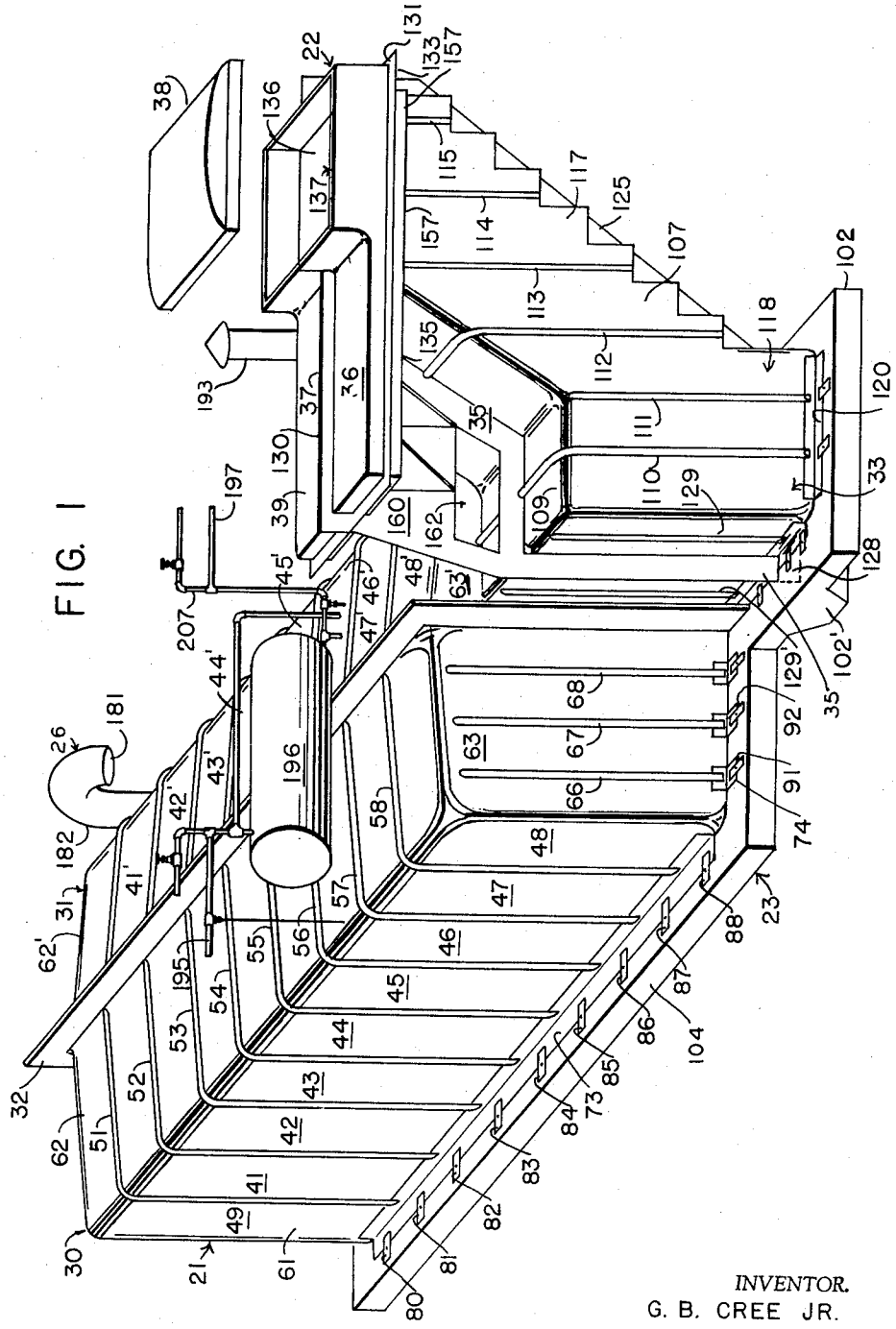
March 16, 1965 G. B. CREE, JR 3,173,387

UNDERGROUND SHELTER

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FIG. 1



INVENTOR.
G. B. CREE JR.

BY

ATTORNEY

March 16, 1965 G. B. CREE, JR 3,173,387

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FIG. 2

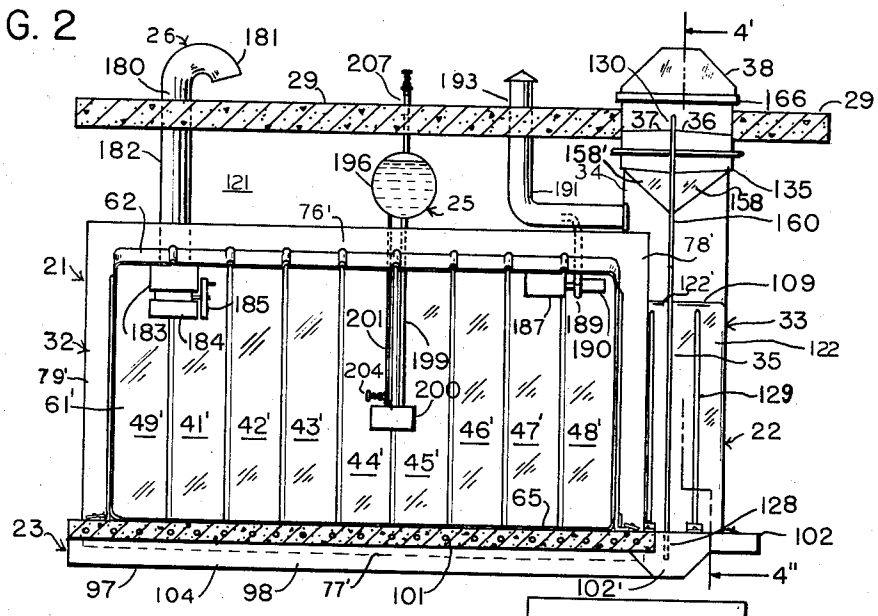
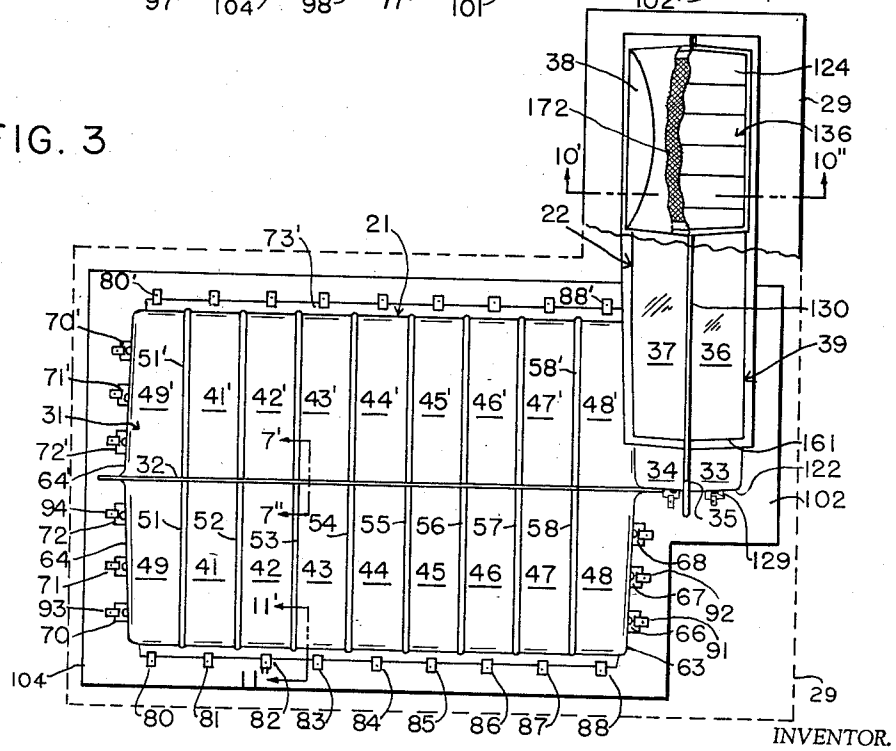


