Jan. 11, 1966 R. S. LEVINE 3,229,004

METHOD OF MOLDING STRUCTURAL MATRICES

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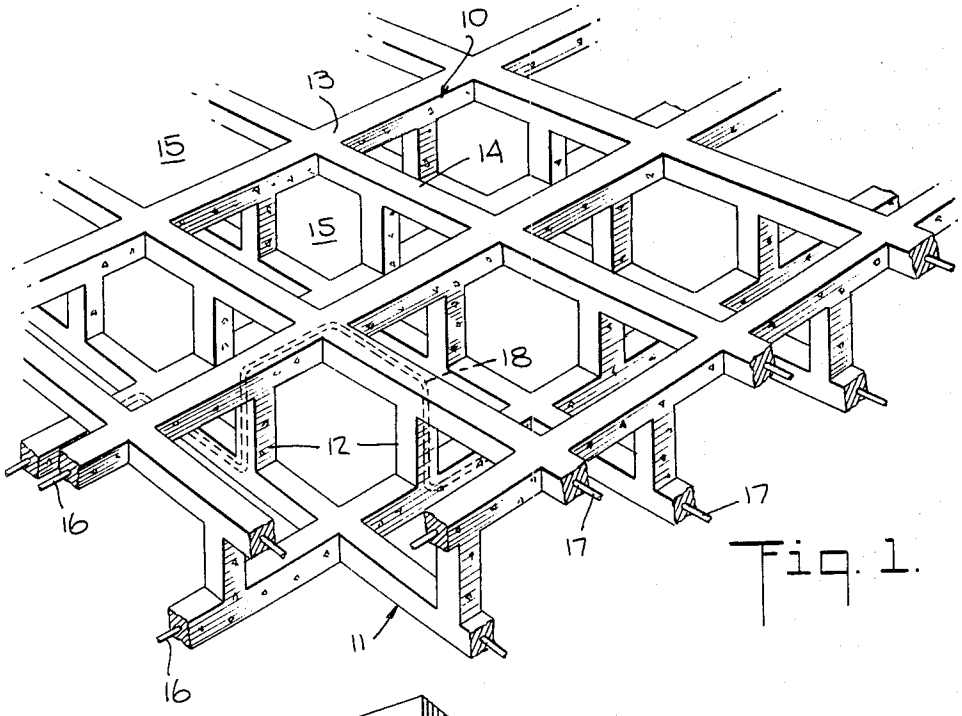


Fig. 1.

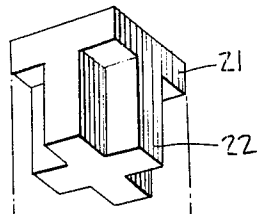
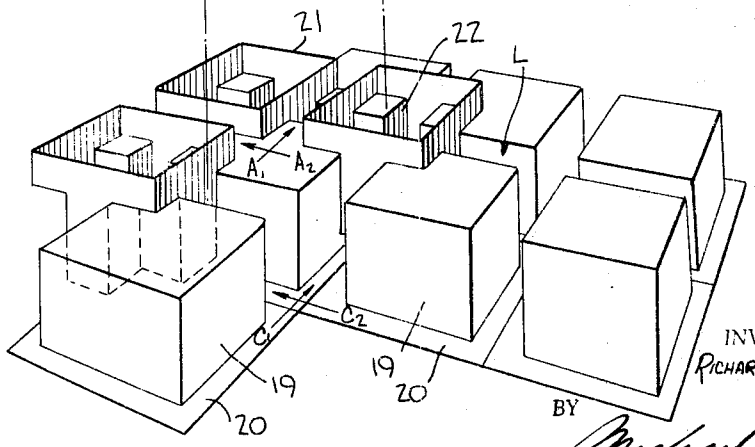


Fig. 2.



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Fig. 3.

