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METHOD AND APPARATUS FOR BUILDING CONSTRUCTION

Filed Aug. 19, 1963

3 Sheets-Sheet 1

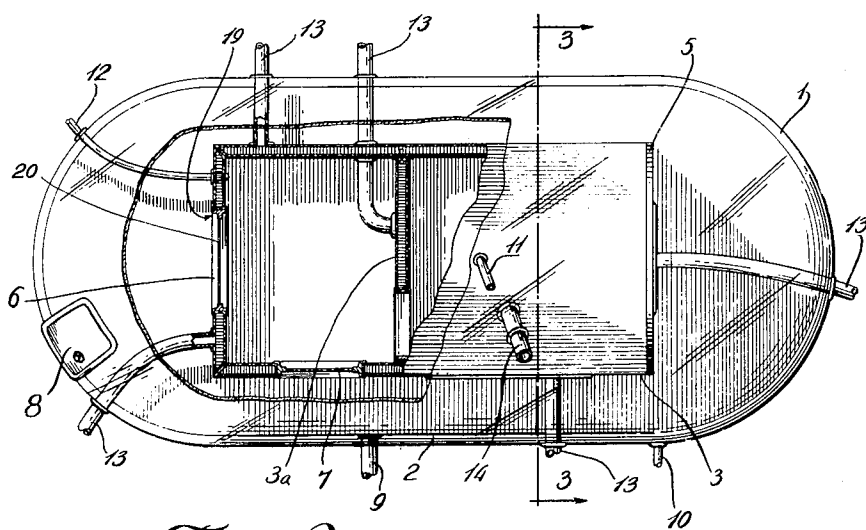
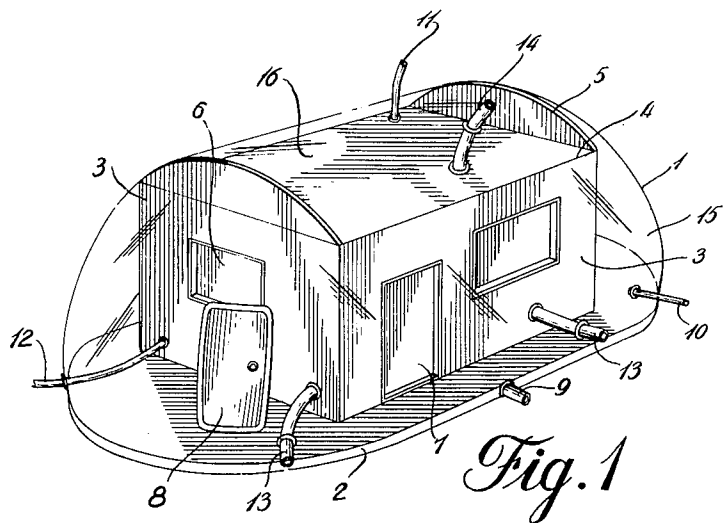


