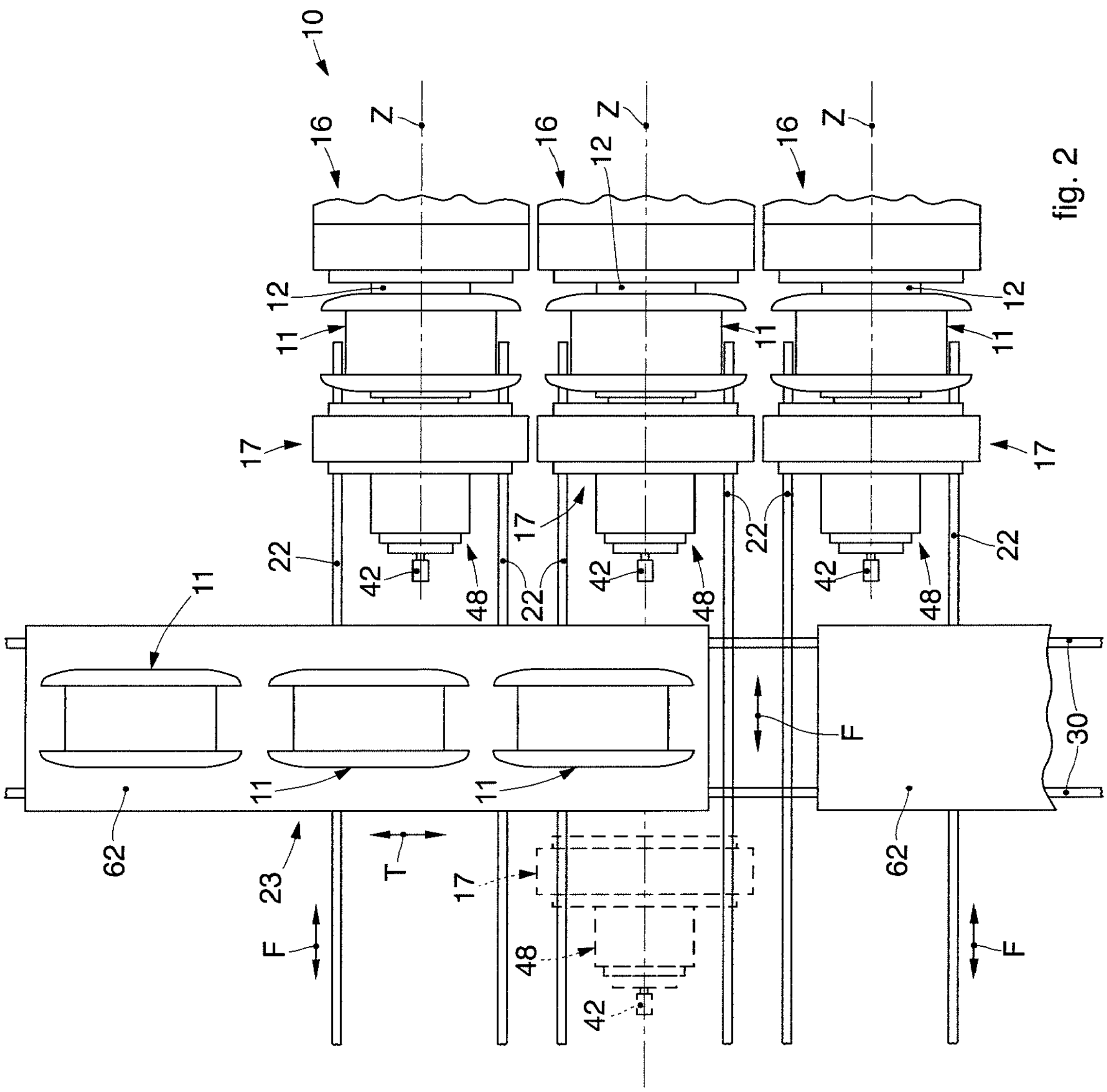


