



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.05.2021 Bulletin 2021/18

(51) Int Cl.:
E04C 3/32 (2006.01) **E04C 3/09 (2006.01)**
E04C 3/04 (2006.01)

(21) Application number: **19205964.0**

(22) Date of filing: **29.10.2019**

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

(72) Inventor: **Van den Brink, Bas**
6611 LE Overasselt (NL)

(74) Representative: **Jacobs, Bart**
Arnold & Siedsma
Bezuidenhoutseweg 57
2594 AC The Hague (NL)

(71) Applicant: **VDL Mast Solutions**
5349 AH Oss (NL)

Remarks:

Claims 16-20 are deemed to be abandoned due to non-payment of the claims fees (Rule 45(3) EPC).

(54) **METHOD FOR MANUFACTURING A TUBULAR BRACE MEMBER AND LATTICE TOWER COMPRISING THE SAME**

(57) The present application concerns a method for manufacturing a tubular brace member. Moreover, the present application concerns a lattice tower comprising such a tubular brace member, preferably manufactured according to said method.

In the method according to the invention, one or more sections are removed from at least one end of a circular hollow section such that one or more curved wall sections remain. Each curved wall section is deformed into a respective gusset plate connection member having a substantially flat connection section, by pressing together molds in between which the curved wall sections are arranged. The flat connection section of each gusset plate connection member comprises a through hole allowing the gusset plate connection members to be connected to a gusset plate of a corner member of a lattice tower.

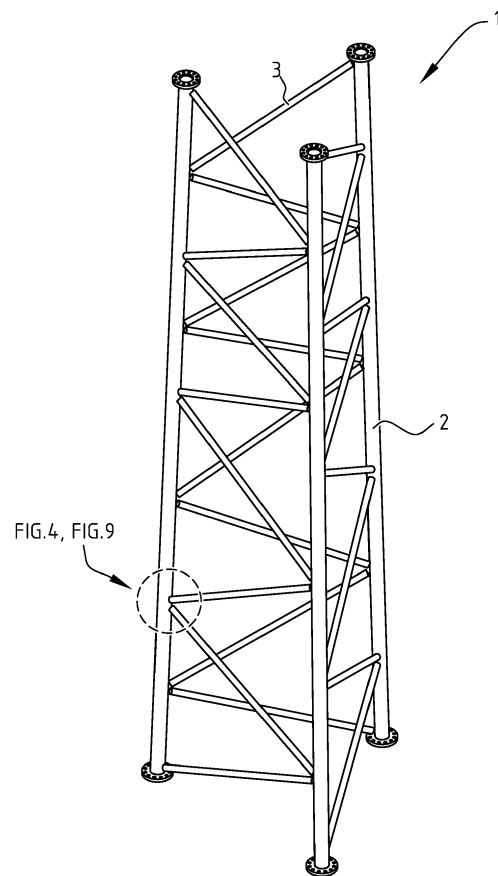


FIG. 1

Description

[0001] The present application concerns a method for manufacturing a tubular brace member. Moreover, the present application concerns a lattice tower comprising such a tubular brace member, preferably manufactured according to said method.

[0002] A general representation of a lattice tower is shown in figure 1. Lattice tower 1 comprises a plurality of corner members 2, each having one or more gusset plates with one or more through holes, and one or more tubular brace members 3, each comprising a circular hollow section (CHS). These tubular brace members are also called diagonals, referring to the direction in which they are commonly installed in the lattice towers. While they may be used for many more purposes, these towers are commonly used in telecommunication, other antenna installations and/or lighting solutions.

[0003] The circular hollow section (CHS) comes with a multitude of known structural advantages and is therefore often used in mast solutions. However, to connect the tubular brace member to a corner member, a flat surface is required to be arranged against the gusset plate of that corner member. The CHS can however not simply be flattened at one end to provide such a flat surface since this would close off the CHS at this end making the tubular member as a whole prone to accumulating fluids in the interior space of the CHS, which could be harmful to the material. Moreover, fully closing off the CHS makes properly submerging the tubular brace member in liquid sink (hot-dip galvanizing) impossible.

[0004] One type of tubular brace member, which can be seen as representative of those known in art, is shown in figures 2A-C and figures 3 and 4. In this tubular brace member 3, CHS 3' is connected to a pair of substantially flat and parallel gusset plate connection members 4', 4" that each have a through hole 6 allowing tubular brace member 3 to be connected to corner member 2.

[0005] Figure 4 illustrates a gusset plate 9 that is welded to corner members 2. A through hole is provided in gusset plate 9 to allow gusset plate 2 to be connected to tubular brace member 3. More in particular, tubular brace member 3 is connected to gusset plate 9 by arranging gusset plate connection members 4', 4" on either side of gusset plate 9, aligning the respective through holes 6 with the through hole in the gusset plate and fixedly attaching tubular brace member 3 and gusset plate 9 by arranging some coupling member, such as a bolt, through the aligned through holes.

[0006] Tubular brace members 3 are manufactured by welding gusset plate connection members 4', 4" to CHS 3'. In this particular example, for each gusset plate connection member 4', 4", a pair of slots was cut in one end of CHS 3' allowing the gusset plate connection member 4', 4" to be arranged therein. Thereafter, gusset plate connection members 4', 4" were welded to CHS 3' thereby producing welding joints 5.

[0007] Welding joints 5 have been found to be the most

vulnerable part of the connection between tubular brace member 3 and corner member 2. Moreover, the process of welding adds a considerable amount of time to the manufacturing process.

[0008] An object of the present invention is to provide a method for manufacturing a tubular brace member in which the abovementioned problems do not occur or at least to a lesser extent.

[0009] According to the present invention, this object has been achieved using the method as defined in claim 1 that comprises the steps of providing a circular hollow section (CHS) having an inner and an outer surface, and removing one or more sections from at least one end of said CHS such that one or more curved wall sections remain. The method additionally comprises positioning a mold on each of the inner and outer surface of each curved wall section, wherein the mold(s) that is/are positioned on the inner surface(s) is/are at least partially received in one or more respective spaces that were left by removing the one or more sections. As a next step, each curved wall section is deformed into a respective gusset plate connection member having a substantially flat connection section, by pressing the respective molds together. For each gusset plate connection member, a through hole in the substantially flat connection section is provided. Alternatively, a through hole is provided in the curved wall section from which the gusset plate connection member was made in such a manner that the through hole will be present in the substantially flat connection section after the curved wall section is deformed.

[0010] According to the invention, the through hole of each gusset plate connection member allows that gusset plate connection member to be connected to a gusset plate of a corner member of a lattice tower.

[0011] Since the flat surface required for sufficient contact between the gusset plate connection member and the gusset plate is provided without having to weld any further elements to the CHS, the abovementioned manufacturing method provides a tubular brace member in which welding connections are less present and in which the overall manufacturing time is reduced.

[0012] The one or more sections can be removed from the at least one end of the CHS by cutting the CHS, preferably by laser cutting the CHS, more preferably with a tube laser cutter. These approaches provide an increasingly higher precision and processing speed at which the tubular brace member can be manufactured.

[0013] Each gusset plate connection member may further comprise a transition section which connects the substantially flat connection section to a remainder of the CHS. This transition sections allows a fairly smooth transition from the CHS to the substantially flat connection area thereby avoiding sharp bends in the tubular brace member, which are known to be vulnerable to buckling.