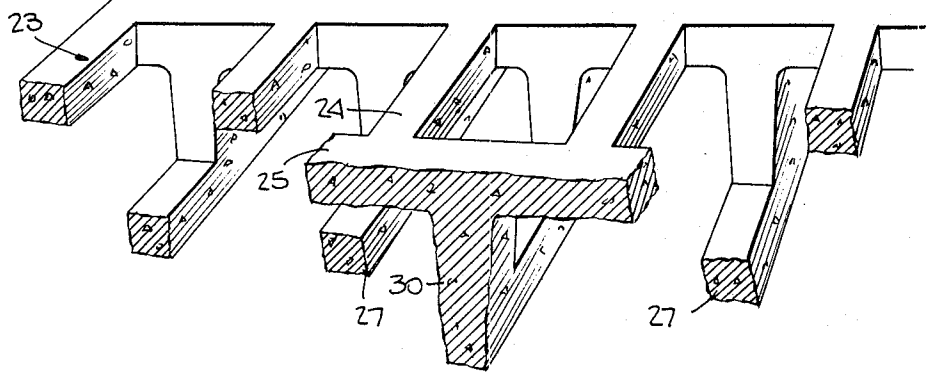
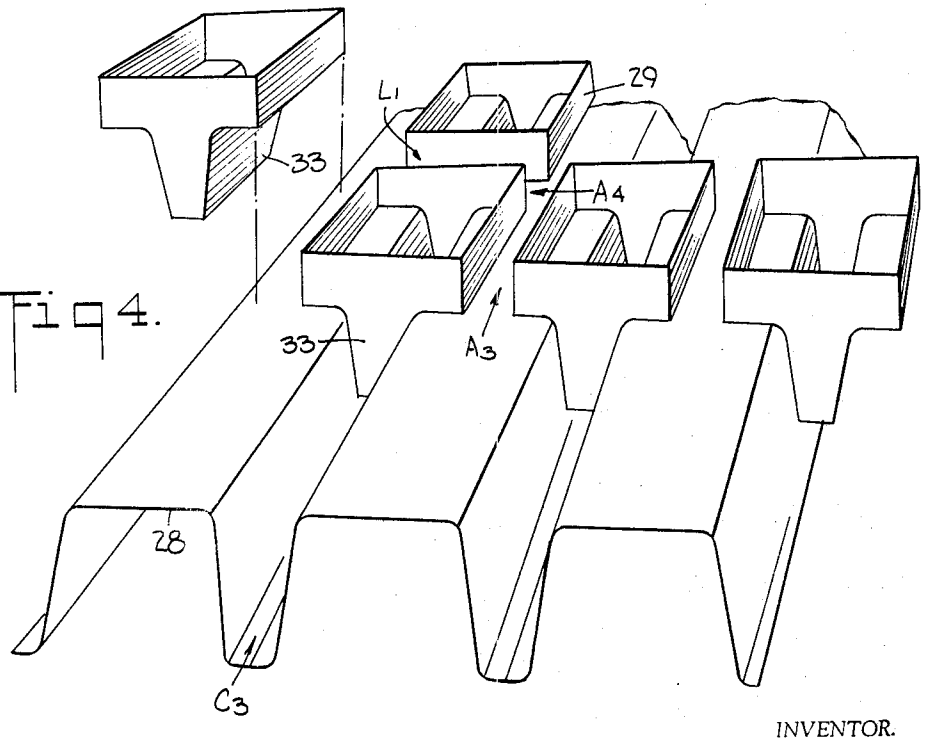


Fig 4.



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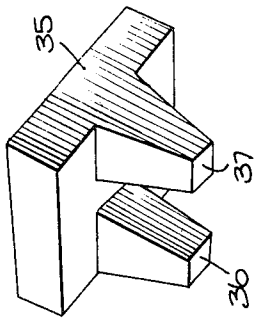


Fig. 6.

