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(54) **JOINING MEANS IN REINFORCED CONCRETE PILES FOR RAMMING**

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(73) Proprietor: **Leimet Oy**
27231 Lappi TL (FI)

(72) Inventor: **KOIVUNEN, Kari**
FIN-27430 Panelia (FI)

(74) Representative: **Laako, Tero Jussi**
Berggren Oy Ab
P.O. Box 16
00101 Helsinki (FI)

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GB-A- 2 171 741 **GB-A- 2 206 367**

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Description

[0001] The invention relates to a stiff joint for end to end jointing of driven precast concrete piles, both the precast concrete pile ends in the joint comprising a principally straight end surface and joining means comprising: at least one first planar joining loop forming a hole transverse to the longitudinal direction of the piles and at least one second planar joining loop, the loops overlapping in the joint in the longitudinal direction of the piles and being placed in adjacent substantially parallel relationship forming a joining space where the holes in these joining loops are mutually aligned; and transverse locking pins passing through the aligned joining loops.

[0002] Precast concrete piles are conventionally jointed in abutting relationship in order to provide the desired length of use of the driven pile. Both ends of the concrete pile of a stiff joint usually comprises, in the end box, an end plate which matches the cross-section of the pile and to which the joining means have been attached by welding. The joining means typically comprise projecting locking bars having a large end with at least one stop face facing the base plate and a counter-part with locking cylinders equipped with a cavity receiving the locking bar and a groove transverse to the length of the locking bars, and a locking pin placed between the groove and the stop face when the pile joint is made so as to remain in position to interconnect the pile members. There are such joints with numerous different details, a number of typical joints having been described in patent specifications FI 76169 and FI 77710. These known pile joints involve several drawbacks. Firstly, the construction of known joints is complex and expensive to manufacture or is unreliable in use. Secondly, both the locking cylinder and the locking bar require high-precision manufacture by machining, and also welding of the locking members of the construction to the base plate and/or rebars, i.e. to concrete reinforcing bars, with a welding seam transverse to the load force. Such a welded seam has unreliable strength, and due to heat stresses it will also result in a thick base plate. The most frequent reason for the breaking of such joints is precisely that the weld bursts as the pile is being driven into the ground. This entails both high material costs and labour costs. In addition, the locking cylinder is a cavity opening to the outside, easily collecting and retaining water which freezes at temperatures below zero and thus prevents the locking bar from penetrating into position. Detaching ice before the joint is made is a cumbersome and time-consuming operation which slows down the entire pile driving considerably. Further, it is not possible during the casting to straighten out a bent base plate of such a joint comprising locking cylinders and locking bars perpendicularly to the pile length, the base plate being often warped during manufacture or by careless handling, because especially the shape of locking cylinders do not allow identification of the correct direction nor gripping of the cylinder with the force required for straightening.

This results in a large amount of refuse, because both locking cylinders and locking bars should be parallel to the pile with a very small tolerance and the base plate should be exactly perpendicular to the pile length.

[0003] FI patent specification 63617, in turn, describes joining loops at the ends of piles to be jointed, only one of the loops projecting well beyond the end of its pile, whereas the two loops of the opposite pile of the joint are completely embedded in their pile. As the joint is made, the single loop projecting from the end of the first pile is inserted through the slot in the end surface of the second pile into this pile, the loops being thus mutually aligned. The sharply protruding single loop is easily bent or otherwise damaged during transport and other handling operations, while the two loops embedded in the pile require holes and recesses with a complex shape, where water tends to freeze to ice, which is hard to remove from such joint recesses. The locking means joining the piles in the reference consists of a mounting means assembled within the aligned loops and extending across the loops, the mounting means comprising a screw, a wedge and a support means. Such a multiple-part locking means is an expensive machined construction involving time-consuming installation.

[0004] SE patent specification 401 221 discloses end blocks extending over the entire pile end, i.e. end face of the pile, the end blocks being clearly made of a cast material, involving a really expensive solution which requires a considerable amount of machining. Besides these, the design of the reference comprises loops projecting more or not at all from the pile end face or loops projecting symmetrically to the same extent, and also recesses opening outwards to receive each locking pin. Since, in the design of this reference, the "base plate", i.e. the cast end block, is made integrally with the loops, there are no means for aligning this combination of base plate and loop exactly relative to the remaining pile, i.e. to the concrete part, and hence the end block of the reference may easily, during manufacture of the pile, assume a position inclined relative to a plane perpendicular to the pile length, or a laterally displaced position relative to the lateral lines of the pile. Even though the loops and the end face of the actual combination of base plate and loop may be in exact mutual alignment owing to their machining, the deviations mentioned in the preceding sentence entail great problems with regard to pile joints.

[0005] GB patent specification 2 206 367 describes a pile joint which differs slightly from the one described above, comprising explicitly one single joining means in the centre of the cross-section of the pile. This solution requires joint members made of a notably thick material and it has very poor buckling resistance. In a first embodiment, the joining means comprise a joining loop projecting from the end of one pile to form a male member and a joint loop embedded in the end of the other pile and attached to the end box to form the female member. A locking wedge is pushed through the hole of the overlapping joining loops. In a second embodiment,

there is a recess formed of sheet material at the end of both the piles to form the female member and a hole across the pile, the piles being jointed by means of the elongated but detached male loop penetrating into the aligned recesses and two locking wedges passing through the hole in this. Both the first and the second embodiment use such a female member or two female members, respectively, which comprise very easily freezing recesses, from which ice is hard to remove. Due to the mutual position of the joining means, the solution of the reference requires the use of a locking wedge, which further increases the material thickness of the joining loops, in order to achieve the strong force required. The wedge-shaped locking pin has a tendency to be detached when the pile is driven into the ground. In addition, the concrete casting of a pile comprising a female joint member involves problems, because the construction includes through-holes and openings in the concrete, which call for casting moulds during the casting of the concrete. The second embodiment has the further drawback of the mounting of the detached loop on the building site being both an awkward and hazardous operation. Detached supplementary parts also risk to get lost. The parts described in the reference require manufacture by machining, as do the other prior art constructions. Also, the base plate of the described solution cannot be straightened, nor can the joint means be exactly aligned with the pile length, should the base plate be bent or warped during manufacture or subsequent handling. Consequently, this solution is also both expensive and impractical.

[0006] The object of the invention is to provide a stiff and strong joint between driven precast concrete piles. The first objective of the invention is such a joint, in which the joint means recesses in both the end portions of the pile included in the joint are as small as possible in order to avoid icing. In accordance with this objective, the end portions of the piles should not either comprise long through-holes forming a space where water may freeze. Also, any recesses should have a shape and position allowing any ice formed in spite of this to be as easily removed as possible.

[0007] A second objective of the invention is such a joint with maximum buckling resistance. A third objective of the invention is such a joint which can be dismantled and preferably similarly assembled whenever necessary, without, however, tending to loosen and come off under the action of strokes during the driving of the pile. A fourth objective of the invention is to make such a joint which cannot be disassembled in case the dismantling feature is unnecessary or disadvantageous in some special use. A fifth objective of the invention is such a joint whose joining means, i.e. the abutting joined pile parts, can be manufactured either entirely without machining or at least with a minimum amount of machining while still achieving adequate or good precision. A sixth objective of the invention is such a joint avoiding any welded seams transverse to the pile length, where

the joining of the piles generates tensile stresses. A seventh objective of the invention is such a joint, which does not, at least not in all its embodiments, require through-holes in the concrete to be allowed for during the concrete casting. An eighth objective of the invention is such a joint allowing an end box totally or partly without end plates to be used. It is true that this may result in a compromise regarding the seventh objective of the invention, in other words, that the concrete casting may call for some kind of supplementary mould part or parts. The ninth objective of the invention is such a joint whose joining means are easily aligned with the pile length with the desired accuracy during the casting of the precast concrete pile and in which any bend in the base plate is also easily straightened. A further objective of the invention is a joint whose components are as straightforward as possible and easy to manufacture, and which can be rapidly, simply and reliably made on the building site even under strenuous conditions.

[0008] The problems described above are eliminated and the objectives defined above are adequately achieved with the joint of the invention, which is characterised by the features defined in the characterising clause of claim 1.

[0009] The chief advantage of the invention is that it enables the pile parts joined in its joint construction to be simply manufactured from a steel bar of a suitable type, either by simply bending, the body then simultaneously acting as a rebar, or by extending it with a rebar attached with an elongated and thus strong and durable welded seam. Machining work steps or compression work steps are not needed at all, or at the most in a small amount, in the finishing of some small individual surface portion. The second advantage of the invention is that its joint design comprises, in the area of the joining loops and the locking pin, only shallow grooves opening up with a large area for the locking pin and the joining loops of the opposed pile, and such grooves do not tend to collect water which subsequently freezes. Should frozen water nonetheless remain in the grooves, the grooves are very easily cleared thanks to their round and open shape. The invention also has the advantage of the joining means protruding from the pile ends only to a small extent, so that they are not damaged even by shocks. In addition, the only surface whose quality has an impact, i.e. the inner surface of the joining loops, faces the pile acting as its mounting base, and is thus very well protected. The joint of the invention also has high resistance to any buckling of the pile, because the joint includes several spaced joining spaces which are at least at a distance from the central line of the pile. These distances between the joint spaces impart the assembly of joined piles good properties, while allowing a decrease in the material thickness of the joining parts without reducing the strength. The invention also has the advantage of the design allowing the locking pins to be made removable or optionally unremovable, and the pile end to be provided with a base plate and also completely

or partly without a base plate, whenever necessary. The invention has the further advantage of the protruding joining loops being alignable with the longitudinal sides or edges of the pile and being engageable in order to straighten any warp or the like in a base plate and to position the base plate perpendicular to the pile length. For use under special conditions, the joining means of the design of the invention can be made of e.g. stainless steel without causing problems, because there are few exposed surfaces and no need for welding together steels of different types, which would involve problems.

