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DESCRIPTION

[0001] The present invention relates to a fixing system for at least one screw connection, a screw connection made with such a fixing system, a nut for use in such a screw connection, a nut-sleeve combination for use in a screw connection, a method for making at least one screw connection with such a fixing system, and a use of such a fixing system.

[0002] Known fixing systems and/or fixing devices for screw connections have a pulling unit for elongating a threaded bolt in order to connect a nut to the elongated threaded bolt in a subsequent process step.

[0003] DE 199 40 976 A1 discloses a screw-nut unit for hydraulic actuation, which is formed on the one hand by a screw having a thread with a screw-thread diameter DS and a screw-thread pitch s and on the other hand by a nut having a thread with a nut-thread diameter DM which is matched to the screw-thread diameter DS, and a nut thread pitch m, and which is intended to be axially tensioned by means of an axially acting tensioning device by which the screw is elongated to such an extent that the screw thread pitch is increased by the value ds, the screw thread pitch s is not equal to the nut thread pitch m and the screw thread pitch s is chosen to be somewhat smaller than the nut thread pitch m.

[0004] Even if the prior art hydraulic tensioning system forms a tight screw-nut connection, this can loosen after a certain time, so that retensioning is necessary. This is particularly difficult in the case of screw-nut connections with a large design and also in the case of those that are difficult to reach, such as screw-nut connections in nuclear reactors or so-called tower-joint connections of off-shore wind power plants. This is labor-intensive and therefore associated with high costs.

[0005] WO 00/51791 A1 describes a hydraulic clamping system for a nut on a bolt. This known clamping system comprises a pulling unit with a pressure cell, a tension rod, a rod nut, a puller and a bridge. The bolt has a continuous external thread and at its upper, free end an internal thread. The nut has an internal thread which engages in the external thread and a conical outer surface which tapers downwards, i.e. towards the base to be bolted. A conical sleeve has a conical inner surface that rests against the conical outer surface of the nut and also tapers downwards, i.e. towards

the base to be bolted. The bottom of the conical sleeve is supported on the base by a washer and the top projects radially from the nut. The tie rod has a threaded end at the bottom that engages the internal thread of the bolt, and a radially outwardly projecting shoulder above the threaded end. The puller has an internal thread that engages the external thread of the bolt and, above the internal thread, a radially inwardly projecting shoulder that rests on the shoulder of the tie rod. The tie rod also has a threaded end at the top that engages the internal thread of the rod nut. The pressure cell of the pulling unit comprises a piston at the top and a cylinder at the bottom. The top of the piston is supported on the underside of the rod nut. The cylinder is supported with its underside - via two further pressure cells of the pulling unit - on the upper side of the bridge. The bottom of the bridge is supported on the top of the cone sleeve. To lengthen the bolt, the tie rod and puller are screwed to the internal thread and the external thread of the bolt. Fluid is then forced into the pulling unit's pressure cell, pushing the rod nut upward, away from the bridge and the base, and thus exerting tension on the tension rod and puller. After the bolt has been lengthened, the nut can be further tightened. In this known clamping system, the nut includes a bottom surface and a top surface opposite to the bottom surface, and the constriction of the conicity of the conical outer surface extends from the top surface to the bottom surface.

[0006] There is therefore a need to provide an improved screw-nut connection that allows at least time-delayed retensioning so that, depending on the service life of the connected components, preferably no retensioning of the same is required.

[0007] It is an object of the present invention to provide a fixing system and a screw connection which generates lower consequential costs than the state of the art.

[0008] This object is solved according to the invention by the subject matters of the independent claims.

[0009] The fixing system according to the invention for at least one screw connection comprises at least one pulling unit and at least one pressure unit, wherein the pressure unit comprises a housing with a first upper end region and a first lower end region with a first recess that is formed open downward, and wherein the pressure unit comprises at the first upper end region of the housing at least one sleeve stroke space and at least one stroke receptacle associated therewith and having a pressure surface, and wherein at the first lower end region of the pressure unit a cone sleeve

is insertable into the first recess, wherein the first recess is designed in such a way that a cone sleeve can be received therein, and the stroke receptacle of the pressure unit is arranged in the housing in such a way that the stroke receptacle can be moved by means of hydraulic and/or mechanical actuation in the direction of a central longitudinal axis z of the housing and exerts a force F_2 on the insertable cone sleeve via a pressure part associated therewith or directly. Preferably, the pressure unit generates a compression of a screw connection. Further preferably, the pressure unit produces a compression of a tensioned screw connection produced by the pulling unit.

[0010] The fixing system according to the invention advantageously makes it possible to create screw connections that are strong over the long term. A so-called anti-loosening protection is created, which does not loosen even under strong dynamic loads such as vibrations. The pulling unit can perform two tasks, namely on the one hand elongating a cylindrical element with an external thread, in particular a threaded bolt, in order to create a tensioned screw connection. On the other hand, the pulling unit can perform preconditioning by lengthening the cylindrical element several times or more to a predetermined pretensioning force in order to generate rearrangement processes in the material structure of the cylindrical element that would otherwise take place when the latter ages. Pre-conditioning can, but does not have to, take place. The pressure unit compresses the screw connection tensioned by the pulling unit until it is positively locked. This creates an almost inseparable connection between the cylindrical element and the nut, which is durable and can hardly come loose by itself. In addition, the fixing system according to the invention makes it possible to create such tensioned and pressed screw connections quickly and cost-effectively, eliminating the need for retightening.

[0011] If the term "about" or "substantially" is used in the context of the invention, in particular with reference to values or ranges of values, this is to be understood to mean that which the person skilled in the art will regard as customary in the art in the given context. In particular, deviations of the specified values or value ranges of ±10%, preferably ±5%, further preferably ±2%, are encompassed by the terms "about" and "substantially".

[0012] Preferably, the housing encloses the pressure unit substantially laterally or from the first lower end region to the first upper end region. Preferably, in the scope

of the invention, the housing is configured as substantially rigid. The term "rigid" does not refer to the material properties of the fixing system, but to a preferred axial movement during the functional exertion of the tension and/or compression unit.

[0013] The first lower end region has the first recess, which forms an interior and is substantially enclosed laterally by the housing and provides space for an insertable cone sleeve. According to the invention, the first recess is formed open towards the bottom and away from the first upper end region, so that the cone sleeve can be inserted into the interior space through the opening formed.

[0014] The pressure unit comprises the at least one sleeve stroke space and the at least one stroke receptacle at the first upper end region. The sleeve stroke space is preferably a space that is variable in size and volume and is adjacent to the housing on at least one side. The sleeve stroke space is preferably mechanically and further preferably hydraulically openable and closable. In a preferred embodiment, the fixing system has at least one hydraulic connection, which is preferably in communication with the at least one sleeve lifting chamber. The stroke receptacle is preferably arranged movably in the pressure unit via at least one axis. Preferably, after exerting a force on a surface of the stroke receptacle facing the sleeve stroke space, the stroke receptacle moves in the direction of a central longitudinal axis z of the housing toward the first lower end region. The central longitudinal axis z preferably extends approximately parallel to a longitudinal extension of the housing. The force is preferably exerted on the surface of the stroke receptacle by opening the sleeve stroke space, which preferably opens by adding a hydraulic fluid and thus increases its volume. The force that is preferably exerted on the surface of the stroke receptacle is thus a surface-acting pressure of the hydraulic fluid. In an alternative embodiment, mechanical pressurization and thus a corresponding design of the pressure unit is provided.

[0015] Preferably, the pressure unit comprises at least one stroke space seal which seals the sleeve stroke space. In a preferred embodiment in which the sleeve stroke space is substantially rotationally symmetrical about the central longitudinal axis z, the stroke space seal is preferably designed as an annular seal. The stroke space seal prevents unintentional volatilization of the preferred hydraulic fluid from the sleeve stroke space.

[0016] Preferably, at least one stroke space seal seals the sleeve stroke space in the direction of the first lower end region of the housing. Preferably, at least one stroke

space seal seals a surface between the stroke receptacle and the housing.

[0017] The pulling unit of the fixing system according to the invention is preferably arranged in the system for transmitting a tensile force $F_{1,z}$ to a cylindrical element, preferably a threaded bolt. The cylindrical element preferably has at least one external thread.

[0018] The pressure unit of the fixing system according to the invention is preferably arranged for transmitting a radial pressure force $F_{2,r}$ to at least one hollow body element with at least one internal thread, preferably a nut, in the system.

[0019] The fixing system is designed in such a way that a screw connection can be made via the cone sleeve and the hollow body element, preferably a nut, and a cylindrical element with an external thread, preferably a threaded bolt, the cylindrical element being arranged on at least one system-exclusive base. The base to which the screw connection is connected is formed in one piece or in several pieces. Insofar as the term " base " is used in the present invention, also in the plural, this is understood to mean, for example, elements from the field of refineries, the chemical industry, power plant technology and marine engine construction, shipbuilding, onshore and/or offshore wind turbines. The base can be, for example, a lid of a reactor vessel, a cylinder cover of a ship's engine, or a flange of a wind turbine tower.

[0020] If the term "assembly" or "assembled state" is used in the context of the invention, this is to be understood as meaning the attachment or fixing of the screw connection by means of the fixing system to the base in preferably several process steps.

[0021] In a preferred embodiment, the pulling unit and the pressure unit of the fixing system have a one-piece housing. Preferably, the pressure unit is arranged substantially below the pulling unit. The term "below" means that adjacent to the first upper end region of the pressure unit is arranged the pulling unit. In a preferred embodiment, in which the fixing system is arranged on a base, the pressure unit is arranged substantially closer to the base than the traction unit. Preferably, during an assembly, the first lower end region of the pressure unit rests on the base.

[0022] In an alternative embodiment, the pulling unit and the pressure unit of the fixing system are at least two separate components and each have their own housing. With the separation of the pulling unit from the pressure unit, the pulling unit is ar-

ranged with a second lower end region adjacent to the base during assembly. The separation of the pulling unit from the pressure unit is preferably advantageous for spatially limited assemblies, since a height of the at least two-part fixing system is lower than a height of a one-part fixing system. Preferably, during an assembly, the pulling unit is first inserted to create a tensioned screw connection and then removed after a nut has been tightened, and then, in a further preferred step, the compression unit is connected to the tensioned screw connection so that compression can then take place.

[0023] In a preferred embodiment, the stroke receptacle of the pressure unit comprises at least one pressure part between the first upper end region and the insertable cone sleeve.

[0024] The pressure part is preferably a type of stamp. Preferably, the pressure part is curved and/or elongated in a perspective view. Alternatively, other designs of the at least one pressure part are also possible. Preferably, the stroke receptacle comprises a plurality of pressure parts extending in the direction of the insertable cone sleeve. The pressure parts of the stroke receptacle are preferably arranged symmetrically to one another about the central longitudinal axis z in the housing. As soon as a force F_2 or pressure is applied to the stroke receptacle, the pressure surface of the stroke receptacle, which is arranged in the area of the pressure part, exerts the force F_2 on the insertable cone sleeve and in particular on a head surface of the insertable cone sleeve. Preferably, a translatory movement can be transmitted from the stroke receptacle to the insertable cone sleeve. Two, three, four, five, six or more pressure parts are particularly preferred. Very preferably, the stroke receptacle has two pressure parts.

[0025] Preferably, the pressure unit comprises at least one first spring means between the stroke receptacle and the insertable cone sleeve. Preferably, several spring means are provided which, in the case of a rotationally symmetrical design of the housing, are preferably distributed and further preferably uniformly distributed over a circumference thereof in the housing. Preferably, the first spring means has a first upper spring surface and a first lower spring surface. Preferably, the first upper and/or the first lower spring surface are support surfaces of an upper spring end and a lower spring end. Further preferably, the first upper and/or the first lower spring surface is a plate or a disk, respectively, or a disk-shaped means is arranged there,

which absorbs and/or delivers the force acting on the first spring means. Preferably, the first spring means is arranged in a guide of the stroke receptacle, which encloses the first spring means on the upper side and at least partially on the edge side. Preferably, the guide is thin-walled in relation to the remaining part of the stroke receptacle. The first spring means is preferably held substantially in position at right angles to the central longitudinal axis z by the guide of the stroke receptacle of the housing.

[0026] Preferably, the first spring means is designed to be tensionable and/or relaxable by means of hydraulic and/or mechanical actuation in the direction of the central longitudinal axis z of the housing. The first spring means is preferably a return spring. As soon as a force F_2 or pressure is exerted on the stroke receptacle, the first spring means is preferably tensioned over the central longitudinal axis z. The first spring means, which is preferably a return spring, pushes at least the stroke receptacle back to its starting position after for example the supply of a preferred hydraulic fluid has stopped. This means that the stroke receptacle, which preferably moves along the central longitudinal axis z, is pushed upwards and closes the sleeve stroke space. If the preferred hydraulic fluid is used, this is pressed out of the sleeve stroke space in the process.

[0027] Preferably, the housing of the pressure unit has at least one guide piece at the first lower end region. The guide piece is preferably a rigid element through which or along which the pressure part of the stroke receptacle is formed, guided. Preferably, the guide piece of the housing is designed to run around the central longitudinal axis z. Preferably, the guide piece of the housing has at least one pressure part recess, preferably as many pressure part recesses as pressure parts are provided. The pressure part recess is preferably a recess penetrating the guide piece in the direction of the central longitudinal axis z. Preferably, the pressure part recess is a substantially curved and/or elongated penetration of the guide piece adapted to the pressure part. Preferably, the guide piece has a surface on an upper side for supporting the at least one first guide means. Preferably, the guide piece has a stop for a cylindrical pin of an overstroke valve on the upper side.