FIG. 3



INVENTOR.
G. B. CREE JR.
BY
Ely Silverman
ATTORNEY

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FIG. 4

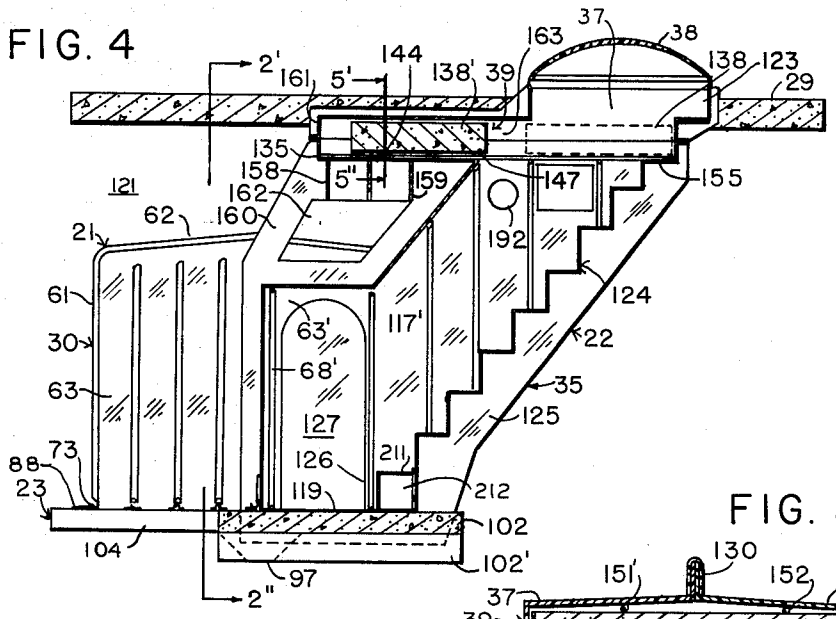


FIG. 5

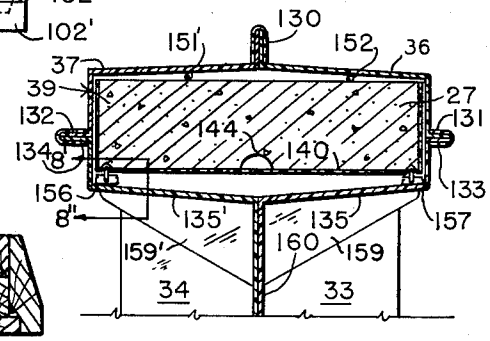
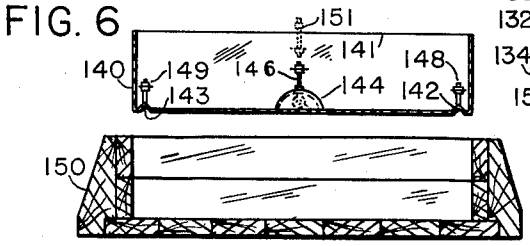


FIG. 6



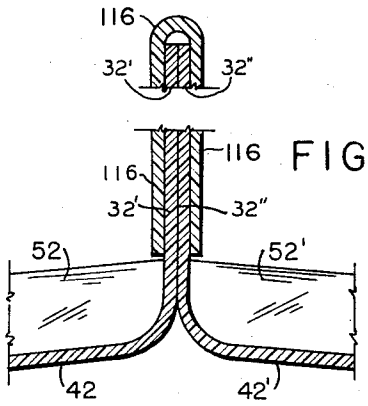


FIG. 7

INVENTOR.
G. B. CREE JR.
BY
Eby Silverman
ATTORNEY

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FIG. 8

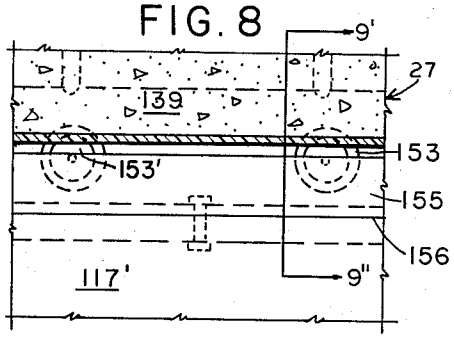
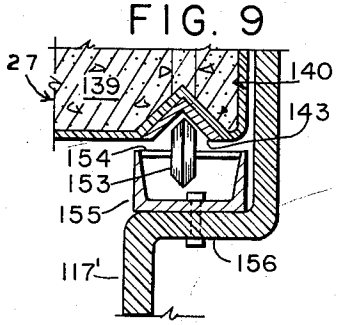


FIG. 9



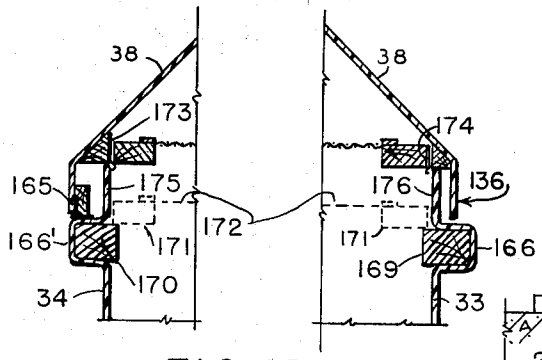


FIG. 10

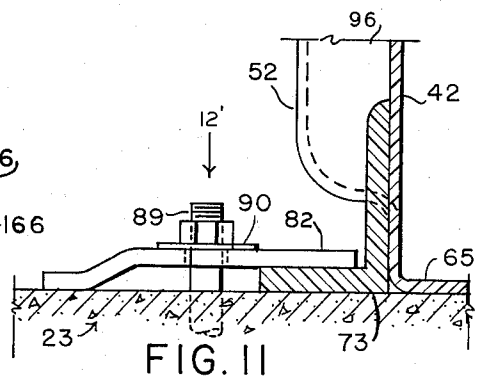
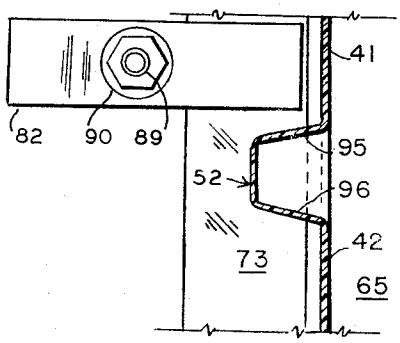


FIG. 11

FIG. 12



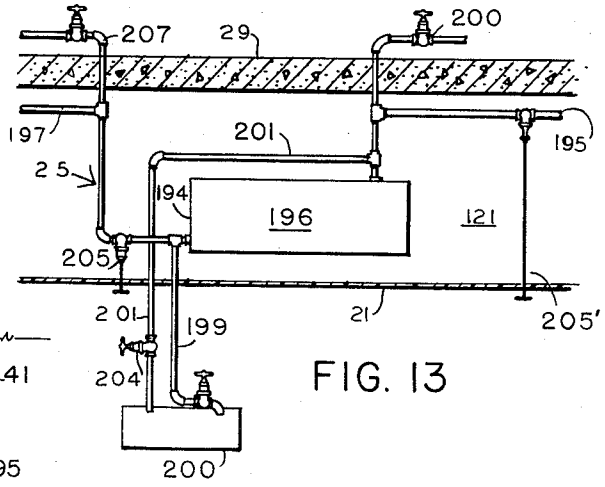


FIG. 13

INVENTOR.
G. B. CREE JR.