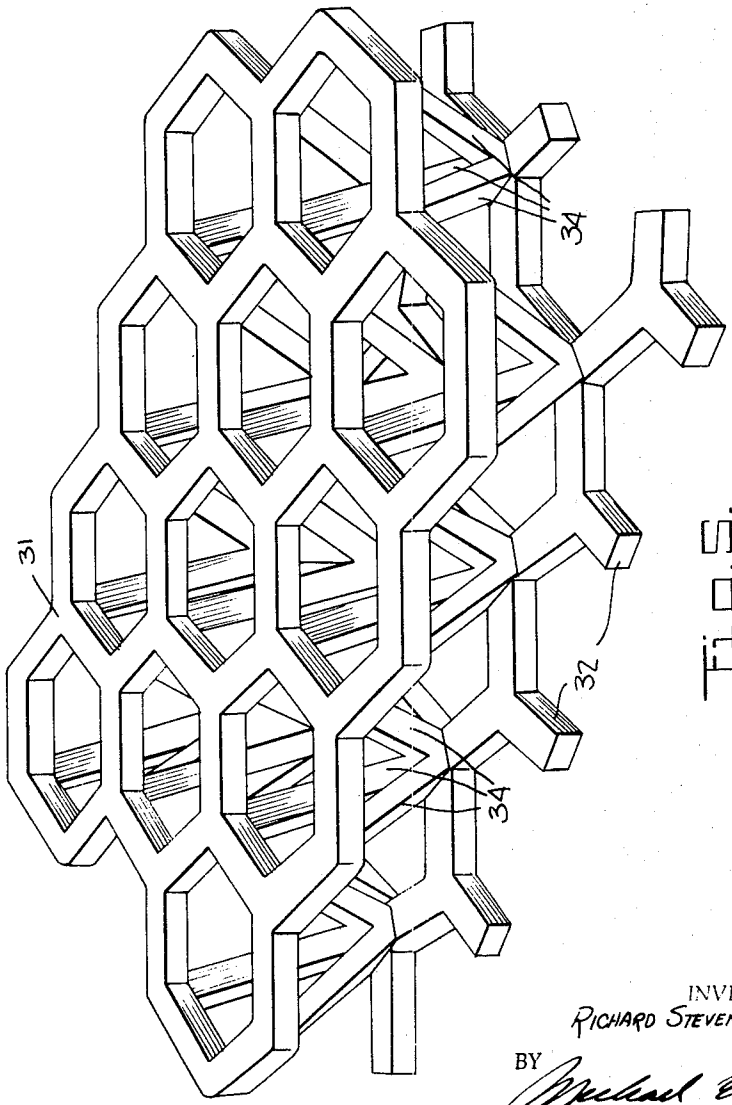


Fig. 5.

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United States Patent Office 3,229,004 Patented Jan. 11, 1966

3,229,004

METHOD OF MOLDING STRUCTURAL MATRICES

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Filed Oct. 17, 1963, Ser. No. 316,869
4 Claims. (Cl. 264—31)

This application is a continuation-in-part of my pending patent application Serial No. 117,876, filed June 19, 1961, entitled "Building Construction," now abandoned.

This invention relates generally to spanning structures, and more particularly to a method for molding an integrated, multicellular spanning structure of reinforced concrete which is adapted to function effectively both as structural load-bearing element and as a matrix for containing building facilities such as plumbing lines, lighting systems, and the like.

In architectural terms, a building may be regarded as a machine for living or a structural organism, hence its total composition involves more than an enclosure whose skeletal frame is divided into stories and rooms. The internal areas encompassed by the floors, ceilings, and walls must be designed to support human activity, and for this purpose provision must be made for lighting, heating, plumbing, air-conditioning, communications, and other electrical and mechanical facilities called for in modern structures.