Fig. 2

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3 Sheets-Sheet 2

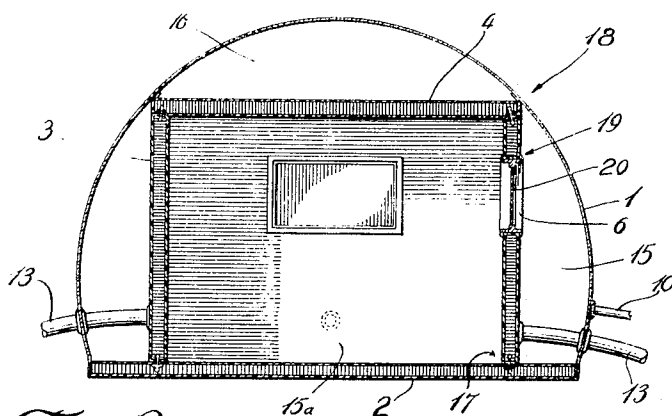


Fig. 3

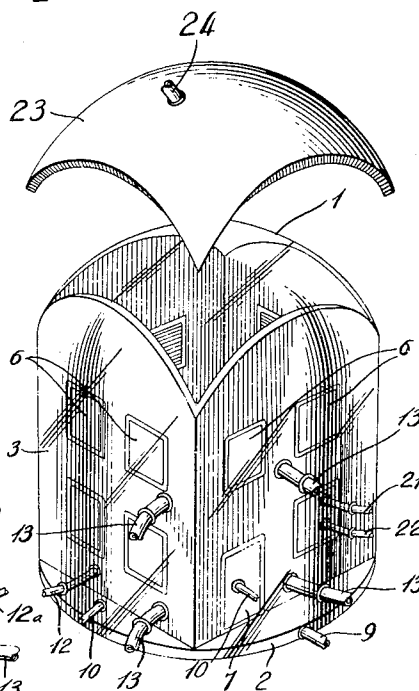


Fig. 4

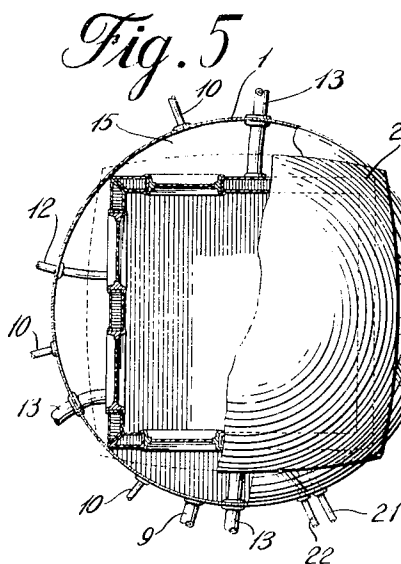


Fig. 5

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METHOD AND APPARATUS FOR BUILDING CONSTRUCTION

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15 Claims. (Cl. 264—34)

This invention relates to improvements in the construction of buildings.

Applicant's co-pending U.S. application Serial No. 239,557 of November 23, 1962, discloses a method of making a building structure through the use of a double layer mold with an inner inflatable chamber, said mold being manufactured from flexible and substantially inextensible fabric and forming, after inflation of the chamber, the confines of the building structure. According to that method a premixed material is introduced between the layers of the inflated mold and is allowed to cure or set therein to produce the desired solid structure.

Such a method is, of course, perfectly applicable to semi-spherical, semi-cylindrical or generally curved structures, since the inflation of the double-layer mold invariably results in a curved shape. This, however, makes it impossible to form conventional buildings with flat ceilings and straight walls and thus limits considerably the field of application of said method.

It has now been found that it is possible to overcome the above mentioned inconvenience while maintaining the advantages obtained through the use of double-layer molds.

According to the new process, as hereinafter disclosed, there is provided a supporting, single-layer, membrane of a semi-spherical, semi-cylindrical or generally curved shape and consisting of flexible and substantially inextensible, air-tight fabric. This membrane is adapted to be inflated and to support double-layer molding jackets which constitute different parts of the building (such as walls, ceiling, etc.) and which are attached to said membrane by their appropriate edges. In turn, the molding jackets are filled with a premixed material which sets therein and forms a solid building structure with straight walls and a flat ceiling, as it is usually required in the building industry.

The supporting membrane itself is attached by its lower edge to a solid or solidifiable base which may also be ultimately used as the floor for the building.

The supporting membrane and the molding jackets forming different parts of the building are usually manufactured and appropriately assembled or connected to each other in a factory; then, they are transported to a chosen site where the base is solidified (if it is not solid to begin with), the membrane is inflated and the molding jackets are filled with adequate premixed materials.

During the manufacture of such a molding combination it is desirable to provide the eventual walls of the building with doors and windows by cutting them out in the molding jackets and by sealing the thus opened edges of the double layer structure. It is equally preferable to pre-equip these molding combinations with proper wiring and piping systems so that when the building is ultimately erected on a chosen site, it would be complete with all required facilities.

As will be described hereinafter, multi-storey buildings can also be constructed in this manner.

Summarizing, the basic concept of the novel process is a provision of a flexible single-layer membrane which can be inflated and onto which the double-layer molding jacket structure, constituting the walls and the ceiling of the eventual building, is appropriately connected

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for support thereby. Therefore, when the membrane is inflated producing a curved envelope, its shape does not affect that of the molding jacket structure of the walls and ceiling thus permitting a formation of a building of square or rectangular shape. After erection of such a building the supporting membrane is removed and discarded or reused for similar purposes.

It is therefore a principal object of the instant invention to provide a process and a flexible or semi-flexible molding combination for erecting buildings with conventional shapes (i.e., straight walls and flat ceilings).