fig. 2

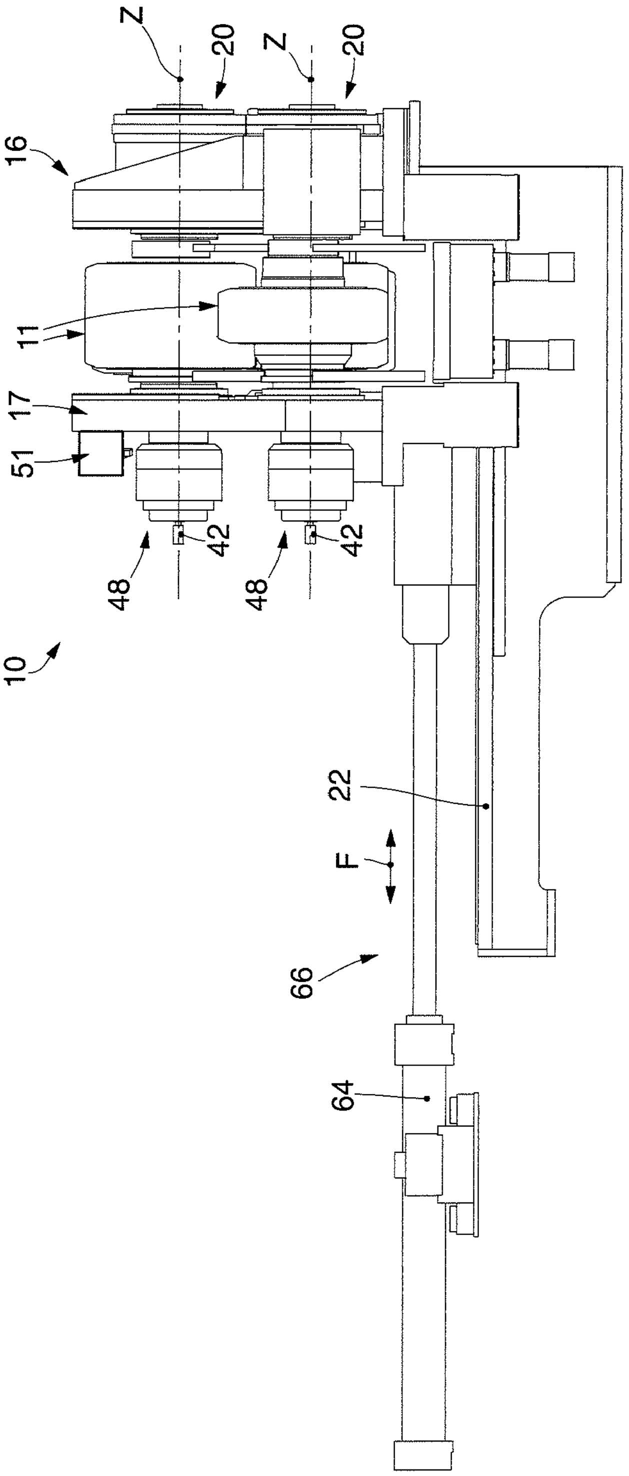