BY Eby Silverman
ATTORNEY

United States Patent Office 3,173,387 Patented Mar. 16, 1965

3,173,387

UNDERGROUND SHELTER

George Benson Cree, Jr., 1912 Charles St., Pampa, Tex.

Filed Mar. 21, 1961, Ser. No. 97,179
6 Claims. (Cl. 109—1)

This invention relates to an underground shelter. More particularly this invention relates to a safe, waterproof underground shelter, especially adapted to provide protection against radioactive fall-out.

Several feet of earth or several inches of concrete are necessary to provide adequate protection for humans against radioactive fall-out. The location of a structure underground, however, creates the problem of waterproofing such structure to protect the comfort as well as the health of the occupants.

The utility of such a shelter to its occupants depends on its availability to them and on their comfort and safety. The purpose of this invention is to provide a comfortable safe shelter which provides convenient and reliable access thereto and exit therefrom.

Accordingly, one object of this invention is to provide a readily assembled, sturdy, underground shelter.

Yet another object of this invention is to provide a moisture-proof, water-proof, rust-proof, yet inexpensive underground shelter.

Still another object of this invention is to provide an underground shelter having an exit which is especially safe as protection against intense radiation attending atomic and other nuclear explosions.

A further object is to provide an underground shelter structure adapted to tolerate ground tremors.

A still further object of this invention is to provide a door structure for an underground shelter which is particularly safe and useful as protection against circumstances following atomic and other nuclear explosions.

Yet another object of this invention is to provide an underground shelter for purposes above described, and the components of which shelter may be uniformly and reliably manufactured and conveniently and reliably assembled for their intended purposes.

Other objects of this invention will be apparent from the following detailed description of a preferred embodiment thereof as illustrated in the accompanying drawings which form a part of this specification, wherein like numerals refer to like parts in the several figures, and wherein:

FIGURE 1 is an overall perspective view showing the shell and other portions of a preferred embodiment of this invention.

FIGURE 2 is a longitudinal sectional view of the device of FIGURE 2 in operative position, as seen along plane 2'–2" of FIGURE 4;

FIGURE 3 is a top view of the device of FIGURE 2 shown, for purpose of illustration, with the dome and the patio portion partly broken away and the earth and the water system and air system below the patio removed;

FIGURE 4 is a sectional view of the device of FIGURE 2 as seen along the plane 4'–4" of FIGURE 2;

FIGURE 5 is an enlarged cross-sectional view of the sliding door chamber as seen along section 5'–5" of FIGURE 4;

FIGURE 6 is a transverse sectional view of the shell and internal components of the sliding door, diagrammatically illustrating a stage in the manufacture of said door.

FIGURE 7 is a sectional view along plane 7'–7" of FIGURE 3 showing detail of the flange structure;

FIGURE 8 is an enlarged longitudinal sectional detail view along plane 8'–8" of FIGURE 5;

FIGURE 9 is a cross-section view taken along section 9'–9" of FIGURE 8;

FIGURE 10 is an enlarged transverse cross-sectional view, broken away in part, to show detail as seen in plane 10'–10" of FIGURE 3;

FIGURE 11 is an enlarged cross-sectional view showing detail of the clip structure as seen along plane 11'–11" of FIGURE 3;

FIGURE 12 is a plan view of the device shown in FIGURE 11 as seen along the direction of the arrow 12' of FIGURE 11; and

FIGURE 13 is a diagrammatic showing of the piping connections for the water supply system.

Generally, the apparatus according to this invention comprises a main chamber shell, 21, and an entrance chamber shell, 22, which opens thereinto. These shells are joined one to the other and to a monolithic floor structure 23. A fresh water system 25 and a fresh air supply system 26 are incorporated within the device of this invention. A "roll away" door 27 and a support and protection system therefor also form a part of the entrance section 22 and are a particular part of this invention. A patio, 29, is comprised within the device and cooperates as below described with the other components thereof.

The complete unit comprises, generally, six shell sections. A left hand main chamber shell section, 30, and a right hand main chamber shell section, 31, are joined by a wide flange structure indicated as 32 to form main chamber shell 21. The entrance chamber shell comprises two lower entrance shell sections, 33 and 34, joined along flange 35 and two upper flanged shell sections, 36 and 37. A dome, 38, fits over the entrance shell 22. The flanged connections of the upper entrance shell sections, 36 and 37, to the lower entrance shell sections, 33 and 34, respectively, and to each other provides for the location of the assembled door structure 27 and for convenient assembly of the chamber 39 provided for the door 27 and its supports. The floor of chamber shell 21 and of the landing chamber of the entrance shell 22 are supported on and firmly attached to a rigid, reinforced concrete floor structure 23 therebelow. This concrete floor structure reinforces the wall structure of the chamber shell sections as well as absorbing the weight of the structures and personnel within the shelter. Accordingly, the device of this invention is made so that it is readily constructed with a minimum of separate parts requiring, correspondingly a minimum of separate fittings thereof in order to reliably provide tight seals in a sturdy waterproof assembly. In the preferred embodiment the chamber shell section 30 comprises several modular sections 41 through 47 and end sections 48 and 49. These modular sections are joined to the section adjacent thereto through exteriorly extending reinforcing ribs 51 through 58. Details of these ribbings are shown in FIGURES 11 and 12. Corresponding modular sections 41' through 49' with corresponding ribs 51' through 58' are provided on section 31. These ribs extend the full height of the vertical side wall 61 and continue over on the roof 62 of section 30 and, correspondingly, over the side wall 61' and roof 62' of section 31. End walls 63 on section 30 (and corresponding end walls 63' on section 31) are continuous with adjacent floor 65, sidewall 61, and roof 62 of section 30. The end walls are provided with separately attached vertically extended ribs as 66, 67, 68 and 68'. End walls 64 and 64' are provided with similar ribbing flanges, 70, 71, 72 and 70', 71', and 72'; which flanges extend from the level of floor 65 to the top of the flat portion of said end walls.

The ribs as 51 through 58 are formed within the mold for a section, as section 30, integral and joined together

with the modular sections 41 through 49 forming the side wall, as 61, and roof, as 62, and end wall, as 63 and 64 and flange as 32' and 73 for that section. These ribs, as 51–58, are U-shaped as shown in FIGURE 12 and are 1½ inches deep and 2 inches overall width and are positioned 16 inches center-to-center from each other in the preferred embodiment. An L-shaped flange 73 is provided at the base of the sidewall 61; this flange 73 runs substantially the length of the sidewall 61 and is firmly attached to the sidewall 61 and formed integral therewith, with the bottom of said flange contacting and being firmly held to the slab 23 as below described. A similar flange 73' is provided for sidewall 61' of section 31. A separate flange, as 74, is provided at the bottom of each of the ribs, as 66 through 68, for each section end wall, as 63, and ribs, as 70 through 72, for each section end wall as 64; each such flange is identical in cross section with the bottom flange 73 and is firmly attached by molding therewith to such ribs and, hence, to the base of such vertical walls and is firmly held, as below described, to the slab 23.

