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(54) **CONCRETE WALL SYSTEMS AND METHODS AND SPACERS THEREFOR**

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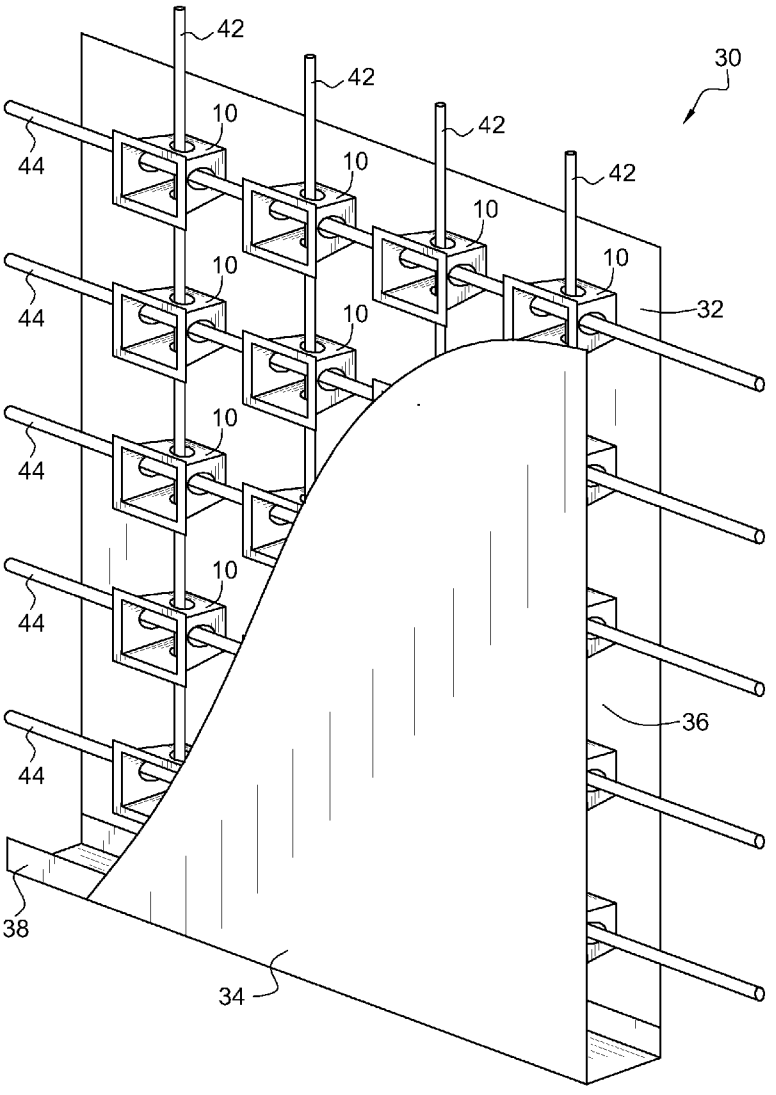
(57) **ABSTRACT**

A concrete wall system includes first and second opposing wall panels and a plurality of spacers disposed between the first and second wall panels. A plurality of reinforcing bars is placed between the first and second wall panels and supported by the spacers, and a concrete core is disposed between the first and second wall panels such that the spacers and the reinforcing bars are embedded in the concrete core. Each one of the spacers has a cup-like body defining a closed first end and an open second end with a flange formed on the second end. The spacer bodies are tapered so that the spacers are stackable.