fig. 3

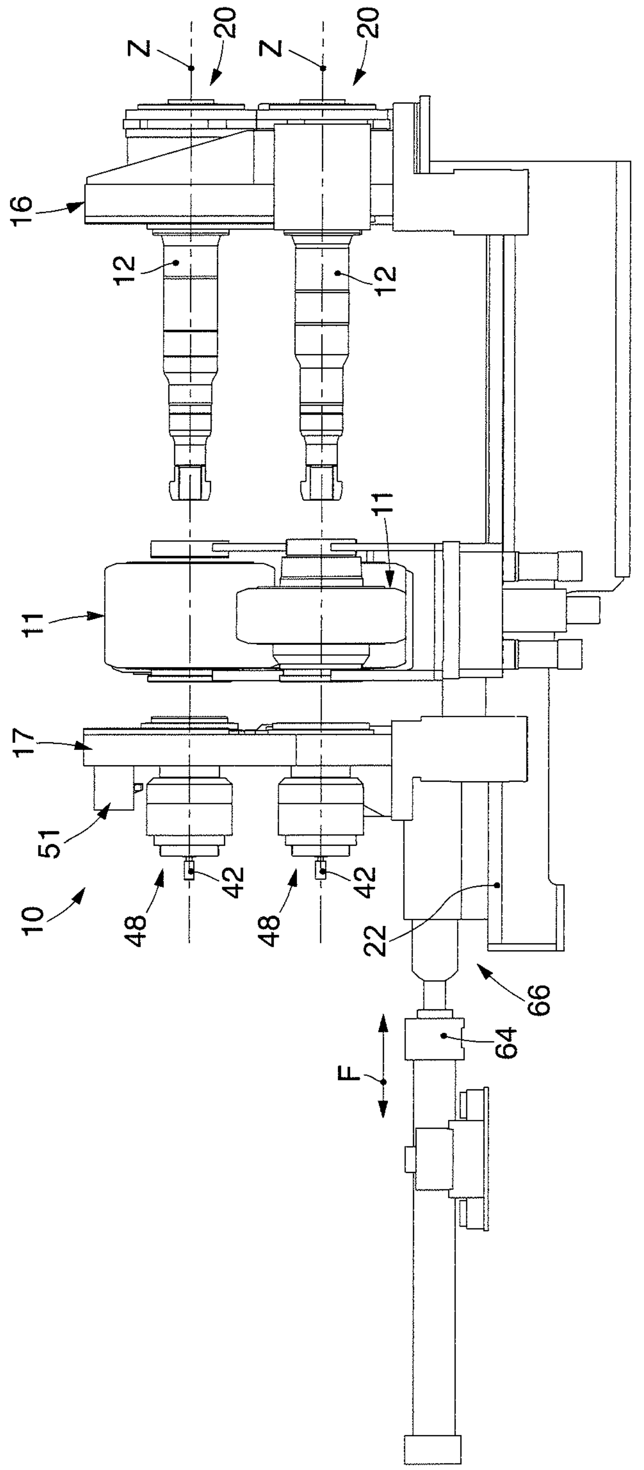