[0028] Preferably, the fixing system has at least one overstroke valve as a safety element and preferably one or more cylindrical pins in each case. Further preferably, the pressure unit of the fixing system has the at least one overstroke valve. The overstroke valve is preferably arranged between the first upper end section of the

pressure unit and the guide piece on or in the stroke receptacle. As soon as a force F_2 or a pressure is applied to the stroke receptacle, the overstroke valve is preferably moved together with the at least one pressure part of the stroke receptacle in the direction of the insertable cone sleeve. Further preferably, the overstroke valve does not engage through the pressure part recess of the guide piece as the pressure part does, but strikes the top of the guide piece with the at least one cylindrical pin to prevent overstroke travel. Preferably, the cylindrical pin has a closable opening, for example closed with a type of ball, which opens when it comes into contact with the upper side of the guide piece, for example when a ball closure is provided by pushing it away sideways, so that the hydraulic fluid escapes and the pressure is reduced. With the overstroke valve, overstroke travel is impossible even in case of wilful misoperation, which prevents destruction of the seals of the fixing system.

[0029] According to the invention, the stroke receptacle of the pressure unit is arranged in the housing in such a way that the stroke receptacle can be moved in the direction of the central longitudinal axis z by means of hydraulic and/or mechanical actuation and exerts a force F_2 on the insertable cone sleeve via the pressure part assigned to it or directly. In one embodiment, the stroke receptacle of the pressure unit preferably has no pressure part and further preferably no guide piece. The stroke receptacle exerts the force F_2 on the insertable cone sleeve directly with the pressure surface. Preferably, when the force F_2 is exerted on the insertable cone sleeve, the radial compressive force $F_{2,r}$ can be transmitted to an insertable hollow body element.

[0030] According to the invention, the fixing system comprises the pulling unit. Preferably, the pulling unit comprises at least one housing having a second upper end region and a second lower end region and at least one pulling unit disposed within the housing, wherein the pulling unit comprises at least one internal thread and a second recess which is substantially cylindrical in the direction of the central longitudinal axis z of the housing and opens towards the bottom.

[0031] In a preferred embodiment, in which the pulling unit is arranged substantially above the pressure unit, the first upper end region of the pressure unit and the second lower end region of the pulling unit further preferably overlap. The preferred pulling unit of the pulling unit, which is arranged in the housing, extends substantially rotationally symmetrically about a central longitudinal axis z, which is identical for the

housing of the pulling unit and the housing of the pressure unit. The first recess of the pressure unit and the second recess of the pulling unit preferably coincide and form a common recess in the housing in a one-piece embodiment of the fixing system according to the invention. Further preferably, the pulling unit is arranged with a bottom end closer to the first lower end region of the pressure unit than at least the sleeve stroke space. The pulling unit is particularly preferably movable in the direction of the central longitudinal axis z.

[0032] Preferably, the traction device of the traction unit is designed as a tie rod. The pulling unit is preferably designed as a piston. Particularly preferably, the pulling unit is designed as a submersible nut. Preferably, the tie rod differs from the piston and the submersible nut in that the tie rod grips a threaded bolt laterally via a preferred internal thread and has a solid body of, in particular, solid material above the arrangeable threaded bolt. In contrast, the piston and the plunging nut grip an arrangeable threaded bolt only laterally via an internal thread and each form a hollow cylinder which is open at the top.

[0033] The tie rod is arranged in the housing in such a way that it grips the edge of a threaded bolt that can be arranged in the housing. The arrangeable threaded bolt is preferably gripped via an internal thread of the tie rod and an external thread of the threaded bolt. The threaded bolt is preferably arranged in the second recess due to the downwardly open design of the housing. Above the arrangeable threaded bolt, which is gripped at the edge by the tie rod, the tie rod preferably has the solid body. Preferably, the solid body is substantially solid material and preferably extends to the second upper end region of the housing.

[0034] The piston preferably has an internal thread and is arranged in the housing in such a way that it grips a threaded bolt, which can be arranged in the housing, at the edge like the tie rod. The housing encloses the piston at least laterally and preferably partially at the top. The piston has substantially the shape of a hollow cylinder.

[0035] The plunging nut is formed approximately like the piston. Preferably, the plunging nut is arranged in the housing in such a way that it can be removed in the direction of the central longitudinal axis z and further preferably in the direction of the second upper end region. Preferably, a plurality of immersion nuts is provided, which preferably have different threads. The removable arrangement of the submersible nut in the housing means that a submersible nut with the required thread can be selected

depending on the situation. Preferably, the submersible nut does not lie directly against or on a displacement chamber with corresponding seals. Preferably, an intermediate element is provided between the displacement chamber and the submersible nut to seal the displacement chamber and thus facilitate removal of the submersible nut.

[0036] In a preferred embodiment, in which the pulling unit is arranged substantially above the pressure unit, the first recess and the second recess are connected to each other and form a common interior space. The common interior space is such that space is provided for a screw connection to be created.

[0037] Preferably, the tension unit comprises at least one spring unit at the second upper end region, which has at least one second spring means, wherein the second spring means is designed to be tensionable and relaxable by means of hydraulic and/or mechanical actuation in the direction of the central longitudinal axis z. Preferably, the at least one second spring means is at least one annular spring and further preferably a disc spring. Preferably, the spring unit is connected on the upper side to a spring cap of the housing or, preferably, the second spring means is in contact with a second upper spring surface of the second spring means on an inner side of the spring cap. The spring cap is preferably rigid and holds the second spring means of the spring unit in its position upwards in the direction of the central longitudinal axis z.

[0038] In a preferred embodiment, a spring pressure piece is arranged on a second lower spring surface of the second spring unit, which substantially serves to transmit force to the second spring means. Preferably, the spring pressure piece is encompassed by the spring unit.

[0039] Preferably, the spring unit rests on the underside of and/or is connected to at least parts of the pulling unit. Preferably, the spring unit rests on at least one upper nut and/or on at least one upper nut guide, the latter embodiment being preferred. Preferably, the spring unit with the second lower spring surface of the second spring means rests on the upper nut, and further preferably on the upper nut guide. In a preferred embodiment, the spring thrust piece rests on the upper nut, and more preferably on the upper nut guide.

[0040] In a particularly preferred embodiment, the spring unit of the pulling unit and the pulling device are designed to work together. Preferably, the spring unit and the

pulling device interact. As soon as the pulling device lifts or moves upwards in the direction of the central longitudinal axis z, at least the second spring means of the spring unit is elastically compressed. The pulling device lowers as soon as the second spring means of the spring unit relaxes.

[0041] Preferably, the pulling unit comprises at least one stroke space and at least one seal associated with the stroke space. Further preferably, at least two seals are associated with each stroke space. Preferably, the stroke space, like the sleeve stroke space, is variable in size and volume. In a preferred embodiment in which the stroke space is substantially rotationally symmetrical about the central longitudinal axis z, the seal is preferably designed as an annular

[0042] In one embodiment, the pulling unit comprises at least the upper nut and/or at least one lower nut, wherein the pulling device is connected to the upper nut and/or the lower nut via an external thread. Preferably, the external thread of the pulling device and the internal thread of the upper and/or lower nut is a fine thread. Preferably, the spring unit of the pulling unit rests at least partially on or is connected to the upper nut. Further preferably, the spring unit at least partially rests on or is connected to the upper nut guide.

[0043] Preferably, the pulling unit comprises at least the upper nut guide and/or at least one lower nut guide on which one of the upper nuts and/or one of the lower nuts rests in each case. Further preferably, the upper nut rests on the upper nut guide and the lower nut rests on the lower nut guide. Preferably, the upper and/or lower nut guide forms with a lower side a ceiling surface of the stroke space of the pulling device. As soon as a hydraulic fluid enters the stroke space or is pressed into it, the cover surface and thus the upper and/or lower nut guide rises. Further preferred, the upper and/or lower nut resting on the nut guide also rises together with the upper and/or lower nut guide as soon as the volume of the stroke space increases. Particularly preferably, the upper and/or the lower nut guide have a surface with a slope in the direction of the pulling device on an upper side. The upper and/or the lower nut have a corresponding slope resting on the slope in the direction of the pulling device. With the preferred slope of the upper and/or lower nut guide, the upper and/or lower nut is pushed upwards towards the second upper end region of the pulling unit on the one hand and towards the central longitudinal axis z on the other hand after the increase in volume of the stroke space. The pulling device, which is connected to the

upper and/or lower nut via the thread, is also pushed upwards. Furthermore, the preferred sloping design of the nut guide advantageously stabilizes the pulling device at right angles to the central longitudinal axis z so that it can move in the direction of the central longitudinal axis z with less play.

[0044] The second spring means of the spring unit is preferably tensioned at substantially the same time as the stroke or the increase in volume of the stroke space. As soon as a hydraulic fluid supply is stopped and the pressure is lower than the spring force of the tensioned second spring means, the spring means relaxes again and presses the hydraulic fluid out of the stroke space, which decreases in volume.

[0045] The screw connection according to the invention, produced with the fixing system according to the invention described above, comprises at least one nut, at least one conical sleeve and at least one threaded bolt, wherein the threaded bolt has a first bolt thread diameter $D_{B,old}$ in an unelongated state and a second bolt thread diameter $D_{B,new}$ with a modified bolt thread geometry in an elongated state. The nut includes an inner surface having an internal thread, an outer surface, a bottom surface, and a top surface opposite the bottom surface. Furthermore, in an unpressed state the nut has a first nut thread diameter $D_{M,old}$ with a thread substantially adapted to the changed bolt thread geometry with the second bolt thread diameter $D_{B,new}$ and in a pressed state a second nut thread diameter $D_{M,new}$. The outside is conical in shape. The constriction of the conicity runs from the bottom surface to the head surface or, starting from a flange that the nut has on the bottom surface, to the head surface.

[0046] In the present invention, the bolt thread diameters are defined as the outer diameter of the thread. Further, the nut thread diameters in the present invention are defined as nominal thread diameters.

[0047] The first bolt thread diameter $D_{B,old}$ of the bolt and its unelongated state is to be understood as the initial position of the bolt before it is elongated by a pulling unit of the fixing system. Lengthening is performed by means of the pulling device, preferably a tie rod or a submersible nut. The bolt is pulled or elongated by the pulling unit with its original, unelongated bolt thread geometry. The resulting second bolt thread diameter $D_{B,new}$ is smaller than the first bolt thread diameter $D_{B,old}$. The modified bolt thread geometry differs substantially from the original bolt thread geometry in that the thread pitch has become steeper.

[0048] The first nut thread diameter $D_{M,old}$ of the nut and its unpressed state is to be understood as the initial position of the nut before it is pressed by the fixing system or by a pressure unit of the fixing system. The nut is pressed by means of the cone sleeve, which is pushed with a corresponding conicity under pressure from a pressure unit onto the nut, which also has a conicity. The cone sleeve has a conicity on an inner side of the cone sleeve and the nut has a conicity on an outer side. The conicities of the inside of the cone sleeve and the outside of the nut are substantially the same, so that the corresponding cone surfaces are in contact with each other. Preferably, the second nut thread diameter $D_{M,new}$ of the pressed condition of the nut substantially corresponds to the second bolt thread diameter $D_{B,new}$ of the elongated condition of the threaded bolt. Preferably, there is some play between the nut thread and the threaded bolt thread. The nut with the second nut thread diameter $D_{M,new}$ can be produced after elongation of the threaded bolt on the basis of a then determined second bolt thread diameter $D_{B,new}$ by corresponding cutting of a thread, or else be provided prefabricated on the basis of knowledge about the range of the elongation that has taken place as a function of the first bolt thread diameter $D_{B,old}$, which can be recorded and reproduced e.g. by material or electronic tables.

[0049] Preferably, the cone sleeve of the screw connection has a head surface via which it is designed to interact with the stroke receptacle. Preferably, the stroke receptacle comprises the pressure part, with the pressure surface being arranged in the area of the pressure part. The term "interact" is to be understood as meaning that the stroke receptacle or the pressure part of the stroke receptacle exerts a force on the cone sleeve via the pressure surface, preferably in the direction of a central longitudinal axis z' of the nut.

[0050] Preferably, the cone sleeve has a pressure connection starting from a cone sleeve outer side in the direction of the cone sleeve inner side. Preferably, the pressure port is a recess through the cone sleeve. Preferably, the pressure port extends from the outside of the cone sleeve at right angles to the central longitudinal axis z'. A fluid reaches the nut through the pressure port and enables the cone sleeve to be separated from the nut by increasing the pressure of the fluid. Preferably, the fluid flows into a space between the nut and the cone sleeve and releases a self-locking connection in a contact area thereof.

[0051] The nut according to the invention for use in a screw connection comprises an

inner side with an internal thread, an outer side, a bottom surface and a head surface opposite the bottom surface, wherein the outer side is conical in shape and the constriction of the conicity extends from the bottom surface of the nut to the head surface of the nut or extends from a flange which the nut has on the bottom surface to the head surface. In addition, a sidewall of the nut has at least one longitudinal recess that completely penetrates the sidewall of the nut in the direction of a central longitudinal axis z' of the nut over at least a partial length and in the direction of an x-axis, perpendicular to the central longitudinal axis z'.

