

(19)



(11)

EP 1 848 867 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:

04.01.2017 Bulletin 2017/01

(51) Int Cl.:

E04C 5/06 (2006.01)

(21) Application number: **06707843.6**

(86) International application number:

PCT/EP2006/050450

(22) Date of filing: **25.01.2006**

(87) International publication number:

WO 2006/079639 (03.08.2006 Gazette 2006/31)

(54) **STRENGTHENING STRUCTURE**

VERSTÄRKUNGSSTRUKTUR

STRUCTURE DE RENFORCEMENT

(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI
SK TR**

• **THEOHARIDES, Dimitris, Sidenor SA**
152 31 Athens (GR)

(30) Priority: **25.01.2005 EP 05075188**

(74) Representative: **TBK**

Bavariaring 4-6
80336 München (DE)

(43) Date of publication of application:

31.10.2007 Bulletin 2007/44

(56) References cited:

WO-A-99/23325 DE-U1- 9 302 006
GB-A- 130 439 GB-A- 2 194 806
US-A- 3 874 062 US-A1- 2004 237 449
US-B1- 6 293 071

(73) Proprietor: **Sidenor SA**

15231 Halandri (GR)

• **EIBL, PROF. DR.-ING. JOSEF: "Beton-Kalender
1997, Teil I" 1997, ERNST & SOHN , BERLIN ,
XP002332973 pages 222-224**

(72) Inventors:

• **KALTEZIOTIS, Dimosthenis, Praksys SA**
152 31 Athens (GR)

EP 1 848 867 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

Field of the Invention

[0001] The present invention relates to structures for strengthening building materials that will be subject to large forces and strains in normal use, and are particularly suitable for use in the construction of buildings in areas prone to earthquakes. More particularly embodiments of the present invention are suitable for insertion into concrete members such as columns, beams and shear walls.

Background of the Invention

[0002] Buildings may be subject to forces associated with the weight of the building and from people moving inside a building in which the material is incorporated, and unpredictable forces from high winds, an earthquake, or a tsunami, for example. Strengthening of these buildings is known as steel reinforcement of concrete, and lateral reinforcement is one of the most important types of reinforcement, especially in case of unpredictable forces where plastic behaviour of the member is required. Lateral reinforcement confines concrete, preventing the concrete from expanding laterally when subjected to loads.

[0003] Lateral steel reinforcement cages (lateral reinforcement) comprise a series of hoops or stirrups formed from steel bars known as lateral bars or lateral reinforcement bars (or simply "rebars") each lying in a plane that is perpendicular to the axes of a concrete column such that, during normal use (i.e. when a concrete column assumes a vertical position), the hoops or stirrups lie in a substantially horizontal plane. Further bars known as longitudinal bars or longitudinal reinforcement are inserted into the cages so that they run vertically in the concrete column in normal use.

[0004] A known strengthening structure is shown in Fig. 1 comprising a series of lengths of steel wire 10 that have been bent into single hoops or stirrups 8 by hand; typically the series of bent-wire hoops are manually positioned as shown, and tied onto a number of so-called longitudinal bars, arranged to form a frame (not shown). Whilst this arrangement could be used for strengthening a material such as concrete, forming a strengthening structure in this way is very time consuming, and laborious. Furthermore, if the positioning of the stirrups on the wire is not optimal or the stirrups are not tied onto the frame correctly the concrete may not be strong enough to withstand the forces experienced during an earthquake. Once this strengthening structure has been formed, longitudinal bars are inserted into the cage, as mentioned above.

[0005] A further example of a known strengthening structure is shown in Fig. 2. In this example a frame 18 is formed from a length of wire 20, and is welded at a welding point 22 to form a single hoop. Further pieces of

wire are bent into smaller hoops 24a, 24b. A series of these hoops is placed on longitudinal bars (not shown), and tied thereon. This method is costly, time consuming, and the points of welding may present points of weakness if the welding is not performed to high quality standards.

[0006] Figure 3 shows a series of hoops 10 disposed in part of a building, such as a concrete pillar 30. As can be seen from this Figure the longitudinal bars 32 are placed in the corners of the hoops, and the axis of the longitudinal bars run perpendicular to the plane of the reinforcement bars or hoops.

[0007] It is known to form such strengthening structures by bending a mesh (also known as a "mantle" in the art") to form a series of hoops; by mesh we mean a plurality of lengths of wire or bars formed so that there are two sets of mutually perpendicular bars: a first comprising a plurality of lateral reinforcement bars disposed in a transverse plane and a second set comprising a plurality of assembly bars disposed in a longitudinal plane. The mesh is pre-formed by fixing together the reinforcement bars and the assembly bars, with pre-formed attachments, so that the relative positions of the lateral reinforcement bars and the assembly bars is fixed in the mesh. Fig. 4 shows such a mesh used for forming strengthening structures, or cages, comprising a plurality of such lateral reinforcement bars 34 and a plurality of such assembly bars 36. Part of the mesh is bent at some point along the transverse plane of the mesh and along an axis parallel to that of the assembly bars, i.e. so that the reinforcement bars are bent (not shown). Figure 5 shows a cross section of a single reinforcement bar 34 forming part of a structure 37 comprising a plurality of bent lateral reinforcement bars 34 formed from a mesh, such as the mesh shown in Fig. 4. As can be seen from this Figure, the cross section of each of the lateral reinforcement bars 34 is in the shape of a square, and hooks 38 are provided at both ends of the bars. Typically, and as can be appreciated from Fig. 4 each lateral reinforcement bar 34 is connected to neighbouring reinforcement bars by means of assembly bars (not shown in Fig. 5). Since any given assembly bar is arranged substantially at right angles to a plane defined by a respective bent lateral reinforcement bar, the planes of the successively formed lateral reinforcement bars are disposed parallel to one another.

[0008] Once the cage structure of Fig. 5 has been inserted into a concrete structure, large diameter longitudinal bars (not shown) are inserted into the cage so that they are held in place by the internal corners of the cage. Fig. 6 shows the structure of Fig. 5 inserted into a block of a concrete 30 with assembly bars 36 running between the hoops 37 formed from the lateral reinforcement bars 34, and running parallel to the longitudinal bars 32. In this way the lateral reinforcement bars 34 offer lateral reinforcement to the building structure, and the longitudinal bars 32 offer longitudinal reinforcement to the building structure. In general, the mesh is bent so that the assembly bars 36 are not positioned on the corners of

the hoops 37, and some countries require the assembly bars to be positioned a certain distance from the corners of the hoops.

[0009] Cage structures such as the one shown in Fig. 5 can be formed by a machine such as the Auto Bend 3000 Special made by Automatic Wire Machines, disclosed in UD2003A000240, UD2001A000188, and UD 2001A00189. The machine is shown schematically in Fig. 7 and typically has a first set of teeth 38 disposed in a horizontal plane and mounted on a movable arm 40, a series of movable bolts 42 defining a series of pivot points, a second set of teeth 44, and a series of pairs of pincers 46. In use the reinforcement bar 34 of the mesh is fed into the machine so that the first set of teeth 38 on the movable arm 40 engage with the mesh near to the point where the mesh is to be bent. The mesh is further held by the second set of teeth 44. The series of bolts 42 are engaged over the reinforcement bars of the mesh, and the first set of teeth 38 move to effect the bending. Since the mesh is held by the second set of teeth 44, bending is effected about the pivot points 42. The first set of teeth 38 move back down once the bending has been completed, the bolts are moved away from the mesh with a movable arm 48, the second set of teeth 44 disengage with the mesh and the pincers 46 move the mesh into a different position. Bending is then effected again. The first or second sets of teeth can be used to effect the bending. In the case where the second set of teeth 44 effect the bending, the first set of teeth 38 hold the mesh during the bending process.

[0010] It will be appreciated that the hooks associated with these known stirrups provide a means of anchoring the mesh to the material, such as concrete, within which the structure is inserted. The hooks are alternatively referred to herein as "anchorage points", "anchorage portions" or "anchorage" and any part described hereinafter having this anchoring functionality will similarly be referred to as an anchorage point, an anchorage portion or an anchorage. The anchorage portions described herein may include hooks, including barbed hooks (i.e. where the hook is bent by an angle of greater than 90°). The degree of bend used in building materials in a particular building depends on the forces to which the building is likely to be subject. For example, the risk of earthquakes in the region in which the stirrups are intended to be used could be taken into account; in seismic regions it may be advantageous to have the hooks bent at an angle of approximately 135°. Anchorage portions bent at a lower angle, such as 90° will typically open out at a lower force than anchorage portions bent at 135°.

[0011] It has been found that the degree of anchorage provided by the structure shown in Figure 5 may not be sufficient in certain circumstances, even if it is provided with hooks bent at 135°. For example, if the building in which the structure is used is subject to a force which is higher than expected (such as from a high-strength earthquake), the anchorages may tend to open out, causing the lateral reinforcement bars to unravel, thus destroying

the strengthening effect of the cage structure, and ultimately causing the building material in which the cage is inserted to collapse.

[0012] One of the most important functions of lateral reinforcement is its use in the lateral reinforcement of concrete columns. Different buildings require different column dimensions, depending on the height and weight of the building. Each country has different rules constraining the shape and form of lateral reinforcement according to the size of the column in which it is to be located, specifically the regulations specify the number of stirrup peaks (the inside corners of the stirrups forming the cages, and this is known to be the n number of the lateral reinforcement). For example, in Greece the width of the column, in centimetres, is divided by 20 to give the minimum number of stirrup peaks of a lateral reinforcement cage which must be accommodated along that side. Similarly, the depth of the column is divided by the same number (i.e. 20) to give the minimum number of stirrup peaks that must be accommodated along the length of the column. Thus for a column of dimensions 80cm by 80cm, four stirrup peaks are required along both of the horizontal axes (width and length) of the column. This means that twelve such stirrup peaks are required in total. Since the number and configuration of stirrup peaks is fixed by the shape of a given stirrup, the cage that is appropriate for the new column can be, and is effectively by default, selected.

[0013] In use, the longitudinal bars are inserted within the gaps in the lateral reinforcement cage defined by the stirrup peaks, which provide respective reinforcing locations. Regulations constrain the placing of longitudinal bars in relation to the stirrups such that each stirrup peak contains a longitudinal bar in such a reinforcing location. This means that, in general, the number of longitudinal bars is greater than or equal to the n number of the cage into which they are inserted. The number of longitudinal bars needed is governed by a separate regulation, namely, that the total cross sectional area of the longitudinal bars be a certain percentage of various parameters. Therefore, the number of longitudinal bars used is selected dependent on the diameter of the bars used (bearing in mind that there must be a sufficient number of longitudinal bars so that no stirrup peak region is empty).

[0014] The requirements relating to the "n" number of the stirrup peaks in discrete stirrups also applies to the hoops formed by bending a pre-fabricated mesh comprising lateral reinforcement bars and assembly bars. For the avoidance of confusion the term "lateral peaks" will be used when referring to embodiments of the invention, being a term describing the bends in the lateral reinforcement bars defining the locations for receiving longitudinal bars. These lateral peaks provide, at the apex of each of the bends formed in the lateral bars in the mesh, a reinforcing location in which a longitudinal bar is to be held by the lateral bar.

[0015] Continuing with the example presented above - a requirement of 12 longitudinal bars - a cage having

four stirrup peaks on each side of the cage must be used. A suitable $n=12$ cage configuration is shown in Fig. 8b, which shows three separate discrete stirrups 56, 57, 58 (i.e. which are not part of a mesh) making up a composite cage 59. It will therefore be appreciated that, with known methods, a particular column having a required number of stirrup peaks can be created. Longitudinal bars 55 are accommodated in the stirrup peaks, inside the corners of the stirrups and along the periphery of the outer stirrup. It will be seen from Fig. 8a and 8b that by combining stirrups in the form of a square, rectangle or circle, various cage structures can be seen.

It will be noted that Fig. 8a shows a cage of square cross section 50 and a cage of rectangular cross section 52 being combined together to form a composite cage 54 having an n value of 8. However, such combinations of single discrete stirrups are cumbersome to make, and the process of making a cage from these single stirrups is expensive. Furthermore, similarly to the structure shown in Fig. 5 above, the degree of anchorage provided by these prior-art cages may not be sufficient in certain circumstances (such as in the case of large unpredictable forces).

[0016] Examples of prior art concrete strengthening structures are disclosed in WO 99/23325 A, DE 9 30 2006 U1 and GB 2194806.

Summary of the Invention

[0017] The subject matter of the invention is set forth in claims 1 to 32. A first aspect of the invention providing an improved strengthening structure relates to:

A structure for strengthening concrete comprising a pre-formed and subsequently bent mesh having a plurality of lateral bars and at least one assembly bar, the at least one assembly bar having a plurality of attachment points, each providing attachment to a respective lateral bar, and having an axis along its length, at least some of the lateral bars being bent along axes substantially parallel to the axis of the at least one assembly bar, each said lateral bar:

defining an anchorage portion at both ends thereof; and
defining an intermediate portion extending between said anchorage portions,
wherein each intermediate portion has a plurality of bends, each of said bends forming a respective reinforcing location for receiving a longitudinal reinforcement bar aligned substantially parallel to the axis of the at least one assembly bar, and wherein the total angle through which each intermediate portion is bent is more than 360° .

[0018] In accordance with a second aspect of the present invention there is provided a method of forming

a structure from a pre-formed mesh, the mesh comprising a plurality of lateral bars and at least one assembly bar, the or each assembly bar having a plurality of attachment points, each providing attachment to a respective lateral bar, and having an axis along its length, the method comprising the steps of: forming a first anchorage of attachment points, each providing attachment to a respective lateral bar, and having an axis along its length, the method comprising the steps of: forming a first anchorage portion at a first end and a second anchorage portion at a second end of each lateral bar, so as to define an intermediate portion extending between said first and second anchorage portions; and winding each intermediate portion starting with the first end of the bar so that a plurality of bends are formed at a plurality of locations along the main strengthening bar portion, each bend being formed substantially parallel to the axis of the at least one assembly bar, such that each of said bends form a respective reinforcing location for receiving a longitudinal reinforcement bar aligned substantially parallel to the axis of the at least one assembly bar, and such that the total angle through which each intermediate portion is bent is greater than 360° .

[0019] Accordingly, the invention in the first and second aspect provides a lateral reinforcement cage formed from lateral bars, the lateral bars having an intermediate portion extending between the anchorage portions. For convenience the lateral bars will hereinafter be referred to as reinforcement bars, consistent with the term of art, typically used to describe the entire bar. It will be appreciated, however, that the "reinforcing" function of such bars is provided by the intermediate portion. In the cage according to the first and second embodiments the intermediate portions of the reinforcement bars have been bent through a total angle of more than 360° , such that the strengthening bar portion has a number of turns. Increasing the number of turns in this way provides for greater structural rigidity of the cage, and reduces the tendency of the cage to unwinding during an earthquake, for example. Each of the bends in the lateral reinforcement cage form a respective reinforcing location for receiving a longitudinal reinforcement bar aligned substantially parallel to the axis of the at least one assembly bar.

[0020] Each of the lateral bars may define a plurality of outer reinforcing locations, and each of the lateral bars may further define at least one reinforcing location disposed between two outer reinforcing locations.

[0021] The building regulations described in the Background section of the specification specify a minimum number of stirrup peaks that are required in order for the building to be constructed. It can therefore be appreciated that, with methods and

[0022] Embodiments of the invention enable cages to be formed having a greater number of lateral peaks than the stirrup peaks of the prior art and are formed from a single pre-formed mesh, thus overcoming the practical limitations of known structures. For example, cages with an n number of 8, 10 or 12, in which two longitudinal bars

only are accommodated on one side can be formed, as shown in Figs 10a to 10c. This means that cages fulfilling the requirements for certain buildings can be constructed, without a cumbersome arrangement of individual stirrups.

[0023] Further, the first and second aspects of the present invention allow a cage having a number of turns and no discontinuity along the lateral length of the cage, or reinforcement bar. This means that the cage has fewer anchorage points than the prior-art cages, which, as described above are formed from a number of different single stirrups. Since the anchorage points are points of weakness in a cage, cages according to embodiments of the invention - with fewer anchorages - have greater structural stability. Therefore the tendency of the cage according to the first and second aspects to unwinding during an earthquake, for example, is reduced. Furthermore, the lateral supports according to the first and second aspects of the present invention help prevent longitudinal bars inserted therein from bending during an earthquake, for example. This effect is twofold: first the cages of the present invention are more structurally rigid than those of the prior art (where a number of cages are joined together). Secondly, each of the prior art cages of the lateral reinforcement can unwind, meaning that the support offered to the longitudinal bars decreases, making it more likely that the longitudinal supports will bend. Since the hoops in the cages of the present invention are made from a single lateral reinforcement bar, cages according to embodiments of the invention have a greater resistance to unwinding, this bending of the longitudinal bars will be reduced.

[0024] Whilst the cage of the first and second embodiments is useful for certain types of buildings it is difficult to increase the complexity of the cage, since the bending is only performed from one end, and the bent mesh becomes too thick for the machine to bend further.