[0014] To provide the gusset plate connection member with the substantially flat surface, a surface of each mold that presses against a curved wall section among the one or more curved wall sections can be substantially

flat. Alternatively, each gusset plate connection member may further comprise a structural profile in the connection section. These structural profiles make the gusset plate connection member more resilient to forces that act on the tubular brace member perpendicular to the flat surface section of the connection section. To provide the gusset plate connection member with both the substantially flat surface and said structural profiles, a surface of each mold that presses against a curved wall section among the one or more curved wall sections may have a substantially flat central part and curved side parts connected on opposite sides to the central part. The curved side parts may have one or more outward and inward bulges.

[0015] The one or more gusset plate connection members may be provided on opposite ends of the CHS. Two gusset plate connection members can be provided on a same end of the CHS. In a preferred embodiment, two gusset plate connection members are provided on each of a pair of opposing ends of the CHS.

[0016] The step of removing one or more sections from at least one end of the CHS may comprise creating two oppositely arranged slots that separate two curved wall sections from each other, wherein a size of the slots is in correspondence with a thickness of the gusset plate to which the corresponding gusset plate connection members are to be connected.

[0017] More in particular, the positioning of a mold on each of the inner and outer surface of each curved wall section may comprise at least partially arranging a single mold in the two oppositely arranged slots for engaging the inner surfaces of said two curved wall section, wherein a thickness of said single mold is in correspondence with a thickness of the gusset plate to which the corresponding gusset plate connection members are to be connected. More in particular, deforming each curved wall section into a respective gusset plate connection member may further comprise pressing the molds arranged on the outer surfaces of the two curved wall sections together while said single mold is arranged between them. The connection sections of the two gusset plate connection members can be substantially parallel. Moreover, it is further preferred that the through holes of the two gusset plate connection members are aligned.

[0018] Furthermore, the two gusset plate connection members may be deformed such that they slightly taper outwardly. This makes it easier to fit these gusset plate connection members around the gusset plate and since there is no welding joint, the gusset plate connection members can be pulled together to compensate for this taper easier.

[0019] The CHS can be made of steel. In this case, the method may further comprise the step of galvanizing the tubular brace member which makes the tubular brace member more robust against various weather conditions.

[0020] The present invention further provides a lattice tower as defined in claim 15 that comprises a pair of corner members, each having a gusset plate with a

through hole, and a tubular brace member that has been manufactured according to any of the abovementioned methods, wherein the gusset plate connection member(s) arranged on one end of the tubular brace member is/are coupled to the gusset plate of one corner member of the pair of corner members using the through hole of the gusset plate and the through hole(s) of the gusset plate connection member(s).

[0021] The present invention further provides a lattice tower as defined in claim 16 that comprises a pair of corner members, each having a gusset plate with a through hole, and a tubular brace member. The latter tubular brace member comprises a circular hollow section (CHS) having an inner and an outer surface, and one or more gusset plate connection members that are integrally connected to at least one end of the CHS, wherein the one or more gusset plate connection members have been obtained by removing one or more sections from the at least one end of the CHS such that one or more curved wall sections remain and by deforming each curved wall section into a respective gusset plate connection member. Each gusset plate connection member has a substantially flat connection section that is provided with a through hole. Moreover, the gusset plate connection member(s) arranged on one end of the tubular brace member is/are coupled to the gusset plate of one corner member of the pair of corner members using the through hole of the gusset plate and the through hole(s) of the gusset plate connection member(s).

[0022] The tubular brace member may further comprise one or more of said gusset plate connection members arranged on an opposing end of the tubular brace member that are coupled to the gusset plate of the other corner member of the pair of corner members. In this manner, the tubular brace member spans the entire length between the corner members. Alternatively, at least two tubular brace members are used, each connected to a different corner member. In this latter, embodiment, the two tubular brace members are mutually coupled.

[0023] For each gusset plate connection member, an inner surface of the substantially flat connection section may lay against the gusset plate to which the gusset plate connection member is connected in such a manner that the through hole in the substantially flat connection section is aligned with the through hole in the respective gusset plate. In this case, the lattice tower may further comprise a plurality of coupling members, such as bolts, that each extend through a pair of aligned through holes. Furthermore, at least one end of the tubular brace member may comprise two gusset plate connecting members of which the through holes are both aligned with the through hole in the gusset plate to which the two gusset plate connecting members are connected. In this case, the plurality of coupling members may comprise a coupling member that simultaneously extends through the aligned through holes of the two gusset plate connecting members and the through hole of the gusset plate.

[0024] Each gusset plate connection member may further comprise a transition section which connects the substantially flat connection section to a remainder of the CHS, wherein at least one of the transition section and the substantially flat connection section are deformed to have a structural profile.

[0025] Further advantages, features and details of possible embodiments of the lattice tower and tubular brace member will be elucidated on the basis of the following description of the accompanying figures, wherein:

Figure 1 shows a general representation of a tubular lattice;

Figures 2A-C show an example of a known tubular brace member that can be used in a lattice tower as shown in figure 1;

Figure 3 shows an isometric view of the known tubular brace member of figures 2A-C;

Figure 4 shows a connection detail in which the known tubular brace members of any of the figures 2A-C or figure 3 are connected to a corner member; Figures 5A-C show aspects of a connection end of a no-weld tubular brace member according to an embodiment of the present invention;

Figure 6 shows an isometric view of the no-weld tubular brace member of figures 5A-C;

Figures 7A-C show aspects of a connection end of a no-weld tubular brace member according to a further embodiment of the present invention;

Figure 8 shows an isometric view of the no-weld tubular brace member of figures 7A-C;

Figure 9 shows a connection detail in which tubular brace members of any of the figures 7A-C or figure 8 are connected to a corner member; and

Figures 10A-D show the various steps which are performed in a method of manufacturing a tubular brace member according to the present invention.

[0026] Figure 5A shows a top-view of a connection end of a no-weld tubular brace member 30 according to an embodiment of the present invention. No-weld tubular brace member 30 comprises a CHS 3' that is provided, on at least one end, with a pair of gusset plate connection members 7', 7" each having a through hole 6. Gusset plate connection members 7', 7" are integrally connected with CHS 3'. Figures 5B and 5C show a side view and a front view, respectively, of the connection end of figure 5A. In these figures, it can be seen that two gusset plate connection members 7', 7" are parallel and spaced apart relative to each other, wherein a distance between defines a space in which gusset plate 9 can be partially received. More in particular, the distance preferably corresponds to the thickness of gusset plate 9.

[0027] Figure 6 shows an isometric view of no-weld tubular brace member 30. In this figure it can be seen that the connection end of no-weld tubular brace member 30 comprises three segments, a circular section 3a that coincides with one end of CHS 3', a transition section 3b,

and a connection section 3c, wherein sections 3b and 3c together define gusset plate connection members 7', 7", and wherein a through hole 6 is arranged in flat connection section 3C of each gusset plate connection member 7', 7".