Another object of the invention is to provide an entirely pre-equipped molding combination which can be used to erect a building with all modern facilities.

A further object of the invention is to provide a process and a molding combination for the erection of multi-storey buildings in a simple and exceptionally economical manner.

These and further objects and features of the invention will become apparent from the following detailed description and accompanying drawings wherein:

FIG. 1 is a perspective view of a one-storey building according to the present invention in combination with the supporting membrane;

FIG. 2 is a top view of the building shown in FIG. 1, partly broken away and partly in section to show internal structure;

FIG. 3 is a cross-section taken along line 3—3 of FIG. 2;

FIG. 4 is a perspective view of a two-storey building according to the invention with the roof shown exploded;

FIG. 5 is a top view of the building shown in FIG. 4, partly broken away and partly in section to show internal structure;

FIG. 6 is a side view of the building shown in FIG. 4, also partly broken away and partly in section to show internal structure;

FIG. 7 is an enlarged section view of an upper corner of a building according to the instant invention showing internal fabric structure of the molding jacket as well as the attachment of wall to ceiling and of both to the supporting membrane;

FIG. 8 is an enlarged section view of a construction at the top of a pre-fabricated door or window in a building according to the present invention;

FIG. 9 is an enlarged section view of an upper corner of a building according to the instant invention showing internal fabric structure of the molding jacket as well as the attachment of wall to a curved roof;

FIG. 10 is an enlarged section view of an attachment of wall to base in a building according to the instant invention, also showing the internal fabric structure of both;

FIG. 11 is an enlarged section view of an inter-floor structure in a multi-storey building according to the instant invention, also showing three fixing corks used to permit better adherence of the premixed material within the molding jacket; and

FIG. 12 is an enlarged section view of a reinforcing beam attached to a ceiling in a building of the instant invention.

The invention will now be described in detail with reference to the accompanying drawings in which like parts are designated by like reference numerals.

It should first of all be understood that the invention comprises two distinct stages carried out separately from one another and consisting in (1) manufacturing a molding combination for a building and (2) using said combination on a selected site for constructing the building.

Referring now more specifically to FIGS. 1 to 3 which show a single-storey building structure, the molding combination in this particular case is manufactured by producing a curve-shaped, single layer, membrane or envelope 1, made of flexible and substantially inextensible air-tight fabric, and attaching it by its bottom open edges to a base 2. The membrane or envelope 1 is preferably made of transparent plastic sheets or impregnated cloth and the base 2 can either be solid or can preferably consist of a flexible double layer molding jacket structure the two layers of which are connected by a plurality of strings or strips, said structure being adapted to receive suitable premixed materials, such as concrete, which would set and solidify therein.

Within the space defined by the membrane or envelope 1 and the base 2 there is provided a plurality of separate double layer molding jackets constituting vertical walls and at least one horizontal ceiling of the ultimate building, which molding jackets are appropriately connected both to the envelope and the base. Thus, the walls of the building 3 and the ceiling 4 are made of a plurality of isolated double-layer molding jacket structures the layers of which consist of flexible and substantially inextensible fabric and are interconnected with a plurality of strings. The walls 3 are attached with their bottom ends to the base 2 and with their upper edges to the ceiling 4 and/or the supporting envelope 1. Additional solid and appropriately curved extensions 5 may also be provided for adequate attachment of the ceiling to the said envelope, particularly when the resulting building is to have an elongated shape.

It is furthermore preferable to cut out windows 6 and doors 7 at the stage of the manufacture of the molding combination and to seal the cut edges as well as to provide them with necessary frame-work as shown at 19. Such doors and windows are then usually closed with an impermeable membrane 20 so as not to disturb the pressure distribution in different compartments of the combination at the time of the construction of the building.

During the manufacture of the molding combination it is of course desirable to provide the eventual building not only with doors and windows but equally with inside partitions such as wall 3a, as well as with other commodities as electrical wiring, piping, etc. These can be incorporated into said combination with relative ease.

A tightly closable door 8 may be included in the supporting envelope for the purpose of on site inspection and repairs.