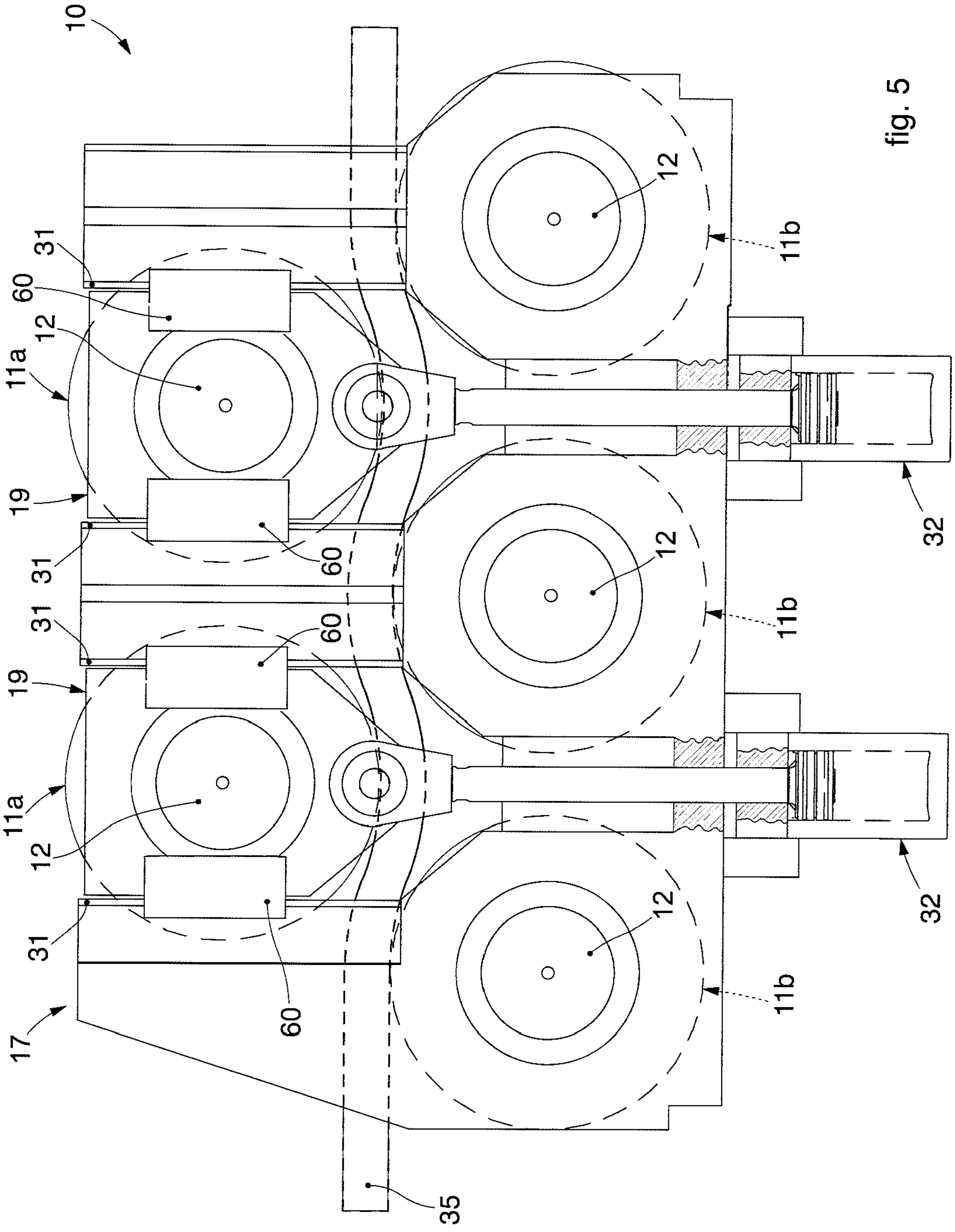


