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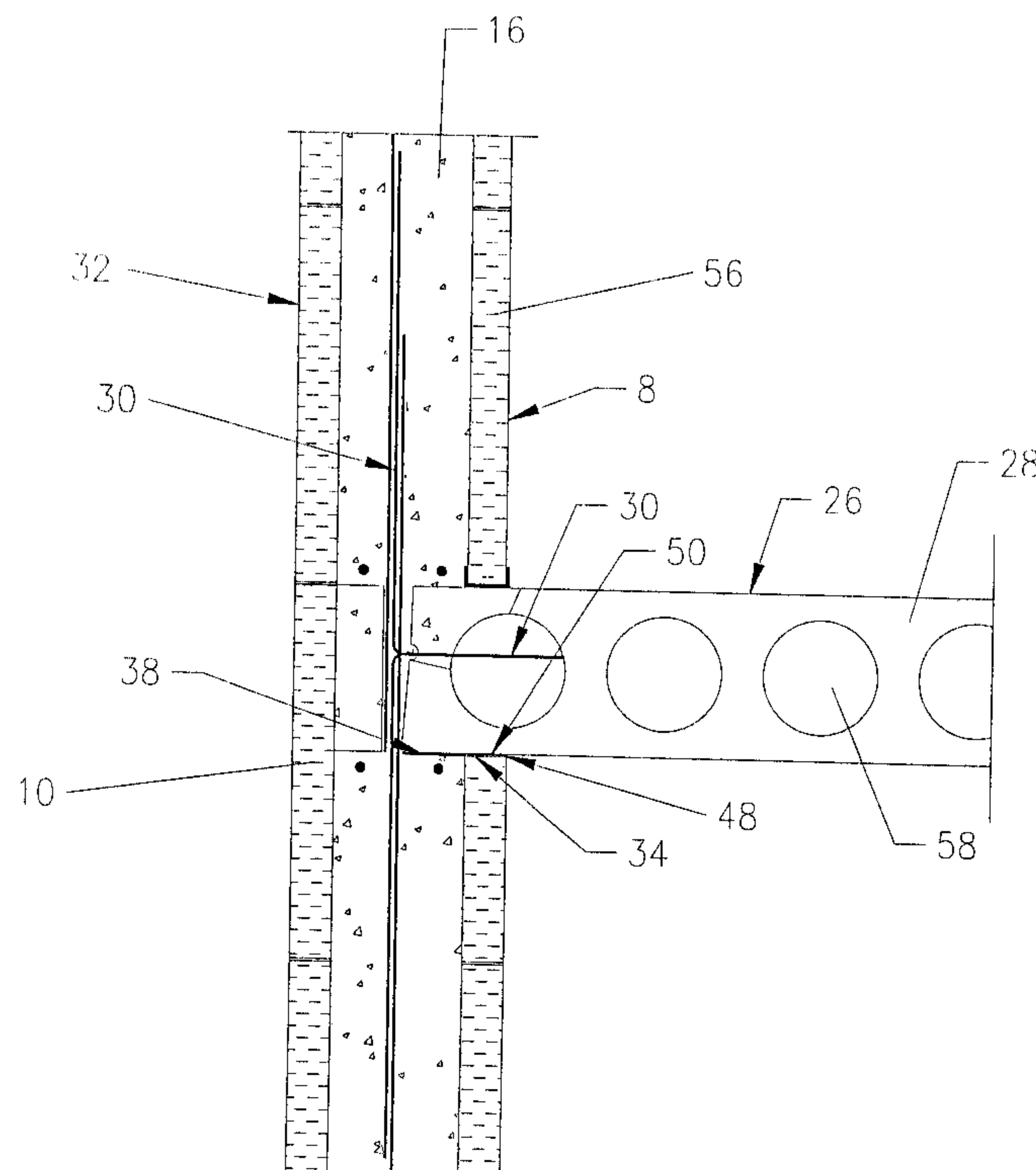
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(54) Title: MULTI-STOREY INSULATED CONCRETE FOAM BUILDING WITH FRAMED OPENINGS



(57) Abrégé/Abstract:

Multi-storey ICF building having concrete walls poured into insulated concrete forms with adjustments mounted between floors and an outside foam layer and guides for an inside for layer. ICF buildings can be constructed with greater than three stories and masonry or stucco exteriors without the use of supplementary forms.



ABSTRACT

Multi-storey ICF building having concrete walls poured into insulated concrete forms with adjustments mounted between floors and an outside foam layer and guides for an inside for layer. ICF buildings can be
5 constructed with greater than three stories and masonry or stucco exteriors without the use of supplementary forms.

**MULTI-STOREY INSULATED CONCRETE FOAM BUILDING WITH
FRAMED OPENINGS**

This invention relates to a multi-storey building and a method of construction thereof wherein the building is constructed using insulated
5 concrete forms. More particularly, this invention relates to buildings exceeding three stories.

Insulated concrete form (ICF) buildings have generally not been constructed with more than three stories because the building code requirements cannot be met in a cost effective manner. Also, great
10 difficulty has been encountered in keeping the ICF walls sufficiently straight. As can be appreciated, it is difficult to keep the ICF walls straight as the concrete is being poured because the foam walls of the forms are lightweight and are preferably not supported by external supports. With some ICF buildings, the foam walls are supported by supplementary
15 supports to keep the walls reasonably straight while the concrete is poured. The supplementary supports are located against the outer side surfaces of the inside and outside foam layers and are usually anchored to the ground. For example plywood supplementary supports are held against the outer side surfaces of the foam layers by wooden boards (e.g. 2' x 4''s) that are
20 anchored on the ground and extend at an angle. After the concrete has set, the supplementary supports, which are used on both the outside and inside foam walls, are removed. Also, the concrete is extremely heavy compared to the weight of the forms. For buildings of three stories or less, if the first wall for example, is not straight within a particular narrow tolerance, then
25 the wall for the second storey will be more out of line and the wall for the third storey will be even further out of line. As can be appreciated, if there are four stories or eight stories or more in the building, the mistakes made on the lower floors are compounded to a point where the walls on the upper stories would be noticeably out of line. Supplementary supports are
30 expensive and time consuming to install and remove. Also, supplementary supports are even more expensive and labour intensive on upper storeys of multi-storey buildings. For example, in some ICF buildings, the first

storey of foam forms are supported inside and outside by supplementary supports that are anchored in the ground and extend at an angle to the foam forms. It is not cost effective to have removable supplementary supports in high rise buildings. It is not feasible to use supplementary forms that
5 extend up from the ground in buildings exceeding three stories. It is extremely expensive, if not impossible, to correct an upper storey ICF wall on a high-rise building that is out of line. Repairs must be made to the outside surface of the misaligned wall from the outside of the building. Often an outer portion of the concrete wall must be removed in an attempt
10 to straighten the wall as much as possible.

ICF buildings can be constructed having a masonry exterior. However, since the forms themselves are very expensive compared to other concrete forms, it becomes extremely expensive to add a masonry or brick exterior to an ICF building. ICF buildings can be cost competitive
15 when the exterior surface of the building is a type of stucco. Many jurisdictions have fire regulations that become more stringent when buildings exceed three stories. In the Province of Ontario, Canada, for example, there is a building code requirement that provides that exterior cladding on a building must remain in place for the minimum time
20 required by the code from the commencement of the fire. The purpose of this regulation is to prevent the exterior cladding of the building from falling onto people who are attempting to escape from the building or from falling onto fire personnel. With ICF buildings completed with a stucco exterior, the exterior foam layer can fall off the building during a fire. If a
25 building will not meet the fire regulations in the jurisdiction where the building is to be constructed, no building permit will be issued. Further, insurers are not willing to insure any building that does satisfy all of the fire regulations.

Insulated concrete forms are known. The form walls are
30 separated by a pre-determined distance by ties that are embedded in the foam. Most forms are designed to construct vertical walls at a 90° angle relative to one another. Some forms are angled to construct walls at a 45°

angle to one another. Other forms are curved to allow curved walls to be constructed. Forms are specifically designed for use as corner forms. One ICF manufacturer is Nudura (a trademark). The Nudura forms have hinged ties so that the parallel foam walls can be collapsed together during
5 transport and separated during use. The Nudura forms have a standard size of 8 feet by 1.5 feet and are made from expanded polystyrene foam with hinged polypropylene ties. The polystyrene foam is stated to have a density of 1.26 lbs/ft³, a flame spread index of less than 75 and a maximum smoke development index of less than 450 when tested under
10 UL723. Nudura and other manufacturers produce numerous accessory forms. Insulated concrete forms can provide the formwork for foundation and basement load bearing walls and interior or exterior load bearing walls. Of course, ICF can be used on non-load bearing walls as well.

While it is common to construct ICF buildings up to three stories,
15 buildings beyond three stories have generally not been constructed using insulated concrete forms. Free standing ICF buildings beyond three stories have not been constructed previously. An advantage of having an ICF building is that the completed building has a monolithic poured concrete wall installed between the two foam layers of the insulated concrete forms.
20 Voids within the concrete are removed using agitators just after the concrete is poured. The foam layers provide the insulation for the building. Thus, the building is solidly constructed and it is well insulated making it less expensive to heat in the winter and less expensive to aircondition in the summer. The disadvantage is that the insulated
25 concrete forms themselves are expensive relative to other types of construction.

It is an object to the invention to provide a multi-storey ICF building and a method of construction thereof that can be suitably used for high-rises or building exceeding three stories or for any multi-storey
30 building. It is a further object of the present invention to provide an ICF building and a method of construction thereof where the building satisfies all of the fire regulations for buildings exceeding three stories. It is a

further object of the present invention to provide a multi-storey ICF building and a method of construction thereof where no removable supplementary supports are required on the outside of the sides of the foam layers for the insulated concrete forms to keep the walls straight while the concrete is poured, the supplementary supports being removed after the concrete sets. It is still a further object of the present invention to provide a multi-storey ICF building where the outside foam layer is periodically straightened and supported by supports that extend inward from the outside foam layer where there is no corresponding inside layer opposed to the outside layer and the supports are anchored directly or indirectly in the wall that has been previously formed. It is a further object of the present invention to provide a multi-storey ICF building and a method of construction thereof using guides at the beginning of each storey for the inside foam layer of the ICF forms, the guides for each storey being vertically aligned with one another.