Accordingly, each section, as 30, is molded as one integral non-porous shell unit comprising the ribbed sidewall 61, ribbed roof 62, end walls 63 and 64, a flat floor 65, and a flange generally indicated as 32', and flange 73. The flange 32' has an upper portion 76', a bottom portion 77', a front portion 78' and a rear 79'. All portions of the flange extend vertically from the exterior of the shell for 8 inches in the preferred embodiment. The section 31 is a mirror image of section 30 and accordingly, has corresponding flange sections 32", 76", 77", 78" and 79" of identical size. Matching bolt holes are provided in the corresponding flange portions of both shell sections, 30 and 31, to expedite and facilitate their proper assembly and bonding, as described below and illustrated in FIGURE 7 to readily and reliably form a water-proof chamber shell.

The juncture of the sidewall 61 and roof 62 has a 4 inch radius of curvature. Similarly, the juncture of walls 61 with 63, and 61 with 64, as well as the juncture of walls 61, 63, and 64 with floor 65, is curved to avoid cracking and to facilitate manufacturing in the mold. Other portions of each shell such as the juncture of flange 31' and roof 62 are similarly curved.

In the preferred embodiment, shell units, as 30, 31, 33, 34, 36 and 37, and flanges as 73 and 73' are formed of 3/16 inch thick glass fiber laminate five layers thick and comprising 60% by weight polyester resin; 5% by weight catalyst; and the remainder glass fiber, preferably as one layer with 4½ ounce cloth, 2 layers of 1.5 ounce matt, 2 layers of 15.7 ounce woven roving. In the preferred embodiment, general purpose polyester hand lay-up resin is sprayed in admixture with an accelerator therefor as cobalt naphthenate, and a catalyst, as methyl ethyl ketone peroxide. Conventional spraying equipment using about 90 p.s.i.g. pressure in the sprayer air tank is used. The catalyst and accelerator are proportioned in well known manner to effect room temperature curing. While the polyester resin hereinabove described has, for purpose of definition, a tensile strength of about 10,000 to 13,000 p.s.i., the higher the laminate glass fiber content (which should be over 25% by weight), the higher, as is well known, will be the strength of the resultant laminate. Other accelerators, as dimethyl aniline can be used with other catalysts, as benzoyl peroxide, especially on warmer days, for the polyester resin, and other methods of admixing the glass fiber and resin may be used. Phenolic or epoxy resins, containing suitable cure promoting agents may be used in place of the polyester composition. However, the details of variations of the resin and fiber composition, and control of the resin curing, and procedure of admixture of resin with the fibers to form a high strength fiber reinforced plastic laminate of well over 20,000 p.s.i. ultimate tensile strength, are well known to those skilled in the art, are described in the technical literature, and are not, per se, a part of this invention. The glass fibers are admixed with or pressed thereinto to thoroughly and evenly incorporate said glass fibers into said resin and remove bubbles therefrom and so form non-porous plastic laminate layers each about 1/32 to 1/16 inch thick and containing, preferably, about 20% to 40% by weight of glass fibers and about 70% to 50% resin.

The flanges, as 32' on section 30 and 32" on section 31, and similar flange portions on other sections as 33, 34, 36, and 37 of which this shelter is composed, are joined by clamping such flanges together with a layer of resin as hereinabove described therebetween and providing a further layer of such resin exterior to such flanges, as 116 in FIGURE 7.

In the preferred embodiment, the inside dimension from end wall 63 to end wall 64 along the central flange 32 would be 12 feet. The width of a section, such as 30, would be 4 feet from flange 32' to the inside of the side wall as 61. There would be a one inch taper along the length of the end walls 63 and 64 from flange 32' to side wall 61 to facilitate removal of such a section from its mold during the manufacturing process. The interior height of a section, as 30 (identical with 31), would be 6 feet 6 inches at the center. The flange 32' would be formed of the same thickness and composition of material as the wall, roof, floor and ribs of the chamber, and projects 8 inches beyond ceiling 62 and each of the end walls 63, 64 and below the floor 65. Flange 73 is, in the preferred embodiment, 3/8 inch thick.

This provides, in the particular preferred embodiment of a 5-person underground shelter hereindescribed, 624 cubic feet in section 21 and 102 square feet of living area for such 8 feet wide, 12 feet long internal dimension shelter. The entire weight of this shelter is only 1475 pounds. The heaviest single component (section 30) weighs less than 450 pounds. Nevertheless, this structure provides adequate sturdiness to support the 24,000 pounds of dirt supported over the sections 30 and 31 as well as the weight of the patio thereabove and provides capacity for five occupants. This light weight permits that only 2 or 3 men are needed to conveniently and rapidly handle each of the component sections and conveniently handle their proper assembly. Flange 73 on sidewall 61 extends laterally for 2 inches and upward for 4 inches. This flange is formed in the mold with the section 30 as above described. Clips, as 80 through 88 on slab 23, hold sections as 30 thereto; each such clip in the preferred embodiment is positioned by anchor bolts, as 89, along a flange, as 73, on one foot centers. These clips measure 3/8" x 1.5" with a 9/16" diameter slot therein, 1 inch long; the bolts as 89, thus anchor each section, as 30—via angle 73—to the slab 23. Clips, as 91 and 92, are provided on the flanges as 74, for each end wall, as 63, and similar clips, as 93 and 94, are provided on the flanges, as 75, for each end wall, as 64.

Each of these ribs as 51–58, 66–68, 70–72, and 51'–58' provides two ribbing elements, as 95 and 96 as shown for ribs 52 in FIGURE 12, which substantially increases rigidity and strength of the side walls, as 61, and of the roof portions, as 62, and provides no opportunity for ingress of water or moisture.

The portion 104' of floor slab 23 for the chamber section 21 comprises an 8 inch thick concrete slab, which is, in the preferred embodiment, 14 feet long and 12 feet wide and weighs approximately 28,000 pounds. The longitudinal center portion thereof, 97, has a total depth of 16 inches for a width of about 8 inches and the side walls of such deepened center portion are at 45° to the horizontal. The lower portion, 77, of the flange 32 is formed by flange portions 77' and 77" and a peripheral resin layer in the same manner as portions 32', 32" and 116 form the top portion of flange 32, and sits in a tapered groove provided therefor in said center portion 97 of slab portion 104 whereby floor portions 65 and 65' may rest directly and smoothly on the top of slab 23 during assembly. This slot is filled with sufficient cement grout

to fill that slot when flange 77 has been fully inserted thereinto. Reinforcing bars as 100 and 101 run transversely and longitudinally through the cement floor 23 and extend also into the portion 102 of slab 23, which portion is located below landing section 119, and which floor slab portion 102 is reinforced and deepened and slotted at 102' for the receipt of the lower portion of flange 35 therein in the same manner as above discussed for the receipt of flange 77 in deepened section 97 of floor slab portion 104.

