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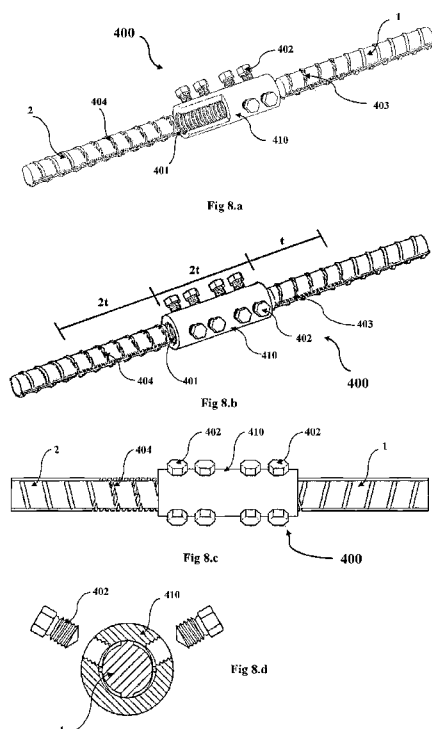
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(54) Title: REINFORCING BAR COUPLER BASED ON DOUBLE ACTION OF SCREW ELEMENTS



(57) Abstract: Most of the reinforcing bars used in reinforced concrete industry have outwardly circumferential ribs. The common form of these ribs, are the inclined shape ribs. In addition, a pair of longitudinal ribs may be formed as a result of the manufacturing process. Despite the importance of these ribs in increasing the bond between it and the surrounding concrete, it represents one of the most important obstacles in finding a strong and small size mechanical coupler to connect two or more bar ends. These ribs significantly reduce the contact surfaces needed to transfer loads and stresses between the reinforcing bars and the inner surface of the mechanical coupler. Presented herein, apparatuses and methods for coupling reinforcing bars based on double action of screw elements and bar end threading without enlargement or undercut. The rebar outwardly circumferential ribs and the inner surface of the mechanical coupler tubular sleeve, are machined to form an interlock between them which significantly enhance the coupling strength. When the screw elements are tightening against a reinforcing bar, the machining that done, make the circumferential surface of the rebar end between the ribs not only in direct contact but also dig into the inner surface of the mechanical coupler and does eliminate the spaces between them. Means for coupling and gripping the tubular sleeve body over the ends reinforcing bar ends.

REINFORCING BAR COUPLER BASED ON DOUBLE ACTION OF SCREW ELEMENTS

TECHNICAL FIELD

5 The present invention relates to the field of devices and methods for coupling bars, in particular but not exclusively, to the coupling of reinforcing bars used in structural concrete.

BACKGROUND:

10 Corrosion of reinforcing bars, cracks in concrete within the lap splice lengths and/or spalling the concrete cover due to dynamic loads makes lap splice ineffective. Lap welded splices of reinforcing steel bars are highly prone to cracking under fatigue loading and suffer from eccentricity problems and probable failures of the surrounding concrete due to the kinematic behavior of the end connections, (Apostolopoulos *et al.*, 2011). These problems greatly affect critically the adequacy and reliability of the design and use of such splices.

15 Furthermore, mechanical coupler retains their strength despite rebar corrosion, or concrete cover spalling. In addition, it's reducing the rebar congestion within the concrete joints and simplifies design details. Its function is to connect two or more reinforcing bars together to behave as a single object providing full strength according to its type: in tension, compression and/or fatigue. Therefore, the coupler must safely transfer the loads and stresses between an end of one bar to the other bar end.

20 The mechanical coupler consists of body and means to transfer the loads and stresses between it and the two coupled rebar ends. The forces transferred between the outside surface of the rebar and the inside surface of the coupler body by one or more of the following resisting forces: bond, shear, bearing and/or friction.

25 The early developed mechanical couplers are straight threaded and tapered threaded coupler as in Fig 1.a and 1.b (patent number US3083043A, 1963 and US3415552A, 1968). It depends on engaging the male threads made in the two ends of the reinforcing bars with the female threads made in the inner surface of coupler sleeve. This type requires hand turning one of the two bars which may be long and heavy. Sometimes, it is physically impossible to rotate either bar when a first bar is already embedded in the concrete and the second is bent.

30 Another mechanical coupler in which neither bar can be rotated was given in the US patent number 5,067,844, (1991) and shown in Fig 1.c. In the two types, the threading process is taking out from the nominal diameter of the reinforcing bar body, therefore, the nominal size as well as the load capacity significantly decreases.

35 The use of tubular coupler with longitudinally thumbscrews for securing interior plates to a shaft began to be in Patent No. 4,314,771. Several innovators made several modifications to this design to use it to couple the ends of two reinforcing bars in a straight line, as in patent numbers US20050169701A1, US5909980A, US20060067785A1 and US5664902A. In this coupling system, the bars are held in place within the tubular sleeve using a set of bolts or screws which engage into the reinforcing bars thereby wedging the bars against an inner surface of the tubular body producing the couple. The tubular sleeve cross-section may take the circular shape with inner threaded surface or diamond-shaped configuration. Another modification which widely used by this system is the tubular sleeve with inner hardened strips having teeth on the opposite side of the engagers (bolts or screws).

40 When the screw elements are tightened against a reinforcing bar, and since there are circumferential ribs (deformations) around it, the screw elements force the ribs into the inner surfaces of the tubular sleeve. Therefore, circumferential deformation prevents the rest of the circumferential surface of the reinforcing bars between ribs from interact and digging into the inner surface of the tubular sleeve. Even in the presence of a pair of elongated serrated strips welded in the inner surface of the tubular sleeve, small areas of the ribs are what bite with the teeth of these strips, and then the strength of the

coupler comes from this positive locking and bearing of these small areas and the shear resistance between the bolts, the coupler and the reinforcing bars. As shown in Fig 5, not all the circumferential surfaces of the bar end and the inner coupler sleeve surface in full contact. Fig 5 illustrates also the bolts digging points and resting points of the reinforcing bar ribs within the mechanical coupler sleeve.

The patent applications WO2005111336A1 and US 2010/0104357 present a mechanical rebar coupler depending on the original male deformations of the reinforcing bars. As shown in Fig 2 and 3, the coupler comprising a pipe split along its longitudinal axis into two portions. The inner surface of each portion is grooved to form female grooves that exactly matching the reinforcing bar male deformations. The coupler is formed of one or two halves of the pipe portion assembled over the ends of the axially aligned reinforcing bars allowing for the bars male deformations to exactly enter into the pipe portion female grooves without any clearance or filling material to be added. The patent present five techniques to tightly close the sleeve over the connected reinforcing bar ends. The outer surface of the pipe portions is processed to be used according to the closure technique either one or two pipe portions over the reinforcing bars ends. However, this approach of the related invention has a significant drawback in manufacturing the reinforcing steel bar circumferential deformations, the bar is subdivided into two sides left and right. The deformations made in the left portion of the bar are not necessarily coinciding with that made in the right portion of that bar. In addition, the two bars to be connected may have different shifts other than that of the first bar as shown in Fig 4. The reason for that shifts originates from the manufacturing process of the steel reinforcement bars. The steel bar is rolled between two rollers. The female grooves of the two rollers are not always starting from the same point, resulting in that shift between the two sides of the deformations in the steel bar. In other words, the two sides of the steel bar deformations are not coincident depending on the two rollers starting points and may differ from manufacturing batch to another. As shown in Fig 4, there is a shift 33 between the deformation in the two bar sides while no shift in the left bar.

DISCLOSURE OF THE INVENTION

According to the aspect of the invention, the coupler types include, machining in the outwardly circumferential ribs of the reinforcing bar ends and in the inner surface of the mechanical coupler sleeve to form a positive interlock between them at the gripping stage. These machining make the circumferential surface of the rebar between the ribs not only in direct contact but also dig into the inner threading surface of the mechanical coupler and does eliminate the spaces between them. It includes, male screw threads or serration that are cut into the rib thickness of the reinforcing bar end, and identical female screw threads or serration are made on the inner surface of a steel alloy tubular sleeve.