A method of constructing a multi-storey building having at least one vertical wall made of insulated concrete forms uses forms each having two layers of foam spaced apart from one another by ties to define a core, said building to have multiple floors with ends that are embedded in said at least one vertical wall, said core to be filled with concrete except for openings through windows and doors, an uppermost row of forms of each storey having at least part of an outside foam layer with no corresponding inside foam layer to allow each floor to be partially embedded into said wall, said method comprising stacking said forms to form a vertical wall for one storey at a time with suitable openings for windows and doors, installing reinforcing rods, pouring concrete to fill said core substantially up to a top of said inside foam layer of said uppermost row of forms, installing supports that are affixed directly or indirectly to a portion of said concrete wall that has previously been poured to straighten and support said outside foam layer of said uppermost row of forms.

A method of constructing a building having multiple stores uses insulated concrete forms, said forms usually having two opposing layers of

foam space apart from one another by ties to define a core. Each of the forms has an inside foam layer and an outside foam layer, the forms being stackable to form a vertical wall with at least part of an uppermost row of forms of each storey having an unopposed outside foam layer. The

5 unopposed outside foam layer being at a higher level than an inside foam layer. The method comprises stacking said forms for an insulated concrete form storey with openings for any windows and doors, with at least part of said uppermost row of forms for each storey having an unopposed outside foam layer with said top being higher than a top of said inside foam layer

10 for each storey, installing reinforcing rods and filling said core with fresh concrete substantially up to said top of said inside foam layer of said uppermost row of forms, allowing said concrete to cure sufficiently to enable said floor to be installed, installing supports to straighten and support said unopposed outside foam layer, said supports extending inward

15 from said unopposed outside foam layer and being anchored directly or indirectly in said wall as previously formed, installing said floor and repeating said method for each subsequent storey, at least partially embedding said supports in said concrete and locating said supports to leave said supports in place when said vertical wall has been completed.

20 A method of constructing a building having multiple stories uses a plurality of insulated concrete forms. Each of the forms has two layers of foam spaced apart from one another by a pre-determined distance to define a core. The two layers are an inside layer and an outside layer. The building has a base and the forms are stackable to form a wall. The

25 method comprises constructing the building in stages on the base, arranging the forms on the base and stacking the forms to form a vertical wall for a first insulated concrete foam storey with openings for any windows and doors, cutting away the inside layer of each form that is located just beneath a floor for a second storey, thereby creating cut forms.

30 The method further includes installing reinforcing rods and filling the core with fresh concrete, removing voids and allowing the fresh concrete to cure, installing a floor for the second storey just above a cut line of the cut

forms in such a manner that the floor can be partially embedded into the vertical wall, installing a plurality of adjustments between the floor for the second storey and the outside foam layer of the cut forms to allow the outside foam layer to be straightened, adjusting the adjustments to
 5 straighten and support the outside foam layer, stacking forms on the cut forms and the floor directly above the forms for the first storey with suitable openings for any doors and windows and installing reinforcing rods, and repeating the method described for the first insulated concrete form storey for subsequent stories and installing a roof on an uppermost
 10 storey.

A method of constructing a building having multiple stories using insulated concrete forms having two parallel foam layers separated by ties that are embedded in the foam layers to define a core for receiving poured concrete, the forms being stackable to form a wall or walls, a method
 15 comprising:

- (a) constructing a base for the walls;
- (b) stacking forms on the base to form the walls one storey at a time with suitable openings for doors and windows;
- (c) removing part of an inside foam layer of an upper level of
 20 forms for each storey to allow a floor to be embedded into the wall, thereby creating a row of cut forms at a cut level for each floor;
- (d) installing frames for the windows and doors as the forms are stacked;
- (e) installing reinforcing rods in the walls;
- (f) filling the core with fresh concrete up to the cut level just
 25 below a lower surface of a floor to be installed and removing voids in said concrete;
- (g) allowing the concrete to cure sufficiently to allow the floor
 30 to be installed and installing the floor;
- (h) installing a plurality of adjustments along the cut forms between the floor and the outside foam layer of the cut

forms to allow the outside form layer to be supported and straightened, adjusting the adjustments to straighten and support the outside form layer;

- 5 (i) stacking forms on the cut forms and on the floor directly above the forms located in the storey beneath the storey that is being constructed to form a subsequent storey with suitable openings for doors and windows while installing frames for any doors and windows;
- 10 (j) repeating steps (c) to (i) for each subsequent storey except for an upper most storey;
- (k) constructing said upper most storey and installing a roof on said upper most storey.

A method of constructing a building using a plurality of insulated concrete forms, each of the forms having two layers of foam spaced apart from one another by a pre-determined distance to define a core, said two
 15 layers having an inside layer and an outside layer, the buildings having a base, the forms being stackable to form a vertical wall with openings for windows and doors therein, the method comprising constructing the building in stages on the base, arranging the forms on the base and
 20 stacking the forms to form a vertical wall with openings for any windows and doors, installing a frame for each window and door, installing retention means on an exterior surface on each frame in such a manner that the retention means is embedded in concrete when concrete is poured, installing mesh on an exterior surface of each frame in such a manner that
 25 the mesh is embedded in concrete when the concrete is poured, the mesh being wide enough to extend along an exterior of the frame along the outside foam layer and partially along the front of the outside foam layer, installing each frame containing retention means and the mesh before the forms are stacked around each frame, pouring the concrete to fill the core
 30 and finishing an exterior surface of the building by embedding an exterior section of mesh in a stucco mixture on the exterior surface.

Preferably, the method includes the steps of constructing the building until the building is greater than three storeys.

A multi-storey building has exterior vertical walls formed using a plurality of insulated concrete forms, the forms each having two layers of foam spaced apart from one another by a pre-determined distance to form a core. The vertical walls include doors and windows. The building comprises a guide for an inside foam layer of said forms located on a floor for each storey. The building has floors embedded in the vertical walls, the forms having part of the inside foam layer that is cut away at a cut level for each floor that is embedded in the vertical wall to create cut forms, with adjustments extending between each floor and an outside foam layer of the cut forms. The core is filled with concrete and the adjustments extend through the concrete at each floor that is embedded in the vertical wall.

Preferably, the guide is a track.

A multi-storey building has vertical walls formed using a plurality of insulated concrete forms. The forms each have two layers of foam spaced apart from one another by a pre-determined distance to form a core for receiving fresh concrete. The vertical walls include doors and windows and the building has a guide for an inside foam layer of the two layers of the two layers of the forms located at an upper surface of a floor of each storey.

A multi-storey building has vertical walls formed using a plurality of insulated concrete forms, the forms each having two layers of foam spaced apart from one another by a pre-determined distance to form a core. The vertical walls include doors and windows. The building comprises floors embedded in the vertical walls. Each form has an inside foam layer and an outside foam layer comprising the two layers of foam. The forms have part of the inside foam layer cut away at a cut level to form cut forms for each floor that is embedded in the vertical wall with adjustments extending between the floor and the outside layers of the cut forms. The core is filled

with concrete and the adjustments extend through the concrete in each floor that is embedded in the vertical wall.

Preferably, the building is greater than three storeys.

A multi-storey building has vertical walls formed using a plurality
 5 of insulated concrete forms, the forms each having two layers of foam as spaced apart from one another by ties to form a core. The vertical walls include openings for doors and windows. The building comprises a guide for an inside foam layer of the forms located on a floor for each storey, the building having floors embedded in the vertical walls. The forms have a
 10 channel located at an uppermost level of each storey that is embedded in the wall at each channel, the core containing reinforcing rods. The core is filled with concrete with supports extending directly or indirectly between the concrete and the outside foam layer at each channel. The supports are at least partially embedded in the vertical wall.

15 A multi-storey building has vertical walls formed using a plurality of insulated concrete forms. The forms each have two layers of foam spaced apart from one another by a predetermined distance to form a core therebetween. The vertical walls include openings for doors and windows with frames thereon. The frames for the windows are constructed of foam
 20 pieces that are inserted between the two layers of foam and held in place by adhesive.

A multi-storey building has vertical walls formed using a plurality of insulated concrete forms. The forms each have two layers of foam spaced apart from one another by a predetermined distance to form a core
 25 therebetween. The vertical walls include openings for doors and windows having frames thereon. The building comprises retention means located in an exterior surface of each frame in such a manner that the retention means is embedded in concrete when the concrete is poured. A mesh is located on an outer surface of each frame in such a manner that the mesh is
 30 embedded in concrete when the concrete is poured. The mesh is wide enough to extend along an outside of the frame around the outside foam layer and partially along a front of the exterior foam layer. The concrete

fills the core, the mesh having an interior section that is embedded in the concrete and an exterior section that is embedded in a stucco mixture.

A method of constructing a multi-storey building has at least one vertical wall made of insulated concrete forms, said forms each having two
 5 layers of foam spaced apart from one another by ties to define a core. The two layers of foam are an inside foam layer and an outside foam layer. The building is to have multiple floors with ends that are embedded in the at least one vertical wall. The core is to be filled with concrete except for openings for windows and doors. The method comprises installing an
 10 alignment guide for the inside foam layer on an upper surface of each floor for each storey. There are a plurality of alignment guides, said guides being vertically aligned with one another for each wall of the at least one vertical wall.

