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(54) **Apparatus for rigidly securing together prefabricated floor-support beams and prefabricated pillars**

(57) An apparatus for rigidly securing together prefabricated floor-support beams and prefabricated pillars for the construction of multi-level reinforced-concrete framework structures is described, these being suitable for multi-functional use and being able to withstand major overloads, including those of seismic origin. The apparatus comprises single-piece side pillars (1) and middle pillars (1') of predefined height which, at each floor level, have integral therewith enlarged zones with lateral projections (101,101') which perform the function of a corbel and which have, embedded in them, at the time of prefabrication, metal inserts (A) which act as a support and system for immediate mechanical engagement with corresponding metal inserts (B) which are provided, again at the time of prefabrication, on the ends of the prefabricated beams (10), all of which so that, immediately after arrangement in position, the said beams are prevented from performing undesirable horizontal movements, without the use of bracing members.

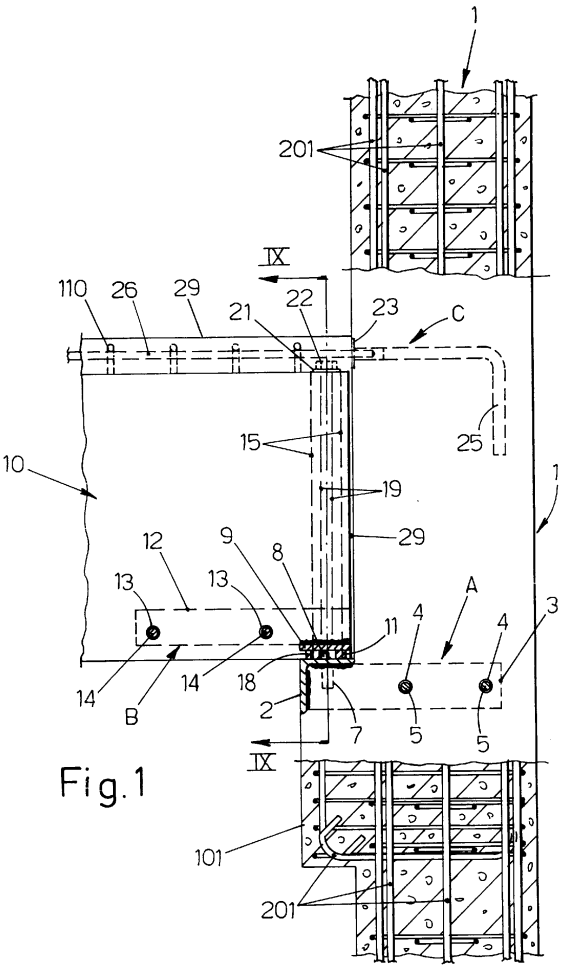


Fig.1

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## Description

**[0001]** The invention falls within the sector of multi-level framework building structures which are suitable for multi-functional use and are intended to withstand major overloads, including those of seismic origin, said structures being formed by prefabricated pillars made of - usually vibrated and precompressed - reinforced concrete and provided in the zones where they are connected to the beams, also made of ordinary or precompressed reinforced concrete, with corbels which then receive, resting on them, the ends of the said beams which finally support the sides of prefabricated honeycomb panels which are also made of reinforced concrete, for forming the floors.

**[0002]** The prior art already teaches the use of prefabricated reinforced-concrete pillars and beams which are provided with metal inserts for connection together on-site, for example as described in the Italian patent Nos. 1,018,104 dated 19.7.74 (Tamburini). These and other known solutions have proved to have a low level of technological reliability and to be difficult to implement, both owing to the need for reinforcements and bracing members and also because of the difficulty of ensuring rapid, reliable and precise installation of the components, with the fixing and supplementary rigidifying casting operations being performed at a later time.

**[0003]** The invention intends to overcome the limitations of the prior art with an apparatus according to Claim 1 and the subsequent dependent claims, which facilitates the correct arrangement in position of the beams on the support corbels of single-piece pillars of predefined height, owing to the presence of teeth and engaging seats on the mutually co-operating metal inserts of the two prefabricated components, which prevent undesirable movements of these components. A further object of the invention consists in facilitating the arrangement in position of supplementary reinforcement irons which secure the horizontal and vertical connections of the beams to the pillars and in improving the results achieved with these connections, so as to obtain connection characteristics similar to those which are obtained in a multi-level framework building structure constructed on-site. The three types of construction components used, i.e. pillars, beams and floor sills, are self-supporting and their installation does not require the temporary use of bracing members. During a first stage these components simply rest on each other. After positioning the necessary supplementary reinforcements and after performing on-site a supplementary casting, the said components are rigidly secured to each other.

**[0004]** Further characteristic features of the invention and the advantages arising therefrom will become clear from the following description of a preferred embodiment thereof, illustrated purely by way of a non-limiting example, in the figures of the accompanying sets of drawings in which:

- Fig. 1 shows, vertically sectioned and in a middle position, a joint for connecting a beam to a side pillar of the multi-level framework structure in question;
- Fig. 2 shows, vertically sectioned and in a middle position, a joint for connecting a beam to a middle pillar of the same multi-level framework structure;
- Fig. 3 shows a perspective view of one of the metal inserts embedded in the support corbels of the side pillars, for allowing upper connection of the beams to the said pillars;
- Fig. 4 shows a perspective view of one of the metal inserts which can be embedded in the support corbels of the middle pillars, for obtaining the upper connection of the oppositely arranged beams to the said pillars;
- Fig. 5 shows a perspective view of the metal insert partially embedded in the lateral corbels of the pillars which form the supports for the prefabricated beams;
- Fig. 6 shows a perspective view of the metal insert partially embedded at the ends of the prefabricated beams, for co-operation with the metal support insert according to Figure 5;
- Figs. 7 and 8 show a top plan view of the arrangement of the inserts according to Figures 5 and 6, in a side joint and middle joint of the multi-level framework structure;
- Fig. 9 shows details viewed along the cross-sectional line IX-IX according to Figures 1 and 2.