[0025] Accordingly, the invention includes a third aspect comprising structure for strengthening concrete comprising: a mesh having a plurality of lateral bars and at least one assembly bar, the or each assembly bar having a plurality of attachment points, each providing attachment to a respective lateral bar, and having an axis along its length, at least some of the lateral bars being bent along axes substantially parallel to the axis of the at least one assembly bar, each said lateral bar: defining a first anchorage portion at a first end thereof and a second anchorage portion at a second end thereof, and defining an intermediate portion extending between said first and second anchorage portions, wherein each intermediate portion has a first set of bends so as to form a first cage portion and a second set of bends so as to form a second cage portion, said first cage portion including said first anchorage portion, and said second cage portion including said second anchorage portion, wherein the second cage portion is at least substantially received in the first cage portion, and wherein the total angle through which each intermediate portion is bent is more

than 360°.

[0026] According to a fourth aspect of the present invention there is provided a method of forming a structure from a mesh, the mesh comprising a plurality of lateral bars and at least one assembly bar, the or each assembly bar having a plurality of attachment points, each providing attachment to a respective lateral bar, and having an axis along its length, the method comprising the steps of: forming a first anchorage portion at a first end and a second anchorage portion at a second end of each lateral bar, so as to define an intermediate portion extending between said first and second anchorage portions; and starting from each of the first and second ends, performing a process comprising winding the intermediate portion so that a plurality of bends are formed at a plurality of locations along the bar portion, each bend being formed substantially parallel to the axis of the at least one assembly bar, thereby forming first and second cage portions; bending the main intermediate portion so the second cage portion is at least substantially received within the first cage portion, the winding and bending being such that the total angle through which each intermediate portion is bent is greater than 360°.

[0027] Structures formed according to the third and fourth aspects of the invention thus provide a cage which may have a greater number of turns than is possible according to cages of the first and second aspects, since the cage is wound from both ends of the reinforcement bar. This, in turn, results in further flexibility in the positioning and cages of the first and second aspects, since the cage is wound from both ends of the reinforcement bar. This, in turn, results in further flexibility in the positioning and number of lateral peaks, and thus range of buildings that can be constructed with mesh fabricated according to the method of the invention.

[0028] According to a fifth aspect of the present invention there is provided a structure for strengthening concrete comprising: a first mesh and a second mesh, each mesh having a plurality of lateral bars and at least one assembly bar, the or each assembly bar having a plurality of attachment points, each providing attachment to a respective lateral bar, and having an axis along its length, and being bent along axes substantially parallel to the axis of the at least one assembly bar, each said lateral bar: defining an anchorage portion at both ends thereof, and defining an intermediate portion extending between said anchorage portions, wherein each intermediate portion has a plurality of bends, and wherein the sum of the angle that each intermediate portion is bent through in the first mesh and the angle that each intermediate portion is bent through in the second mesh is more than 360° and wherein the first mesh is at least substantially received in the second mesh, thereby forming a composite cage for internally strengthening concrete.

[0029] According to a sixth aspect of the present invention there is provided a method of forming a strengthening structure from a first mesh and a second mesh, each mesh comprising a plurality of lateral bars and at

least one assembly bar, the or each assembly bar having a plurality of attachment points, each providing attachment to a respective lateral bar, and having an axis along its length, the method comprising the steps of: for each mesh, forming a first anchorage portion at a first end and a second anchorage portion at a second end of each lateral bar, so as to define an intermediate portion extending between said first and second anchorage portions of each lateral bar; and winding each intermediate portion starting with the first end of each lateral bar so that a plurality of bends are formed at a plurality of locations along each intermediate portion, each bend being formed substantially parallel to the axis of the at least one assembly bar of each mesh, the winding being such that the sum of the angle that each intermediate portion is bent through in the first mesh and the angle that each intermediate portion is bent through in the second mesh is more than 360°, and locating the first and second increased by interlinking two cages. In this way a complex cage having a larger "n" value of lateral peaks can be provided, which may be useful in the construction of large buildings.

[0030] Further features and advantages of the invention will become apparent from the following description of preferred embodiments of the invention, given by way of example only, which is made with reference to the accompanying drawings.

Brief Description of the Drawings

[0031]

Figure 1 shows a known bent wire structure;
 Figure 2 shows a known welded bent wire structure;
 Figure 3 shows a concrete block fitted with a bent wire structure;
 Figure 4 shows a mesh for forming structures;
 Figure 5 shows a cross section of a known bent wire structure formed from a mesh such as that shown in Figure 4;
 Figure 6 shows a concrete block fitted with a bent wire structure formed from a mesh;
 Figure 7 shows a schematic diagram of a known bending machine
 Figures 8a and 8b show known composite cage structures;
 Figure 9a shows a cross section of a known reinforcement bar prior to bending;
 Figure 9b shows a cross section of an example of a cage structure according to an embodiment of the invention;
 Figure 10a to 10c show cross sections of examples of cage structures having a different number of turns of the reinforcement bars;
 Figure 11a and 11b show cross sections of examples of cage structures including polygons according to an embodiment of the invention;
 Figure 12a to 12e show cross sections of examples

of cage structures including struts according to an embodiment of the invention;

Figure 13 shows a cross section of a further example of a cage structure according to an embodiment of the invention;

Figure 14a shows an example of a shape made by the second embodiment of the present invention, and Figure 14b shows an example of the bending process used to make the shape of Fig. 14a;

Figure 15a shows an example of a shape made by the second embodiment of the present invention, and Figure 15b shows an example of the bending process used to make the shape of Fig. 15a;

Figure 16a shows an example of a shape made by the second embodiment of the present invention, and Figure 16b shows an example of the bending process used to make the shape of Fig. 16a;

Figure 17a shows an example of a shape made by the second embodiment of the present invention, and Figure 17b shows an example of the bending process used to make the shape of Fig. 17a;

Figure 18 shows a further example of a shape which can be made using the second embodiment of the present invention;

Figure 19 shows some examples of shapes that can be made using the first and second embodiments of the present invention;

Figure 20 shows a cross section of an example of a composite cage formed from a combination of the cage of Fig. 9c and a rectangular cage according to the second embodiment of the invention;

Figure 21 shows a cross section of an example of a composite cage formed from the cage of Fig. 12b with that of 12d according to the second embodiment of the invention;

Figure 22 shows a cross section of an example of a composite cage formed from the cage of Fig. 12c with that of Fig. 12e according to the second embodiment of the invention;

Figure 23 shows a cross section of an example of a composite cage formed from the combination of the cage of Fig 12b and two of the cages shown in Fig. 12c according to a second arrangement of the second embodiment of the invention;

Figure 24 shows a cross section of an example of a composite cage formed from the cage of Fig. 10c with that of Fig. 9b according to a second arrangement of the second embodiment of the invention;

Figure 25 shows a cross section of an example of a composite cage formed from two of the cages shown in Fig. 13 according to a second arrangement of the second embodiment of the invention.

Detailed Description of the Invention

[0032] Embodiments of the present invention are concerned with improvements in structures for strengthening building materials. Various arrangements that can per-

form these functions will be described.

[0033] Fig. 9a shows a cross section of a reinforcement bar 60, which forms part of a mesh, such as the mesh shown in Fig. 4, prior to being bent. Fig. 9b shows in cross section an example of a strengthening structure 61 formed from the bar 60 of Fig. 9a. As can be seen from the figure each reinforcement bar 60 has been bent so that it has a plurality of bends 64_1 to 64_5 along its length, effectively forming an outer hoop and an inner strut, and having six lateral peaks, giving the structure an n value of 6. The bar has hooks, or anchorage points 62a, 62b at each end, and the structure forms a cage structure having several 90° bends 64_1 to 64_5 . As can be seen from Fig. 9b the lateral reinforcement bar 60 from Fig. 9a has been bent through a first angle of α_1 . The dotted line shows the position of the bar prior to bending, and α_1 is measured between this dotted line and the position to which the bar is bent. The angle α_1 therefore represents the actual angle through which the bar was turned to effect the bend 64_1 . The total angle through which the bars are bent for the bends 64_1 to 64_5 (i.e. the sum of the actual angles through which the bar is bent), excluding the bends forming the anchorages is 450° , which is greater than 360° .

[0034] In use, a structure such as the one shown in Fig. 9b is placed in a selected position, and a longitudinal bar is inserted into each of the lateral peaks (i.e. on the insides of the bends 64_1 to 64_5 , and on the inside of the anchorage 62a). Concrete is poured over the structure, so as to form a desired shape, such as a concrete pillar, for example. A concrete pillar formed in this way is strengthened by the skeleton of the cage, and is therefore less likely to fracture, split or otherwise break. The cage shown in Fig. 9b may, for example, be made of steel. cage, and is therefore less likely to fracture, split or otherwise break. The cage shown in Fig. 9b may, for example, be made of steel.

[0035] The following passages will describe various alternative configurations of a cage structure such as that shown in Figure 9b.

[0036] Turning to Figs. 10a to 10c a first alternative configuration will be described. As can be seen from these figures, each of the cages has a plurality of bends 64_1 to 64_1 in the reinforcement bars, forming complex cage structures defining hoops as the bar is bent around itself in successive turns. Fig. 10a shows an example in which the bar is bent in seven places (64_1 to 64_7), so that $n=8$ to form a structure 66, in which the total angle through which the strengthening parts of the bars are bent (excluding the bends used to form the anchor portions) is 630° . Similarly, Fig. 10b shows the bar being bent in nine places (64_1 to 64_9), giving $n=10$ and a total angle of 810° for the structure 70, and Fig. 10c shows the bar being bent in eleven places (64_1 to 64_{11}), so that the structure 72 has $n=12$ and a total angle of 990° . The latter cage structure 72 would be used in a situation where the building regulations of the particular country specified that two lateral peaks were required along one side of a column

or pillar, and six lateral peaks were required along the other side of the pillar. In Fig. 10a and 10c the successive turns are concentric, whereas in the cages shown in Fig. 10a and Fig. 10b, the axis of each turn is parallel, but not co-incident, with that of other turns. It will be apparent that any number of turns or any combinations of turns are within the scope of the invention. The cage 66 of Fig. 10a is equivalent to the prior art cage 54 of Fig. 8a. However, it will be noted that whilst the cage of Fig. 8a has two pairs of anchorages, the cage of Fig. 10a only has one pair, and these are not adjacent to the same longitudinal bar. Since the anchorages present points of weakness in the case of the building material being subject to a large force the cage of Fig. 8a is structurally weaker than that of Fig. 10a both because there are more anchorage portions, and because in Fig 8a both anchorage portions in each pair are located adjacent to the same longitudinal bar.

[0037] Turning to the next configuration, Fig. 11a and 11b show examples of cage structures 74, 80 where the cage is formed from polygons, by bending the bar. Fig. 11a shows a cage structure where each reinforcement bar comprises two hoops, i.e. a square frame 78 and a further square 76 disposed inside the frame. It can be seen that this inner square 76, then bending the bar through 45° at 64_4 to begin the square frame 78; the bar is then bent through 90° four times (64_5 to 64_8) to form the frame 78 around the inner square 76. The structure shown in Fig. 11a has a value of $n=8$, and would be suitable for use in a column of square cross section which requires at least three lateral peaks along each side. Turning now to the anchorages 62a, 62b, in this example the innermost anchorage 62a is shown as being bent at 180° ; however, the anchorage can be bent at any suitable angle, such as 90° , 135° or at any angle in between. Fig. 11b shows a structure again comprising two hoops: a square frame 78 and an octagon 82 inside the square frame. In order to form the octagon the bar is bent by 45° seven times (64_1 to 64_7). The bar is then bent a further four times by 90° (64_8 to 64_{11}) to form the hoop 78 forming the frame outside the octagon 82. This structure has an n -value of 12, and would be suitable for a square column which requires at least four lateral peaks along each side.

[0038] Turning now to Fig. 12a to 12e, further arrangements are shown, in which the reinforcement bar forming the cage of the structure is bent into an outer hoop 78 forming a frame, and further forms at least one strut or joint 86 or hoop 87 across the centre of the outer hoop. Figs. 12a and 12b show examples where the cage comprises an outer hoop 78 and one strut 86 extending across the centre of the outer hoop to form structures 91, 93. The structure 95 shown in Fig. 12c has one inner hoop 87_1 . The cage 97 shown in Fig. 12d has one strut and one hoop (86 and 87_1). The cage 99 shown in Fig. 12e has two hoops, 87_1 and 87_2 . These structures are generally intended to be used as a component of a so-called composite structure (see below for a more detailed discussion).

[0039] Fig. 13 shows a further example of a cage. In this structure the reinforcement bars are bent (in positions 64_1 to 64_4) so that the cage comprises a rectangle 100 having a "U" shaped portion reinforcing one half of the rectangle; this structure has an "n" value of 4. This structure may be useful in a building in which it is necessary to reinforce one side of the hoop more than the other. It may not be possible to realise a cage having such a cross section in the prior art, using single hoops.

Second embodiment

[0040] It will be noted that, in the cage configurations described above, there is no cross over between, or winding within, elements of the cage. A second embodiment, having first and second arrangements, will now be described, which enables manufacture of such intersecting and enclosing structures; these structures are referred to herein as "complex structures". The essence of the first arrangement of the second embodiment is that bending of the mesh is effected from each end thereof; alternatively, in the second arrangement, two separate cage structures can be combined so as to effect the requisite cooperation between mesh portions.

[0041] Turning to Figs. 14a and 14b a first arrangement, in which a simple mesh is bent from both ends, will now be described. Fig. 14a shows a shape 102 formed by a cross section of a mesh, in which the reinforcement bars have been bent in shape by a process according to the second embodiment of the present invention, while Fig. 14b shows, step-by-step, the process of making the shape shown in Fig. 14a. As can be seen, in step 1 an anchorage portion is first defined at one end of the reinforcement bar. The bar is then bent clockwise about a bending point 64_1 in step 2. In steps 3 to 5 the bar is further bent clockwise around different bending points 64_2 to 64_4 to form a first cage portion, having closed loop. In step 6 an anchorage portion is defined at the other end of the reinforcement bar. The reinforcement bar is then bent anticlockwise around a plurality of bending points 65_1 and 65_2 in steps 7 and 8 to form a second cage portion. In step 9 the reinforcement bar is bent about a bending point 67 so that the second cage portion intrudes into the first cage portion. The first and second cage portions now overlap to form a complex cage structure 102 having an n value of 8.

[0042] The positioning of the assembly bars 36 (which are directed perpendicularly into the page in Fig. 14a and 14b) can be seen in Fig. 14a and 14b; as can be seen from step 8 of Fig. 14b assembly bars are not present in the region of the first cage portion into which the second cage portion is folded (shaded in Fig. 14a and 14b). Similarly, the region of the second cage portion which intrudes into the first portion is free from assembly bars. This is so that this region is free from obstruction, facilitating intrusion of the second cage portion into the first cage portion.

[0043] Fig. 15a and 15b show a further example of a

shape 104 formed by bending both ends of the mesh in steps 1 to 11. Again, from this Fig. the positioning of the assembly bars 36 can be identified; from the schematic shown in relation to step 10 it can clearly be seen that no assembly bars are positioned in the upper part of the first cage portion. This shape has an n value of 10.

[0044] Similarly Figs 16a and 16b, and 17a and 17b show shapes 106, 108 made from bending both ends of a mesh both having n values of 16. It will be apparent that a large number of different shapes may be made in this way.

[0045] Fig. 18 shows a hoop shape 109 formed from bending the mesh from both ends.

A first portion of the cage of Fig. 18 has been formed by bending the mesh in one direction five times (64_1 to 64_5) and a second portion has been formed by bending the mesh in the other direction five times (65_1 to 65_5). Further, the mesh has been bent at a point 67 so as to introduce the second portion into the first portion, to form a shape with 12 lateral peaks, and hence, an n value of 12. The placement of the assembly bars 36 which allows the second portion to intrude into the first portion can be seen. In this Figure a possible positioning of longitudinal bars 68 can also be seen. The hoop shape of Fig. 18 is equivalent to the shape 59 shown in Fig. 8b of the prior art. However, the cage 59 shown in the prior art has three pairs of anchorages, whereas the cage 109 shown in Fig. 18 has one pair of anchorages; as discussed above, this means that the cage shown in Fig 18 is stronger than that shown in Fig 8b, since it has fewer anchorages, and the individual parts of the pair of anchorages are adjacent to different longitudinal bars, as can be seen from Fig. 18. Therefore, the cage of Fig. 18 is stronger than the shape of Fig. 8b, in that it is less likely to unwind under the forces created in an earthquake, for example.

[0046] Fig. 19 shows various hoop shapes that can be made using the process of the present invention. As can be seen, the positioning of the assembly bars 36 depends on the region in which respective first and second regions intersect or overlap one another. More specifically, the assembly bars can only be present in parts of the first and second cage portions which do not overlap each other in the winding process. It will be apparent to the skilled person that placing of the assembly bars is permitted in any position where this condition is fulfilled. A discussion of the second arrangement of the second embodiment of the present invention will now be given.

[0047] In the second arrangement a cage is combined with one or more other cages to form a complex structure, having the desired value of n, dictated by the dimensions of the column and the relevant building requirements as described above. Fig. 20 shows an example in which a first cage and a second cage 95, 52 are combined together to form such a complex structure 110, having an n-value of 12. In this example, the cage 95 of Fig. 12c is combined with a simple, known rectangular cage 52 (shown in Fig. 8a) to form a composite cage 110. Each of the cages is formed in the usual way, as described

above. However, during formation of the mesh it may be necessary to omit some of the assembly bars before using the mesh to form each of the constituent cages, so that when the formed cages are fitted together there are regions without assembly bars. This enables the respective cages to be fitted together easily.

