March 16, 1971 J. A. ARMISTEAD 3,570,206

MONOLITHIC CONCRETE SLAB CONSTRUCTION

Filed Nov. 21, 1968 3 Sheets-Sheet 1

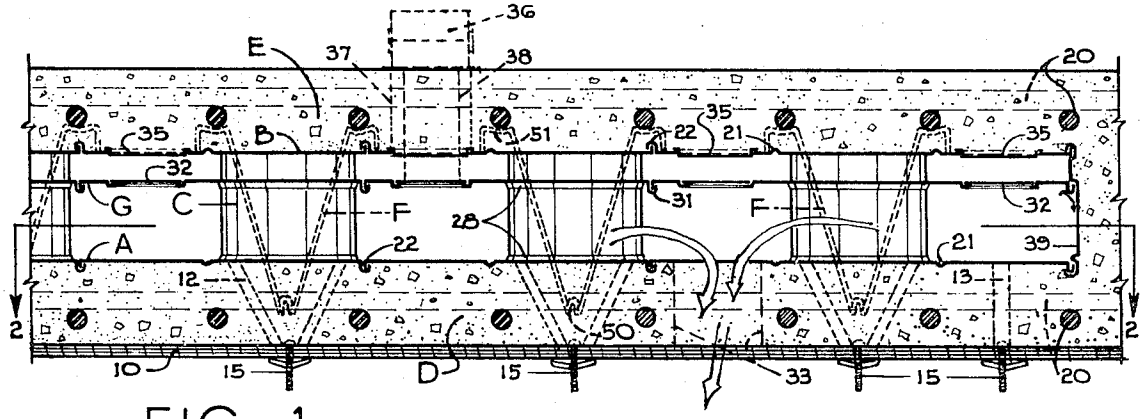