[0010] The invention is described in detail below with reference to the accompanying drawings.

[0011] **Figure 1** is an axonometric exploded view of the design of a first embodiment of the stiff joint of the invention, comprising one of several joining spaces at the end of the precast concrete pile. The figure also shows a first embodiment of the first and second joining loop of the invention, where the loop consists of a rebar.

[0012] **Figure 2** is an axonometric exploded view of a second embodiment of the stiff joint of the embodiment, comprising one of several joining spaces at the end of the precast concrete pile, as figure 1.

[0013] **Figures 3 to 6** are principal views of various conceivable positions of the joining loops of the invention and thus of the joining spaces and the locking pins on the cross-section of a precast concrete pile, viewed in the longitudinal direction of the pile and in the plane of the interface between the end faces of the joined piles along planes III-III and IV-IV respectively of figures 10 and 11.

[0014] **Figure 7** shows a second optional embodiment of the first and second joining loop of the invention, with the loop joined to a rebar, viewed in a direction perpendicular to the plane of the joining loop and in the same projection as figure 8.

[0015] **Figure 8** shows a third optional embodiment of the first and second joining loop of the invention with the loop bar material simultaneously providing the rebars, viewed in a direction perpendicular to the plane of the joining loop and in direction V of figure 1, with the other parts removed.

[0016] **Figure 9** shows a fourth optional embodiment of the first and second joining loop of the invention with the loop plate material integrated with the rebar, viewed perpendicularly to the plane of the joining loop in the same projection as figure 8.

[0017] **Figure 10** is a cross-sectional view of the joining space of the invention in a plane perpendicular to the central line of the joining loops along plane II-II of figures 3 and 4.

[0018] **Figure 11** is a longitudinal section of a joining space of the invention, corresponding to the embodiment of figures 4 and 9, in a plane parallel to the central line of the joining loops, in section along plane I-I of figures 4.

[0019] **Figure 12** is a generic and principal view of the design of the precast concrete pile, including the joining

means of the invention, in a longitudinal section of the pile.

[0020] **Figures 13A-13B** show a fifth optional embodiment of a first and second joining loop of the invention with the loop plate material extending as a rebar, viewed in a direction perpendicular to the plane of the joining loop in direction VI of figure 13B and laterally in direction VII of figure 13A.

[0021] **Figure 14** shows a sixth optional embodiment of a first and second joining loop of the invention with the loop welded both to the rebar and to the base plate, viewed in a direction perpendicular to the plane of the joining loop and in the same projection as figures 8 and 9.

[0022] Figure 12 illustrates generally a driven precast concrete pile and its main structural components. Firstly, such a pile P1, P2 comprises at least two, but usually four longitudinal reinforcing rods, i.e. pile end bars 29, extending preferably continuously over the major portion of the pile length. Depending on the pile dimensions, these reinforcing end bars 29 extend to a distance of approx. 40 mm - 500 mm from the pile end faces 10. Surrounding the assembly of reinforcing end bars 29 on their upper side there is a spiral reinforcement 32, which forms a coarse helical layer or network around the reinforcing end bars. In addition, at least one end of the pile, but usually both ends K1 and K2 comprise an end box of some type, as well as joining means for joining, i.e. attaching the piles in the required abutting mutual relationship by means of a stiff joint. The remainder of the pile material is concrete 27, which engages the reinforced end bars 29, the spiral reinforcement 32, the end boxes and the joining means. The driven precast concrete pile typically has a length of several metres and a square cross-section, with dimensions most typically in the range from 200x200 mm to 350x350 mm. It is true that piles with different sizes and cross-sectional shapes, such as round and hexagonal piles are used sometimes, but very rarely.

[0023] The end K1, K2 of driven precast concrete piles, i.e. of both the precast concrete piles P1, P2 in the end to end joint, comprise a mainly straight end face 10, particularly planar portions of the end face 10, which abut in the stiff joint. In addition, the pile ends K1, K2 comprise joining means consisting firstly of first planar joining loops 1 forming a hole transverse to the longitudinal direction Lp of the piles and second planar joining loops 2 forming a hole transverse to the longitudinal direction Lp of the piles. In the finished joint, these joining loops 1, 2 extend overlapping in the longitudinal direction of the piles and are adjacent substantially in parallel, forming a joining space 9. Each joining space 9, at which the planes T1 and T2 of the joining loops are at least mainly parallel and the joining loops 1, 2 overlap as intended, the holes 3, 4 of these joining loops are mutually aligned Lt. It should be noted that reference numeral 9 stands for joining spaces in general when there is no need to specify the joining spaces, specified reference

numerals 9a, 9b, 9c, 9d being used only when one or a number of joining spaces should be pinpointed among other spaces.

[0024] The joining means also comprise locking pins 6 made preferably in one piece and passing through the aligned Lt holes 3, 4 of the adjacent and overlapping joining loops 1, 2. The locking pins 6 have been disposed to assume a transverse position over a length M and preferably perpendicular to the length Lp of the pile. In the joint of the invention, the locking pins 6 are preferably substantially round in cross-section and have a straight length M and mainly an equal thickness substantially or almost over the length N of the pin hole 31 formed by the joint loop holes 3, 4 together. This means that for instance the input ends 36 of the pins may have a tapered point, such as a truncated cone or a convex portion or a similar shape, as shown in the figure. Also the opposite ends 38 of the pins 6 may have any desired shape, provided that it does not extend substantially within the length N of the pin holes 31. Such a locking pin has no tendency to loosen and be removed from the joining loop holes 3, 4 as the pile assembly P1+P2 formed with the stiff joint is being driven into the ground, nor does the locking pin require correct positioning about its central line Lt for the insertion, which is performed by striking in direction F. In this case, the diameter of the locking pin equalling the permanent diameter G2 is equal to the diameter G1 formed by the joining loop holes 3 and 4 together. The diameter G2 of the locking pins parallel to the pile end 10 is specifically substantially equal to the diameter G1 of the joining loop holes 3 and 4 in the same direction, in other words, the locking pin fills up the joining loop holes 3, 4 at least in their transverse direction perpendicular to the longitudinal direction of the precast concrete piles P1, P2 and thus to the forces exerted on the loops and the pins. This prevents deformations of the joining loop holes under forces exerted on the joint. In accordance with the invention, the locking pins 6 are made substantially in one piece, allowing their strength and ease of use to be easily and economically provided. The locking pin can, of course, be equipped e.g. with narrow longitudinal ridges and grooves, the outer diameter of the ridges in the pin being slightly greater than the diameter G1 of the pin holes, so that a partly plastic and partly resilient deformation of the ridges during the insertion in direction F of the pin into the pin hole 31 will lock the locking pin 6 firmly in position. Another way of better securing a locking pin 6 made in one piece into position is to shape the input end 36 of the pin with a longitudinal groove or recess and to provide it with a wedge with the point pointing into the pin parallel to the shank portion and the broader end pointing in the same direction as the input end. When, during the insertion of the locking pin, the broader wedge end is adapted to hit the stop face at the bottom of the locking pin hole in the pile P1, P2, the portion of the input end of the locking pin will expand and be tightly pressed against the inner surface 7 of the join-

ing loop holes 3, 4 under the action of plastic deformation. It is also conceivable to make the locking pins 6 very slightly tapered over their length M or part of it from the outer end 38 towards the input end 36, and then the angle between the longitudinal central line and the outer surface of the pin is under 5° and preferably 3° at the most, and possibly only $1-2^\circ$. Such slightly tapered locking pins should be kept substantially flat, however, they still contribute to the clamping of the joint of the invention. The locking pins can naturally have an exactly equal thickness over their entire length M or over a section equalling the length N of the pin holes. Other ways of securing the locking pin are suitable in connection with the embodiments of figures 3-4 and 6. If, on the other hand, a locking pin 6 which is removable when needed is desired, for instance the embodiments of figures 5 and 6 are performed with through-holes in the pile P1, P2 aligned Lt with the joining loop holes 3, 4, so that the locking pin can be removed by striking in a direction F2 opposed to the inlet 11 from the pin hole 31 formed by the joining loop holes 3, 4. The length M of the locking pin in the embodiments of figures 3-4 and 6 is almost half of the diameter R of the pile or slightly shorter, and in the embodiment of figure 5, almost equal to the diameter R of the pile, or somewhat shorter.

[0025] In accordance with the invention, each of the said joining spaces 9 comprise at the end K1, K2 of the first precast concrete pile P1 of the joint at least two first planar joining loops 1 and at the end K1, K2 of the second precast concrete pile P2 of the joint two second planar joining loops 2. Also in accordance with the invention, the joint comprises at least two such joining spaces 9a, 9c or 9b, 9d disposed at a support distance W from the central line 13 or from the bisectonal plane 12 of the pile. Even if the joining spaces 9a-9d were at a support distance W from the bisectonal plane 12, all the joining spaces are still at a substantial distance from the central line of the pile P1, P2, even if this latter distance has a length different from said support distance W. The bisectonal plane or planes 12 are planes through the central line 13 of the pile, and normally two such mutually perpendicular bisectonal planes are implied, which in the figure are also perpendicular to the lateral surfaces 13a-13d of the piles. Unless the pile is square or rectangular in cross-section, the bisectonal planes defined above will naturally adapt to the curved or otherwise angular outer surface of the pile.