**[0005]** From Figure 1 it can be seen that the prefabricated side pillars 1 and the middle pillars 1' are single-piece and of predefined height for forming a framework with a predetermined number of levels and that, in the region of the floor sill of each level, the said pillars are provided integrally with laterally projecting parts which are arranged on one side, as indicated by 101 in Figure 1, in the case of the side pillars 1, whereas they are situated on both sides opposite each other, as indicated by 101' in Figure 2, in the case of the middle pillars 1' and form actual corbels reinforced by the special internal reinforcements 201 of the pillars which have a greater number of brackets in the linear direction close to the joint which comprises these corbels. These reinforcements are not shown in the joints where the pillars are connected to the beams, both because they are known and can be deduced by persons skilled in the art and because they would hinder illustration of the metal inserts A which according to the invention are situated inside the said corbels 101, 101'.

**[0006]** From Figures 1, 2, 5 and 7-9 it can be seen that, during prefabrication of the pillars 1 and 1', each corbel

101, 101' thereof receives, embedded therein, a metal insert A, as shown in Figure 5, which comprises a robust angle-piece 2 of suitable dimensions, which forms mainly the upper side and consecutive front side of the corbel 101, 101' and which has, welded internally and perpendicularly to its flanges, the ends of anchoring plates 3 which are positioned edgewise and are inserted to a considerable depth inside the body of the pillar 1,1' and which have intermediate holes 4 passed through by corresponding reinforcing irons 5 able to interact with the reinforcing irons of the said pillar so as to keep the aforementioned parts 2 and 3 firmly in position. As shown in Figures 7, 8 and 9, the anchoring plates 3 have an asymmetrical position with respect to the angle-piece 2 so that it is possible to use, in the corbels 101' of the middle pillars 1', inserts A with identical characteristics which, with the angle-pieces 2 in the centred position, carry the anchoring plates 3 arranged alongside each other, with the holes 4 mutually aligned, so as to be able to be anchored in the pillar with common reinforcing irons 5.

**[0007]** The insert A is completed by at least one pair of vertical holes 6 with a symmetrical arrangement on the top flange of the angle-piece 2, at a short distance from the sides of this angle-piece, which allow access with tie-rods described further below to the inner threaded part of metal bushes 7 welded underneath the said upper flange of the angle-piece 2. A tooth 8 formed for example by a square metal block of suitable dimensions and described more fully below is longitudinally welded in the space between the said holes 6, on the visible side of the upper flange of the angle-piece 2.

**[0008]** From Figures 1, 2 and 6-9 it can be seen that the ends of the prefabricated reinforced-concrete beam 10 incorporate during prefabrication a metal insert B which comprises a robust plate 9 which is able to form mainly the bottom side of the bottom end corner zone of the beam 10, which is visible and which has, welded longitudinally and at a short distance from its visible front edge, a tooth 11 formed for example also by a square metal block and having for example the same height as the block which forms the tooth 8 of the aforementioned insert A and which at the bottom is coplanar with the bottom side of the beam 10, such that, with respect to this side, the said plate 9 is suitably raised. The plate 9 is anchored firmly to the beam 10 by means of a pair of anchoring plates 12, at one end of which the said plate is welded, these plates 12 being positioned edgewise and being provided with intermediate holes 13 passed through by reinforcing irons 14 which interact suitably with the internal reinforcement of the beam 10. The ends of the plate 9 have, welded thereto, the bottom ends of metal tubular members 15 of equal height, for example with a rectangular cross-section, which with their bottom end project from the plate 9 so as to touch the ideal horizontal plane which contains the visible bottom side of the tooth 11 and the inner wall of this projecting bottom section of the tubes 15 is open as indicated by 16 in Figure 9, so as to establish a connection between the internal cavity of the said tubes and the chamber 17 which is situated underneath the plate 9 and which is defined, as well as by this plate, by the bottom section of the tubes 15, by the tooth 11 and, parallel to the latter, by a folded sheet-metal wall 18 welded at least to the bottom side of the plate 9. The wall 18 has the same height as the tooth 11. The tubes 15 have an interaxial distance substantially the same as that of the upper holes 6 in the insert A of the pillars.