[0028] Transition section 3b integrally connects connection section 3c to circular section 3a. The gap between gusset plate connection members 7', 7" stretches from the outer end of connection section 3c to the point where transition section 3b transitions into circular section 3a. It is in part due to this gap between transition sections 3B that gusset plate connection members 7', 7" can be pulled towards each other more easily, and therefore do not have to be an equally tight fit over gusset plate 9 as the gusset plate connection members 4', 4" shown in figures 2A-2C. More in particular, it may even be advantageous to let gusset plate connection members 7', 7" taper outwards slightly (not shown in the figures) to increase the contact surface between gusset plate connection members 7', 7" and gusset plate 9.

[0029] Figure 7A shows a top view of a connection end of a no-weld tubular brace member 300 according to a further embodiment of the present invention. No-weld tubular brace member 300 comprises a CHS 3' that is provided on at least one end with a pair of profiled gusset plate connection member 8', 8", each having a through hole 6 and that are integrally connected with CHS 3'. It can also be seen that the connection end of no-weld tubular brace member 300 consists of three segments, a circular section 3a, which coincides with one end of CHS 3', a transition section 3b, and a profiled connection section 3C, wherein sections 3b and 3c together define profiled gusset plate connection members 8', 8", wherein through hole 6 is arranged in flat connection section 3c.

[0030] Figures 7B and 7C show a side view and a front view of a connection end of tubular brace member 300, and figure 8 shows an isometric view. In these figures, it can be seen that the profiled gusset plate connection members 8', 8" are parallel and spaced apart relative to each other, wherein the distance between profiled gusset plate connection members 8', 8" is configured to partially accommodate gusset plate 9. More in particular, the distance preferably corresponds to the thickness of gusset plate 9.

[0031] Specifically in figures 7A and 7C it can be seen how profiled gusset plate connection members 8', 8" are formed to provide further firmness. Profiled gusset plate connection member 8', 8" each comprise a flat central part 8B that is connected to curved side parts 8A, 8C. Side parts 8A, 8C ensure that the profiled gusset plate connection members 8', 8" are more resilient against deformation by forces that act on the connection end in a direction perpendicular to the substantially flat section of central part 8B in which through hole 6 is arranged.

[0032] Whether it is possible to form the gusset plate connection members with the additional profile depends on the CHS diameter. Common diameters for such tubular brace members are for example 48, 60, 76 and 89

mm. In the case of a 48 mm diameter CHS having a regular wall thickness, the wall to radius ratio is rather large and the structural profile could be omitted.

[0033] In figure 9 it is shown how tubular brace member 300 is connected to corner member 2 by arranging the profiled gusset plate connection members 8', 8" on either side of gusset plate 9, aligning the respective through holes 6 and fixedly attaching tubular brace member 300 and corner member 2 by some connection means, such as a bolt 301.

[0034] Tubular brace members 30 and 300, using the well known circular hollow section as the largest part of their bodies, have superior stiffness in the longitudinal direction over other profile shapes such as a corner profile. Moreover, thanks to the space which is present between gusset plate connection members 7', 7" and 8', 8", tubular brace members 30 and 300 as a whole are not prone to accumulating fluids in the interior space, which could be harmful to the material.

[0035] Figures 10A-C show the various steps which are performed in a method of manufacturing a tubular brace member 30 as shown in figure 10D according to the present invention.

[0036] In particular, figure 10A shows a circular hollow section 3' and figure 10B shows CHS 3' from which two sections have been removed leaving behind respective spaces 10. The remaining parts of CHS 3' that are defined by spaces 10 are referred to as curved wall sections 31, 32. This removing step can for example be done by using a tube laser cutter that can rapidly outline the sections at high precision. In this embodiment in particular, through hole 6 has already been provided in curved wall sections 31, 32. After the sections have been removed, it can be seen that the inner surfaces of curved wall section 31, 32 are exposed.

[0037] Wall sections 31, 32 still have the curvature corresponding to that of circular hollow section 3' and are therefore not yet suitable to be used to connect tubular brace member 30 to corner member 2. In figure 10C it is shown how molds 11a, 11b, 11c can be arranged around curved wall sections 31, 32 to deform curved wall sections 31, 32 into gusset plate connection members 7', 7". That is, one mold 11a is arranged to come into contact with the outer surface of curved wall section 31 and a first surface of a second mold 11b is arranged to come into contact with the inner surface of curved wall section 31. A third mold 11c is arranged to come into contact with the outer surface of curved wall section 32 and a second surface of mold 11b is arranged to come into contact with the inner surface of curved wall section 32. In the scenario that through holes 6 are provided in curved wall sections 31, 32, it is possible that one or more molds 11a, 11b, 11c are provided with stubs which are arranged in the through holes 6 of respective curved wall sections 31, 32 to provide a more stable positioning of said curved wall section 31, 32 during deformation thereof..

[0038] When molds 11a and 11c are pressed together with mold 11b arranged in between them gusset plate

connection members 7', 7" can be formed in a single step. Said pressing together is commonly guided with guide members, shown in figure 10C to be attached to mold 11b and wherein guide openings are provided in molds 11a and 11c. The position of mold 11b is maintained during this step while molds 11a and 11c are simultaneously moved towards mold 11b through which they both deform curved wall sections 31, 32.

[0039] In this particular embodiment, it can be seen that molds 11a, 11b, 11c have parallel, substantially flat surfaces, which, when used to deform curved wall sections 31, 32 into gusset plate connection members 7', 7", provide connection members 7', 7" with a substantially flat connection section in which through hole 6 is provided.

[0040] The result of the deformation can be seen in figure 10D, which corresponds to tubular brace member 30 shown in figure 6.

[0041] While not shown in the exemplary embodiments, it is also possible to manufacture a no-weld tubular brace member with a single gusset plate connection member, which can then also be connected to a similar gusset plate 9. If the part of the corner member to which the tubular brace member is connected to has a different shape than that of a plate, it is also possible to provide a tubular brace member with three or more gusset plate connection members.

[0042] The skilled person will realize that the above-mentioned embodiments are merely exemplary. The method for manufacturing may comprise further steps not mentioned depending on the lattice tower in which it is implemented. Moreover, the tubular brace members may be retrofitted into existing lattice towers if tubular brace members that are present are at risk of failure. Furthermore, the lattice tower and tubular brace member may take many shapes, sizes, and include many other types of elements.

Claims

1. A method for manufacturing a tubular brace member suitable for being connected to a gusset plate of a corner member in a lattice tower, comprising:

providing a circular hollow section (CHS) having an inner and an outer surface;
removing one or more sections from at least one end of said CHS, such that one or more curved wall sections remain;
positioning a mold on each of the inner and outer surface of each curved wall section, wherein the mold(s) that is/are positioned on the inner surface(s) is/are at least partially received in one or more respective spaces that were left by removing the one or more sections;
deforming each curved wall section into a respective gusset plate connection member hav-