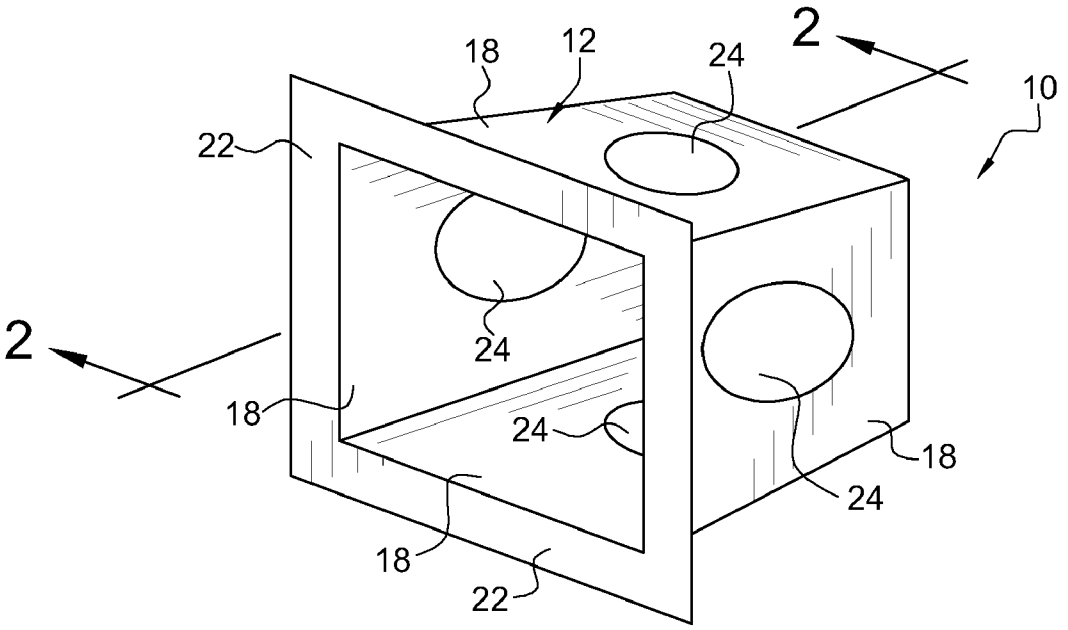

2
18
12
24
10
22
24
2
18
24
18
24
18
22

FIG. 1

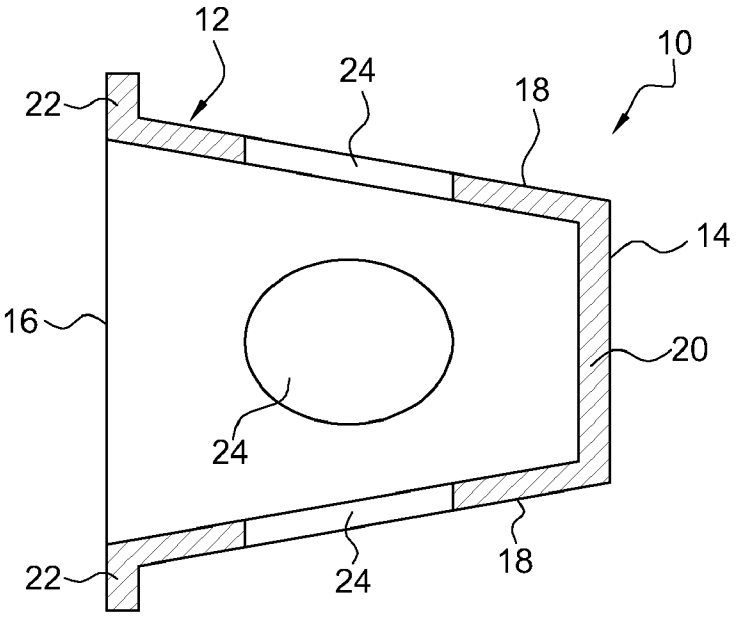

12
10
22
24
18
14
16
20
24
22
24
18

FIG. 2

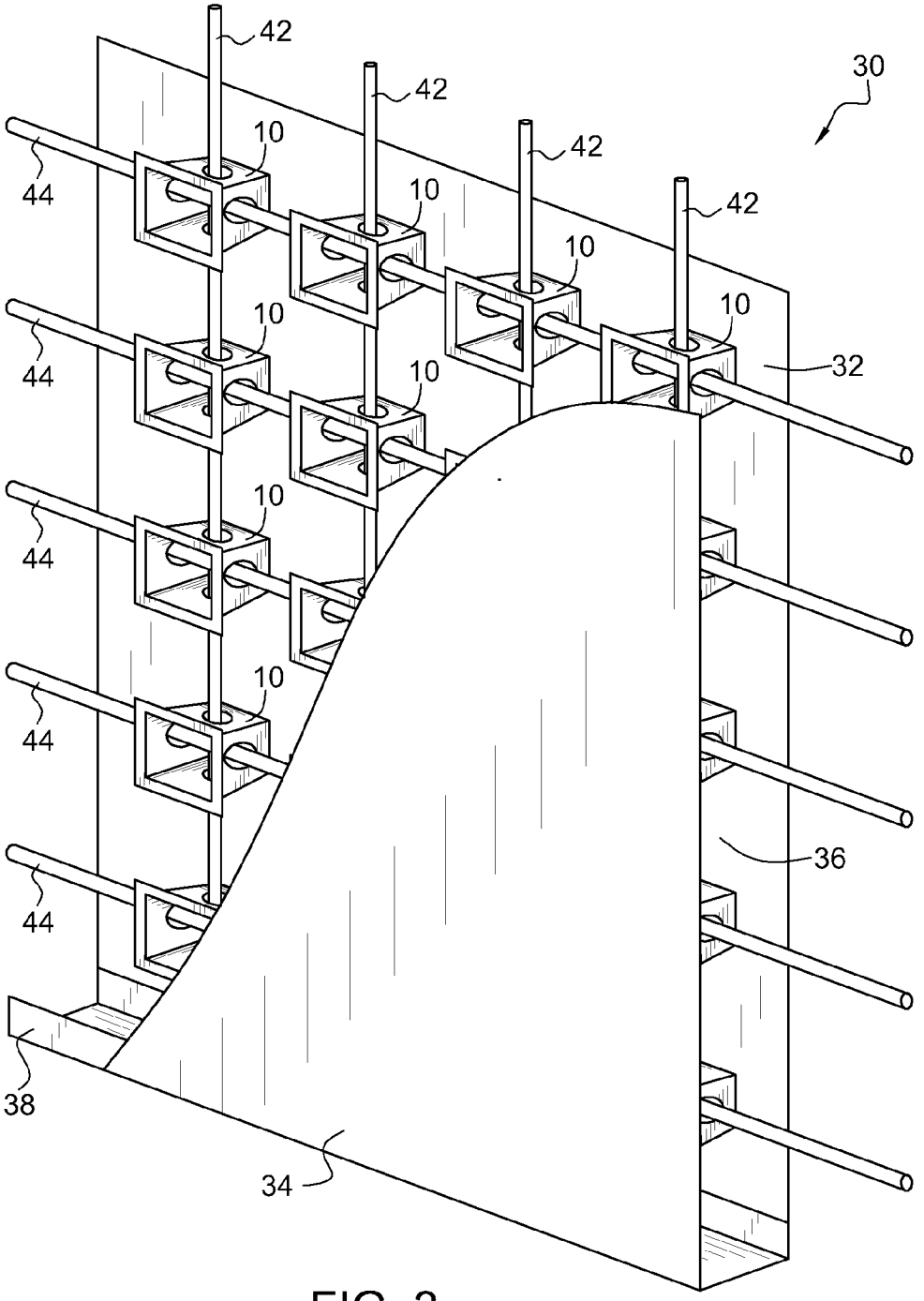


FIG. 3

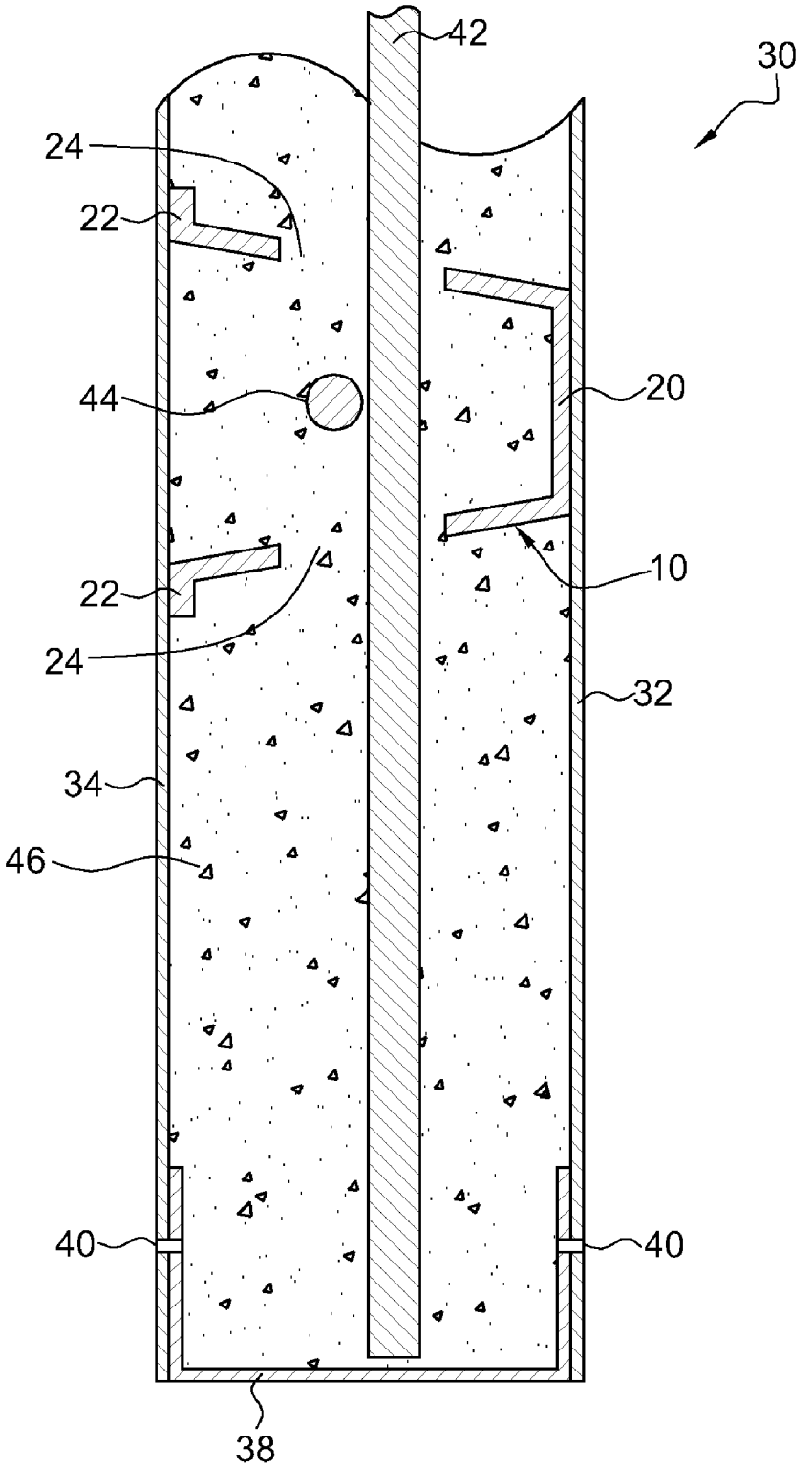