According to still another aspect of the invention, the outer surface of the coupler body is prepared with down taper thread directed towards the sleeve ends, the coupler tubular body is then split along its longitudinal axis into two similar halves. Then, these two halves are assembled over the two reinforcing bar ends, assuring the coincidence of the reinforcing bars male threading with the inner coupler sleeve halves female threading. The two halves of the coupler tubular body are assembled along the ends of the two reinforcing bars to be connected, assuring that, interring of the reinforcing bars male threading into the inner coupler sleeve halves female threading. The two halves of the coupler tubular body are tightly closed on the two-bar ends by two lock nuts having internal taper thread and slope identical to the external thread and slope of tubular sleeve halves. The coupling is performed by interring and turning the two nuts over the two sleeve halves.

According to another aspect of the invention, an elongated tubular sleeve prepared with two eccentric longitudinal holes along the longitudinal axis of the tubular sleeve body. The first hole has a diameter larger than the diameter of the reinforcing bar to be joined so that it can be inserted easily, and the second hole has a cross-section centered slightly below the center of the first hole and the diameter of its section is close to the nominal diameter of the reinforcing bar (without deformations).

Identical female screw threads with the male that cut into the reinforcing bar ribs of the end portion are made in the inner surface of the second hole of the tubular sleeve body. A plurality of Longitudinally spaced threaded holes are also formed within the tubular sleeve body in opposing relation to the inner threading of the tubular coupler sleeve and a plurality of bolts with hex or socket head shaped outer end portion and some with cone point set screw is threaded into each hole. Tightening torque bolts against the reinforcing bar ends, generating positive bearing pressure between the reinforcing bar and the inner lower surface of the tubular sleeve as well as increasing the shear resistance of the circumferential reinforcing bar male threading with inner coupler sleeve female threading.

According to still another aspect of the invention, an elongated tubular sleeve is prepared with a longitudinal hole along its longitudinal axis. The inner sleeve diameter is close to the nominal diameter of the reinforcing bar (without deformations). Identical female screw threads with the male thread that cut into the circumferential ribs of reinforcing bar end portion are made in the inner surface of the hole of the tubular sleeve body. A plurality of longitudinally spaced threaded holes is also formed within the tubular sleeve body and a plurality of bolts with hex or socket head shaped is threaded into holes. Then, tightening the bolts against the reinforcing bar provide the entire circumferential surface of the reinforcing bar end including ribs in contact and dig the inner surface of the sleeve. This technique enhancing the engagement of the inner coupler sleeve female threading into the bar ribs male threading as well as digging the circumferential surface of the reinforcing bar between the ribs. The present aspect gives the slimmer mechanical coupler size and does not reduce the nominal size of the reinforcing bar.

According to still another aspect of the invention the idea is not limited to connecting two aligned reinforcing bars, therefore, the invention provides a mechanical coupler to connect two perpendicular reinforcing bars to overcome the problems arising from cold bending as presented in ACI Structural Journal manuscript S-2020-092.R1, doi: 10.14359/51728189. The presented method does not affect the nominal size of bar end to be coupled.

According to still another aspect of the invention, the mechanical coupler can connect reinforcing bars in various directions to be used as a mechanical coupler joint for trusses to reinforce the concrete members. As an example, the mechanical coupler joint connects one longitudinal horizontal reinforcing bar represent truss upper or lower chord and ends of two reinforcing bars represent two truss diagonals. The joint comprise of a steel plate of sufficient thickness having three internal holes with threaded surfaces. One of them drilled longitudinally crossing the plate thickness along the upper front length of the coupler joint. The cross section diameter of this hole is slightly larger than the diameter of the chord to be joint. The plate is prepared also with two diagonal holes as shown in Fig 10. The outwardly circumferential reinforcing bar end ribs to be coupled of the two diagonal bars (553 and 554) are prepared with male threads identical with the inner female threaded of these holes. The longitudinal axes of the three holes correspond to the longitudinal axes of the reinforcing rods that will coupled in this coupler joint. Three sets of threaded holes are drilled perpendicular to the front plane of the coupler joint. Each set comprises of a plurality of holes which drill perpendicular to the front plane of the plate along each hole axis for the three threaded holes. Three other holes passing through the plate thickness are drilled perpendicular to the front plane of the coupler joint between the longitudinal hole axis. Means for gipping the three reinforcing bar ends. This aspect present more economic, easier and applicable mechanical joints for trusses to reinforce the concrete and composite elements. It simplifies the mechanical joints presented in the patent application number WO/2016/138912 and European patent number EP15883847.

DETAILED DESCRIPTION**First coupler type:**

Fig 6 a, b and c illustrates the details of the second coupler shape (200). As in the first coupler closure technique, the coupler body is made of a tubular sleeve with an inner female threads surface (205 and 206) while the outer surface made with down taper thread (203 and 204) directed towards the two tubular sleeve ends. As shown in Fig 6.a and b, the coupler tubular sleeve is then split along its axis into two similar halves (201 and 202).

Each bar end is prepared with male threads (110 and 111) which cut into the bar ribs (deformations) thickness. These threads (110 and 111) are identical with the inner female threads of the coupler tubular sleeve (205 and 206).

As shown in Fig 6.c, the two halves of the coupler tubular body (201 and 202) are assembled over the ends of the two reinforcing bars 1 and 2 to be connected, assuring that, interring of the reinforcing bars male threading (110 and 111) into the inner coupler sleeve halves female threading (205 and 206).

The two halves of the coupler tubular body (201 and 202) are tightly closed on the two-bar ends (1 and 2) by two lock nuts (210 and 211) having internal taper thread and slope identical to the external thread and slope of tubular sleeve halves (204 and 203). The coupling is performed by assembling the tubular sleeve halves (201 and 202) over the reinforcing bar ends (1 and 2) assuring that, fitting the reinforcing bars male threading (110 and 111) into the inner two sleeve halves female threads (206 and 205) , then, interring and turning the two nuts (210 and 211) over the two sleeve halves, Fig 6.c. This step presses the two coupler sleeve halves over the two bar ends and digging the circumferential male threads of the reinforcing bar ends and the circumferential surfaces between the ribs into the inner female threads of the tubular sleeve body halves. The final shape of the mechanical coupler gripping the ends of the reinforcing bars 1, 2 with the two nuts 210 and 211 is shown in Figure 6.d.

Second coupler type:

The previous two methods are effective, but they require torque wrenches with the open ends of large size and big torque capacity, which may cause problems in implementation, especially in the congestion due to the presence of a big number of reinforcing bars.

Another further aspect of the invention, a coupler (300) for gripping the end portion of reinforcing bar, comprises:

Male screw threads are cut into the outwardly projecting rib thickness for the designed coupling length of the reinforcing bar end portion 1 as shown in Fig 7.b and 7.c.

As shown in Fig 7.a, an elongated tubular sleeve (301) having two eccentric longitudinal holes (303 and 304) drilled along the longitudinal axis of the tubular body. The first hole (303) has a diameter larger than the diameter of the reinforcing bar (1 or 2) to be joined so that it can be inserted easily, and the second hole (304) has a cross-section centered slightly below the center of the first hole and the diameter of its section is close to the nominal diameter of the reinforcing bar (without deformations).

Identical female screw threads (302) with the male threads (110) that cut into the circumferential male threads of the reinforcing bar ends portion are made in the inner surface of the second hole of the tubular sleeve body.

A plurality of Longitudinally spaced threaded holes (305) are also formed within the tubular sleeve body in opposing relation to the inner threading (302) of the tubular coupler sleeve (301) and a plurality of bolts (306) with hex or socket head shaped outer end portion and some with cone point set screw is threaded into each hole.

The coupling of the two axially aligned reinforcing bars is done by the following steps:

- Inserting the ends of the two reinforcing bars (1 and 2) into the two tubular sleeve opening insuring interring of the reinforcing bars deformation male threading into the inner female threading portion of the coupler sleeve, Fig 7.c.
- Tightening torque the bolts (305) against the reinforcing bars (1 and 2), generating positive bearing pressure and interlocking between the reinforcing bar and the inner lower surface of the tubular sleeve and increasing the shear resistance of the circumferential reinforcing bar male threading (110 and 111) with inner coupler sleeve female threading (302).