[0048] Fig. 21 shows another example of combining a first cage and a second cage together 97, 93. In this example the cage 97 of Fig. 12d and the cage 93 of Fig. 12b are fitted together to form a complex cage 120, with $n=16$. Similarly, Fig. 22 shows a combination of the cage 99 of Fig. 12e and the cage 95 of Fig. 12c to form a complex cage 130 with $n=20$. Furthermore, Fig. 23 shows the cage 93 of Fig. 9b being combined with two of the cages 91 of the type shown in Fig. 12c to form a composite cage 140 having an n -value of 18. As can be seen from the figures the complex cages formed comprise a series of squares in cross section. Fig. 24 shows the cage 77 of Fig. 10c being combined with the cage 58 shown in Fig. 8b to form an L-shaped composite 150 with an n value of 14 and Fig. 25 shows two of the cages 100 shown in Fig. 13 being combined to form an L-shaped cage 160 having an n value of 8.

[0049] L-shaped concrete columns are typically used in the corners of buildings, and the L-shaped lateral reinforcements discussed above may be used in these. The complex cages in general may be useful for strengthening large buildings, which require concrete columns of a large value of n . As with the second embodiment, consideration of the placement of the assembly bars should be made: more specifically, assembly bars can only be placed in positions in the first and second cages which do not pass through the other cage during the formation of the complex cage.

[0050] The term "hoop" or "stirrup" referred to herein should be taken to include a bar, which is bent into any shape such as a polygon (including a circle); it need not be bent so as to form a closed loop, but in embodiments of the present invention the lateral bar should be bent in such a way that it forms lateral peaks in which a respective longitudinal bar can be received, and so that anchorage portions are defined at either end of the lateral bar.

[0051] Note that, in the embodiments described herein, all include the feature of the strengthening parts, i.e. those parts not including the anchor portions, of the lateral bars being bent through more than 360° . Moreover, most include the feature of the strengthening parts of the bars being bent through more than 450° . Some include the feature of the strengthening parts of the bars being bent through more than 540° , 630° , 720° , 810° or even more.

[0052] The above embodiments are to be understood as illustrative examples of the invention. Further embodiments of the invention are envisaged. For example, the cages according to the present invention may be made up of any number of successive turns of the reinforcement bars of the mesh.

[0053] Furthermore, equivalents and modifications not

described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

Claims

1. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100; 102; 104; 106; 108; 109) for strengthening concrete comprising a pre-formed mesh being subsequently bent to a cage having hoops made from single lateral bars (60) and at least one assembly bar (36), the at least one assembly bar having a plurality of attachment points, each providing attachment to a respective lateral bar (60), and having an axis along its length, at least some of the lateral bars (60) being bent along axes substantially parallel to the axis of the at least one assembly bar (36), each said lateral bar (60):

defining an anchorage portion (62a, 62b) at both ends thereof; and

defining an intermediate portion extending between said anchorage portions,

wherein each intermediate portion has a plurality of bends (64), so that it forms at least one substantially closed hoop, **characterised in that**

each of said bends (64) forms a respective reinforcing location for receiving a longitudinal reinforcement bar (68) aligned substantially parallel to the axis of the at least one assembly bar (36), and

the total angle of the bends forming the substantially closed hoop is more than 360° .

2. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to claim 1, wherein each of said lateral bars (60) defines a plurality of outer reinforcing locations, and wherein each of said lateral bars (60) further defines at least one reinforcing location disposed between two outer reinforcing locations.
3. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to claim 1 or 2, wherein each intermediate portion of the mesh is bent to form at least two concentric hoops (76; 78).
4. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to claim 3, wherein an inner square hoop (76) is rotated with respect to the outer square frame hoop (78) by 45° .
5. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to

- claim 3 or 4, wherein at least one substantially closed hoop comprises an n-sided polygon, and n is an integer between 2 and infinity.
6. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein each said intermediate portion is bent so that it forms an outer hoop and an inner strut disposed within the outer hoop (78). 5
 7. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to claim 6, wherein each intermediate portion forms two inner struts crossing the outer hoop. 10
 8. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein each intermediate portion includes at least five bends (64). 15
 9. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein each intermediate portion includes at least one bend (64) of 90°. 20
 10. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein each intermediate portion includes at least one bend (64) of 45°. 25
 11. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein the lateral (60) and assembly bars (36) are attached at attachment points along their length by machine bonding. 30
 12. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein the lateral (60) and assembly bars (36) are attached together by welding. 35
 13. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein each anchorage portion comprises a hook formed by the ends of the lateral bars (60). 40
 14. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to claim 13, wherein the hooks are bent at an angle of approximately 90°. 45
 15. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to claim 13, wherein the hooks are barbed. 50
 16. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein the assembly bars (36) have a yield strength of 200-500MPa. 55
 17. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein the lateral bars (60) have a yield strength of 200-800MPa.
 18. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein the lateral bars (60) are made of steel.
 19. A structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) for strengthening concrete according to any of the preceding claims, wherein the assembly bars have a lower yield strength than the lateral bars (60).
 20. A structure (102; 104; 106; 108; 109) according to claim 1, wherein each intermediate portion has a first set of bends (64) so as to form a first cage portion and a second set of bends (65) so as to form a second cage portion, said first cage portion including said first anchorage portion, and said second cage portion including said second anchorage portion, and wherein the second cage portion is at least substantially received in the first cage portion.
 21. A structure (102; 104; 106; 108; 109) for strengthening concrete according to claim 20, wherein the second cage portion is received within a region of overlap of the first cage portion, such that at least some of the lateral bars (60) of the second cage portion are located between the lateral bars (60) of the first cage portion.
 22. A structure (102; 104; 106; 108; 109) for strengthening concrete according to claim 20 or 21, wherein said at least one assembly bar in the first and second cage portion is positioned so that the second cage portion can be received within the first cage portion.
 23. A structure (102; 104; 106; 108; 109) for strengthening concrete according to any of claims 20 to 22, wherein the region of overlap defines a first region within the first cage portion and a second region within the second cage portion, said first and second regions being free from assembly bars (36).
 24. A structure (102; 104; 106; 108; 109) according to any of claims 1 to 19, characterized by a first mesh and a second mesh, each mesh having said plurality of lateral bars (60) and at least one assembly bar (36), wherein the first mesh is at least substantially received in the second mesh, thereby forming a com-

posite cage for internally strengthening concrete.

25. A structure according to claim 24, wherein the said first and second mesh portions are located so that at least one lateral bar (60) of the first mesh portion is disposed between two lateral bars (60) of the said second mesh portion. 5
26. A method of forming a structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100; 102; 104; 106; 108; 109) from a pre-formed mesh, the mesh comprising a plurality of lateral bars (60) and at least one assembly bar (36) having a plurality of attachment points, each providing attachment to a respective lateral bar (60), and having an axis along its length, the method comprising the steps of: 10
- forming a first anchorage portion at a first end and a second anchorage portion at a second end of each lateral bar (60), so as to define an intermediate portion extending between said first and second anchorage portions; and winding each intermediate portion starting with the first end of the bar (60) so that a plurality of bends (64) are formed at a plurality of locations along the intermediate portion, so as to form at least one substantially closed hoop, each bend (64) being formed substantially parallel to the axis of the at least one assembly bar (36), such that each of said bends (64) form a respective reinforcing location for receiving a longitudinal reinforcement bar (68) aligned substantially parallel to the axis of the at least one assembly bar (36), and such that the total angle of the bends forming the substantially closed hoop is more than 360°. 15 20 25 30 35
27. A method according to claim 26, **characterized by** winding the intermediate portion thereby forming first and second cage portions and bending the intermediate portion so the second cage portion is at least substantially received within the first cage portion. 40
28. A method according to claim 27, wherein the step of bending the intermediate portion so that the second cage portion is received in the first cage portion includes the step of moving the second cage portion through an angular extent towards the first cage portion so as to form a region of overlap in which at least some of the lateral bars (60) of the second cage portion are located between or have been moved between the parallel lateral bars (60) of the first cage portion. 45 50
29. A method according to claim 27 or 28, wherein said at least one assembly bar (36) in the first and second cage portion is positioned so that the second cage portion can be received within the first cage portion. 55

30. A method according to any of claims 27 to 29, wherein the region of overlap defines a first region within the first cage portion and a second region within the second cage portion, said first and second regions being free from assembly bars (36).

31. A method of forming according to claim 26, wherein the strengthening structure (102; 104; 106; 108; 109) is formed from a first mesh and a second mesh, each mesh comprising said plurality of lateral bars (60) and at least one assembly bar (36), and wherein the first and second meshes are located so that the first mesh is at least substantially received within the second mesh, thereby forming a composite cage for internally strengthening concrete.

32. A method of anchoring a structure (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100; 102; 104; 106; 108; 109), according to any of claims 1 to 25, comprising the step of: embedding said structure in a substance such as concrete and anchoring the mesh in the substance so that it strengthens the substance.

25 Patentansprüche

1. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100; 102; 104; 106; 108; 109) zur Verstärkung von Beton mit einem vorgeformten Gitter, das anschließend zu einem Käfig mit Ringen gebogen wird, das aus einzelnen Querstäben (60) und mindestens einem Montagestab (36) hergestellt ist, wobei der mindestens eine Montagestab eine Vielzahl von Anbringungspunkten hat, wobei jeder eine Anbringung an einen jeweiligen Querstab (60) vorsieht, und eine Achse entlang seiner Länge hat, wobei mindestens einige der Querstäbe (60) entlang von Achsen gebogen sind, die im Wesentlichen parallel zu der Achse des mindestens einen Montagestabs (36) sind, wobei jeder der Querstäbe (60):

einen Verankerungsabschnitt (62a, 62b) an dessen beiden Enden definiert; und einen Zwischenabschnitt definiert, der sich zwischen den Verankerungsabschnitten erstreckt, wobei jeder Zwischenabschnitt eine Vielzahl von Biegungen (64) hat, sodass er mindestens einen im Wesentlichen geschlossenen Ring ausbildet, **dadurch gekennzeichnet, dass** jede der Biegungen (64) jeweils eine Bewehrungsstelle zum Aufnehmen eines Längsbewehrungsstabs (68), der im Wesentlichen parallel zu der Achse des mindestens einen Montagestabs (36) ausgerichtet ist, ausbildet und der Gesamtwinkel der Biegungen, die den im Wesentlichen geschlossenen Ring ausbilden, mehr als 360° ist.

2. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß Anspruch 1, wobei jeder der Querstäbe (60) eine Vielzahl von Außenbewehrungsstellen definiert und wobei jeder der Querstäbe (60) des Weiteren mindestens eine Bewehrungsstelle definiert, die zwischen zwei Außenbewehrungsstellen angeordnet ist.
3. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß Anspruch 1 oder 2, wobei jeder Zwischenabschnitt des Gitters gebogen ist, um mindestens zwei konzentrische Ringe (76; 78) auszubilden.
4. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß Anspruch 3, wobei ein Innenrechteckring (76) hinsichtlich des Außenrechteckrahmenrings (78) um 45° gedreht ist.
5. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß Anspruch 3 oder 4, wobei mindestens ein im Wesentlichen geschlossener Ring ein n-seitiges Vieleck aufweist und n eine ganze Zahl zwischen 2 und unendlich ist.
6. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei jeder Zwischenabschnitt gebogen ist, so dass er einen Außenring und eine innerhalb des Außenrings (78) angeordnete Innenstrebe ausbildet.
7. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß Anspruch 6, wobei jeder Zwischenabschnitt zwei Innenstreben ausbildet, die den Außenring kreuzen.
8. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei jeder Zwischenabschnitt mindestens fünf Biegungen (64) enthält.
9. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei jeder zwischen Abschnitt mindestens eine Biegung (64) von 90° enthält.
10. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei jeder Zwischenabschnitt mindestens eine Biegung (64) von 45° enthält.
11. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei die Quer- (60) und Montagestäbe (36) an Anbringungspunkten entlang ihrer Länge durch maschinelles Binden angebracht sind.
12. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei die Quer- (60) und Montagestäbe (36) durch Schweißen zusammengefügt sind.
13. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei jeder Verankerungsabschnitt einen Haken aufweist, der durch die Enden der Querstäbe (60) ausgebildet ist.
14. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß Anspruch 13, wobei die Haken um einen Winkel von annäherungsweise 90° gebogen sind.
15. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß Anspruch 13, wobei die Haken mit Widerhaken versehen sind.
16. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei die Montagestäbe (36) eine Streckgrenze von 200-500MPa haben.
17. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei die Querstäbe (60) eine Streckgrenze von 200-800MPa haben.
18. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei die Querstäbe aus Stahl hergestellt sind.
19. Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100) zur Verstärkung von Beton gemäß einem der vorhergehenden Ansprüche, wobei die Montagestäbe eine niedrigere Streckgrenze als die Querstäbe (60) haben.
20. Struktur (102; 104; 106; 108; 109) gemäß Anspruch 1, wobei jeder Zwischenabschnitt einen ersten Satz von Biegungen (64), um einen ersten Käfigabschnitt auszubilden, und einen zweiten Satz von Biegungen (65) hat, um einen zweiten Käfigabschnitt auszubilden, wobei der erste Käfigabschnitt den ersten Verankerungsabschnitt enthält und der zweite Käfigabschnitt den zweiten Verankerungsabschnitt enthält, und wobei der zweite Käfigabschnitt in dem ersten Käfigabschnitt mindestens im Wesentlichen aufgenommen ist.

21. Struktur (102; 104; 106; 108; 109) zur Verstärkung von Beton gemäß Anspruch 20, wobei der zweite Käfigabschnitt innerhalb eines Überlappungsbereich des ersten Käfigabschnitts derart aufgenommen ist, dass mindestens einige der Querstäbe (60) des zweiten Käfigabschnitts zwischen den Querstäben (60) des ersten Käfigabschnitts gelegen sind. 5
22. Struktur (102; 104; 106; 108; 109) zur Verstärkung von Beton gemäß Anspruch 20 oder 21, wobei der mindestens eine Montagestab in dem ersten und zweiten Käfigabschnitt positioniert ist, so dass der zweite Käfigabschnitt innerhalb des ersten Käfigabschnitts aufgenommen werden kann. 10
23. Struktur (102; 104; 106; 108; 109) zur Verstärkung von Beton gemäß einem der Ansprüche 20 bis 22, wobei der Überlappungsbereich einen ersten Bereich innerhalb des ersten Käfigabschnitts und einen zweiten Bereich innerhalb des zweiten Käfigabschnitts definiert, wobei der erste und zweite Bereich frei von Montagestäben (36) ist. 15
24. Struktur (102; 104; 106; 108; 109) gemäß einem der Ansprüche 1 bis 19, **gekennzeichnet durch** ein erstes Gitter und ein zweites Gitter, wobei jedes Gitter die Vielzahl von Querstäben (60) und mindestens einen Montagestab (36) hat, wobei das erste Gitter in dem zweiten Gitter mindestens im Wesentlichen aufgenommen ist, wodurch einen zusammengesetzten Käfig zur inneren Verstärkung von Beton ausgebildet ist. 20
25. Struktur gemäß Anspruch 24, wobei der erste und zweite Gitterabschnitt so gelegen sind, dass mindestens ein Querstab (60) des ersten Gitterabschnitts zwischen zwei Querstäben (60) des zweiten Gitterabschnitts angeordnet ist. 25
26. Verfahren zum Ausbilden einer Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100; 102; 104; 106; 108; 109) aus einem vorgeformten Gitter, wobei das Gitter eine Vielzahl von Querstäben (60) und mindestens einen Montagestab (36) mit einer Vielzahl von Anbringungspunkten, wobei jeder eine Anbringung an einen jeweiligen Querstab (60) vorsieht, und mit einer Achse entlang seiner Länge aufweist, wobei das Verfahren folgende Schritte aufweist: 30
- Ausbilden eines ersten Verankerungsabschnitt an einem ersten Ende und eines zweiten Verankerungsabschnitt an einem zweiten Ende von jedem Querstab (60), um einen Zwischenabschnitt zu definieren, der sich zwischen dem ersten und zweiten Verankerungsabschnitt erstreckt; und 35
- Wickeln jedes Zwischenabschnitts beginnend mit dem ersten Ende des Stabs (60), so dass eine Vielzahl von Biegungen (64) an einer Vielzahl von Stellen entlang des Zwischenabschnitts ausgebildet werden, um mindestens einen im Wesentlichen geschlossenen Ring auszubilden, wobei jede Biegung (64) im Wesentlichen parallel zu der Achse des mindestens einen Montagestabs (36) derart ausgebildet ist, dass jede der Biegungen (64) jeweils eine Bewehrungsstelle zum Aufnehmen eines Längsbewehrungsstabs (68), der im Wesentlichen parallel zu der Achse des mindestens einem Montagestabs (36) ausgerichtet ist, ausbildet, und dass der Gesamtwinkel der Biegungen, die den im Wesentlichen geschlossenen Ring ausbilden, mehr als 360° ist. 40
27. Verfahren gemäß Anspruch 26, **gekennzeichnet durch** Wickeln des Zwischenabschnitts, wodurch ein erster und zweiter Käfigabschnitt ausgebildet wird, und Biegen des Zwischenabschnitts, so dass der zweite Käfigabschnitt innerhalb des ersten Käfigabschnitts mindestens im Wesentlichen aufgenommen ist. 45
28. Verfahren gemäß Anspruch 27, wobei der Schritt des Biegens des Zwischenabschnitts, so dass der zweite Käfigabschnitt in dem ersten Käfigabschnitt aufgenommen ist, den Schritt eines Bewegens des zweiten Käfigabschnitts über einen Winkelbereich in Richtung des ersten Käfigabschnitts enthält, um einen Überlappungsbereich auszubilden, in dem mindestens einige der Querstäbe (60) des zweiten Käfigabschnitts zwischen den parallelen Querstäben (60) des ersten Käfigabschnitts gelegen sind oder zwischen die parallelen Querstäben (60) des ersten Käfigabschnitts bewegt wurden. 50
29. Verfahren gemäß Anspruch 27 oder 28, wobei der mindestens eine Montagestab (36) in dem ersten und zweiten Käfigabschnitt positioniert ist, so dass der zweite Käfigabschnitt innerhalb des ersten Käfigabschnitts aufgenommen werden kann. 55
30. Verfahren gemäß einem der Ansprüche 27 bis 29, wobei der Überlappungsbereich einen ersten Bereich innerhalb des ersten Käfigabschnitts und einen zweiten Bereich innerhalb des zweiten Käfigabschnitts definiert, wobei der erste und zweite Bereich frei von Montagestäben (36) sind.
31. Verfahren zum Ausbilden gemäß Anspruch 26, wobei die Verstärkungsstruktur (102; 104; 106; 108; 109) aus einem ersten Gitter und einem zweiten Gitter ausgebildet ist, wobei jedes Gitter die Vielzahl von Querstäben (60) und mindestens einen Montagestab (36) aufweist, und wobei das erste und zweite Gitter so gelegen sind, dass das erste Gitter innerhalb des zweiten Gitters mindestens im Wesentlichen

chen aufgenommen ist, wodurch ein zusammengesetzter Käfig zur inneren Verstärkung von Beton ausgebildet wird.