- ing a substantially flat connection section, by pressing the respective molds together; and providing, for each gusset plate connection member, a through hole in the substantially flat connection section or providing a through hole in the curved wall section from which said gusset plate connection member was made in such a manner that said through hole will be present in the substantially flat connection section after the curved wall section is deformed; wherein the through hole of each gusset plate connection member allows that gusset plate connection member to be connected to a gusset plate of a corner member of a lattice tower.
2. The method according to claim 1, wherein the one or more sections are removed from the at least one end of the CHS by cutting the CHS, preferably by laser cutting the CHS, more preferably with a tube laser cutter.
 3. The method according to claim 1 or 2, wherein each gusset plate connection member further comprises a transition section which connects the substantially flat connection section to a remainder of the CHS.
 4. The method according to claim 1, 2 or 3, wherein a surface of each mold that presses against a curved wall section among the one or more curved wall sections is substantially flat.
 5. The method according to claim 1, 2 or 3, wherein each gusset plate connection member further comprises a structural profile in the connection section.
 6. The method according to claim 5, wherein a surface of each mold that presses against a curved wall section among the one or more curved wall sections has a substantially flat central part and curved side parts connected on opposite sides to the central part.
 7. The method according to any of the previous claims, wherein one or more gusset plate connection members are provided on opposite ends of the CHS.
 8. The method according to any of the previous claims, wherein two gusset plate connection members are provided on a same end of the CHS.
 9. The method according to claim 8, wherein said removing one or more sections from at least one end of said CHS comprises creating two oppositely arranged slots that separate two curved wall sections from each other, a size of the slots being in correspondence with a thickness of the gusset plate to which the corresponding gusset plate connection members are to be connected.
 10. The method according to claim 9, wherein said positioning a mold on each of the inner and outer surface of each curved wall section comprises at least partially arranging a single mold in the two oppositely arranged slots for engaging the inner surfaces of said two curved wall section, and wherein a thickness of said single mold is in correspondence with a thickness of the gusset plate to which the corresponding gusset plate connection members are to be connected.
 11. The method according to claim 10, wherein deforming each curved wall section into a respective gusset plate connection member further comprises pressing the molds arranged on the outer surfaces of the two curved wall sections together while said single mold is arranged between them.
 12. The method according to any of the claims 8-11, wherein the connection sections of the two gusset plate connection members are substantially parallel, and wherein the through holes of the two gusset plate connection members are preferably aligned.
 13. The method according to any of the claims 8-12, wherein the two gusset plate connection members are deformed such that they slightly taper outwardly.
 14. The method according to any of the previous claims, wherein the CHS is made of steel, the method further comprising the step of galvanizing the tubular brace member.
 15. A lattice tower, comprising:
 - a pair of corner members, each having a gusset plate with a through hole; and
 - a tubular brace member that has been manufactured according to any of the previous claims, wherein the gusset plate connection member(s) arranged on one end of the tubular brace member is/are coupled to the gusset plate of one corner member of the pair of corner members using the through hole of the gusset plate and the through hole(s) of the gusset plate connection member(s).
 16. A lattice tower, comprising:
 - a pair of corner members, each having a gusset plate with a through hole; and
 - a tubular brace member, comprising:
 - a circular hollow section (CHS) having an inner and an outer surface;
 - one or more gusset plate connection members that are integrally connected to at least one end of the CHS, said one or more gus-

set plate connection members having been obtained by removing one or more sections from said at least one end of the CHS such that one or more curved wall sections remain and by deforming each curved wall section into a respective gusset plate connection member; 5

wherein each gusset plate connection member has a substantially flat connection section that is provided with a through hole; 10
 wherein the gusset plate connection member(s) arranged on one end of the tubular brace member is/are coupled to the gusset plate of one corner member of the pair of corner members using the through hole of the gusset plate and the through hole(s) of the gusset plate connection member(s). 15

17. The lattice tower according to claim 15 or 16, wherein the tubular brace member further comprises one or more of said gusset plate connection members arranged on an opposing end of the tubular brace member that are coupled to the gusset plate of the other corner member of the pair of corner members. 20 25

18. The lattice tower according to claim 15, 16, or 17, wherein for each gusset plate connection member, an inner surface of the substantially flat connection section lies against the gusset plate to which the gusset plate connection member is connected in such a manner that the through hole in the substantially flat connection section is aligned with the through hole in the respective gusset plate, the lattice tower further comprising a plurality of coupling members, such as bolts, that each extend through a pair of aligned through holes. 30 35

19. The lattice tower according to claim 18, wherein at least one end of the tubular brace member comprises two gusset plate connecting members of which the through holes are both aligned with the through hole in the gusset plate to which the two gusset plate connecting members are connected, said plurality of coupling members comprising a coupling member that simultaneously extends through the aligned through holes of the two gusset plate connecting members and the through hole of the gusset plate. 40 45

20. The lattice tower according to each of the claims 15-19, wherein each gusset plate connection member further comprises a transition section which connects the substantially flat connection section to a remainder of the CHS, wherein at least one of the transition section and the substantially flat connection section are deformed to have a structural profile. 50 55