FIG. 1

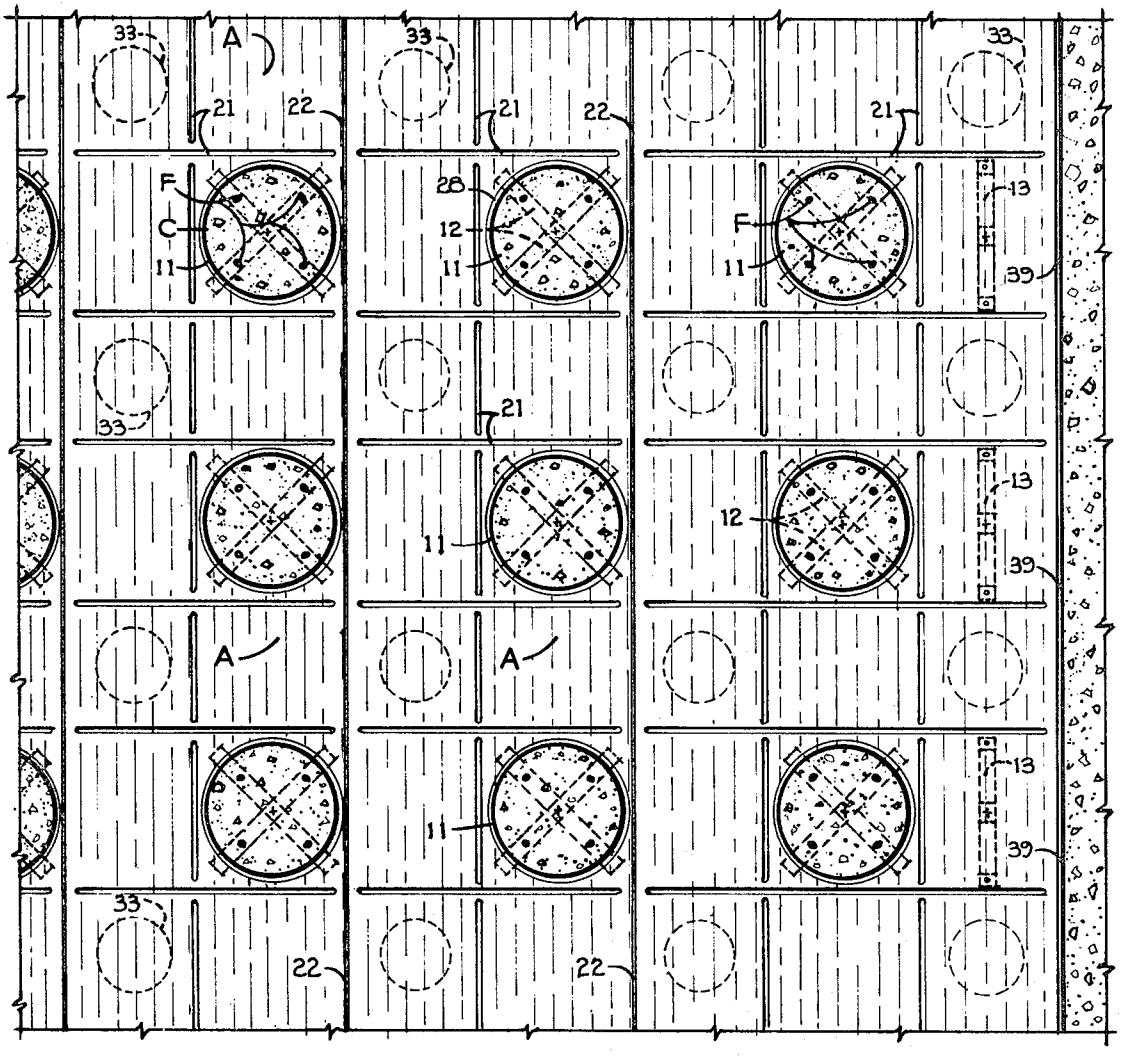


FIG. 2

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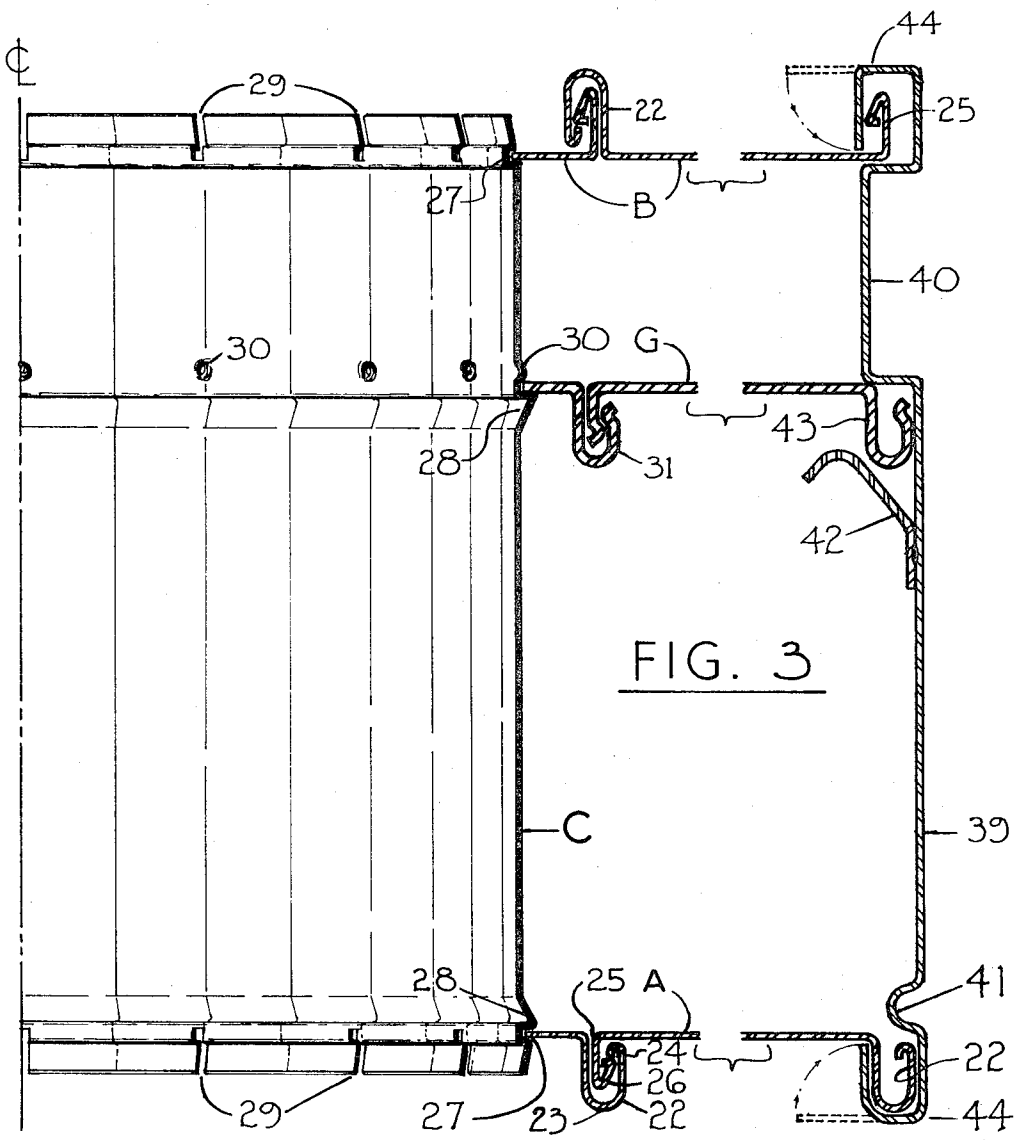