**[0009]** When the prefabricated beam 10 is rested with its ends on the corbels 101, 101' of the pillars 1, 1', the tooth 8 of the insert A of the corbels engages inside the aforementioned chamber 17 of the insert B of the beams and rests on the plate 9, while the tooth 11 of this plate rests on the upper flange of the angle-piece 2 of the insert A and this flange closes at the bottom the said chamber 17. The holes 6 in the insert A are situated inside the bottom end of the tubes 15. With this solution the beams 10 are anchored mechanically to the corbels 101, 101' of the pillars and are prevented from performing undesirable horizontal movements, so as to allow rapid and correct mounting of the prefabricated beams on the pillars 1, 1' which are fixed on-site, without the use of reinforcements or bracing members. During a subsequent step, as shown in Figures 1, 2 and 9, the tubes 15 receive, inserted in them, the threaded tie-rods 19 which, with one end, are screwed into the bushes 7 of the insert A and which, with the opposite - also threaded - end, project conveniently from the said tubes 15 into which a self-levelling, high-strength, expanding cement mortar 20 is subsequently injected, said mortar filling completely these tubes and saturating also the chamber 17 with the engaging teeth 8 and 11, thereby improving the strength of the joint and helping preserve over time all the metal components which form it, since they are completely embedded in the cement. The mortar manages to withstand extremely high loads, which are substantially twice those which are usual for this type of product, since it is confined within a box-shaped structure of the metal system for supporting the beam, enabling the apparatus to absorb lower horizontal forces which allow it to counteract effectively the reverse moments which may occur during seismic events, providing a rigid and hyperstatic joint.

**[0010]** In operating sequence, the tubes 15 are closed at the top by inserts 21 or with the holed end of reinforcing plates extending partly over the outer side of the beam 10 and then the said inserts 21 are fixed to the top end of the tie-rods 19 with nuts 22 and/or other suitable means.

**[0011]** From Figures 1-4 and 9 it can be seen that, at the level of the outer side of the beam 10, which has some of the metal reinforcing brackets 110 projecting therefrom, the side pillars 1 have visible a transverse metal plate 23 with holes 24 which allow access to the threaded blind end seats 125 of robust L-shaped anchoring irons 25 embedded in the body of the pillar. The ends of threaded bars 26 which extend along a suitable section of the outer side of the beam 10 are screwed into the

threaded seats 125 of such a metal insert C embedded in the side pillars 1, so as to interact mechanically with the projecting reinforcement 110 of the beam 10. The middle pillars 1' may have embedded therein, instead of the insert C according to Figure 3, oppositely arranged inserts C' as can be seen in Figure 4, said inserts comprising internally threaded bushes 125' for being able to screw in there the threaded bars 26 which co-operate with the upper reinforcements 110 of the beams 10, these bushes 125' being able to be connected to the reinforcements of the pillar by means of special anchoring irons 25'. As an alternative to this solution, it is possible to use a design of joint C" which is very much simpler (see Figure 2) whereby the said joint is formed by corrugated sheet-metal tubes which are embedded transversely in the middle pillars so as to form therein through-holes inside which it is possible to secure, using expanding cement mortar and/or other suitable means, reinforcing bars 26 which project by equal amounts into the beams resting on the opposite corbels 101' of a same middle pillar 1'.

**[0012]** As illustrated in Figures 1, 2 and 9, once fixing of the bars 26 to the aforementioned inserts C, C' or C" of the pillar has been completed, the honeycomb floor sills S are arranged in position, resting them partly on the beams 10, a supplementary reinforcement 27 which co-operates both with that 110 of the beams and with that 28 of the floor sills S is provided, and then the supplementary casting 29 is performed, rigidly securing in a definitive manner the beams to the pillars and the floor sills to the beams. Saturation with cement mortar 20 of the aforementioned bottom box 17 and the tubes 15 of the insert B and the upper final casting 29 ensure that, once the assembly operation has been completed, the connection between beams and pillars is without play and is able to absorb in the best possible manner the horizontal compressive and tractional stresses.

**[0013]** The solution as described was tested by imparting to the beam-pillar joint firstly a flexing action which induced a pulling force on the inner side of the said beam and then a flexing action in the opposite direction. The stresses were increased until there were signs of severe cracking on the pillar and on the beam, while the metal connection inserts did not gave way. Both the upper and lower connections met the requirements in terms of ductility of the joint, since the stresses produced did not result in a sudden collapse, but gradual yielding of the reinforced-concrete cross-section of the beam or the pillar. If the strength of the beam-pillar connecting joint has to be increased, after checking that the pillar and beam are able to withstand the respective shearing and flexing stresses, steps are taken to increase proportionally the number of bushes and upper bars in the fixture along the outer side and the size of the teeth 8, 11 formed by the square opposition blocks on the supports of the inner side, all of which can be easily deduced also by means tests. It will also be possible to improve the insert B according to Figure 6, by providing special means for connecting together the tubes 15 and the anchoring plates 12, for example using at least one reinforcing iron which passes through the holes in the parts concerned, without interfering with the tie-rods 19 and without hindering installation of the latter. The plate 9 of the insert B of the beams may be replaced with an angle-piece so as to form also a frontal protection for the said beams, which is particularly useful for preventing damage thereto during transportation and arrangement in position.

## Claims

1. Apparatus for rigidly securing together prefabricated floor-support beams and prefabricated pillars for the construction of multi-level reinforced-concrete framework structures is described, these being suitable for multi-functional use and being able to withstand major overloads, including those of seismic origin, **characterized in that** it comprises single-piece side pillars (1) and middle pillars (1') of predefined height which, at each floor level, have integral therewith enlarged zones with lateral projections (101, 101') which perform the function of a corbel and which have, embedded in them, at the time of prefabrication, metal inserts (A) which act as a support and system for immediate mechanical engagement with corresponding metal inserts (B) which are provided, again at the time of prefabrication, on the ends of the prefabricated beams (10), all of which so that, immediately after arrangement in position, the said beams are prevented from performing undesirable horizontal movements, means being envisaged for ensuring the subsequent vertical fixing of the said metallic inserts (A,B), as well as means for arranging the reinforcing irons (16) on the outer side of the beams, between their projecting reinforcements (110), and for fixing them to the pillars (1, 1'), all of which so that, after positioning on the beams the edges of the prefabricated floor sills (S) and after installing the supplementary reinforcing irons (27) for connecting the reinforcements (28) of the said floor sills to those (110) of the beams (10), it is possible to perform a supplementary casting (20, 29) which rigidly fixes together the said prefabricated components of the building structure, blocking the beam-pillar connecting joints by means of a rigid hyperstatic connection, in which all the metal parts are substantially embedded in the cement, as though the entire structure were built on-site, and which is able to prevent also the horizontal movements so as to be particularly suitable for withstanding high-intensity composite stresses, such as seismic stresses.