fig. 4


10
31
60
12
11a
19
31
31
19
11a
12
31
17
60
60
60
12
12
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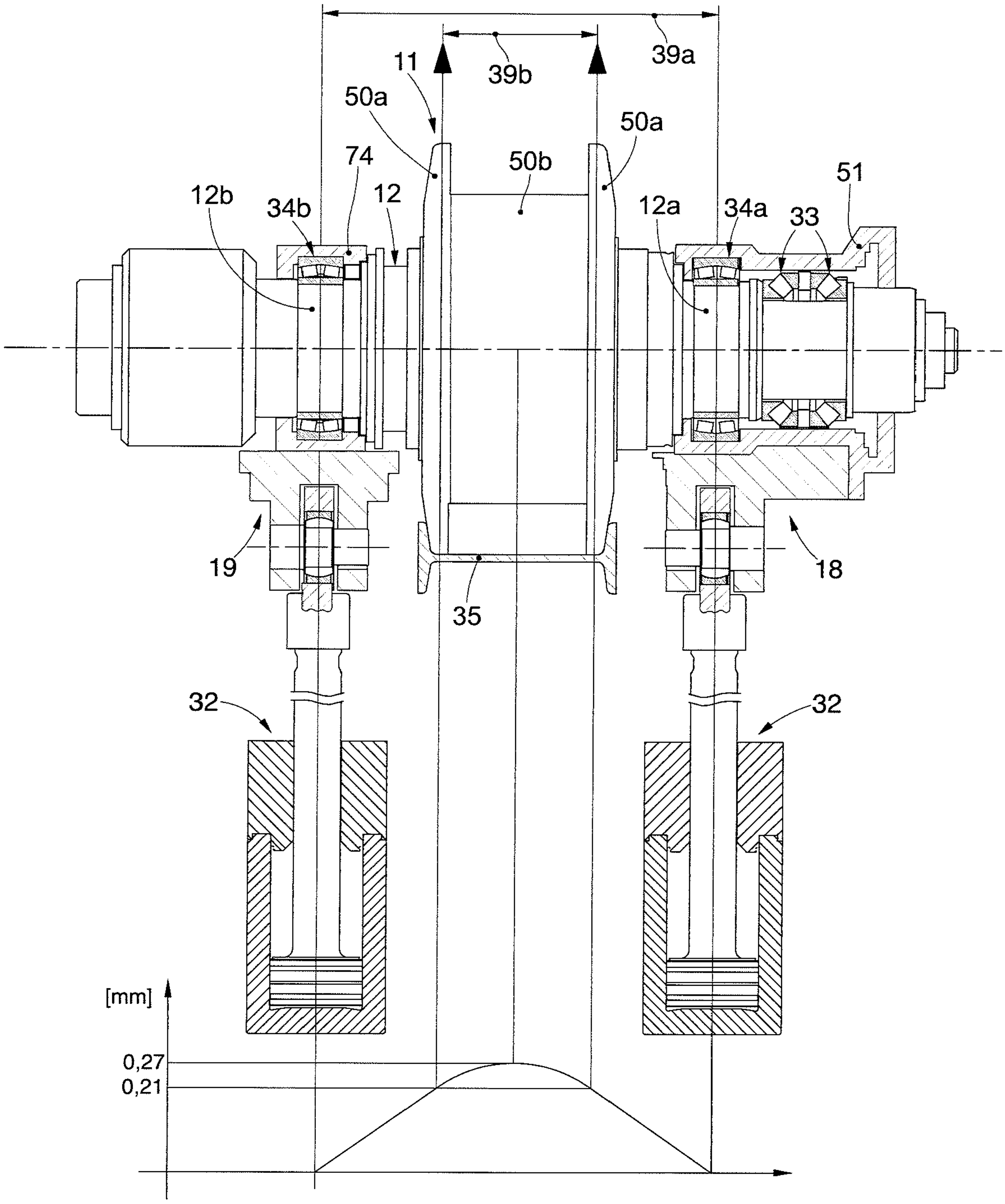
11b
11b
11b
32
32
35

