Methods and assemblies for above-ground fire refuge shelters are provided. The fire refuge shelter includes an inner fire resistant enclosure for heat protection which is separated by a void from an exterior shell for protection from flames and embers. The shelter may also include a structural support disposed between the inner and outer structures. The shelter may have at least two exterior doors. The inner enclosure may include one or more antechambers separated by an operable barrier from a main chamber and may further include storage facilities. A water tank may be located above the inner enclosure.
ABOVE-GROUND FIRE SHELTER
CROSS-REFERENCE TO RELATED APPLICATIONS

[0011] This application claims the benefit of priority under 35 U.S.C. §119(a-d) of Australian Provisional Patent Application No. 20099004878, filed on Oct. 8, 2009 and entitled “Above-Ground Fire Shelter,” the entirety of which is hereby incorporated herein by reference to be considered part of this specification.

BACKGROUND

[0002] The present application relates to fire refuge shelters.

[0003] There are many populated regions of the world that are subject to bushfires or forest fires. Such fires may result in major losses of life, property, and other assets. For example, the devastating bushfires which occurred on Saturday, Feb. 7, 2009 in Victoria, Australia, resulted in the death or injury of over 500 people and the loss of over 2,000 homes.

[0004] In many instances, people who would prefer to leave in the face of an approaching fire may receive insufficient warning or may find that their planned escape routes have been cut off. Other residents and property owners in fire-prone areas may wish to remain with their properties in order to defend them during a fire. In such circumstances, a suitable fire refuge may save lives.

[0005] Most existing fire refuges fall into one of two categories. The first category comprises converted water tanks or similar bunkers manufactured from concrete or the like, often as a single molded structure. Most commonly, such bunkers are installed underground, with entry being provided via a trapdoor located in the roof. While underground structures may provide effective protection from a passing fire, accessibility can be a problem for individuals with infirmities or disabilities. Furthermore, there is a real risk that occupants may become trapped, for example, due to trees or other debris blocking the doorway. In addition, an underground bunker provides no effective exterior visibility in order to assess when the fire danger has passed.

[0006] An alternative prior art approach is based upon embedding a dedicated fire refuge shelter within the earth, such as a natural or artificial embankment, thereby providing access via a side entrance. Such shelters may provide improved accessibility, although the entrance may still be located below the normal ground level, with access via stairs or a ramp. As with the above-described underground shelters, primary protection from fire and physical damage is provided by the surrounding earth, and if a suitable natural embankment is not available, the shelter must be at least partially buried and/or embedded within a sufficiently thick mound of earth.

[0007] All of the aforementioned shelters consist essentially of a single chamber, which is sealed in use and typically encloses sufficient air to sustain the occupants for up to three to four hours. However, contamination of this air supply, for example by the ingress of smoke, may reduce the effectiveness and safety of the shelter.

[0008] None of the aforementioned forms of fire shelter provide a freestanding, above-ground refuge that is easily accessible, even by people with mobility problems, while nonetheless providing a high level of safety and security during extreme fire conditions. The present invention seeks to meet the need for such a fire refuge shelter.

SUMMARY

[0009] Assemblies and methods for constructing an above-ground fire refuge shelter are provided. The fire shelter comprises two parts: an inner fire resistant enclosure providing primary heat protection and a streamlined, exterior shell, separated by a space having a relatively low thermal conductivity (such as a void for example) from the inner structure. The shelter may comprise a structural cage disposed between the inner enclosure and outer shell. The inner fire resistant enclosure may have doors leading to one or more antechambers that are separated by an openable barrier from the main refuge chamber. Storage facilities can be located within the inner fire resistant enclosure.

[0010] In one embodiment, an above ground fire refuge shelter is provided. The shelter comprises an inner fire resistant enclosure that is designed to provide protection from radiant heat. The shelter further comprises an exterior shell configured to provide protection from flame or ember attack. The exterior shell comprises a curved top portion where a middle portion of the curve is rounder than the flatter ends of the curve. Walls that are either substantially straight or that extend the flatter curve extend from the ends of the top curved portion. The inner fire resistant enclosure is separated from the exterior shell by a void or space with a low thermal conductivity. The sides of the exterior shell and the inner fire resistant enclosure define, in cross section, a truncated triangle. The roof of the inner fire resistant enclosure and the top portion of the exterior shell define, in cross section, a curved rectangle.

