

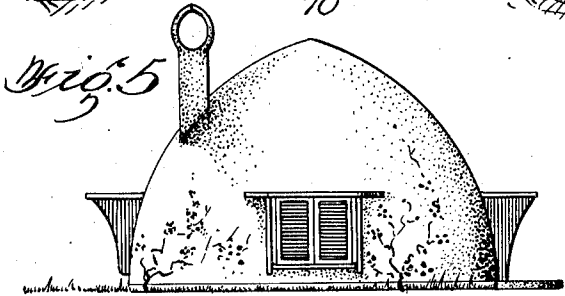
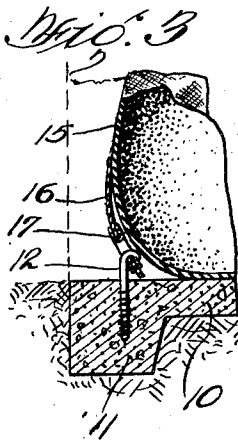
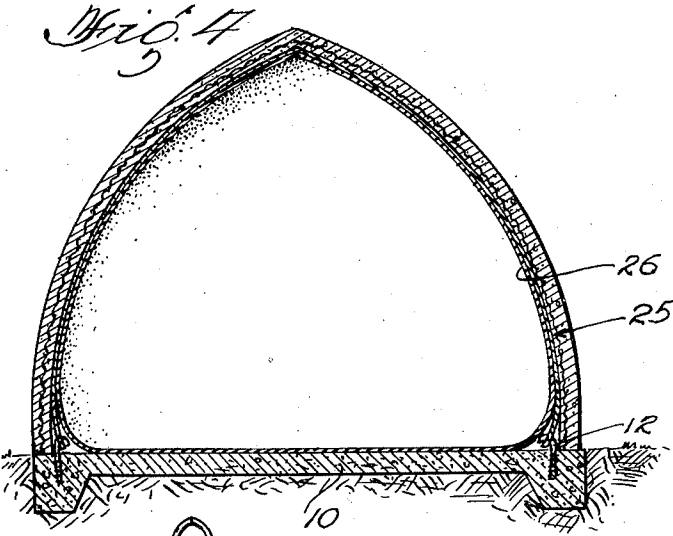
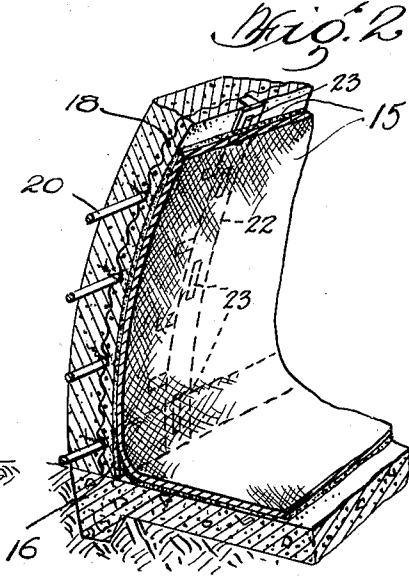
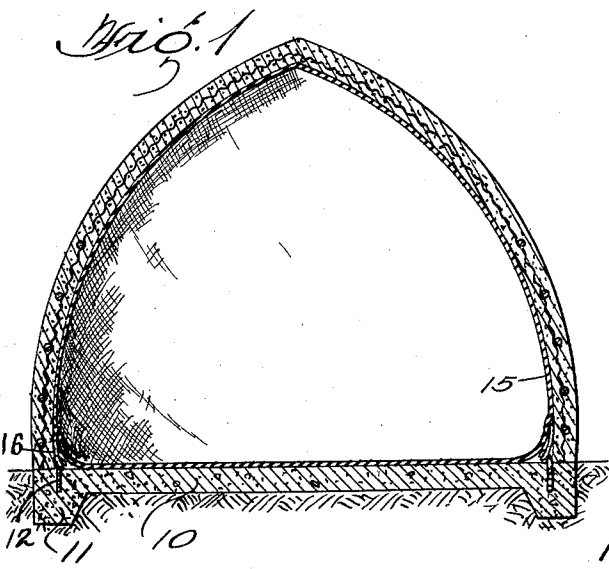
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W. NEFF

2,270,229

BUILDING CONSTRUCTION

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By

Inventor
Wallace Neff
Rein & Kiersey
Attorneys

UNITED STATES PATENT OFFICE

2,270,229

BUILDING CONSTRUCTION

Wallace Neff, Hollywood, Calif.