fig. 5



39a
39b
11
50a
50a
74
50b
51
12b
34b
12
12a
34a
33
19
18
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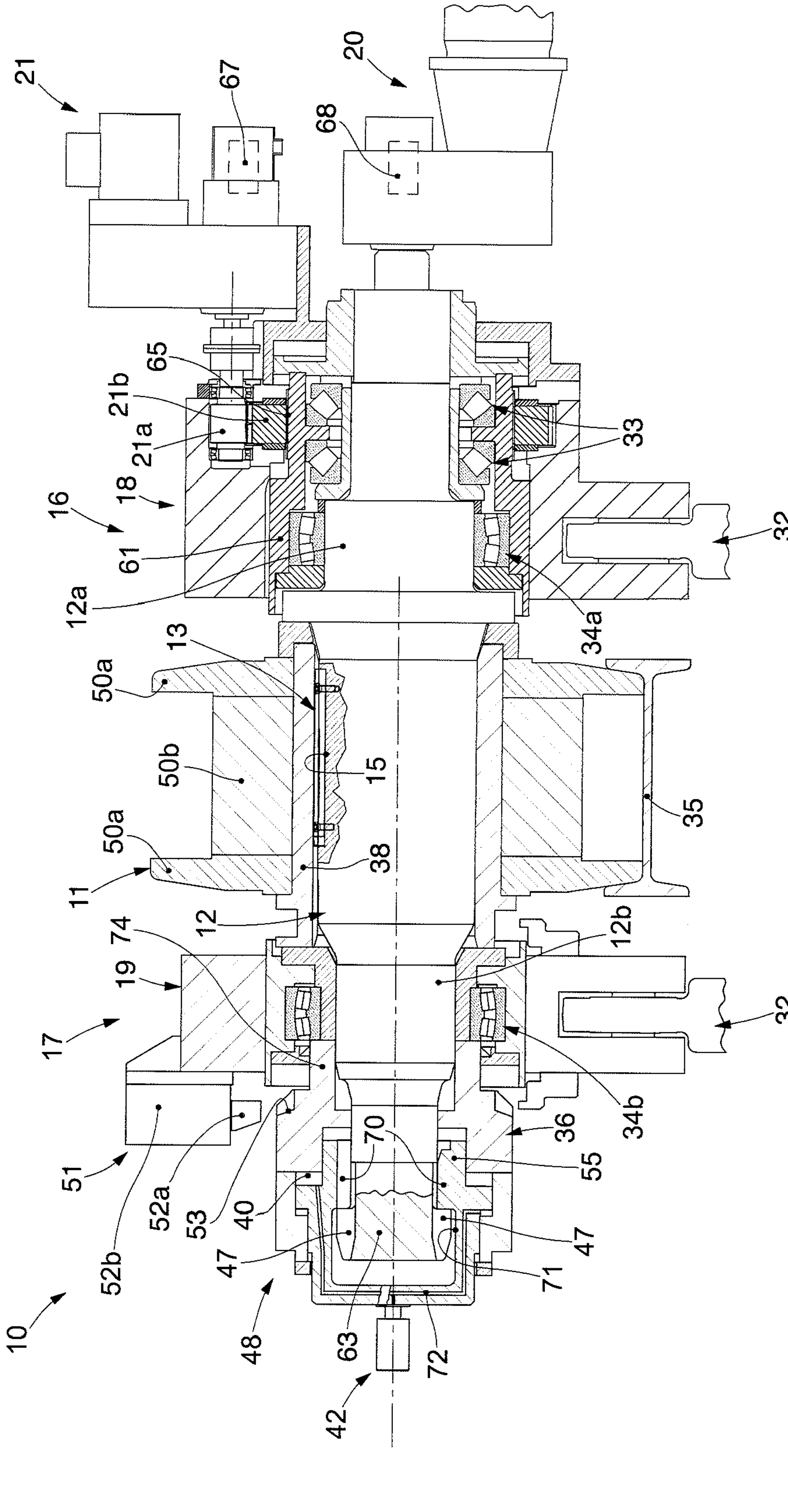
32
32
[mm]
0,27
0,21