[0052] Preferably, a sidewall of the nut is cylindrical and further preferably formed with the conicity. Further preferably, the conicity does not extend completely over the entire outer surface of the nut. In the present invention, the term "constriction" describes a decreasing circumference in a defined direction. The head surface of the nut preferably has a smaller circumference in relation to the bottom surface. Starting from the central longitudinal axis z', the nut has a pitch over its outer side at an angle α. The angle α is preferably in a range from about 0.2° to about 5°, further preferably in a range from about 0.7° to about 3°, and particularly preferably in a range from about 1.5° to about 2.5°. Preferably, the nut further comprises a flange associated with the bottom surface of the side wall of the nut. The flange preferably extends from the side wall of the nut away from the central longitudinal axis z'. The flange substantially forms a reinforcement or widening of the nut in the area of the bottom surface of the side wall. Preferably, the flange has no conicity on its outer surface from the bottom surface of the nut toward the top surface of the nut. The flange preferably has a stop on an upper side for an arrangeable cone sleeve, in particular in the pressed state. Further preferably, to achieve the pressed state, the cone sleeve merely approaches the stop of the flange and stops its movement before coming into contact with the stop. A bottom surface of the flange is preferably flush with the bottom surface of the side wall of the nut.

[0053] Preferably, the side wall of the nut, away from an arrangeable cone sleeve, has on its inner side at least one step running round, further preferably at least one edge rounding, and particularly preferably at least one chamfer. This enlarges an inner diameter of the nut, preferably when a lower chamfer is formed, toward the bottom surface of the side wall of the nut. However, the inner diameter can also be expanded in the direction of the top surface of the side wall of the nut if an upper chamfer is provided. Particularly preferably, the side wall of the nut adjacent to the bottom

surface has on its inner side over a certain partial length of the side wall an initially constant diameter and then a lower chamfer, whereby in the area of the lower chamfer the inner diameter decreases towards the top surface of the nut. Adjacent to the bottom chamfer is a portion, preferably formed to adjacent to the top surface of the side wall of the nut, in which the thread of the internal thread is formed to its full depth. Alternatively, the thread of the internal thread is formed without a chamfer or the like at full depth. In the portion of the lower chamfer or an edge rounding, a thread can also be present, but then with decreasing depth running out towards the bottom surface of the side wall of the nut. A portion of constant inner diameter arranged starting from the bottom surface of the side wall of the nut preferably does not have a thread of the internal thread. In addition, an upper chamfer etc. may be provided, which is preferably adjacent to the head surface of the side wall of the nut.

[0054] Preferably, the penetration of the longitudinal recess through the side wall extends from the top surface to the bottom surface of the nut. Further preferably, the nut has a plurality of longitudinal recesses. Preferably, the side wall of the nut has the longitudinal recess or recesses in the direction of the central longitudinal axis z' from the top surface of the nut to approximately the top surface of the flange. Preferably, the flange is substantially not penetrated by a longitudinal recess. In a preferred embodiment, the flange and the portion of the sidewall laterally enclosed by the flange hold the nut together to form an element. Alternatively, the flange also has the at least one longitudinal recess. In an embodiment with a plurality of longitudinal recesses penetrating the side wall and the flange, the nut consists of several partial elements. In a preferred embodiment, the side wall of the nut is completely penetrated in the direction of the x-axis and at least over a partial length in the direction of the central longitudinal axis z'. In an alternative embodiment in which the nut does not have a flange, the side wall of the nut preferably has a full penetration in the direction of the central longitudinal axis z'. If a circumferential shoulder, further preferably an edge rounding, and particularly preferably a chamfer, is arranged on the inner side of the side wall of the nut not adjacent to the head surface, the at least one longitudinal recess is preferably formed over a partial length of the shoulder, the edge rounding or the chamfer, preferably only to a small extent, further preferably not over a partial length thereof. The at least one longitudinal recess is preferably arranged in the region of the internal thread of the nut, which is formed on the inside of the side wall of the nut. An inner area adjacent to the bottom surface or the top surface of the side wall, preferably with a larger inner diameter than in the area of the internal thread,

has substantially no thread of the internal thread. An inner area adjacent to the bottom surface or the head surface of the side wall, preferably with a larger inner diameter than in the area of an internal thread, preferably does not essentially have the at least one longitudinal recess, at most only over a small partial length in the direction of the central longitudinal axis z'. Preferably, the at least one longitudinal recess is configured to be open towards the head surface and/or bottom surface, more preferably towards the head surface, of the side wall of the nut. In this embodiment, the at least one longitudinal recess can be addressed as a slot in the side wall of the nut. However, it may also be provided that the at least one longitudinal recess is closed towards the head surface and towards the bottom surface of the side wall of the nut. The at least one longitudinal recess can then be addressed as a longitudinal hole in the side wall of the nut.

[0055] The nut-cone sleeve combination according to the invention for use in a screw connection comprises a nut according to the invention and a cone sleeve, wherein the cone sleeve is formed on at least one cone sleeve inner side approximately corresponding to a side wall of the nut. Preferably, the cone sleeve is a ring-like member having at least one conicity, preferably a uniform conicity over the entire cone sleeve inner surface. Further preferably, the nut has a conicity, preferably a uniform conicity over the entire surface of the outer side, on the outer side of the sidewall. In an alternative embodiment, the nut has a conicity only over partial portions of the outer surface. Preferably, the cone sleeve wall thickness of the cone sleeve can be freely designed to produce different degrees of compression of the nut through the cone sleeve onto a cylindrical element that can be arranged, in particular a threaded bolt, and to reduce, shift, increase or eliminate radial deformations depending on the specific application.

[0056] Preferably, the outer surface of the nut forms substantially a positive shape of the inner surface of the cone sleeve. Preferably, the nut has a head surface and a bottom surface, and is further preferably formed as described above. Preferably, the head surface of the nut forms a substantially equal or flat surface with a head surface of the cone sleeve. However, the head surface of the nut can also be arranged below or above the head surface of the cone sleeve before assembly or pressing. Furthermore, the inside of the cone sleeve preferably lies completely on the outside of the nut.

[0057] The method according to the invention is used to create at least one screw connection with a fixing system according to the invention, wherein a pressure unit of the fixing system and a cone sleeve effect a compression of a nut with a threaded bolt. Preferably, the nut has a first nut thread diameter $D_{M,old}$. The first nut thread diameter $D_{M,old}$ of the nut in the unpressed state is to be understood as the initial position of the nut. The nut is screwed to the threaded bolt with its internal thread and preferably with a certain flank play.

[0058] Preferably, a stroke receptacle of the pressure unit or a pressure part of the stroke receptacle pushes the cone sleeve onto the nut of the bolted connection in the direction of a central longitudinal axis z, z' via a cone sleeve inner side which substantially abuts on an outer side of the nut. The pushing on causes a movement of the cone sleeve towards the nut, which is caused by the conicity of both. The cone sleeve, pushes over the rising outer side of the nut in the direction of the central longitudinal axis z, z' and causes a radial force $F_{2,r}$ on the nut. Preferably, the cone sleeve is designed as rigid and further preferably as substantially less flexible in relation to the nut. Preferably, the nut is designed to be flexible. The nut decreases in circumference over the outside during compression.

[0059] In one embodiment, the decrease in the circumference of a sidewall of the nut occurs due to the material, whereby the material is pressed. In an alternative and preferred embodiment, the nut has at least one longitudinal recess which penetrates the side wall of the nut in the direction of the central longitudinal axis z, z' at least over a partial length and in the direction of an x-axis, perpendicular to the central longitudinal axis z, z', completely. Preferably, the at least one longitudinal recess of the nut has a width B that is reduced and optionally closes by the movement of the cone sleeve onto the nut. The width B extends substantially parallel to the plane of the head surface of the nut.

[0060] Preferably, nut thread flanks of the nut arranged opposite to bolt thread flanks of the threaded bolt are pushed onto the bolt thread flanks until a preferred partial contact and especially preferably substantially complete contact is achieved. The partial contact is preferably due to the contact of one bolt thread flank with the opposite nut thread flank, while the other bolt and nut thread flanks have a certain amount of play between them. Preferably, the movement of the nut thread flanks onto the bolt thread flanks is due to the force $F_{2,r}$, which is the radial force applied to the outside of

the nut by the cone sleeve or by the inside of the cone sleeve, respectively. Preferably, the movement of the nut thread flanks in cooperation with the bolt thread flanks is pressure and/or form controlled. The term "pressure-controlled" in relation to the thread flanks means that in an unpressed state they have substantially no flank play, but a cavity is formed between a maximum nut thread depth and a bolt core diameter. As the force $F_{2,r}$ is applied, the cavity decreases by preferential compression until it closes, preferably nearly and further preferably completely. The term "form-controlled" in relation to the thread flanks means that a nut thread flank rests against a bolt thread flank, whereas the other nut and bolt thread flanks have a certain amount of play between them. When the force $F_{2,r}$ is applied, the flank play between the nut thread flank and the bolt thread flank is reduced. Preferably, after the nut thread flank has preferably partially contacted the bolt thread flanks, and more preferably substantially fully contacted the bolt thread flanks, the nut thread flanks are compressed with the bolt thread flanks as in the "pressure-controlled" operation. Preferably, at least one positive connection is made between the nut thread flanks and the bolt thread flanks. In a particular embodiment of the nut thread, radial shrinkage - triggered by the axial force F_2 and the resulting radial force $F_{2,r}$ - with flank contact on one side produces additional radial compression of the bolt and the bolt thread base, which in turn generates residual compressive stresses in the bolt thread, which in turn increase the fatigue strength of the connection (similar to a cold-formed thread, as in a thread rolling process). Preferably, the closing of the flank play due to the contact of the flanks maximizes the friction surface to about 100%, resulting in almost maximum static friction μ0. Advantageously, the pressure- and/or form-controlled screw connection does not loosen even under strong dynamic loads such as vibrations.

[0061] Preferably, a pulling unit of the fixing system elongates the threaded bolt of the screw connection several times in the direction of the central longitudinal axis z, z' until it reaches an elongated state. When the threaded bolt is lengthened several times, it is prestressed several times. The multiple or repeated pretensioning is done in order to anticipate a so-called material relaxation, which occurs at the place of use of the screw connection due to possible dynamic loads or weather conditions. The material of the threaded bolt is thus preconditioned by being stretched several times.

[0062] Preferably, the pulling unit elongates the threaded bolt several times up to a predetermined pretensioning force. Multiple pretensioning up to a predetermined pre-

tensioning force has the effect that so-called microsettling phenomena are minimized or completely eliminated over time.

[0063] Furthermore, preferably after the threaded bolt has reached the elongated state with a predetermined preload force, further preferably after preconditioning as described above, the nut is tightened to a base. The base to which the nut is tightened is preferably a one-piece and further preferably a multi-piece system exclusive element, as described above in connection with the fixing system according to the invention.

[0064] According to the invention, the multiple lengthening of the threaded bolt and the subsequent tightening of the nut are carried out before the cone sleeve is pressed onto the nut.

[0065] The invention further proposes the use of a fixing system according to the invention for creating at least one screw connection, wherein the pressure unit of the fixing system and a cone sleeve effect a compression of a nut with a threaded bolt.

[0066] Further advantageous embodiments are shown in the following figures. Identical parts or parts with the same function can have the same reference signs. They show:

FIG. 1 a first embodiment of a fixing system for a screw connection according to the invention in a lateral sectional view I-I;
FIG. 2 the fixing system according to FIG. 1 in a sectional view along section II-II;
FIG. 3 an overstroke valve of a pressure unit according to FIG. 2;
FIG. 4 a second embodiment of a fixing system for a screw connection according to the invention in a plan view;
FIG. 5 the fixing system according to FIG. 4 in a lateral sectional view V-V;
FIG. 6 a first embodiment of a nut and sleeve combination in a perspective view;
FIG. 7 the nut and cone sleeve combination of FIG. 6 in a bottom view;
FIG. 8 a second embodiment of a nut and cone sleeve combination in a perspective view;
FIG. 8.1 the second embodiment of the nut and cone sleeve combination in a perspective underside view;
FIG. 9 an embodiment of a screw connection with a cone sleeve with a base;

FIG. 10.1 a threaded bolt of the screw connection in a side view with a magnified view of the thread with a base of FIG. 9 in a first process step;

FIG. 10.2 the threaded bolt of the screw connection in a side view with enlarged view of the thread with the base of FIG. 9 in a second process step

FIG. 10.3 the screw connection in a sectional view with the base of FIG. 9 in a third process step

FIG. 10.4 the screw connection in a side view with enlarged view of the threads with the base from FIG. 9 in the third process step

FIG. 10.5 the screw connection in a side view with enlarged view of the threads with the base of FIG. 9 in a fourth process step

FIG. 10.6 the screw connection in a sectional view with enlarged view of the thread with the base from FIG. 9 in the fourth process step;

FIG. 10.7 the screw connection in a sectional view with enlarged view of the form-locked, pressed threads with the base of FIG. 9 in a fifth process step; and

FIG. 11 the screw connection of FIG. 9 with a base in an assembled state with cone sleeve on one side in a sectional view.

[0067] FIG. 1 shows a first, hydraulically actuated embodiment of a fixing system 100 for a screw connection 10 in a lateral sectional view I-I comprising at least one pulling unit 108 and at least one pressure unit 107, wherein the pulling unit 108 is arranged to a large extent above the pressure unit 107. The pressure unit 107 includes a housing 110.1 having a first upper end region 106 and a first lower end region 105 with a first recess 165.1 formed to be open at the bottom. The pulling unit 108 includes a housing 110.2 having a second upper end region 196 and a second lower end region 195. The pressure unit housing 110.1 and the pulling unit housing 110.2 form a common housing 110 that substantially rim and top encloses the fixing system 100. The fixing system 100 is mounted on a system-exclusive base U. The first lower end region 105 of the pressure unit 107 is adjacent to the base U. The housings 110.1 and 110.2 are arranged one above the other and connected to each other as a one-piece housing.