32. Verfahren zum Verankern einer Struktur (61; 66; 70; 72; 74; 80; 91; 93; 95; 97; 99; 100; 102; 104; 106; 108; 109) gemäß einem der Ansprüche 1 bis 25, das den folgenden Schritt aufweist: Einbetten der Struktur in eine Substanz wie zum Beispiel Beton und Verankern des Gitters in der Substanz, so dass es die Substanz verstärkt.

Revendications

1. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100 ; 102 ; 104 ; 106 ; 108 ; 109) pour renforcer du béton comprenant un treillis préformé qui est sensiblement coudé sur une cage ayant des cadres réalisés à partir de barres latérales uniques (60) et au moins une barre d'assemblage (36), la au moins une barre d'assemblage ayant une pluralité de points de fixation, chacun fournissant la fixation à une barre latérale (60) respective, et ayant un axe le long de sa longueur, au moins certaines des barres latérales (60) étant coudées le long d'axes sensiblement parallèles à l'axe de la au moins une barre d'assemblage (36), chacune desdites barres latérales (60) :

définissant une partie d'ancrage (62a, 62b) au niveau de ses deux extrémités ; et
définissant une partie intermédiaire s'étendant entre lesdites parties d'ancrage,
dans laquelle chaque partie intermédiaire a une pluralité de coudes (64), de sorte qu'elle forme au moins un cadre sensiblement fermé, **caractérisée en ce que** ;
chacun desdits coudes (64) forme un emplacement de renforcement respectif pour recevoir une barre de renforcement longitudinale (68) alignée de manière sensiblement parallèle à l'axe de la au moins une barre d'assemblage (36), et l'angle total des coudes formant le cadre sensiblement fermé est supérieur à 360°.

2. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon la revendication 1, dans laquelle chacune desdites barres latérales (60) définit une pluralité d'emplacements de renforcement externes, et dans laquelle chacune desdites barres latérales (60) définit en outre au moins un emplacement de renforcement disposé entre deux emplacements de renforcement externes.
3. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon la re-

vendication 1 ou 2, dans laquelle chaque partie intermédiaire du treillis est coudée afin de former au moins deux cadres concentriques (76 ; 78).

4. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon la revendication 3, dans laquelle un cadre carré interne (76) est entraîné en rotation par rapport au cadre de bâti carré externe (78) à 45°.
5. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon la revendication 3 ou 4, dans laquelle au moins un cadre sensiblement fermé comprend un polygone à n côtés, et n est un nombre entier compris entre 2 et l'infini.
6. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une quelconque des revendications précédentes, dans laquelle chacune desdites parties intermédiaires est coudée de sorte qu'elle forme un cadre externe et une entretoise interne disposée à l'intérieur du cadre externe (78).
7. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon la revendication 6, dans laquelle chaque partie intermédiaire forme deux entretoises internes traversant le cadre externe.
8. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une quelconque des revendications précédentes, dans laquelle chaque partie intermédiaire comprend au moins cinq coudes (64).
9. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une quelconque des revendications précédentes, dans laquelle chaque partie intermédiaire comprend au moins un coude (64) de 90°.
10. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une quelconque des revendications précédentes, dans laquelle chaque partie intermédiaire comprend au moins un coude (64) de 45°.
11. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une quelconque des revendications précédentes, dans laquelle les barres latérales (60) et d'assemblage (36) sont fixées au niveau des points de fixation le long de leur longueur par liaison à la machine.
12. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une

quelconque des revendications précédentes, dans laquelle les barres latérales (60) et d'assemblage (36) sont fixées par soudage.

13. Structure (61 ; 66 ; 70 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une quelconque des revendications précédentes, dans laquelle une partie d'ancrage comprend un crochet formé par les extrémités des barres latérales (60). 5
14. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon la revendication 13, dans laquelle les crochets sont cou- 10
dés à un angle d'approximativement 90°. 15
15. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon la re- 20
vendication 13, dans laquelle les crochets compor- tent des ardoillons. 25
16. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une 30
quelconque des revendications précédentes, dans laquelle les barres d'assemblage (36) ont une limite d'élasticité de 200-500 MPa. 35
17. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une 40
quelconque des revendications précédentes, dans laquelle les barres latérales (60) ont une limite d'élasticité de 200-800 MPa. 45
18. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une 50
quelconque des revendications précédentes, dans laquelle les barres latérales (60) sont réalisées à par- tir d'acier. 55
19. Structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100) pour renforcer du béton selon l'une 50
quelconque des revendications précédentes, dans laquelle les barres d'assemblage ont une limite d'élasticité inférieure aux barres latérales (60). 55
20. Structure (102 ; 104 ; 106 ; 108 ; 109) selon la re- 50
vendication 1, dans laquelle chaque partie intermédiaire a un pre- mier ensemble de coudes (64) afin de former une première partie de cage et un second ensemble de coudes (65) afin de former une seconde partie de cage, ladite première partie de cage comprenant la- dite première partie d'ancrage, et ladite seconde par- tie de cage comprenant ladite seconde partie d'an- crage, et dans laquelle la seconde partie de cage est au moins sensiblement reçue dans la première 55
partie de cage.
21. Structure (102 ; 104 ; 106 ; 108 ; 109) pour renforcer

du béton selon la revendication 20, dans laquelle la seconde partie de cage est reçue à l'intérieur d'une région de chevauchement de la première partie de cage, de sorte qu'au moins certaines des barres la- térales (60) de la seconde partie de cage sont posi- tionnées entre les barres latérales (60) de la premiè- re partie de cage.

22. Structure (102 ; 104 ; 106 ; 108 ; 109) pour renforcer 10
du béton selon la revendication 20 ou 21, dans la- quelle ladite au moins une barre d'assemblage dans les première et seconde parties de cage est posi- tionnée de sorte que la seconde partie de cage peut être reçue à l'intérieur de la première partie de cage. 15
23. Structure (102 ; 104 ; 106 ; 108 ; 109) pour renforcer 20
du béton selon l'une quelconque des revendications 20 à 22, dans laquelle la région de chevauchement définit une première région à l'intérieur de la premiè- re partie de cage et une seconde région à l'intérieur de la seconde partie de cage, lesdites première et seconde régions étant dépourvues de barres d'as- semblage (36). 25
24. Structure (102 ; 104 ; 106 ; 108 ; 109) selon l'une 30
quelconque des revendications 1 à 19, **caractérisée par** un premier treillis et un second treillis, chaque treillis ayant ladite pluralité de barres latérales (60) et au moins une barre d'assemblage (36), dans la- quelle le premier treillis est au moins sensiblement reçu dans le second treillis, formant ainsi une cage composite pour renforcer intérieurement le béton. 35
25. Structure selon la revendication 24, dans laquelle 40
lesdites première et seconde parties de treillis sont positionnées de sorte qu'au moins une barre latérale (60) de la première partie de treillis est disposée en- tre deux barres latérales (60) de ladite seconde par- tie de treillis. 45
26. Procédé pour former une structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100 ; 102 ; 104 ; 106 ; 108 ; 109) à partir d'un treillis préformé, le treillis 50
comprenant une pluralité de barres latérales (60) et au moins une barre d'assemblage (36) ayant une pluralité de points de fixation, chacun fournissant la fixation à une barre latérale (60) respective, et ayant un axe le long de sa longueur, le procédé compren- ant les étapes consistant à : 55

former une première partie d'ancrage au niveau d'une première extrémité et une seconde partie d'ancrage au niveau d'une seconde extrémité de chaque barre latérale (60), afin de définir une partie intermédiaire s'étendant entre lesdites première et seconde parties d'ancrage ; et enrouler chaque partie intermédiaire en com- mençant avec la première extrémité de la barre

- (60) de sorte qu'une pluralité de coudes (64) sont formés à une pluralité d'emplacements le long de la partie intermédiaire, afin de former au moins un cadre sensiblement fermé, chaque coude (64) étant formé de manière sensiblement parallèle à l'axe de la au moins une barre d'assemblage (36), de sorte que chacun desdits coudes (64) forme un emplacement de renforcement respectif pour recevoir une barre de renforcement longitudinale (68) alignée de manière sensiblement parallèle à l'axe de la au moins une barre d'assemblage (36) et de sorte que l'angle total des coudes formant le cadre sensiblement fermé est supérieur à 360°.
27. Procédé selon la revendication 26, **caractérisé par** l'étape consistant à enrouler la partie intermédiaire, formant ainsi des première et seconde parties de cage et couplant la partie intermédiaire de sorte que la seconde partie de cage est au moins sensiblement reçue à l'intérieur de la première partie de cage.
28. Procédé selon la revendication 27, dans lequel l'étape consistant à couder la partie intermédiaire de sorte que la seconde partie de cage est reçue dans la première partie de cage comprend l'étape consistant à déplacer la seconde partie de cage sur une étendue angulaire vers la première partie de cage afin de former une région de chevauchement dans laquelle au moins certaines des barres latérales (60) de la seconde partie de cage sont positionnées entre ou ont été déplacées entre les barres latérales parallèles (60) de la première partie de cage.
29. Procédé selon la revendication 27 ou 28, dans lequel ladite au moins une barre d'assemblage (36) dans la première et la seconde partie de cage est positionnée de sorte que la seconde partie de cage peut être reçue à l'intérieur de la première partie de cage.
30. Procédé selon l'une quelconque des revendications 27 à 29, dans lequel la région de chevauchement définit une première région à l'intérieur de la première partie de cage et une seconde région à l'intérieur de la seconde partie de cage, lesdites première et seconde régions étant dépourvues de barres d'assemblage (36).
31. Procédé de formage selon la revendications 26, dans lequel la structure de renforcement (102 ; 104 ; 106 ; 108 ; 109) est formée à partir d'un premier treillis et d'un second treillis, chaque treillis comprenant ladite pluralité de barres latérales (60) et au moins une barre d'assemblage (36) et dans lequel les premier et second treillis sont positionnés de sorte que le premier treillis est au moins sensiblement reçu à l'intérieur du second treillis, formant ainsi une cage composite pour renforcer intérieurement le béton.
32. Procédé pour ancrer une structure (61 ; 66 ; 70 ; 72 ; 74 ; 80 ; 91 ; 93 ; 95 ; 97 ; 99 ; 100 ; 102 ; 104 ; 106 ; 108 ; 109) selon l'une quelconque des revendications 1 à 25, comprenant l'étape consistant à : encastrer ladite structure dans une substance telle que du béton et ancrer le treillis dans la substance de sorte qu'il renforce la substance.

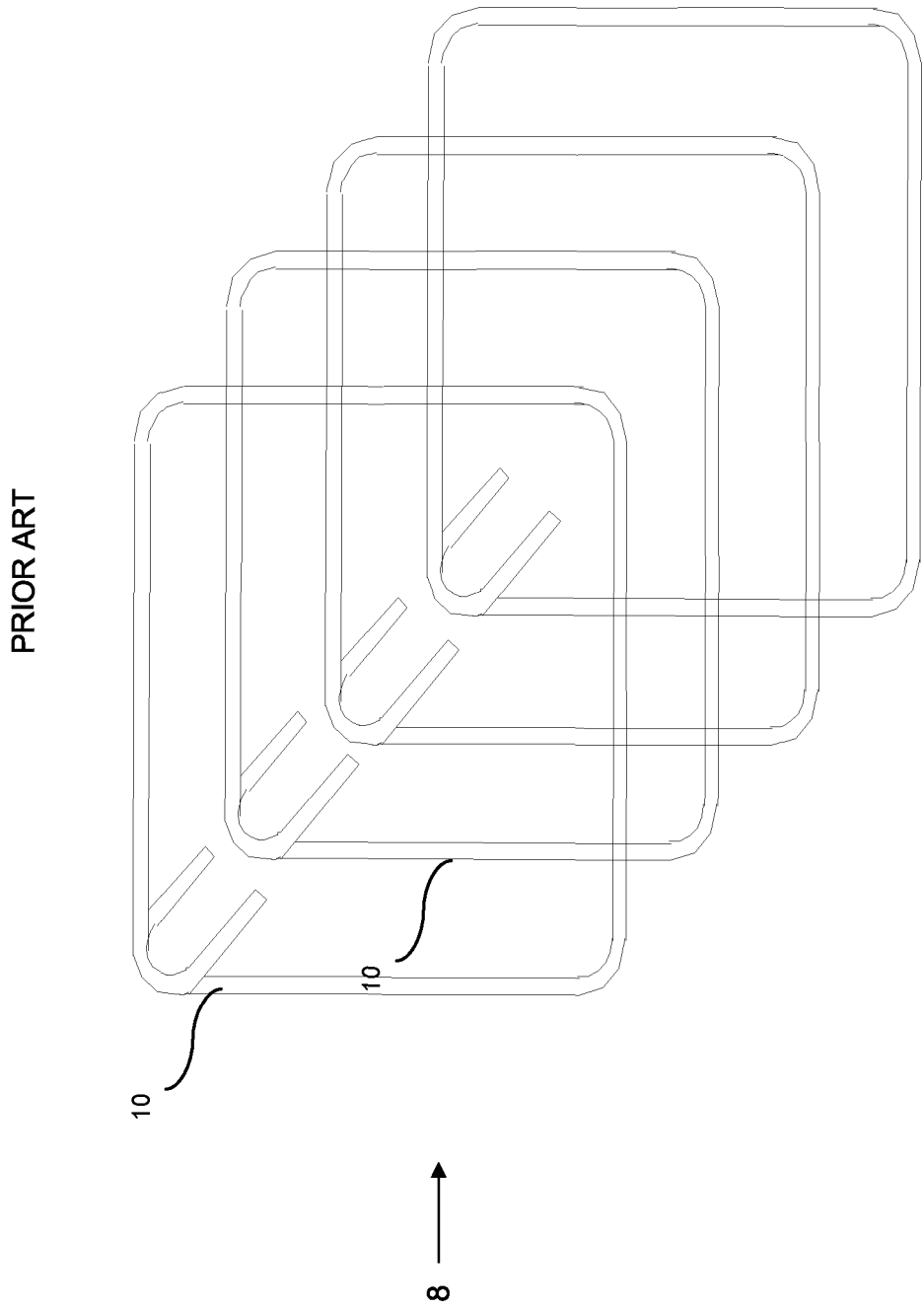
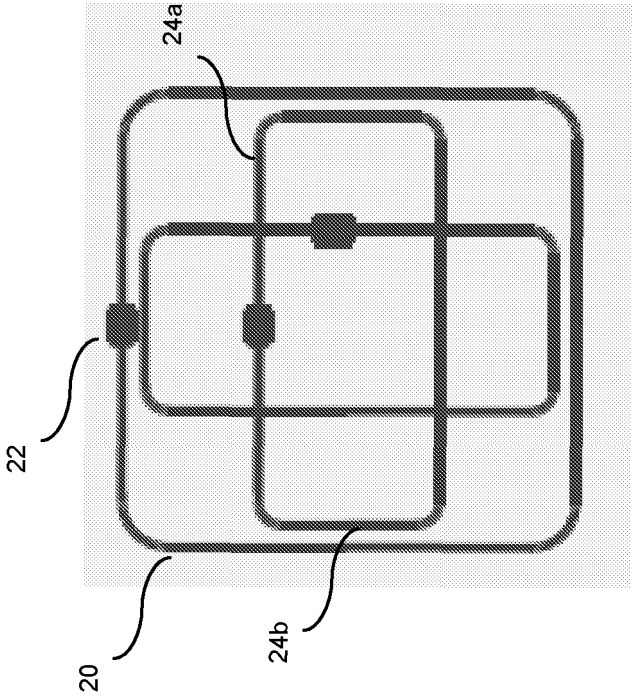