FIG. 4

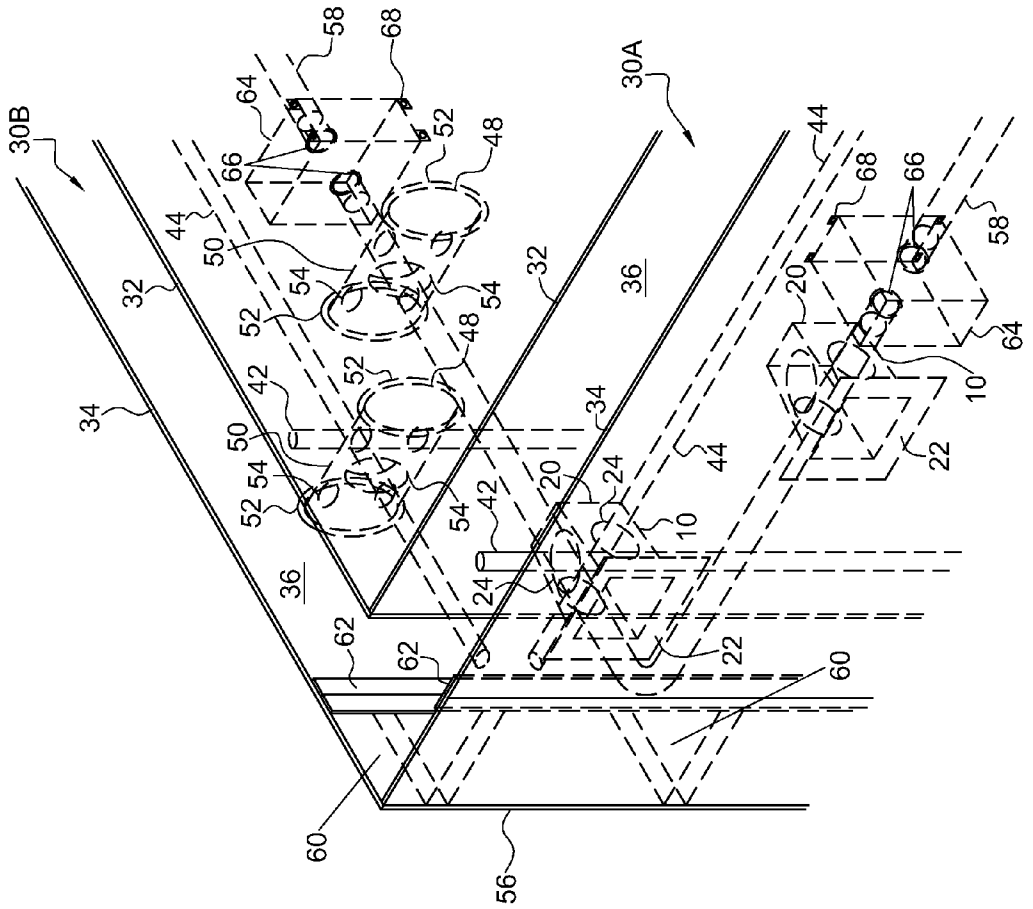


FIG. 5

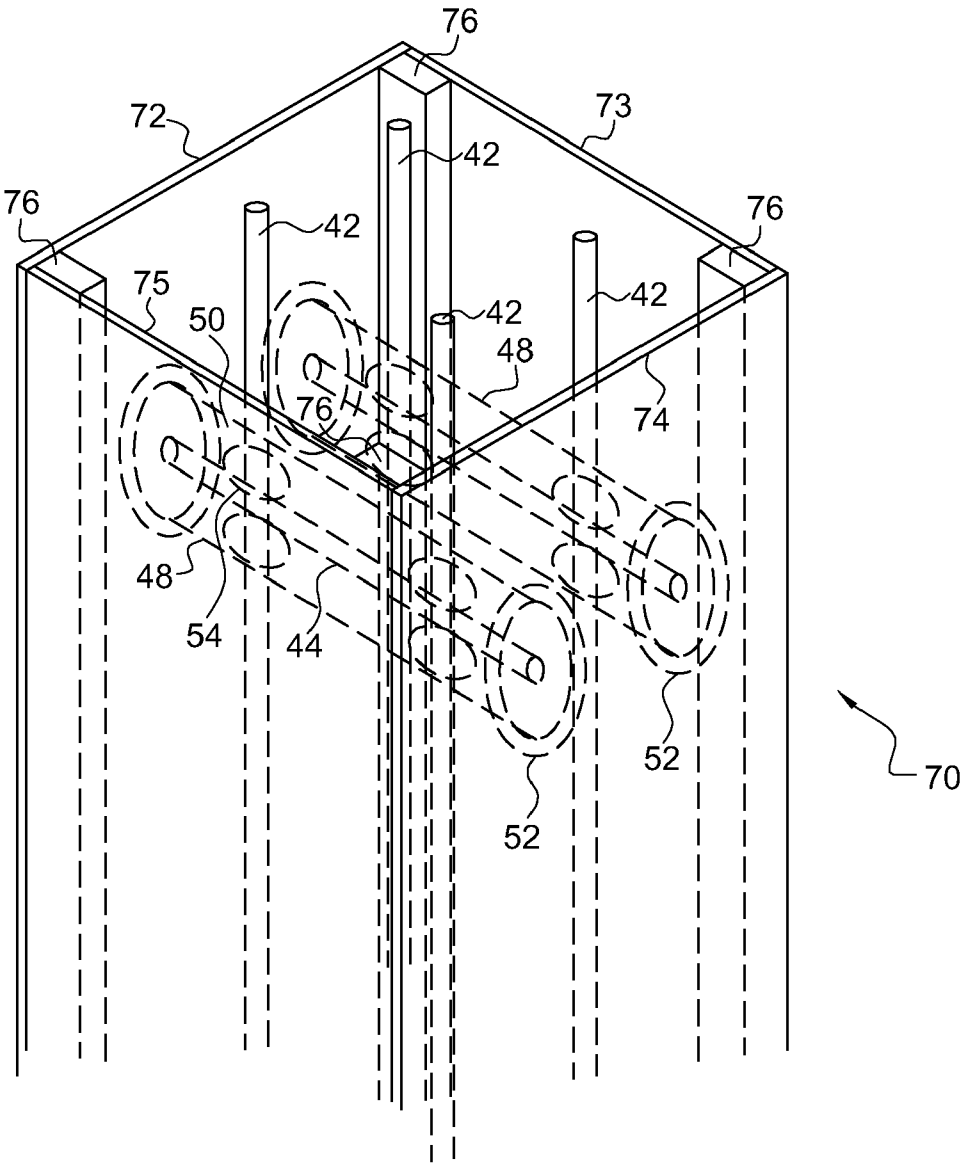


FIG. 6

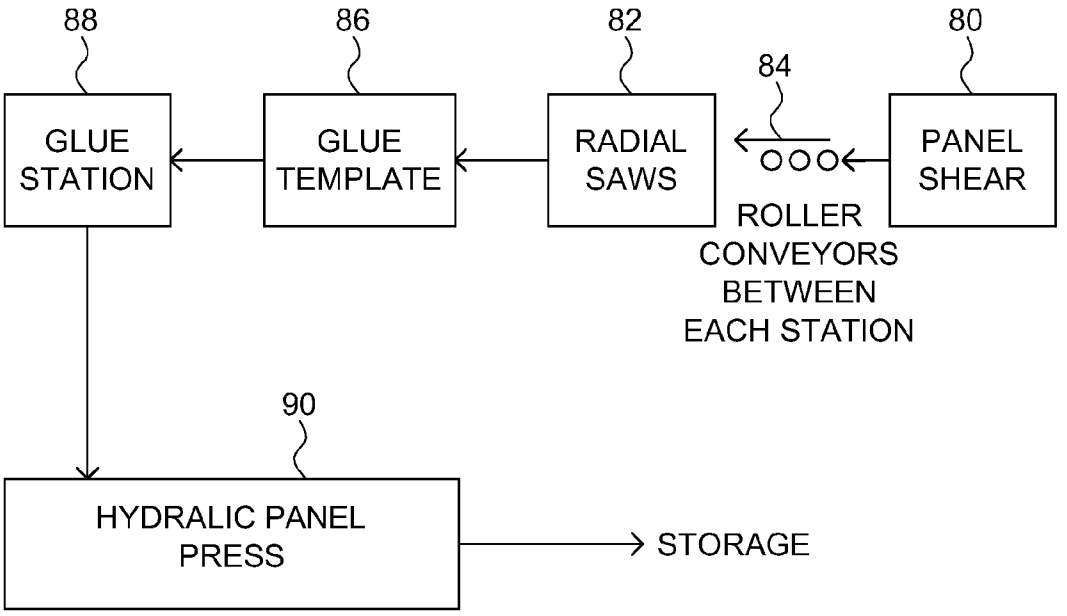

88
86
82
84
80
GLUE STATION
GLUE TEMPLATE
RADIAL SAWS
PANEL SHEAR
ROLLER CONVEYORS BETWEEN EACH STATION
90
HYDRALIC PANEL PRESS
STORAGE

FIG. 7

CONCRETE WALL SYSTEMS AND METHODS AND SPACERS THEREFOR

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to concrete wall systems, methods for making concrete wall systems, and spacers used in concrete wall systems.