[0026] Thus, as defined above, the joining space 9 means the space where the first joining loops 1 or second joining loops 2 slightly protruding from the end face 10 of the second pile P1 and the first joining loops 1 or second joining loops 2, respectively, slightly protruding from the end face 10 of the second pile P2 are pushed adjacently and overlapping so that the holes 3 in the first joining loops and the holes in the second joining loops are aligned Lt, producing a pin hole 31, which consequently passes through the holes 3, 4 in the two first

joining loops 1 and the two second joining loops. This alignment means that the line Lt also forms the central line of the locking pin 6 when it is inserted by striking into the pin hole formed by the holes 3, 4 together. Each joining space may, of course, comprise several joining loops 1 and 2. There may be three or four of each or both, so that in each joining space there may be the same number or a different number of joining loops, provided that there are at least two of each of them.

[0027] In each joining space 9, the second joining loops 2 are spaced by a distance equalling at least the maximum thickness S1 of the first joining loops 1 and the first joining loops 1 are spaced by a distance equalling at least the maximum thickness S2 of the second joining loops 2. If the distances between the first joining loops and/or the distances between the second joining loops are exactly equal to the maximum thicknesses of the second joining loops and the maximum thicknesses S1 of the first joining loops, respectively, the joining loop holes will be tightly fitted to each other in the direction of the central line Lt of the holes. In fact, it is useful to provide the said distances between the joining loops somewhat greater than the maximum thicknesses S1 and S2, i.e. exceeding these by a play. This play may be in the range from 1 mm to 10 mm, such as 2 mm to 5 mm. Notably larger plays are in fact applicable, such as up to 20 mm, or a play large enough to distribute for instance the first and second joining loops of figure 5 evenly over the entire pile thickness in the direction of the locking pins 6. In the embodiment of figure 5, the four joining spaces 9a-9d described will then actually be reduced to two joining spaces, one on one side of the bisecting plane 12 and the other on the other side of this bisecting plane 12, regardless of the fact whether there are two or more of each set of first and second joining loops. In some cases this may imply that the plays are larger than the maximum thicknesses mentioned above, and then the said distances between the joining loops may be multiples of the maximum thicknesses. Very sparsely distributed joining loops may in fact cause the problem of maintaining the locking pin direction as it is being inserted into position. Accordingly, it is now believed useful to maintain the said distances between the joining loops under twice the maximum thicknesses, but still as defined above in other respects. The large distances between the joining loops described above have not been represented in the figures, while small plays cannot be distinguished. In each joining space 9, one of the first joining loops 1 is at a first distance A1 from the inlet 11 of the locking pin and one of the second joining loops 2 is at a second distance A2 from the inlet 11 of the locking pin. This second distance A2 is larger than the first distance A1 at least by the maximum thickness S1 of the first joining loops or alternatively smaller than the first distance A1 at least by the maximum thickness S1 of the first joining loops. The difference between these distances A1 and A2 follows preferably the same play rule as described above in this

paragraph. Considering the distance between the first joining loops and the distance between the second joining loops described above, each individual joining space 9 thus comprises first joining loops 1 parallel to the central line of the holes 3, 4 at different locations than the second joining loops 2, thus enabling the first and second sets of joining loops to overlap while the jointed lateral surfaces 8a-8d of the two jointed piles P1 and P2 are mutually aligned. Hence the pile assembly is straight over the stiff joint.

[0028] In a preferred embodiment of the invention, each joining loop 1, 2 is made of a bar-like steel material with optional design details. The material may i.a. consist of conventional reinforcement bars used in concretes and bent to a U-shape, the inner surface of the U-bend forming the hole 3, 4 or part of the hole of the joining loop thus formed, as shown in figure 2. At the same time, the principally parallel legs 19a of this U-shaped body extending from the end surface of the pile to the pile interior constitute one rebar 16 of the joining means in the stiff joint. In this case, the fluting of the inner surface 7 of the holes 3, 4 in the reinforcement bar should be eliminated e.g. by machining or preferably by pressing, for the locking pin 6 to get a gliding surface which is smooth enough for insertion. In a second option, shown in figure 7, U-shaped joining loops 30 can be used, whose short legs 19b engage a reinforcement bar and are attached to this conventional reinforcement bar with welded seams 20 parallel to the reinforcement bar and the legs 19b, the bar forming one rebar 17 in the joining means of the stiff joint. The inner surface of the bend in this U-shaped loop body constitutes the joining loop hole 3, 4 and the body may be made either by machining a solid piece to this shape or preferably by bending a bar or bar section with the suitable and desired cross-sectional shape. The length La of the loop body 30 parallel to the rebar 17 is at least three times the material thickness + the diameter G1 of the hole 3, 4 and at the most six times the material thickness + the diameter G1 of the hole 3, 4. A third particularly preferred embodiment involves bending of a long square bar or rectangular bar or angular bar 33 to the useful U-shape, the inner surface of the bend forming the joining loop hole 3, 4. In addition, both ends of this bar 33, forming the legs 19c, have been axially twisted to a spirality 21, as can be clearly seen in figures 1 and 8, or and/or shaped to comprise curves 22 and/or recesses and projections, as schematically shown in figure 12, the curves corresponding to the curves appearing in figures 13A-13B. The legs 19c of the principally U-shaped angular bar 18 shaped in this manner will stay in excellently engaging relationship with the concrete even under longitudinal tensile or compression stresses, and hence the legs act simultaneously as one rebar 17 in the joining means of the stiff joint. In the first and second embodiment above, the legs 19a and 19c then continue into the precast concrete pile (P1, P2) as rebars 16 and 17, respectively. In a fourth embodiment of the forming of the

joining loop, shown in figure 9, one starts from the plate piece by machining a hole 3, 4 in this and then a lateral recess 35 aligned with the hole, thus forming a loop body 34 comprising two legs 19d. One rebar 17 formed by the reinforcement bar is fixed to the legs 19d by welded seams 20 parallel to the legs. Still a fifth embodiment of the loop 34 made of sheet material or flat bar is dimensioned with a length extending from the pile end surface 10 inside the concrete, forming the rebar 17. In this case, the section of the rebar made of a plate embedded in the concrete over a length L_b comprises axial spiralties in alternating directions, each of which is e.g. of the same type as the spiralties 21 of the square bar described above, and/or alternating curves 22, which are e.g. of the same type as the curves of the square bar described above, and/or recesses and protrusions and/or through-holes in the plate material, providing a non-gliding engagement with the concrete in the direction of the said length L_b . In the sixth embodiment shown in figure 14, the loop 30 is made e.g. of a square bar, as in figure 7, but in this case the loop is welded 20 to the reinforcement bars forming the rebars 17 on the opposite outer sides of the loop legs 19b. In addition, these rebars ends are attached with welded seams 39 to the pile end plate 26. In all these cases, the length L_b of the rebar 16, 17 determined from the end surface 10 of the pile inwards, regardless of its production method described above, is substantially shorter than the length L_p of the pile P1, P2, but at least equal to the outer diameter R of the pile. Usually this length L_b of the rebar is greater than the diameter R of the pile, or one and a half times R or two times R or three times R, but most frequently smaller than ten times R or six times R. Frequent lengths L_b of rebars are in the range from 350 mm to 700 mm. The material thicknesses S1, S2 of U-shaped joining loops 1, 2 produced in accordance with the invention as above are typically of the order of 10 mm to 20 mm and preferably of 12 mm to 15 mm. The rebars 16, 17 receive forces exerted by the stiff joint, without, however, contributing to the strength proper of the pile, for which reinforcing end bars 29 are provided within the concrete 27, as explained above in this text. The sections of the rebars 16, 17 pointing inside the pile and the end sections of the reinforcing end bars 29 pointing towards the end surfaces should actually overlap slightly in the driven precast concrete pile P1, P2, however, only over a section of the length L_b of the rebar, as can be seen in figure 12. In the overlapping area of the rebars 16, 17 and the reinforcing end bars 29, the bars should be close to each other, but preferably not in mutual contact, and by no means attached to each other, and in addition, the reinforcing end bars should be principally located between the rebars and the next lateral surface of the pile, as shown in figure 12. Thus the driven precast concrete piles comprise typically at least an equal number of reinforcing end bars and rebars.

[0029] Only the design and arrangement described above provide such driven piles with adequate strength

and flexibility at the same time.

[0030] The maximum thickness S1, S2 of the joining loops extends substantially around the entire circumference of the joining loops 1, 2, i.e. the material surrounding the joining loop hole has a principally even thickness, as circular, rectangular and square bars always do. This even thickness contributes to the overlapping of the joining loops, and also to their remaining free from ice and to any ice removal required. The portion 7 of the inner surface of the said joining loop hole 3, 4 facing in the direction of the precast concrete pile P1, P2 serving as a mounting for the joining loop is preferably semi-circular in shape, the semi-circles of the overlapping joining loops in each joining space 9 forming together a circular hole 3, 4 for the locking pin 6. The way of forming this round pin hole 31 formed jointly by the aligned L_t holes 3, 4 of the overlapping first and second joining loop 1, 2 appears and is understood very clearly with the aid of figure 8.

[0031] Moreover, the first joining loops 1 and second joining loops 2 of the invention have a small projection E on the planar end surface 10 of the pile. The joining loops 6 at the ends of the opposed piles P1, P2 in the stiff joint have substantially identical projections E, which means that all the joining loops 1, 2 have substantially equal projections E in the planar portion of the end surface 10 of its pile serving as a mounting. The central lines L_t of the joining loop holes 3, 4 and thus also the central line of the locking pin 6 will then be aligned with the planar portion of the end surface 10. This solution reduces the risk of damage to the joining loops, the joining loop design described above contributing to reducing this risk.