The walls 3 and ceiling 4, together with the extensions 5, are so attached to the supporting envelope (for instance as shown at 18) as to form two compartments 15 and 16 separated from one another in an airtight manner. Other such compartments, such as 15a, may be confined by walls, ceiling and different partitions of the building inside said envelope. Finally, it should be noted that the thus formed flexible or semi-flexible molding combination is fitted with appropriate inlet and valve means for the introduction of compressed air into different compartments formed inside the envelope and for injection of pre-mixed materials into the molding jackets constituting the base, the walls, the ceiling, the partitions as well as other fixtures of the ultimate building. These inlet and valve means are represented in FIGS. 1 to 3 by tubes 9, 10, 11, 12, 13 and 14.

The expression "semi-flexible molding combination" has been used above to indicate that in case when the base 2 is solid to begin with, the resulting mold will not be entirely flexible. Also, the frame-work employed for doors and windows, the extensions 5, whenever used, as well as piping and other similar fixtures usually consist of solid non-flexible material. Nevertheless, after its completion and especially when the base 2 is flexible, the obtained molding combination can easily be folded into a relatively compact package and transported to the place where the building is to be erected.

The second stage of the invention, namely the construction of the building on a selected site, is commenced by firmly fixing the base 2 to the ground, if it is solid, or by injecting a premixed material, such as concrete, through a conduit such as 9 between the two layers of said base, if the latter is formed of a flexible double-layer jacket structure, and allowing said material to solidify. It is, of course, understandable that whenever the base 2 is solid to begin with it cannot be made of a very heavy material that would be prohibitive as regards the transportation of the molding combination and, such solid base, would therefore have to be firmly attached to the ground on the selected site by mechanical means. On the other hand, when the base consists of a flexible double layer jacket, the latter can be filled with heavy premixed material, such as concrete, and no further attachment to the ground would usually be required in such circumstances.

The following step would be to inflate the compartments such as 15, 15a and 16, within the membrane or envelope 1, with compressed air through conduits 10, 11 and 12 until the walls of the building are risen to their vertical position. It should be noted that these walls can only be straight when a same pressure prevails in both compartments 15 and 15a. This can be easily accomplished by inflating these compartments from the same source of compressed air or, in simpler constructions, by leaving the prefabricated doors and windows open.

When the walls 3 and the partitions 3a (whenever they are present) are so erected, a premixed material is injected into each of said walls through inlets 13 and is allowed to set or cure therein until solid. After solidification of the walls, a premixed material is injected through the inlet 14 into the ceiling 4 and the pressures in compartments 15a and 16 are so adjusted as to obtain a flat horizontal ceiling. The required pressures for the respective spaces are easily calculated and can also be applied in advance. Thus, if P is the pressure in compartment 15a and W the weight of the premixed material injected in the ceiling per unit area, in order to produce a flat ceiling the pressure P_1 in the space 16 would have to be:

$$P_1 = P - W$$

all quantities of the equation being expressed in same units.

It is, of course, obvious that if any adjustments in the pressures in compartments 15a and 16 are to be made to produce a flat ceiling, they must be carried out before solidification of the premixed material in said ceiling.

When the ceiling 4 has been solidified, all the compartments (15, 15a and 16) within the envelope 1 are deflated and the envelope along with the tubing 9 to 14 is removed. The solid extensions 5 can also be removed or they can be maintained and used in the construction of a roof. The base 2 can be left intact or it may be somewhat modified for decorative purposes. To complete the operation, regular doors and windows are hinged onto the provided framing after removal of membranes 20.

In the case of the construction of two or multi-storey buildings, reference is made to FIGS. 4 to 6 of the accompanying drawings which illustrate this additional embodiment of the invention.

Here again the molding combination is manufactured and assembled in a factory with all necessary partitions and fixtures, then it is folded into a relatively compact package and transported to the selected site.

During the manufacture of said molding combination for multi-storey buildings it has been found useful to connect the vertical edges of the walls to the supporting membrane or envelope 1 so as to form four separate spaces 15. This facilitates a regular distribution of weight to be supported by the envelope, but also produces the requirement that each of said spaces be inflated through a separate conduit 10. The compressed air may, however, come from a same source for all compartments as well as

for other compartments where the same pressure should be maintained.

In such multi-storey structures all prefabricated door and window apertures should be closed by an impermeable membrane such as 20 so that each storey forms a separate air tight compartment. Also, the walls of each storey consist of separate double-layer molding jackets similar to those used in a single-storey building.