A method of constructing a multi-storey building uses at least one
 15 vertical wall made of insulated concrete forms. The forms each have two layers of foam spaced apart from one another by ties to define a core, said two layers of foam being an inside foam layer and an outside foam layer. The building is to have a stucco exterior with the core to be filled with concrete except for openings for windows and doors. There are frames
 20 around an outside of the windows and doors with retention means extending beyond an outer surface of each frame. The method comprises installing the retention means to extend from the core to an outside of the frame around the outside foam layer and partially along a front of the outside foam layer, embedding an inner portion of the retention means in
 25 concrete poured into the core, and embedding an outer portion of the retention means in a stucco mixture when installing stucco on the building.

Preferably, the building exceeds three storeys.

In the drawings:

Figure 1 is a schematic end view of a vertical wall using ICF
 30 construction;

Figure 2 is a schematic end view of a floor embedded in a sidewall of an ICF building;

Figure 3 is a partial perspective view of supports extending between a floor and an exterior foam layer of an uppermost row of forms of a storey;

Figure 4 is a schematic end view of a floor embedded in an end wall of an ICF building;

Figure 5 is a partial perspective view of a window frame partially installed in an ICF wall;

Figure 6 is a partial perspective view of mesh installed around a frame for an opening in an ICF wall;

Figure 7 is a partial perspective view of mesh installed around a frame of an opening where an exterior foam surface has been coated with stucco;

Figure 8 is a partial perspective view of an ICF wall having a masonry exterior;

Figure 9 is a partial perspective view of mesh installed around a foam frame of an opening;

Figure 10 is a partial perspective view of a window opening having a frame made of foam; and

Figure 11 is a partial perspective view of a support system for an exterior foam layer adjacent to a floor.

The present invention can be used with insulated concrete forms of various manufacturers and is not in any way restricted to Nudura forms. The forms must have sufficiently strong ties to hold the two foam layers together and a high enough density and chemical formula to meet the fire requirements. Various types of insulated concrete forms can be used on the same building. For example, the forms can be straight forms where the two foam layers are flat and are rectangles of substantially the same size. The forms can be curved forms for forming a curved wall. When curved forms are used, the inner foam layer will be smaller than the outer foam layer simply because the inside of a curve is a shorter distance than an outside of a curve. Corner forms can be used where the outside foam layer has a 90° angle and the inside foam layer has a corresponding 90° angle.

The inside foam layer will be smaller than the outside foam layer to compensate for the difference in distance around the outside of a corner compared to the inside of a corner of a corner form. Angled forms can also be used. Angled forms, for example, will be similar to corner forms except that the angle between the two planes of the form would not be 90°. The angled forms could be 45° in order to construct a wall that is at an angle of 45° to another wall. Special forms can also be used. Special forms can have, for example, unique shapes for specific purposes. Also, the forms can be supplied as components of forms that are assembled on site. The forms can also be non-symmetrical forms where the inside foam layer does not correspond to the outside foam layer. For example, the inside foam layer can have a shorter height than the outside foam layer of the same form. Forms of any of the types described can be cut on site to fit the particular location where the form is to be installed.

In Figure 1, there is shown an end view of an ICF exterior wall 2 that forms part of a building. The ICF wall 2 is constructed on a foundation 4, which in turn is constructed on a footing 6. The ICF wall 2 has an inside foam layer 8 and an outside foam layer 10. Each insulated concrete form has two parallel foam layers separated by a pre-determined distance that defines a core 14 between the two layers. The core 14 is filled with poured concrete 16. It can be seen that a lower edge of the outside foam layer 10 is supported by a wood support 18 that is attached to the outside of the foundation 4. The wood support 18 can be left in place after the concrete cures, but is preferably removed. The wood support 18 is not used where the ICF wall is constructed directly on the footing 6. The wood support is not essential, but is preferred to provide the maximum interior space for a particular foundation wall and to have the outside foam layer extend outward beyond the foundation wall so that water on the outside foam layer will be outside the foundation wall. If the ICF forms are moved slightly inward from the position shown in Figure 1, the wood support 18 can be eliminated. Inside the building, there is a finished floor 20 constructed on a stone base 22. In this particular

building, there is no basement and the floor 20 is constructed directly on the stone base 22, which is, in turn, constructed on grade. The inside foam insulated layer 8 is constructed on a guide 24, which is located on the floor 20. The insulated concrete form wall can be installed directly on the
5 footing or a building can be constructed having a full or partial basement where the ICF wall is formed on top of a foundation wall. Further, in some buildings, it might be desirable to have all or part of one or more walls constructed in a conventional manner without the use of ICF construction while another wall or walls are constructed using ICF
10 construction.

In Figure 2, there is shown a schematic side view of a side wall 25 of a building having a floor 26 partially embedded in the wall 25. Preferably, the floor 26 is a precast concrete slab 28 having a series of channels (not shown in Figure 2) extending therein to allow for wiring and
15 other connections to be made. It can be seen that reinforcing rods 30 are located in the core 14 of the wall 25 and also extend into the grout joint between two adjacent slabs 28 (only one of which is shown). Each form has the inside foam layer 8 and the outside foam layer 10. The forms 32 are stacked on top of one another and at the location of the floor 26 the
20 inside foam layer is partially cut away at cut line 34 to allow the floor 26 to be embedded into the vertical wall. The partially cut away portion makes this row of forms (only one of which is shown) a row of cut forms 36.

Preferably, in constructing a building, the insulated concrete forms
25 are stacked and arranged on the base of the building in such a manner that the building can be constructed one storey at a time. The forms are placed on the base and stacked up to the level where the floor of the second storey is to be installed. The forms along the top of the first storey are then partially cut away to create the cut forms 36 as shown in Figure 2. Freshly
30 poured concrete is then installed up to the level of the cut line 34. Agitators (not shown) are used to remove voids from the fresh concrete. The agitators are conventional and are not further described. The concrete

is then allowed to cure sufficiently to support the weight of the floor slab 28. A bearing pad 38, preferably made from masonite, is inserted on top of the concrete as shown in the enlarged portion of Figure 2. The floor 26 is then installed as shown to rest on the bearing pad 38. The slab 28 has a
 5 rigid insulation disk 40 aligned with each channel (not shown) of the floor slab. The insulation disk insulates the air within the channel in the interior of the building from the outside wall.

As shown in Figure 3, a support in the form of an adjustment 42 is installed between an upper surface 44 of the floor 26 and the outside foam
 10 layer 10 of the cut forms 36. The adjustment is preferably a wire tie or a plastic zip tie, but various types of ties will be suitable. There are a plurality of adjustments 42 that are adjusted longitudinally to straighten and support the outside foam layer 10 of the cut forms 36. A guide 46 is installed on top of the floor 26. The guide 46 is located directly above the
 15 guide 24 (see Figure 1) for the inside foam layer 8 for the storey located immediately beneath the floor 26. Preferably, the guide is a track that is sized and shaped to receive the inside foam layers. Preferably, there is a guide for each vertical wall on the floor for each storey, the guides being vertically aligned with one another for each vertical wall.

20 Insulated concrete forms 32 (not shown in Figure 3) are then placed and stacked above the floor 26 up to the next storey and reinforcing rods are installed within the core 14. The method just described for the first storey and second storey floor 26 is then repeated for each of the subsequent stories and floors until the vertical walls for all of the stories
 25 have been completed and a roof is installed on the uppermost storey. Foam 48 is inserted into a gap 50 between a lower surface 52 of the floor 26 and the cut line 34 (see Figure 2). The gap 50 is created by the bearing pad 38.

Instead of cutting the forms on site or installing the forms on site
 30 and then cutting them, non-symmetrical forms can be manufactured for use as the uppermost foam layer of each storey where the inside foam layer is shorter than the outside foam layer by a distance that is

substantially equal to the thickness of a floor to be installed at the top of that storey. These non-symmetrical forms can be manufactured in that manner or can be supplied as components to be assembled at the site. When the forms are cut on site, the inside foam layer is cut away and much of that foam layer is wasted. That waste can be eliminated by manufacturing the forms with the lower height inside foam layer, but non-symmetrical forms are also more expensive than straight forms because they are not produced in the same quantity.

In Figure 4, there is shown a vertical end wall 56. It can be seen that the floor 26 is formed of the precast concrete slab 28 with longitudinal channels 58 extending therein. Reinforcing rods 30 extend from the core 14 into one or more of the channels 58. The method of installing the floor 26 into the vertical end wall 56 is essentially the same as the method of installing the floor 26 into the sidewall 25. The same reference numerals are used in Figure 3 to describe those components that are identical to the components of Figure 2. The adjustments 42 shown in Figure 3 are also installed between the upper surface 44 of the floor 26 and the outside foam layer 10 of the cut forms 36.

From Figures 1, 2, 3 and 4, it can be seen that there are no supplementary supports on the ICF wall. The ICF wall is free standing and the forms are supported only by the wooden support 18, the guides 24, 46 and the supports provided by the adjustments 42. All of these supports are provided by that part of the wall or building already constructed and are not supplementary supports.

In Figure 5, there is shown a window frame 60 that is partially installed in an ICF exterior wall 25. The same type of frame (with a different size and usually a floor at a base) would be used for a door. A groove 62 extends longitudinally along an outer surface 64 of the frame 60. The purpose of groove 62 is to receive the freshly poured concrete within the core relative to the frame and thereby better secure the frame in the concrete wall. Figure 5 is a partial perspective view from an interior of the building. The same reference numerals are used in Figure 5 as those

used in the previous figures to describe those components that are identical. A peel and stick membrane 70 prevents moisture from getting inside the frame and is affixed to the inside foam layer 8 around the window (or other openings). A bottom 72 of the frame 60 has an interior
 5 portion 74 and exterior portion 76 with a gap (not shown) between the portions filled with foam 78.