The side wall 107 of section 33 of entry section 22 and the roof 109 are provided with a plurality of ribbing elements 110 through 115, similar in cross-section to the ribs 51 through 58 along side wall 61 of section 30.

An L-shaped locking flange 120 is provided at the bottom of wall 107 in the same manner as flange 73 is attached to wall 61. Similar clips hold such flange to the section 102 of slab 23. The side wall 107 is composed of a stair section wall 117 and a landing section wall 118. Section 117' of the entrance section 34 is generally a mirror-image of section 117 of section 33, as shown in FIGURE 4. End wall 63' of the chamber section 21 is broken away in part to provide space 126 for a door 127 providing access therefrom to the landing section 119 of the entrance section 22. The maximum interior width of the stair section of entrance section 22 is two feet 4 inches. The front end walls as 122 (and 122') are provided with a small (½ inch) taper across their 1 foot 2 inch width whereby to facilitate removal of corresponding sections 33 and 34 from the mold during their manufacture. The side and roof ribs 110–115 are formed in the mold with the side wall, ceiling, end wall, floor, stairs and locking flange in the same manner as the ribbing members 51–58 and flange are provided on the side walls and roof of the chamber section 30. The flange 35 joining the sections 33 and 34 is composed of one portion joined to the floor, end, stair and ceiling portion of shell section 33 and a mirror image thereof, 34', joined to corresponding components of shell. By bonding of such flange portions by the resin of which the shells 33 and 34 are made (the same composition as above discussed for shell sections 30 and 31), shell sections 33 and 34 form one unitary water proof element, which similarly joins with the shell sections 31 and 30 of chamber section 21 to form two interconnected water proof chambers supported on the slab, 23, and firmly attached thereto by clips as 81–88, 81'–88', 91–94, and 91'–94'. Such bonding is readily formed at the construction site by placing a wet (as with resin and glass fiber mix as above described for the matt mixture) matt between the matching section portions forming a flange—as flange 32—and clamping the flange portions firmly together, making sure the saturated matt covers the entire flange interior; three interior coats with 1.5 ounce matt and one exterior coat with 4.5 ounce cloth are preferred.

The reinforcing ribs, as 66–68 and 70–72, are bonded to the wall to which are attached, from the outside with, not less than two coats of 1.5 ounce matt covering the entire length of the rib and one coat of 4.5 ounce cloth not less than 6 inches wide on either side of the rib for its entire length.

The lower portion 125 of the flange 35 is 9 inches wide in the preferred embodiment; the steps as 124 in the preferred embodiment are each 1 foot high and 9 inches deep. The landing 119 provides 2 feet 9 inches between the end wall 122 and the bottom step. The wall 63' has a door opening 126 therein 2 feet 3 inches wide in the preferred embodiment wherein is placed the door 127. The length from end wall 122 to end wall 123 of shell 33 (and 34) in the preferred embodiment would be about 10 feet 6 inches. In combination with earth 121 above the chamber 21 and rolling door 27 below described in detail, no harmful radiation can directly enter the shelter. The lowest portion of the flange 35, namely portion 128, below the floor of the landing section 119, is firmly secured to the slab section 102 and the enlarged portion 102' thereof as hereinabove described. Reinforcing ribs, as 129 (and 129'), are attached to the periphery of the walls 122 (for 122') in the same manner as the ribs 66 through 68 are attached to the end wall 63. These ribs have flanges, as 74 above described. Clips, similar to 82, are used similarly and support and fix these flanges in place on portion 102 of the block 23 therebelow.

The rolling door chamber 39 comprises a left and a right upper portions 36 and 37 which are joined by a flange 130. Another flange (131 on part 36 and 132 on part 37) joins sections 36 and 37 via the sections 33 and 34, respectively, to flanges 133 and 134 of the sections 33 and 34, respectively. These joinings are accomplished by the same secure chemical bonding, effecting leak proof joints and wherein these mirror image flanges are held together as for sections 30 and 31 and by bolts. The upper portion of shell section 33 forms an elongated projection 135 for the bottom portion of the front part of chamber 39. A corresponding projection 135' is formed by section 34. The rolling door chamber 39 comprises the projecting door storing portion 135–135' and the closure portion 136, located below the entrance opening 137.

The door 27 is composed of a plastic shell 140 of the same composition as shell 61, 2 feet 8 inches wide in the preferred embodiment and 44 inches long. Except as below described, the shell is filled with concrete to the level of the top of shell 140. This shell is open at its top, 141. In the bottom of shell 140, two tracks 142 and 143 are fixed. These tracks run the length of the door 27 and their centers are spaced inwardly ¾ inch from the edge thereof. These tracks, in the preferred embodiment are made of ½ inch angle iron to form a V-track as shown in FIGURE 9. In the center line of the door 27 are located two hemispherical recesses as 144 and 145, on the top of which are located ¼ inch diameter 4 inch long eyebolts, 146 and 147, respectively each, with an eye at the bottom thereof. This eye is for attachment of a hook or ring for an occupant to roll the door open and closed from a position below said door to the closed position 138 shown in FIGURE 4 in solid lines from the open position 138' there shown in broken lines, and vice versa.

The tracks 142 and 143 are each firmly supported in the concrete 139 contained within the shell 140 by a plurality of eyebolts as 148 for track 142 and 149 for the track 143. Additional eyebolts, as 151' and 152, may be provided in the top of the door, embedded in the concrete or reinforced concrete 139, to facilitate the handling of such door. The door is supported through tracks 142 and 143 on a plurality of rollers as 153 and 153'. These rollers are in turn each supported on a shaft therefor as 154. Such shafts, in turn, each rest on a support therefor, as bracket channel 155. This bracket, in turn, is supported on and secured to a shoulder as 156 on shell 34, or 157 on shell 33, of the chamber 39.

As shown in FIGURE 6, the door is conveniently made at the building site by filling the prefabricated shell 140 with cement, reinforced concrete, or the like. The tracks may be bonded to the shell or can be assembled thereto prior to adding such cement in a conventional mold 150 with an interior cavity dimensioned to provide support to the outside dimensions of shell 140.

The door storage projection portion 135–135' of chamber 39 is provided at its bottom with a plurality of ribs, as 158 and 159, for the projection portion 135 of section 33, and ribs as 158' and 159' corresponding thereto for the projection 135' of section 34. The flange 35 is provided with an extension 160 which vertically extends from the roof 109 of sections 22 to the floor of chamber 39; in the preferred embodiment these ribs adjacent flange 160 each extend downwardly about a foot from chamber 39 and extend to the extreme lateral width of the bottom of the projection portion 135–135' for the support of the rolling door chamber 39. The forward end 161 of chamber 39 is 4 feet distant from the entrance opening 163 of

chamber 39 into the entrance section 22 in the preferred embodiment above described. This provides storage of the door 27 out of the way of those entering or leaving the shelter.

The wheels as 153–153', which are ½ inch in their maximum diameter and ¼" thick in the preferred embodiment, are spaced 3 inches apart from each other along the shoulder 155 in order to support tracks 142 and 143. The shaft 154 is ⅝ inch long and ⅛ inch in diameter thus providing flexibility in location of the angularly edged wheels in the track in which they fit.

This arrangement provides a ½ inch draft between the bottom of the door 27 and the top of the shoulder 156.