[0068] The pressure unit 107, shown in FIG. 1 in a closed position, includes at least one sleeve stroke space 158 at the first upper end region 106 and at least one stroke receptacle 148 associated therewith. The sleeve stroke space 158 of FIG. 1 is reproduced in the closed position, in which it contains no hydraulic fluid. The sleeve stroke space 158 has a first stroke space seal 156.1, 156.2 and a second stroke space seal

156.2 formed as an annular seal, wherein the first stroke space seal 156.1 is arranged laterally and above in the direction of a central longitudinal axis z of the housing 110 on the sleeve stroke space 158. The second stroke space seal 156.2 is arranged laterally below and away from the central longitudinal axis z at the sleeve stroke space 148. The stroke receptacle 148 is arranged partially below the sleeve stroke space 158 and partially adjacent thereto in the direction of the central longitudinal axis z. As soon as the sleeve stroke space fills with a hydraulic fluid, a force is exerted on the part of the stroke receptacle 148 that is arranged below the sleeve stroke space 158.

[0069] The stroke receptacle 148 has a thin-walled guide 155 on the underside and edge thereof, in which a first spring means 152 is arranged. A plurality of such first spring means 152 are arranged about the circumference of the pressure unit 107, for example two, three, four, five or more. The guide 155 of the stroke receptacle 148 encloses the first spring means 152 on the upper side and at least partially on the edge side. The first spring means 152 extends with its longitudinal extension in the direction of the central longitudinal axis z, in which the first spring means 152 absorbs tensile and/or compressive forces. The first spring means 152 is designed as a return spring. The stroke receptacle 148 and the first spring means 152 are designed to be movable in the direction of the central longitudinal axis z or to be tensioned and released. Furthermore, the housing 110.1 of the pressure unit 107 has a guide piece 150 at the first lower end region 105. The guide piece 105 has one or more pressure part recesses (not shown in FIG. 1) at an upper end. The number of pressure part recesses corresponds to a number of provided pressure parts 161. The pressure part recess is formed as a curved and elongated penetration through the guide piece 150. The pressure part 161 is associated with the stroke receptacle 148 and arranged opposite the cone sleeve 130.

[0070] The screw connection 10 is inserted in the first recess 165.1 of the lower end region 105, which is designed to be substantially rotationally symmetrical about the central longitudinal axis z of the housing 110. The screw connection 10 comprises a nut 60, a cone sleeve 130 and a threaded bolt 30. The nut 60 has a flange 68 on a bottom surface 66, by means of which the nut 60 rests on the base U. The nut 60 is connected to the threaded bolt 30 via an internal thread on an inner side 61. The nut 60 is connected to the threaded bolt 30 via an internal thread on an inner side 61 in the direction of the central longitudinal axis z. On an outer side 62 of the nut 60,

which is a side facing away from the inner side 61, the nut 60 has a conicity. The conicity extends from the flange 68 to a head surface 67 of the nut 60 and constricts it due to a reduction in diameter. A cone sleeve 130 is disposed on an outer surface 62 of the nut 60. The cone sleeve 130 has a conicity on a cone sleeve inner side 132. The conicity of the cone sleeve 130 corresponds approximately to the pitch or diameter reduction of the outer side 62 of the nut 60. The cone sleeve 130 has a head surface 134 that is arranged opposite a pressure surface 154 of the stroke receptacle 148 in the area of the pressure part 161. The stroke receptacle 148 of the pressure unit 107 with the pressure part 161 exerts a force F_2 on the head surface 134 of the cone sleeve 130 in the direction of the central longitudinal axis z. The pressure part 161 is arranged opposite the pressure surface 154 of the stroke receptacle 148 in the area of the pressure part 161.

[0071] The pulling unit 108, shown in FIG. 1 in the closed position, that is, shown without hydraulic fluid, includes the housing 110.2 having the second upper end region 196 and the second lower end region 195, and a pulling device 120 disposed in the housing 110.2. The pulling device 120 includes an internal thread 122 and a second recess 165.2, which is substantially cylindrical in the direction of the central longitudinal axis z of the housing 110.2 and open at the bottom. The second recess 165.2 forms a unitary overall recess with the first recess 165.1, which is rotationally symmetrical and formed along the central longitudinal axis z. The pulling device 120 of the pulling unit 108, which is arranged in the housing 110.2, extends substantially rotationally symmetrically about the central longitudinal axis z. The pulling device 120 is designed in such a way that it can be moved in the direction of the central longitudinal axis z. In this embodiment, the pulling device 120 of the pulling unit 108 is designed as a tie rod that is arranged in the housing 110.2 in such a way that it grips the threaded bolt 30 of the screw connection 130, which is arranged in the housing 110, at the edge via the internal thread 122. The threaded bolt 30 is preferably arranged in the second recess 165.2 by the downwardly open design of the housing 110.1/110.2. Above the arrangeable threaded bolt 30, which is gripped at the edge by the tie rod, the tie rod has a solid body. The first recess 165.1 and the second recess 165.2 are connected to each other and form a common interior space. The common interior space is such that space is provided for a screw connection that can be arranged therein.

[0072] Furthermore, the pulling unit 108 comprises a spring unit 180 at the second

upper end region 195, which has at least two second spring means 175, the second spring means 175 being designed such that they can be tensioned and released in the direction of the central longitudinal axis z by means of hydraulic and/or mechanical actuation. The at least two second spring means 175 are designed as disc springs. The top of the spring unit 180 is connected to a spring cap 184 of the housing 110.2 or, preferably, the second spring means 175 rest against the spring cap 184. The spring cap 184 is rigid and holds the second spring means 175 of the spring unit 180 in position in the upward direction of the central longitudinal axis z. A spring pressure piece 182 is arranged below the second spring means 175, which substantially serves to transmit force to or from the second spring means 175 to the pulling unit 108.

[0073] The pulling unit 108 includes a lower and an upper stroke space 114, 118 and two (ring) seals associated with each of the stroke spaces 114, 118, the upper stroke space 114 having associated therewith a first upper seal 112.1 and a second upper seal 112.2 and the lower stroke space 118 having associated therewith a first lower seal 116.1 and a second lower seal 116.2. Like the sleeve stroke space 158, the upper and lower stroke spaces 114, 118 are variable in size and volume. The seals 112.1, 112.2 and 116.1, 116.2 are designed as ring seals.

[0074] The pulling unit 108 includes an upper nut 115 and a lower nut 119, wherein the pulling device 120 is externally threaded to the upper nut 115 and the lower nut 119. The spring compression piece 182 of the spring unit 180 rests at least partially on an upper nut guide 113 of the pulling unit 108. The upper nut 115 and the lower nut 119 rest on the upper nut guide 113 and on a lower nut guide 117 of the pulling unit 108, the upper nut 115 resting on the upper nut guide 113 and the lower nut 119 resting on the lower nut guide 117. The upper and lower nut guides 113, 119 form a top surface of the upper and lower stroke spaces 114, 118 of the pulling unit 108 with a bottom surface. As soon as a hydraulic fluid enters or is forced into the upper and lower stroke spaces 114, 118, the top surface lifts and thus the upper and lower nut guides 113, 117.

[0075] A hydraulic connection 170 is arranged on the housing 110.2 of the pulling unit 108 remote from the central longitudinal axis z, which is responsible for the supply and return of the preferred hydraulic fluid into the fixing system 100 and into the stroke spaces 114, 118, 158, respectively. In the closed position of the stroke spaces

114, 118 and 158 shown in FIG. 1, no elongation of the threaded bolt 30 or preconditioning as well as no pressing of the nut 60 onto the threaded bolt 30 and also no tightening of the nut 60 takes place. There, a formation of the screw connection 10 prior to assembly or use of the fixing device 100 is shown.

[0076] FIG. 2 shows the fixing system according to FIG. 1 in a sectional view along section II-II, which passes through two axes arranged at right angles to each other. Enclosing the housing 110.1, five first spring means 152, an overstroke valve 157, two pressure parts 161 and the pulling device 120. The housing 110.1, which is substantially rotationally symmetrical about the central longitudinal axis z, encloses the first spring means 152, the overstroke valve 157, the pressure parts 161 and the pulling device 120. The pulling device 120 forms a core, so to speak, through the central longitudinal axis z. Between the pulling device 120 and the housing 110.1, the first spring means 152, the overstroke valve 157 and the pressure parts 161 are arranged in an annular recess. The two pressure parts 161 are arranged opposite each other in the annular recess along an axis at right angles to the central longitudinal axis z. Pressure surfaces 154 are arranged in the area of one end face of each pressure part 161. Along a further axis, at right angles to the central longitudinal axis z, the first spring means 152 are arranged opposite each other in the annular recess. Three first spring means 152 are arranged on one side of the further axis and the two further first spring means 152 are arranged on another side of the further axis. On the side on which the two first spring means 152 are arranged, the overstroke valve 157 is arranged between them in the annular recess.

[0077] FIG. 3 shows the overstroke valve 157 of the pressure unit 107 in a detailed side view. The overstroke valve 157 is enclosed above by the stroke receptacle 148 and partially laterally by the guide 155 of the stroke receptacle 148. Below the overstroke valve 157, the latter is arranged with a cylindrical pin 159 opposite the guide piece 150 of the housing 110.1. Adjacent to a side of the stroke receptacle 148 that is closer to the central longitudinal axis z is the pulling device 120. Above the overstroke valve 157, the sleeve stroke space 158 is arranged in the closed position. The sleeve stroke space 158 has the first and second stroke space seals 156.1, 156.2 in the form of an annular seal, the first stroke space seal 156.1 being arranged laterally and above-half in the direction of the central longitudinal axis z of the housing 110.1 on the sleeve stroke space 158. The second sleeve stroke space 156.2 is arranged laterally below and away from the central longitudinal axis z at the sleeve stroke

space 148.

[0078] FIG. 4 shows a second embodiment of a likewise hydraulically actuated fixing system 200 for a screw connection 10 in a plan view. The substantially rotationally symmetrical design of the fixing system 200 and the screw connection 10 is illustrated, with the fixing system 200 having a handwheel 240 at the top, the fixing of which on a pulling unit 208 of the fixing system 200 is slightly eccentric. In the first embodiment of a fixing system 100 in FIG. 1, a handwheel can also be arranged on the spring unit 180, but is not shown.

[0079] FIG. 5 shows the fixing system 200 and the screw connection 10 of FIG. 4 in a side sectional view V-V comprising at least the pulling unit 208 and at least one pressure unit 207. The pressure unit 207 comprises a housing 210.1 having a first upper end region 206 and a first lower end region 205 with a first recess 265.1 that is formed open downward. The pulling unit 208 includes a housing 210.2 having a second upper end region 296 and a second lower end region 295. The pressure unit housing 210.1 and the pulling unit housing 210.2 form a common housing that substantially rim and top encloses the fixing system 200.

[0080] The pressure unit 207 includes at least one sleeve stroke space 258 at the first upper end region 206 and at least one stroke receptacle 248 associated therewith and having a pressure surface 254. The sleeve stroke space 258 of FIG. 5 is shown in an open position containing a hydraulic fluid. The sleeve stroke space 258 has a first and a second stroke space seal 256.1, 256.2, wherein the first stroke space seal 256.1 is arranged laterally and below in the direction of a central longitudinal axis z of the housing 210 at the sleeve stroke space 258. The second stroke space seal 256.2 is arranged laterally below and away from the central longitudinal axis z at the sleeve stroke space 248. The stroke cavity 248 is below the sleeve stroke space 258.

[0081] The screw connection 10 is inserted in the first recess 265.1 of the lower end region 205. The screw connection 10 comprises a nut 60, a cone sleeve 130 and a threaded bolt 30. The nut 60 has a flange 68 on a bottom surface 66. The nut 60 is connected to the threaded bolt 30 via an internal thread on an inner side in the direction of the center longitudinal axis z. The cone sleeve 130 is arranged on the outside 62 of the nut 60. The cone sleeve 130 has a head surface 134, which is arranged opposite the pressure surface 254 of the stroke receptacle 248. On the head surface

134 of the cone sleeve 130, the pressure unit 207 exerts a force F_2 in the direction of the central longitudinal axis z in the shown open position of the stroke space 258.

[0082] The pulling unit 208 includes the housing 210.2 having the second upper end region 296 and the second lower end region 295, and a pulling device 220 disposed within the housing 210.2. The pulling device 220 includes an internal thread 222 and a second recess 265.2, which is substantially cylindrical in the direction of the central longitudinal axis z of the housing 210.2 and open towards the bottom. The pulling device 220 of the pulling unit 208, which is arranged in the housing 210.2, extends substantially rotationally symmetrically about the central longitudinal axis z. The pulling device 220 is designed in such a way that it can be moved in the direction of the central longitudinal axis z. In this embodiment, the pulling device 220 of the pulling unit 208 is designed as a piston with an internal thread, which is arranged in the housing 210.2 in such a way that it grips the threaded bolt 30 of the screw connection 10, which can be arranged in the housing 210, at the edge like a tie rod according to FIG. 1. The piston has substantially the shape of a hollow cylinder with an internal thread 222. The first recess 265.1 and the second recess 265.2 are connected to each other and form a common interior space. The common interior space is such that space is provided for an arrangeable screw connection 10.