2. Apparatus according to Claim 1, **characterized in that** the metal inserts (A) embedded in the corbels (101, 101') for supporting the pillars (1, 1') comprise

a robust angle-piece (2) of suitable dimensions which forms mainly the upper side and the consecutive front side of the corbel (101, 101') and which has, welded internally and perpendicularly to its flanges, the ends of anchoring plates (3) which are positioned edgewise and which are inserted to a considerable depth inside the body of the pillar (1, 1') and which have intermediate holes (4) which are passed through by corresponding reinforcement irons (5) which interact with the reinforcement irons of the said pillar and which firmly retain the said parts (2, 3) in position.

**3.** Apparatus according to Claim 2, **characterized in that** the said anchoring plates (3) are at least two in number and have an asymmetrical arrangement on the angle-piece (2) so that it is possible to use in the corbels (101') of the middle pillars (1') metal inserts (A) with identical characteristics which have the angle-pieces (2) in a centred position and support the anchoring plates (3) arranged alongside each other with the associated holes (4) mutually aligned so as to be able to be secured in the pillar using common reinforcing irons (5).

**4.** Apparatus according to Claim 2, **characterized in that** the upper flange of the said angle-piece (2), at a short distance from the sides thereof, is provided with at least one pair of holes (6) with a symmetrical arrangement which allow access to the internal threaded part of metal bushes (7) welded underneath the said upper flange of the angle-piece (2), all of which so as to be able to screw fixing tie-rods (19) in these bushes.

**5.** Apparatus according to Claim 4, **characterized in that** a tooth (8) formed for example by a metal bar (8) of suitable dimensions and with a square cross-section or other suitable cross-section is welded longitudinally and raised in the space between the said holes (6), on the visible side of the upper flange of the angle-piece (2).

**6.** Apparatus according to Claim 1, **characterized in that** the metal insert (B) provided on the ends of the prefabricated beams (10) comprises a robust plate (9) which is able to form mainly the bottom side of the bottom corner end zone of the beam, which is visible and which has, welded longitudinally and at a short distance from its visible front edge, a tooth (11) formed by a metal bar which has, for example, the same height and the same shape as that which forms the tooth (8) of the said insert (A) of the corbels of the pillars, so as to ensure the engaging or interlocking co-operation between the two inserts (A, B), the said plate (9) being firmly anchored in the beam (10) by means of one or more anchoring plates (12) to one end of which the said plate (9) is welded, these anchoring plates being positioned edgewise and being provided with intermediate holes (13) passed through by reinforcement irons (14) which interact suitably with the internal reinforcement of the beam (10).

**7.** Apparatus according to Claim 6, **characterized in that** the said tooth (11) is such as to be coplanar at the bottom with the bottom side of the beam (10) such that, with respect to this side, the said plate (9) which has the said tooth (11) welded underneath and raised, is suitably set back.

**8.** Apparatus according to Claim 6, **characterized in that** the ends of the said plate (9) have, welded thereto, the bottom ends of metal tubular members (15) of equal height, for example with a rectangular cross-section, which with their bottom end project from the plate (9) so as to touch the ideal horizontal plane which contains the bottom visible side of the tooth (11) and the internal wall of this projecting bottom section of the tubes (15) has an opening (16) which creates a connection between the internal cavity of the said tubes and a chamber (17) which is situated underneath the plate (9) and which is defined, as well as by this plate, by the bottom section of the said tubes (15), by the tooth (11) and, parallel to the latter, by a folded sheet-metal wall (18) which is welded at least to the bottom side of the plate (9) and has the same height as the said tooth (11), it being envisaged that the said tubes (15) have an interaxial distance which is substantially the same as that of the upper holes (6) in the insert (A) of the pillars.

**9.** Apparatus according to one or more of the preceding claims, **characterized in that** the said inserts (A, B) have dimensions such that, when the prefabricated beam (10) is rested with its ends on the brackets (101, 101') of the pillars (1, 1'), the tooth (8) of the insert (A) of the said corbels engages inside the aforementioned bottom chamber (17) of the insert (B) of the beams and rests on the plate (9) of this insert, while the bottom tooth (11) of this plate rests on the upper flange of the angle-piece (2) of the bottom insert (A) and this flange closes the said chamber (17) at the bottom, it being envisaged that the holes (6) of the said bottom insert (A) are arranged inside the said tubes (1) of the insert (B) of the beams which in this way are mechanically secured to the corbels (101, 101') of the pillars and are prevented from performing undesirable horizontal movements.