This arrangement of apparatus provides that, after the lower sections 33 and 34 have been assembled and put in place and earth added to support from below the shell portions 135 and 135', brackets as 155 and wheels, as 153, therein are laid in place on top of each of shoulders 156 and 157. Thereafter the concrete filled door 27 may be laid in place in the position 138 or 138' as shown in FIGURE 4. Following this placement of the door, the upper sections 36 and 37 of the rolling door chamber 39 may be added. The ribs 158, 159 and 158' and 159' serve to stabilize the structure during the filling in of dirt and further still to stabilize the structure against any twisting that might make difficult the opening and closing of the rolling door 27. In view of the close proximity of the end wall 63' to the flange 160 it is desirable, and in the preferred embodiment is provided, that there be a substantial orifice 162 in flange 160 to expedite the distribution of the earth filling material beneath the chamber 39. With a distance of some 3 foot 6 inches between the top of the roof of sections 33 and 34 and the flanges 133 and 134, the flange 35 may have a minimum height of 6 inches at its top portion over roof 109 and yet in the neighborhood of the reinforcing flanges 158, 159, 158', 159', which are each 1 foot away from each other on centers, the height of the flange 160 above the hole 162 is also 1 foot. The interior height of the chamber 39 is 10½ inches which provides adequate space to avoid any interference with the function of the door on sliding of the earth. Accordingly, even if there is a slide or a twist the angled tracks 141 and 142 move freely over the movable and edged wheels as 153 and so avoid any entombment of the occupants of the shelter.

The entrance opening 136, of section 22, is 4 feet 2 inches long in the preferred embodiment and two feet 6 inches wide. It is provided with upstanding side walls 175 and 176, as shown in section in FIGURE 10 which project some 3 inches above the level of the ground or patio 29 to avoid any influx of water in the shelter. The dome shaped rectangular door 38 is hingedly attached by a piano hinge, as 165, whereby to hingedly rotate about one section as 34. The interior of each of the shoulders 166 and 166' is provided with interiorly projecting shoulders 169 and 170, respectively, on which the frame 171 of a screen generally indicated as 172 may rest. The screen thereof, 172, thus rests on the shoulders during the opening of the door 27 and the dome 38 for the purposes of driving air out of the shelter in order to keep it free from musty odor, while at the same time preventing dust from falling therein. Thereby the shelter may be kept open to the air while kept free from dust, by use of the air circulation system below described. Additionally, the dome is provided with an elbow catch 173 on the side of the piano hinge 165 and with another steel spring 174 adjacent the other side 166'. The screen frame 171 thus may be held in place as shown by solid lines of FIGURE 10, said frame 171 being then held into place by these springs 173 or 174 which run the length of the entrance 136; thereby, such screen frame 171 serves to seal these steel springs against the upstanding walls as 175, 176 and so prevent the ingress of radioactive fall-out dust in through such space between the shoulder 166 and 166' and the dome 38 as may exist due to minor displacement as by wind. The arrangement of the concrete 139 in the sliding door 27 and patio 29 above chamber 39 shields and protects tracks 142 and 143 and movable members as wheels 153 which permit the door to move to and from its closed position 138 as shown in FIGURE 4 by shielding the channels 155, 156, and wheels as 153 thereon from the heat effects of explosive blasts.

Nevertheless, notwithstanding the excellent radiation protection provided by such a heavy door, there is no difficulty with the movement of such door, even following exposure of the exterior thereof to the intense heat of a high energy explosion blast of atomic or other nuclear blast. Further, this structure is created by the use of a complete unit having only six major components which components may be reliably yet quickly sealed together to provide a water-proof, moisture-proof, sturdy unit.

The wide central flange 32, it will be noted, is directly connected to the ribs 51 through 58 on section 30 and ribs 51' through 58' on section 31. Accordingly, the compressive stress exerted across the roof by the earth is not necessarily transmitted across the entire 8 foot width for support of said roof but rather only need be transmitted across half the width of said roof, i.e., from one wall, as 61 or 61' to the flange 32. Thereby the compressive strength of the roof is greatly increased—roughly about four times its strength in that direction. So far as the roof strength in the vertical direction is concerned, the wide flange 32, which is made rigid by ribs 51 through 58, and 51' through 58' and panels of sections 41 through 49, and 41' through 49' is also 4 layers each 3/16 inch thick and a substantial roof-supporting member. Further, the tie-down flanges as 73 and 73' and various clips as 98 and 99 provide that floor 65 and 65' and the bottom of sides 61 and 61' act as a firm support member. This enhances the strength of the structure to resist vertical stresses. The fixing of the flange 73 to the sturdy concrete structure 23 by the clips, as 80–88 and 80'–88', and as 91–93 and 91'–93', provide that the bottom of the shell 21 acts as a fixed member against any compressive lateral forces. The top and the rounded juncture of the roof 62 and the side wall 61 (and 61' and 62') also finds firm support by the ribbed flange 32 which, of course, increases the resistance of the roof to stresses applied thereto. Flange 32 provides support to the end walls 63, 64, and 64' against the horizontal force of the earth applied thereto; the additional ribs, as 66, 67, 68, further provide strengthening as needed as does the firm attachment of the slab 23 thereto by the clips.

During the construction of the device, a wooden frame as 150 is used to support the plastic shell 140 while it is being filled with cement as shown in FIGURE 6; during construction also the projection 135–135' of chamber 39 is supported, as by a wooden chock, prior to pouring the cement on the top thereof.

In the preferred embodiment a slab 29, with an overall length of 18 feet and an overall width of 18 feet is used generally as shown in FIGURE 3. Nevertheless, in a more economic embodiment of this invention only the projecting portion 135–135' of chamber 39 is thoroughly covered by concrete to provide protection to the transport mechanism for the door 27. Such slab is 6 inches thick.

Further provided for use with this invention is an air system comprising an intake 180 provided with a filter 181, an intake duct 182 which might have, for instance, an 8 inch internal diameter, a further filter, as 183' of charcoal, and an intake orifice 184. A hand pump 185 may be used to draw air through the intake duct, 182. Additionally the shelter is provided with an exhaust orifice 187 which leads to a pump 189 which may be hand driven or electrically driven as by an electric motor 190; this pump discharges into an exhaust line 191 which also

drains the stairway section, **117**, through orifice **192** of said exhaust duct, to outlet **193**.

Further still, the device of this invention incorporates therein a water tank system. This water tank system comprises an inlet line **195** which feeds into a tank **196** and out through an outlet line **197** which feeds into the normal household line or to the lawn sprinkler system of the home; in the preferred embodiment this device feeds to the house water system and maintains fresh water in the supply tank **196**. This device comprises a tank which has a length 5 feet 0 inches, a diameter of 20 inches and a capacity of 82 gallons. The water inlet **195** connects to the top of the tank only and provides a siphon break there to prevent drainage from the tank in the event of any failure of the line. The outlet of the tank is connected to the bottom of the end wall, **194**. Another outlet, **199**, passes to the sink **200**, and another line **201** provides for direct feed, using the line pressure of the tank, to the sink. This water pressure system provides that the occupants of the shelter may know when the water utility pressure is in operation in event of a disaster where communications are generally broken down and there is no way of knowing when public utility service has been restored. This provides a measure of line pressure provided by the city at the time.

As shown in FIGURE 4, the lowermost step adjacent the landing section **119**, is made with a hinged plate, **212**, to provide space **212** for storage of waste by the occupants of the shelter.