[0083] Further, the pulling unit 208 includes a spring unit 280 at the second upper end region 295 that includes at least two second spring means 275. The pulling unit 208 includes a stroke space 214 and first and second seals 212.1, 212.2 shown in the closed position. In the working position of the fixing system 200 shown in FIG. 5, the pressing of the nut 60 onto the threaded bolt 30 via the cone sleeve 130 takes place after prior elongation and, if necessary, preconditioning of the threaded bolt 30 as well as tightening of the nut 60 in the elongated state.

[0084] FIG. 6 shows a first embodiment of a nut and cone sleeve combination 20 in a perspective view comprising a nut 60 and a cone sleeve 130, as shown in FIG. 1 in the device 100 in the inserted state. The nut 60 includes a flange 68 and a sidewall 64 on a bottom portion 66. The side wall 64 has a longitudinal recess 65 that completely penetrates the side wall 64 in the direction of a central longitudinal axis z' (see FIG. 7) of the nut 60 and at right angles to the central longitudinal axis z'. Surrounding the side wall 64 of the nut 60, the cone sleeve 130 abuts the nut 60 almost completely. A head surface 134 of the cone sleeve 130 and a head surface 67 of the nut

60 form a substantially common and planar surface. The sidewall 64 has an internal thread on its inner surface. The internal thread is not formed to the bottom surface of the sidewall 64 or flange 68, but ends spaced therefrom. An upper chamfer 63.1 and a lower chamfer are formed on the inside of the side wall 64. The lower chamfer 63.2 forms a transition from the internally thread-free area to the internal thread, and also has the internal thread at least in part, but with the depth of the thread of the internal thread decreasing towards the bottom surface.

[0085] FIG. 7 shows the nut and cone sleeve combination 20 of FIG. 6 in a bottom view of the nut 60 and the cone sleeve 130 and flange 68 of the nut 60, illustrating the longitudinal recess 65, which has a width B, and which also penetrates the flange 68 of the nut 60.

[0086] FIG. 8 shows a second embodiment of a nut and cone sleeve combination 25 in a perspective view comprising a nut 60.1 and cone sleeve 130. The nut 60.1 has four longitudinal recesses 65.1 that penetrate the sidewall 64.1 in the direction of the central longitudinal axis z' (see FIG. 7) of the nut 60.1 and at right angles to the central longitudinal axis z' to about an outer surface 69.1 of a flange 68.1. Adjacent to a head surface 67.1 of the side wall 64.1 and remote from the cone sleeve 130 on the inside of the side wall 64.1, the side wall 64.1 has a circular upper chamfer 63.1 and an inner, lower chamfer 63.2 (see FIG. 8.1). Running into and slightly beyond the lower chamfer 63.2 are the four longitudinal recesses 65.1, which are slot-shaped, open towards the head surface 67. Starting from a cone sleeve outer side 133 of the cone sleeve 130, a pressure port 131 extends through the cone sleeve 130 and towards the central longitudinal axis z'. A fluid reaches the nut 60.1 through the pressure port 131 and enables the cone sleeve 130 to be separated from the nut 60.1 by increasing the pressure of the fluid. Furthermore, the side wall 64.1 of the nut 60.1 comprises an internal thread, which cannot be seen in FIG. 8 (but see FIG. 6).

[0087] FIG. 8.1 shows the second embodiment of the nut and cone sleeve combination 25 in a perspective underside view comprising the nut 60.1 and the cone sleeve 130. Two of the four longitudinal recesses 65.1 of the nut 60.1 are illustrated, which the nut 60.1 does not completely penetrate in the region of the flange 68.1 in the direction of the central longitudinal axis z' (see FIG. 7). The flange 68.1 and the portion of the sidewall 64.1 laterally enclosed by the flange hold the nut 60.1 together into one member, whereas the remaining portion of the sidewall 64.1 is compressible by

lateral force application. The lateral force application reduces the longitudinal recesses 65.1 in a width B (see FIG. 7). The lower chamfer 63.2 and its formation are clearly visible.

[0088] FIG. 9 shows an embodiment of a screw connection 10 having a base U, the screw connection 10 comprising a nut 60, a cone sleeve 130, and a threaded stud 30. The nut 60 has an inner side 61 and an outer side 62, wherein the inner side 61 is arranged closer to a central longitudinal axis z' of the nut 60 than the outer side 62. Further, the nut 60 has a flange 68 on a bottom surface 66 and a head surface 67 opposite the bottom surface 66. With the flange 68 and the bottom surface 66, the nut 60 rests on the lower base U. On the outer side 62 of the nut 60, the cone sleeve 130 lies completely with a cone sleeve inner side 132. The screw connection 10 has a gap S between the flange 68 of the nut 60 and a lower end of the cone sleeve 130. The gap S decreases to a maximum of closure as soon as a force F_2 acts on a head surface 134 of the cone sleeve 130.

[0089] FIG. 10.1 shows the threaded bolt 30 of the screw connection 10 of FIG. 9 with a base in a first process step, wherein the threaded bolt 30 has a first bolt thread diameter $D_{B,old}$ with an original bolt thread geometry in an unlengthened state.

[0090] FIG. 10.2 shows the threaded bolt 30 of the screw connection 10 of FIG. 9 with the base U in a second process step, wherein the threaded bolt 30 in an elongated state has a second bolt thread diameter $D_{B,new}$ with a modified bolt thread geometry. In the second process step, the threaded bolt 30 is first elongated, if necessary, several times over the central longitudinal axis z of the nut 60 (see FIG. 10.3) with a force $F_{1,z}$ in order to obtain a preconditioning as addressed above in the general description. Otherwise, the threaded bolt 30 is pulled by the pulling unit 107, 207 of a fixing device 100, 200 until it reaches the elongated state shown in FIG. 10.2. In the elongated state, the second bolt thread diameter $D_{B,new}$ is smaller than the first bolt thread diameter $D_{B,old}$ in the non-elongated state. The modified bolt thread geometry differs substantially from the original bolt thread geometry (see FIG. 10.1) in that the thread pitch has become steeper, which is readily apparent from the enlarged views of the thread flight of the threaded bolt in FIGS. 10.1 and 10.2.

[0091] FIG. 10.3 shows the screw connection 10 in a sectional view with the base U of FIG. 9 in a third process step, wherein the screw connection 10 comprises the nut 60, the cone sleeve 130 and the elongated threaded bolt 30. In the unpressed condi-

tion shown, the nut 60 has a first nut thread diameter $D_{M,old}$ (see FIG. 10.6) with a thread substantially matching the modified bolt thread geometry. The nut 60 was placed on the threaded bolt 30 prior to elongation and, if necessary, preconditioning performed in the second process step. In the third process step, the nut 60 and the cone sleeve 130 have a gap L between the base U and the flange 68.

[0092] FIG. 10.4 shows the screw connection 10 with the base U of FIG. 9 in the third process step, wherein the screw connection 10 comprises the nut 60, the cone sleeve 130 and the threaded bolt 30. A zoomed-in detail view illustrates that there is some flank play between nut thread flanks 80 of nut 60 and bolt thread flanks 40 of bolt 30.

[0093] FIG. 10.5 shows the screw connection 10 with the base U of FIG. 9 in a fourth process step, wherein the screw connection 10 comprises the nut 60, the cone sleeve 130 and the threaded bolt 30. In the fourth process step, the nut 60 and the cone sleeve 130 are tightened until the gap L (see FIG. 10.3) is completely closed and the flange 68 of the nut 60 is resting on the base U. A zoomed-in detail view illustrates that a nut thread flank 80 of the nut 60 abuts a bolt thread flank 40 of the bolt 30, providing some static friction due to the abutting surfaces.

[0094] FIG. 10.6 shows the screw connection 10 in a sectional view with the base U of FIG. 9 in the fourth process step, wherein the screw connection 10 comprises the nut 60, the cone sleeve 130 and the threaded bolt 30. In the fourth process step, the nut 60 still exhibits the unpressed state and the first nut thread diameter $D_{M,old}$.

[0095] FIG. 10.7 shows the screw connection 10 in a sectional view with the base U of FIG. 9 in a fifth process step, wherein the screw connection 10 comprises the nut 60, the cone sleeve 130 and the threaded bolt 30. Due to the application of the force F_2 (see FIG. 9), the gap S (see FIG. 9) has decreased. Due to the conicity of the nut 60 and the cone sleeve 130, a radial force $F_{2,r}$ acts on the nut 60, which now has a pressed state with a second nut thread diameter $D_{M,new}$. The second nut thread diameter $D_{M,new}$ is smaller than the first nut thread diameter $D_{M,old}$ (see FIG. 10.6). A detailed view illustrates that the nut thread flank 80 of the nut 60 is in almost complete contact with the bolt thread flank 40 of the bolt 30. There is a form fit between the nut thread flanks 80 and the bolt thread flanks 80. Due to the closing of the flank play and the almost complete contact of the flanks, the friction surface is maximized to about 100%, whereby almost the maximum static friction μ_0 is given.

[0096] FIG. 11 shows the screw connection of FIG. 9 with a base U in an assembled state. The base U, which is formed in two parts, is completely penetrated by the threaded bolt 30. On a first surface 90 of the base U, the pressed nut 60 is arranged with the cone sleeve 130, enclosing the threaded bolt 30. On a second surface 91of the base U, which is an opposite surface to the first surface 90, a bolt head 70 of the threaded bolt 30 is arranged. The threaded bolt 30 is thus gripped from both sides of the base U by the nut 60 and the bolt head 70, and fixes the two-piece base U.

[0097] The embodiments shown in the figures are not to be interpreted restrictively. For example, the fixing device can have one or more hydraulic connections which are connected to the respective lifting chambers. Further, the pulling unit and the pressure unit may be at least two separate components that are attached to the screw connection depending on the process step. Furthermore, the number of stroke spaces and the seals arranged on them can vary depending on the dimensioning of the stroke spaces.

[0098] The present invention provides a high-strength, durable screw connection that reduces labor costs and, in particular, maintenance costs, allows a tightened and pressed screw connection to be made quickly, and avoids the need for retightening during the service life of the connected bases or components.

PATENTKRAV

1. Fastgørelsessystem (100, 200) for i det mindste en skrueforbindelse (10), omfattende

- mindst en trækenhed (108, 208),

kendetegnet ved

- mindst en trykenhed (107, 207),

hvorved

- trykenheden (107, 207) omfatter et hus (110.1, 210.1) med et første øvre endeområde (106, 206) samt et første, nedre endeområde (105, 205) med en første udsparing (165.1, 265.1), der er udformet som åben nedadtil,
- trykenheden (107, 207) omfatter mindst eet bøsningsslagrum (158, 258) i det første, øvre endeområde (106, 206) samt mindst én slagbeholder (148, 248) tilordnet dertil og med en trykflade (154, 254),
- i det første, nedre endeområde (105, 205) af trykenheden (107, 207) en konusbøsning (130), som kan indsættes i den første udsparing (165.1, 265.1), og
- slagbeholderen (148, 248) for trykenheden (107, 207) er arrangeret i huset (110.1, 210.1) på en sådan måde, at slagbeholderen (148, 248) kan bevæges ved hjælp af hydraulisk og/eller mekanisk aktivering i retningen for en central længdeakse z for huset (110.1, 210.1) og udøver en kraft F_2 på den indsættelige konusbøsning (130) via en trykdel (161), som er tilordnet dermed eller direkte.

2. Fastgørelsessystem (100, 200) ifølge krav 1, **kendetegnet ved, at** trykenheden (107, 207) er arrangeret i det væsentlige neden under trækenheden (108, 208).

3. Fastgørelsessystem (100, 200) ifølge krav 1, **kendetegnet ved, at** trækenheden (108, 208) og trykenheden (107, 207) i det mindste er to separate komponenter.

4. Fastgørelsessystem (100, 200) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** trykenheden (107, 207) omfatter mindst et første fjedermiddel (152) mellem slagbeholderen (148, 248) og den indsættelige konusbøsning (130).

5. Fastgørelsessystem (100, 200) ifølge krav 4, **kendetegnet ved, at** det første fjedermiddel (152) er udformet til at kunne spændes og/eller afspændes ved hjælp af hydraulisk og/eller mekanisk aktivering i retning af en central længdeakse z for huset (110.1, 210.1).

6. Fastgørelsessystem (100) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** huset (110.1) i trykenheden (107) omfatter mindst eet føringselement (150) i det første nedre endeområde (105).

7. Fastgørelsessystem (100, 200) ifølge et eller flere af de foregående krav, **kendetegnet ved, at** trækenheden (108, 208) omfatter mindst eet hus (110.2, 210.2) med et andet øvre endeområde (196, 296) og et andet nedre endeområde (195, 295) samt i det mindste en trækindretning (120, 220), der er arrangeret i huset (110.2, 210.2), hvorved trækindretningen (120, 220) omfatter mindst eet indvendigt gevind (122, 222) samt en anden udsparing (165.2, 265.2), som i det væsentlige er cylindrisk i retningen for den centrale længdeakse z for huset (110.2, 210.2) og er åben i bunden.