Figure 1

PRIOR ART



18

Figure 2

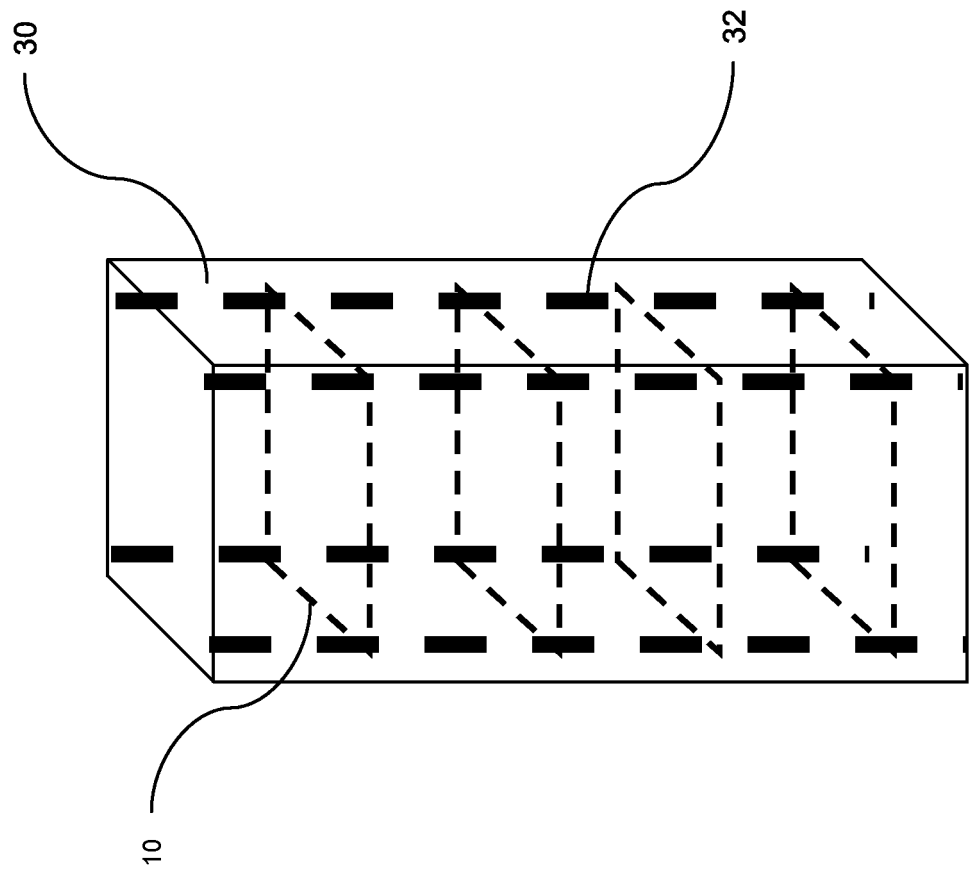


Figure 3

PRIOR ART

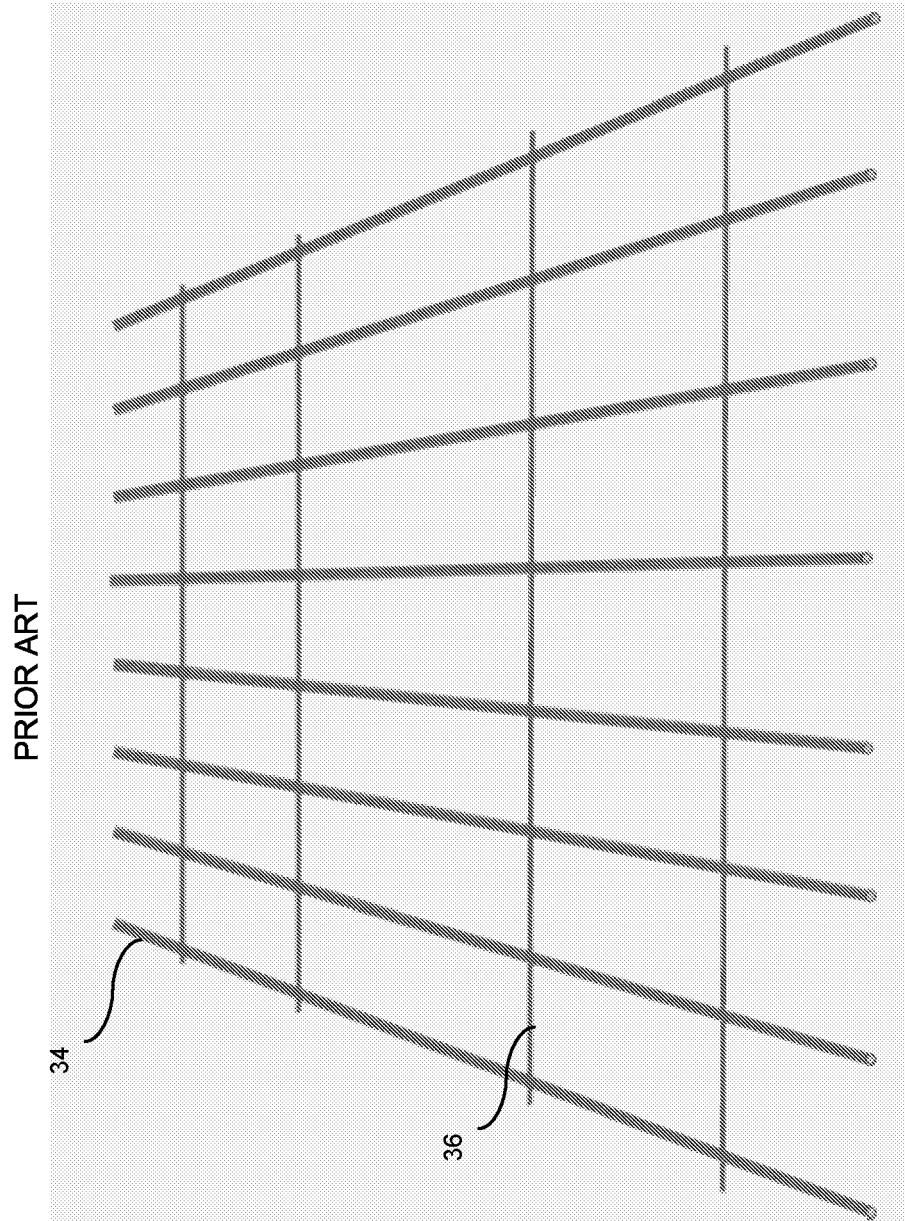


Figure 4

PRIOR ART

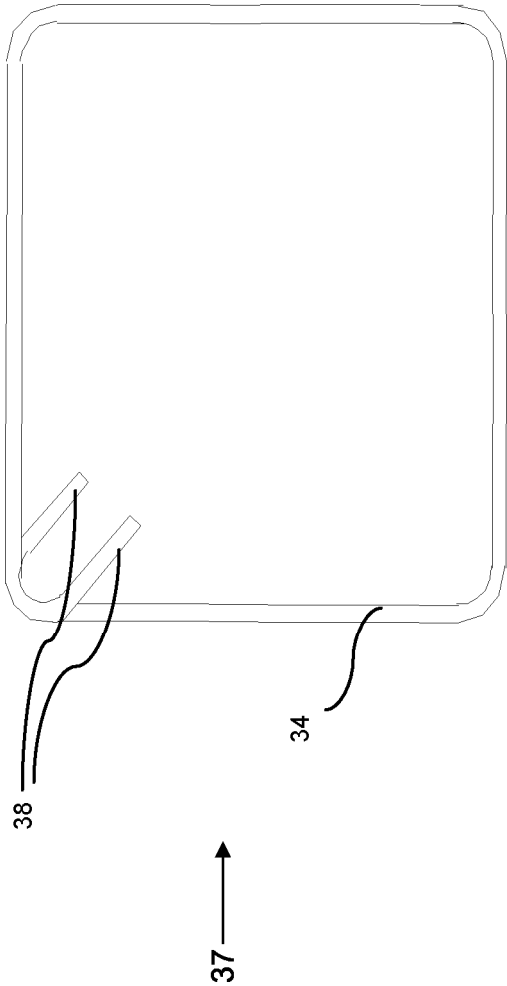


Figure 5

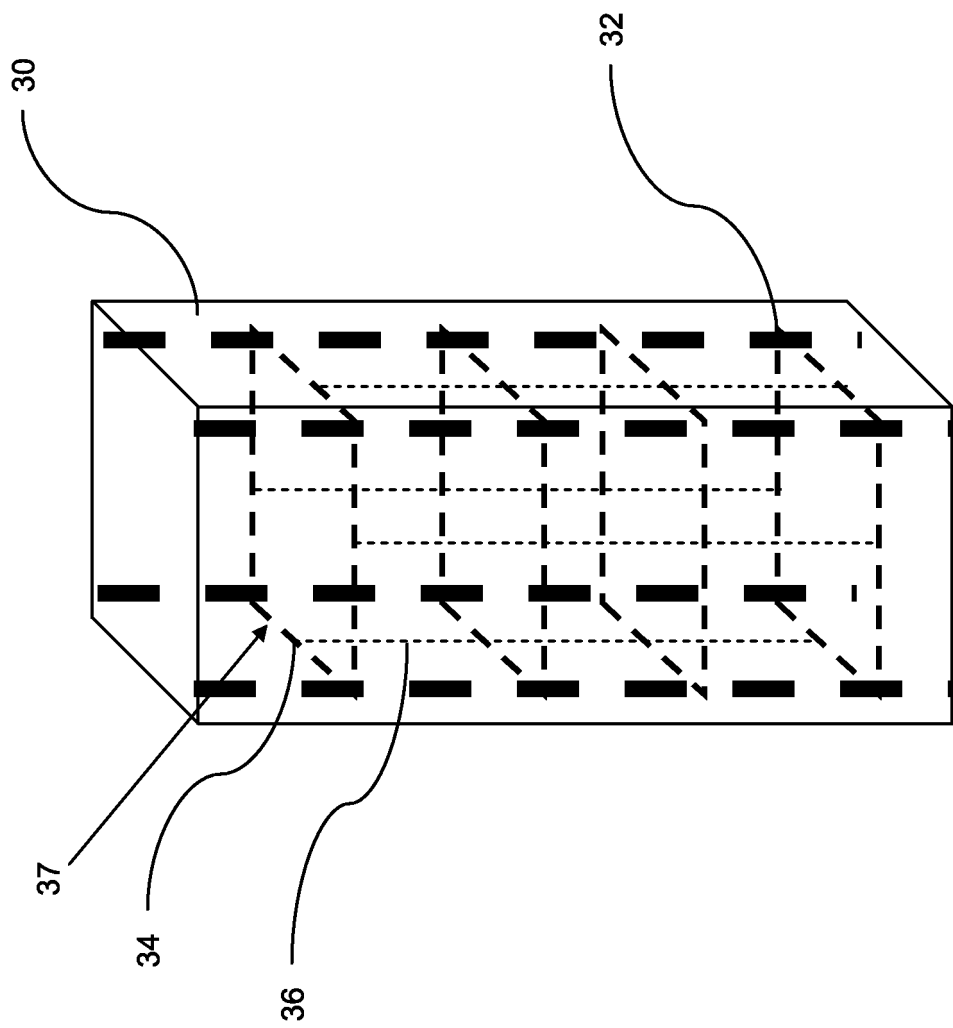


Figure 6

PRIOR ART

PRIOR ART

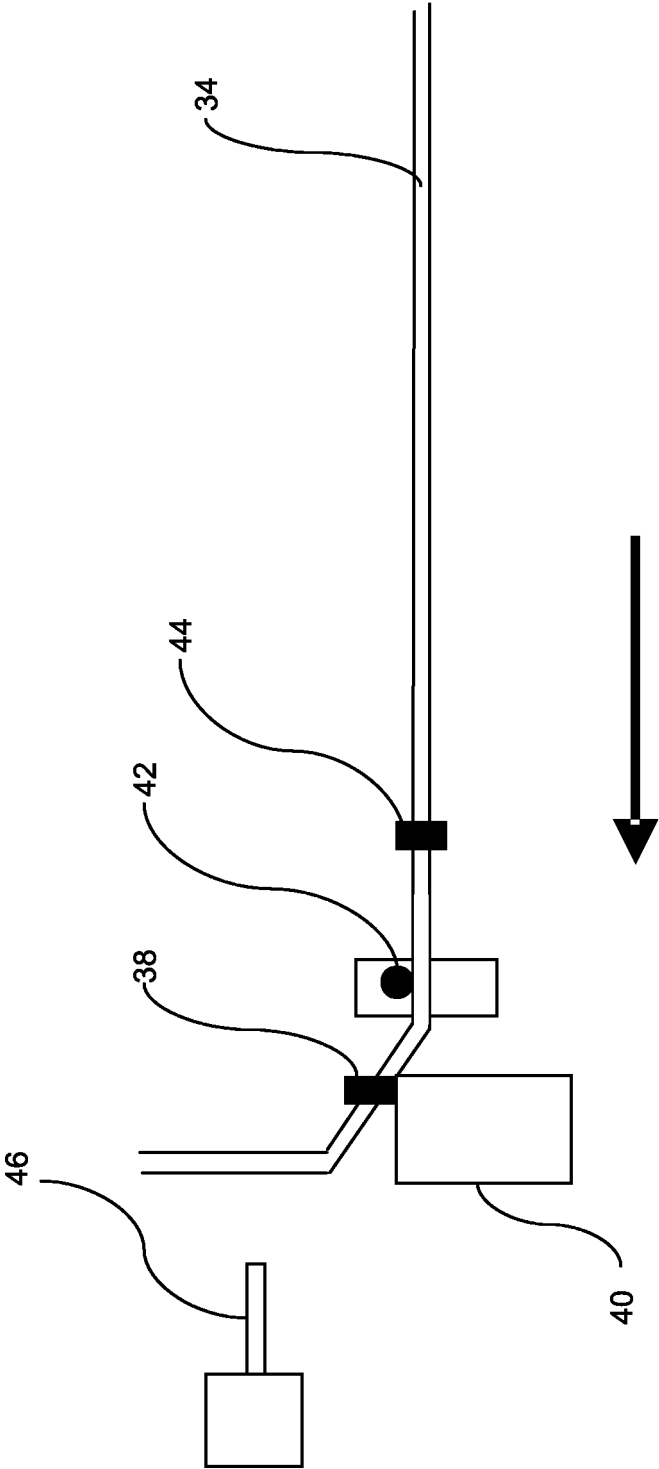


Figure 7

PRIOR ART

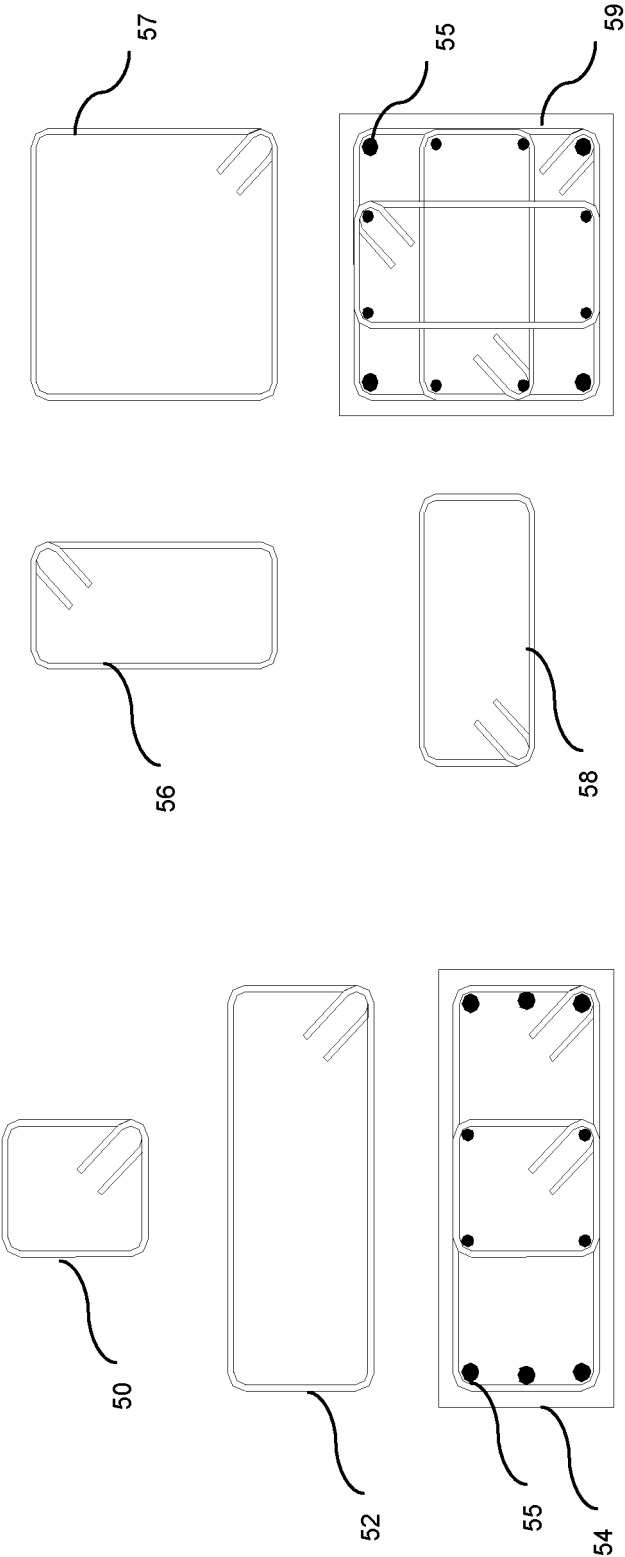


Figure 8a

Figure 8b

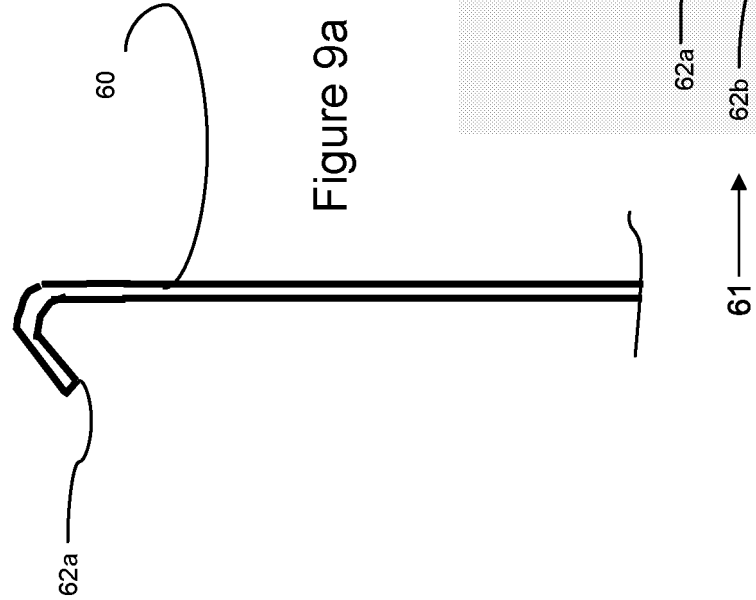


Figure 9a

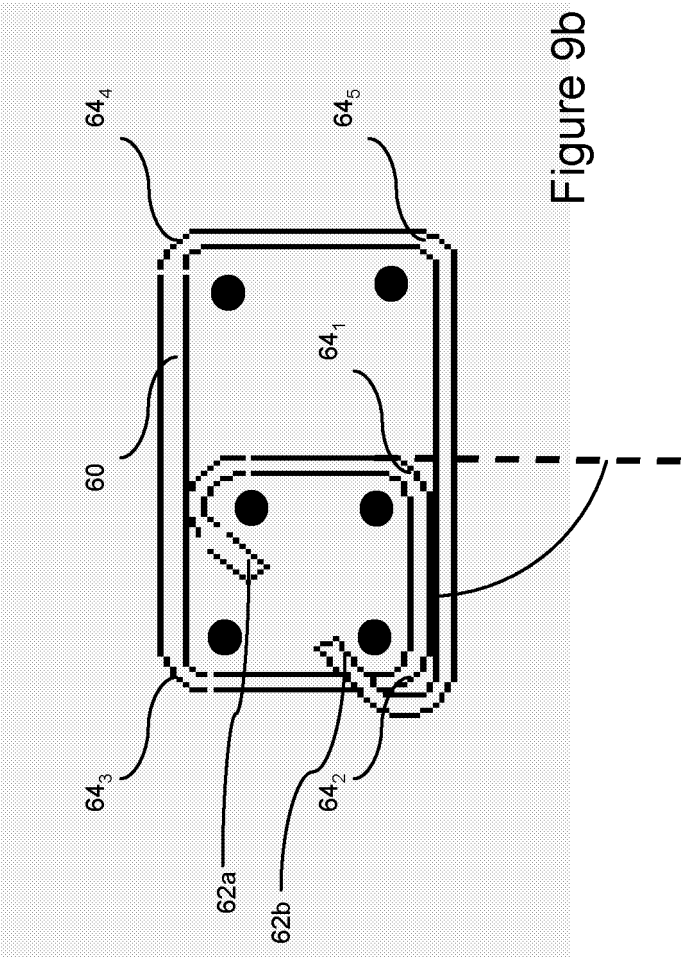


Figure 9b