The inter-storey division 29, which forms the ceiling for the first storey of the building and the floor for the second storey, can be reinforced with beams 32 which can also be prefabricated and be made of the same type of double layer jacket structure as the walls, floors and ceilings. This division 29 can be attached to the walls 3b and 3c as shown at 25.

If desired, a dome-like roof 23 can be easily made on such buildings by connecting to the upper part of the membrane 1 an additional jacketed structure which, subsequently, at the appropriate stage of the operation, is injected with a suitable premixed material through a conduit 24 and allowed to solidify.

The construction of a two-storey building as represented in FIGS. 4 to 6, is carried out by first injecting into the base 2 a premixed material, such as concrete, and allowing it to set or cure until perfectly solid. Then, the building structure is raised to its erected position by inflating with compressed air all compartments within the envelope 1 through inlets 10, 12 and 12a. A same pressure should, at first, be maintained in all these separate compartments.

As the next step, vertical walls 3b (including any partition walls) of the lower storey of the building are injected with premixed material through inlets 13 and are allowed to solidify. Next, walls 3c of the upper storey are made solid in the same manner. Then, concrete is injected into the horizontal inter-storey partition 29 through inlet 22 and allowed to set or cure therein. Care must be taken during this operation to adjust the pressures in the lower and upper storey spaces so as to make said partition 29 as flat and as horizontal as possible. After this operation, beams 32 which are attached to the partition 29, as shown at 27, may be filled with premixed material through inlets 21 and permitted to solidify.

The ceiling of the second storey compartment, which is not shown in FIGS. 4 to 6, is made in the similar manner as that of the one storey building of FIGS. 1 to 3.

Tubes 21 and 22 are usually passed through window membranes 20 taking, however, a precaution to seal them with said membrane in an air-tight manner.

It would also be possible to somewhat alter this operating procedure and to solidify, for instance, dividing floor 29 before walls 3c, as well as to carry out certain other changes evident to those familiar with the art.

FIGS. 7 to 12 show enlargements of different structural features used according to the instant invention.

Thus, in FIG. 7 it is shown that ceiling 4 and wall 3 are each formed of two layers interconnected by strings or strips 30. Both the layers and the strings or strips are made of flexible and substantially inextensible material. Wall 3 is cemented or glued by its top edge to the bottom layer of ceiling 4 and the two are attached by means of strip 29 to the supporting membrane or envelope 1. It is also desirable to use several fixing corks 31 at the intersection of attachment of wall 3 to ceiling 4. These corks are made of suitable solid fabric, such as plastic or wood, and greatly facilitate the adherence of premixed materials, such as concrete, to the places where they are provided. These corks may and preferably should be positioned in all places where such adherence is difficult to achieve for one reason or another.

FIG. 8 shows a prefabricated window and framing assembly according to the invention. Thus, after a cut has been made in the wall 3, the opened end is sealed at 37 and a frame 38 is fitted and firmly cemented onto that end. Then, if it is necessary to tightly close the window by an impermeable membrane 20, the latter is connected

by means of a member 35 and plastic strips 34 to the frame 33. Other similar ways may, of course, be used for this purpose.

FIG. 9 illustrates the construction of a dome shaped or semi-cylindrical roof on a building according to the instant invention, as shown at 26 in FIG. 6. Such roof can be made by simply connecting to the outside and at the upper end of the supporting envelope 1 a second layer 23 and by interconnecting the two layers by strings or strips 30. Fixing corks 31 can also be used at appropriate places. The premixed material used for the roof should be somewhat lighter than that employed for other parts of the building.

FIG. 10 exemplifies the attachment of wall 3 to base 2 as shown at 17 in FIG. 3. Fixing corks 31 may equally be positioned at these places. The attachment itself is usually effected by gluing or cementing.

In FIG. 11 there is shown an embodiment whereby a three-way connection in a multi-storey building (as at 25 in FIG. 6) can be made. Thus, preferably, the lower wall 3b should be of a greater thickness than the upper wall 3c and the inter-floor structure 29 can be connected to the upper wall 3c while shouldering the horizontal edge of wall 3b that extends towards the inside of the building. A number of fixing corks 31 can also be provided to facilitate the adherence of the injected material in these places. A membrane 33 may be used to cover the parts of the fixing corks 31 which extend to the outside and this membrane can be of any suitable material and can be properly positioned either before or after erecting the building. The membrane 33 may also extend over the entire length of the edges produced by the walls and the ceiling and the space defined thereby may then be injected with a premixed material to form, after solidification of the latter, a reinforcing structure for the ceiling.