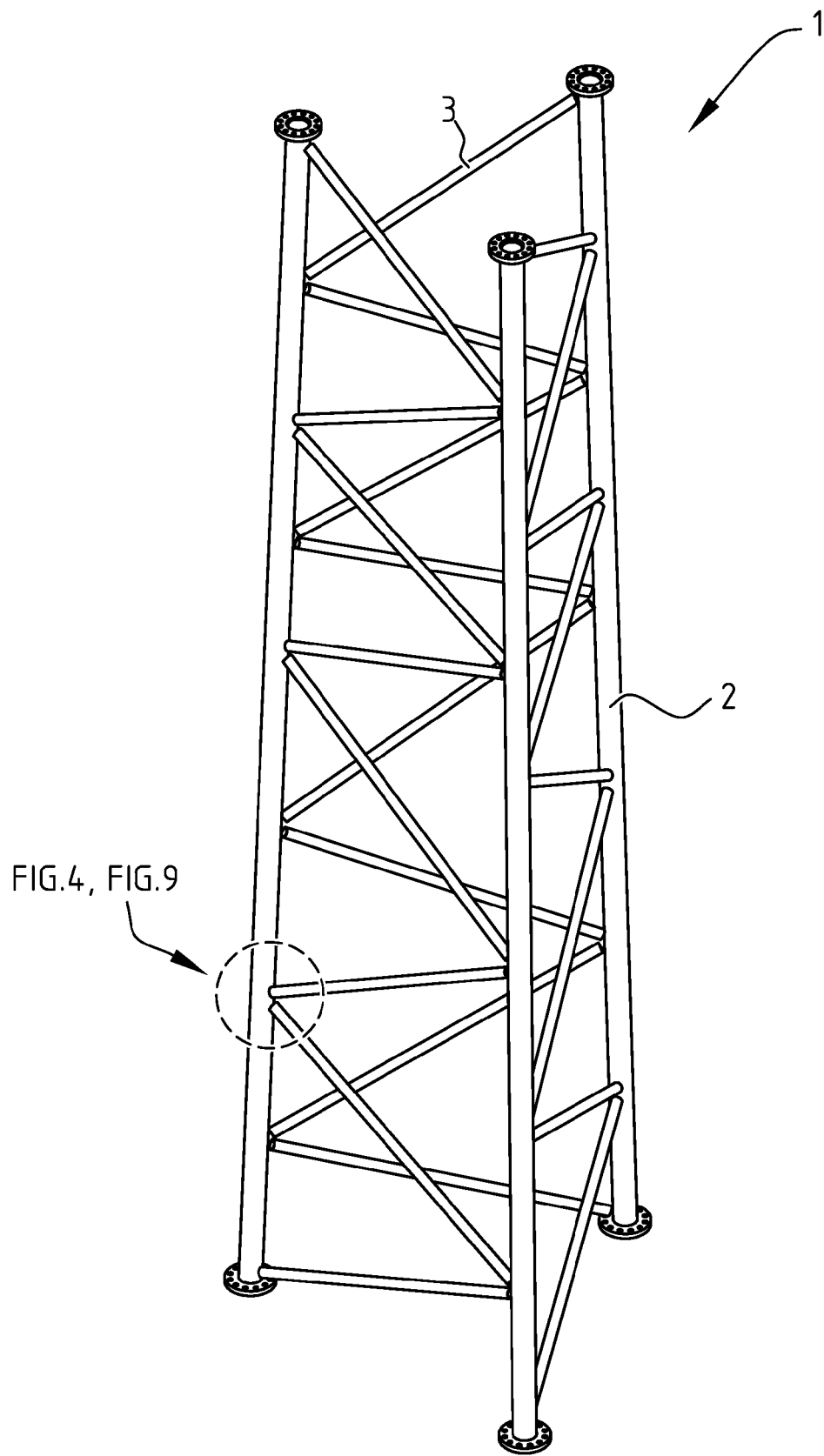


FIG. 1

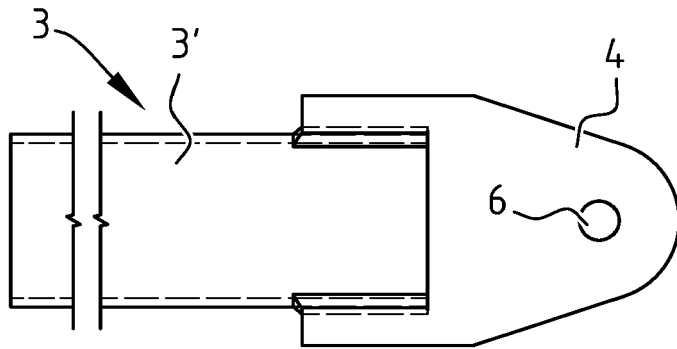


FIG. 2A

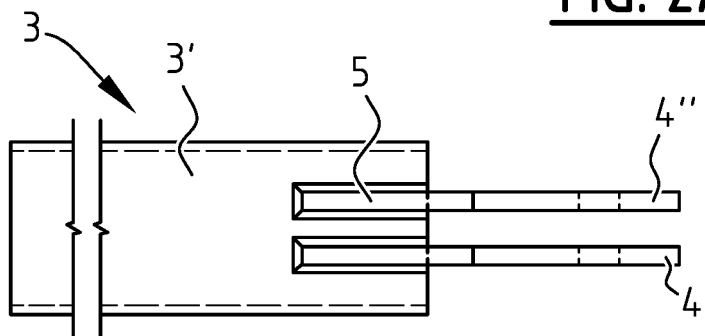


FIG. 2B

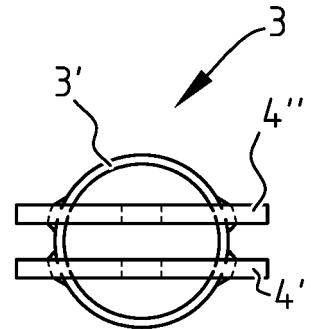


FIG. 2C

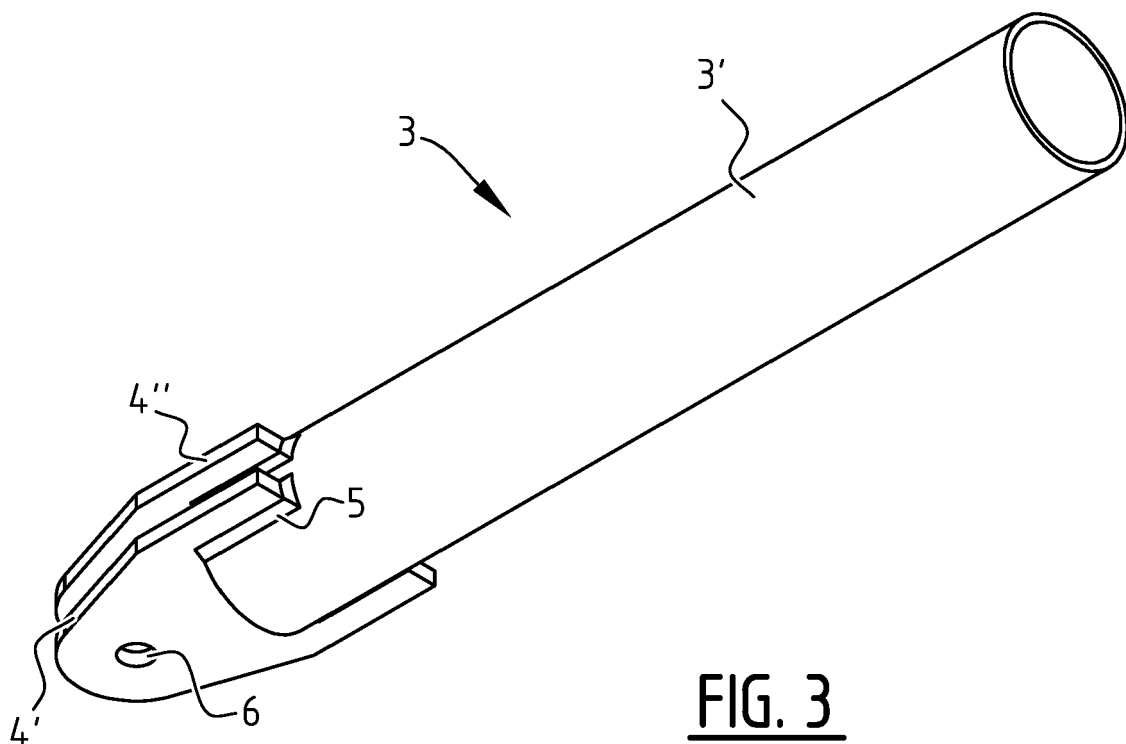


FIG. 3

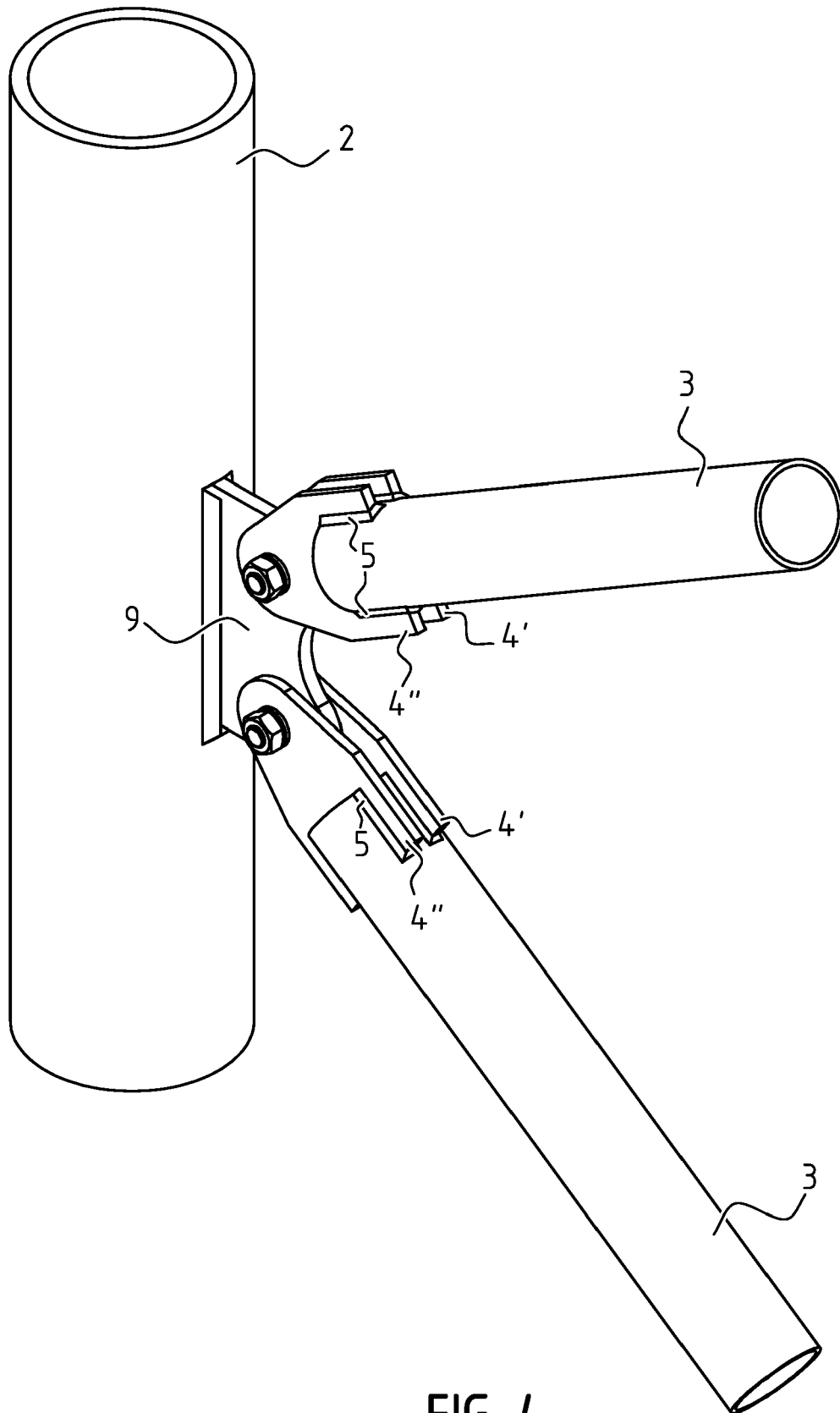


FIG. 4

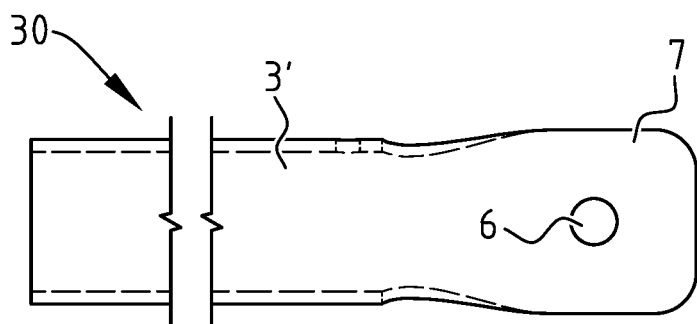


FIG. 5A

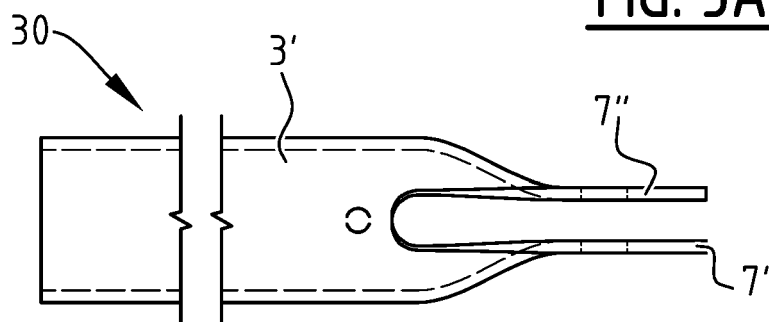


FIG. 5B

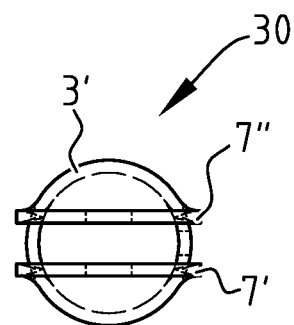


FIG. 5C

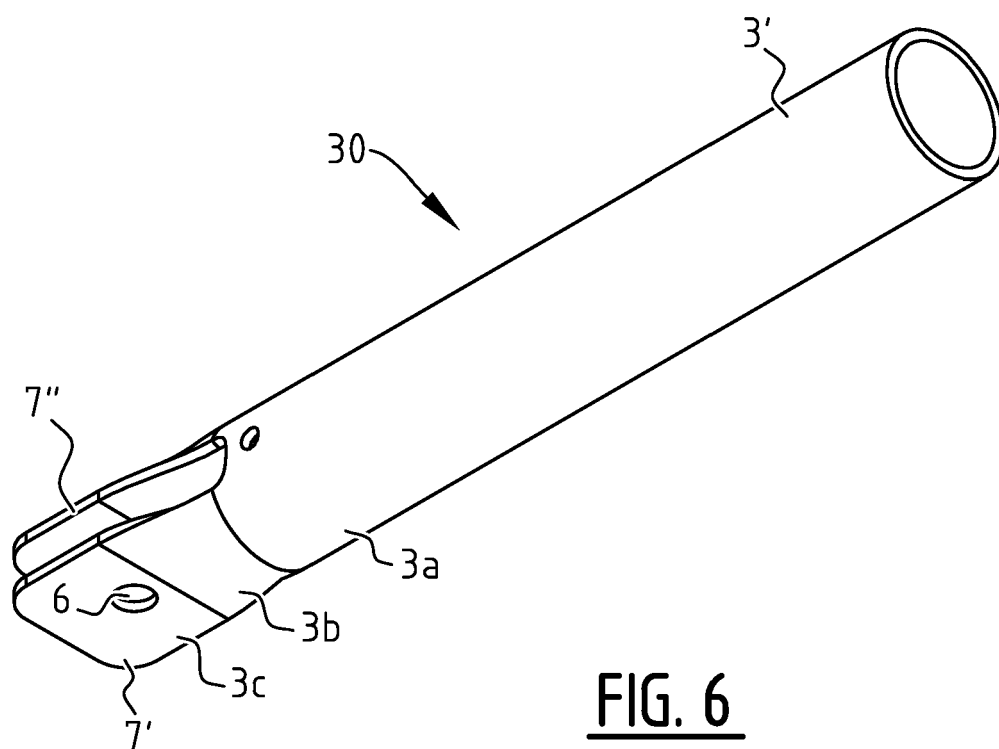


FIG. 6

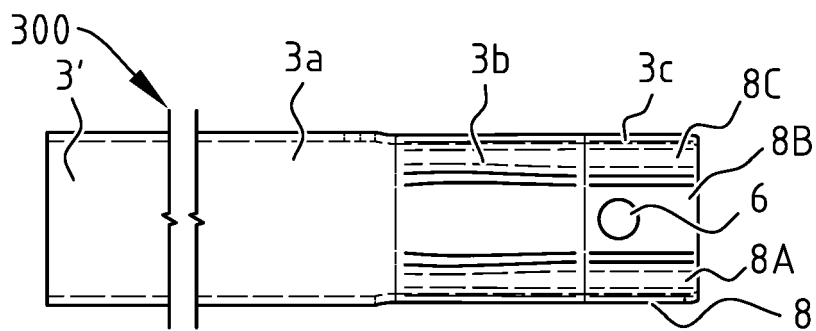


FIG. 7A

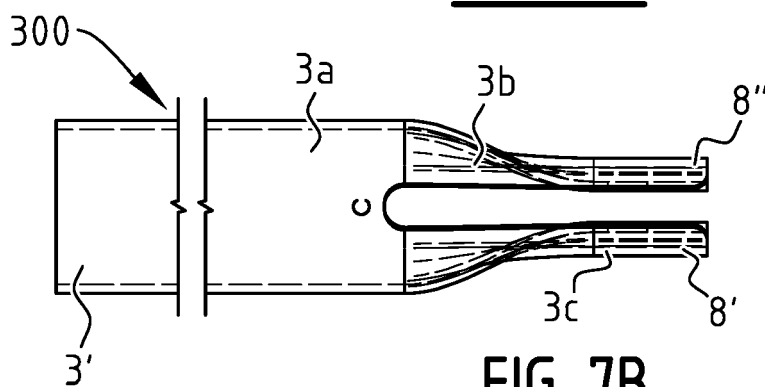