fig. 6


21
67
20
68
65
21b
21a
18
16
61
12a
13
50a
50b
15
50a
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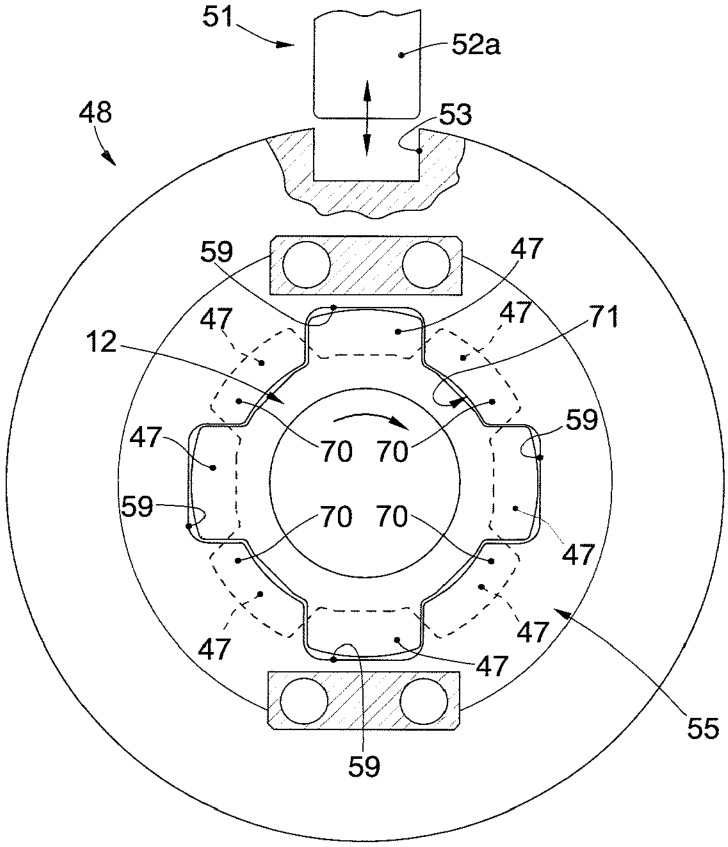
12
74
19
17
51
52a
52b
53
40
47
48
63
42
72
71
47
55
36
70
70
34b
32
12b
35
34a
32
33
10

fig. 7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52a
53
48
59
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47
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12
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59
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70
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47
47
55
59

fig. 8

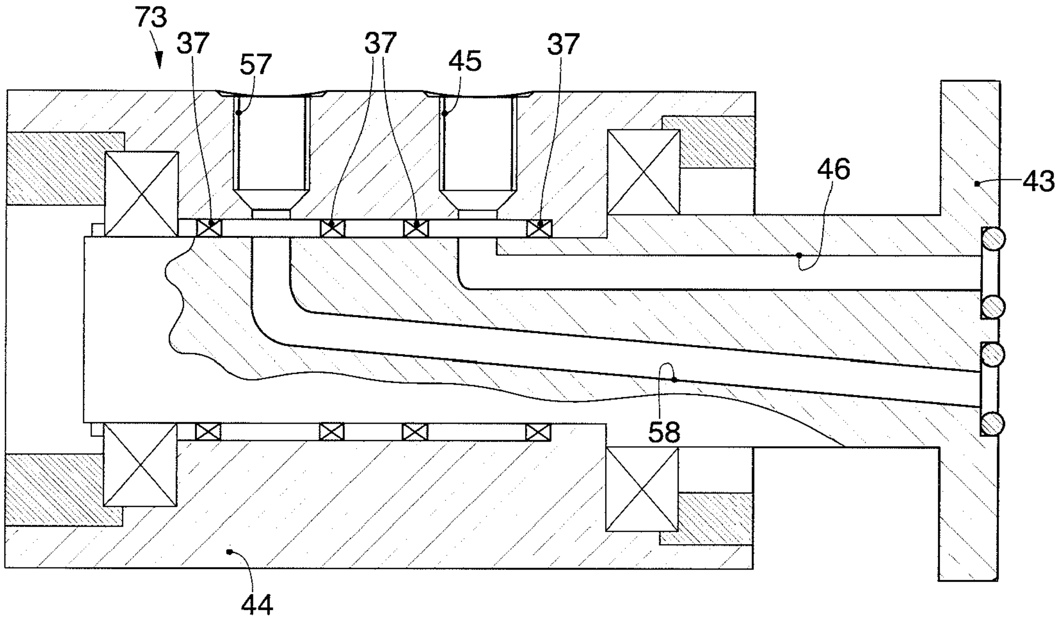
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fig. 9