8. Skrueforbindelse (10), fremstillet med et fastgørelsessystem (100, 200) ifølge et eller flere af de foregående krav, omfattende

- mindst én møtrik (60), omfattende
  - en indvendig side (61) med et indvendigt gevind,
  - en udvendig side (62),
  - en bundflade (66), og
  - en hovedflade (67), som er beliggende modsat bundfladen (66),

- mindst én konusbøsning (130) og
- mindst én gevindbolt (30),

hvorved

- gevindbolten (30) omfatter en første boltgevinddiameter $D_{B,\ gammel}$ i en ikke-forlænget tilstand og en anden boltgevinddiameter $D_{B,\ ny}$ med en modificeret boltgevindgeometri i en forlænget tilstand;
- møtrikken (60) i en ikke-spændt tilstand har en første møtrikgevinddiameter $D_{M,\ gammel}$ med et gevind, som i det væsentlige er tilpasset til den modificerede boltgevindgeometri og i en spændt tilstand har en anden møtrikgevinddiameter $D_{M,\ ny}$;
- ydersiden (62) er konisk;
- indsnævringen af koniciteten strækker sig fra bundfladen (66) til hovedfladen (67) eller strækker sig fra en flange (68), som møtrikken (60) omfatter på bundfladen (66), til hovedfladen (67).

9. Skrueforbindelse (10) ifølge krav 8, **kendetegnet ved, at** konusbøsningen (130) omfatter en hovedflade (134), via hvilken den er udformet til at virke sammen med trykfladen (154, 254) for slagbeholderen (148, 248).

10. Skrueforbindelse (10) ifølge et eller flere af kravene 8 og 9, **kendetegnet ved, at**

- en sidevæg (64) på møtrikken (60) omfatter mindst en langstrakt udsparing (65), som helt gennemtrænger møtrikkens (60) sidevæg (64) i retningen for en central længdeakse z' for møtrikken (60), i det mindste over en dellængde og i retningen for en x-akse, vinkelret på den centrale længdeakse z'.

11. Møtrik (60) til anvendelse i en skrueforbindelse (10) ifølge et eller flere af kravene 8 til 10, omfattende:

- en indvendig side (61) med et indvendigt gevind,

- en udvendig side (62),
- en bundflade (66), og
- en hovedflade (67), beliggende over for bundfladen (66);

hvorved

- den udvendige side (62) er konisk;
- indsnævringen af koniciteten strækker sig fra bundfladen (66) til hovedfladen (67) eller strækker sig fra en flange (68), som møtrikken (60) omfatter på bundfladen (66), til hovedfladen (67);
- en sidevæg (64) på møtrikken (60) omfatter mindst én langstrakt udsparing (65), som gennemtrænger møtrikkens (60) sidevæg (64) i retningen for en central længdeakse z' for møtrikken (60), i det mindste over en dellængde og i retningen for en x-akse, vinkelret på den centrale længdeakse z'.

12. Møtrik-konusbøsning-kombination (20, 25) til anvendelse i en skrueforbindelse (10), omfattende

- en møtrik (60) ifølge krav 11, og
- en konusbøsning (130),

hvorved

- konusbøsningen (130) på mindst én konusbøsningsinderside (132) er dannet cirka svarende til en sidevæg (64) på møtrikken (60).

13. Fremgangsmåde til fremstilling af mindst én skrueforbindelse (10) med et fastgørelsessystem (100, 200) ifølge et eller flere af kravene 1 til 7, hvorved trykenheden (107, 207) i fastgørelsessystemet (100, 200) samt en konusbøsning (130) bevirker en sammenpresning af en møtrik (60) med en gevindbolt (30).

14. Fremgangsmåde ifølge krav 13, **kendetegnet ved, at,** ved hjælp af en slagbeholder (248) i trykenheden (107, 207) eller en trykdel (161) i slagbeholderen (148), konusbøsningen (130) skubbes på møtrikken (60) i skrueforbindelsen (10) i retning for en central længdeakse z, z' via en konusbøsnings indvendige side

(132), som i det væsentlige ligger an mod en udvendig side (62) af møtrikken (60).

15. Fremgangsmåde ifølge et eller flere af kravene 13 og 14, **kendetegnet ved, at** mindst en langsgående udsparing (65) i møtrikken (60) har en bredde B, som reduceres ved bevægelsen af konusbøsningen (130) på møtrikken (60).

16. Fremgangsmåde ifølge et eller flere af kravene 13 til 15, **kendetegnet ved, at** møtrikgevindflangen (80) på møtrikken (60), arrangeret som modsat beliggende boltgevindflangerne (40) på gevindbolten (30), skubbes op på boltgevindflangerne (40), indtil der opnås et i det væsentlige fuldstændigt anlæg.

17. Anvendelse af et fastgørelsessystem (100, 200), som er dannet ifølge et eller flere af kravene 1 til 7, med henblik på fremstilling af mindst én skrueforbindelse (10), hvorved fastgørelsessystemets (100, 200) trykenhed (107, 207) og en konusbøsning (130) bevirker en sammenpresning af en møtrik (60) med en gevindbolt (30).

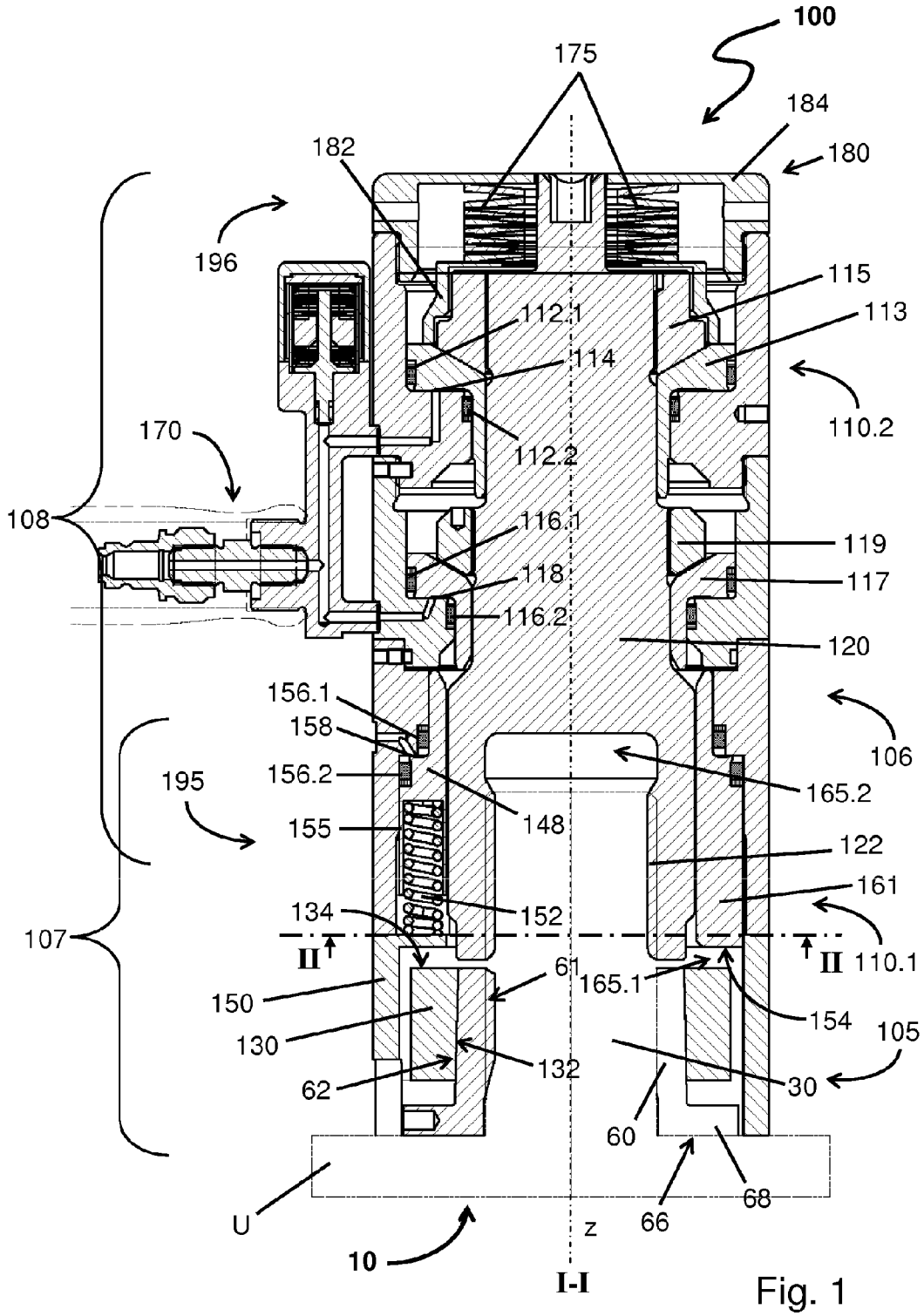
100
175
184
182
180
196
115
113
112.1
114
110.2
170
112.2
108
116.1
119
118
117
116.2
120
156.1
158
106
156.2
165.2
195
148
155
122
161
134
152
107
II
II
110.1
61
165.1
150
154
105
130
132
30
62
60
68
U
66
z
10
I-I

Fig. 1

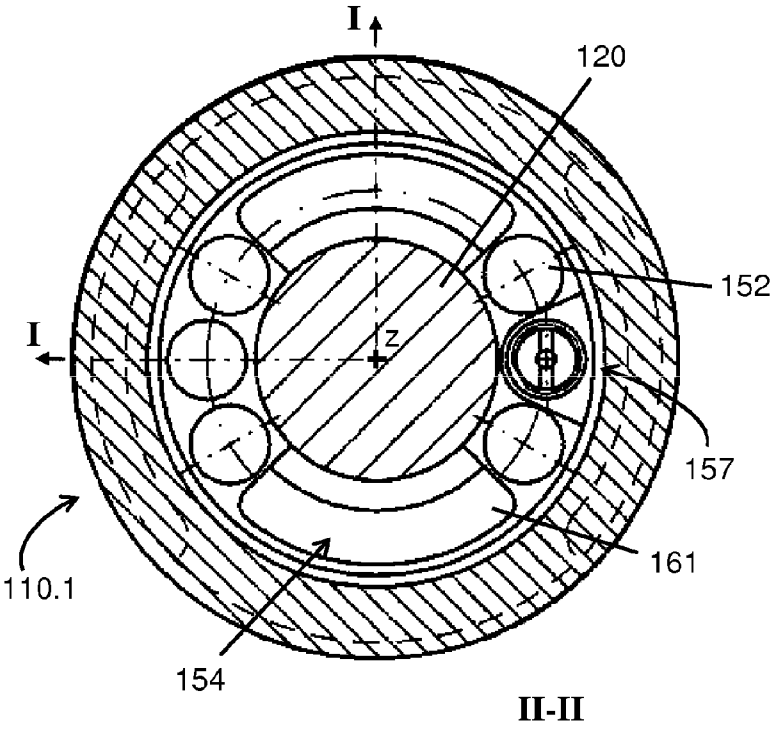
I
120
152
I
z
157
161
110.1
154
II-II

Fig. 2

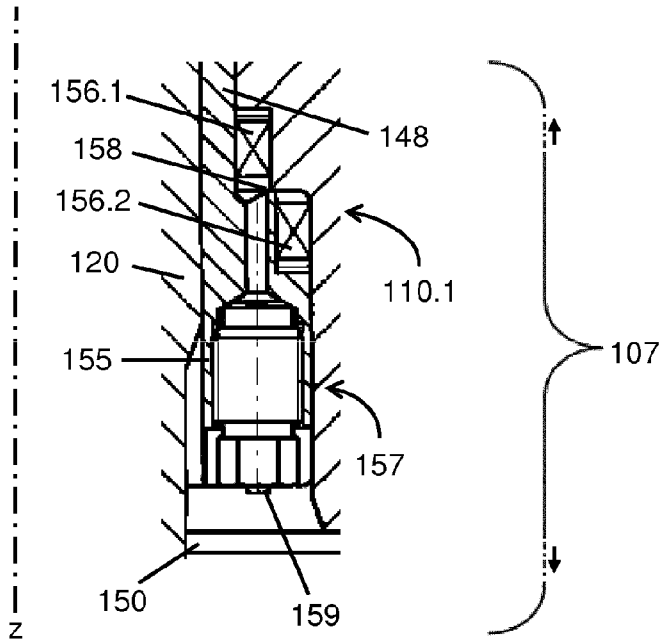
156.1
148
158
156.2
120
110.1
155
107
157
150
159
z