[0032] In accordance with the invention, the stiff joint may comprise two joining spaces 9a, 9c or 9b, 9d, at which the lines L_t of the joining loop lines are parallel. Such a joint can be imagined with the aid of figures 3-5, by leaving only two diagonally opposed joining spaces in the joint. The joint may, and often does, comprise four joining spaces 9a-9d, each of which is at a support distance W from at least one of the bisectonal planes 12 explained above. Thus, in the embodiments of figures 3 and 4, the successive joining spaces 9a→9d are at a support distance W from the respectively subsequent section of the bisectonal plane 12 located outwards from the central line 13, whereas the joining spaces are tangential to the other bisectonal planes, even if the centres of the joining spaces are at unequal distances W from these bisectonal planes. In the embodiments of figures 5 and 6, the joining spaces are simultaneously at a distinct and substantial support distance W from both the bisectonal planes 12. In these joining spaces, the lines L_t of the joining loop holes are e.g. alternately transverse to the lines L_t in the adjacent joining space holes, and in the diagonally opposed joining spaces the line L_t are parallel, as shown in figures 3-4 and 6. Figure 5 illustrates an optional arrangement comprising each pair of adjacent aligned joining spaces 9a and 9b, 9c

and 9d, forming two pairs 23a and 23b of joining spaces. In each pair 23a, 23b of joining spaces, the lines Lt of the holes 3, 4 of the joining loops 1, 2 are parallel, i.e. the line Lt of the first pair 23a is parallel to the line Lt of the second pair 23b. When the distance discussed above between the first joining loops and the second joining loops 1, 2 in the pairs of joining spaces is increased above the maximum thicknesses S1, S2 of the loops, each of the pairs of joining spaces mentioned above will eventually form one single joining space, because their components are no longer detachable from each other. Each of the pairs 23a and 23b of joining spaces is at a support distance W from their mutual bisecting plane 12, however, in the case of figure 5, the individual joining spaces are at a support distance also from the second bisecting plane. Nonetheless, this latter condition does not need to be fulfilled, especially if the pairs 23a and 23b of joining spaces extend parallel to their mutual bisecting plane over a substantial portion of the diameter R of the pile. When the pile is substantially square in cross-section and the joint comprises two or four joining spaces, the said planes T1, T2 of the joining spaces in each joining space 9 are optionally substantially parallel to one lateral surface 8a and 8b or 8c or 8d of the precast concrete pile and the line Lt of the joining loop holes perpendicular to this lateral surface, as visible in figures 3.5, or the said planes T1, T2 of the joining loops are substantially parallel to the diagonal 15a, 15b between the longitudinal edges 14 of the precast concrete piles, as shown in figure 6. In the embodiments of figures 5 and 6, through-holes in the pile material can be provided for the locking pins, so that the locking pins 6 are removable from their position whenever necessary by striking in the insertion direction F1 relative to the opposite direction of removal F2.

[0033] The ends K1, K2 of the precast concrete piles comprise end boxes 24 with a frame 25 of sheet material surrounding the end K1 and K2 of the pile P1, P2 and possibly also a base plate 26 principally perpendicular to the lateral faces. In accordance with the invention, the end K1, K2 of the precast concrete pile comprises in the area of each joining space 9 a recess 5 parallel to the line Lt of the joining loop holes 1 and 2 and with a depth D from the planar end face 10 of the pile P1 or P2 which is at least equal to the projection E of the joining loops 2 or 1 from the planar end surface 10 of that pile P2 or P1 at the end of the opposite pile of this joining space. The width B of the recess 5 is at least equal to the width C of the joining loops parallel to the planar end face 10 of the piles. The recess 5 extends at least over one of the lateral faces 8a-8d of the precast concrete pile either on the same cross-section B, D as defined above, as in figures 1 and 2, or alternatively on a smaller cross-section, such as a cross-section equal to the diameter G2 of the locking pin, as shown in figure 11. The groove-like recesses 5 extend parallel to the hole lines Lt from one lateral surface 8a, 8b, 8c, 8d of the pile to its second lateral surface 8c, 8d, 8a, 8b or 8b, 8c, 8c, 8d, 8a, ena-

bling insertion of the locking pin 6, as explained above in this text.

[0034] The end box 24 of the precast concrete piles of the invention may be completely devoid of base plates, and then the groove-like recesses 5 and also the planar end faces 10 are made entirely of concrete material 27 and the end box comprises the frame 25 alone. Optionally, the end box may be provided with an end plate, and then at least the planar end faces 10 are made of metal sheet or metal casting forming the base plate 26. The base plate 26 has been fixed to the frame 25 for instance by welding. In this case, the groove-like recesses 5 are made either of concrete material 27, the base plate 26 providing merely the planar portions of the end faces 10, or optionally of metal sheet or metal casting 28, so that the base plate 28 covers both the planar portions of the end faces 10 and the recesses 5. If the end box comprises a base plate 26 or 28, the joining loops 1 and 2 are typically welded to the base plate regardless of the joining loop design described above. If the base plate 26 is of the type leaving the groove-like recesses 5 open and defined by the concrete, the joining loops are welded to the edge of the base plate defined by the recess or to the cavity in the base plate at this location. In the case of a fully covering base plate 28 of the end face 10, the joining loops are welded with seams 37 to the holes in the base plate, through which the joining loops or their legs 19a, 19b, 19c or the loop body 34 itself pass.

[0035] Firstly, with a view to the joint, the first end K1 of the pile may comprise merely first joining loops 1 and the other end of the pile K2 merely second joining loops 2. The first and second joining loops 1, 2 are otherwise identical as explained above, with the exception that their distances from the insertion 11 of the locking pin differ in a specific manner necessary for their overlapping. Thus, in this joining loop array, all the joining loops 1 of each joining space of the first end K1 of the pile are at a distance A1 and $A1+S2$ and possibly $A1+2xS2$, if there are more than two joining loops, from the inlet 11. At the other end K2 of the pile, respectively, all the joining loops 2 in each joining space are at a distance A2 and $A2\pm S1$ and possibly $A2\pm 2xS1$ etc. from the inlet 11. However, the solution mentioned above calls for checking of the correct type of pile end, and thus a preferred solution is that both ends K1 and K2 of the pile comprise both first joining loops 1 and second joining loops 2, forming an even number of joining spaces 9 with the second and first joining loops 2 and 1 of the joint, respectively. In this array of the invention, the joining loops 1 at every second joining space, e.g. joining spaces 9a and 9c, or the second pair of joining spaces, e.g. the pair 23a, are at a distance A1 and $A1\pm S2$ and possibly $A1\pm 2xS2$ etc., if there are more than two joining loops in the joining space, from the insertion 11. Similarly, the second joining loops 2 at every second other joining space, e.g. joining spaces 9b and 9d, or the second pair of joining spaces, e.g. the pair 23b, are at a distance A2

and $A2 \pm S1$ and possibly $A2 \pm 2 \times S1$ etc., if there are more than two joining loops in the joining space, from the inlet 11. In this embodiment the pile ends K1 and K2 are identical, and it will be sufficient to rotate the pile P2 about the central line 13 to align its first joining loops 1 and second joining loops in direction F3 with the second joining loops 2 and first joining loops respectively of the second pile P1. After this, the locking pins 6 are inserted by striking in direction F1, as can be seen in figures 1 and 2.

[0036] During the casting of the precast concrete pile and the use of the joint of the invention, and especially if the joint comprises four spaced joining spaces 9 at a support distance W from the central line 13 of the pile, or two spaced joining spaces 9 at a support distance W from the bisectonal plane 12 of the pile, the joining loops 1 and 2 forming these joining spaces can be engaged by suitable engaging means, which do not require any explanation in this context, but which are guided by the concrete casting mould. As the engaging means are clamped into position they position the joining loops 1, 2 correctly, i.e. parallel to the pile length, while straightening any curved or warped base plate by pulling or forcing, so that the base plate 26, 28, or more specifically the portion of it corresponding to the planar end face 10, becomes straight, i.e. planar with high precision, and at the same time perpendicular to the central line 13 of the pile P1, P2.

Claims

1. A stiff joint for end to end jointing of precast concrete driven piles, **characterised in that** each end of the precast concrete pile (P1, P2) of the joint having on its end surface (10) portions abutting in the stiff joint and joining means comprising:
 - a first planar joining loop (1) and a second planar joining loop (2) forming a hole transverse to the longitudinal direction (L_p) of the piles, which loops overlap in the joint in the longitudinal direction of the piles and are located adjacent and substantially in parallel, forming a joining space (9) in which the holes (3, 4) of these joining loops are mutually aligned (L_t),
 - the joint comprising at least two such joining spaces disposed at a support distance (W) from the central line (13) or bisectonal plane (12) of the pile,
 - both the said first joining loops (1) and the second joining loops (2) having a projection (E) from the said portions of the pile end surface,
 - transverse locking pins (6) passing through the aligned joining loops, and

wherein each joining loop (1, 2) comprises:

- U-shaped rebars (16) of the joint for a precast

- concrete pile (P1, P2); or
- loop members (30, 34) extending into the precast concrete pile (P1, P2) as rebars (17) of the joint or being attached with welded seams (20) to the rebars (17) of the joint; or
- U-shaped angular bars (33) whose legs (19c) continue into the precast concrete pile (P1, P2) as rebars (17) of the joint.