In Figure 6, there is shown more detail of the bottom 72 of the frame 60. A gap 80 between the interior portion 74 and exterior portion 76 in the frame 60 allows for inspection of the space beneath the frame to
 10 ensure that the concrete placement is complete. The gap 80 is subsequently filled with foam (not shown). The same reference numerals are used in Figure 6 as those used in the previous figures to describe those components that are identical. Mesh 82 is preferably made from plastic fibre and is sufficiently wide so that at least 2 ½ inches of the mesh can be
 15 embedded into the concrete that will ultimately be poured into the core 14. Mesh 82 is affixed to the outer surface 64 of the frame 60 and is wide enough to extend along a front 84 of the frame and an end 86 of the outside foam layer 10 partially around an outer surface 88 of the outside foam layer 10. When the exterior surface is completed with stucco (not
 20 shown in Figure 6), a layer of mesh (not shown) is installed along the entire outer surface 88 of the outside foam layer 10. The stucco has a fire-rated base coat.

Figure 7 shows a similar view to Figure 6 except that additional finishing components are added to Figure 7. The same reference numerals
 25 are used in Figure 7 as those used in Figure 6 and previous figures for those components that are identical. In Figure 7, the concrete 16 has been poured into the core 14 and the groove 62 of the frame 60 is filled with concrete. Also, the minimum 2½ inch width of mesh on the outer surface 64 of the frame 60 is embedded in the concrete 16. The gap 80 (shown in
 30 Figure 6) has been filled with foam 78 and the poured concrete fills the space beneath the frame 60. The mesh 82 is coated and embedded in an exterior base coat 89 as is the mesh on the outer surface 88 of the outside

foam layer 10. After the base coat, stucco is added in the conventional manner.

In Figure 8, there is shown a perspective view of an ICF wall with a masonry exterior 90. The same reference numerals are used as those used for Figures 6 and 7 for those components that are identical. The masonry exterior 90 is conventional and held in place by anchors 92 preferably connected to the ties (not shown in Figure 8) of the insulated concrete forms. The mesh shown in Figures 6 and 7 is not required with masonry exteriors. Some ICF buildings can be part masonry exterior and part non-masonry exterior. When a masonry exterior is used, a shelf or base (not shown) must be properly located to support the masonry wall.

In Figure 9, there is shown a partial perspective view of an ICF wall with a window frame 94 (only partially shown) that is similar to the frame 60 shown in Figures 6 and 7, except that the frame 94 has a elongated members 96, 98 that are made from foam pieces rather than wood. The same reference numerals are used in Figure 9 as those used in Figures 6 and 7 for those components that are identical. The foam pieces 96, 98 can be taken from foam that have been cut away from ICF forms in the building and would otherwise be wasted.

Figure 10 is a partial perspective view of the frame 94 made up of two vertical foam pieces 96 and two horizontal foam pieces 98. Steel bucks 100 have a U-shaped cross section and are sized to fit around the two vertical foam pieces 96. A buck 102 is also U-shaped but is smaller than the bucks 100 as the buck 102 fits around the foam piece 98 at the top of the frame 94. The same reference numerals are used in Figure 10 as those used in Figure 5 for those components that are identical. The bucks 100, 102 are long enough to extend along the full length of the frame but are shown as being cut-off so as not to fully obscure the frame 94. A triangular brace 104 has U-shaped brackets 106 at the two sides and a U-shaped bracket 108 at the top, the brackets being sized to fit onto the bucks 100, 102 respectively. The triangular brace 104 can be adjustable in size or it can have a fixed size for use with a window frame of a particular size.

A horizontal linear brace 110 has pads 112 at either end (only one of which is shown). The linear brace 112 can also be either adjustable or it can have a fixed size. The pads 112 rest against the bucks 100 on either side of the frame 94. The braces 104, 110 and the bucks 100, 102 are left
 5 in place until the concrete has been poured and has cured sufficiently so that it will not damage the frame 94 when the braces 104, 110 are removed. The braces 104, 110 have handles 114, 116 respectively thereon. The lower foam piece 98 is cut off to expose the poured concrete. The foam pieces 96, 98 are held in the ICF forms on the wall 25 by
 10 adhesive (not shown). The ICF forms are not individually identified and there are no ICF forms shown around the upper portion of the frame for ease of illustration. Since the foam pieces 96, 98 are held between the inner foam layer 8 and the outer foam layer 10 by adhesive, the peel and stick membrane 70 (used for the wood frame shown in Figure 5) is not
 15 necessary when the foam frame 94 is used as the joints are already moisture resistant. The mesh 82 is embedded in the concrete 16 and extends past the foam pieces 96, 98 around the outer surface of the exterior foam layer 10 of the wall 25.

In Figure 11, the same reference numerals are used as those used in
 20 Figure 3 for those components that are identical. The cut forms 36 are the uppermost row of forms 118. Vertical reinforcing rods 30 (only one of which is shown in Figure 11) extend from the core 14 above the uppermost row of forms 118. Ties 120 extend from the outer foam layer 10 toward the inner foam layer 8, but there is no inner foam layer corresponding to
 25 the outer foam layer 10 above the cut line 34. Rather than cutting the uppermost row of forms 118, non-symmetrical forms can be used for the uppermost row of forms of each storey where the inner foam layer is shorter than the outer foam layer by a distance approximately equal to the thickness of the floor 44. Horizontal reinforcing rods 121 are snapped into
 30 place within the ties 20 just inside the exterior foam layer 10 of the uppermost row of forms 118. At each vertical reinforcing rod 30, the horizontal reinforcing rod 121 is attached by a tie 122 to support and

straighten the outside foam layer 10 of the uppermost row of forms 118. The ties 122 are adjusted to straighten and support the outside foam layer 10 by lengthening or shortening each tie as required to achieve the desired result. In this way, the horizontal reinforcing rods 121 are supported
5 directly by that part of the wall 25 that has already been poured. There are various ways to straighten and support the outside foam layer of the uppermost row of forms 118, all of which directly or indirectly use the previously poured portion of the wall 25. In Figure 3, adjustments 42 extend between the outside foam layer 10 and the floor 44. The floor 44 is
10 in turn supported by the concrete wall that has previously been poured. In addition, supports can be installed between the outside foam layer or the ties to the outside foam layer and the concrete in that part of the wall that has been previously poured.

While the present invention can be used to improve any
15 construction of all ICF buildings, it is preferably used for buildings exceeding three stories in height. ICF buildings constructed in accordance with the present invention will be constructed with a much narrower tolerance for straightness and squareness than previous ICF buildings. In addition, substantial cost savings can be achieved over the construction
20 costs of conventional buildings. With buildings constructed in accordance with the present invention, there is no need to be on the outside of the building during the construction of the outside walls except for the masonry or stucco exterior. ICF buildings constructed in accordance with the present invention are fast and easy to construct relative to conventional
25 buildings and relative to previous ICF buildings. Conventional high-rise buildings require a crane to be available on the building site almost from the start of construction until construction has been almost completely finished. With the method of construction of the present invention, it may be desirable to have a crane on site sometimes during construction, but a
30 tower crane is generally not required and construction cost savings of 20 percent or higher can be achieved. Site size restrictions may make it necessary to use a tower crane for some ICF buildings. Also, no

removable supplementary supports are required to support the two foam layers while the concrete is being formed resulting in a further saving.

While ICF forms are usually used for exterior walls, circumstances could arise where the forms are used for an interior wall or walls. One
5 foam layer of each form is considered to be an inside layer and the other foam layer of each form is considered to be an outside layer when an interior wall is being constructed with ICF forms. Interior walls are within the scope of the claims.

The uppermost row of forms of each storey has an inside foam
10 layer that is shorter than an outside foam layer for at least part of said row. Since there is no corresponding inside foam layer the outside foam layer must be straightened and supported. Otherwise, the outside foam layer will not remain straight and/or will move outward as the fresh concrete is poured. The outside foam layer is said to be an unopposed outside foam
15 layer as there is no corresponding inside foam layer directly opposite the outside foam layer. The outside foam layer is straightened and supported by supports that are directly or indirectly anchored in that part of the concrete wall that has previously been poured. The supports extend inward from the outside foam layer and are embedded in the concrete wall
20 when it is poured beyond a level of the outside foam layer. The supports can be anchored in a floor or they can be anchored to reinforcing rods in the concrete wall or they can be anchored directly into the concrete wall. The supports can each comprise more than one component. In many buildings, the uppermost row of forms of each storey will have an
25 unopposed outside foam layer. However, where balconies or other external structures are added to the outside portion of the vertical wall at the uppermost row of forms for each storey, the portion of the uppermost row of forms where an external structure is added will not have an unopposed foam layer as both the inside foam layer and outside foam layer
30 will be substantially at the same height in order to accommodate the external structure. In that portion of the vertical wall where there is no external structure, there will be an unopposed outside foam layer in the

uppermost row of forms for each storey. The supports will be installed for the unopposed outside foam layer before the concrete is poured against that outside foam layer.

5 Preferably, the mesh is embedded in concrete when the concrete is poured and extends along an exterior of the outside foam layer along the bottom of a bottom row of forms of each building and along a top of the top row of forms of each building and along any border or edge of the insulated concrete form wall. The guides are preferably vertically aligned with one another using lasers as each storey is constructed.