[0002] Many structures and buildings are made with concrete walls. Traditionally, this type of construction involves setting up forms, pouring concrete between the forms, and then removing the forms after the concrete hardens. It is also common to utilize reinforcing bars (commonly referred to as "rebar") in the concrete.

[0003] Australian Patent Application No. 2000101212 discloses another type of concrete wall that comprises an opposing pair of formwork boards and a plurality of wall spacers located between the formwork boards. Reinforcing bars are placed through respective openings formed in the spacers, and the cavity between the formwork boards is then filled with concrete. The formwork boards remain in place, acting as the finished internal or external wall surface.

[0004] The concept disclosed by Australian Patent Application No. 2000101212 has several drawbacks. For instance, the spacers are box-shaped and thus occupy a considerable volume when packed for shipping, thereby resulting in relatively high shipping cost. Australian Patent Application No. 2000101212 also does not disclose techniques for efficiently assembling the formwork boards and spacers. Nor does Australian Patent Application No. 2000101212 teach how to build high structures or columns or efficiently incorporate electrical conduits and the like within the pre-filled wall prior to pouring concrete.

SUMMARY OF THE INVENTION

[0005] The above-mentioned need is met by the present invention, which provides a concrete wall system comprising first and second opposing wall panels and a plurality of spacers disposed between the first and second wall panels. A plurality of reinforcing bars is placed between the first and second wall panels and supported by the spacers, and a concrete core is disposed between the first and second wall panels such that the spacers and the reinforcing bars are embedded in the concrete core. Each one of the spacers has a cup-like body defining a closed first end and an open second end with a flange formed on the second end. The spacer bodies are tapered so that the spacers are stackable.

DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a perspective view of a first embodiment of a spacer for positioning two opposing wall panels relative to one another.

[0007] FIG. **2** is a cross-sectional view of the spacer taken along line **2-2** of FIG. **1**

[0008] FIG. **3** is a perspective view (in partial cut-away) of a concrete wall system.

[0009] FIG. **4** is a cross-sectional view of a portion of the concrete wall system of FIG. **3**.

[0010] FIG. **5** is a perspective view of a portion of a building constructed with concrete wall systems.

[0011] FIG. **6** is a perspective view of an integrated concrete column.

[0012] FIG. **7** is a diagram depicting a process for making shell assemblies for concrete wall systems.

DETAILED DESCRIPTION OF THE INVENTION

[0013] The present invention includes integrated concrete wall systems that comprise two opposing wall panels separated by a plurality of spacers and a concrete core located between the two wall panels. The spacers position the two wall panels relative to one another. Specifically, the spacers maintain the two wall panels parallel to one another and spaced apart a particular distance to insure that the resulting wall system has a uniform and desired thickness. The spacers are also adapted to support reinforcing bars, as well as other items such as electrical conduit, in place between the wall panels before the concrete is poured into the inter-panel space.

[0014] Referring to the drawings wherein identical reference numerals denote the same elements throughout the various views, FIGS. **1** and **2** show one embodiment of a spacer **10** for use in a concrete wall system. The spacer **10** comprises a cup-like body **12** having a closed end **14**, an open end **16** and an interior that defines a hollow cavity. The body **12** is shown in the drawings as having a box-shaped configuration by way of example, but it should be noted that other shapes (such as a circular cross-section) are possible. In the illustrated embodiment, the body **12** comprises four side walls **18** joined together in mutually orthogonal fashion to define four corners. Each side wall **18** is joined to a rectangular base piece **20** at the closed end **14** of the body **12**. The body **12** includes a rectangular flange **22** formed along the perimeter thereof at the open end **16**. The rectangular flange **22** extends outward from each of the four side walls **18** and is substantially parallel to the base piece **20**.

[0015] The exterior or outwardly-facing surface of the base piece **20** can be attached to the one of the wall panels, and the outwardly-facing surface of the flange **22** can be attached to the other wall panel. These surfaces can be attached via any suitable means, such as adhesive or the like. Because the flange **22** and the base piece **20** are substantially parallel, an attached spacer **10** functions to maintain the opposing wall panels in parallel relation and at the desired spacing (which is determined by the length of the spacer **10**).

[0016] The body **12** includes an opening **24** formed in each one of the four side walls **18** for receiving reinforcing bars (vertical and horizontal) as well as other items such as electrical conduit. As described in more detail below, a number of spacers **10** are deployed to hold the reinforcing bars in the proper positions during construction of a concrete wall system.

[0017] The body **12** is tapered with the four side walls **18** converging slightly so that the cross-sectional area of the closed end **14** is smaller than the cross-sectional area of the open end **16**. The tapered configuration and hollow cavity of the body **12** make the spacer **10** stackable; that is, multiple spacers **10** can be stacked together. This stackable spacer configuration greatly reduces packing and shipping costs as large volumes of the spacers can be packed and shipped in a minimum of space.

[0018] The spacers **10** can be made as a one-piece construction, such as with an injection molding process. Injection molding is highly automated, and the spacers **10** can be molded and stacked as they are produced, which further lowers packing costs. The spacers **10** can be made of any suitable

material, including plastic. Plastic materials are generally lightweight and will not corrode when set in concrete.

[0019] Referring to FIGS. **3** and **4**, one embodiment of a concrete wall system **30** is shown. The concrete wall system **30** shows a first wall panel **32** and an opposing second panel wall **34** (shown partially cut-away in FIG. **3**) arranged in parallel, spaced-apart relation so as to define an inter-panel space **36** therebetween. The bottom portion of each wall panel **32**, **34** abuts a corresponding side of a channel **38** that is attached to the floor and is typically made of metal. The wall panels **32**, **34** are secured to the channel **38** by any suitable fastener **40**. While the panels **32**, **34** could be placed inside the channel **38**, they are preferably positioned externally of the channel **38**, as depicted in the drawings, so as to present a continuous surface finish.