FIG. 3

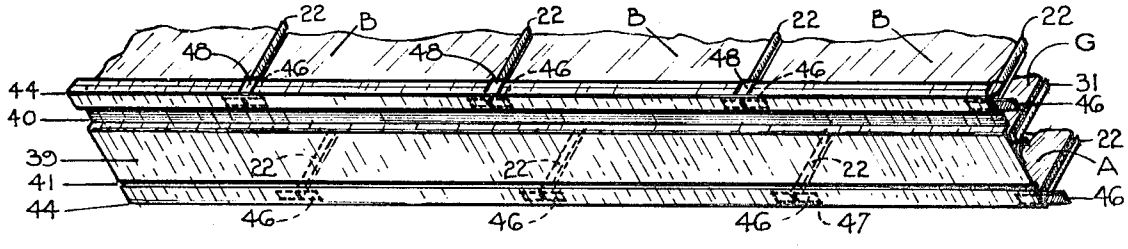


FIG. 4

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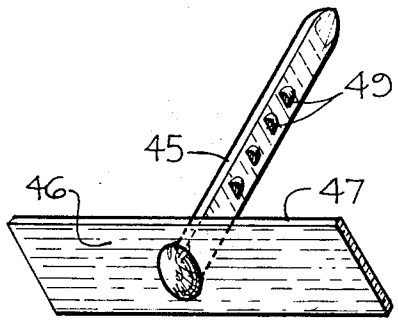