Finally, FIG. 12 illustrates the attachment of a reinforcing beam 32 to the inter-floor partition 29 as shown at 27 in FIG. 6. The beam has preferably the same jacketed structure, with strings or strips 30, as the walls and floors and concrete or other suitable premixed material is thus injected at the appropriate stage of the construction into such beam through a conduit 21. It is also of interest to use fixing corks 31 at the place of contact of said beams with the bottom layer of the inter-floor structure 29.

In summary, this invention provides a simplified and more economical way of constructing buildings. The molding combination can be made in factories in a relatively simple way. Usually each wall, floor, ceiling as well as other fixtures of the building are made of separate double layer flexible and substantially inextensible molding jackets and are then appropriately interconnected. The entire structure is then attached to a base and to a supporting membrane or envelope which can be inflated to erect and support said structure. Such relatively flexible molding combination is easily folded into a compact package thus facilitating its transportation to a selected site.

The construction of the building according to the invention is generally done by two alternatively applicable procedures, namely inflation and injection. The vertical parts of the building are injected with premixed materials and are allowed to solidify under isobaric pressure, while the horizontal parts are injected and allowed to solidify under differential pressures in the respective compartments. Materials such as concrete, curable plastics or resins are particularly suitable.

It will, of course, be understood that the invention is not limited to the specific embodiments described above and illustrated in the appended drawings but that different modifications and equivalent procedures evident to those skilled in the art may be applied without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. A substantially flexible molding combination appli-

cable for construction of bulidings comprising: a supporting membrane made of a layer of flexible and substantially inextensible fabric; a base; said membrane being connected to said base by its lower edges and being adapted to be inflated to define a desired curved space; a plurality of separate double layer molding jackets constituting vertical walls and at least one horizontal ceiling of the building positioned within said space, each of said molding jackets being made of two layers of flexible and substantially inextensible fabric interconnected with a plurality of strings; the vertical walls being appropriately attached to one another and being connected with their bottom ends to the base and with their top ends to the ceiling and the obtained upper edges being tightly attached to the supporting membrane for producing within the space defined thereby an air tight compartment delimited by the ceiling and the membrane above said ceiling and at least one other air tight compartment below said ceiling; and tube and valve means between each compartment in the space defined by said membrane and the outside atmosphere and between the molding jackets and the outside atmosphere, respectively, being provided for inflating and deflating said compartments and for injecting into said molding jackets a premixed material capable of solidifying therein.

2. A substantially flexible molding combination as claimed in claim 1, wherein the base consists of a solid piece of material.

3. A substantially flexible molding combination as claimed in claim 1, wherein the base consists of a double layer molding jacket the two layers of which are made of flexible and substantially inextensible material and are interconnected with a plurality of strings, said jacket being adapted to receive premixed materials capable of curing therein.

4. A substantially flexible molding combination as claimed in claim 1, in which the molding jackets which constitute the walls are provided with appropriate apertures which are sealed and framed at their edges so as to receive doors and windows after erection of the building and in which the apertures of the exterior walls of the building are tightly closed with an air impermeable membrane.

5. A substantially flexible molding combination as claimed in claim 1, in which arcuate solid and upright-positioned extensions are provided on two opposite sides of the ceiling for better attachment of the latter to the curved supporting membrane.

6. A substantially flexible molding combination as claimed in claim 1, in which a roof having the same configuration as that of the top of the supporting membrane is provided by making the upper part of the said membrane in the form of a double layer jacket in which the layers are interconnected by a plurality of strings and an inlet valve means being connected with said jacket for injection thereinto of a premixed material capable of solidifying therein.