[0020] A plurality of spacers **10** is disposed in the inter-panel space **36** between the first and second wall panels **32**, **34**. The base piece **20** of each spacer **10** is attached to the first wall panel **32**, and the flange **22** of each spacer **10** is attached to the second wall panel **34** in any suitable manner. For example, the base pieces **20** and the flanges **22** can be attached to the respective wall panels using a fast-drying urethane glue. In the illustrated embodiment, the spacers **10** are arranged in a grid-like layout of vertical columns and horizontal rows. The number and spacing of the spacers **10** will depend on the structural design. For example, about forty spacers **10** would typically be equidistantly spaced on a four-foot by ten-foot panel as would be used for most home or commercial construction. This assemblage of the first and second wall panels **32**, **34** and the spacers **10**, referred to hereinafter as the shell assembly, is typically made at a factory and then transported to the construction site. At the construction site, the shell assembly is slip fit over its floor channel **38** and the wall panels **32**, **34** are fastened thereto as described above. Reinforcing bars are then interlaced with the spacers **10**. Specifically, a vertically-extending reinforcing bar **42** is placed to extend through the openings **24** formed in the horizontally-oriented side walls **18** of each column of spacers **10**, and a horizontally-extending reinforcing bar **44** is placed to extend through the openings **24** formed in the vertically-oriented side walls **18** of each row of spacers **10**.

[0021] Once the wall panels **32**, **34**, channel **38**, spacers **10** and reinforcing bars **42**, **44** are assembled as shown in FIG. **3**, the concrete wall system **30** is completed by pouring concrete into the inter-panel space **36** of the shell assembly. The concrete cures and forms a concrete core **46** (shown in FIG. **4**) that provides structural integrity to the concrete wall system **30**. The spacers **10** and the reinforcing bars **42**, **44** are embedded in the concrete core **46**. The two wall panels **32**, **34** remain and function as the inner and outer wall surfaces of the concrete wall system **30**.

[0022] Referring to FIG. **5**, a portion of a building constructed with the concrete wall systems is depicted. Specifically, FIG. **5** shows a corner of a building formed by two concrete wall systems **30**A, **30**B arranged perpendicularly to one another. Each concrete wall system **30**A, **30**B includes a floor channel (not shown in FIG. **5**), and a shell assembly comprising a first or inner wall panel **32** and a second or outer wall panel **34** arranged in parallel, spaced-apart relation with the inner wall panel **32** so as to define the inter-panel space **36** therebetween. The wall panels **32**, **34** can be made from any suitable materials approved by the structural engineer and meeting applicable fire and building codes. For example, the inner wall panels **32** could comprise any wood (e.g., plywood or other composition board material), composite material or the like having adequate strength for attaching the spacers **10** and retaining the poured concrete.

[0023] The outer wall panels **34** could comprise a board of an insulating material (such as polyurethane (PU) closed-cell foam or expanded polystyrene (EPS)) having an outer finish surface of wood, metal or plastic clad thereto. Pre-finished outer wall panels **34** with an insulating foam board would provide thermal insulation for the building, thereby eliminating the need for a separate layer of insulation and consequently saving labor costs and speeding up overall construction time. Any number of exterior sidings, including horizontal or vertical metal clad sidings, can be applied to the outer surface of the insulating foam board using pressure sensitive adhesives. For example, foam panels can be purchased pre-finished with vacuum bag applied exterior sidings such as aluminum and steel. To quickly apply finish-lapping strips to joints (not shown), tape adhesives can be used and can withstand temperatures to 200 F. Concrete adheres well to PU foam, which has an R-value of 6.5 per inch compared to an R-value of 4 per inch for EPS foam.

[0024] As an alternative to insulated outer wall panels, the concrete wall systems **30**A, **30**B could be provided with a third wall panel (not shown) arranged in parallel, spaced-apart relation outside of the outer wall panels **34** (which would thus become intermediate wall panels). The spaces between these sets of panels would be filled with insulating material.

[0025] Each concrete wall system **30**A, **30**B further includes a plurality of spacers disposed in the inter-panel space **36** between the wall panels **32**, **34**. One of the wall systems **30**A uses the tapered, cup-like spacers **10** shown in FIGS. **1** and **2**. The other wall system **30**B uses a plurality of alternative spacers **48**. The alternative spacers **48** can be custom made from a length of PVC pipe **50** having a thin end cap **52** secured to each end thereof. The outer surfaces of the end caps **52** present surfaces that can be attached to the respective wall panel **32**, **34** by any suitable means, such as adhesive or the like. The PVC pipe **50** is provided with several openings **54** spaced around the circumference thereof so as to be aligned in pairs for receiving reinforcing bars (vertical and horizontal) as well as other items such as electrical conduit. The alternative spacers **48** can be custom cut to length and generally would be used for thicker walls and columns.

[0026] The construction further includes a corner assembly **56**, described in more detail below, which connects the two perpendicular concrete wall systems **30**A, **30**B and completes the building corner. Prior to installing the corner assembly **56**, the vertical and horizontal reinforcing bars **42**, **44** are interlaced with the spacers **10**/**48**. In addition, electrical conduit **58** can be installed by insertion through the openings **24**/**54** of selected spacers **10**/**48**. In the illustrated embodiment, additional spacers **10**/**48** are located between columns and rows of spacers **10**/**48** that hold vertical and horizontal reinforcing bars **42**, **44** in order to support electrical conduit **58** at a desired height or heights. Preferably, each such additional spacer is centered between a two adjacent columns of reinforcing bar-holding spacers and between two adjacent rows of reinforcing bar-holding spacers.