FIG. 5

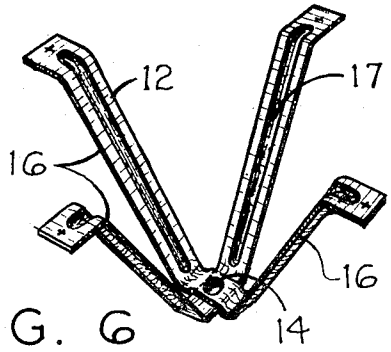


FIG. 6

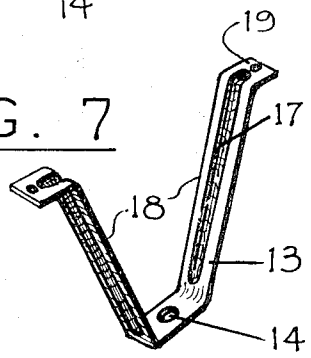


FIG. 7

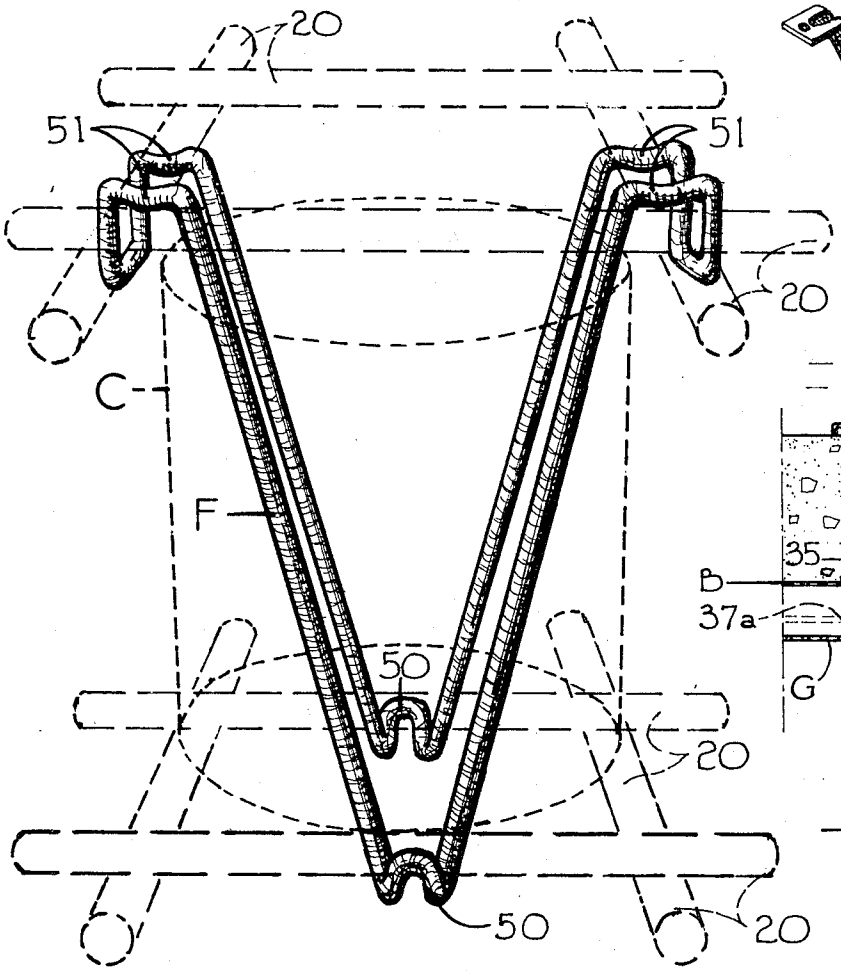


FIG. 9

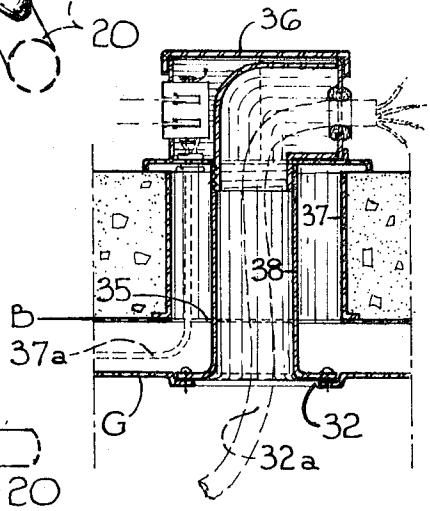


FIG. 8

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MONOLITHIC CONCRETE SLAB CONSTRUCTION

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Int. Cl. E04b 5/48, 1/38
U.S. Cl. 52—503 5 Claims

ABSTRACT OF THE DISCLOSURE

A slab construction for use in multistory buildings which includes a pair of spaced slabs being integrally joined by a plurality of vertically spaced cylindrical members. An omni-directional void is provided between the slab members for accommodating electrical wiring, air conditioning, passageways, etc. The entire slab construction is poured monolithically in concrete, so as to increase the shear strength of the cylindrical connectors.

This invention relates to a slab construction, and more particularly to a relatively lightweight floor construction which has an intermediate void therein for accommodating elements such as electrical wiring, air conditioning, passageways, etc.

Normally, a building floor system is composed of several separate systems which must occupy the space between the ceiling and the finished floor of the story above. These systems include the structural floor, the mechanical duct work provided for accommodating conditioned air, the electrical wiring, lighting fixtures, and ceiling diffusers. Plumbing is another system which is normally eliminated from the floor system by the use of centralized rest rooms having vertical chases or walls for accommodating the piping. The structural floor system is the primary one because all other systems must be fitted over, under, or through the structure to arrive at their point of outlet. In many cases, the duct work for the conditioned air and electrical wiring must pass under deep beams and girders, and the depth of the floor system must be increased to accommodate all the systems at the most congested point. For high rise buildings the depth of the floor system can be critical because this space is unusable for human occupancy and produces no income from rentability.