According to this invention, the air exhaust line duct **191** opening **192** into the entrance shell permits that the entrance section chamber may be vented to the air above the ground level without passage of the air in that chamber—which may be contaminated with radioactive dust or odors from the waste storage—through the chamber **21** wherein occupants are staying. This is accomplished by movement of air from the inlet chamber **21** by pump **189** into the duct **191**, whereby, by jet action, it moves the air in that duct out of its outlet opening **193**.

According to this invention, the water reservoir tank **196** is provided with fresh water continually by the passage of water from the main water line to the house via said reservoir tank. As line **195** enters the chamber at its top, in the event of main line pressure failure, there is no loss of water from tank **196** because hydraulic connection is broken when the level of water in the tank falls below the level of the opening of the inlet line **195** into the chamber of tank **196**. In the event of disaster requiring the use of the shelter, inlet conduit **195** has an above ground connection **200** which permits pressure to be applied to the fluid in the reservoir for discharge thereof above ground, as by outlet **207** which is operatively connected to outlet **197** of the reservoir. A tubular connection **201** is provided between the inlet conduit **195** and the interior of chamber **21**. This conduit may be opened, as by valve **204** after the line pressure has fallen and occupants are inside the shelter, in order to prevent persons outside the shelter from similarly pressuring the contents of the tank via connection **200** and draining off the water in said reservoir by outlet **207**. Outlet conduit **197** may also be controlled by a valve **205** within chamber **21**. Valve **205'** in chamber **21** may also be provided to control line **195**.

Concrete is relatively brittle and requires water proofing; steel is subject to corrosion and heavy. By the combination of structure and materials of this invention, an apparatus avoiding the expense and weight of concrete and steel and having low labor requirements for assembly is provided. Because only a few large (yet readily handled) components are used the problems of waterproofing is especially limited; because plastic is used less weight than steel per unit area of the shell is provided; this permits only a few men to conveniently handle, position and locate all the component units, which would not be permissible with heavier materials. Further, the sound absorption characteristics of the plastic used in the preferred embodiment are desirable especially compared to the noise problem of a metal-walled room. Another advantage of this device lies in the high strength/weight ratio obtained by use of thin-walled strong panels alternating with U-shaped ribs as hereinabove described. A desirable feature of this invention thus lies in the ribbing structure of walls as **61**, **61'**, **117**, **117'**, **63**, **64**, and **64'** which permit some deformation. The wall panels are only $\frac{3}{16}$ inch thick: the ribs are spaced 16 inches on centers—this is a spacing of about 100 times the thickness of the walls. The detail shown in FIGURES 11 and 12 illustrates that the side walls, as **61**, composed of the U-shaped ribbing elements as **51–58** and panels as **41–49** may deform (rotate) in a direction normal to their exterior surface while their dimensions parallel to the direction of the ribbing element in their surface are maintained. Accordingly, in event of tremors, the elasticity of the wall structure herein normal to the surface permit toleration of such temporary displacement without rupture of the walls or the seams joining the components. It is to be noted that the seams formed by flange **32** are about forty times the wall thickness and 5 times the thickness of the ribs. This large seam area is desirable when extremely severe ground tremors are likely to be met and the safe opportunity for disposal of water gathered through any ruptured seam in an underground structure is relatively negligible. To make a structure having such large seam area with more components would require much time and labor in joining such seams; according to this invention the few seams used are strong and capable of tolerating such shock while maintaining their water proof integrity and non-porous characteristics of the glass fiber plastic laminate formed as above described.

The use of the slotted slab **23** provides a firm support for the occupants' weight while not interfering with the water proof characteristics of the shell and its toleration to shock—note that the flange **73** firmly laterally positions the panels as **41–49** but the ribbing elements as **52** are not rigidly fixed to the slab, and some rotative motion thereof is permitted relative to the slab. The large seam structure also permits the chambers to withstand skewing stress and strain without rupture.

This theme of a structure adapted to tolerate displacement is carried into the door chamber **39**, whereat substantial play is allowed the wheels as **153** on shaft **154** in tracks as **143**; accordingly, moderate displacement of walls does not affect the self-aligning rollers in their tracks and the ready movement of the door from the closed position. This is in addition to the arrangement provided by this invention wherein the tracks are protected by the concrete in door **27** or patio **29** over chamber **37** from the fusing effects of intense radioactive and heat waves on metal tracks that might otherwise render such tracks inoperative to permit removal of a heavy door from an underground shelter exit.

Having thus described the means by which the objects of the invention are obtained, in the form at present preferred, modifications thereof within the skill of the art are intended to be included within the scope of the appended claims.

I claim:

1. An underground shelter comprising a first chamber having a greater width than height and within a unitary waterproof shell below the ground level, earth above and surrounding said shell and reaching from said shell to the ground level, whereby the earth surrounding said shell protects same from nuclear radiation, said shell comprising two matching units substantially mirror images of each other, each unit comprising a non-porous floor, roof, side wall and end walls joined together, and a second, entrance section, chamber connecting with said first chamber and opening thereinto and extending from the level of the floor of said first chamber to an opening above the level of the ground and a central vertical longi-

tudinal peripheral flange extending externally for the full length of said floor and said roof, and externally for the full height of each of said end walls, and a flange extending laterally from the bottom of each of said side walls, said walls and roof having ribs U-shaped in cross-section, said ribs each extending substantially the full height of said side wall, extending onto said roof and running the full width of said roof and joining the longitudinally extending flange projecting therefrom, said ribs projecting outwardly, said ribs spaced apart 100 times the thickness of the walls and roof, each of said units being bonded to the other along said longitudinally extending flange extending the length of said unit on the top and bottom of said shell, said flange projecting outwardly for a distance three times the thickness of said ribs, said shell supported by and attached to a flat horizontal concrete base, said base extending at least the full width and length of said shell, said base firmly attached to the flange at the bottom of said side wall for the full length thereof and contacting and supporting the floor of said shell, said shelter also comprising an enclosed water reservoir with its bottom above the floor level of said shell and below the level of the ground, an outlet duct from said reservoir to said first chamber, an outlet connection from said outlet duct to above said ground level, an inlet duct to said reservoir operatively connected to the top of said reservoir, said inlet duct also having a connection opening above ground, and a tubular connection from said inlet duct to the interior of said first chamber.

2. An underground shelter comprising a first chamber within a unitary waterproof shell below the ground level, earth above and surrounding said shell and reaching from said shell to the ground level, whereby the earth surrounding said shell protects same from nuclear radiation, said shell comprising two matching units each substantially mirror images of each other, each unit comprising a non-porous floor, roof, side wall and end walls joined together and a central longitudinal peripheral flange vertically extending externally from each of said floor, roof and end walls, said side walls and ceiling having ribs U-shaped in cross-section, said ribs each extending substantially the full height of said side walls, extending onto said roof and running the full width of said roof and joining the flange projecting therefrom, each of said units being bonded to the other along said longitudinally extending flanges extending the length of each of said units on the top and bottom of said shell, said side walls of said shell being supported on and firmly attached to a flat horizontal concrete base, said base extending at least the full width and length of said shell and contacting and supporting the floor of said shell, and an entrance section chamber connecting with said first chamber, extending from the level of the floor in said first chamber to level of ground and projecting thereabove, said entrance section chamber formed of a waterproof non-porous entrance section shell, said entrance section shell being bonded to a vertical wall of said first chamber, a door assembly housing attached to and opening only into said entrance section chamber, a sliding door assembly in said housing, a pair of shoulders on said entrance section shell supporting said door assembly, means for movably supporting said door assembly on said shoulders along the length of said door assembly housing, means between the housing and the said level of ground protecting from radiation said means for movably supporting said door, said housing extending horizontally for a distance at least the length of said door from said entrance shell, a second door hingedly attached to the top of said entrance shell above the ground, said door assembly comprising a thin plastic shell and a plurality of tracks on the bottom surface of said shell parallel to the length thereof, said radiation protection means including a mass of concrete within said plastic shell of the door assembly, supports for said tracks fixed in said cement, handles fixed in said cement and extending to the bottom surface of said door whereby to manipulate said door on the means for its movable support.