2. A stiff joint as defined in claim 1, **characterised in that** the said portions of the end surface (10) at the ends of the precast concrete piles are planar; and that a groove-like recess (5) is provided in the area of each joining space (9) at the end of the precast concrete pile, the recess being
 - parallel with said line (L_t) of the holes of the joining loops (1 or 2) and having a depth (D) in the planar end surface (10) of the pile (P1 or P2) which is at least equal to the projection (E) of the joining loops (2 or 1) at the end of the opposite pile in this joining space from the planar end surface (10) of the corresponding pile (P2 or P1) and a width (B) which is at least equal to the width (C) of the joining loops parallel to the planar end surface (10) of the piles, and
 - extending at least to one lateral surface (8a-8d) of the precast concrete pile.
3. A stiff joint as defined in claim 1 or 2, **characterised in that** in each joining space (9), the second joining loops (2) are spaced by a distance equalling at least the maximum thickness (S1) of the first joining loops (1) and the first joining loops (1) are spaced by a distance equalling at least the maximum thickness (S2) of the second joining loops (2).
4. A stiff joint as defined in any of claims 1-3, **characterised in that** in each joining space one in the first set of joining loops (1) is at a first distance (A1) from the inlet (11) of the locking pin and one in the second set of joining loops (2) is at a second distance (A2) from the inlet (11) of the locking pin, said second distance (A2) being at least greater than or optionally smaller than the first distance (A1) by the maximum thickness (S1) of the first joining loops.
5. A stiff joint as defined in claim 3 or 4, **characterised in that** optionally:
 - the first end (K1) of the pile comprises merely first joining loops (1) and the other end of the pile (K2) comprises merely second joining loops (2); or
 - both ends (K1 and K2) of the pile comprise both first joining loops (1) and second joining loops (2), forming an even number of joining spaces (9).

6. A stiff joint as defined in claim 3 or 4, **characterised in that** the maximum thickness (S1, S2) of the joining loops extends substantially over the circumference of the joining loops (1, 2); that the portion of the inner surface of the said hole (3, 4) of the joining loops pointing towards the precast concrete pile (P1, P2) serving as a mounting base for this joining loop is semi-circular in shape; and that the said semi-circles of the joining loops overlapping in each joining space jointly form a circular hole (3, 4) for the locking pin (6).

7. A stiff joint as defined in claim 1, **characterised in that** the projections (E) of the joining loops (2) are substantially equal when measured from the planar portion of the end surface (10) of the piles, the central line (Lt) of the holes and thus also the central line of the locking pin (6) accordingly being aligned with the planar portion of the end surface.

8. A stiff joint as defined in claim 1 or 6 or 7, **characterised in that** the diameter (G2) of the locking pin parallel to the end surface (10) of the pile is substantially equal to the diameter (G1) of the locking loop holes (3, 4) in the same direction; and that the locking pins (6) are made substantially of one piece and are substantially round in cross-section and have a straight length (M) and principally an even thickness.

9. A stiff joint as defined in claim 3 or 4 with a precast concrete pile principally square in cross-section and the joint comprising two or four joining spaces, **characterised in that** in each joining space (9) optionally:

- the said planes (T1, T2) of the joining loops are substantially parallel to one lateral surface (8a or 8b or 8c or 8d) of the precast concrete pile and the line (Lt) of the joining loop holes is perpendicular to this lateral surface; or
- the said planes (T1, T2) of the joining loops are substantially parallel to the diagonal (15a, 15b) between the longitudinal edges (14) of the precast concrete pile.

10. A stiff joint as defined in claim 1 or 3 or 4, **characterised in that**

- the rebars (16) bent to U-shape comprise legs (19a);
- the loop members (30, 34) comprise legs (19b or 19d) and are attached with welded seams (20) to the rebar (17) of the joint of the precast concrete pile; or
- the length (Lb) of the legs (19c) of the angular bar (33) bent to U-shape is equal to the length of the optional rebar and the said legs (19c)

comprise an axial spirality (21) and/or curves (22) end/or recesses and protrusions, forming rebars (17) in the joint.

5 11. A stiff joint as defined in any of the preceding claims, **characterised in that** in each of the said joining spaces (9) the end (K1, K2) of the first precast concrete pile (P1) of the joint comprises at least two first planar joining loops (1) and the end (K1, K2) of the second precast concrete pile (P2) of the joint comprises at least two second planar joining loops (2); that the joint preferably comprises four joining spaces (9a-9d) aligned in pairs, the lines (Lt) of the holes in the pairs (23a, 23b) of joining spaces being parallel, that groove-like recesses (5) extend parallel to the said lines (Lt) of the holes from one lateral surface (8a, 8b, 8c, 8d) to the other lateral surface (8c, 8d, 8a, 8b or 8b, 8c, 8d, 8a) of the pile, enabling the locking pin (6) to be inserted by striking.

20 12. A stiff joint as defined in any of the preceding claims, **characterised in that** the ends (K1, K2) of the precast concrete piles comprise end boxes (24) having a frame (25) made of a sheet-like material and enclosing the pile end around the lateral surfaces of the pile and possibly also a base plate (26) principally perpendicular to the lateral surfaces.

25 30 13. A stiff joint as defined in claim 1 or 2, **characterised in that**, when the end box (24) of the precast concrete piles is:

{A} without a base plate, the groove-like recesses (5) and the planar end surfaces (10) are formed of the concrete material (27); or
{B} equipped with a base plate,

- the planar end surfaces (10) are made of metal sheet or metal casting forming the base plate (26) and
- the groove-like recesses (5) are formed either of concrete material (27) or optionally of metal sheet or metal casting (28).

Patentansprüche

1. Feste Verbindung für die Stirn-zu-Stirn-Verbindung vorgefertigter Betonrammpfähle, **dadurch gekennzeichnet, daß**

jedes Ende des vorgefertigten Betonpfahls (P1, P2) der Verbindung an seiner Stirnfläche (10) Abschnitte, die in der festen Verbindung aneinander stoßen, und Verbindungsmittel aufweist, umfassend:

eine erste flache Verbindungsschleife (1) und eine zweite flache Verbindungsschleife (2), die

ein Loch quer zur Longitudinalrichtung (Lp) der Pfähle bilden, wobei die Schleifen in der Verbindung in Longitudinalrichtung der Pfähle überlappen und nebeneinander und im wesentlichen parallel angeordnet sind, wodurch ein Verbindungsraum (9) gebildet wird, in welchem die Löcher (3, 4) dieser Verbindungsschleifen aufeinander ausgerichtet sind (Lt), die Verbindung wenigstens zwei solcher Verbindungsräume umfaßt, die in einem Unterstützungsabstand (W) von der Mittellinie (13) oder der Halbierungsebene (12) des Pfahles angeordnet sind,

wobei sowohl die ersten Verbindungsschleifen (1) als auch die zweiten Verbindungsschleifen (2) einen Vorsprung (E) von den Abschnitten der Pfahlstirnfläche aufweisen,

Querverriegelungsstifte (6), die durch die ausgerichteten Verbindungsschleifen laufen,

und wobei jede Verbindungsschleife (1, 2) umfaßt:

U-förmige Betonrippenstäbe (16) der Verbindung für einen vorgeformten Betonpfahl (P1, P2); oder

Schleifenelemente (30, 34), die sich in den vorgeformten Betonpfahl (P1, P2) als Betonrippenstäbe (17) der Verbindung erstrecken oder mit Schweißnähten (20) an den Betonrippenstäben (17) der Verbindung befestigt sind; oder U-förmige Winkelstäbe (33), deren Schenkel (19c) sich als Betonrippenstäbe (17) der Verbindung in den vorgeformten Betonpfahl (P1, P2) fortsetzen.

2. Feste Verbindung nach Anspruch 1, **dadurch gekennzeichnet, daß** die Abschnitte der Stirnfläche (10) an den Enden der vorgeformten Betonpfähle eben sind; und eine nutartige Vertiefung (5) im Bereich jedes Verbindungsraums (9) am Ende des vorgeformten Betonpfahls vorgesehen ist; wobei die Vertiefung:

parallel zur Linie (Lt) der Löcher der Verbindungsschleifen (1 oder 2) ist und eine Tiefe (D) in der ebenen Stirnfläche (10) des Pfahls (P1 oder P2) aufweist, die wenigstens gleich dem Vorsprung (E) der Verbindungsschleifen (2 oder 1) am Ende des gegenüberliegenden Pfahls in diesem Verbindungsraum von der ebenen Stirnfläche (10) des entsprechenden Pfahls (P2 oder P1) ist, und eine Breite (B) aufweist, die wenigstens gleich der Breite (C) der Verbindungsschleifen parallel zur ebenen Stirnfläche (10) der Pfähle ist; und sich wenigstens bis zu einer lateralen Oberfläche (8a-8d) des vorgeformten Betonpfahls er-

streckt.

3. Feste Verbindung nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** in jedem Verbindungsraum (9) die zweiten Verbindungsschleifen (2) in einem Abstand angeordnet sind, der wenigstens gleich der maximalen Dicke (S1) der ersten Verbindungsschleifen (1) ist, wobei die ersten Verbindungsschleifen (1) in einem Abstand angeordnet sind, der wenigstens gleich der maximalen Dicke (S2) der zweiten Verbindungsschleifen (2) ist.

4. Feste Verbindung nach irgendeinem der Ansprüche 1-3, **dadurch gekennzeichnet, daß** in jedem Verbindungsraum sich eine in dem ersten Satz von Verbindungsschleifen (1) in einem ersten Abstand (A1) vom Einlaß (11) des Verriegelungsstifts befindet, und sich eine in den zweiten Satz von Verbindungsschleifen (2) in einem zweiten Abstand (A2) vom Einlaß (11) des Verriegelungsstiftes befindet, wobei der zweite Abstand (A2) wenigstens um die maximale Dicke (S1) der ersten Verbindungsschleifen größer als, oder optional kleiner als der erste Abstand (A1) ist.

5. Feste Verbindung nach Anspruch 3 oder 4, **dadurch gekennzeichnet, daß** optional:

das erste Ende (K1) des Pfahles lediglich erste Verbindungsschleifen (1) umfaßt und das andere Ende des Pfahles (K2) lediglich zweite Verbindungsschleifen (2) umfaßt; oder beide Enden (K1 und K2) des Pfahles sowohl erste Verbindungsschleifen (1) als auch zweite Verbindungsschleifen (2) umfassen, die eine gerade Anzahl von Verbindungsräumen (9) bilden.