According to another aspect of the invention, tightening the bolts (306) against the reinforcing bar ends (1 and 2) provide also engaging the inner coupler sleeve threading (302) into the circumferential surface of the lower half of the reinforcing bar between the ribs, adding more inter-locking area of the reinforcing bar coupled portion with the inner coupler sleeve. On the contrary, the conventional methods which rely on engaging in very small areas from the reinforcing bar deformation surfaces with the inner tubular sleeve. Fig 4. Illustrates, the forces P_i ($i=1$ to 4) arising from tightening the bolts that force the reinforcing bar and reactions R_i on the reinforcing bar ribs. Fig 4 also shows, bolts digging points and resting points of the reinforcing bar ribs within the mechanical coupler sleeve. Not all the circumferential surfaces of the bar end and the inner coupler sleeve surface in full contact. Therefore, the proposed method in this section gives a much greater area of bearing with friction and positive interlocking between the coupled circumferential surfaces of the reinforcing bar including the ribs than the traditional methods in patents such as U.S. Pat. No. 4,314,771, US20050169701A1, US5909980A, US20060067785A1 and US5664902A.

Third coupler type

In the first and second devices and methods, tubular coupler depending on making male threads cut into the bar ribs (deformations) thickness and identical to female threads made on the inner surface of the coupler tubular sleeve. The coupler tubular sleeve is then split along its axis into two similar halves. These two halves are assembled over the two reinforcing bar ends, assuring the coincidence of the reinforcing bars male threading with the inner coupler sleeve halves female threading. The two halves of the coupler tubular body are tightly closed on the two bar ends by two closure techniques to produce confining and pressing the tubular coupler sleeve halves over the both ends of the reinforcing bars. As described above, the two methods require machining in the external surface of the coupler body, torque wrenches with the open ends of large size and big torque capacity.

The third closure technique engages half of the lower outer surface of the reinforcing bar end to be coupled with the lower inner surface of the mechanical coupler sleeve body.

Still another aspect of the invention takes advantage of the engagement and friction of most circumferential surfaces of the bar end to be coupled with the inner circumferential surface of the tubular sleeve coupler. In addition a plurality of longitudinally spaced threaded holes are also formed within the tubular sleeve body and a plurality of bolts with hex or socket head shaped is threaded into each hole. Tightening the bolts against the reinforcing bars provide also enhanced the engagement of the inner coupler sleeve female threading into the bar ribs male threading as well as the digging the circumferential surface of the reinforcing bar between the ribs. In this method, threading is carried out at the end of a reinforcing bar (1) with a length equal to half the length of the mechanical coupler sleeve, while the end of the second bar (2) is threaded with a length equal to twice the length at the end of the first bar, so that neither bar need to be rotated.

In the coupler type (400), an elongated tubular sleeve (410) prepared with longitudinal hole along the longitudinal axis of the tubular sleeve body (410). The inner sleeve diameter is close to the nominal diameter of the reinforcing bar (1 and 2). Male screw threads (403 and 404) are cut into the outwardly projecting ribs thickness for the designed coupling length of the reinforcing bar end portion (1 and 2) as shown in Fig 8.a. The thread length (404) that cut into the outwardly projecting rib thickness of the bar (2) twice that cut into the bar ribs end (1). The reason of this longer threading length is the need of neither bar can be rotated. Identical female screw threads (401) with the male

threads (403 and 404) that cut into the circumferential ribs of reinforcing bar end portion are made in the inner surface of the hole of the tubular sleeve body (400). Two or three rows of longitudinally spaced threaded holes is also formed within the tubular sleeve body and a plurality of bolts (402) with hex or socket head shaped is threaded into holes. The coupler body is turned around the end of the bar (2) to engage the reinforcing bar male thread (404) inside inner coupler body female thread (401) with its longitudinal full length. Then the coupler body is then turned in the reverse direction around the bar (1) so that it inserted from the other opening of the coupler sleeve while the coupler sleeve departs from bar (2) at the same length as it entered into the bar (1). Then, tightening the bolts (402) against the reinforcing bar end. As mentioned above, two or three rows of bolts can be used, between each two row, an angle of 120 degrees, as shown in Fig 8.d and e. This technique enhances the engagement of the inner coupler sleeve female threading into the bar ribs male threading as well as the female threads digging the circumferential surface of the reinforcing bar between the ribs. In addition, it gives the slimmer mechanical coupler size and does not reduce the nominal size of the reinforcing bar.

Another aspect that combines the third and fourth coupler types needed where the continuation bars cannot be rotated as illustrated in Figure 8.f. The coupler (340) comprises a tubular sleeve divided longitudinally into two parts (410 and 301). Each part is similar, both internally and externally, to one of the third and fourth coupler types (300 and 400) respectively. After threading the circumferential ribs of the two reinforcing bar ends, the coupler is rotating to receive the reinforcing bar (2) by the method described in the fourth coupler type, then the reinforcing bar (1) is inserted without rotation from the other sleeve opening, and then the bolts (306 and 402) are tightened to fix the two reinforcing bars.

Other uses

According to still another aspect of the invention the idea is not limited to connecting two aligned reinforcing bars, therefore, the invention provides a mechanical coupler (500 or 700) to connect two perpendicular reinforcing bars with any of the coupler techniques presented in this application. As shown in Fig (9.a and 9.b) the coupler type like the first coupler type (100). The addition in this part is a bolt pass through a hole prepared at the meeting of the longitudinal axis of the two sleeves and the two perpendicular reinforcing bars to tightly close the two coupler halves, Fig 9.a. The need for this type of coupler type to overcome the problems arising from cold bending as discussed in ACI Structural Journal manuscript S-2020-092.R1, doi: 10.14359/51728189. The results of this research showed that using L-shaped mechanical couplers instead of bending bars significantly improved the ductility and load-carrying capacity of the specimens.

According to still another aspect of the invention, the mechanical coupler can connect reinforcing bars in various directions to be used as a mechanical coupler joint for trusses of reinforcing the concrete members, as in Fig 10.a. A mechanical coupler joint for reinforcement the structural concrete members connecting a plurality of reinforcing bars, upper or lower chord (551 or 552) and diagonals (553 and 554) comprises:

- a) A steel plate (550) of sufficient thickness having three internal holes with inner threaded surfaces, one of them design to couple a continuous upper or lower truss chord (551 or 552), drilled longitudinally along the front length of the said coupler joint with a diameter slightly larger than the diameter of the rebar to allow the bar to enter easily. As shown in Fig 10.b, the coupler joint couple upper chord (551). The other two threaded holes prepared for gripping the two diagonal members of the truss (553 and 554).
- b) As in all the coupler types presented in this invention, the outwardly circumferential reinforcing bar end ribs to be coupled of the two diagonal bars prepared with threads identical with the inner female threaded of the holes. The longitudinal axes of the three holes correspond to the longitudinal axes of the three reinforcing bars that coupled in the said coupler joint (551, 553 and 554).
- c) Three sets of threaded holes (560, 561 and 562) are drilled perpendicular to the thickness and front plane of the coupler joint, each set comprises of a plurality of threaded holes drilled

perpendicular to the specified plane of the said steel plate along each hole longitudinal axis of the three threaded holes,

d) Three sets of bolts (560, 561 and 562) with hex or socket head shaped outer end portion and some with cone point set screw is threaded into three sets of threaded holes,

e) The coupling is done by turning the coupler joint around one of the diagonal bar or a diagonal bar ends to inter one diagonal threaded hole according to the truss assembling system. The same sequence is done for the other into the diagonal bar insure interring of the reinforcing bars deformation male threading into the inner female threading portion of each hole opening, then inter the upper or lower chord bar into the longitudinal horizontal threaded hole, then tightening torque the bolts (560, 562 and 563) against the longitudinal and the diagonal reinforcing bars respectively.

DESCRIPTION OF THE DRAWING FIGURES

Fig 1.a: The early developed threaded mechanical coupler (patent number, US3083043A, 1963).

Fig 1.b: The early developed taper mechanical coupler (patent number, US3415552A, 1968).

Fig 1.c: A mechanical coupler in which neither bar can be rotated (patent number US 5,067,844, 1991)

Fig 2: Mechanical coupler based on copying bar deformation into the inner coupler sleeve surface, (patent application WO2005111336A1).

Fig 3: Mechanical coupler based on copying bar deformation into the inner coupler sleeve surface and external taper surface, (patent application WO2005111336A1).

Fig 4: The rebar deformation shapes due to the rolling manufacturing process.

Fig 5: Forces P_i ($i=1$ to 4) arising from tightening the bolts that force the reinforcing bar and reactions R_i on ribs.

Fig 6.a: Exploded view of the second coupler (200) with sleeve two halves, an inner female thread surface (105) and outer taper threading and as well as locking sleeves with internally taper threads.