One of the primary objects of this invention is to create a structure that has high strength and incorporates the duct work within the center of the structure without impairing the strength of such substantially. While providing a void in the center of the structures, such also reduces the weight. Reinforced concrete is the logical vehicle for slab construction because of its moldability, continuity, rigidity, and very importantly, fire resistance. The usefulness of a void spaced within a slab is determined by its accessibility. One way tubular voiding, such as illustrated in U.S. Pat. No. 640,176, granted to Bremer on Jan. 2, 1900, requires some type of duct header at right angles to the tubes for the delivery of air to the tubes. The header duct must pass under the structure and thus the depth of the system is determined by the header ducts.

The slab system constructed in accordance with the present invention eliminates header ducts by having an omni-directional void into which air can be supplied at any point and let out at any point on the void. A floor

system requiring a flexible electrical distribution system has a header raceway space problem similar to that with air conditioning ducts. Using an omni-directional void for the electrical raceway eliminates header raceways. Wiring can be routed so that the number of wires in any one cross-section does not exceed that allowed by the electrical cords.

One of the problems encountered with a conventional waffle slab structure, for example, is that it is poorly suited for compression adjacent to column capitals or continuous walls. The slab system constructed in accordance with the present invention is designed to resist horizontal shear stress. Such is accomplished by joining the forms of an upper and lower slab by means of a plurality of horizontally spaced vertical cylindrical form members. This enables the concrete to be poured monolithically so that as such is poured in one of the cylindrical cylinders and fills the lower slab it is then extruded up through the other cylindrical members to form the upper slab. The cylindrical shape of the piers is equally able to receive stress from any direction and offers the minimum resistance to the passage of air around the piers. Since the horizontal shear stress of the piers is constant at each pier (proportional to the vertical shear stress at a given point), and since the tensile and compressive strength of the top and bottom slabs are no greater than at their least cross-section, a void space which is flat at top and bottom is therefore, the most efficient use of materials because the slabs are uniformly thick at all cross-sections. Passageways can be drilled through the upper and lower slab members for accommodating outlets. Primary use of the slab construction is where long spans are required or desired.

Accordingly, it is an important object of the present invention to provide a lightweight slab construction which has a void therein for accommodating wiring and conditioned air.

Another important object of the present invention is to provide a lightweight slab construction which includes a pair of vertically spaced slabs that are joined by a plurality of cylindrical shear connectors which are poured monolithically with the two slabs.

Another important object of the present invention is to provide a combination slab construction and form therefor, wherein the forms define the physical shape of the slab construction plus, they act as plenums for conditioned air and electrical wiring to be used in the building.

The construction designed to carry out the invention will be hereinafter described, together with other features thereof.

The invention will be more readily understood from a reading of the following specification, and by reference to the accompanying drawings, forming a part thereof, wherein an example of the invention is shown and wherein:

FIG. 1 is a cross-section through a part of a slab construction constructed in accordance with the present invention,

FIG. 2 is a horizontal plan section taken along line 2—2 of FIG. 1,

FIG. 3 is an enlarged elevational view, partially in section, illustrating the cylindrical form and a portion of the planar form members utilized therewith,

FIG. 4 is an enlarged perspective view, partially in section, illustrating the manner in which the space form

members are joined at the ends for closing the void intermediate the spaced slab members,

FIG. 5 is an enlarged perspective view illustrating a clip for attaching closures to the end of the form members,

FIG. 6 is an enlarged perspective form support utilized in conjunction with the cylindrical form members,

FIG. 7 is an enlarged perspective view of another type of form support,

FIG. 8 is a fragmentary sectional view illustrating conduit extending through one of the slab members, and

FIG. 9 is an enlarged fragmentary perspective view illustrating a portion of the reinforcement utilized in the circular connectors and slab members.