6. Feste Verbindung nach Anspruch 3 oder 4, **dadurch gekennzeichnet, daß** die maximale Dicke (S1, S2) der Verbindungsschleifen sich im wesentlichen über den Umfang der Verbindungsschleifen (1, 2) erstreckt; der Abschnitt der Innenfläche des Loches (3, 4) der Verbindungsschleifen in Richtung zum vorgeformten Betonpfahl (P1, P2) zeigt und als Montagebasis für diese Verbindungsschleife in halbkreisförmiger Form dient; und die Halbkreise der Verbindungsschleifen, die in jedem Verbindungsraum überlappen, gemeinsam ein kreisförmiges Loch (3, 4) für den Verriegelungsstift (6) bilden.

7. Feste Verbindung nach Anspruch 1, **dadurch gekennzeichnet, daß** die Vorsprünge (E) der Verbindungsschleifen (2) im wesentlichen gleich sind, wenn sie vom ebenen Abschnitt der Stirnfläche (10) der Pfähle aus gemessen werden, wobei die Mittellinie (Lt) der Löcher und somit auch die Mittellinie des Verriegelungsstifts (6) entsprechend auf den

ebenen Abschnitt der Stirnfläche ausgerichtet ist.

8. Feste Verbindung nach Anspruch 1, 6 oder 7, **dadurch gekennzeichnet, daß** der Durchmesser (G2) des Verriegelungsstifts parallel zur Stirnfläche (10) des Pfahls im wesentlichen gleich dem Durchmesser (G1) der Verriegelungsschleifenlöcher (3, 4) in derselben Richtung ist; und die Verriegelungsstifte (6) im wesentlichen aus einem Stück gefertigt sind und im wesentlichen im Querschnitt rund sind und eine gerade Länge (M) und hauptsächlich eine gleichmäßige Dicke aufweisen.

9. Feste Verbindung nach Anspruch 3 oder 4 mit einem vorgeformten Betonpfahl, der im Querschnitt hauptsächlich quadratisch ist, wobei die Verbindung zwei oder vier Verbindungsräume umfaßt, **dadurch gekennzeichnet, daß** in jedem Verbindungsraum (9) optional:

die Ebenen (T1, T2) der Verbindungsschleifen im wesentlichen parallel zu einer lateralen Oberfläche (8a oder 8b oder 8c oder 8d) des vorgeformten Betonpfahls sind und die Linie (Lt) der Verbindungsschleifenlöcher senkrecht zu dieser lateralen Oberfläche ist; oder die Ebenen (T1, T2) der Verbindungsschleifen im wesentlichen parallel zur Diagonalen (15a, 15b) zwischen den longitudinalen Kanten (14) des vorgeformten Betonpfahls sind.

10. Feste Verbindung nach Anspruch 1 oder 3 oder 4, **dadurch gekennzeichnet, daß**

die Betonrippenstäbe (16) zu einer U-Form gebogen sind, die Schenkel (19a) umfassen; die Schleifenelemente (30, 34) Schenkel (19b oder 19d) umfassen und mit Schweißnähten (20) am Betonrippenstahl (17) der Verbindung des vorgeformten Betonpfahls befestigt sind; oder die Länge (Lb) der Schenkel (19c) des Winkelstabes (33), der in U-Form gebogen ist, gleich der Länge des optionalen Betonrippenstahls ist, wobei die Schenkel (19c) eine axiale Spiralförmigkeit (21) und/oder Bögen (22) und/oder Vertiefungen und Vorsprünge umfassen und Betonrippenstäbe (17) in der Verbindung bilden.

11. Feste Verbindung nach irgendeinem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** in jedem der Verbindungsräume (9) das Ende (K1, K2) des ersten vorgeformten Betonpfahls (P1) der Verbindung wenigstens zwei erste ebene Verbindungsschleifen (1) umfaßt, und das Ende (K1, K2) des zweiten vorgeformten Betonpfahls (P2) der Verbindung wenigstens zwei zweite ebene Verbindungsschleifen (2) umfaßt; die Verbindung vor-

zugsweise vier Verbindungsräume (9a-9d) umfaßt, die in Paaren ausgerichtet sind, wobei die Linien (Lt) der Löcher in den Paaren (23a, 23b) von Verbindungsräumen parallel sind; nutartige Vertiefungen (5) sich parallel zu den Linien (Lt) der Löcher von einer lateralen Oberfläche (8a, 8b, 8c, 8d) zu der anderen lateralen Oberfläche (8c, 8d, 8a, 8b oder 8b, 8c, 8d, 8a) des Pfahls erstrecken, wodurch das Einschlagen des Verriegelungsstifts (6) ermöglicht wird.

12. Feste Verbindung nach irgendeinem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** die Enden (K1, K2) der vorgeformten Betonpfähle Endkästen (24) umfassen, die einen Rahmen (25) aufweisen, der aus einem plattenartigen Material gefertigt ist und das Pfahlende um die lateralen Oberflächen des Pfahls umschließt, sowie möglicherweise auch eine Basisplatte (26), die im wesentlichen senkrecht zu den lateralen Oberflächen ist.

13. Feste Verbindung nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** dann, wenn der Endkasten (24) der vorgeformten Betonpfähle:

{A} ohne eine Basisplatte ist, die nutartigen Vertiefungen (5) und die ebenen Stirnflächen (10) aus dem Betonmaterial (27) geformt sind; oder
{B} mit einer Basisplatte ausgestattet ist,

die ebenen Stirnflächen (10) aus einer Metallplatte oder einem Metallformteil geformt sind, die die Basisplatte (26) bilden, und die nutartigen Vertiefungen (5) entweder aus Betonmaterial (27) oder optional aus einer Metallplatte oder einem Metallformteil (28) gebildet sind.

Revendications

1. Assemblage rigide pour assembler bout à bout des pieux forcés en béton moulé d'avance **caractérisé en ce que** chaque extrémité de pieu en béton moulé d'avance (P1, P2) de l'assemblage ayant sur sa surface d'extrémité (10) des parties qui viennent en butée dans l'assemblage rigide et des moyens d'assemblage comprenant :

une première boucle d'assemblage plane (1) et une seconde boucle d'assemblage (2) formant un trou transversal par rapport à la direction longitudinale (Lp) des pieux, dont les boucles se chevauchent sur l'assemblage dans la direction longitudinale des pieux et sont situées de manière adjacente et sensiblement parallèles,

formant un espace d'assemblage (9) dans lequel les trous (3, 4) de ces boucles d'assemblage sont mutuellement alignés (Lt), l'assemblage comprenant au moins deux espaces d'assemblage à une certaine distance de support (W) de la ligne centrale (13) ou du plan de bissection(12) du pieu, lesdites premières boucles d'assemblage (1) ainsi que lesdites secondes boucles d'assemblage (2) possédant une saillie (E) à partir desdites parties de la surface d'extrémité du pieu, des broches de blocage transversales (6) qui passent à travers les boucles d'assemblage alignées, et dans lesquelles chaque boucle d'assemblage (1, 2) comprend :

des barres d'armature en forme de U (16) de l'assemblage pour un pieu en béton moulé d'avance (P1, P2) ; ou des éléments de boucle (30, 34) qui s'étendent dans le pieu de béton moulé d'avance (P1, P2) en tant que barres d'armature (17) de l'assemblage ou qui sont fixés avec des jointures soudées (20) aux barres d'armature (17) du joint ; ou des barres angulaires en forme de U (33) dont les pattes (19c) continuent dans le pieu de béton moulé d'avance (P1, P2) en tant que barres d'armature (17) de l'assemblage.

2. Assemblage rigide selon la revendication 1, **caractérisé en ce que** lesdites parties de la surface d'extrémité (10) situées au niveau des extrémités des pieux en béton moulé d'avance sont planes ; et **en ce qu'un** enfoncement en forme de rainure (5) est prévu dans la zone de chaque espace d'assemblage (9) au niveau de l'extrémité du pieu en béton moulé d'avance, l'enfoncement étant :

parallèle par rapport à ladite ligne (Lt) des trous des boucles d'assemblage (1 et 2) et ayant une profondeur (D) dans la surface d'extrémité plane (10) du pieu (P1 ou P2) qui est au moins égale à la saillie (E) des boucles d'assemblage (2 ou 1) à l'extrémité du pieu opposé dans cet espace d'assemblage à partir de la surface d'extrémité plane (10) du pieu correspondant (P2 ou P1) et une largeur (B) qui est au moins égale à la largeur (C) des boucles d'assemblage parallèles à la surface d'extrémité plane (10) des pieux, et étendu au moins vers une surface latérale (8a-8d) du pieu en béton moulé d'avance.

3. Assemblage rigide selon la revendication 1 ou 2, **caractérisé en ce que** dans chaque espace d'assemblage (9), les secondes boucles d'assemblage

(2) sont espacées par une distance qui est au moins égale à l'épaisseur maximale (S1) des premières boucles d'assemblage (1) et les premières boucles d'assemblage (1) sont espacées par une distance qui est au moins égale à l'épaisseur maximale (S2) des secondes boucles d'assemblage (2).

4. Assemblage rigide selon l'une quelconque des revendications 1-3, **caractérisé en ce que** dans chaque espace d'assemblage, celui qui est situé dans le premier ensemble des boucles d'assemblage (1) se trouve à une première distance (A1) de l'entrée (11) de la broche de blocage et celui qui est situé dans le second ensemble de boucles d'assemblage (2) se trouve à une seconde distance (A2) de l'entrée (11) de la broche de blocage, ladite seconde distance (A2) étant au moins supérieure à ou facultativement inférieure à la première distance (A1) de l'épaisseur maximale (S1) des premières boucles d'assemblage.