[0027] Openings for doors and windows can be zip cut in the shell assemblies at the factory where they are made or on site, with pre-assembled rough opening spacers (not shown) inserted and fastened in place to the wall panels prior to pouring concrete. The corner assembly **56** comprises two

corner pieces **60** joined together at a 90 degree angle and two pre-glued strips **62** that are used to attach the corner pieces **60** to the corresponding outer wall panels **34** once the reinforcing bars **42**, **44** and conduit **58** are all installed. Generally, the corner pieces **60** and the pre-glued strips **62** would be used with fiber cement panels, which are chamfered on the outer edges to apply finishing tape for application of other finish coatings. If the outer wall panels **34** have insulating foam thickness pre-applied inside, a slot would be cut in the foam adjacent to the inside surface of each wall panel to accommodate the pre-glued strips **62**. Any number of combinations of wall panels **32**, **34** can be used providing they are engineer approved for the particular construction system.

[0028] Reinforcing bars, conduit, junction boxes and all interior plumbing are installed prior to the pour of concrete into inter-panel space **36**. Once the wall panel assemblies are all in place with reinforcing bars secured and connected and all conduit is secured and connectors glued, junction boxes **64** can be installed. Because junction boxes are located at an engineered height from the floor, the conduit **58** is placed at this height. Junction box panel openings can thus be rotary zip cut into the inner wall panel **32** anywhere along the conduit length, and the conduit **58** is cut to produce a gap equal to the exact outside width of the junction box **64** and aligned with the junction box panel opening. Glue is applied to the fittings **66** formed in the sides of the junction box **64**, and the junction box **64** is then inserted into the opening in the inner wall panel **32** and the gap in the conduit **58** such that tabs **68** on the junction box abut the inner wall panel **32**. Thus, as many junction boxes as needed can be quickly and efficiently located anywhere along the length of the conduit with a tight and secure fit made to the junction box **64**, the conduit **58** and the inner wall panel **32** before pouring concrete. Conduit that does not have a well-defined location can have junction boxes and fittings pre-installed as wall panels are set, which, with location rough-marked on the inner wall panel **32** and/or with a iron washer (not shown) taped to the inside a plastic junction box, can also be quickly and exactly located later with a magnet to rotary zip cut the junction box opening into the inner wall panel **32**. Channels (not shown in FIG. **5**) for positioning inner and outer wall panels would be secured to poured concrete floors, with the slip fit of panels over the pre-installed channel and fastened though the outside of the panel to the channel to hold in the concrete from the pour. All panel walls are buttressed as needed before filing with concrete to maintain the desired position. Straight, angled, curved, or irregular wall panel configurations are possible. The wall panels can also be tilted or positioned at an angle, such as for decoration or special architectural effect.

[0029] Turning to FIG. **6**, one embodiment of a column **70** made with the principles of the present invention is shown. The column **70** is a specialized concrete wall system that comprises four panels **72-75** arranged in mutually orthogonal fashion to form a rectangular configuration. The first and third panels **72**, **74** are arranged parallel to each other, and the second and fourth panels **73**, **75** are arranged parallel to each other. Adjacent panels **72-75** are joined together with pre-glued corner pieces **76** that are set in place and the whole assembly is banded together (not shown) for glue drying so as to maintain the integrity and dimensions of the assembly prior to filling with concrete. Two spacers **48** (of the alternate type described above) extend horizontally between the first and third panels **72**, **74**. Each spacer **48** comprises a length of PVC pipe **50** having a thin end cap **52** secured to each end thereof. Horizontal reinforcing bars **44** are inserted lengthwise in the PVC pipe **50** prior to securing the end caps **52**. The outer surface of each end cap **52** is attached to the respective panel **72**, **74** by any suitable means, such as adhesive or the like.

[0030] Vertical reinforcing bars **42** are inserted through openings **54** in the PVC pipe **50** and tied to the horizontal reinforcing bars **44**. The openings **54** are larger than the reinforcing bars **42** in order to receive the reinforcing bars **42** and still have clearance to allow the PVC pipe **50** to fill with concrete. The amount and size of the vertical and horizontal reinforcing bars **42**, **44** depends on the size of the column **70** with as many horizontal layers of reinforcing bars **44** as needed to meet code. Each layer of spacers **48** and horizontal reinforcing bars **44** would be shifted 90 degrees with respect to its adjacent layers. In other words, the layer of spacers **48** and horizontal reinforcing bars **44** located directly below the layer shown in FIG. **6** would be rotated 90 degrees so that the spacers **48** extend between, and are attached to, the second and fourth panels **73**, **75**.

[0031] Once the panels **72-75**, spacers **48** and reinforcing bars **42**, **44** are assembled, concrete is poured into the assembly. The concrete fills the interior of the assembly and also flows into the spacers **48** via the openings **54**. The concrete cures and forms a concrete core that provides structural integrity to the column **70**.

[0032] FIG. **7** is a diagram depicting how shell assemblies for concrete wall systems can be economically assembled at a factory or the like for future field assembly of concrete wall systems at a construction site. The first step is to shear the panels to size at a station **80**. The panels are conveyed to the next station **82** via rollers **84** located between stations **80** and **82**. Although not shown, there are similar rollers located between all of the subsequent stations. If fiber cement panels are used, the next station **82** provides a radial saw for cutting and removing a small amount of panel material at the edges thereof, to accommodate adding tape and joint compound for finishing wall joints flat on the exposed sides of the panels. The next station **86** provides a template positioned onto a panel to facilitate placing spacers. Glue is then applied at the next station **88** and panels sandwiched together as needed. As previously noted, there could be two panels joined together or as many as three panels making two spaces, one for concrete and one for insulation. The assembled panels are then conveyed to the next station **90** to be clamped and compressed until the glue sets. After removing from the clamp assembly, the assembled panels can be further processed by installing window and door rough opening inserts and then delivered to the job site for final assembly prior to pouring concrete.