The drawings illustrate a slab construction which is suitable for use in multistory buildings that include a removable base supporting form member and a planar top form member A which is spaced from the base supporting form member. The planar top form member A has a plurality of circular openings therein. An upper supporting form member B is spaced above the top form member A defining a void therebetween. The upper supporting form member B has a plurality of circular openings therein aligned with the openings in the top form member A. A plurality of cylindrical forms C extend between the upper supporting form member B and the planar top form member A. Each provides a passageway between one of the openings in the upper supporting form member and a corresponding opening in the top form member. Concrete is poured in the cylindrical forms C to fill the space between the base supporting member and the top form member A to produce a lower slab D. As the concrete is continuously poured in the cylindrical forms and the lower slab is completed, it is then extruded through the other cylindrical forms onto the upper supporting form member B to form an upper slab E. Reinforcing members F are carried in the cylindrical form C for reinforcing the concrete therein, whereby a relatively lightweight slab construction having a high shear strength and an omni-directional void therein is produced. Additional form members, such as the planar form member G, are positioned within the void for producing ducts therein which can accommodate conditioned air and electrical wiring.

Referring in more detail to FIG. 1 of the drawings, the slab construction or floor structure is constructed upon a base form member **10** of plywood shored into position according to traditional practice. Vertically spaced above the base form member **10** is the top form member A which is constructed of sheet metal. The distance between the base form member **10** and the top form member A defines the thickness of the lower slab D.

Circular cutouts **11** are provided in the top form member A, and are spaced horizontally in an arrangement of columns and rows such as illustrated in FIG. 2. The upper supporting form member B is supported on the base form member A by suitable bracing **12** and **13**, respectively. The braces **12** are constructed of strap steel, such as illustrated in FIG. 6, and take the form of an inverted pyramid with a flattened tip or vertex in which a hole **14** is drilled for receiving a toggle bolt **15** that is used to bolt the braces **12** and **13** to the base form member **10**. The four legs **16** of the brace **12** extend upwardly and terminate in horizontal portions which are suitably welded to the top form member A adjacent the circular cutouts **11**. In order to add strength to the legs **16** longitudinal ridges **17** are stamped therein. The braces **13** are also constructed of strap steel, and are used adjacent the ends of the form member A for maintaining the base form member **10** and the top form member A separated. Such is triangular shaped and only has two legs **18** extending upwardly to a horizontal portion **19** which is welded (or otherwise attached) to the top form member A. It is also noted that longitudinal ridges are carried in the legs **18** for adding strength thereto.

Steel reinforcing rods **20** are laid in a crisscross pattern on the base form member **10**, such as illustrated in FIG. 9, prior to filling the space thereabove with concrete. The top form member A is a relatively long sheet metal section, flat except for stiffener ridges **21**, and extending lock seams **22** adjacent its long edges.

The lock seams **22** are formed by rolling the edge of the sheet metal into a U-shaped configuration **23** which terminates in an inwardly rolled edge **24** adjacent the top. The adjacent sheet metal member which forms part of the form member A has a downwardly turned edge **25** which terminates in an upwardly extending portion **26** which when placed in the U-shaped member **23** is locked down under the inwardly rolled edge **24** to secure together the adjoining sheets which form the top form member A.

The circular cutouts **11** are provided for receiving the snap-in cylinders or cylindrical form members C. The cylindrical form members C are constructed of light gauge sheet metal with recesses **27** spaced vertically therein for receiving the various sheet form members A, G and B, respectively. A restraining stop **28** protrudes outwardly adjacent the recess **27** for aiding in locking the form members within the recess. Radial cuts **29** spaced around the circumferential edges of the cylinder C enable the recess **27** to be compressed upon insertion of the cylindrical form C into one of the circular cutouts **11** in the member A, and to expand to lock the cylinders C into a fixed position, such as shown in FIG. 3. Projecting locks in the form of stamped bumps **30** are spaced around the circumference of the cylinder C adjacent where the planar form member G is to be placed for holding the form member G in position against another projecting restraining stop **28**. After the cylinders C are in place intermediate electrical support form member G with circular cutouts **11** corresponding to the shape of the cylinder C are snapped into position over the cylinder C and held in place by the bumps **30** and restraining stop **28**. The form member G is of heavier gauge sheet metal than form members A or B in order to meet electrical code requirements. The planar form member G is also constructure of a plurality of sheet metal pieces which are joined edge to edge in the same manner as the form member A by a standing lock seam **31**. The form members G have no stiffeners because of the heavier gauge metal used, but include flush circular access panels **32** which may be removed to allow telephone wires, computer wires **32*a***, etc., to pass therethrough from the air void space between forms A and G. Air conditioning access for ceiling fixtures are field drilled into form piece A to receive sleeves **33** and can be at any point corresponding to the dotted line positions illustrated in FIG. 2. The conditioned air can be supplied to the void between the slabs in any suitable manner, from any suitable means or source through passageways cut into the slabs or at the end of the slab construction.