5. Assemblage rigide selon la revendication 3 ou 4, **caractérisé en ce que** facultativement :

la première extrémité (K1) du pieu comprend simplement les premières boucles d'assemblage (1) et l'autre extrémité de la pile (K2) comprend simplement les secondes boucles d'assemblage (2) ; ou

les deux extrémités (K1 et K2) du pieu comprennent à la fois les premières boucles d'assemblage (1) et les secondes boucles d'assemblage (2) formant un nombre pair d'espaces d'assemblage (9).

6. Assemblage rigide selon la revendication 3 ou 4, **caractérisé en ce que** l'épaisseur maximale (S1, S2) des boucles d'assemblage s'étend sensiblement sur la circonférence des boucles d'assemblage (1, 2) ; **en ce que** la partie de la surface interne dudit trou (3, 4) des boucles d'assemblage qui pointe vers le pieu en béton moulé d'avance(P1, P2) et qui sert de base de montage pour cette boucle d'assemblage a une forme semi circulaire ; et **en ce que** lesdits demi cercles des boucles d'assemblage qui se chevauchent dans chaque espace d'assemblage forment conjointement un trou circulaire (3, 4) pour la broche de blocage (6).

7. Assemblage rigide selon la revendication 1, **caractérisé en ce que** les saillies (E) des boucles d'assemblage (2) sont sensiblement égales lorsqu'elles sont mesurées à partir de la partie plane de la surface d'extrémité (10) des pieux, la ligne centrale (Lt) des trous et donc également la ligne centrale de la broche de blocage (6) étant par conséquent alignées avec la partie plane de la surface d'extrémité.

8. Assemblage selon la revendication 1 ou 6 ou 7, **caractérisé en ce que** le diamètre (G2) de la broche de blocage parallèle à la surface d'extrémité (10) du pieu est sensiblement égal au diamètre (G1) des trous de la boucle de blocage (3, 4) dans la même direction ; et **en ce que** les broches de blocage (6) sont sensiblement fabriquées d'une seule pièce et ont une section sensiblement ronde et une longueur droite (M) et une épaisseur principalement régulière.

9. Assemblage rigide selon la revendication 3 ou 4 avec un pieu en béton moulé d'avance de section principalement carrée et l'assemblage comprenant deux ou quatre espaces d'assemblage, **caractérisé en ce que** dans chaque espace d'assemblage (9) facultativement :

lesdits plans (T1, T2) des boucles d'assemblage sont sensiblement parallèles à une surface latérale (8a ou 8b ou 8c ou 8d) du pieu en béton moulé d'avance et la ligne (Lt) des trous de la boucle d'assemblage est perpendiculaire à cette surface latérale ; ou

lesdits plans (T1, T2) des boucles d'assemblage sont sensiblement parallèles à la diagonale (15a, 15b) entre les bords longitudinaux (14) du pieu en béton moulé d'avance.

10. Assemblage rigide selon la revendication 1 ou 3 ou 4, **caractérisé en ce que** :

les barres d'armature (16) pliées en forme de U comprennent des pattes (19a) ;

les éléments de boucle (30, 34) comprennent des pattes (19b ou 19d) et sont fixés avec des jointures soudées (20) à la barre d'armature (17) de l'assemblage du pieu en béton moulé d'avance ; ou

la longueur (Lb) des pattes (19c) de la barre annulaire (33) pliée en forme de U est égale à la longueur de la barre d'armature facultative et lesdites pattes (19c) comprennent un vrillage axial (21) et/ou des courbes (22) et/ou des enfoncements et saillies, qui forment des barres d'armature (17) dans l'assemblage.

11. Assemblage rigide selon l'une quelconque des revendications précédentes, **caractérisé en ce que** dans chacun desdits espaces d'assemblage (9) l'extrémité (K1, K2) du premier pieu en béton moulé d'avance (P1) de l'assemblage comprend au moins deux premières boucles d'assemblage planes (1) et l'extrémité (K1, K2) du second pieu en béton moulé d'avance (P2) de l'assemblage comprend au moins deux secondes boucles d'assemblage planes (2) ; **en ce que** l'assemblage comprend de préférence quatre espaces d'assemblage (9a - 9d) ali-

gnés en paires, les lignes (Lt) des trous dans les paires (23a, 23b) des espaces d'assemblage étant parallèles, de sorte que les enfoncements en forme de rainure (5) s'étendent parallèles auxdites lignes (Lt) des trous à partir d'une surface latérale (8a, 8b, 8c, 8d) vers l'autre surface latérale (8c, 8d, 8a, 8b ou 8b, 8c, 8d, 8a) du pieu, permettant à la broche de blocage (6) d'être insérée par amorçage.

12. Assemblage rigide selon l'une quelconque des revendications précédentes, **caractérisé en ce que** les extrémités (K1, K2) des pieux en béton moulé d'avance comprennent des boîtes d'extrémité (24) ayant un châssis (25) en matériau de type acier et comprenant l'extrémité du pieu autour des surfaces latérales du pieu et éventuellement une plaque de base (26) principalement perpendiculaire aux surfaces latérales.

13. Assemblage selon la revendication 1 ou 2, **caractérisé en ce qu'**au moment où la boîte d'extrémité (24) des pieux en béton moulé d'avance se trouve :

{A} sans plaque de base, les enfoncements en forme de rainure (5) et les surfaces d'extrémité planes (10) sont formées avec du béton (27) ; ou

{B} équipée avec une plaque de base ;

les surfaces d'extrémité planes (10) sont en tôle ou métal moulé pour former la plaque de base (26), et les enfoncements en forme de rainure (5) sont formés soit avec du ciment (27) soit facultativement avec de la tôle ou un métal moulé (28).