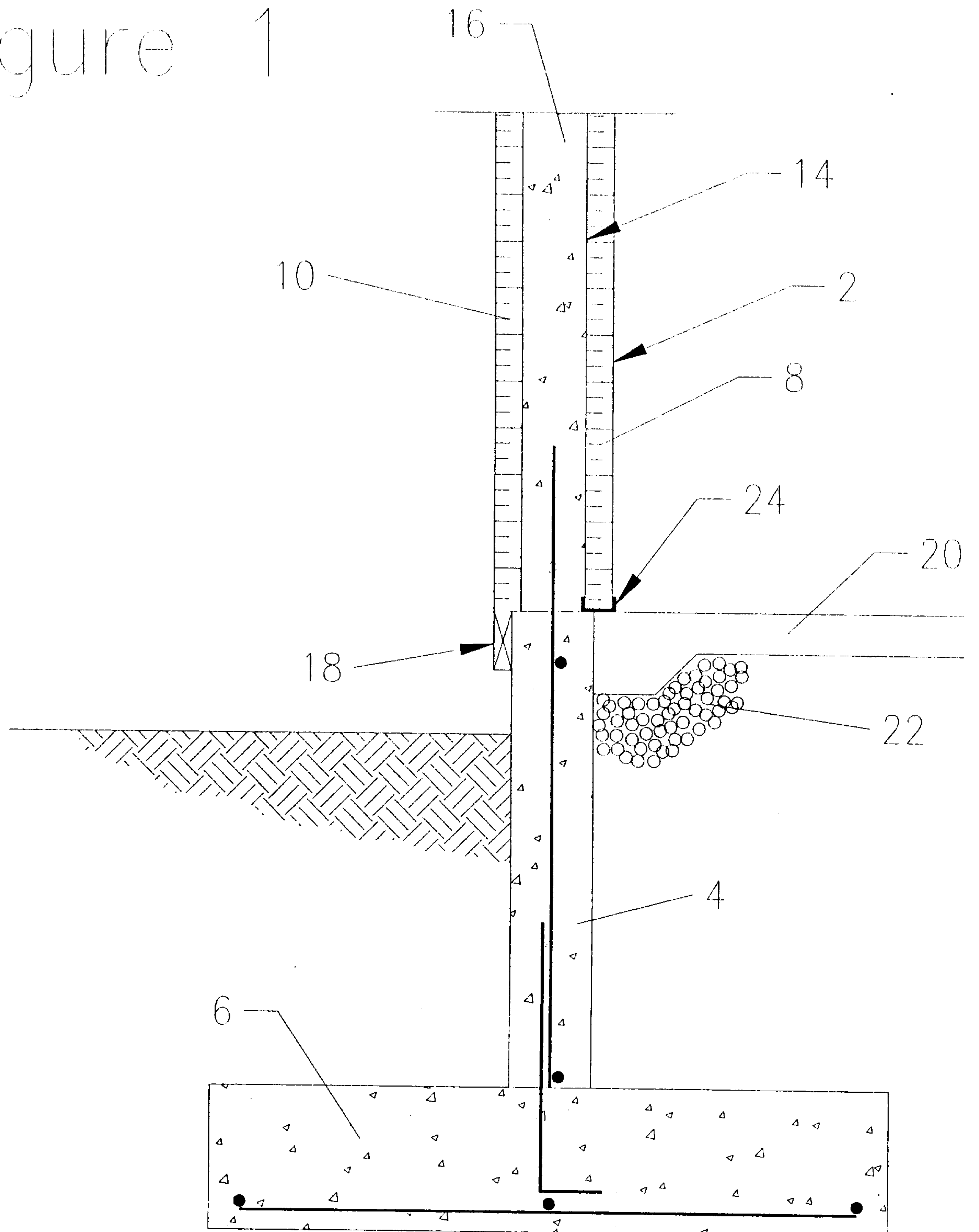
The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

We Claim

1. A method of constructing a multi-storey building having at least one vertical wall made of insulated concrete forms, said forms each having two layers of foam spaced apart from one another by ties to define a core, said two layers of foam being an inside foam layer and an outside foam layer, said building to have multiple floors and a stucco exterior with openings in said vertical wall for windows and doors and frames around an outside of said windows and doors with retention means extending beyond an outer surface of each frame, said method comprising installing said retention means to extend from said core to an outside of said frame around said outside foam layer and partially along a front of said outside foam layer, embedding an inner portion of said retention means in concrete poured into said core, embedding an outer portion of said retention means in a stucco mixture when installing stucco on said building.
2. A method of constructing a multi-storey building as claimed in Claim 1 wherein said retention means is a mesh.
3. A multi-storey building having vertical walls formed using a plurality of insulated concrete forms, said forms each having two layers of foam spaced apart from one another by a pre-determined distance to form a core therebetween, said vertical walls including openings for doors and windows having frames thereon, said building comprising retention means located in an exterior surface of each frame in such a manner that said retention means are embedded in concrete when said concrete is poured, a retention means located on an outer surface of each frame in such a manner that the retention means is embedded in concrete when said concrete is poured, said retention means being wide enough to extend along an outside of said frame, around said outside foam layer and partially along a front of said exterior foam layer, said concrete filling said core, said retention means having an interior section that is embedded in said concrete and an exterior section that is embedded in a stucco mixture.

4. A multi-storey building as claimed in Claim 3 wherein said retention means is a mesh.
5. A multi-storey building as claimed in Claim 4 wherein said building exceeds three storeys.
6. A multi-storey building having vertical walls formed using a plurality of insulated concrete forms, said forms each having two layers of foam spaced apart from one another by a predetermined distance to form a core therebetween, said vertical walls including openings for doors and windows with frames thereon, said frames for said windows being constructed of foam pieces that are inserted between said two layers of foam and held in place by adhesive.
7. A multi-storey building as claimed in Claim 6 wherein said building exceeds three storeys.

Figure 1



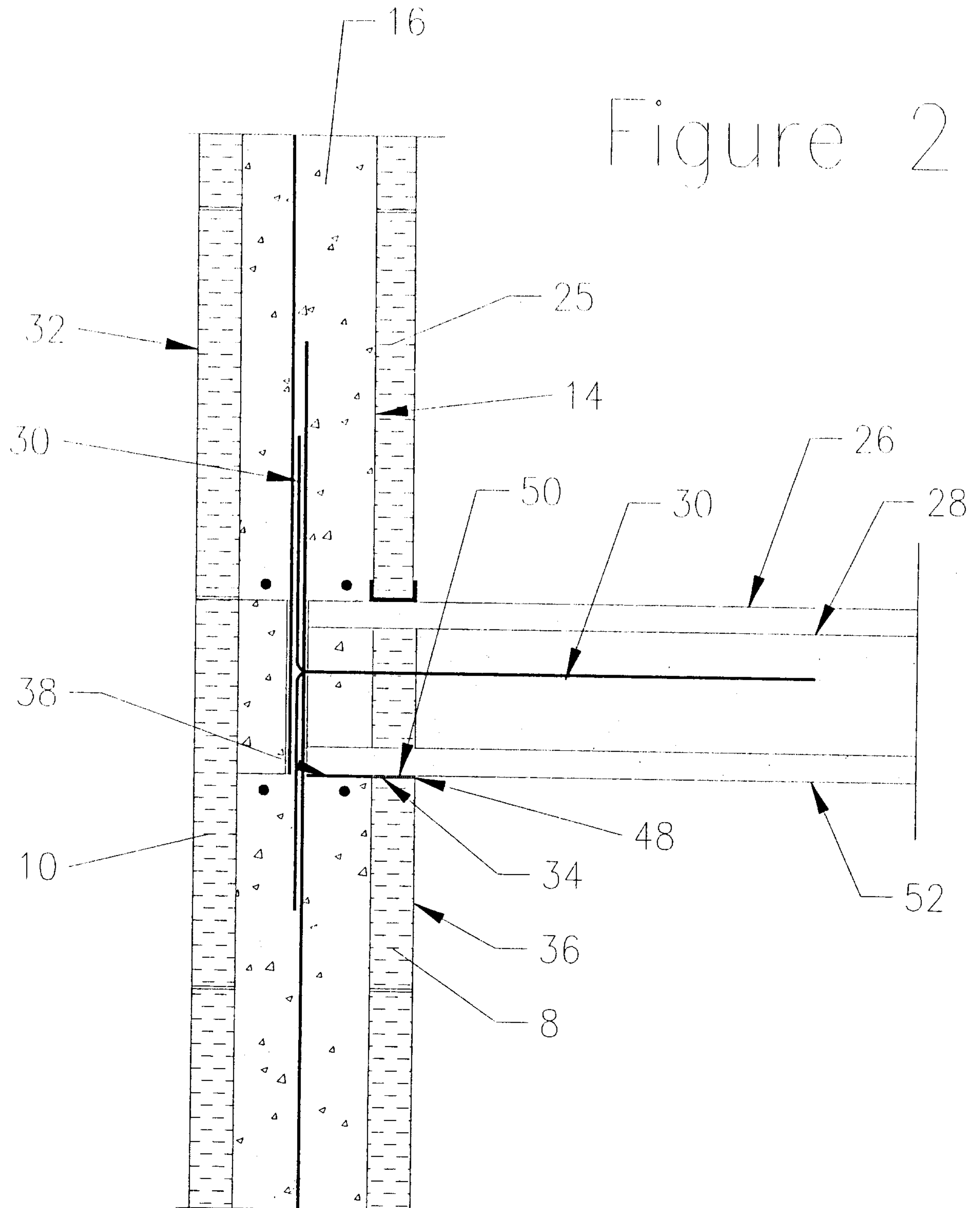
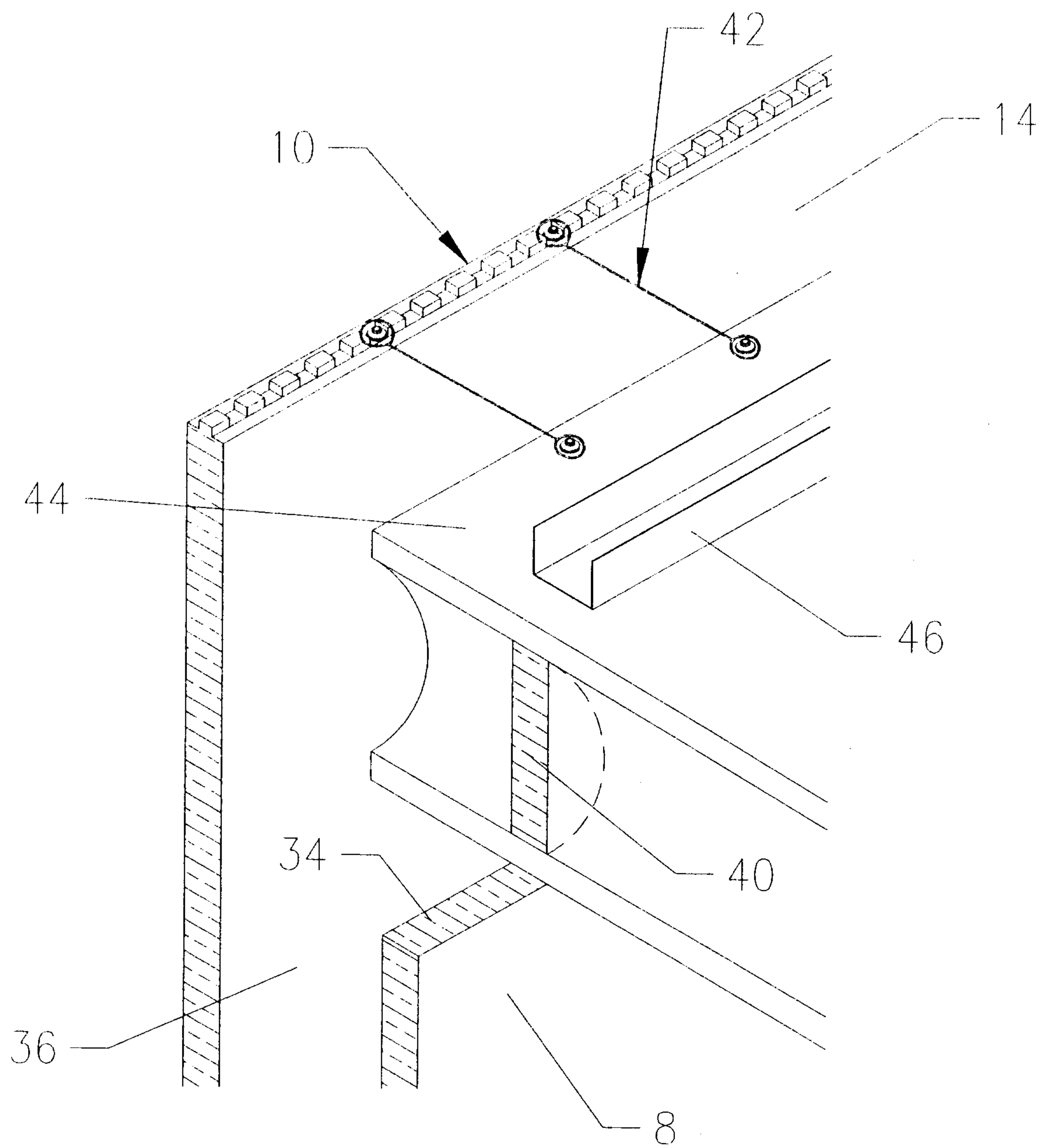