Various forms of spanning systems in reinforced concrete are currently in use, the concrete being cast into slabs serving as wall panels, floors or other structural elements. In some instances, the slabs are in attenuated form wherein those areas of concrete which are structurally ineffective are excised, thereby reducing the weight of the span without appreciably affecting its load-bearing capacity. Although such attenuated concrete slabs attain some degree of economic and structural efficiency, such savings as are gained from their initial configuration are considerably lessened when the necessary electrical and mechanical duct work and other facilities are attached or combined with the initial structure.

For example, it is generally the practice, after having formed a primary structure of reinforced concrete, to suspend the various mechanical and electrical components from the concrete slabs and to then hang a false ceiling therebelow to conceal these components. This gives rise to a substantial loss in available room volume. It is evident, therefore, that any initial attenuation in the structural forms is diminished in value when these forms are effectively aborted by the various facilities essential to modern architecture.

Accordingly, it is the principal object of this invention to provide a method of casting an integrated, multicellular matrix of reinforced concrete which is adapted to function as a spanning element in the formation of the primary structure of the building, and at the same time to accommodate all secondary functional aspects of the building.

More specifically, it is an object of the invention to provide a novel, high-speed method of molding a matrix of reinforced concrete, which method is efficient and economical, the matrix being constituted by two planar grids in parallel relation joined together by cross-pieces, whereby the load-bearing components are concentrated in the upper and lower planes, the cross-space therebetween containing voids for the inclusion of the functional systems.

Also an object of the invention is to provide a matrix of the above-described type, which attains high stress strength with extremely low weight, and thereby effects substantial savings in transportation and construction costs. A significant advantage of the invention is that it does away with the need for hung services or false ceilings, in that the service components or facilities may be run internally or contained within the matrix or plenum

itself. Hence while the depth of the three-dimensional, integrated matrix may be increased to compensate for the loss of material, the overall room volume is nevertheless increased, inasmuch as the need for a false ceiling is obviated.

Another salient advantage of the invention resides in the fact that the matrix is constituted by open cells or cubicles which communicate with each other, hence functional components may be installed within individual cells and duct work and conduit may be run through the cells without permanently imprisoning these elements, thereby making these elements readily accessible for future repair or replacement.

Briefly stated, these objects are accomplished in a novel method for fabricating an integrated, multicellular matrix formed of reinforced concrete and constituted by two, planar, open-work grids which are disposed in parallel relation with their openings offset from each other, the grids being joined into a unitary structure by cross-pieces, the method involving the use of intermeshing male and female mold sections which together define a negative impression of the matrix.

The female section is formed of a waffle-like assembly of uniformly spaced pans, the channels between the pans having the configuration of the lower grid. The male section is formed by an array of individual pans which lie across adjacent female pans and are provided with projections which are received in the channels, the male pans being so distributed whereby the alleys between the male pans define the configuration of the upper grid, while the spaces between projections inserted in the channels form passageways interconnecting said channels and said alleys to define the configuration of the cross-pieces.

By varying the geometry of the male and female sections, various forms of integrated matrices may be fabricated, in which the openings in the grids are square, rectangular, hexagonal or in any other geometric form, and in which the cross-pieces extend perpendicularly relative to the grids or at an angle with respect thereto.

For a better understanding of the invention, as well as other objects and further features thereof, reference is made to the following detailed description to be read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view of one embodiment of an integrated matrix of reinforced concrete made by a method according to the present invention;

FIG. 2 is a perspective view of the two male and female mold sections in accordance with the invention, for forming the integrated matrix shown in FIG. 1;

FIG. 3 is a perspective view of another embodiment of an integrated matrix made in accordance with the invention;

FIG. 4 shows the two mold sections required to produce the matrix illustrated in FIG. 3;

FIG. 5 is still another form of monolithic matrix made in accordance with the invention; and

FIG. 6 is a view of a modified form of male pan.

Referring now to FIG. 1, there is shown one preferred form of integrated, multicellular matrix made in accordance with the invention, the structure being formed entirely of reinforced concrete and being constituted by two, planar, open-work grids disposed in spaced parallel relation, generally designated by numerals **10** and **11**, which are joined into a unitary structure by cross-piece **12**. Each grid is constituted by longitudinally extending arms **13** which are intersected by transversely extending arms **14** to form the boundaries of square openings **15**.