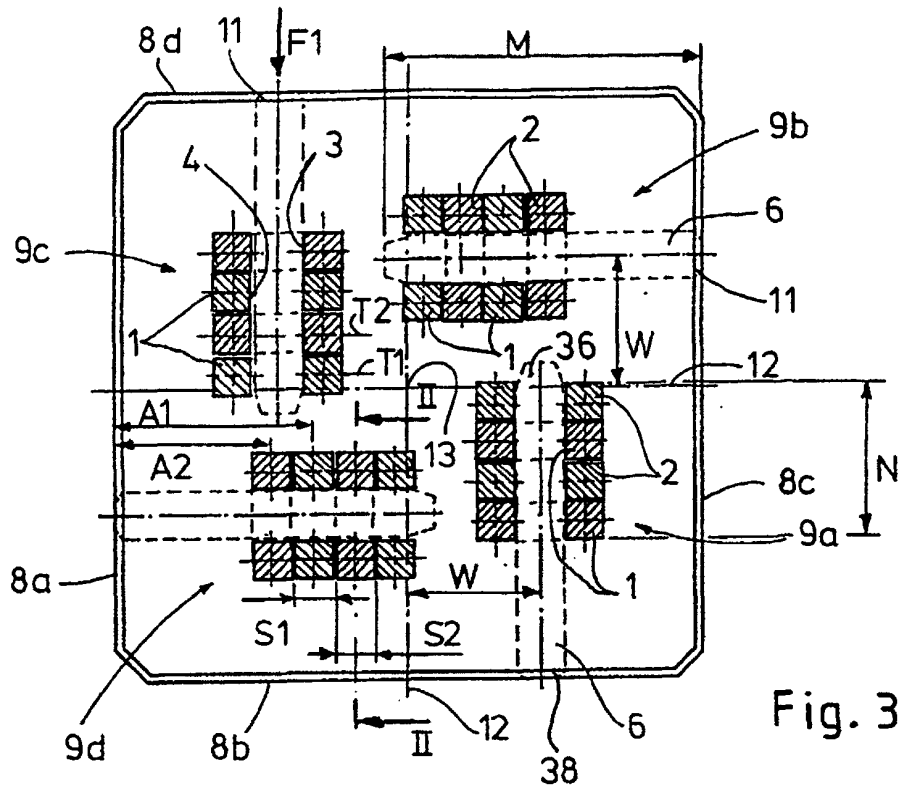


Fig. 3

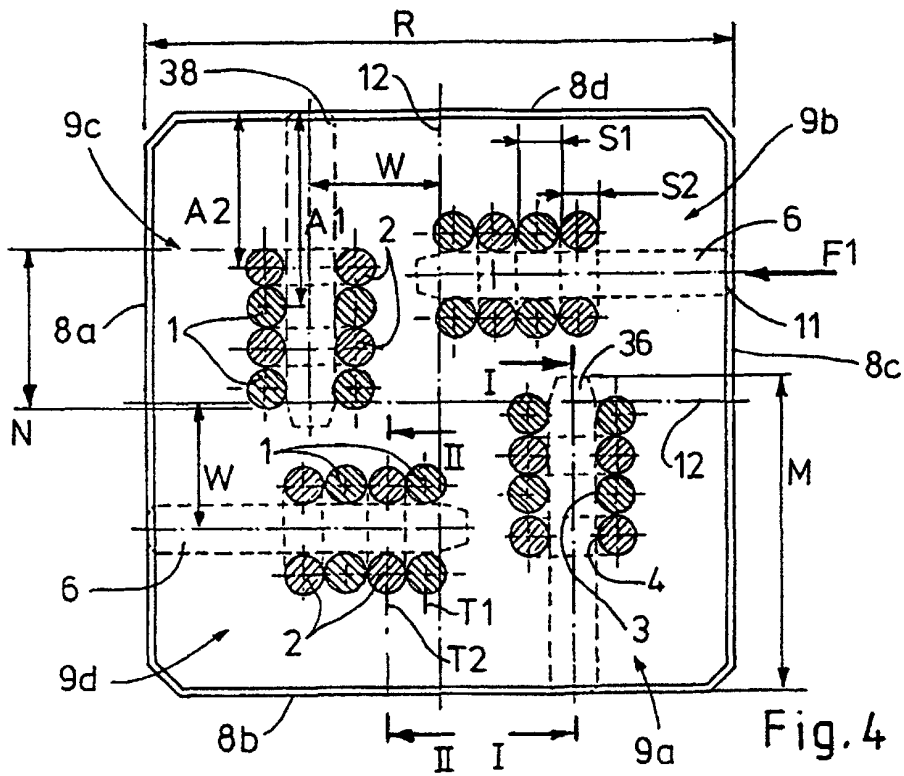
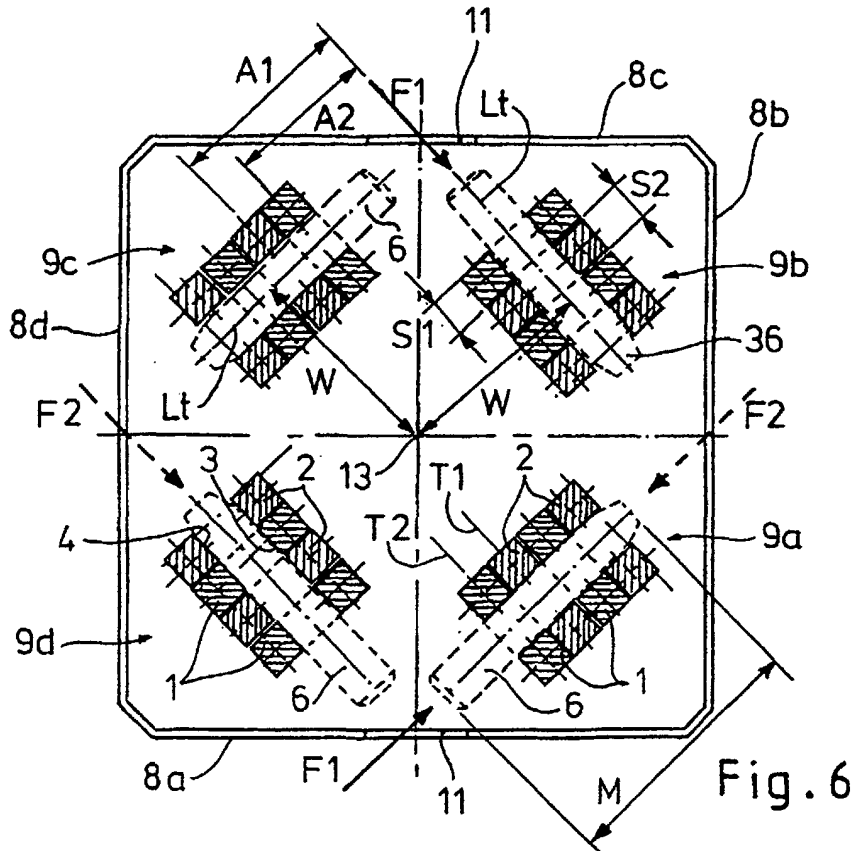
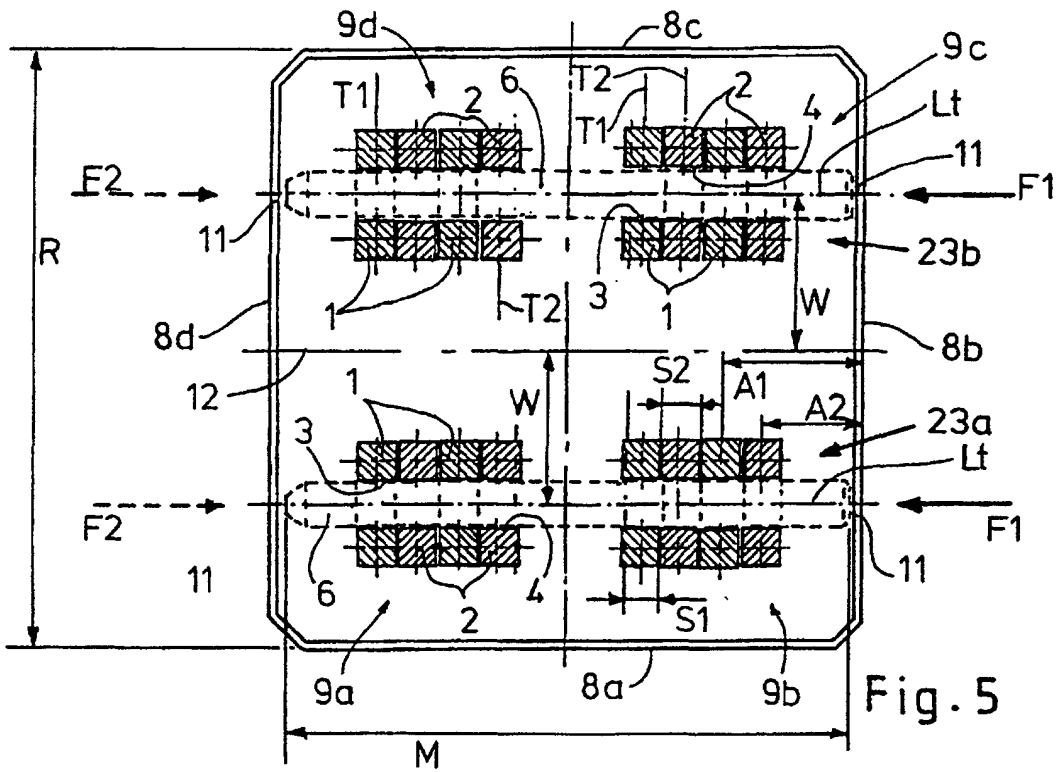


Fig. 4



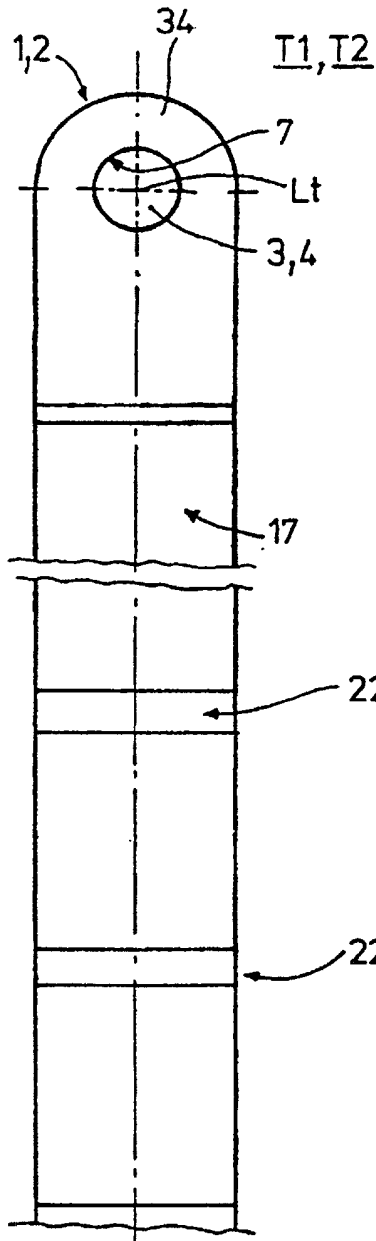


Fig. 13A

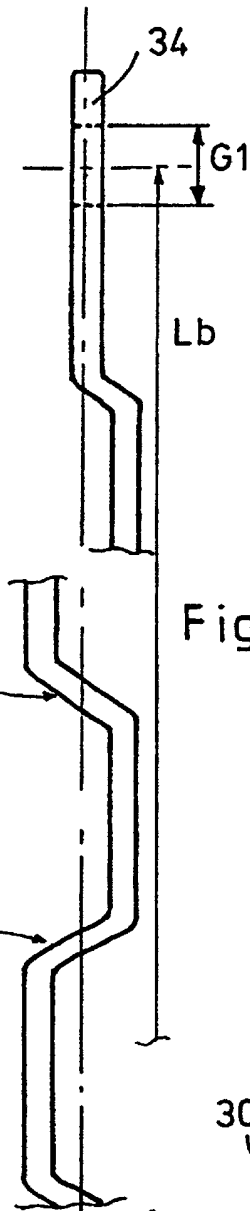


Fig. 13B

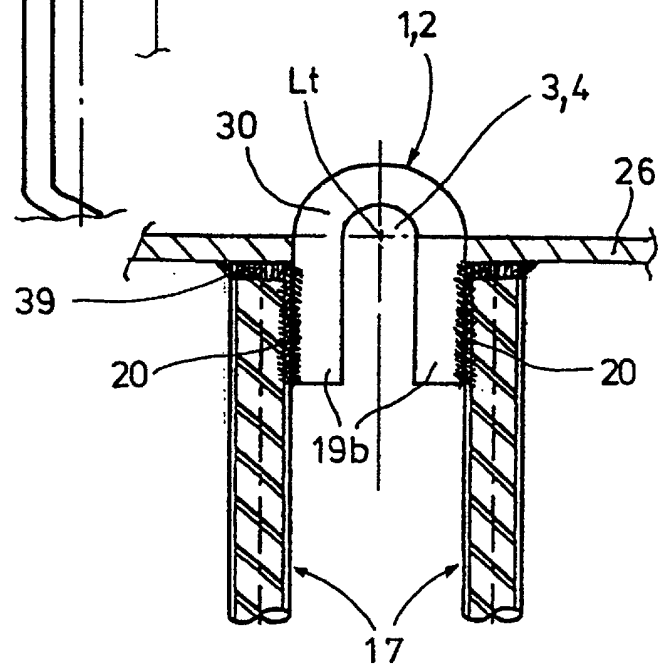


Fig. 14