Fig 6.b: Exploded view of the two coupler sleeve halves for the second coupler type 200.

Fig 6.c: 3-D view of the coupler second type during assembly.

Fig 6.d: 3-D view of the assembled coupler second type.

Fig 7.a: Isometric view of the coupler type (300), cut off part of it, showing the tubular sleeve 301 with inner lower threads (302), threaded holes (305) and bolts (306).

Fig 7.b: Exploded view of the coupler type (300), cut off part of it, showing the tubular sleeve 301 and circumferential rib threads (110) of the bar end (1).

Fig 7.c: Exploded view of the coupler type (300), cut off part of it, showing the two bars to be coupled as well as tubular sleeve 301 and circumferential rib threads (110) of the bar ends (1 and 2).

Fig 7.d: A section of the assembled coupler (300) showing: the sleeve, the two longitudinal holes (301 and 302), the bolt and the interlock of the bar and sleeve threads in black color.

Fig 8.a: Exploded view of the coupler type (400), cut off part of the tubular sleeve (410), the inner threads, the two bars with rib threads (403 and 404) and bolts (402).

Fig 8.b: Exploded view of the coupler type (400), sleeve (410), the two bars and the lengths of the bar end rib threads.

Fig 8.c: Plane view of the assembled coupler type (400). Half of the bar ribs threads of the reinforcing bar (2) are outside the coupler body.

Fig 8.d: A section of the assembled coupler (400) showing: the sleeve and the two rows of bolts.

Fig 8.e: A section of the coupler (400) showing: the sleeve, the assembled bar (1) and the three rows of bolts.

Fig 8.f: A plane and a front section of the coupler type (340) combine of the two coupler type (300 and 400) used where the continuation bar cannot be rotated.

Fig 9.a: Exploded view of the second coupler (500) for coupling two perpendicular bars using the technique in the coupler type (100).

- 5 Fig 9.b: A section of the coupler (700) for coupling two perpendicular bars using the technique in the third and fourth coupler types.

Fig 10.a: A front elevation of a truss with mechanical joint (550).

Fig 10.b: A front elevation and a side view of the truss coupler joint.

CLAIMS

1. A mechanical coupler for gripping the ends of generally reinforcing bars, having outer circumferential ribs, comprises: a coupler body, including tubular sleeves and screw elements, wherein each said tubular sleeve has received a bar end of one of the reinforcing bars, each sleeve has an inner female threaded surface corresponds with the male threads that cut into the circumferential protruding rib thicknesses of each bar end, the gripping of the bar ends is based on the double action of screw elements and the threading of the outwardly circumferential bar ribs without enlargement or undercut the nominal bar diameter.
2. The mechanical coupler for joining a pair of two axially-aligned reinforcing bars according to claim 1, comprises:
 - a) the outer surface of the said tubular sleeve made with down taper thread directed towards the two sleeve ends, the coupler tubular sleeve is then split along its axis into two similar halves,
 - b) the two halves of the coupler tubular sleeve are assembled over the ends of the two reinforcing bars to be connected, assuring that, interring of the reinforcing bars male threading into the inner coupler sleeve halves female threading,
 - c) the two sleeve halves of the coupler tubular body are pressed over the two-bar ends by two lock nuts having internal taper thread and slope identical to the external thread and slope of tubular sleeve halves,
 - d) the coupling is performed by assembling the tubular sleeve halves and reinforcing bar ends assuring that, fitting the reinforcing bars male threading into the inner two sleeve halves female threads, then, interring and turning the two nuts over the two sleeve halves, this step presses the two coupler sleeve halves over the two bar ends and digging the circumferential male threads of the reinforcing bar ends and the circumferential surfaces between the ribs into the inner female threads of the tubular sleeve body halves.
3. The mechanical coupler for joining a pair of two axially-aligned reinforcing bars according to claim 1, comprises:
 - a) an elongated tubular sleeve having two eccentric longitudinal holes drilled along the longitudinal axis of the tubular sleeve, the first hole has a diameter larger than the diameter of the reinforcing bars to be joined so that it can be inserted easily, and the second hole has a cross-section centered slightly below the center of the first hole and the diameter of its section is close to the nominal diameter of the reinforcing bar (without deformations),
 - b) for the inner surface of the said second hole, each opening prepared with inner female threaded surface corresponds with the male threads that cut into the circumferential protruding rib thicknesses of each bar end,
 - c) a plurality of Longitudinally spaced threaded holes are formed within the tubular sleeve in opposing relation to the inner threading of the tubular coupler sleeve and a plurality of bolts with hex or socket head shaped outer end portion and some with cone point set screw is threaded into the threaded holes,
 - d) the coupling of the two axially aligned reinforcing bars is done by inserting the ends of the two reinforcing bars into the two tubular sleeve opening insuring interring of the reinforcing bars deformation male threading into the inner female threading portion of the coupler sleeve, then tightening torque the bolts against the reinforcing bars, generating positive bearing pressure and interlocking between the reinforcing bar and the inner lower surface of the tubular sleeve as well as increasing the shear resistance of the circumferential reinforcing bar male threading with inner coupler sleeve female threading.

4. The mechanical coupler for joining a pair of two axially-aligned reinforcing bars according to claim 1, comprises:
 - a) an elongated tubular sleeve prepared with longitudinal threaded hole along the longitudinal axis of the tubular sleeve body, the inner sleeve diameter is close to the nominal diameter of the reinforcing bar,
 - b) male screw threads are cut into the outwardly projecting ribs thickness for the designed coupling length of the reinforcing bar end portion, the thread length that cut into the outwardly projecting rib thickness of one bar end twice that cut into the continuation bar ribs end, two or three rows of longitudinally spaced threaded holes are formed within the tubular sleeve body and a plurality of bolts with hex or socket head shaped is threaded into the said threaded holes.
 - c) each inner coupler sleeve opening prepared with inner female threaded surface corresponds with the male threads that cut into the circumferential protruding rib thicknesses of each bar end,
 - d) the coupler sleeve is turned around the end of the first bar to engage the reinforcing bar male thread inside inner coupler body female thread with its longitudinal full length, then the coupler is then turned out in the reverse direction to receive the continuation bar so that it inserted from the other opening of the coupler sleeve, so that it is inserted from the other coupler sleeve opening while the coupler sleeve departs from the first bar at the same length as it entered into the continuation bar,
 - e) tightening the bolts against the reinforcing each bar end, between each two row an angle of 120 degrees.
5. The mechanical coupler for joining a pair of two axially-aligned reinforcing bars according to claim 4 and 5, comprises:
 - a) a coupler tubular sleeve divided longitudinally into two portions, each portion is similar, both internally and externally, to one of that described in claim 4 and 5 respectively,
 - b) for gripping the two aligned reinforcing bars, the said tubular sleeve portion similar to that claimed in claim 5 is rotate around one of the two reinforcing bar to insert it inside this coupler portion,
 - c) the continuation bar end is then inserted without rotation from the other opening assuring that, fitting the reinforcing bars male male threading with the corresponding inner tubular sleeve female threading like that described in claim 4, and then the bolts are tightened to fix the two reinforcing bars.
7. The mechanical coupler for joining two perpendicular reinforcing bars according to claim 1, comprises a coupler body including two sleeve opening, each one prepared to receive one from the two reinforcing bars end by one of the methods claimed in claims 4 and 5.
8. A mechanical coupler joint for reinforcement the structural concrete members connecting a plurality of reinforcing bars according to claim 1 comprises:
 - a) a steel plate of sufficient thickness having three internal holes with inner threaded surfaces, one of them, design to couple a continuous upper or lower truss chord, drilled longitudinally along the front length of the said coupler joint with a diameter slightly larger than the diameter of the rebar to allow the bar to enter easily and two diagonal threaded holes for gripping the two diagonal members of the truss,
 - b) the outwardly circumferential reinforcing bar end ribs to be coupled of the two diagonal bars prepared with threads identical with the inner female threaded of the two diagonal holes, the longitudinal axes of the three holes correspond to the longitudinal axes of the three reinforcing bars that coupled in the said coupler joint,
 - c) three sets of threaded holes are drilled perpendicular to the front plane of the coupler joint, each set comprises of a plurality of threaded holes drilled perpendicular to the

front plane of the said steel plate along each hole longitudinal axis of the three threaded holes,

d) three sets of bolts (560, 561 and 562) with hex or socket head shaped outer end portion and some with cone point set screw is threaded into three sets of threaded holes,

e) The coupling is done by turning the coupler joint around one of the diagonal bar or a diagonal bar ends to inter one diagonal threaded hole according to the truss assembling system. The same sequence is done for the other into the diagonal bar insure interring of the reinforcing bars deformation male threading into the inner female threading portion of each hole opening, then inter the upper or lower chord bar into the longitudinal horizontal threaded hole, then tightening torque the bolts (560, 562 and 563) against the longitudinal and the diagonal reinforcing bars respectively.