**10.** Apparatus according to one or more of the preceding claims, **characterized in that** the said end insert (B) of the beams is such that, once assembly of these said beams on the pillars has been performed, the tubes (15) of the said insert (B) are able to receive, inserted in them, threaded tie-rods (19) which with

one end are screwed into the bushes (7) of the insert (A) of the pillar and with the opposite - also threaded - end project conveniently from the said tubes (15) inside which a self-levelling and high-strength expanding cement mortar (20) is subsequently injected, said mortar filling completely these tubes and saturating also the said chamber (17) with the engaging teeth (8, 11), the said tubes (15) being then closed at the top with inserts (21) or with the holed end of reinforcing plates extending partly over the outer side of the beam (10) and then these inserts (21) are fixed to the top end of the said tie-rods (19) with nuts (22) and/or other suitable means, all of which being envisaged so that the said mortar manages to withstand extremely high loads which are substantially double those usual for this type of product, since it is completely confined within a box-shaped structure of the metal system for supporting the beam, allowing the apparatus to absorb lower horizontal forces which allow it to counteract effectively the reverse moments in the event of seismic events, providing a rigid and hyperstatic joint.

**11.** Apparatus according to one or more of the preceding claims, **characterized in that**, at the level of the outer side of the beam (10), which has a part of its metal reinforcement (110) projecting, the side pillars (1) have visible a transverse metal plate (23) with holes (24) which allow access to threaded and blind end seats (125) of robust L-shaped anchoring irons (25) embedded in the body of the pillar (1), these threaded seats (125) of such a metal insert (C) embedded in the side pillars (1) receiving, screwed therein, the ends of threaded bars (26) which extend over a suitable section along the outer side of the beam (10), so as to interact mechanically with the projecting reinforcement (110) of the latter.

**12.** Apparatus according to one or more of the preceding claims, **characterized in that**, instead of the said metal insert (C), oppositely arranged inserts (C') may be embedded in the middle pillars (1'), said inserts comprising internally threaded bushes (125') for being able to screw in there the threaded bars (26) which co-operate with the upper reinforcements (110) of the beams (10), these bushes (125') being able to be connected to the reinforcements of the pillar by means of special anchoring irons (25').

**13.** Apparatus according to Claim 12, **characterized in that**, by way of an alternative to the said inserts (C') of the middle pillars, the said pillars may have, embedded therein, inserts (C") formed by corrugated sheet-metal tubes which form in the said pillars through-holes inside which it is possible to secure, using expanding cement mortar and/or other suitable means, reinforcing bars (26) which project by equal amounts into the beams resting on the opposite corbels (101') of a same middle pillar (1').

**14.** Apparatus according to one or more of the preceding claims, **characterized in that** it comprises means for ensuring that, once fixing of the said bars (26) to the said inserts (C, C', C"') of the pillars has been completed, it is possible to arrange in position the honeycomb floor sills (S), resting them partly on the beams (10) and then provide a supplementary reinforcement (27) which co-operates both with that (110) of the beams and with that (28) of the floor sills (S) and perform finally a supplementary casting (29) which definitively secures the beams to the pillars and the floor sills to the beams, all of which so that, once the assembly operation has been finished, the connection between beams and pillars is without play and able to withstand in the best possible manner horizontal compressive and tractional stresses.

**15.** Apparatus according to one or more of the preceding claims, **characterized in that** it may be envisaged improving the operating performance of the metal insert (B) embedded in the beams by providing special means for mechanically connecting together said holes (15) and the anchoring plates (12).

**16.** Apparatus according to one or more of the preceding claims, **characterized in that** the plate (9) of the metal insert (B) of the beams may be replaced by an angle-piece so as to provide also a frontal protection in the said beams, particularly useful for preventing damage thereto during transportation and arrangement in position.

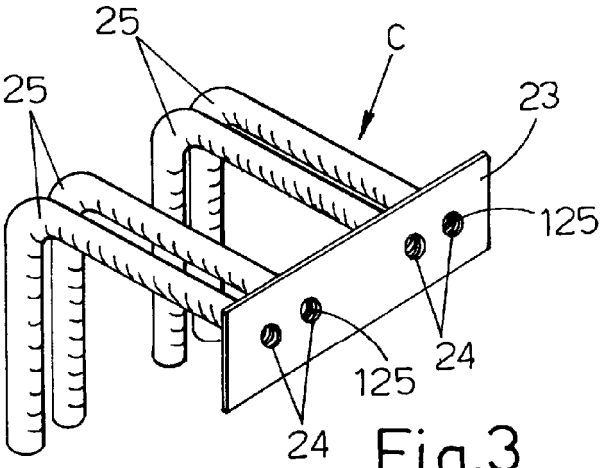
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Fig.3


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Fig.1

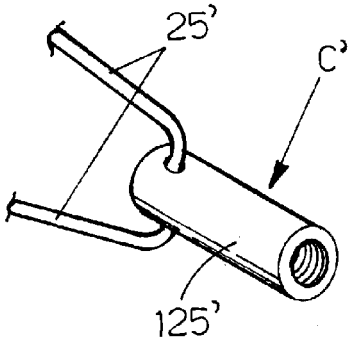
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Fig.4