Application April 3, 1941, Serial No. 386,727

20 Claims. (Cl. 25-154)

This invention relates to improvements in building construction and in its more specific aspects to a method of constructing thin-shell concrete structures known as barrel shells and shell domes.

In furtherance of the proposal of my copending application Serial No. 386,726, filed under even date, to provide thin-shell concrete structures of barrel and dome type for dwellings and barracks for defense housing purposes as well as for use in the field of low-cost housing, the present invention contemplates and provides a novel method by which such structures can be fabricated at a minimum of time and cost. The invention is also directed to an improved form against which wet concrete, which on hardening constitutes a continuous shell, can be placed by the use of a cement gun or like apparatus.

Other objects will be in part obvious and in part hereinafter pointed out in connection with the following analysis of this invention wherein is illustrated an embodiment of the invention in detail.

In the drawing—

Fig. 1 is a section through a shell placed in accordance with the present invention against a form of the character herein contemplated;

Figs. 2 and 3 are sectional details through the foundation, shell and form as illustrated in Fig. 1;

Fig. 4 is a section illustrating another embodiment of the invention;

Fig. 5 is representative of a typical structure resulting from the practice of the method of the present invention.

Referring to the drawing, reference character 10 designates a concrete foundation slab which is rectangular for the barrel shell structure and circular for the shell dome structure. The slab, which is preferably provided with a marginal footing 11, is suitably reinforced and is laid over a gravel bed and suitably waterproofed. Secured to the slab at spaced intervals along its edge portion are a plurality of hooks 12 (Fig. 3) for anchoring to the slab the form to be described. Preferably these hooks are placed in the slab during laying thereof. Other form-securing means may be employed in place of the hooks referred to.

The present invention contemplates the use of an inflatable pneumatic form which, in the preferred embodiment of the invention, is shaped as upon inflation thereof to assume a size and shape corresponding substantially to the interior of the structure under fabrication. Thus, if a barrel structure is desired, the form is so con-

structed that upon inflation it assumes the barrel shape corresponding to the interior of a barrel shell. Likewise, for a shell dome the form is so constructed that upon inflation it assumes a shape corresponding to the interior of the desired dome shell structure. If desirable or necessary, the form may be built up where desired so as to provide, for example, a central peak or ridge characteristic of the barrel shell structure.

Such a form 15 is illustrated in Figs. 1 and 2 and, as shown, is fabricated from an airtight and substantially non-stretchable material of sufficient strength to withstand hard usage. One suggested material from which the form may be fabricated is rubber-impregnated canvas. To obviate the possibility of the cement, which is placed against the exterior of the form, from sticking thereto or bonding therewith, the outer side of the fabric form may be surfaced with a parting material or substance such as rubber, or the form may be overlaid with a rubber lamination suitably secured to the fabric body.

Preferably, the form is preferably flat-bottomed and along its lower side edge or perimeter is provided with means by which it may be anchored to the foundation slab 10. Such securing means may take the form of a flap 16 provided with grommets openings 17 through which the anchoring hooks 12 may be passed.

The form is normally collapsed for ready handling and, when it is desired to be set up, it is placed on the foundation slab 10 to which it is anchored in the manner suggested. The form is inflated by inflating means such as a source of pneumatic pressure or of hot gases made available for this purpose and, upon inflation, the form assumes a shape corresponding to the interior of the structure to be fabricated.

Upon the form being inflated, the same is covered with a wire reinforcing mesh 18 of approved type. Preferably, the mesh is spaced outwardly from the form by suitable spacing means.