3. An underground shelter comprising a first chamber within a unitary waterproof shell below the ground level, earth above and surrounding said shell and reaching from said shell to the ground level, whereby the earth surrounding said shell protects same from nuclear radiation, said shell comprising two matching units each substantially mirror images of each other, each unit comprising a non-porous floor, roof, side wall and end walls joined together and a central longitudinal peripheral flange vertically extending externally from each of said floor, roof and end walls, said side walls and roof having ribs U-shaped in cross-section, said ribs each extending substantially the full height of said side walls, extending onto said roof and running the full width of said roof and joining the flange projecting therefrom, each of said units being bonded to the other along said longitudinally extending flanges extending the length of each of said units on the top and bottom of said shell, said side walls of said shell being supported on and firmly attached to a flat horizontal concrete base, said base extending at least the full width and length of said shell and contacting and supporting the floor of said shell, and an entrance section chamber connecting with said first chamber, extending from the level of the floor in said first chamber to the level of ground and projecting thereabove, said entrance section chamber formed of a waterproof non-porous entrance section shell, said entrance section shell being bonded to a vertical wall of said first chamber, a door assembly housing attached to and opening only into said entrance section chamber, a sliding door assembly in said housing, a pair of shoulders on said entrance section shell supporting said door assembly, means for movably supporting said door assembly on said shoulders along the length of said door assembly housing, means between the housing and the said level of ground protecting from radiation said means for movably supporting said door, said housing extending horizontally for a distance at least the length of said door from said entrance shell, a second door hingedly attached to the top of said entrance shell above the ground, said entrance section chamber shell being formed of two substantially mirror image units, each unit comprising a non-porous floor, roof, side and end walls, and a central longitudinal flange extending from said floor and end walls, the top of said entrance section shell forming the bottom portion of said door assembly housing, permitting the door assembly to be located therein prior to adding the upper portion of said housing thereon, said radiation protecting means including a cement slab at ground level extending over said first chamber and over said entrance section chamber.

4. An underground shelter comprising a first chamber within a unitary waterproof shell below the ground level, earth above and surrounding said shell and reaching from said shell to the ground level, whereby the earth surrounding said shell protects same from nuclear radiation, said shell comprising two matching units substantially mirror images of each other, each unit comprising a non-porous floor, roof, side wall and end walls joined together, and a central vertical longitudinal peripheral flange extending externally from each of said floor, roof, and end walls, each of said units being bonded to the other along said longitudinally extending flange extending the length of said unit on the top and bottom of said shell, said shell supported by and attached to a flat horizontal concrete base, said base extending at least the full width and length of said shell, said base contacting and supporting the floor of said shell, said shelter also comprising an enclosed water reservoir with its bottom above the floor level of said shell and below the level of the ground, an outlet duct from said reservoir to said first chamber, an outlet connection from said outlet duct to above said ground level,

an inlet duct to said reservoir operatively connecting to the top of said reservoir, said inlet duct also having a connection opening above ground, and a tubular connection from said inlet duct to the interior of said first chamber and a second, entrance section, chamber connecting with said first chamber and opening thereinto and extending from the level of the floor in said first chamber to an opening above the level of the ground.

5. An underground shelter comprising a first chamber within a unitary waterproof shell below the ground level, earth above and surrounding said shell and reaching from said shell to the ground level, whereby the earth surrounding said shell protects same from nuclear radiation, said shell comprising two matching units substantially mirror images of each other, each unit comprising a non-porous floor, roof, side wall and end walls joined together, and a central vertical longitudinal peripheral flange extending externally from each of said floor, roof, and end walls, and a flange extending laterally from the bottom of each of said side walls, each of said units being bonded to the other along said longitudinally extending flange extending the length of said unit on the top and bottom of said shell, said shell supported by and attached to a flat horizontal concrete base, said base extending at least the full width and length of said shell, said base contacting and supporting the floor of said shell, and an entrance section chamber connecting with said first chamber, extending from the level of the floor in said first chamber to the level of ground and projecting thereabove, said entrance section chamber formed of a waterproof non-porous entrance section shell, said entrance section shell being bonded to a vertical wall of said first chamber, a door assembly housing attached to and opening only into said entrance section chamber, a sliding door assembly in said housing, a pair of shoulders on said entrance section shell supporting said door assembly, means for movably supporting said door assembly on said shoulders along the length of said door assembly housing, means between the housing and the said level of ground protecting from radiation said means for movably supporting said door, said housing extending horizontally for a distance at least the length of said door from said entrance shell, a second door attached to the top of said entrance shell above the ground, said door assembly comprising a thin plastic shell and a plurality of tracks on the bottom surface of said shell parallel to the length thereof, said radiation protection means including a mass of concrete within said plastic shell of the door assembly, supports for said tracks fixed in said cement, handles fixed in said cement and extending to the bottom surface of said door whereby to manipulate said door on the means for its movable support.

6. An underground shelter comprising a first chamber within a unitary waterproof shell below the ground level, earth above and surrounding said shell and reaching from said shell to the ground level, whereby the earth surrounding said shell protects same from nuclear radiation, said shell comprising two matching units substantially mirror images of each other, each unit comprising a non-porous floor, roof, side wall and end walls joined together, and a central vertical longitudinal peripheral flange extending externally from each of said floor, roof, and end walls, and a flange extending laterally from the bottom of each of said side walls, each of said units being bonded to the other along said longitudinally extending flange extending the length of said unit on the top and bottom of said shell, said shell supported by and attached to a flat horizontal concrete base, said base extending at least the full width and length of said shell, said base contacting and supporting the floor of said shell, and an entrance section chamber connecting with said first chamber, extending from the level of the floor in said first chamber to the level of ground and projecting thereabove, said entrance section chamber formed of a waterproof non-porous entrance section shell, said entrance section shell being bonded to a vertical wall of said first chamber, a door assembly housing attached to and opening only into said entrance section chamber, a sliding door assembly in said housing, a pair of shoulders on said entrance section shell supporting said door assembly, means for movably supporting said door assembly on said shoulders along the length of said door assembly housing, means between the housing and the said level of ground protecting from radiation said means for movably supporting said door, said housing extending horizontally for a distance at least the length of said door from said entrance shell, a second door attached to the top of said entrance shell above the ground, said entrance section chamber shell being formed of two substantially mirror image units, each unit comprising a non-porous floor, roof, side and end walls, and a central longitudinal flange extending from said floor and end walls, the top of said entrance section shell forming the bottom portion of said door assembly housing, permitting the door assembly to be located therein prior to adding the upper portion of said housing thereon, said radiation protecting means including a cement slab at ground level extending over said first chamber and over said entrance section chamber.

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