Figure 3



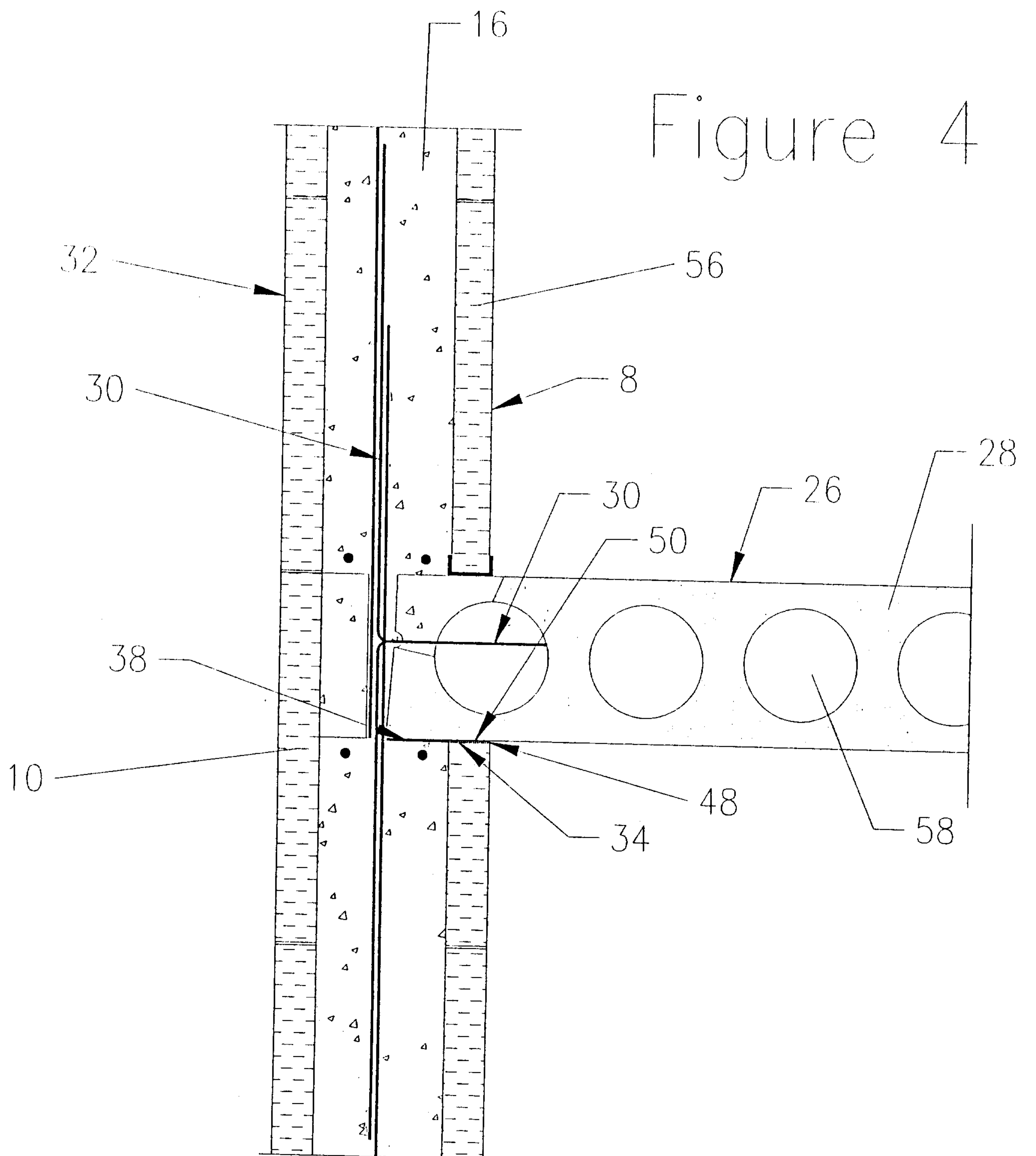


Figure 5

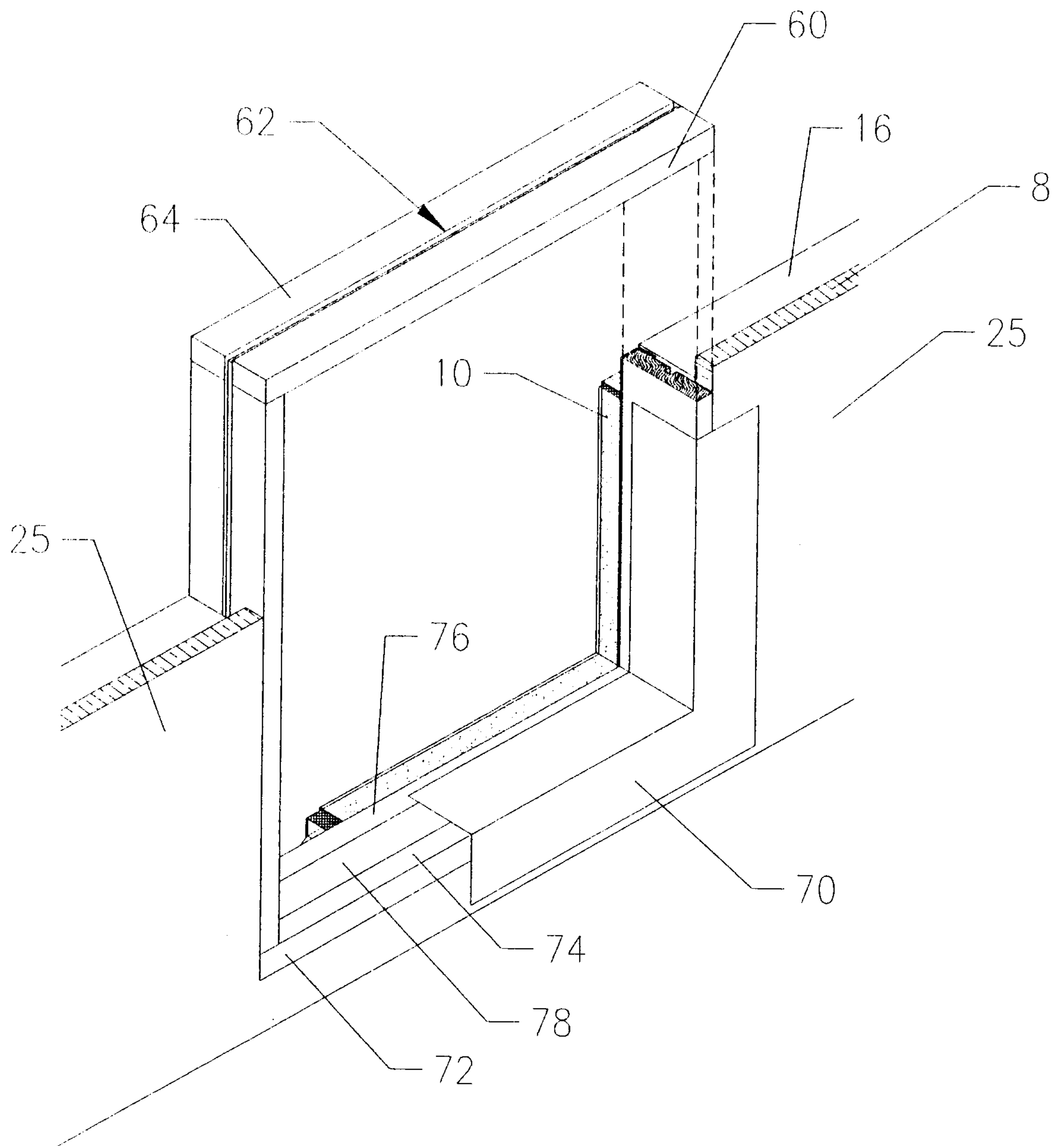


Figure 6