Fig. 3

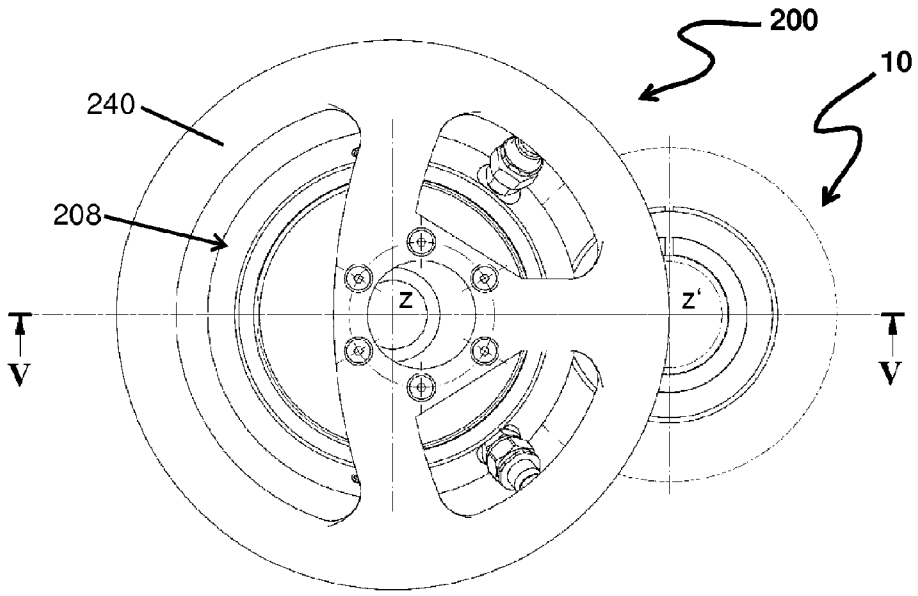
200
10
240
208
z
z'
V
V

Fig. 4

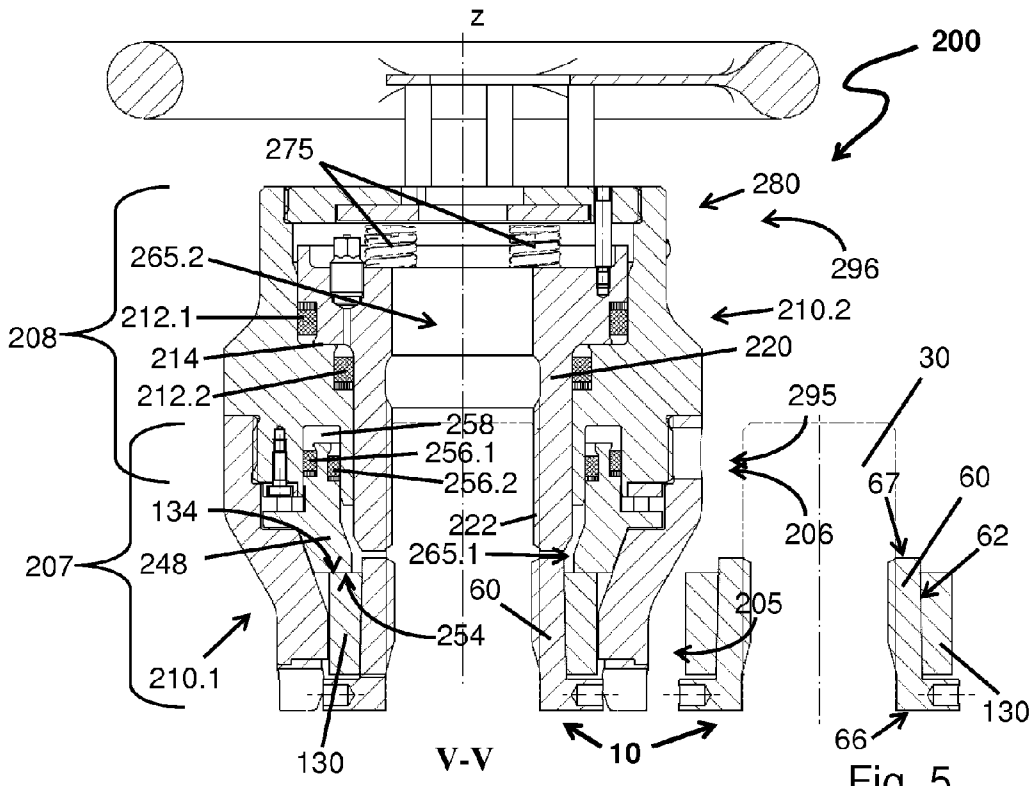
z
200
275
280
296
265.2
212.1
210.2
208
214
220
212.2
30
295
258
256.1
256.2
67
60
134
222
206
62
207
248
265.1
60
205
254
210.1
130
V-V
10
66
130

Fig. 5

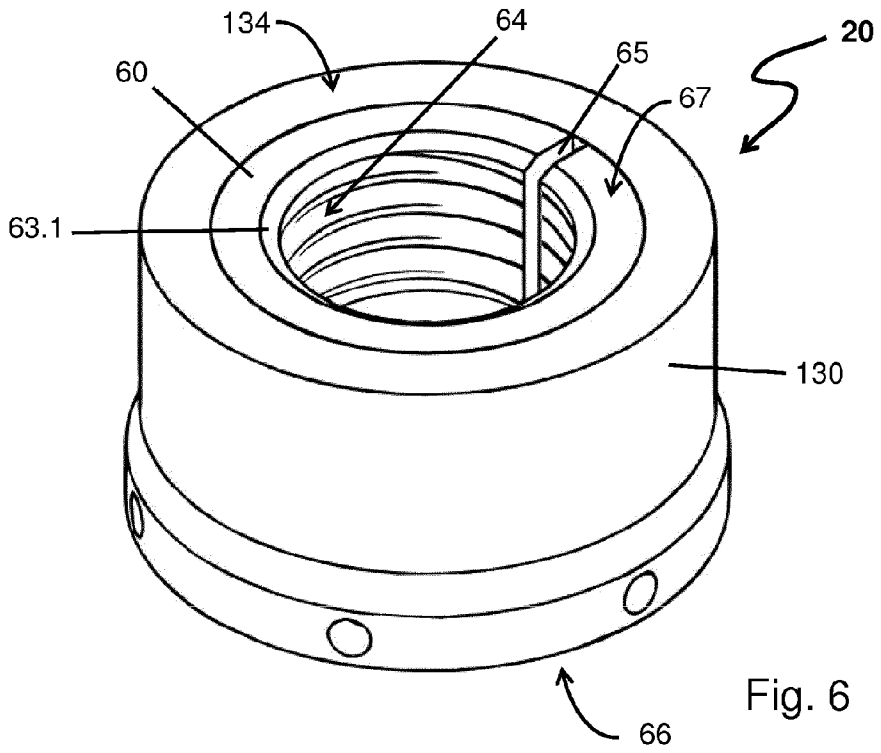

Fig. 6

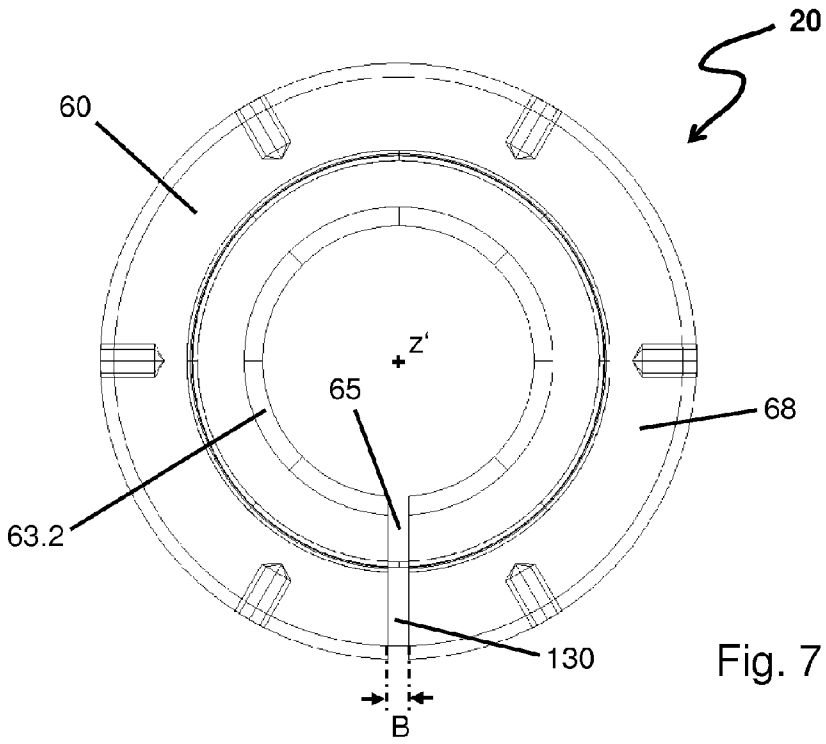

Fig. 7

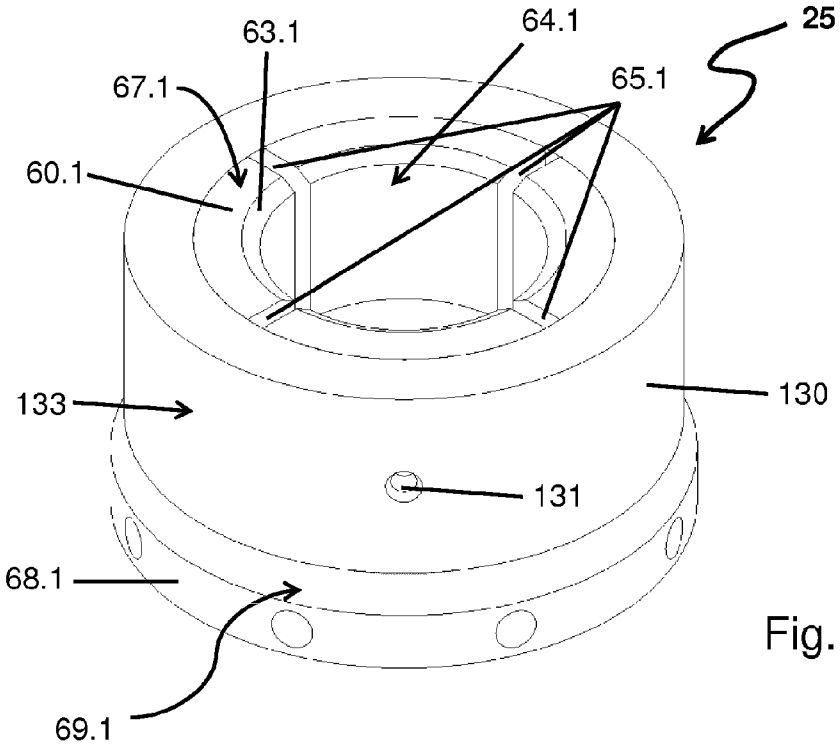
63.1
64.1
25
67.1
65.1
60.1
133
130
131
68.1
69.1