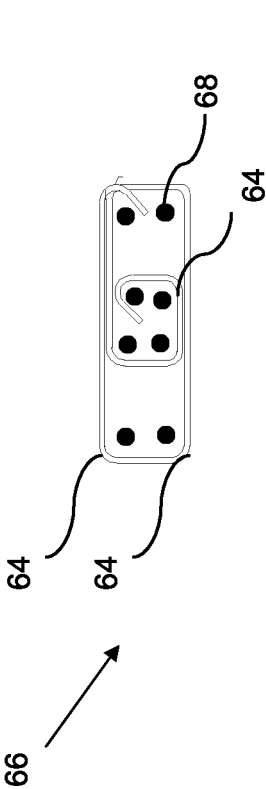


Figure 10a

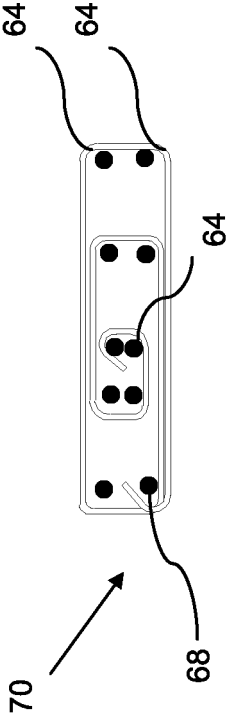


Figure 10b

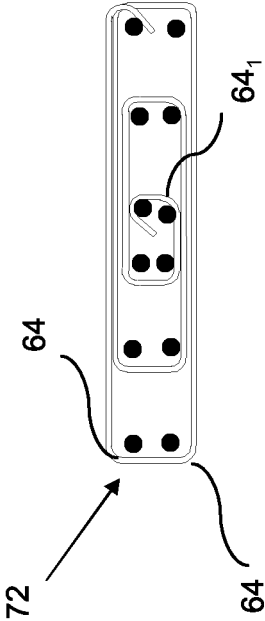
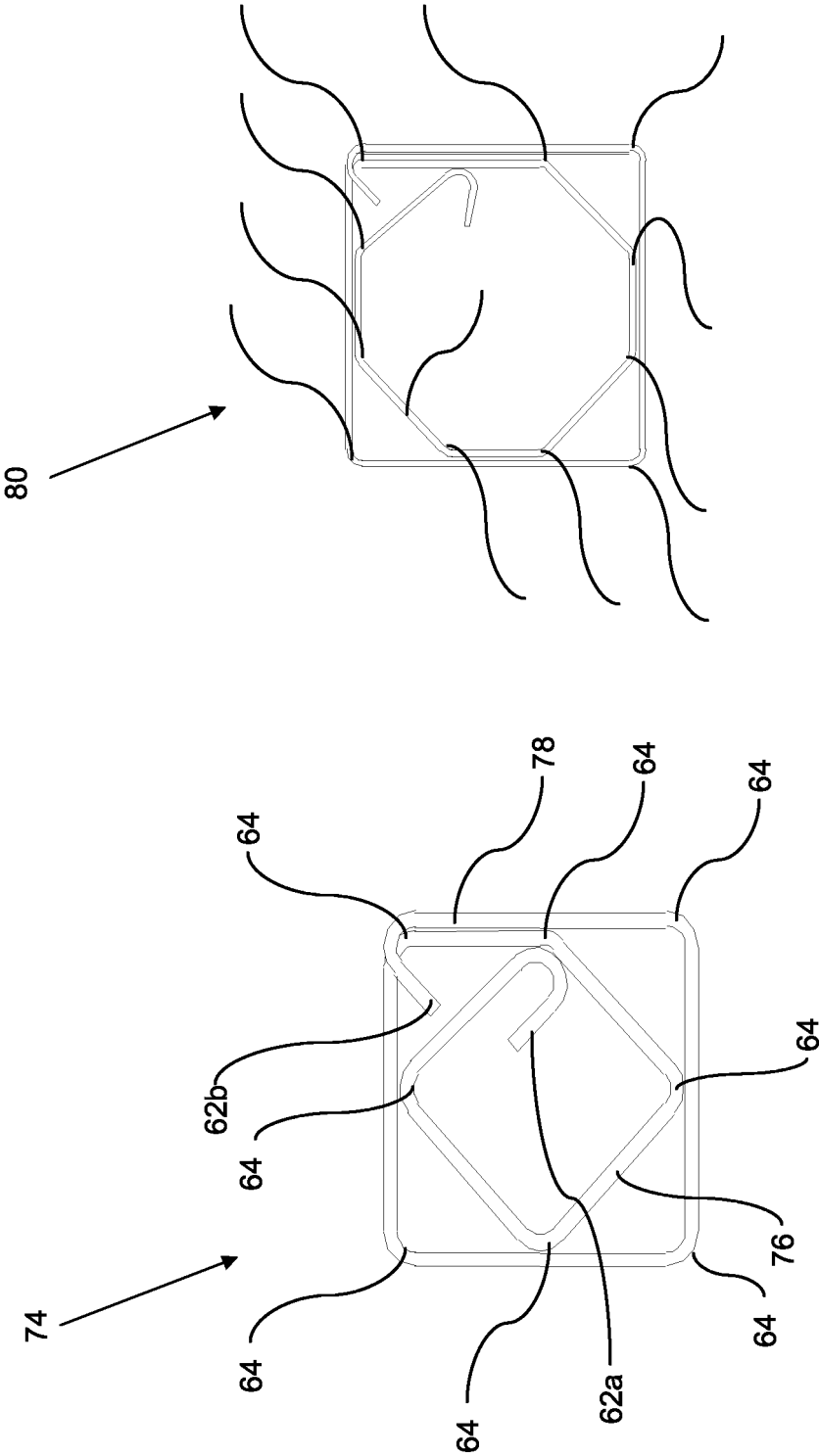
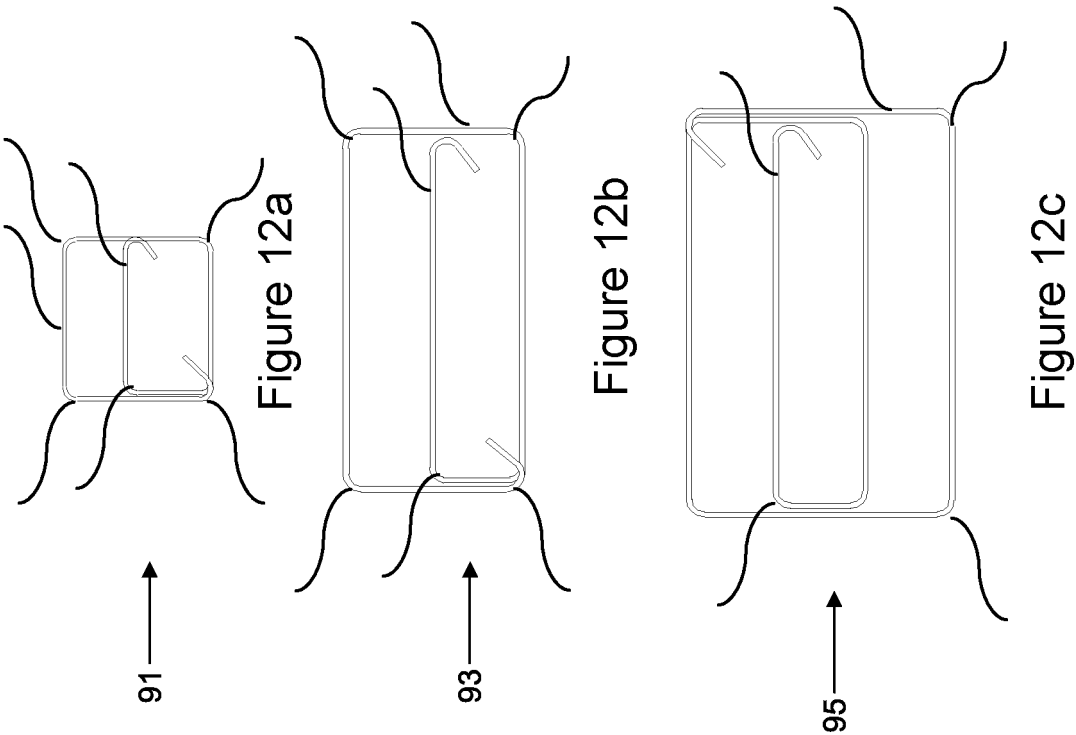


Figure 10c





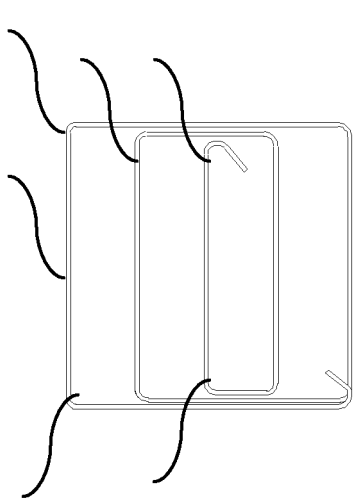


Figure 12d

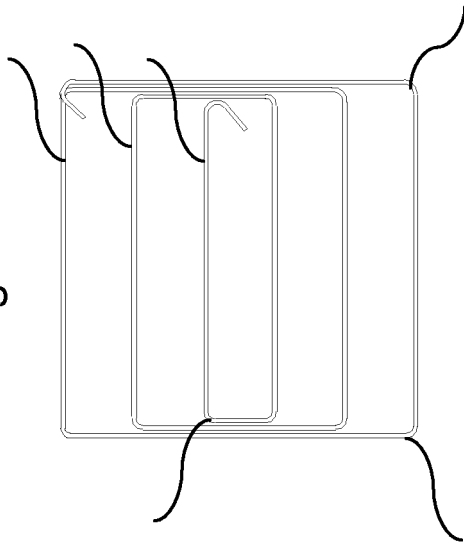


Figure 12e

97

99

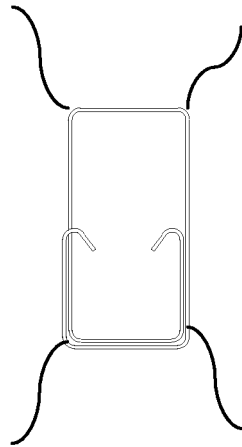


Figure 13

100



A vertical arrow pointing upwards, indicating a reference or a specific direction related to the number 100.