To take care of any lateral stresses to which the continuous span-shell is subjected, the lower section of the mesh, which corresponds to the lower side wall portion or portions of the final shell, may have secured thereto a requisite number of reinforcing elements 20 such as $\frac{3}{4}$ " steel rods which extend horizontally along the sides of the form for the barrel shell structure and around the form for the shell dome structure. Or the mesh may be of the character incorporating therein structural reinforcing elements, thus to eliminate the labor costs incident to securing separate reinforcing rods to the mesh.

To provide for openings such as door and window openings, unitary opening frames may be placed against the form and suitably secured in proper location, the reinforcing mesh and the reinforcing rods, or equivalent, being provided with suitable cut-outs for the opening frames, or the mesh and reinforcing rods may be placed around the already positioned frames.

With the inflated form providing a backing therefor the outer shell may now be applied, preferably by the so-called gunite method, according to which a mixture of cement, fine aggregate and water is shot on to the form under pneumatic pressure by a cement gun or equivalent placing apparatus in such manner that the wet concrete remains in position on the form without any requirement for an external form. In shooting the cement mixture, care should be taken to build up a continuous layer of about three inches in thickness, the form being under sufficient pressure as ably to resist the force of projection and the load of the concrete, and the reinforcing mesh relieving to a degree the impact pressure of the cement mixture against the form. The mesh and the structural elements are embedded in so applied wet concrete, which passes rearwardly of the mesh and directly against the rubber surface of the form. Before hardening of the mixture, the exterior of the placed shell is preferably rodged to true curvature and, upon hardening, the concrete provides a continuous monolithic thin shell of concrete.

Following hardening of the shell, the form is deflated and readily falls away from the inner surface of the shell whereupon it may be bodily removed through one of the shell openings or from an open end of the barrel shell if the ends thereof are left open.

For outside finish, a finish coat of cement may be shot on to the outer surface of the shell or it may be left rough. Where color is desired, such may be incorporated into the cement mixture prior to placing of the latter.

In the case of the barrel shell being formed with open ends, said ends may be closed by end walls of cement plaster on metal lath construction, although in the case of the end wall supporting loads, such as that of an overhead storage room, they may be of conventional stud construction.

The resulting structure may be interiorly partitioned according to a desired floor plan, plaster on metal lath partitions being contemplated, although if the partitions serve to support an overhead storage room they may be of conventional stud construction.

If an interior finish is desired, as where the structure is to be used as a dwelling, the inner surface of the shell may be shot with a coat of insulating plaster which is bonded to the inner shell face. Where structures of the type under consideration are intended for use as barracks, hangars, or the like, the interior finish coat of plaster may be omitted.

Where plaster on metal lath interior finish is desired, such may be provided for in various ways. One simple way is through the use of strips 22 (Fig. 2) which space the reinforcing mesh from the form, having extensions 23 which lie flat against the form during shooting of the cement mixture, but which upon hardening of the concrete and collapse and removal of the form are bent out to extend inwardly of the shell. To the bent extensions 23 may be secured

insulation and/or metal lath. A finish coat of plaster may be applied against the so secured plaster mesh in conventional manner.

In Fig. 4, a further embodiment of the invention is illustrated, according to which, the form is provided by an apron 25 placed over an inflatable balloon-like member 26 which is of requisite size that upon inflation it acts to expand or distend the apron from its edge anchoring points so that the apron assumes a size and shape corresponding to the interior of the structure to be fabricated. Inasmuch as the apron need not be airtight, it may be fabricated of conventional heavy canvas, although to prevent the concrete from sticking thereto the outer face of the apron is preferably coated with rubber or carries a lamination of rubber.

In setting up the form shown in Fig. 3, the apron 25, which may carry securing grommets spaced along its lower edges corresponding to the corner of the structure to be fabricated, is placed in proper position on a foundation slab 10 and is anchored thereto by suitable anchoring means such as the anchoring hooks 12. The normally deflated balloon is disposed beneath the apron and, upon inflation of the balloon as by forcing air or hot gases thereto, the apron is distended and assumes its intended shape corresponding to the interior space of the intended structure.

Thereupon the expanded metal mesh 18 may be placed over the distended apron in the manner previously described, and the cement mixture shot against the apron to provide a concrete layer which on hardening forms a continuous shell in the manner previously described.