[0011] In another embodiment, an above-ground fire shelter is provided. The shelter comprises an inner fire resistant enclosure that is designed to provide protection from radiant heat and an exterior shell designed to protect from flame or ember attack. The fire resistant enclosure comprises a main chamber and at least one antechamber. The main chamber and at least one antechamber are separated by an openable barrier. The exterior shell comprises a curved top portion where a middle portion of the curve is rounder than the flatter ends of the curve. Walls that either extend the flatter curve or that are substantially straight extend from the ends of the top curved portion. The inner fire resistant enclosure and exterior shell are separated by a void or space of low thermal conductivity. The shelter also comprises a support structure configured to provide protection against impact that is disposed between the fire resistant enclosure and the exterior shell.

[0012] Another embodiment provides a method for constructing an above-ground fire resistant refuge shelter. The method comprises providing an inner fire resistant enclosure which is designed to provide protection from radiant heat. The inner fire resistant enclosure comprises a main chamber and at least one antechamber. The main chamber and at least one antechamber are separated by an openable barrier. The method further comprises providing an exterior shell over the inner fire resistant enclosure, but separated by a void or space of low thermal conductivity from the inner enclosure. The exterior shell comprises a curved top portion where a middle portion of the curve is flatter than the ends of the curve. Walls that either extend the flatter curve or that are substantially straight extend from the ends of the top curved portion. The exterior shell is designed to provide protection from flame or ember attack. The method also comprises providing a support...
structure configured to provide protection against impact that is disposed between the fire resistant enclosure and the exterior shell.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 depicts a perspective and front view of a fire refuge shelter according to an embodiment of the invention.

[0014] FIG. 2 illustrates an exploded view of an above-ground fire refuge shelter according to an embodiment of the invention.

[0015] FIG. 3 illustrates the description of a ‘curve’.

[0016] FIG. 4 depicts various dimensions of an embodiment of an exterior shell.

[0017] FIGS. 5A-C show front panel views of different embodiments of a fire refuge shelter.

[0018] FIG. 6A-D depicts various views of a fire refuge shelter according to an embodiment.

[0019] FIG. 7 illustrates the six-person fire refuge shelter according to an embodiment of the invention.

[0020] FIG. 8 shows a floor plan of a six-person fire refuge shelter according to an embodiment of the invention.

[0021] FIG. 9 illustrates a floor plan of a twenty-four-person fire refuge shelter according to an embodiment of the invention.

[0022] FIGS. 10A-E depict various views of a twenty-four-person fire refuge shelter.

DETAILED DESCRIPTION

[0023] The embodiments disclosed herein relate to assemblies and methods of construction for an above-ground fire refuge shelter.

[0024] Embodiments will now be described with reference to the accompanying Figures, wherein like numerals refer to like elements throughout. The terminology used in the description presented herein is not intended to be interpreted in any limited or restrictive manner, simply because it is being utilized in conjunction with a detailed description of certain specific embodiments disclosed herein. Furthermore, embodiments disclosed herein may include several novel features, no single one of which is solely responsible for its desirable attributes or which is essential to the embodiments herein described.

[0025] FIG. 1 shows a perspective view of an above-ground fire refuge 100 according to an embodiment of the current invention. An exterior shell 104 of a fire refuge shelter is visible along with a front panel 110 with an entryway 114 through which a door 118 is visible. This view is meant to aid in giving context to the description of the following embodiments.

[0026] FIG. 2 shows an exploded view of an embodiment of the above-ground fire refuge shelter 100. The refuge shelter 100 is constructed above-ground, and preferably sits at ground level. The shelter 100 may be located on a non-flammable surface 108 which prevents the growth of plants or weeds. The surface may comprise a concrete slab, gravel, or pebbles. It is contemplated that other surfaces that are non-flammable are also possible and may be used.