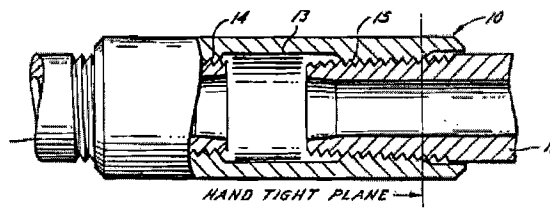


Fig 1.a

US3083043, 1963

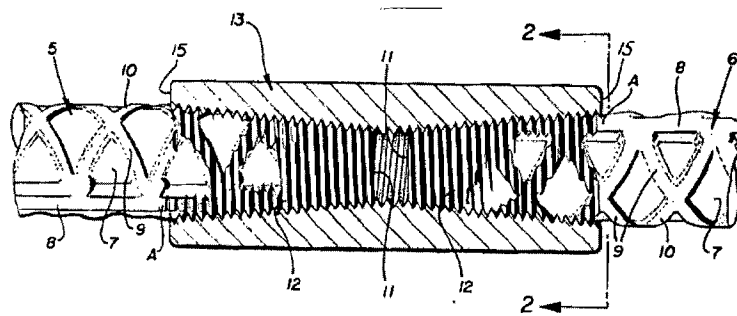


Fig 1.b

US3,415,552, 1968

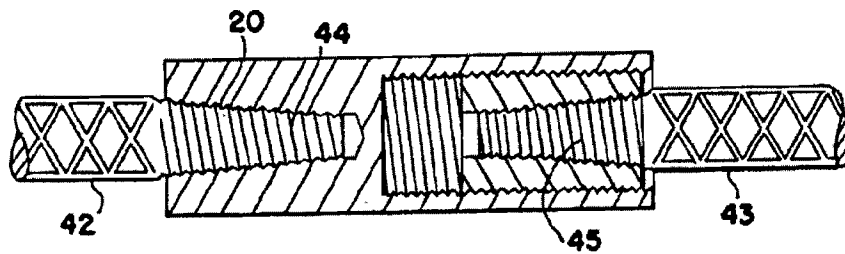
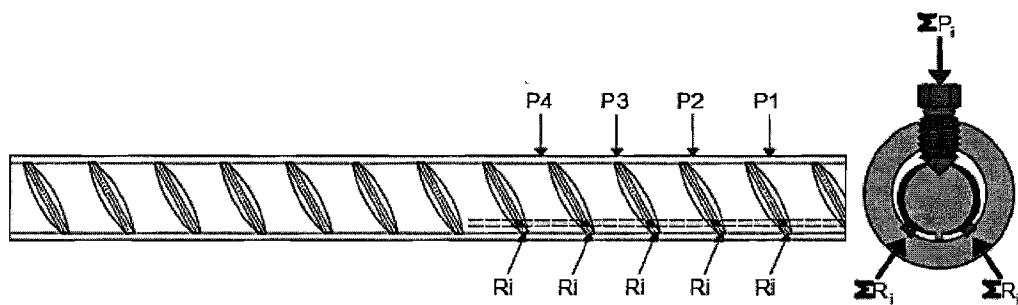
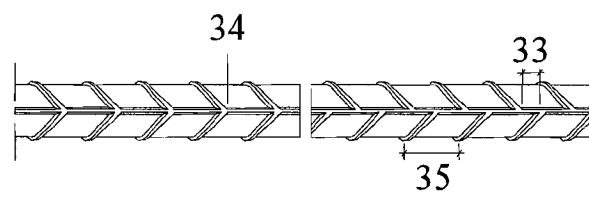
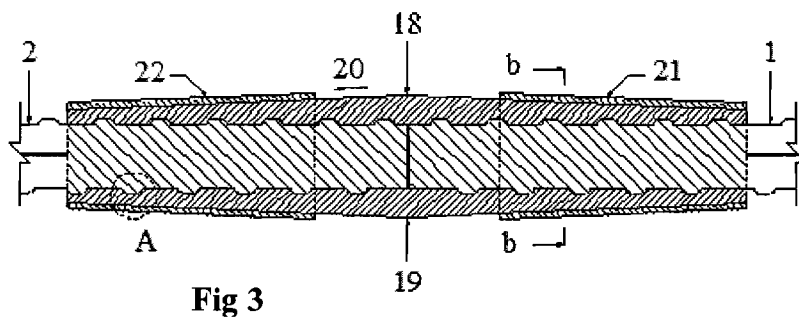
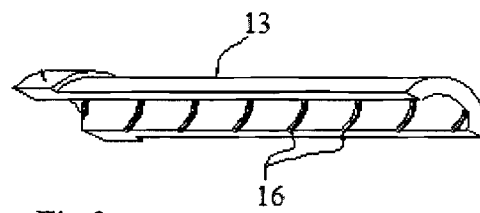
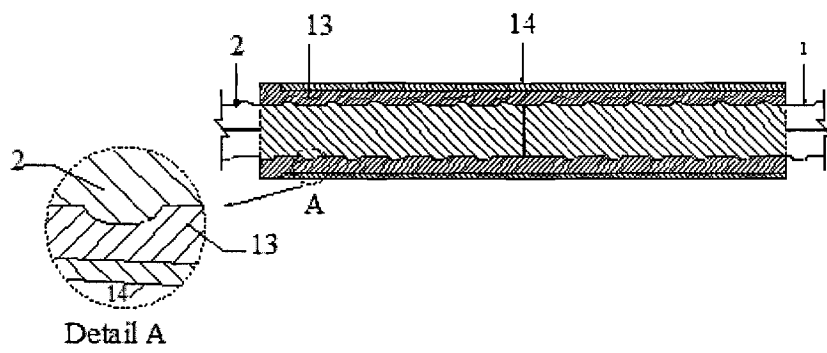
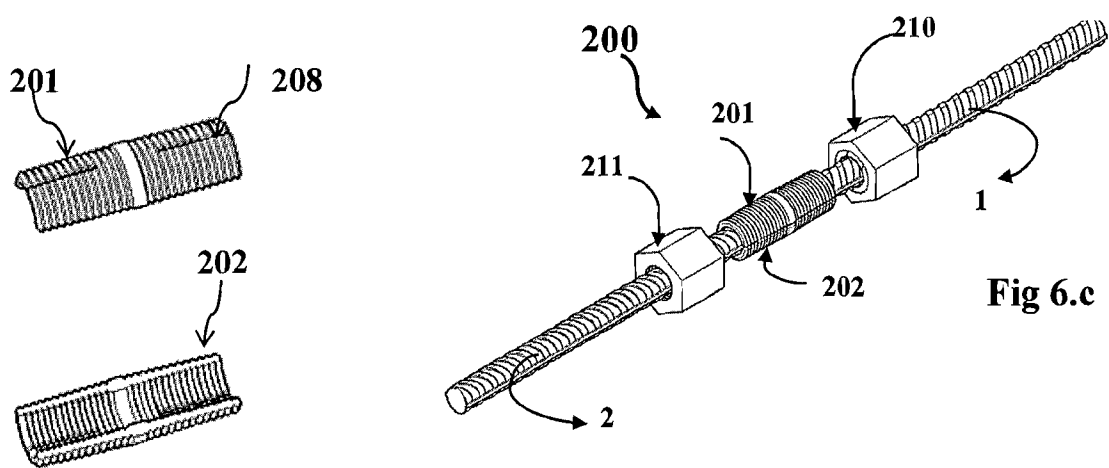
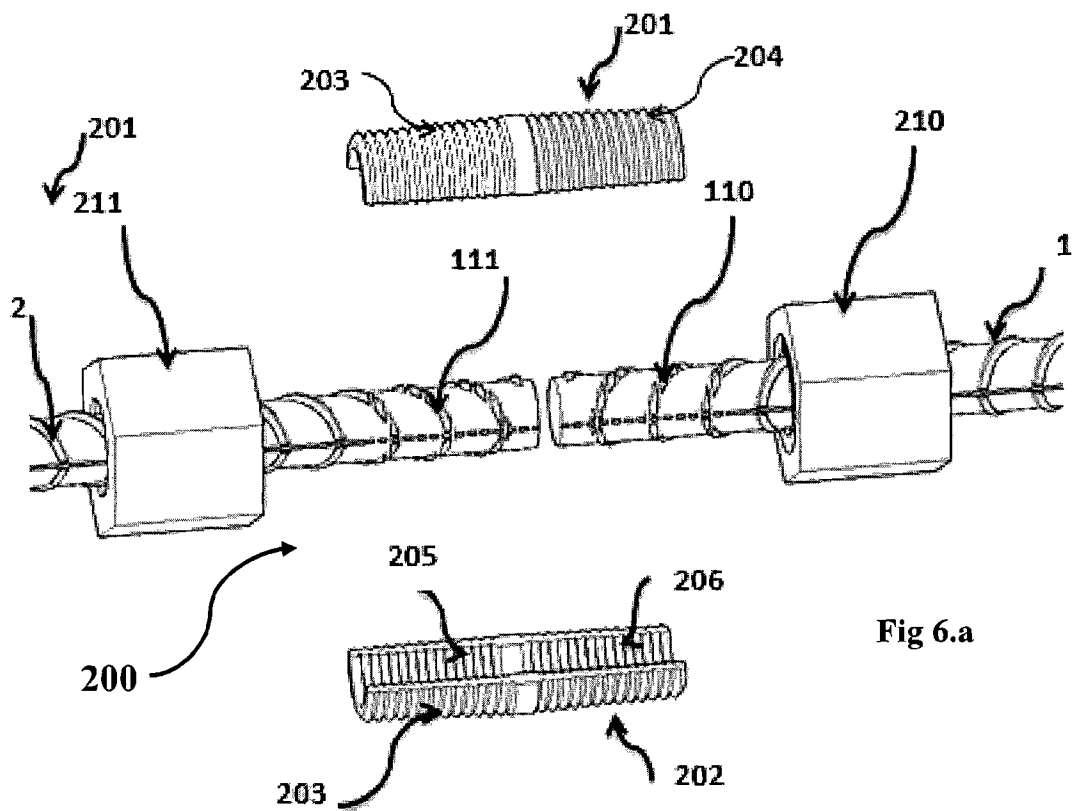