FIG. 7B

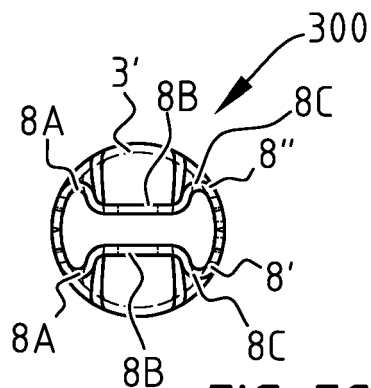


FIG. 7C

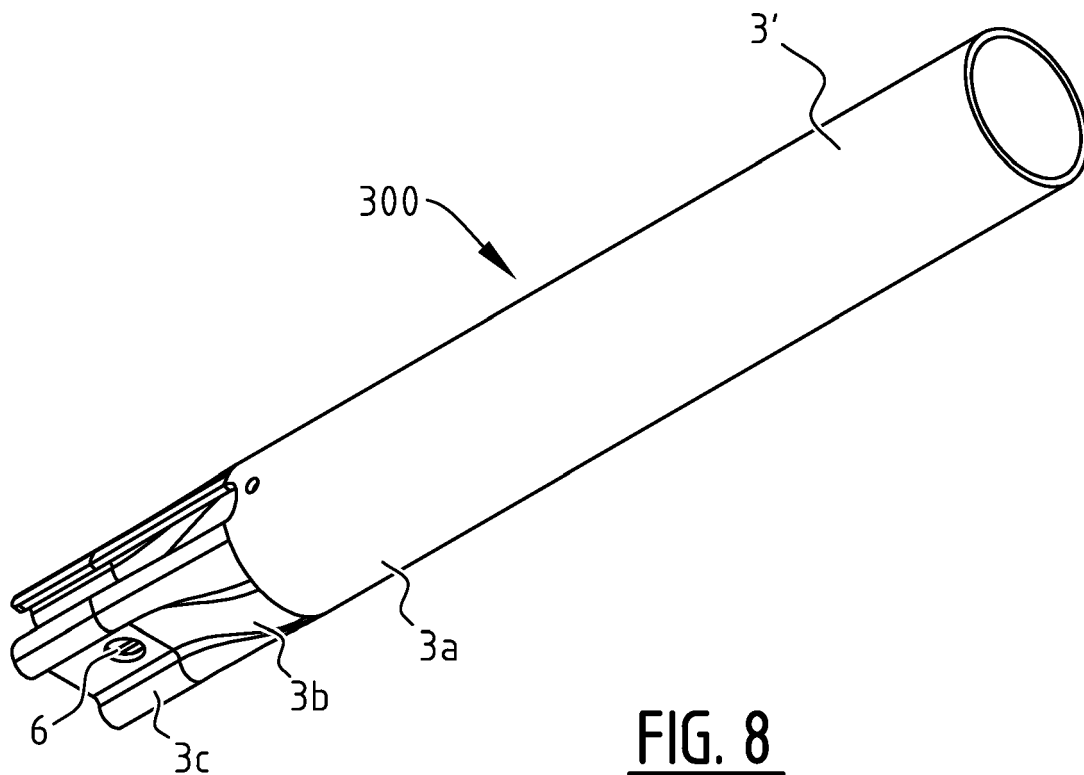


FIG. 8

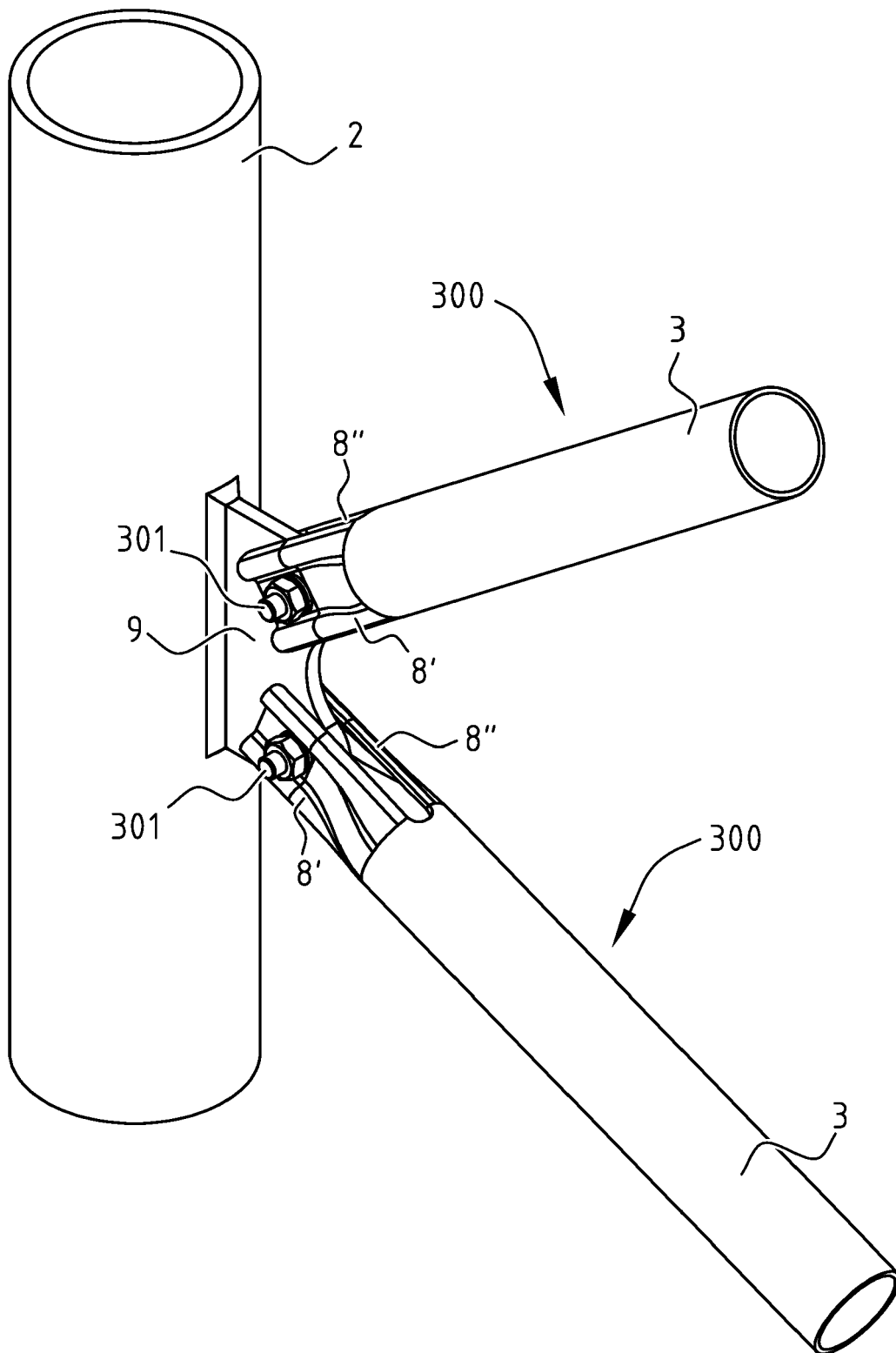


FIG. 9

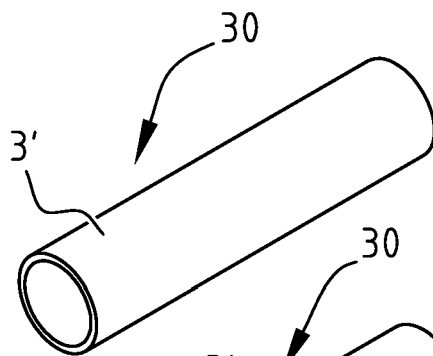


FIG. 10a

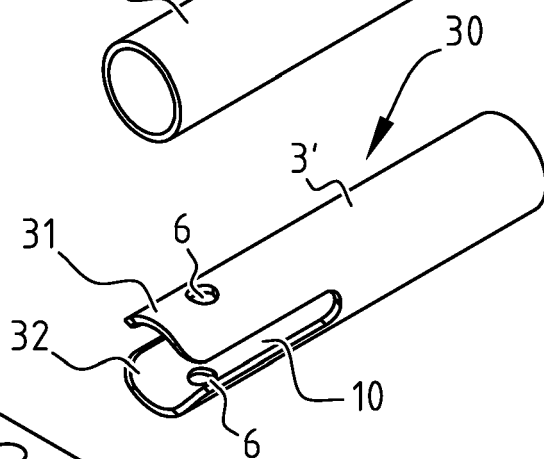


FIG. 10b

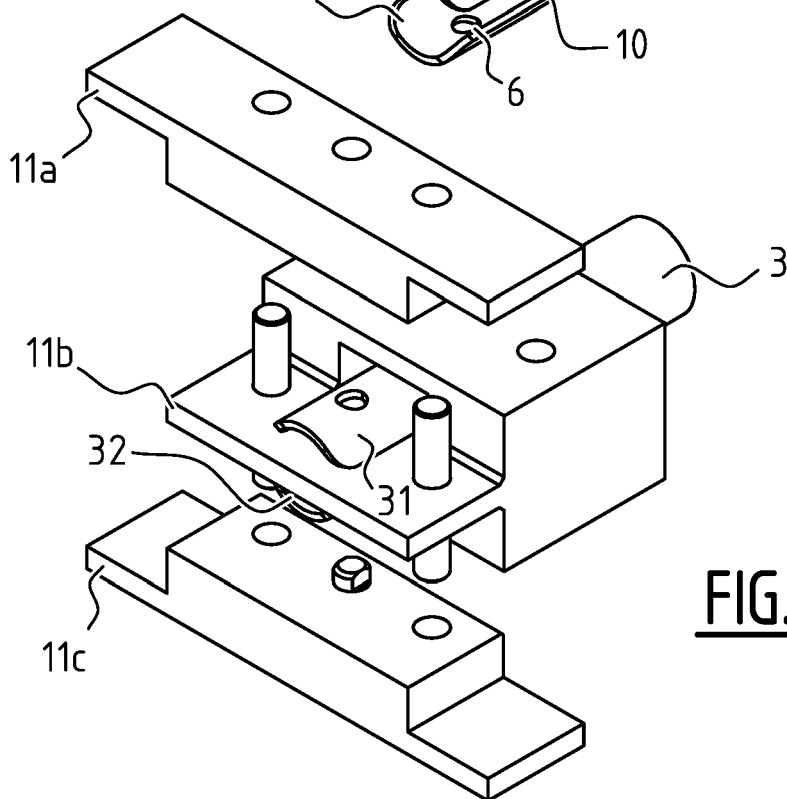


FIG. 10c

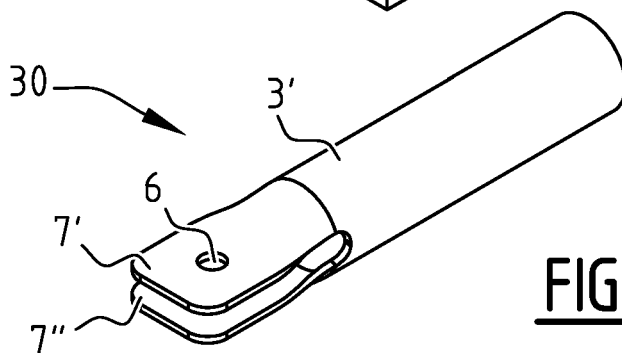


FIG. 10d



EUROPEAN SEARCH REPORT

Application Number
EP 19 20 5964

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2010/005752 A1 (HAWKINS ROBERT [US] ET AL) 14 January 2010 (2010-01-14) * figures 3a,5,6,7,8 * * paragraph [0005] * * paragraph [0016] *	1-15	INV. E04C3/32 E04C3/09