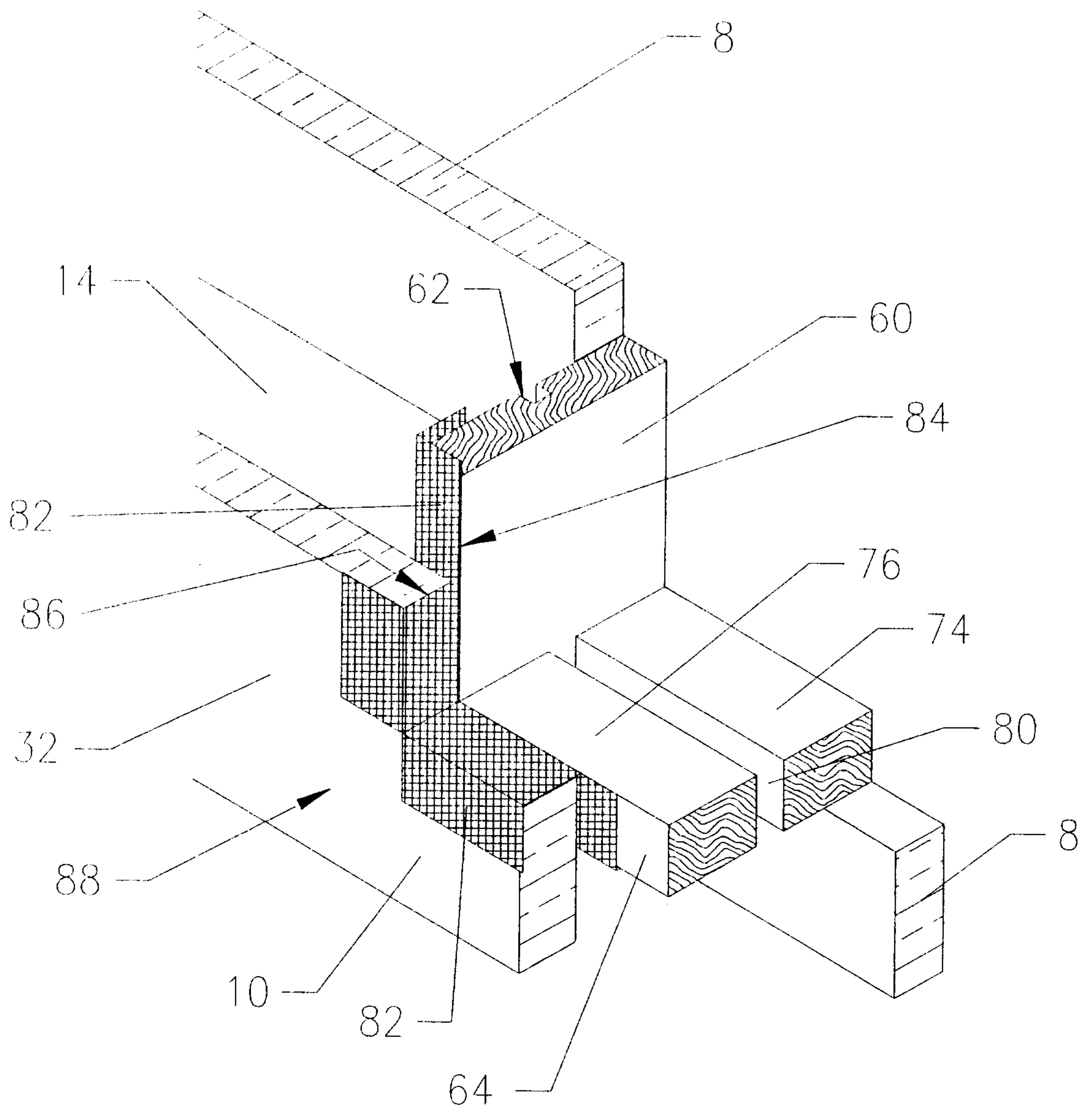


Figure 7

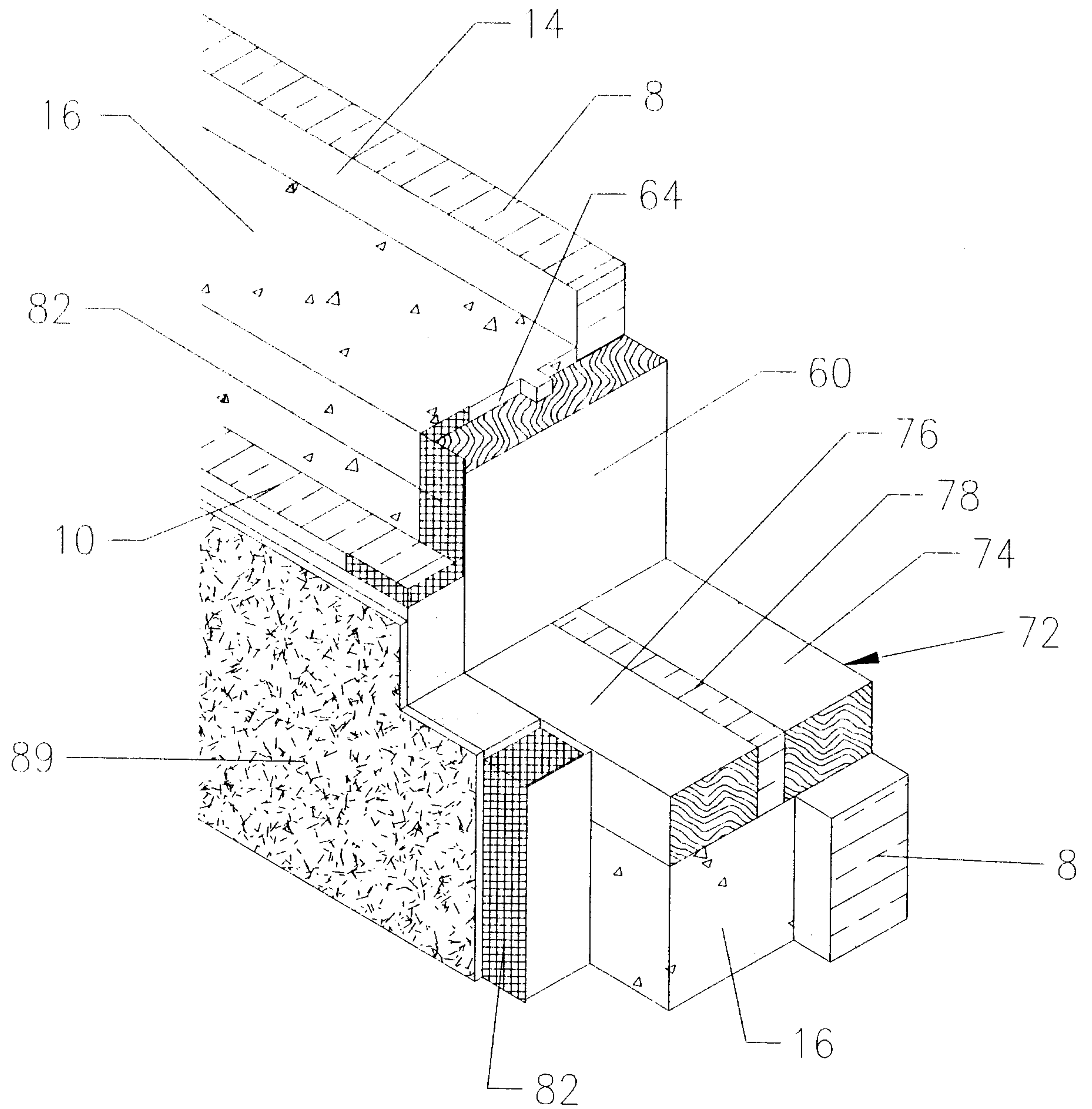


Figure 8

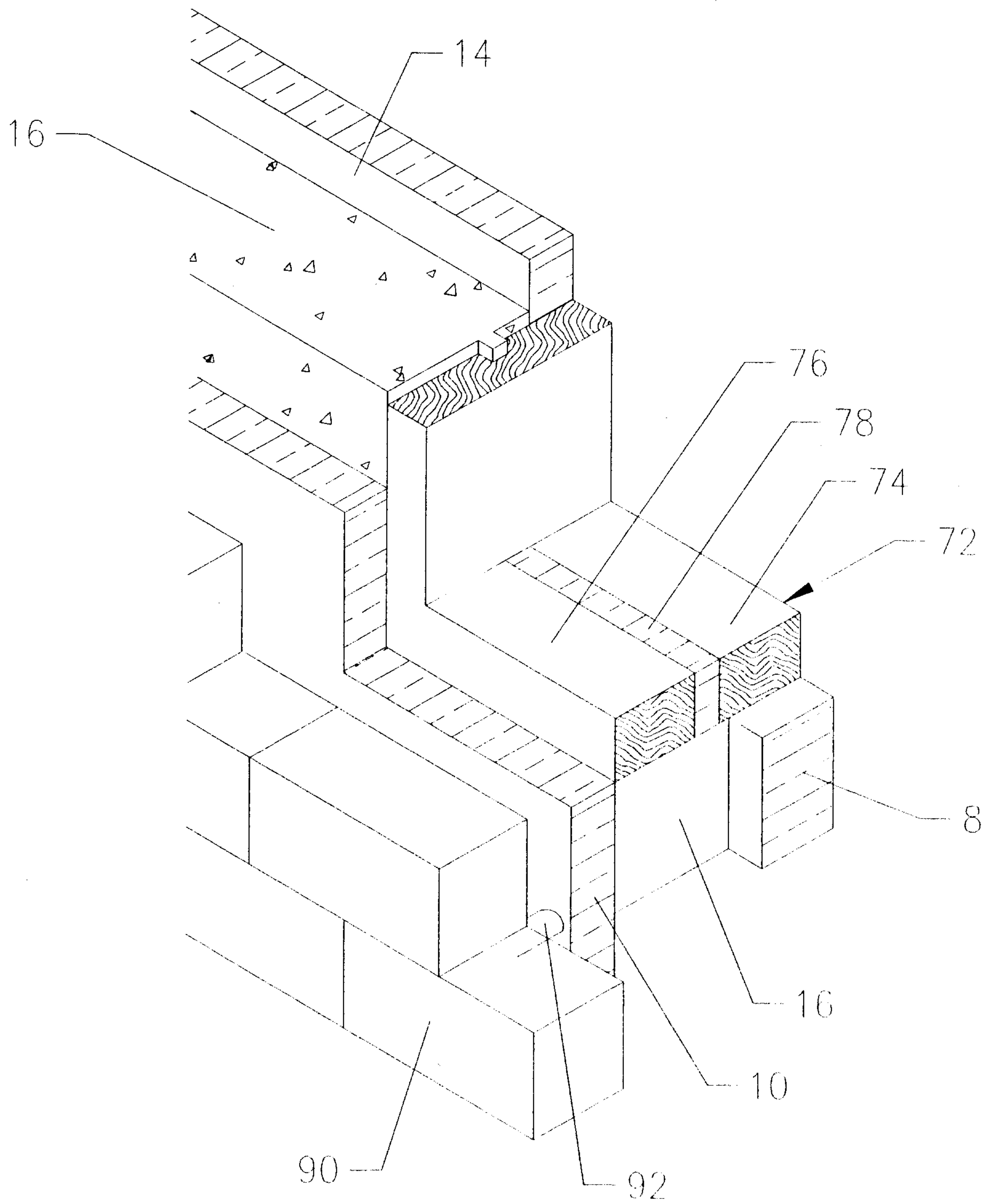