After the form G is completed and snapped into position over all of the cylinders C, form piece B is attached to the top edge of the cylinders C in a similar manner as form A. Form B is identical to form A except for the orientation of the lock seam **22**. Such, also, includes circular access panels **35** with friction closure plates. The access panels **35** are suitably located and serve to attach the floor outlets **36** and conduit **37** wherever the electrical requirements of the building demands. The space between the form members B and E is for accommodating electrical power cables **37*a*** which can pass through conduit **37** into outlet **36** or the conduit **37** can serve as a floor access box for pulling wires. The conduit **37** used with concentric conduit **38** can provide both power and signal wiring to a single floor outlet **36**. It is to be understood that any suitable electrical fixture can be used in

place of the conduit **37** or floor outlet **36** to provide external access for the wire carried within the floor void.

With the form members A, B, C, G and the braces **12** and **13** in place, a form closure piece **39** is attached at peripheral conditions corresponding to spandrel beams, column capitals, and large floor openings, etc., to prevent concrete from filling up the void spaces. The form piece **39** is of somewhat heavier gauge metal than the form members A or B but lighter gauge than form member G, and includes indented portions **40** and **41** which act as stops for holding the form members A, B and G in relative position and, also, includes a spring clip stop **42** which cooperates with a downwardly folded end portion **43** of the member G for holding up the form member G. The spring clip member **42** is resilient and extends inwardly so that as the downwardly folded portion **43** is pressed against the upper turned-in edge it can be snapped into position between the end of the wall **39** and held flush thereagainst by the resiliency of the spring clip **42**.

Continuous tabs **44** are bent over the standing lock seam **22** of the form members A and B wherever they occur parallel to the closure piece **39** (see FIG. 3). Where the closure piece **39** occurs perpendicular to the standing lock seam **22** or **25** a shank portion **45** of a T-shaped auxiliary attachment clip **46** is driven into the end of the lock seams **22** so that the cross portion **47** provides a surface over which the form closure piece **44** can be bent to secure such thereto. Cuts **48** are provided in the form closure **39** adjacent the edge thereof to enable the tabs **44** to bend tightly over the seams **22** and **25** and to engage the pieces **46**. The cuts **48** are on the same spacing as the standing lock seams **22** and **25**. The shank portions **45** of the pieces **46** have a barb spike **49** which prevents the form closures **39** from pulling away from the form members A, B and G.

After the form member is completed the shear reinforcement members F (FIG. 9) are dropped into the cylindrical form member C and workmen squeeze the reinforcement member F in at the bottom so that a hook **50** carried adjacent the bottom thereof can engage the reinforcing rods **20** which are lying on the plywood base form member **10**. The bottom reinforcement **20** is then lifted clear of the plywood form member **10**, using the reinforcement members F as handles. The reinforcement members F are then spread apart at the top so that a downwardly turned portion **51** can rest on the upper form piece D and thus suspending the bottom reinforcing rods **20** at the proper position within the lower slab space according to structural design and fire protection requirements for the slab reinforcement. The shear reinforcing piece takes the shape of a tetrahedron bent out of one or more steel bars.

The upper portion of the downturned members **51** are slightly cradle shaped for accommodating the reinforcing rods **20** provided for the upper slab E so as to properly seat such at the desired height above the form member B in order to correctly position the top slab reinforcing rods **20** to meet the structural and fireproofing requirements.

The floor system is completed by pumping concrete under pressure down into every fifth or sixth cylindrical form member C on a square, these cylindrical form members having not been reinforced with the reinforcing member F, but which cylinders are reinforced after the pumping is completed. The concrete spreads out to form the lower slab D and extrudes up the adjacent cylinders C, and onto the form B where it can be spread and screeded to form the upper slab E, all in the same pour. The hose is then moved to the next pumping cylinder and the operation is repeated until the entire floor is completed. Mechanical vibrators are inserted into the cylindrical members C from above as the pumping proceeds to increase the area of the bottom slab that can be pumped from any one cylinder. After the slab has cured, the plywood base form member **10** is unbolted and removed leaving the toggle bolts **1** for attaching suspended ceilings or fixtures for the room below.