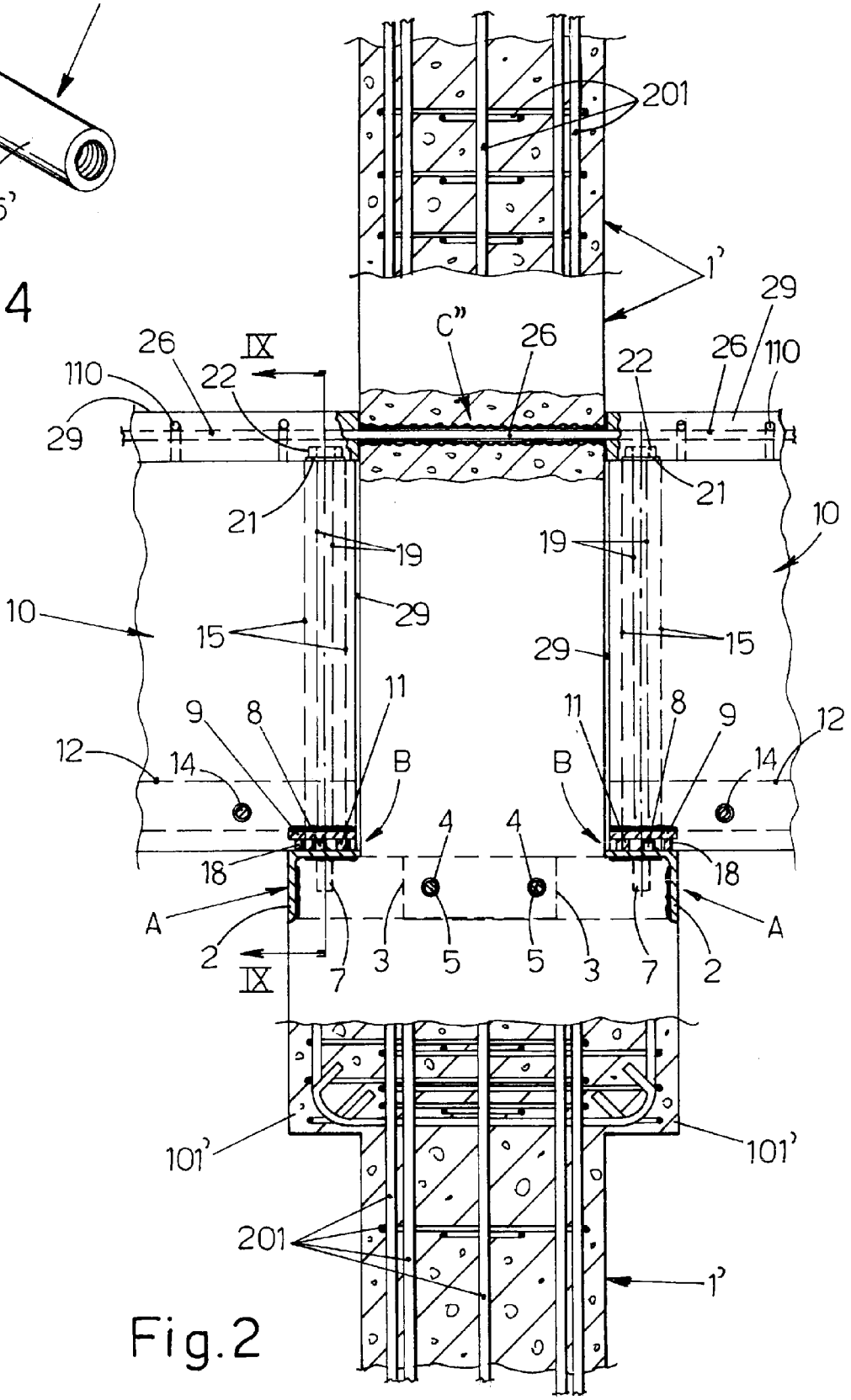
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Fig.2