7. A substantially flexible molding combination applicable for the construction of multi-storey buildings in which the first storey is the lowermost and the last storey is the uppermost, comprising: a supporting membrane made of a layer of flexible and substantially inextensible fabric; a base; said membrane being connected to said base by its lower edges and being adapted to be inflated to define a desired curved space; a plurality of separate double layer molding jackets positioned within said space and constituting vertical outer and inner walls of the building and horizontal inter-storey partitions serving as a ceiling for one storey and as a floor for the storey immediately above as well as horizontal ceiling at the top of the building, each of said molding jackets being made of two layers of flexible and substantially inextensible fabric interconnected with a plurality of strings; the outer vertical walls of the building being appropriately attached to one another, the bottom ends of the

walls of the first storey being connected to the base and the top ends of the walls of the last storey to the ceiling; the obtained side edges between the vertical outer walls and the obtained upper edges between said outer walls and the ceiling being tightly attached to the supporting membrane for producing within the spaces defined thereby air tight compartments, one of these compartments being delimited by the ceiling and the membrane above said ceiling and the other compartments being delimited by each outer wall of the building, the portion of the base which is outside of the buliding and adjacent to said wall and the membrane on each side of the building; the outer vertical walls also being so connected with the base, the ceiling and the inter-storey partitions as to produce air tight compartments within each storey of the building; and tube and valve means between each air tight compartment and the outside atmosphere and between each molding jacket and the outside atmosphere, respectively, being provided for inflating and deflating said compartments and for injecting into said molding jackets a premixed material capable of solidifying therein.

8. A substantially flexible molding combination as claimed in claim 7, in which the inter-storey partitions are reinforced with beams made of two layer jacketed fabric capable of receiving solidifiable premixed materials.

9. A substantially flexible molding combination as claimed in claim 7, in which the double layer jackets forming each outer wall of the different storeys are separate from one another and the jacket of one storey is narrower than that of the storey immediately below.

10. A method of constructing a building comprising: forming a substantially flexible molding combination having a supporting membrane made of a layer of flexible and substantially inextensible fabric, a solid base, said membrane being connected to said base by its lower edges and being adapted to be inflated to define a desirable curved space, a plurality of separate double layer jackets constituting vertical walls and at least one horizontal ceiling of the building positioned within said space, each of said molding jackets being made of two layers of flexible and substantially inextensible fabric interconnected with a plurality of strings, the vertical walls being tightly attached to one another and being connected with their bottom ends to the base and with their top ends to the ceiling and the obtained upper edges being attached in an air tight manner to the supporting membrane for producing within the space defined thereby an air tight compartment delimited by the ceiling and the membrane above said ceiling and at least one other air tight compartment below said ceiling; inflating said compartments with compressed air to the point where the walls and the ceiling, supported by said inflated membrane, are in their required erect position; injecting into the molding jackets, forming the walls, a premixed material capable of solidifying therein and allowing said material to solidify; injecting into the molding jacket forming the ceiling a premixed material capable of solidifying therein and allowing said material to solidify while adjusting the air pressures between the upper and the lower compartments so as to obtain a substantially flat horizontal ceiling; exhausting the compressed air from the compartment; and removing the supporting membrane; whereby a solid building of desired form is obtained.

11. A method as claimed in claim 10 in which the premixed material is selected from concrete, curable resins and curable plastics.

12. A method as claimed in claim 10, in which the said base consists of a double layer molding jacket the two layers of which are made of flexible and substantially inextensible material and are interconnected with a plurality of strings, said base having been solidified by injecting between said layers a premixed material capable of curing therein and allowing said material to cure.

13. A method as claimed in claim 10, for constructing

a multi-storey building in which each storey is made in the form of an air tight compartment, comprising, after inflation of the compartments, injecting a premixed material into the molding jackets forming the first storey walls; allowing said material to solidify; injecting a premixed material into the ceiling of the first storey and allowing it to solidify with appropriate adjustment of the air pressures between the compartments separated by said ceiling to render the latter as flat as possible; and repeating this procedure for each subsequent storey.

14. A method as claimed in claim 13, comprising reinforcing the inter-storey partitions by means of beams made of molding jackets of flexible and substantially inextensible fabrics and attached to said partitions, said beams being then injected with a premixed material capable of being cured therein and being allowed to solidify.

15. A method as claimed in claim 10, for constructing a multi-storey building in which each storey is made in the form of an air tight compartment, comprising, after inflation of the compartments, injecting a premixed material into the molding jackets forming the vertical walls

of the building, allowing said material to solidify; and injecting a premixed material into the ceilings and allowing it to solidify with appropriate adjustment of the air pressures between the compartments separated by said ceilings to render the latter as flat as possible.

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