[0033] For supporting concrete wall systems in multi-story structures, wall system thickness at the ground floor will start at a relative thick value, say twelve inches thick. The wall system thickness will be gradually reduced for higher and higher floors, such as to ten inches, then to eight inches, then to six inches, then to four inches thick per the structural engineer's design for a twenty-four story building, for example, to create an earthquake and fire proof building of high quality. To accomplish this, stackable spacers could be mass produced at the various widths and panel assemblies fit over and secured to the standard width channels that are attached to the concrete floors at each story to accommodate securing and lining up panels for pouring concrete. Alternatively, PVC fabricated spacers could also be produced as necessary for thicker starting walls. And regardless of climate, as noted previously, either PU or EPS insulated foam

board outer panel can be used, or a second outside insulating space can be created with a third panel and filled with approved insulating materials to construct a strong, airtight structure enabling good air quality control and being well insulated. Everything combines to make highly energy efficient, quality buildings.

[0034] While specific embodiments of the present invention have been described, it should be noted that various modifications thereto can be made without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A spacer for positioning two opposing wall panels relative to one another, said spacer comprising:

a cup-like body defining a first end and an open second end and having a base piece at said first end and a flange formed on said second end;

wherein said base piece presents a surface that is attachable to a first one of said two wall panels and said flange presents a surface that is attachable to a second one of said two wall panels; and

wherein said body is tapered such that said first end has a smaller cross-sectional area than said second end.

2. The spacer of claim **1** wherein said body comprises four side walls arranged in mutually orthogonal fashion, said base piece is rectangular in shape and is connected to said four side walls at said first end of said body, and said flange is rectangular in shape and extends outward from each of said four side walls.

3. The spacer of claim **2** further comprising at least one opening formed in each one of said four side walls.

4. The spacer of claim **1** wherein said spacer is of a single-piece construction.

5. The spacer of claim **1** wherein said spacer is made of injection molded plastic.

6. A concrete wall system comprising:

first and second opposing wall panels;

a plurality of spacers disposed between said first and second wall panels, each one of said spacers comprising a cup-like body defining a first end and an open second end and having a base piece at said first end and a flange formed on said second end, said body being tapered such that said first end has a smaller cross-sectional area than said second end;

wherein each base piece is attached to said first wall panel and each flange is attached to said second wall panel;

a plurality of reinforcing bars placed between said first and second wall panels and supported by said spacers; and

a concrete core disposed between said first and second wall panels such that said spacers and said reinforcing bars are embedded in said concrete core.

7. The concrete wall system of claim **6** wherein each cup-like body comprises four side walls arranged in mutually orthogonal fashion, said base piece is rectangular in shape and is connected to said four side walls at said first end of said body, and said flange is rectangular in shape and extends outward from each of said four side walls.

8. The concrete wall system of claim **7** wherein each cup-like body has at least one opening formed in each one of said four side walls, and wherein said reinforcing bars extend through corresponding openings.

9. The concrete wall system of claim **6** wherein each base piece is attached to said first wall panel with an adhesive and each flange is attached to said second wall panel with an adhesive.

10. The concrete wall system of claim **6** further comprising a channel attached to a floor, and wherein a bottom portion of said first wall panel abuts and is fastened to one side of said channel and a bottom portion of said second wall panel abuts and is fastened to another side of said channel.

11. The concrete wall system of claim **6** wherein one of said first and second wall panels comprises a board of insulating material with an outer finish surface clad thereto.

12. A method of constructing a concrete wall system comprising:

providing a shell assembly comprising first and second opposing wall panels in parallel, spaced-apart relation so as to define an inter-panel space therebetween with a plurality of spacers disposed in said inter-panel space, each one of said spacers comprising a cup-like body defining a first end and an open second end and having a base piece at said first end and a flange formed on said second end, said body being tapered such that said first end has a smaller cross-sectional area than said second end;

inserting reinforcing bars through openings formed in said spacers; and

pouring concrete into said inter-panel space.

13. The method of claim **12** further comprising:

attaching a channel to a floor;

fitting said shell assembly over said channel with a bottom portion of said first wall panel abutting a first side of said channel and a bottom portion of said second wall panel abutting a second side of said channel; and

fastening said first wall panel to said first side of said channel and said second wall panel to said second side of said channel prior to pouring concrete into said inter-panel space.

14. The method of claim **12** further comprising inserting at least one electrical conduit through openings formed in said spacers prior to pouring concrete into said inter-panel space.

15. The method of claim **14** further comprising installing a junction box in said shell assembly prior to pouring concrete into said inter-panel space.

16. The method of claim **15** wherein installing a junction box includes:

cutting an opening in said first wall panel;

cutting a gap is said conduit, wherein said gap is aligned with said opening in said first wall panel; and

inserting said junction box into said opening in said first wall panel and said gap such that tabs on said junction box abut said first wall panel.

17. A column comprising:

first, second, third and fourth panels arranged in mutually orthogonal fashion to form a rectangular configuration, wherein said first and third panels are arranged parallel to each other and said second and fourth panels are arranged parallel to each other;

at least one spacer extending between said first and third panels, said spacer comprising a length of pipe having an end cap attached to each and multiple openings formed therein;

a horizontal reinforcing bar inserted lengthwise in said length of pipe;

at least one vertical reinforcing bar inserted through a pair of said openings formed in said length of pipe; and

a concrete core disposed between said first, second, third and fourth panels such that said spacer and said reinforcing bars are embedded in said concrete core.

18. The column of claim **17** wherein said length of pipe is PVC pipe.

19. The column of claim **17** further comprising a second vertical reinforcing bar inserted through a second pair of said openings formed in said length of pipe.

20. The column of claim **17** further comprising:

a second spacer extending between said first and third panels, said second spacer comprising a second length of pipe having an end cap attached to each and multiple openings formed therein;

a second horizontal reinforcing bar inserted lengthwise in second said length of pipe; and

a second vertical reinforcing bar inserted through a pair of said openings formed in said second length of pipe.

21. The column of claim **17** further comprising:

a second spacer extending between said second and fourth panels, said second spacer comprising a second length of pipe having an end cap attached to each and multiple openings formed therein; and

a second horizontal reinforcing bar inserted lengthwise in second said length of pipe.

22. The column of claim **21** wherein said at least one vertical reinforcing bar is inserted through a pair of said openings formed in said second length of pipe.

23. The column of claim **21** further comprising a second vertical reinforcing bar inserted through a pair of said openings formed in said second length of pipe.

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