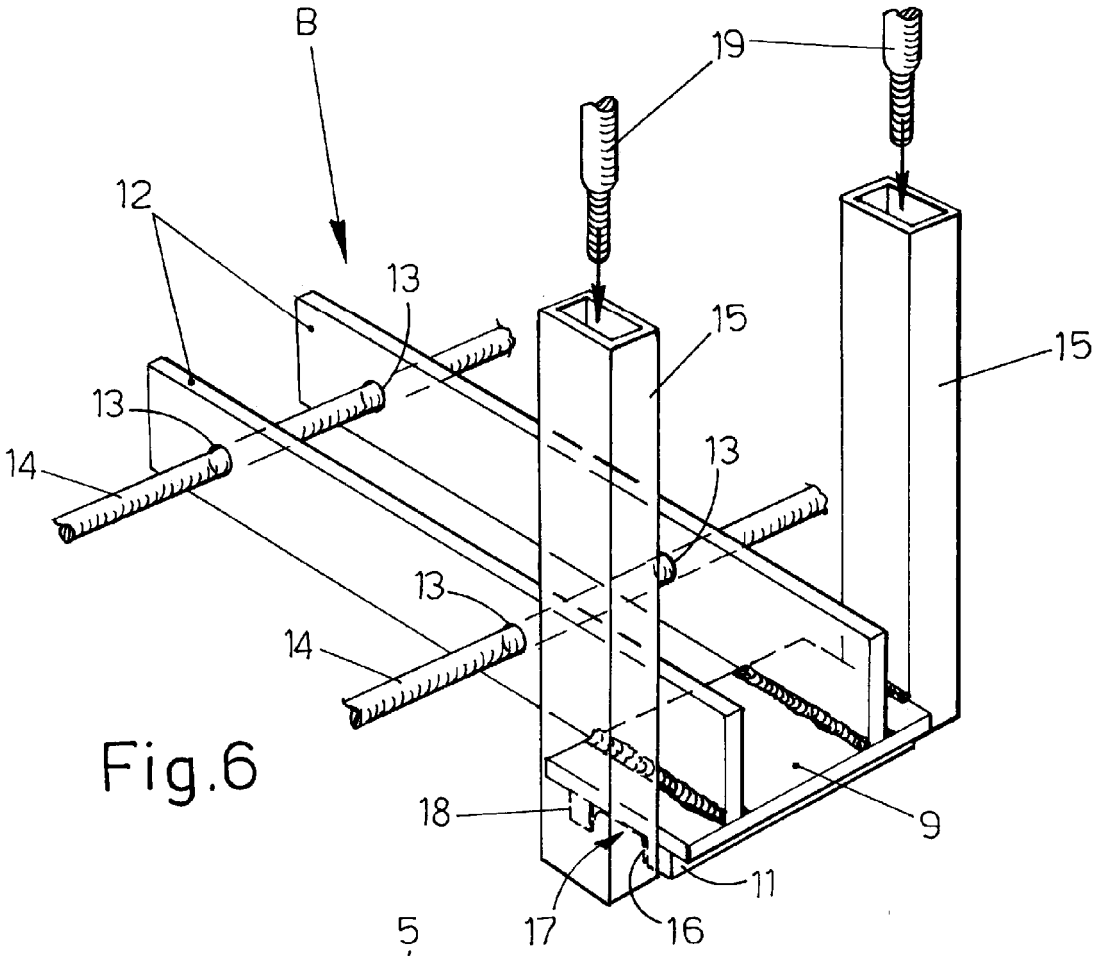


Fig.6

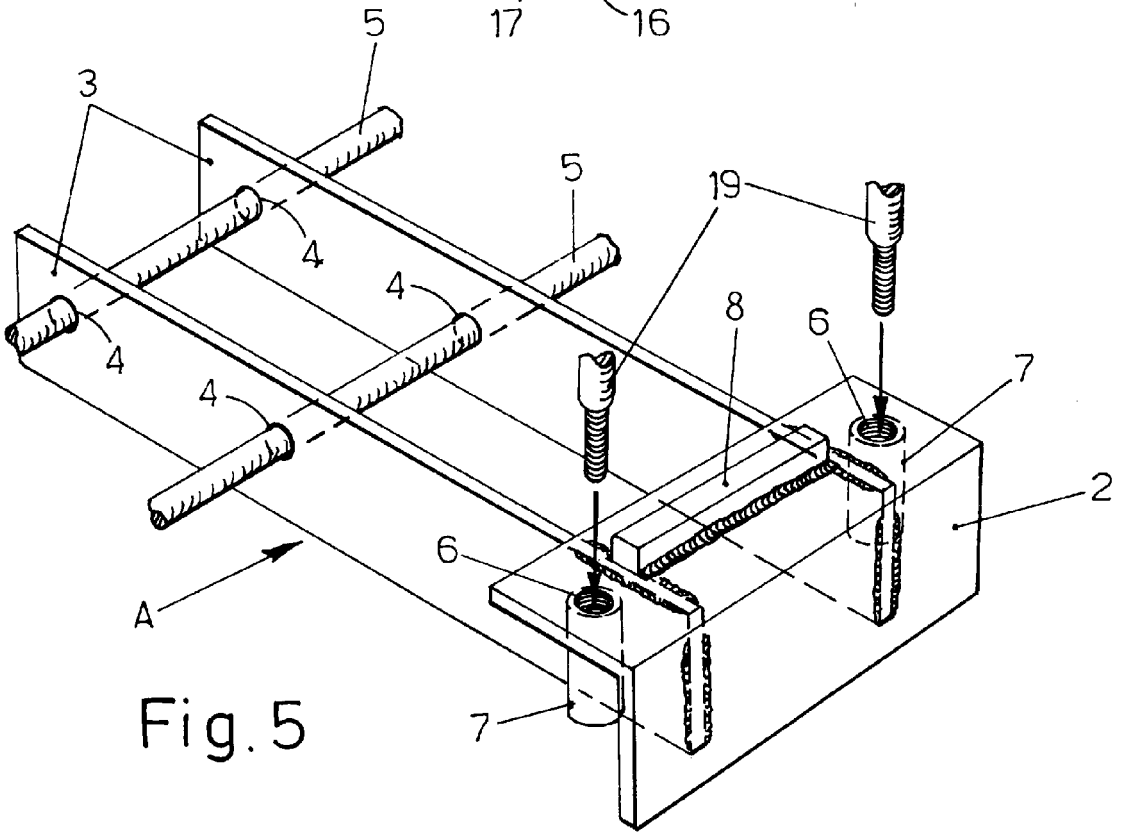


Fig.5

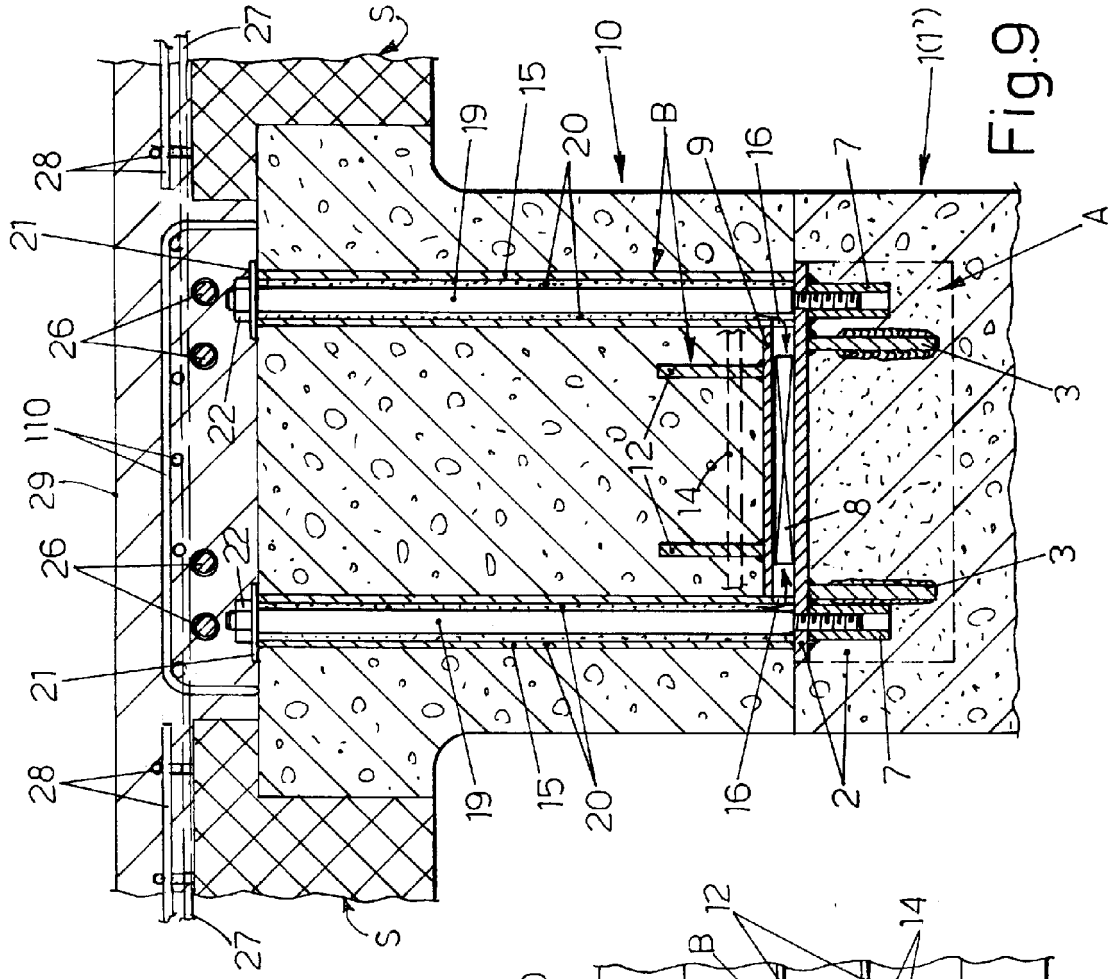


Fig.9