Figure 9

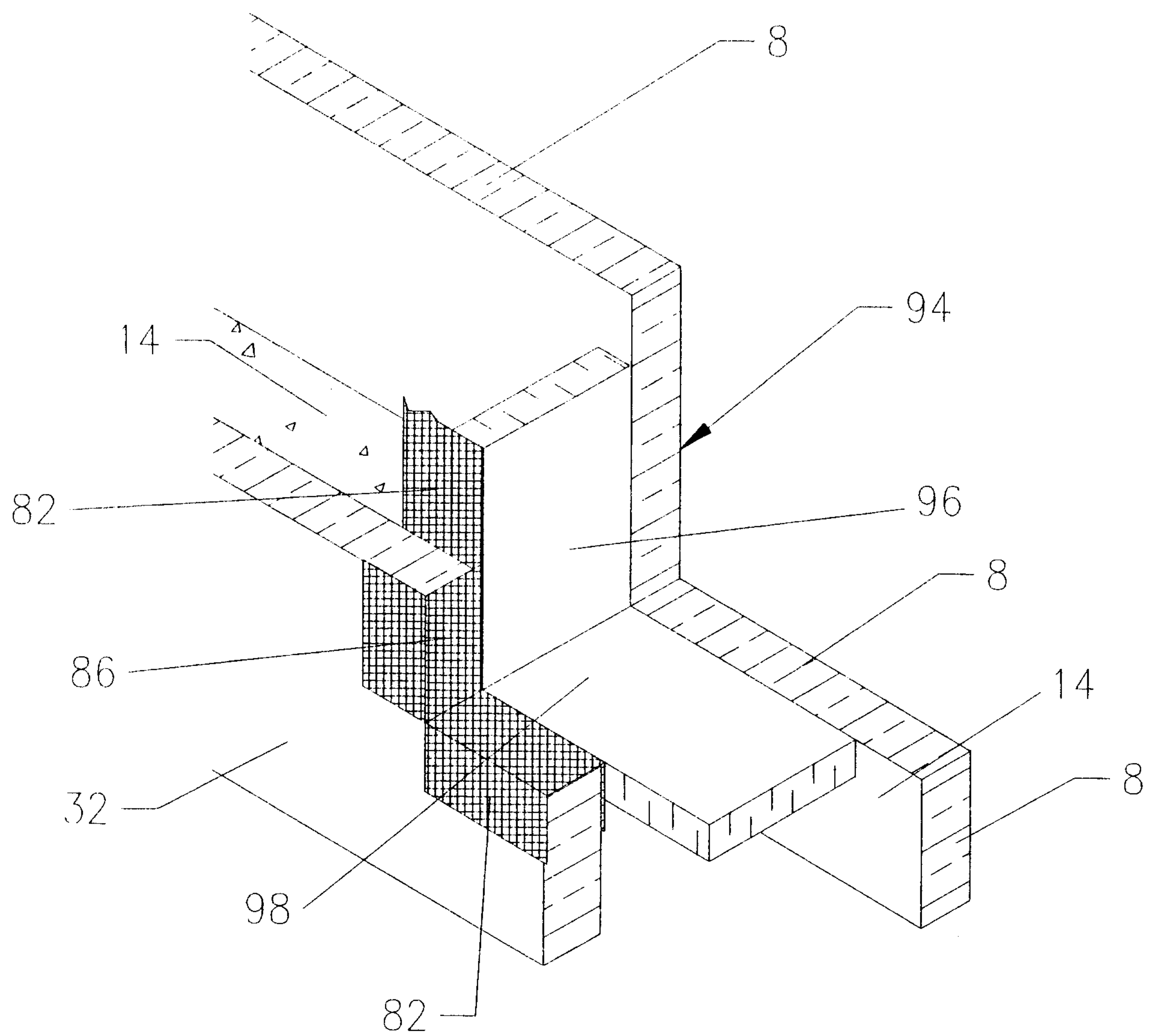


Figure 10

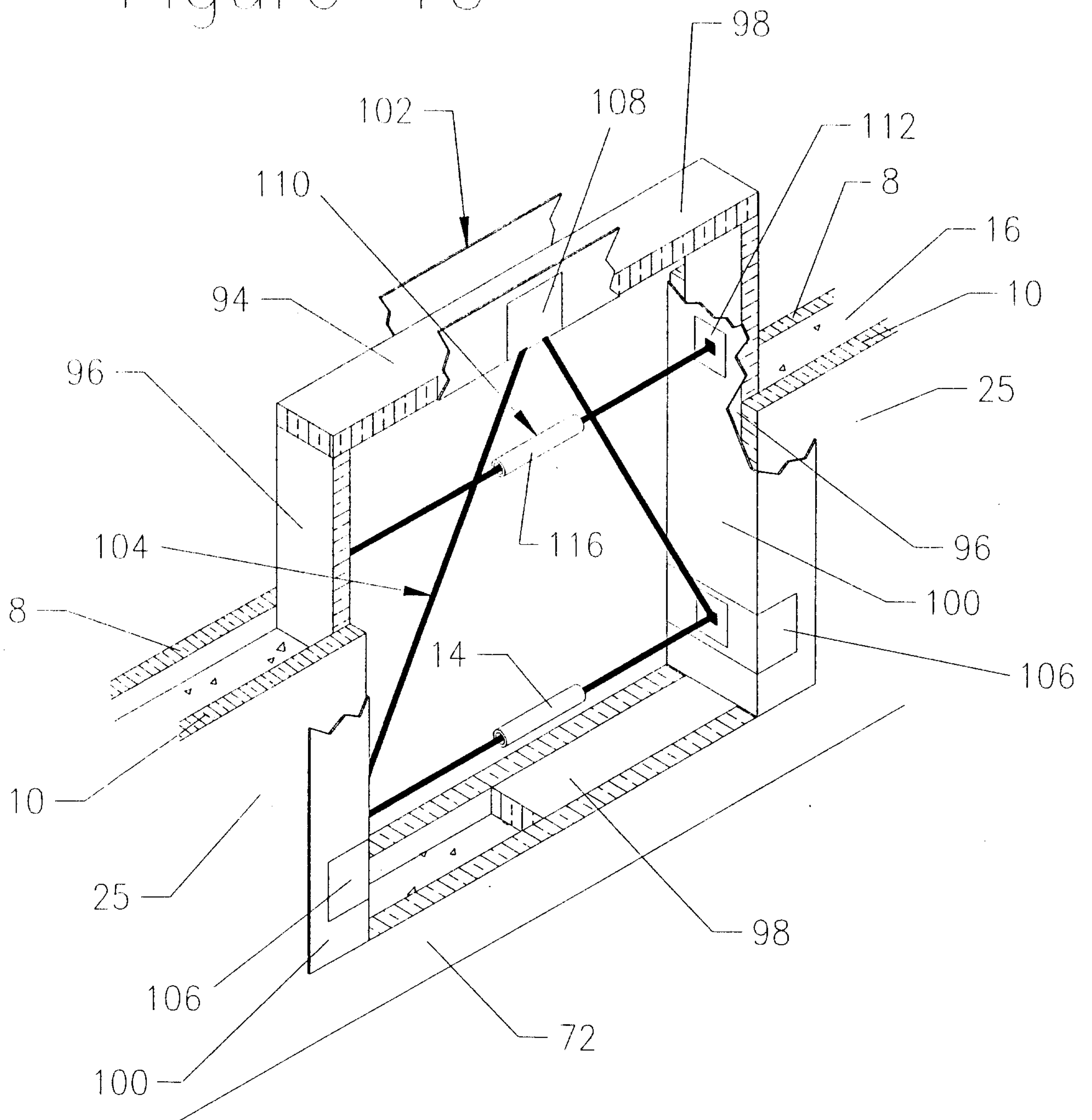


Figure 11