X	US 5 927 138 A (RICHARDSON DOWNIE S [US]) 27 July 1999 (1999-07-27) * figures 1-6 *	1-15	ADD. E04C3/04
X	FR 1 579 060 A (SOCIÉTÉ D'ÉTUDES INDUSTRIELLES ET DE CONSTRUCTIONS CAMUSAT GUEGUEN FRA) 22 August 1969 (1969-08-22) * figures 1-6 *	1-15	
A	US 3 698 224 A (SAYTES ADAM ERIC) 17 October 1972 (1972-10-17) * figures 1-21 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			E04C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 10 August 2020	Examiner Petrinja, Etjel
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

 1
EPO FORM 1503 03.82 (P04C01)

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

EP 19 20 5964

5

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

10-08-2020

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010005752 A1	14-01-2010	AU 2009268529 A1	14-01-2010
		CN 102089486 A	08-06-2011
		EP 2318620 A1	11-05-2011
		IL 210410 A	24-09-2015
		US 2010005752 A1	14-01-2010
		WO 2010006193 A1	14-01-2010
		ZA 201100954 B	30-09-2015

US 5927138 A	27-07-1999	NONE	

FR 1579060 A	22-08-1969	NONE	

US 3698224 A	17-10-1972	NONE	

EPO FORM P0459

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