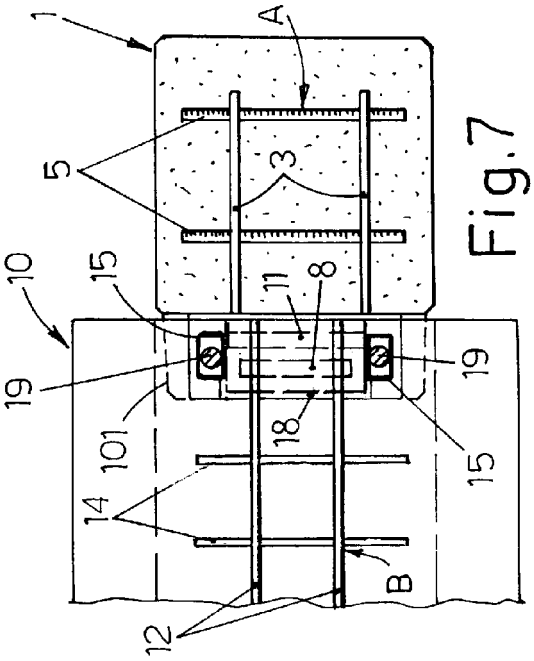


Fig.7

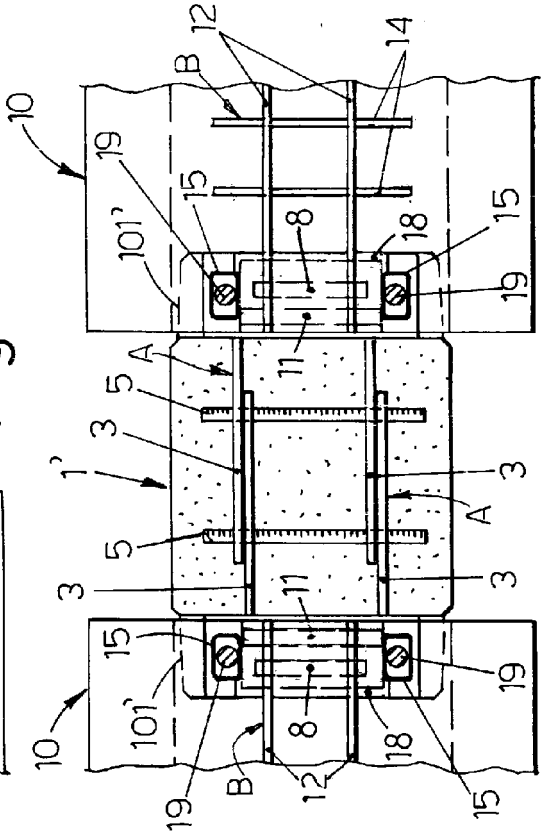


Fig.8

## REFERENCES CITED IN THE DESCRIPTION

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