Referring to Fig. 5, this figure, while showing a dwelling in the nature of a shell dome dwelling, is also to be regarded as typical of shells such as barrel shells which may be fabricated according to the practice of the present invention on a pneumatic internal form and without the aid of an external form. This figure further illustrates the mounting of windows and/or doors in window and door openings provided in the shell during the course of its fabrication. Such shell structures are characterized by a continuous concrete wall of monolithic construction, in which the wall is in the nature of a continuous span extending from spaced anchor points. Due to the fact that such a wall is substantially self-sustaining and requires no structural reinforcement within the span for the purpose of preventing spreading thereof, the entire interior space provided by the shell may be utilized.

It is also possible according to the present invention to subdivide the curved walls into merging or intersecting curved areas, as in the case of a square structure with a roof provided by four subdivided areas, each of generally triangular outline, which merge into each other. This type of construction, as well as variants thereof, may be built up on a collapsible form or centering having cross wires or stiffening sewed in or otherwise secured in intersecting relation to the top portion of the form which corresponds to the roof. Upon inflation of such a form, and shooting of a cement mixture thereon, the roof or dome is correspondingly divided into curved quadrants providing great strength.

The present invention is believed to provide an inexpensive and fast method of erecting shell-like structures, as made possible by the use of collapsible forms or centerings of the character

described. Moreover, the invention provides a method of building construction which is of exceedingly simple nature and in practice may be carried out at the expenditure of a minimum of labor and material costs.

As many changes could be made in carrying out the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. The method of constructing concrete shell-form structures of the continuous wall, self-sustaining type suitable for use as dwellings, barracks, hangars, and the like by the use of an internal form only, which consists in providing a normally collapsed, pneumatic form having a flat bottom and anchoring points along the perimeter thereof and which is adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, arranging the flat bottom of the form on a horizontal supporting surface, anchoring the form along its lower edge to a footing provided therefor, shooting a continuous layer of concrete over the exposed outer surface of the form in such manner as to build up thereon a continuous layer of concrete without the aid of an external form, maintaining the form inflated until the concrete has set, and collapsing and thereupon withdrawing the form following setting of the concrete.

2. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in placing on a suitable support a collapsed, inflatable hollow member adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, inflating said member while on said support, applying wet concrete on to the exterior surface of the inflated member in such manner that the applied concrete will remain in position on the member without the aid of an external form and will provide upon setting a self-sustaining shell, deflating and collapsing said member after the concrete has set, and thereupon withdrawing said member from the shell.

3. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in placing on a suitable support a collapsed, inflatable hollow member adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, covering the inflated member with a reinforcing mesh, applying wet concrete through said mesh and on to the exterior surface of the inflated member in such manner that the applied concrete will remain in position on the member without the aid of an external form and will provide upon setting a reinforced and self-sustaining shell, deflating and collapsing said member after the concrete has set, and thereupon withdrawing said member from the shell.

4. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an in-

ternal form only, which consists in arranging on a suitable support a collapsed, inflatable hollow member adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure and which is provided with anchoring means along its side portion, anchoring the member along its side portion to said support, thereupon inflating said member, applying wet concrete on to the exterior surface of the inflated member in such manner that the applied concrete will remain in position on the member without the aid of an external form and will provide upon setting a self-sustaining shell, deflating and collapsing said member after the concrete has set, and thereupon withdrawing said member from the shell.

5. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in arranging on a suitable support a collapsed, inflatable hollow member adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure and which is provided with anchoring means along its side portion, anchoring said member along its side portion to said support, covering the inflated member with a reinforcing mesh, applying wet concrete through said mesh and onto the exterior surface of the inflated member in such manner that the applied concrete will remain in position on the member without the aid of an external form and will provide upon setting a reinforced and self-sustaining shell, deflating and collapsing said member after the concrete has set, and thereupon withdrawing said member from the shell.

6. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in arranging on a suitable flat support a collapsed inflatable hollow member having a flat bottom and which is adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, anchoring said member to said support, thereupon inflating said member, applying wet concrete on to the exterior surface of the inflated member in such manner that the applied concrete will remain in position on the member without the aid of an external form and will provide upon setting a self-sustaining shell, deflating and collapsing said member after the concrete has set, and thereupon withdrawing said member from the shell.

7. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in placing on a suitable support a normally collapsed pneumatic form adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, inflating said form while on said support, forcibly projecting wet concrete on to and over the exterior surface of the form in such manner as to build up thereon a continuous layer of concrete without the aid of an external form and which upon setting will provide a self-sustaining shell, deflating and collapsing said form after the concrete has set, and thereupon withdrawing the collapsed form from said shell.

8. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in placing on a suitable support a normally collapsed pneumatic form adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, inflating said form while on said support, covering the inflated form with a reinforcing mesh, forcibly projecting wet concrete through said mesh and on to and over the exterior surface of the form in such manner as to build up thereon a continuous layer of concrete without the aid of an external form and which upon setting will provide a reinforced and self-sustaining shell, deflating and collapsing said form after the concrete has set, and thereupon withdrawing the collapsed form from said shell.

9. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in arranging on a suitable support a normally collapsed pneumatic form adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure and which is provided with anchoring means along its side portion, anchoring the form along its side portion to said support, inflating said form, forcibly projecting wet concrete on to and over the exterior surface of the form in such manner as to build up thereon a continuous layer of concrete without the aid of an external form and which upon setting will provide a self-sustaining shell, deflating and collapsing said form after the concrete has set, and thereupon withdrawing the collapsed form from the shell.

10. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in arranging on a suitable support a normally collapsed pneumatic form adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure and which is provided with anchoring means along its side portion, anchoring the form along its side portion to said support, inflating said form, covering the inflated form with a reinforcing mesh, forcibly projecting wet concrete through said mesh and on to and over the exterior surface of the form in such manner as to build up thereon a continuous layer of concrete without the aid of an external form and which upon setting will provide a reinforced and self-sustaining shell, deflating and collapsing said form after the concrete has set, and thereupon withdrawing the collapsed form from the shell.

11. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in arranging on a suitable flat support a normally collapsed, pneumatic form having a flat bottom and which is adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, anchoring said form to said support, thereupon inflating said form, forcibly projecting wet concrete on to and over the exterior surface of the form in such manner as to

build up thereon a continuous layer of concrete without the aid of an exterior form and which upon setting will provide a self-sustaining shell, deflating and collapsing said form after the concrete has set, and thereupon withdrawing the collapsed form from said shell.

12. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in arranging on a suitable flat support a normally collapsed, pneumatic form having a flat bottom and which is adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, anchoring the form to said support, thereupon inflating said form, covering the inflated form with a reinforcing mesh, forcibly projecting wet concrete through said mesh and on to and over the exterior surface of the form in such manner as to build up thereon a continuous layer of concrete without the aid of an external form and which upon setting will provide a reinforced and self-sustaining shell, deflating and collapsing said form after the concrete has set, and thereupon withdrawing the collapsed form from said shell.

13. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in placing over a collapsed balloon-like member arranged on a suitable support a flexible apron-like member having edge anchoring points and which upon inflation of said balloon-like member to effect distention thereof from its anchoring points is adapted to assume a size and shape corresponding generally to the interior of the intended structure, anchoring the apron-like member to said support, inflating the balloon-like member, forcibly projecting wet concrete on to and over the exterior surface of the apron-like member in such manner as to build up thereon a continuous layer of concrete without the aid of an external form and which upon setting will provide a self-sustaining shell, deflating the balloon-like member after the concrete has set, stripping the apron-like member from the inner face of the shell, and thereupon withdrawing both the apron-like member and the deflated balloon-like member from said shell.

14. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in placing over a collapsed balloon-like member arranged on a suitable support a flexible apron-like member having edge anchoring points and which upon inflation of said balloon-like member to effect distention thereof from its anchoring points is adapted to assume a size and shape corresponding generally to the interior of the intended structure, anchoring the apron-like member to said support, inflating said balloon-like member, covering the distended apron-like member with a reinforcing mesh, forcibly projecting wet concrete through the mesh and on to and over the exterior surface of the apron-like member in such manner as to build up thereon a continuous layer of concrete without the aid of an external form and which upon setting will provide a reinforced and self-sustaining shell, deflating the balloon-like member after the concrete has set,

stripping the apron-like member from the inner face of the shell, and thereupon withdrawing both the apron-like member and the deflated balloon-like member from said shell.

15. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in placing on a suitable support a collapsed inflatable hollow member adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, anchoring said member along its side portion to said support, thereupon inflating said member, securing a frame for a door or window opening in desired position against said member, forcibly projecting wet concrete on to and over the exterior surface of said member and around said frame in such manner as to build up on the member a continuous layer of concrete without the aid of an external form and which upon setting will provide a self-sustaining shell in which the opening frame is sealed, deflating and collapsing said member after the concrete has set, and thereupon withdrawing said member from the shell.

16. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in placing on a suitable support a collapsed inflatable hollow member adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, anchoring the member along its side portion to said support, thereupon inflating said member, securing a frame for a door or window in desired position against said member, laying reinforcing mesh over the member and around the opening frame, forcibly projecting wet concrete through said mesh and on to and over the exterior surface of the member and around said frame in such manner as to build up on the member a continuous layer of concrete without the aid of an external form and which upon setting will provide a reinforced and self-sustaining shell in which the frame is sealed, deflating and collapsing said member after the concrete has set, and thereupon withdrawing said member from the shell.

17. The method of constructing a concrete shell-form structure of the continuous wall, self-sustaining type suitable for use as a dwelling, barracks, hangar or the like by the use of an internal form only, which consists in placing on a suitable support a collapsed inflatable hollow member adapted upon inflation to assume a size and shape corresponding substantially to the interior of the intended structure, securing said member along its side portion to said support, thereupon inflating said member, covering the inflated member with a reinforcing mesh, spacing said mesh outwardly of said member through the provision of bendable spacing strips having portions adapted to lie flat against the exterior sur-

face of said member, forcibly projecting wet concrete through said mesh and onto and over the exterior surface of said member in such manner as to build up thereon a continuous layer of concrete without the aid of an external form and which upon setting will provide a self-sustaining shell in which said mesh is embedded, collapsing and thereupon withdrawing said member after the concrete has set, bending the flat portions of said spacing strips inwardly of the shell, securing plaster mesh to said inbent portions, and plastering on the plaster mesh.

18. A pneumatic form for use in the construction of concrete shell-form structures of size and shape suitable for use as dwellings, hangars, barracks, and the like, consisting of a hollow inflatable body having a bottom portion and merging side and top wall portions and which is so shaped that upon being placed on a suitable flat support and inflated the bottom portion will assume a flat shape corresponding to the shape of the support and the side and top wall portions will assume a size and shape corresponding substantially to the interior of the intended structure, the body being formed from an air-tight, non-stretchable and flexible material, a coating of parting material on the exterior surface of said body to render said body non-adherent to concrete, and anchoring means on the side wall portions of said body for anchoring the body to the support.

19. A pneumatic form for use in the construction of concrete shell-form structures of size and shape suitable for use as dwellings, hangars, barracks, and the like, consisting of a hollow inflatable body having a flat bottom and merging side and top wall portions and which is so shaped that upon being placed on a suitable flat support and inflated the flat bottom will lie flat on said support and the side and top wall portions will assume a size and shape corresponding to the interior of the intended structure, the body being formed from fabric material carrying a substance rendering it air-tight and non-adherent to concrete and being provided with means extending along the perimeter of its flat bottom for anchoring the body to the support.

20. A pneumatic form for use in the construction of concrete shell-form structures of size and shape suitable for use as dwellings, hangars, barracks, and the like, consisting of a hollow inflatable body having a flat bottom and merging side and top wall portions and which is so shaped that upon being placed on a suitable support and inflated the flat bottom will lie flat on said support and the side and top wall portions will assume a size and shape corresponding to the interior of the intended structure, the body being formed from fabric material carrying a substance rendering it air-tight and non-adherent to concrete, and being provided with an anchoring flap extending along its sides and adjacent the perimeter of its flat bottom which is adapted for cooperation with anchoring means carried by the support.

WALLACE NEFF.