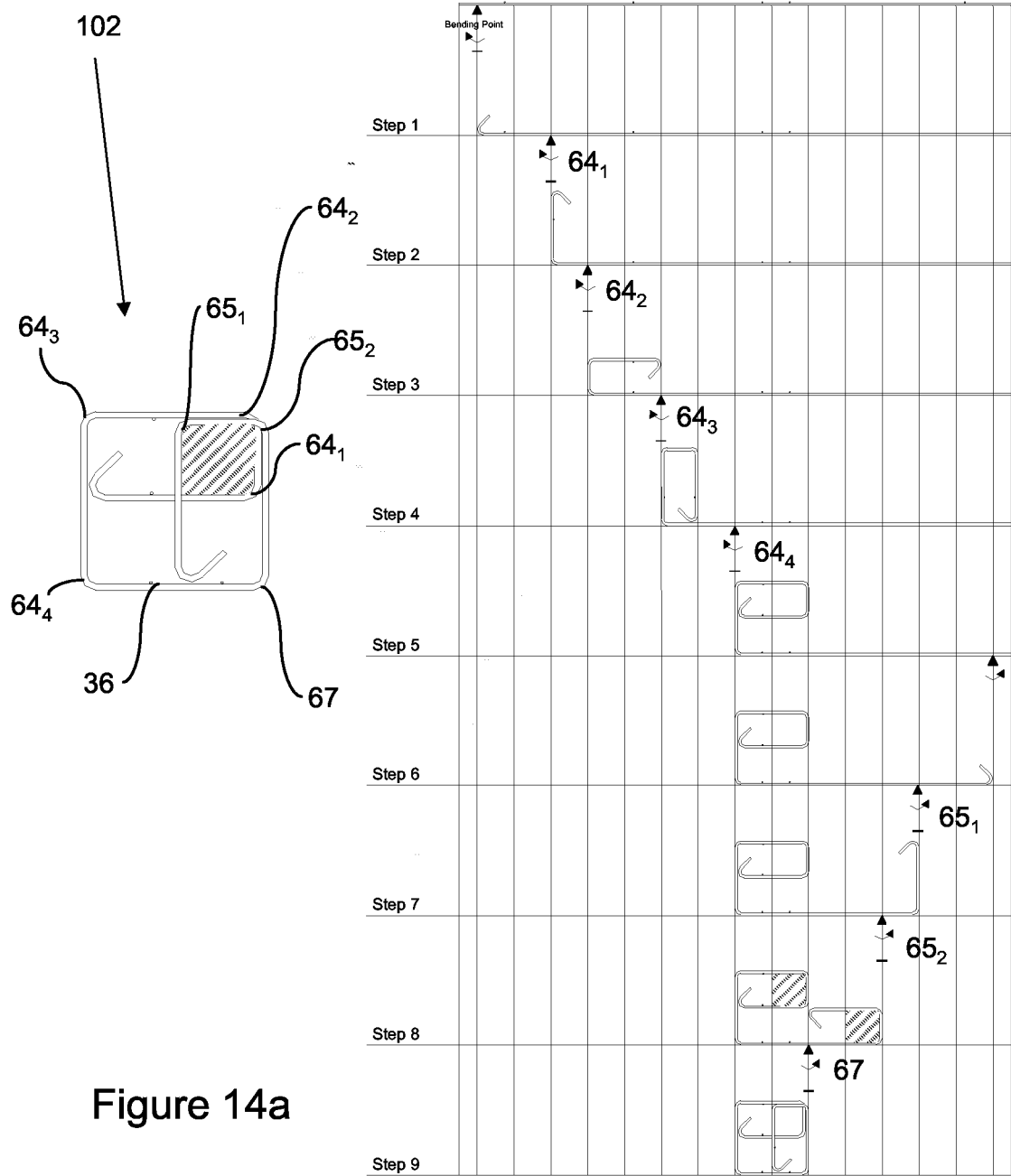


Figure 14a

Figure 14b

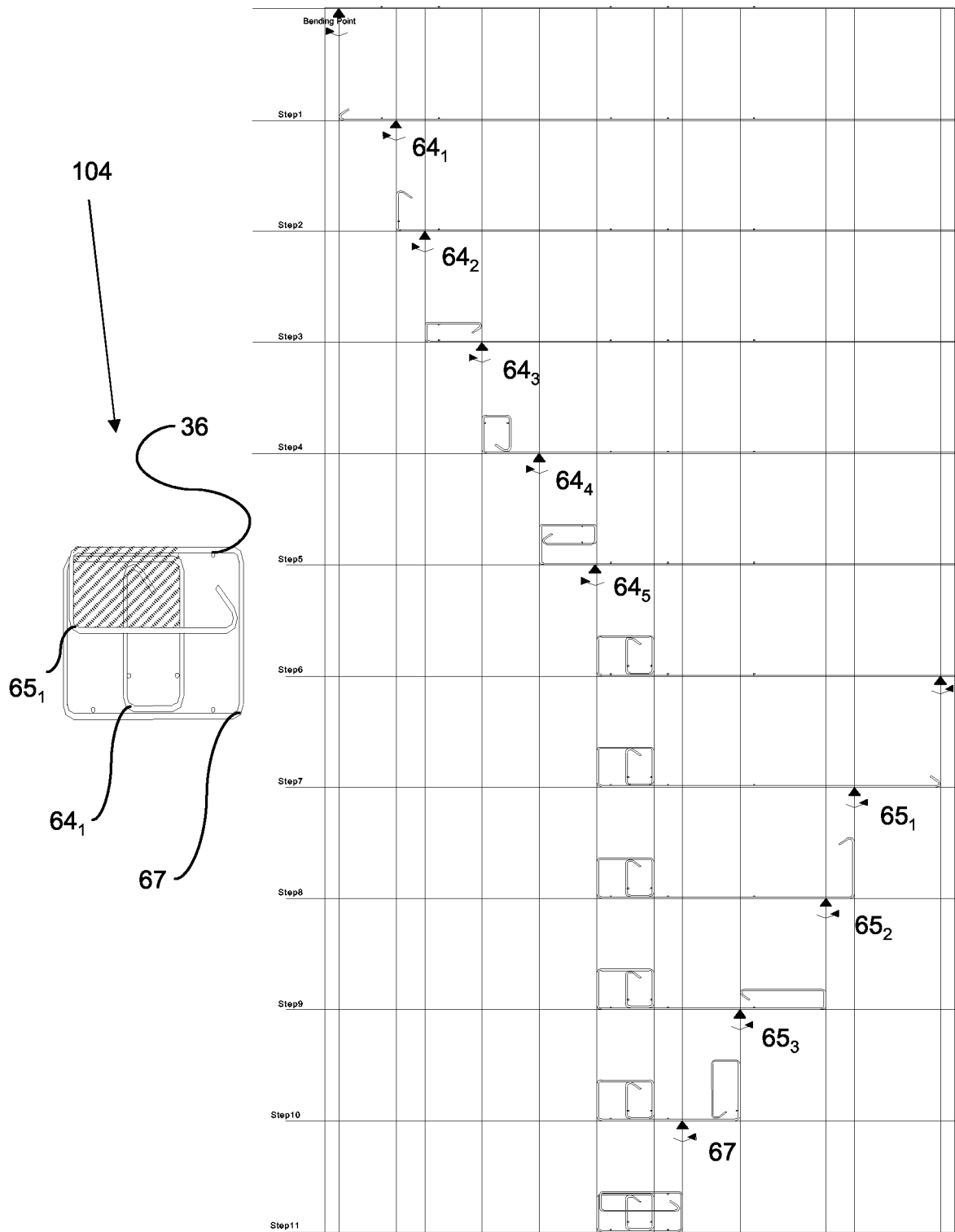


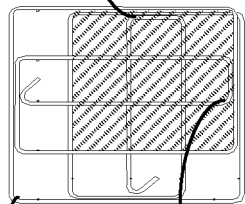
Figure 15a

Figure 15b

106



64₁



67

65₁

Figure 16a

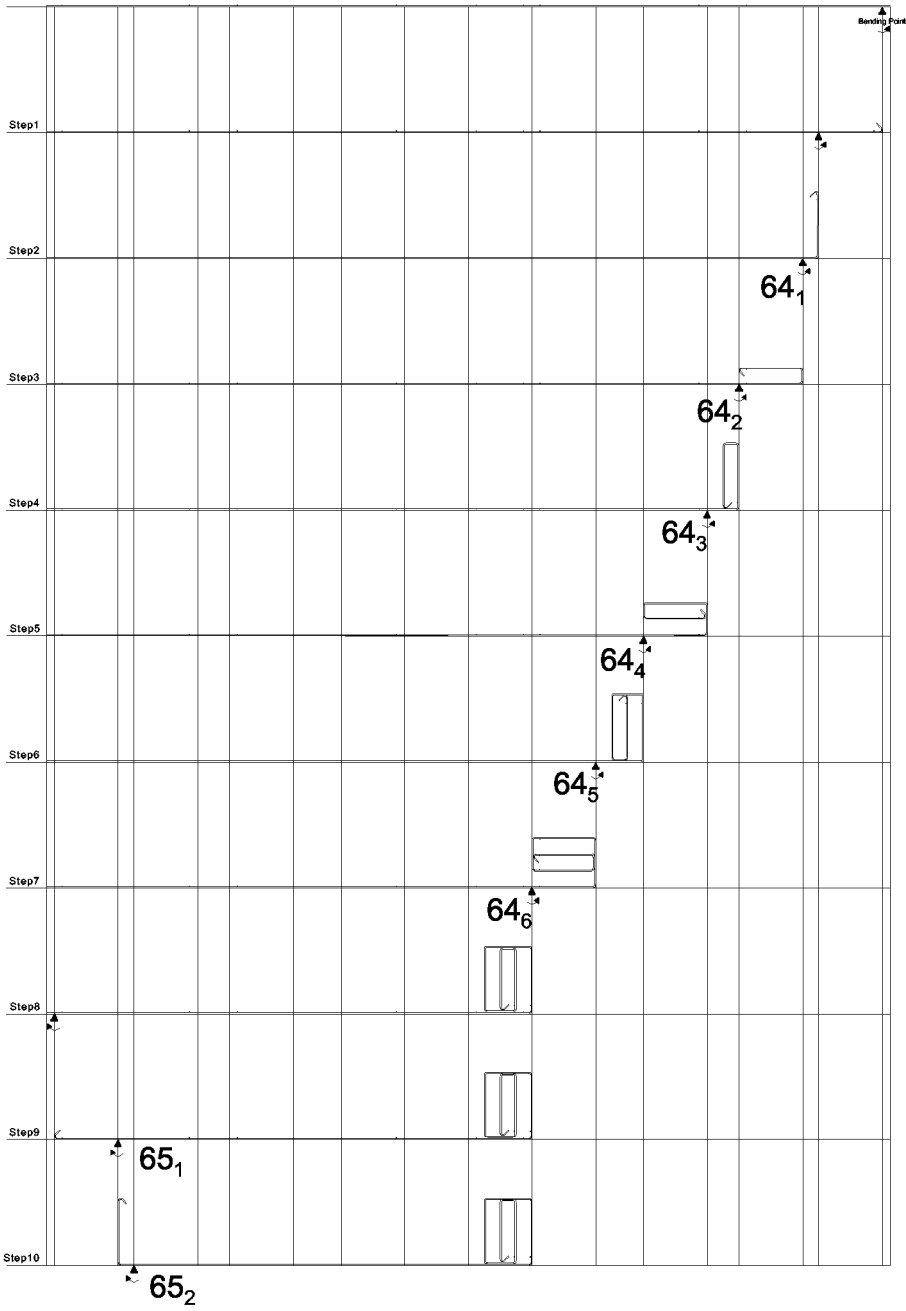


Figure 16b

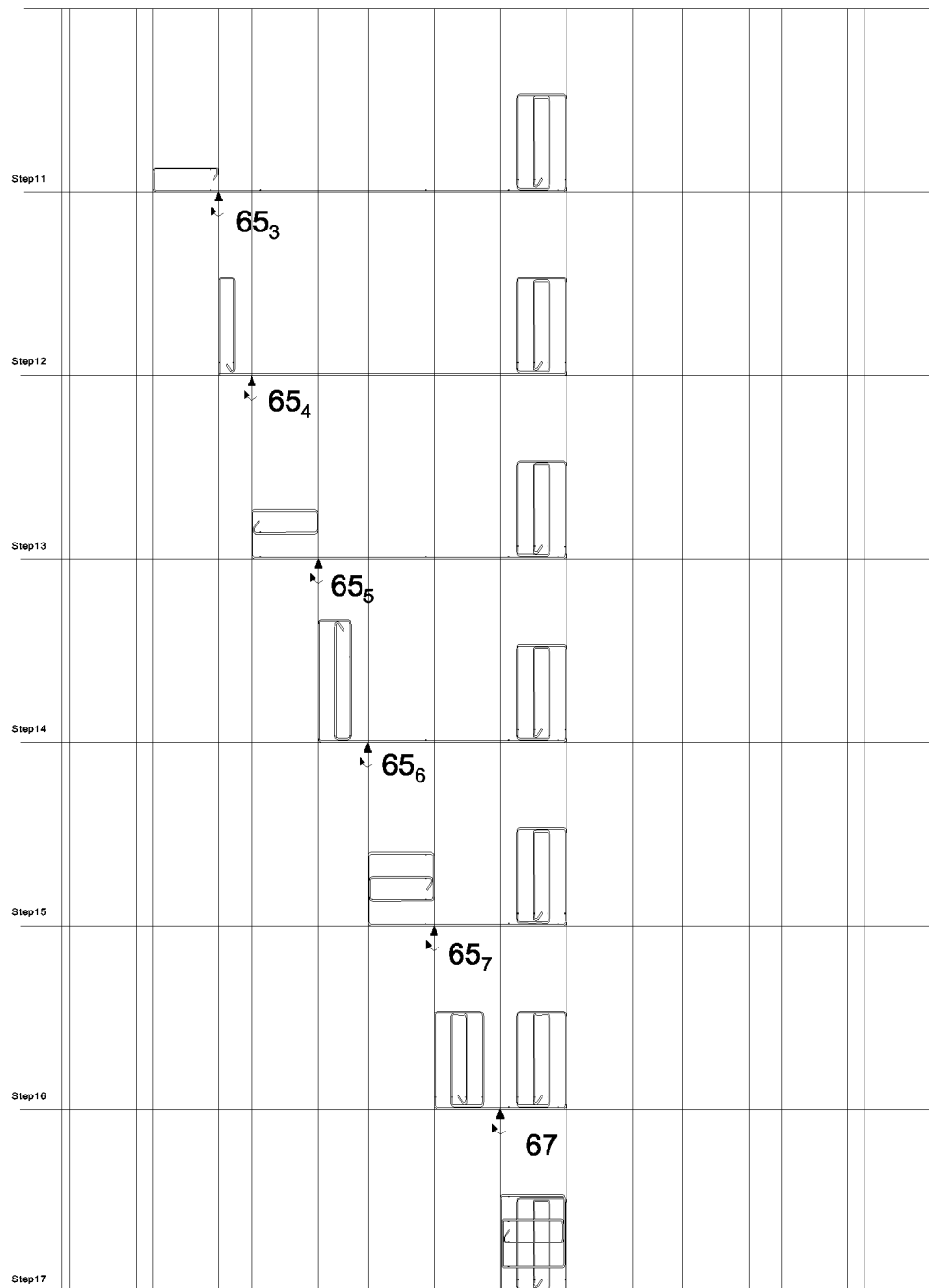


Figure 16b cont

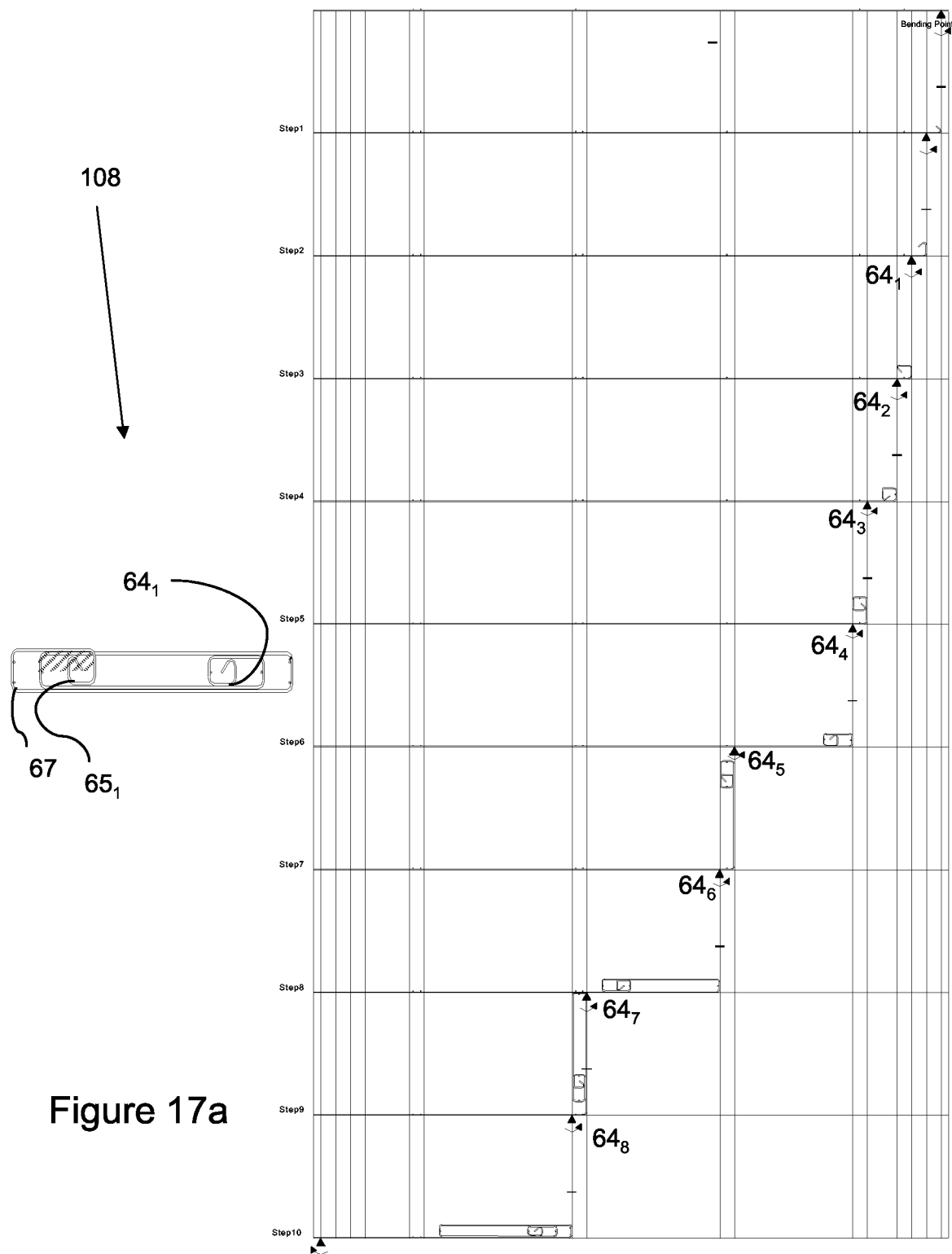


Figure 17a

Figure 17b

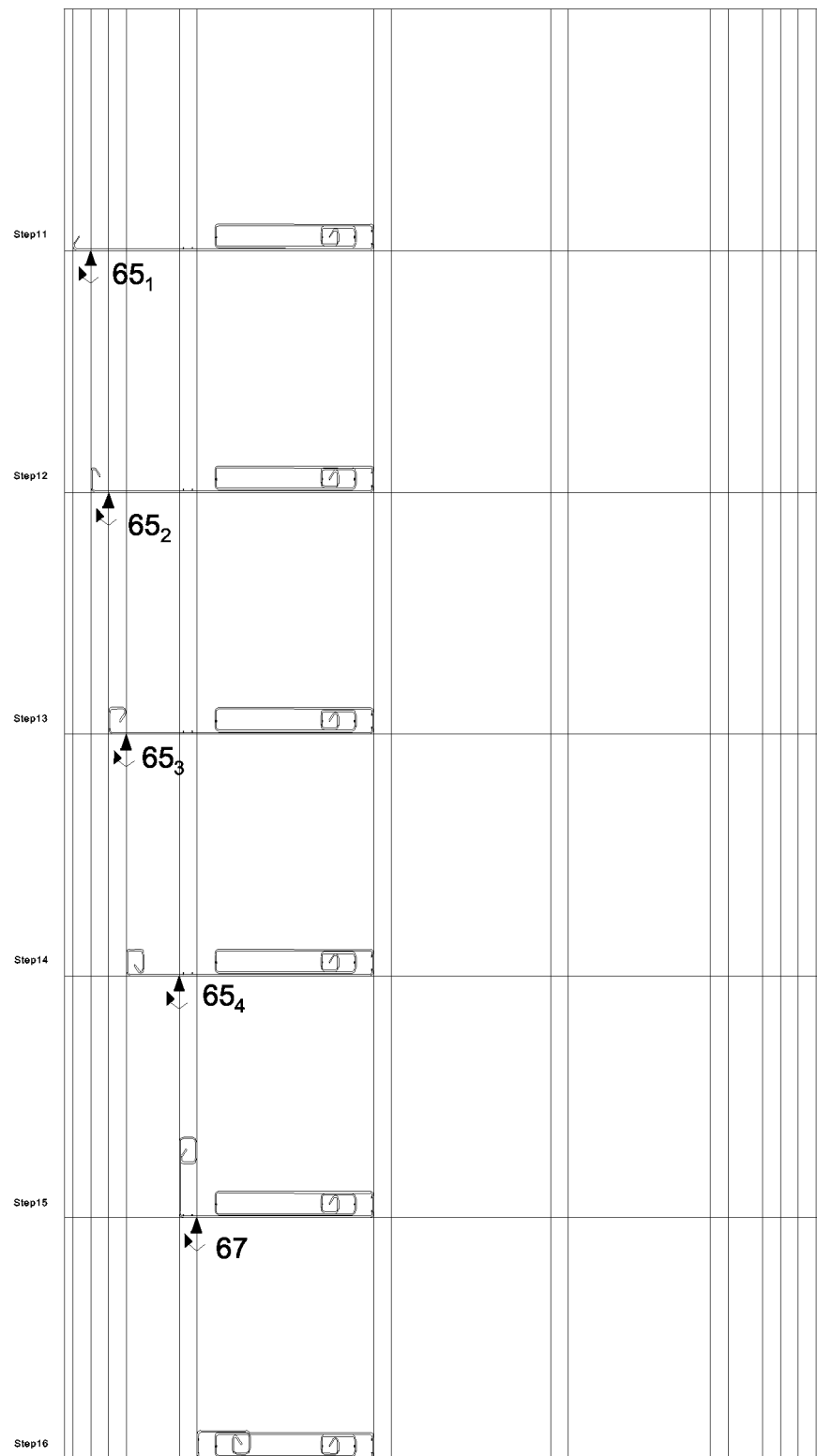


Figure 17b cont

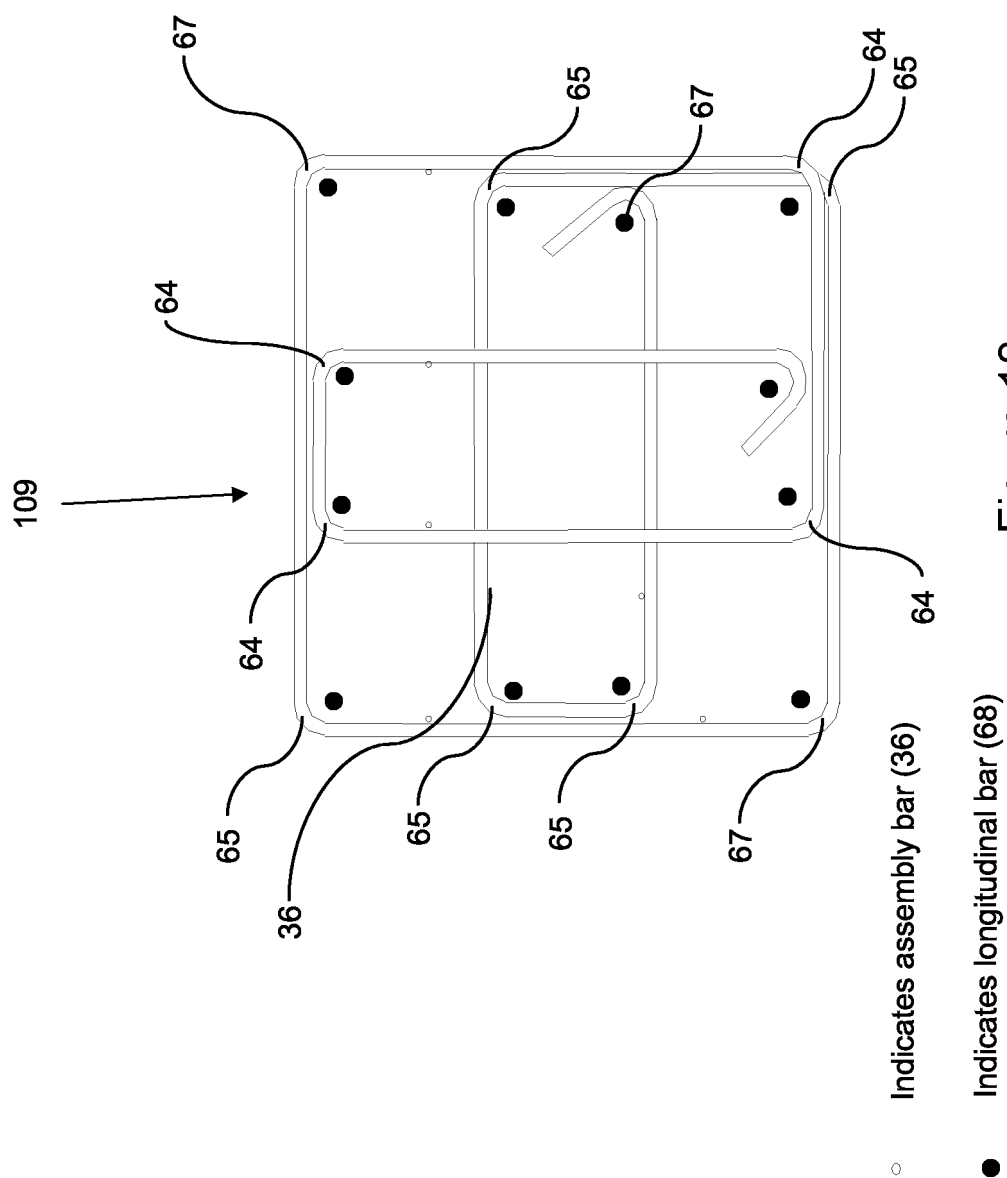


Figure 18

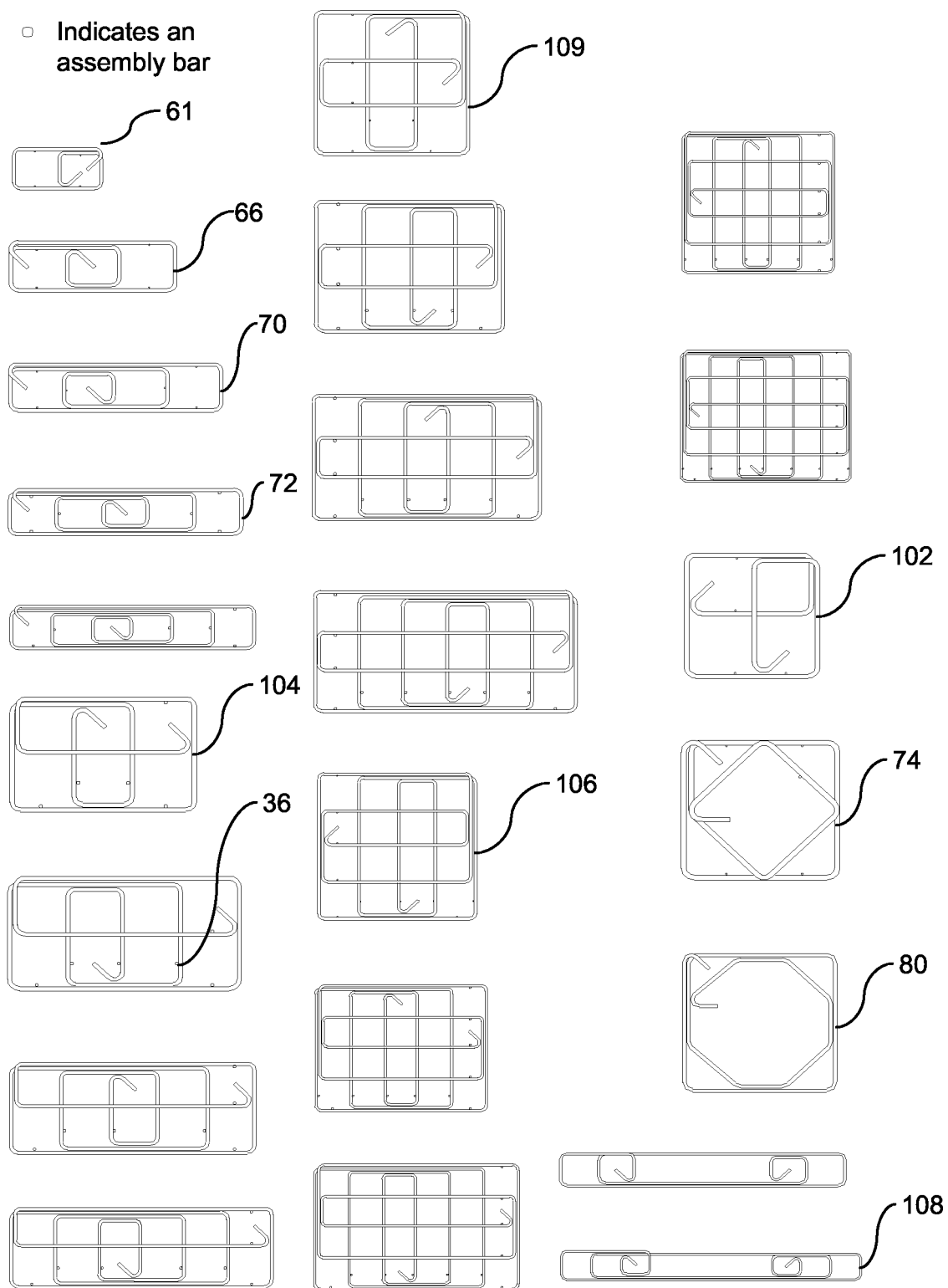