As can be seen, an omni-directional void is provided within a monolithic, flat floor slab which includes a pair of spaced slabs integrally connected by cylindrical members. The void space between the form members A and G serves as a continuous duct for the horizontal distribution of conditioned air, and the void space between the form members G and B serves as a separate, parallel raceway space for electrical wiring. The voided floor slab is like two reinforced concrete slabs spaced apart by cylindrical concrete piers between the slabs, and poured monolithically with the slabs. The piers are arranged on a square grid and have an open space on all sides of each pier. The resulting void space is uninterrupted adjacent to and parallel to any line of piers, and at right angles to that line at any point not on the grid line of the piers. All portions of the main void space for conditioned air are interconnected and are one space with the piers arranged to interrupt the space only at the intersection of the grid lines.

By providing a slab construction with a void therein, such as described, long spans can be achieved due to the fact of its relatively lightweight as compared to solid slabs. Conventional slab systems which are not formed monolithically obtain their resistance to horizontal shear solely through reinforcing members with a minimum amount provided by the concrete itself.

While a preferred embodiment of the invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.

What is claimed is:

1. In combination a slab construction comprising: a removable base supporting form member; a planar top form member spaced from said base supporting form member; said planar top form member having a plurality of openings therein; an upper supporting form member spaced above said top form member defining a void therebetween, said upper supporting form member having a plurality of openings therein aligned with said openings in said top form member; a plurality of cylindrical forms extending between said upper supporting form member and said planar top form member each providing a passageway between one of said openings in said upper supporting form and a corresponding opening in said top form member; a unitary concrete body including a lower slab being defined by a space between said base supporting form member and said top form member, and cylindrical piers extending through said cylindrical forms and terminating in an upper continuous monolithic structure; means for anchoring said top form member to said base supporting member, and reinforcing members carried in said cylindrical forms for reinforcing the concrete therein whereby a relatively lightweight slab construction having a high horizontal shear strength is produced.

2. The slab construction as set forth in claim **1**, wherein ducts extend through at least one of said slabs, means joining the perimeter of said slabs for providing sealed passageways therebetween, means for supplying conditioned air to said passageways allowing such to pass out said ducts whereby when said slab constructions are used in a multistory building as a ceiling for one story and a floor for the adjacent story conditioned air can be fed through the slab construction into the building.

3. The slab construction as set forth in claim **1**, wherein said top form member and said upper form member are constructed of sheet metal, said cylindrical forms each having retaining means thereon for engaging, said form members adjacent the perimeter of said openings for supporting said form members.

4. The structure as set forth in claim **2**, wherein said means for anchoring said top form member to said base supporting form member provides connections adjacent

said cylindrical forms whereby as said concrete is poured in at least one of said cylindrical forms into the space between said base form and said top form to fill said last mentioned space, the concrete extrudes up through said cylindrical forms to produce said upper slab.

5. A slab construction comprising: a substantially planar concrete lower slab, an upper concrete slab spaced vertically from and parallel to said lower slab, a plurality of horizontally spaced concrete vertical shear connectors positioned between said upper and lower slabs, each vertical shear connector having a lower end integral with said lower slab and an upper end integral with said upper slab, said concrete shear connectors having embedded therein a double V-shaped reinforcing member having four bars in shear aiding in producing high horizontal shear resistance at the junction of the upper and lower slabs with said vertical shear connectors so that said spaced slabs and said joining vertical shear connectors form a rigid continuous monolithic structure, said slabs and connectors having been poured in a single continuous pouring operation producing said monolithic structure, said upper and lower slabs and said vertical shear connectors defining a plurality of criss-crossed intersecting passageways for providing access to the majority of the

inner portion of said slabs; and means for supplying conditioned air to said passageways to be conveyed horizontally relative to said slabs, whereby a relatively lightweight slab construction having a high horizontal shear strength is produced which is capable of long spans.

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