The openings in the two grids are offset from each other by half a square, so that each connecting cross-piece **12**, joins a longitudinal arm of one grid to a transverse arm of the other. Thus each opening, on either side

of the matrix, looks into an open cubicle whose boundaries are defined by an intersection of a longitudinal and transverse arm in the opposing grid and by four cross-pieces. It will be evident that conduit, ducts and various other lines may be run through the cubicles, and that functional components may be installed therein with ready access thereto.

Extending through the longitudinal arms **13** of both grids are reinforcing rods **16**, while extending through the transverse arms **14** are reinforcing rods **17**. And as shown in phantom in FIG. 1, also provided are reinforcing rods **18** in a formation which passes laterally through the cross-pieces into the transverse and longitudinal arms and back and forth through the two grids, to reinforce the structure against shear forces and bending moment forces. Thus the rods are woven through the matrix to form an interlacing reinforcing network.

The system shown in FIG. 1 may be regarded as a square slab perforated both horizontally and vertically. In plan view it appears as two rectangular, planar grids offset half a square from each other, and connected by a vertical member where the grids cross one another. This creates a two-dimensional, rectangular truss with horizontal voids running in two perpendicular directions and along the diagonals.

The major constructional advantage of this matrix is its ease of forming. In spite of its apparent complexity, only one set of complementary forms is required, this being illustrated in FIG. 2. The mold for the matrix is based on a novel coupled pan principle and is constituted by a female section formed by an assembly of identical square pans **19**, each provided with a rectangular flange **20**, the pans being symmetrically arranged whereby the resultant waffle-like iterative arrangement is effectively constituted by block-shaped mounds separated by longitudinal and transverse channels C_1 and C_2, as indicated by the arrows, whose lattice-like configuration corresponds to the configuration of the lower grid of the matrix.

Intermeshing with the female mold section is a male section constituted by an aray of individual pans **21** also of square shape, the pans being provided with a cruciform projection **22**. Each male pan is seated symmetrically at the junction of four female pans with the cruciform projection extending into the intersection of a longitudinal and transverse channel C_1 and C_2. Thus the longitudinal and transverse alleys A_1 and A_2, as indicated by the arrows, formed in the spaces between the male pans, correspond to the configuration of the upper grid in the matrix, whereas the lateral passageways L formed between adjacent sides of the cruciform projections **22** and which connect the alleys and channels define the molding spaces for the cross-pieces **12**.

The interfitting male and female sections, when put together, in effect constitute a negative impression of the three-dimensional, monolithic matrix, such that when the spaces defined between the molds are filled with concrete, the resultant structure forms the desired positive impression.

In practice, the constructional procedure is as follows: First the female mold forms are set up and the reinforcing bars for the bottom grid are put in place. Next the shear reinforcing rods are placed and attached to the bottom bars. The male forms are then inserted and locked by suitable means to the female forms. Thereafter the top grid-reinforcing rods are put in place and fastened to the shear reinforcing rods.

The concrete is then poured into the passageways, alleys and channels noted above, with concrete of suitable consistency, accompanied by vigorous internal and external vibration. In practice, the molds may be constructed of fiber glass reinforced plastic, and are rigidly connected so as to withstand this treatment. After proper curing of the concrete, the forms are removed.

Among the advantages of the matrix formed in the above manner, are the following:

(1) Instead of sheet metal ducts, pre-cut fiber panels placed between the cross-pieces, together with the floor and ceiling enclosing the grid, may be used to create air ducts.

(2) The whole structure is useable as a low-pressure air plenum, or the matrix may be divided by fiber panels into a system of supply and return low-pressure air plenums.

(3) Precast in-fill panels may be set into the cells of the matrix and used as floors, some panels containing electrical and telephone outlets, the panels being removable for changing requirements.