Figure 19

Figure 20

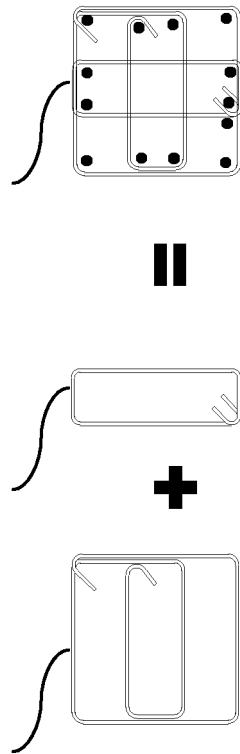
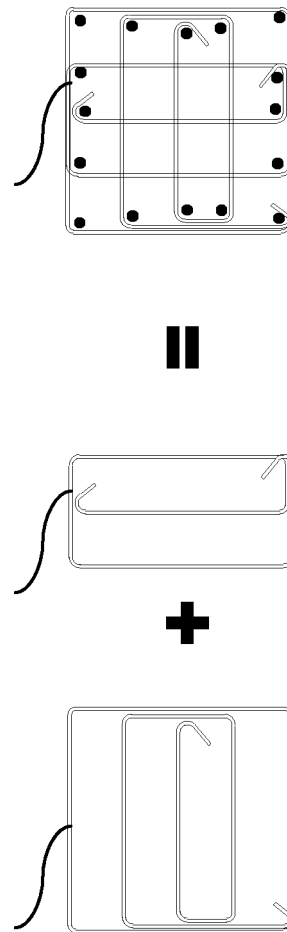


Figure 21



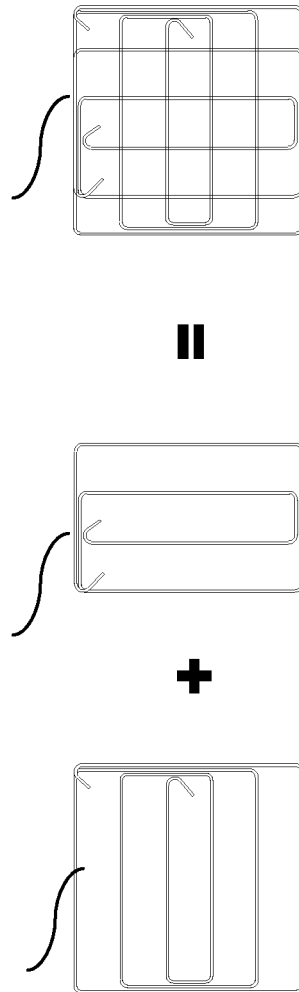


Figure 22

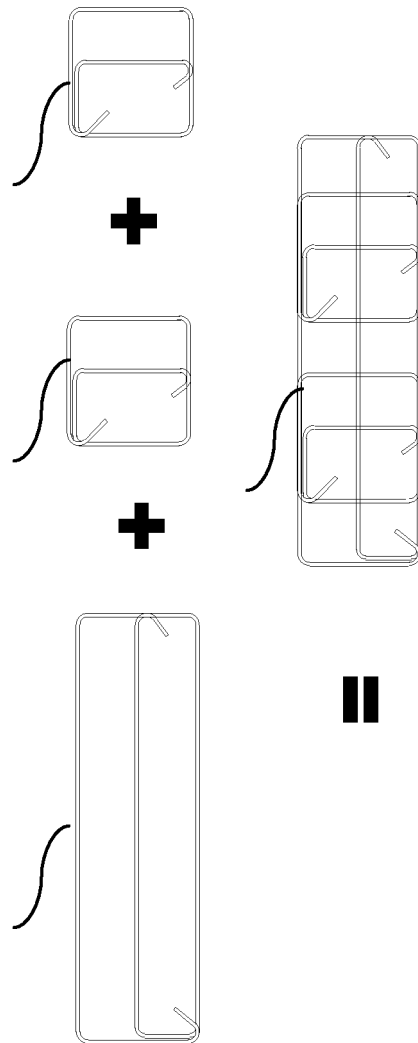


Figure 23

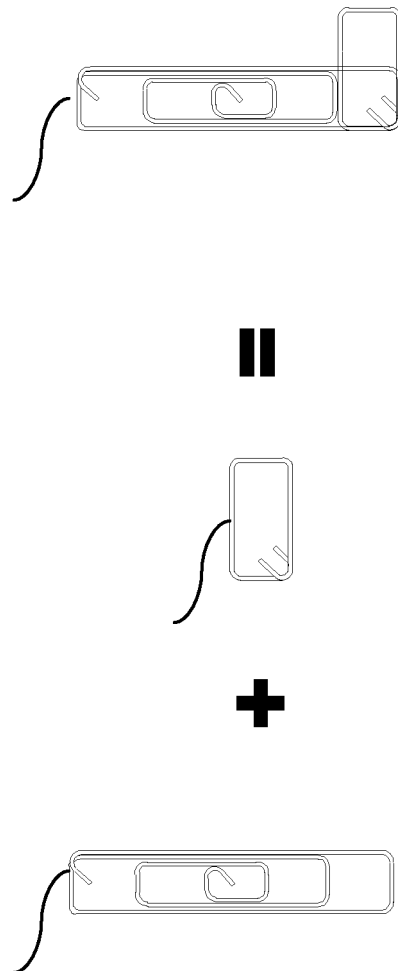


Figure 24

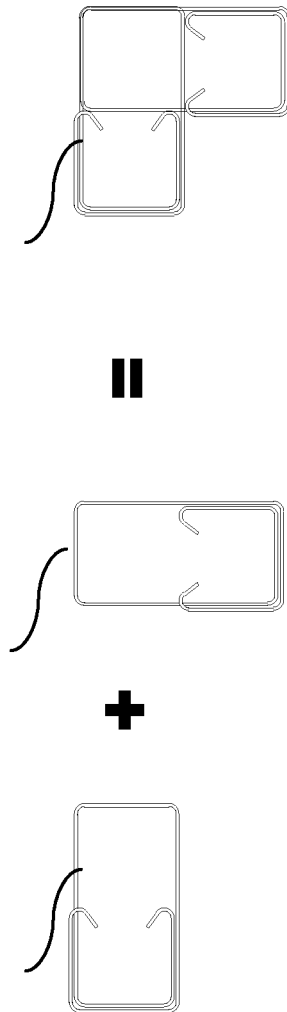


Figure 25

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- WO 2003000240 A [0009]
- WO 2001000188 A [0009]
- WO 200100189 A [0009]
- WO 9923325 A [0016]
- DE 9302006 U1 [0016]
- GB 2194806 A [0016]