Fig 1.c

US 5,067,844, 1991





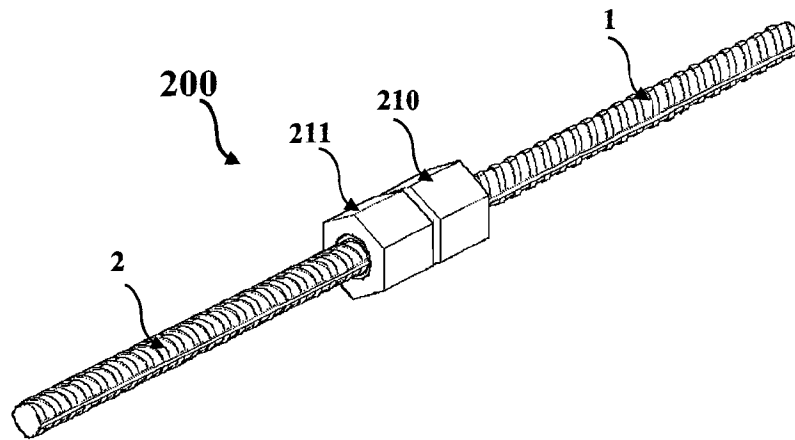
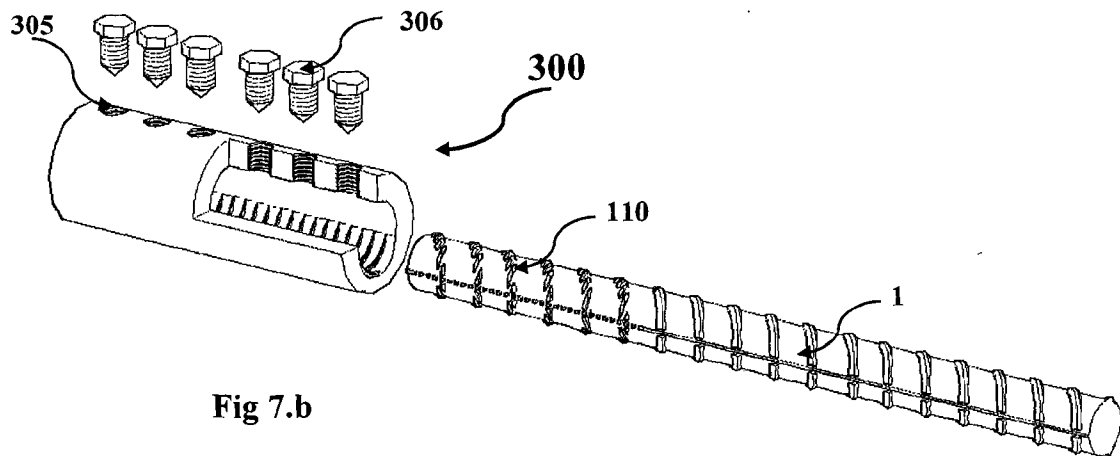
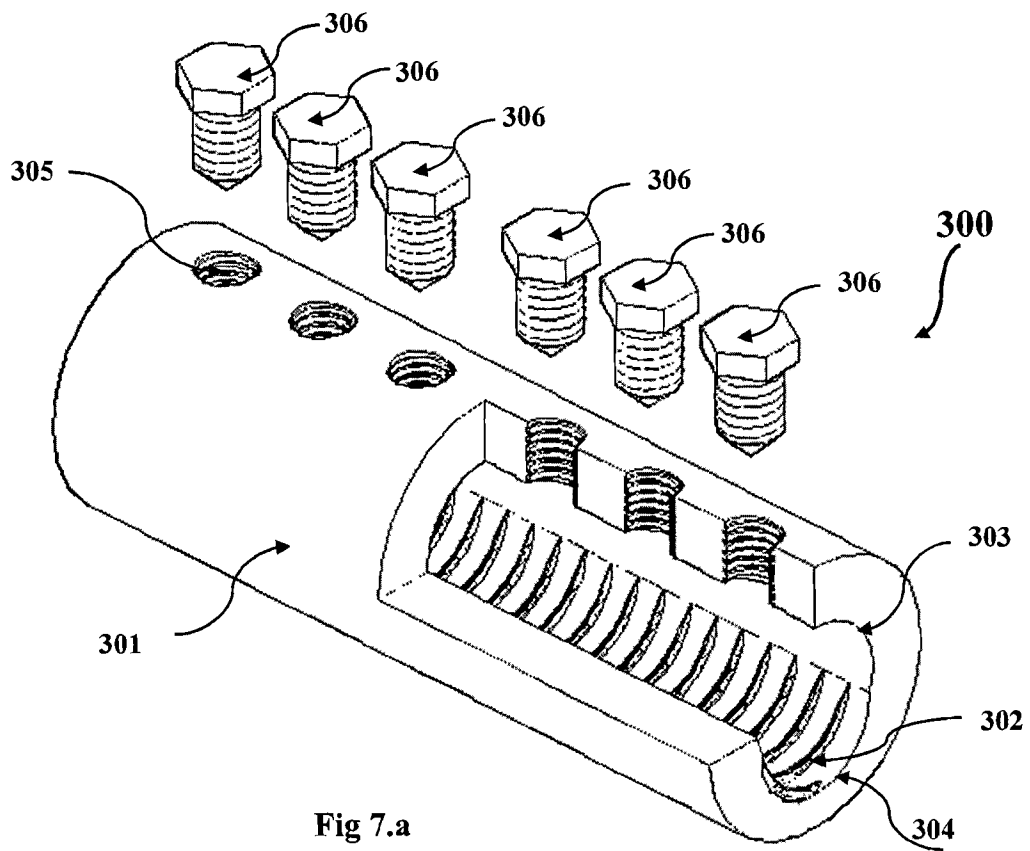