Fig. 8

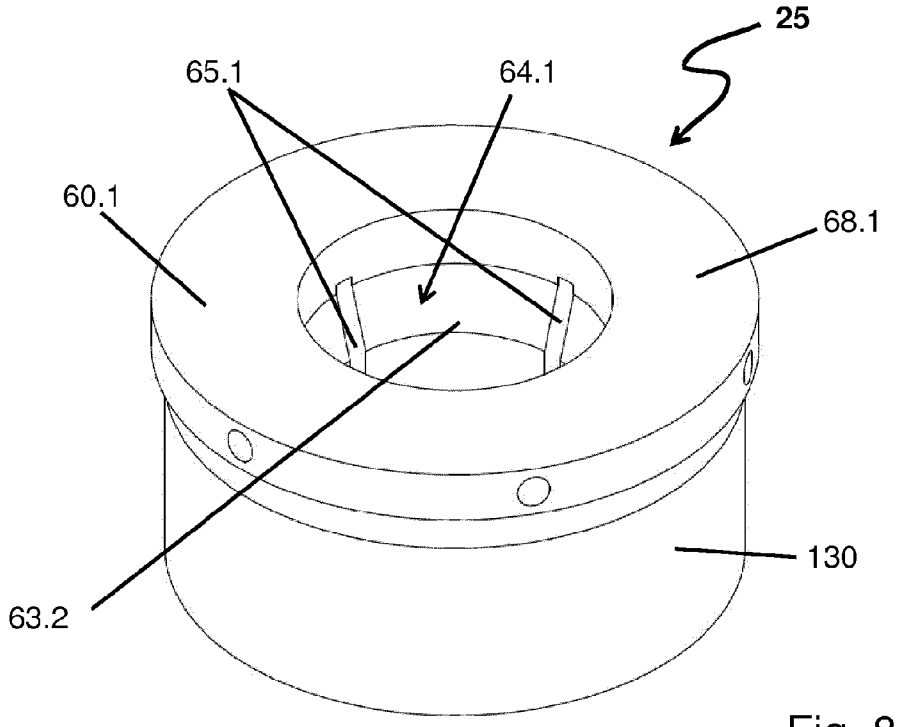
25
65.1
64.1
60.1
68.1
130
63.2

Fig. 8.1

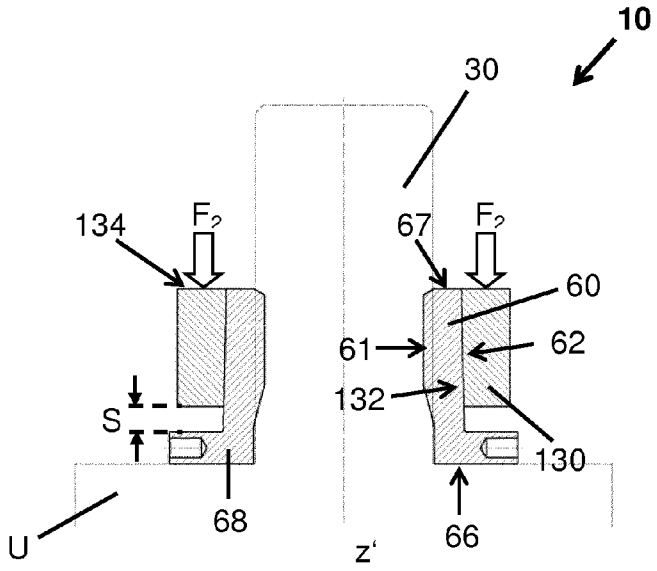

Fig. 9

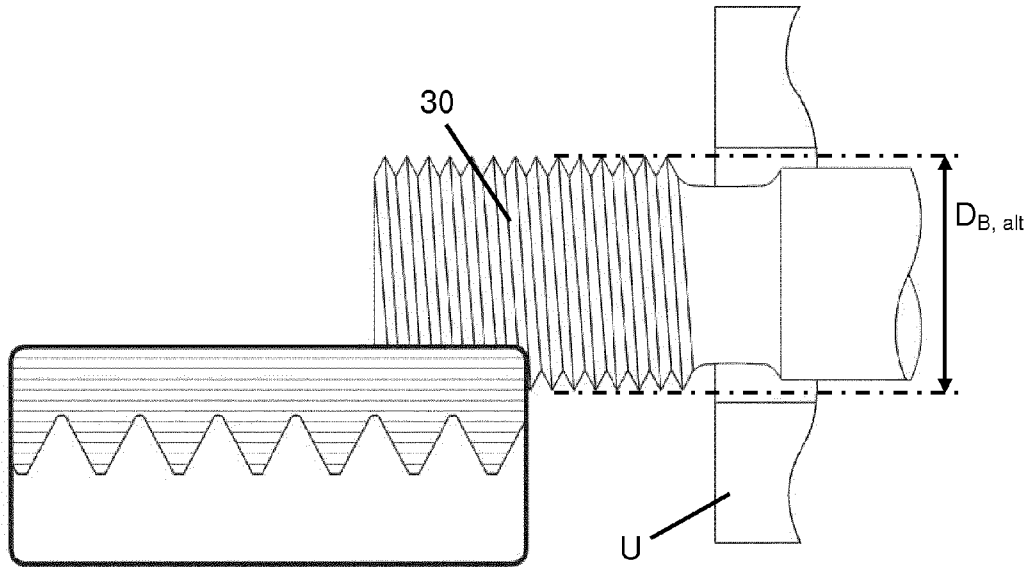

Fig. 10.1

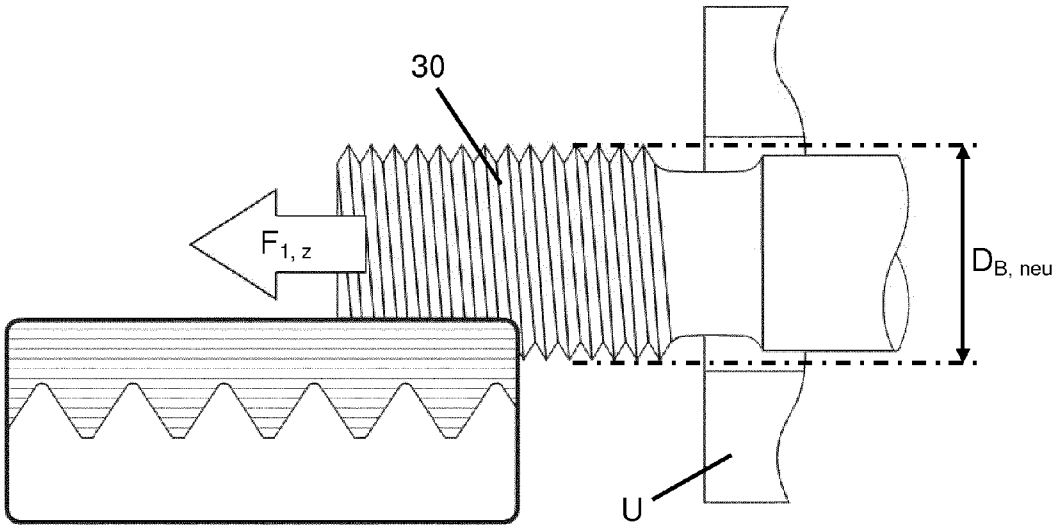

Fig. 10.2

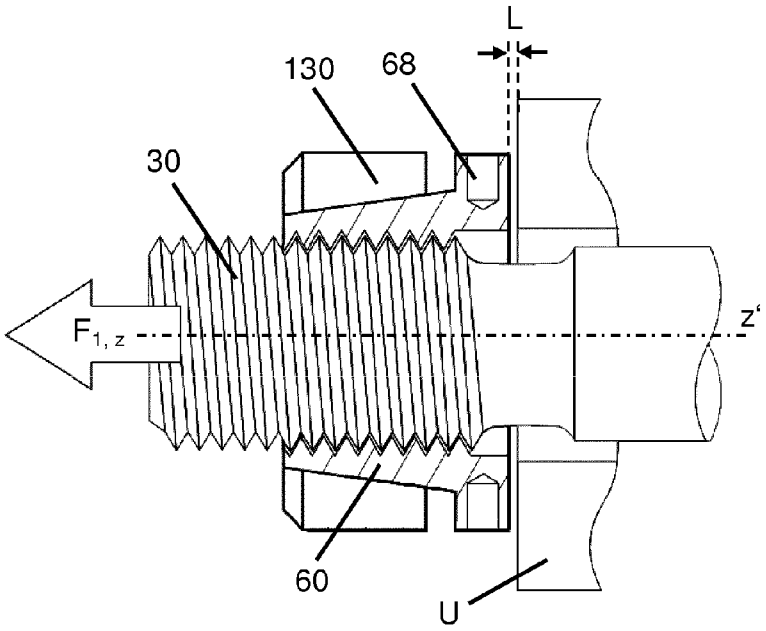

Fig. 10.3

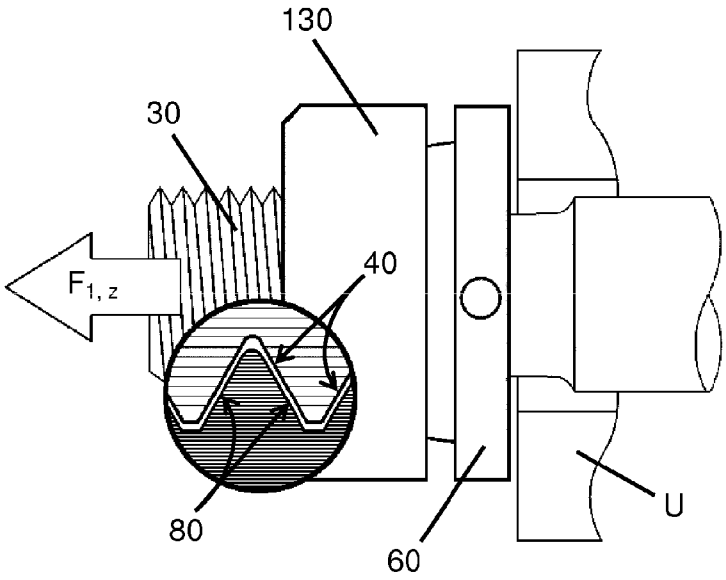

Fig. 10.4

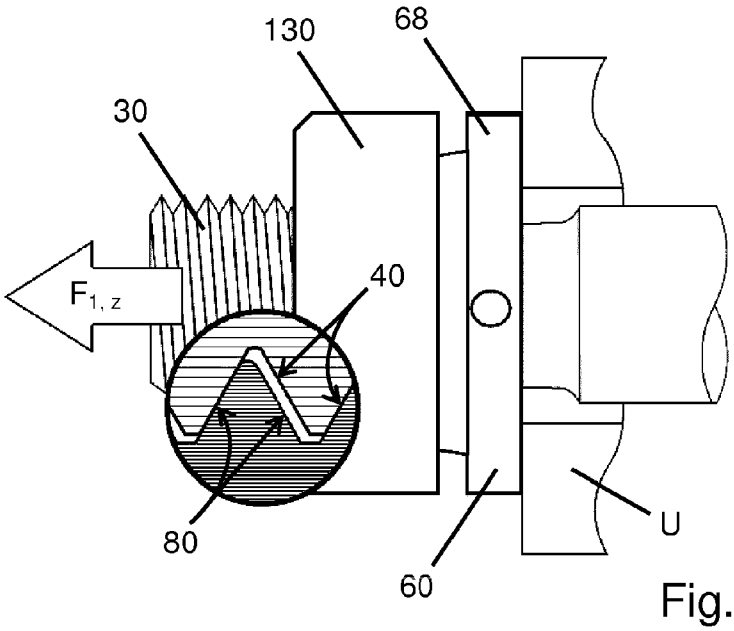

Fig. 10.5

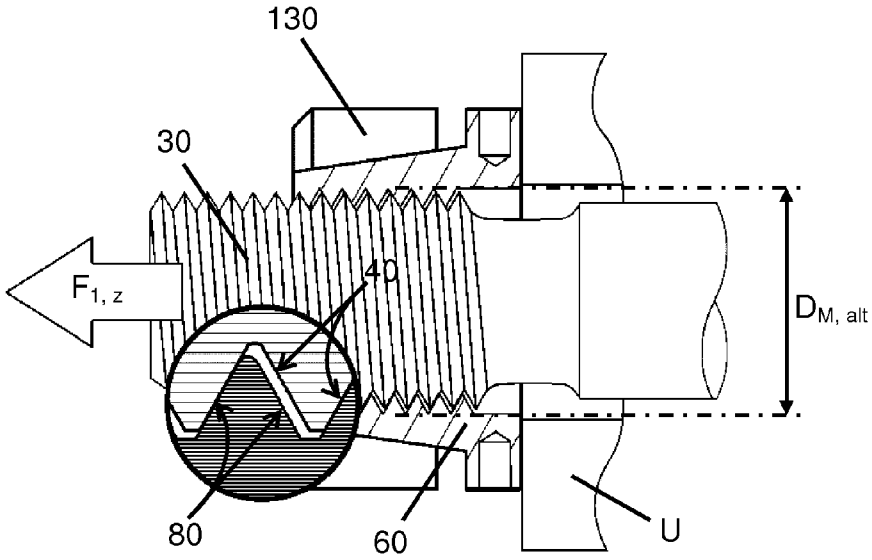

Fig. 10.6

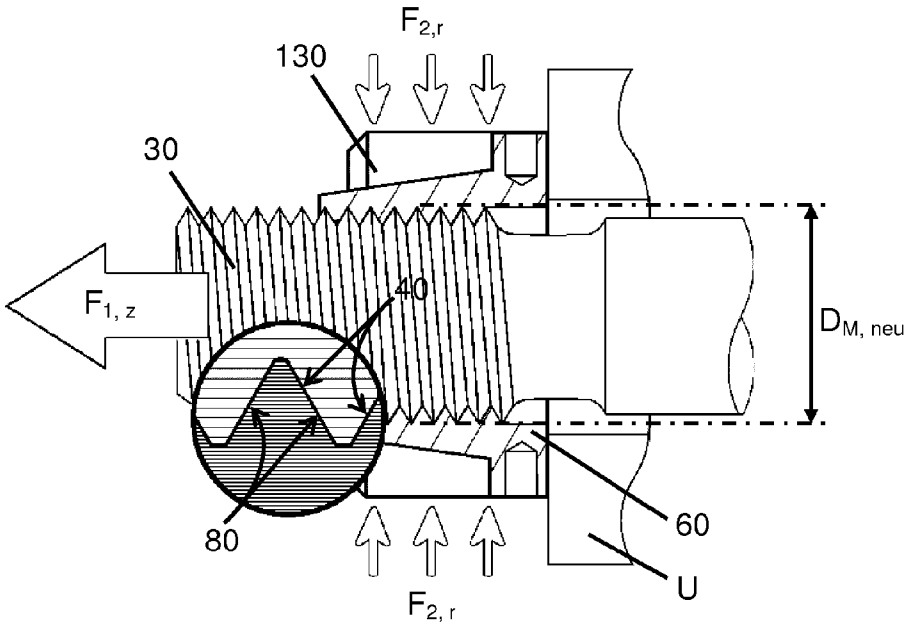

Fig. 10.7

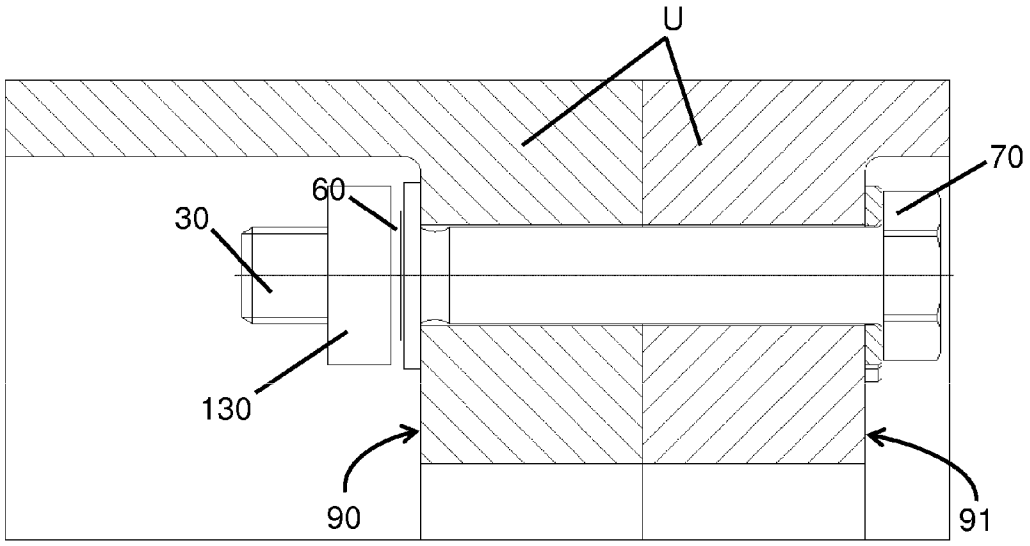

Fig. 11