(4) Cast-in-place, in-fill panels may be bonded by epoxy to the matrix to enhance its load-carrying capacity.

(5) The matrix may be used to contain lighting and ventilation registers.

(6) The matrix is capable of direct bearing for partitioning systems.

(7) The half-a-square, offset nature of the matrix may be used as a means for spatial articulation in openings and edges of the system and for creating changes in level.

The coupled pan mold principle disclosed above is not limited to square cubicle configurations, nor is it limited to the formation of two grids having identical configurations. Thus, as shown in FIG. 3, it is possible to produce a monolithic matrix in which the upper grid **23** is formed by longitudinal arms **24** and intersecting transverse arms **25**, whereas the lower grid **26** is formed only of longitudinal arms **27**, the two grids being connected by cross-pieces **30**.

The mold formation for carrying out this configuration is illustrated in FIG. 4, where the female section is a unitary sheet having an undulatory formation which defines an assembly of elongated mounds **28** separated by longitudinal channels C_3 providing the configuration of the lower grid. An array of square male pans **29** is provided, having slab-like projections **33** which are received in the channels and are so spaced as to form longitudinal alloys A_3 and transverse alleys A_4 having the configuration of the upper grid. The lateral passageways L_1 between adjacent slabs **33** define the cross-pieces **30**. The matrix is otherwise fabricated in the same manner as that shown in FIG. 1.

In FIG. 5, another version of the matrix is shown, the two grids **31** and **32** having hexagonal openings which are offset relative to each other. Each cell of the upper grid **31** is connected to the bottom grid **32** by three cross-pieces **34** which join together at a common apex at the bottom grid, whereby the resultant cubicles have essentially conical boundaries. Thus male and female mold sections to form this matrix, must be so arranged as to provide a negative impression of the desired matrix.

FIG. 6 shows another form of male pan which may be used in place of pan **21** in FIG. 2 to form a more solid matrix system with occasional voids, the pan including a square portion **35** and a pair of projections **36** and **37**.

While there have been shown several preferred embodiments of integrated matrix in accordance with the method of the invention, it will be obvious that many changes may be made without departing from the essential spirit of the invention as defined in the annexed claims.

What is claimed is:

1. The method of fabricating an integrated multicellular matrix formed of two identical planar open-work grids disposed in parallel relation with their openings offset relative to each other and joined together by cross-pieces: said method comprising the steps of intermeshing a male mold section with a female mold section, the female mold section being constituted by an assembly of uniformly spaced pans separated by a network of channels whose configuration corresponds to the lower grid of the matrix, the male mold section being constituted by an array of

uniformly spaced pans each of which lies across at least two adjacent female pans and is provided with a projection which is received in the channel therebetween, the spaces between said male pans forming alleys corresponding to the configuration of the upper grid of said matrix, the spaces between adjacent projections forming passageways which connect said alleys and said channels and which correspond to the configuration of said cross-pieces, inserting rods which are bent to extend through said channels, said passageways and said alleys, whereby said rods interconnect the upper and lower grids through said cross-pieces to reinforce said matrix against shear forces, said channels, said alleys and said passageways intercommunicating with each other to define a three-dimensional negative impression of said matrix; filling said channels, said alleys and said passageways with moldable concrete to form a positive of said matrix, and removing said male and female mold sections to free the multicellular integrated matrix therefrom.

2. The method set forth in claim 1 wherein said molds are formed by fiber glass-reinforced plastic material.

3. The method set forth in claim 1 wherein said grids are formed by intersecting longitudinal and transverse arms forming square openings.

4. The method as set forth in claim 1 wherein said female pans have a block-like shape and said male pans are each formed of a square pan having a cruciform projection.

References Cited by the Examiner

UNITED STATES PATENTS

918,231	4/1909	Warren	264—225 XR
2,891,397	6/1959	Hauer	50—270 XR

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