Fig 6.d



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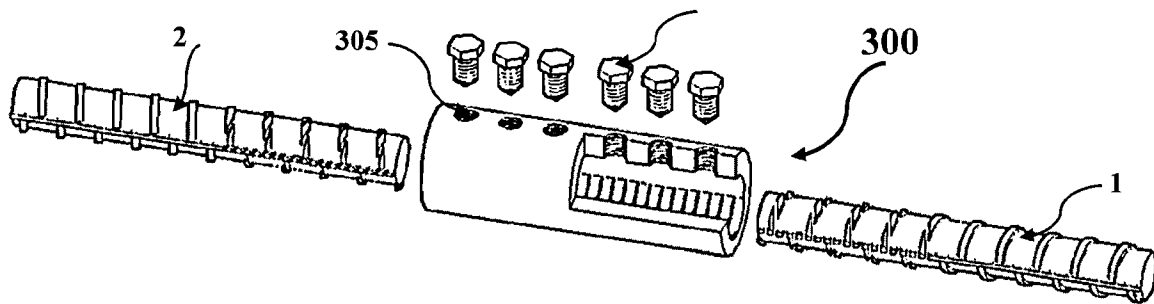


Fig 7.c

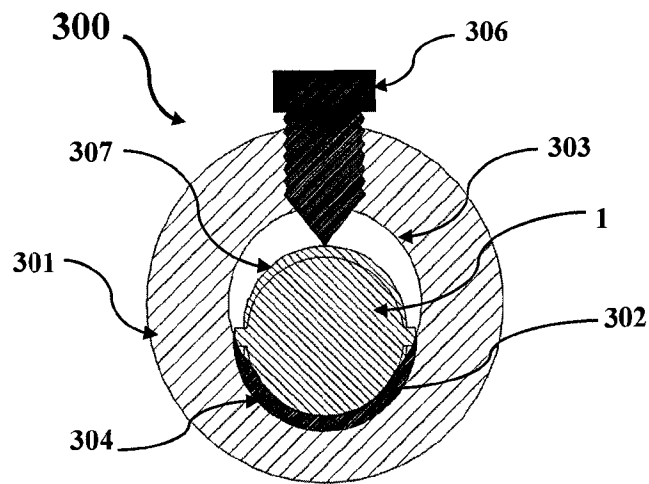


Fig 7.d

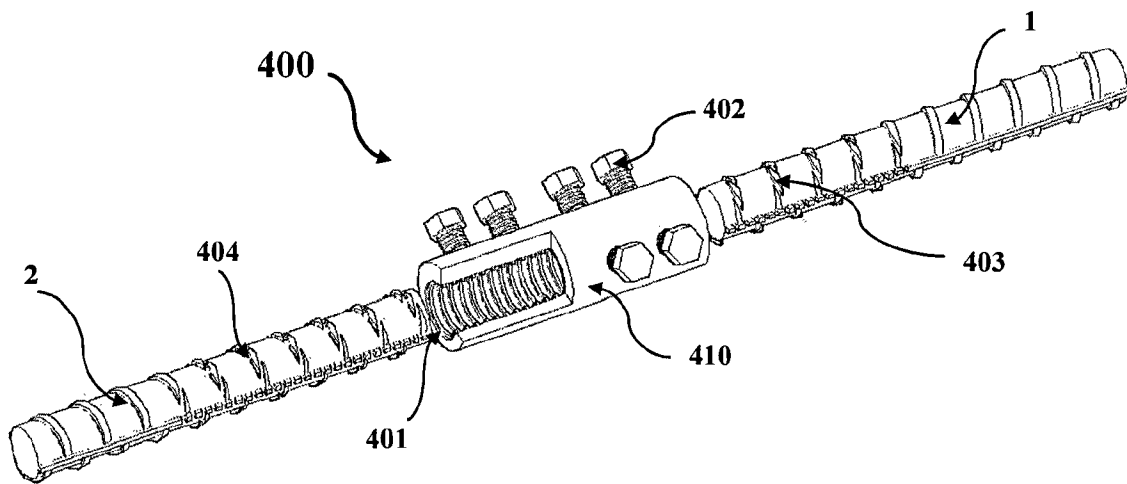


Fig 8.a

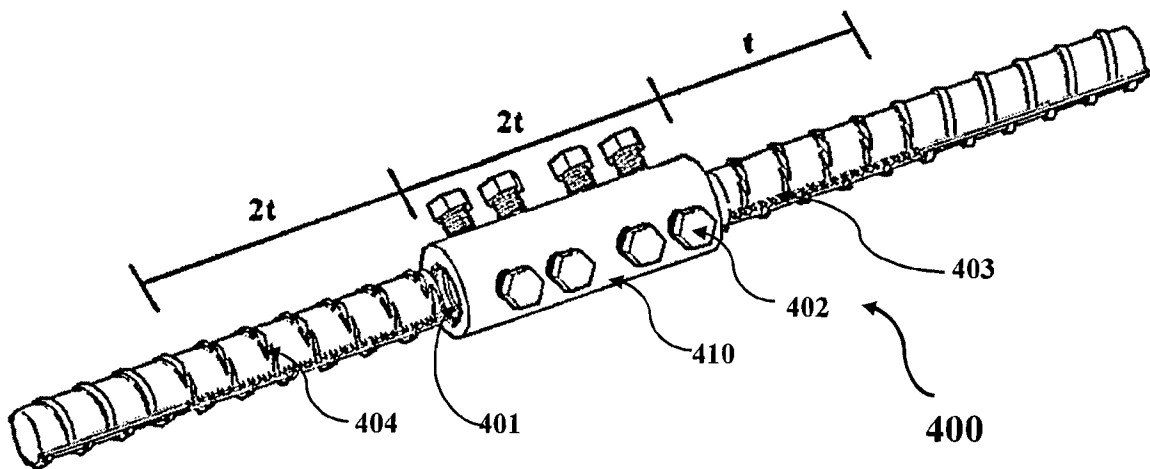


Fig 8.b

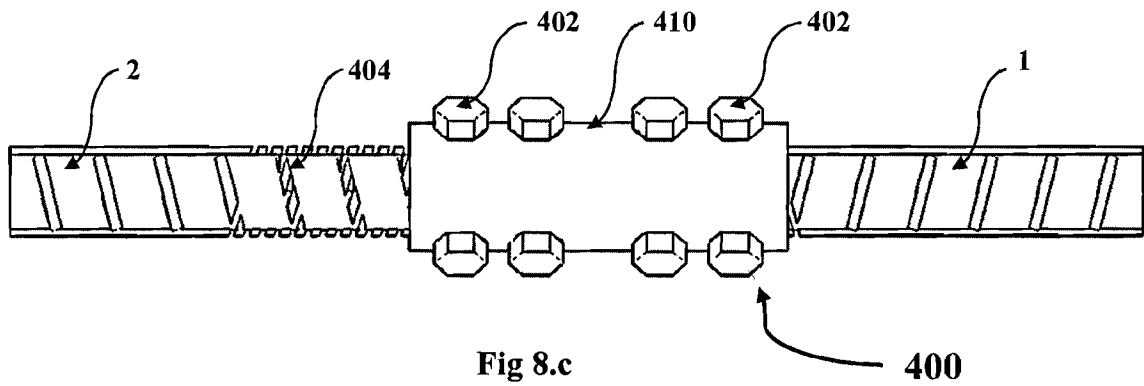


Fig 8.c

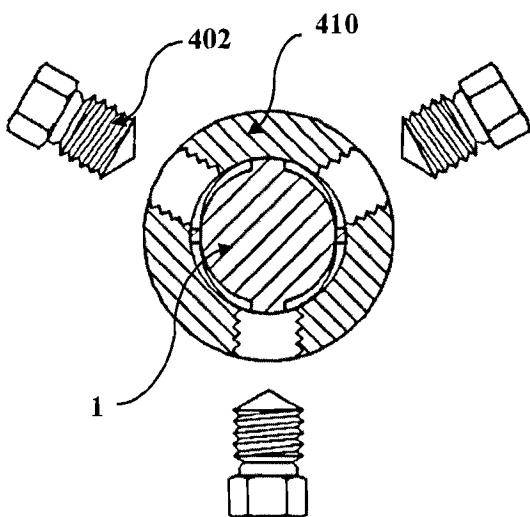


Fig 8.e

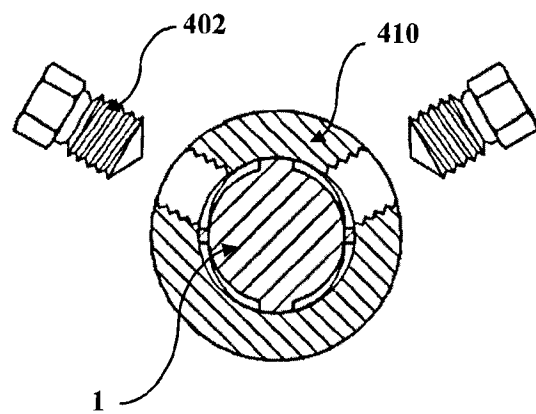
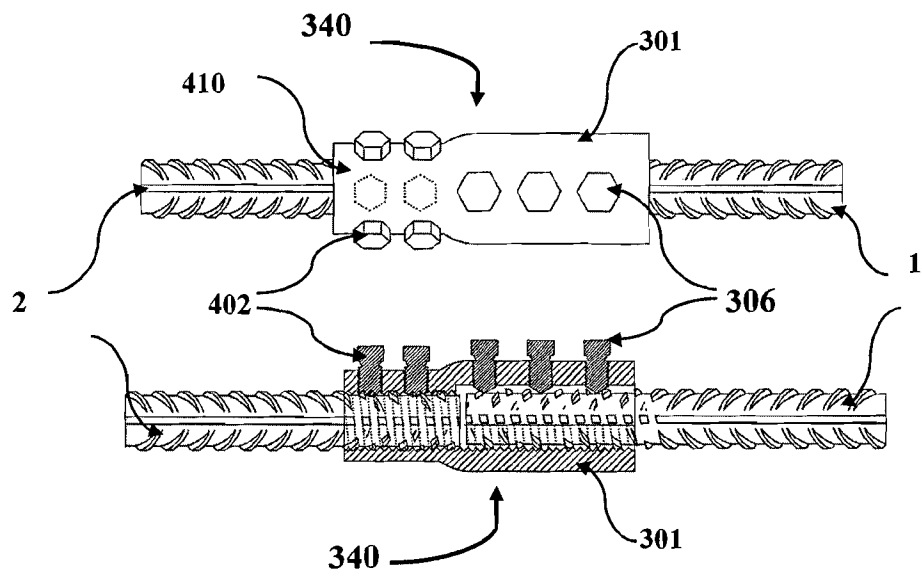


Fig 8.d

**Fig 8.f**

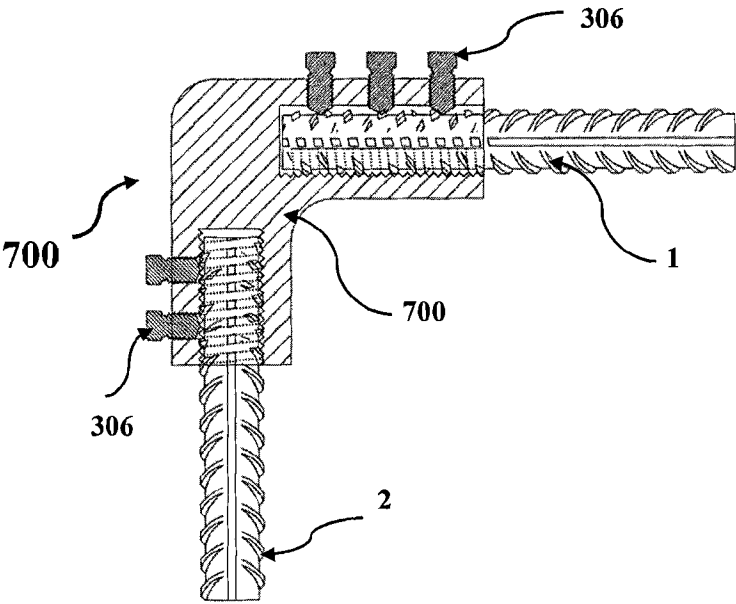
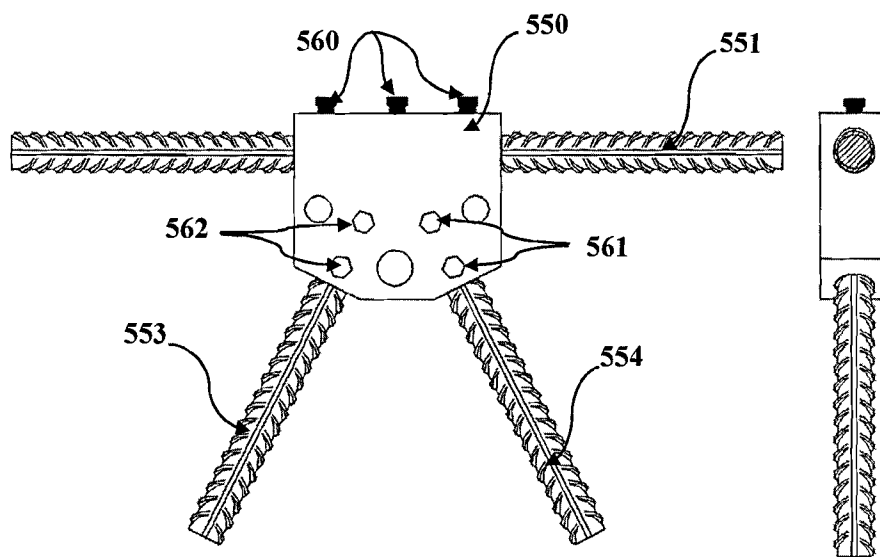
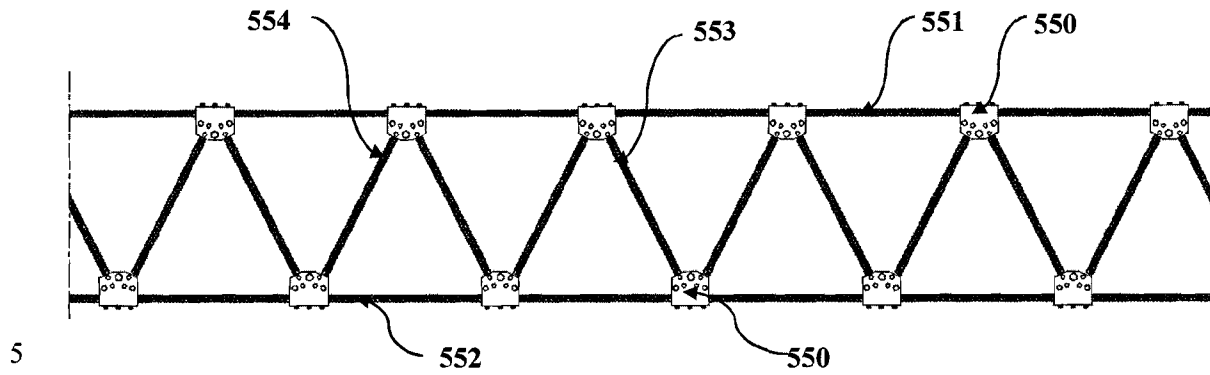


Fig 9.a



INTERNATIONAL SEARCH REPORT

International application No

PCT/EG2021/000039

A. CLASSIFICATION OF SUBJECT MATTER**INV. E04C5/16****ADD.**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E04C

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

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

EPO-Internal**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 105 781 018 B (UNIV SHANDONG JIANZHU)	1, 2
A	9 February 2018 (2018-02-09)	
	abstract; figures 1, 2	3-5, 7, 8

X	KR 101 493 403 B1 (KEPCO ET AL)	1, 3
	23 February 2015 (2015-02-23)	
A	figures 11a, 11b	2, 4, 5, 7, 8

X	WO 2005/061814 A1 (ERICO INT CORP [US];	1, 3, 4
	KIES ANTONIUS M [NL]; KERKAY COLLEEN M	
	[US]) 7 July 2005 (2005-07-07)	
A	abstract; figures 1-3, 8-11	2, 5, 7, 8

A	EP 1 504 163 A2 (ULTIMATE DESIGN SOLUTIONS	1, 3
	LTD [GB]) 9 February 2005 (2005-02-09)	
	abstract; figures	

	-/--	



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

26 August 2022

Date of mailing of the international search report

12/09/2022

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EG2021/000039

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	WO 2016/138912 A1 (AL-TUHAMI AL-TUHAMI ABUZEID [EG]) 9 September 2016 (2016-09-09) abstract; figures -----	1, 8

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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