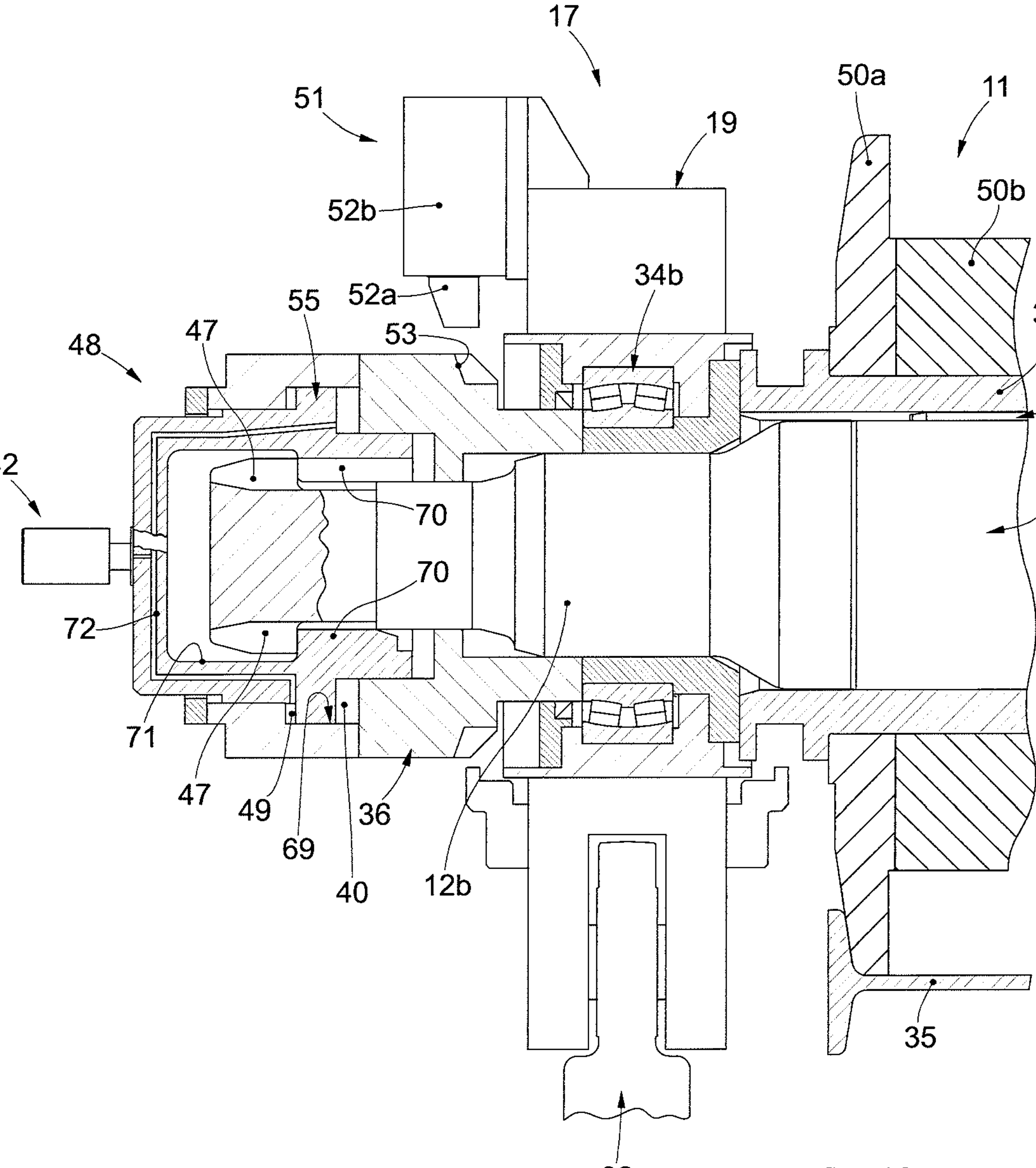
17
51
19
50a
11
50b
52b
52a
34b
55
53
48
47
38
13
42
70
12
70
72
71
47
49
69
40
36
12b
35
32

fig. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 16 16 5153

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Place of search	Date of completion of the search	Examiner
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