[0027] The refuge shelter 100 further comprises the exterior shell 104, which is configured to provide protection from flame and ember attack and front and rear exterior panels 110, 112 which close off the ends of the exterior shell 104. The exterior shell 104 may have a streamlined form such as the vaulted shape depicted in FIG. 1. When flames, embers, or other loose flammable materials encounter conventional structures without a streamlined shape, they tend to stick to, enter, or remain present at the structure. This phenomenon can either spark a new fire or cause the fire to remain at the structure, resulting in more damage. The streamlined form of the shell 100 encourages embers and other loose flammable materials to pass over the structure, minimizing their ingress into the structure. The streamlined form also allows a fire to pass over the shelter as rapidly as possible.

[0028] As described below, a fire resistant enclosure 102 may be located within the exterior shell 104. Thus, the shape of the exterior shell 104 may be configured to achieve a balance between providing a low streamlined shape, admitting the inner enclosure as dictated by the height of the inner enclosure 102, and minimizing the aesthetic footprint of the shelter. This balance is best achieved by the exterior shell 104 having a top section that is curved with walls that extend from the curved or rounded portion to the ground. As shown in FIG. 3, as used herein, ‘curved’ or ‘curve’ refers to a segment 9 connecting two endpoints 2, 4. The segment 9 has a highest point 6 that is equidistant from the two endpoints. The sub-segments 8, 10 connecting the highest point to the two endpoints 2, 4 respectively are substantially symmetrical about a line 12 connecting the highest point 6 to the midpoint 14 of a line connecting the two endpoints.

[0029] In some embodiments the top most part of the curve 9 comprises a curve with a lower radius of curvature than the curved portions to either side of the top portion. In other words, the top portion may be a rounder curve than the flatter curved segments extending from it. Referring to FIG. 4, in some embodiments the ratio of a height 16 of the rounder top portion to a length 15 of the flatter top portion is between about 10% to about 80%. In other embodiments, the ratio is between about 10% to about 50%. In some embodiments, the height 16 of the rounder portion of the curve may comprise between 10-45% of a total height 14 of the curve. In other embodiments, the height 16 of the rounder portion of the curve may comprise between 12-25% of the total height 14 of the curve.

[0030] In some embodiments, the exterior shell 104 comprises wall portions 17 extending from the ends of the curve. In some embodiments, the wall portions extend from the curved portion in a substantially straight orientation. In other embodiments, the wall portions extend along the flatter curve of the sides of the top portion of the shell 104. Preferably, the wall height 18 of the shell comprises about 50 to about 80% of a total height 20 of the shell 104. More preferably, the wall height 18 of the shell comprises between about 55 and about 70% of the total height 20 of the shell 104.

[0031] In some embodiments, an angle 22 between the wall 17 and the horizontal ground is between about 65 and about 85°. In certain embodiments, the angle 22 between the wall 17 and the horizontal ground is between about 70 and about 80°.

[0032] The curved top 9 allows the exterior shell 104 to remain streamlined. At the same time, the curve 9 being rounder in the middle, the ratio of the rounder section to the remainder of the curve 9, the angle 22 of the walls 17, and the ratio of wall height 18 to shelter height 20 all allow the exterior shell 104 to accommodate the inner structure 102 and minimize its aesthetic footprint.

[0033] In other embodiments, the shape of the exterior shell 104 comprises a top section 9 that approximates a shallow curve that is an arc segment representing less than 180° of a 360° circle with walls 17 extending tangentially to the curve.
at an angle of about 75° from horizontal. In certain embodiments, the top section 9 approximates a shallow curve with an arc from between about 90° and about 100°. In certain embodiments, the angle 22 between the wall 17 and the horizontal is between about 65° and about 85°. In other embodiments, the angle 22 between the wall 17 and the horizontal ground is between about 70° to about 80°. As described below, the top section 9 may be made from multiple sheets of metal. In such a case, the substantially straight sheets of metal may be sized and placed in such an orientation that the overall top section approximates a shallow curve while not actually being a smooth curve.

In other embodiments, the shape of the exterior shell 104 may approximate a catenary curve. A catenary curve is superficially similar to a parabolic curve. However, unlike a parabola, in Cartesian coordinates, a catenary curve has the following mathematic formula:

\[ y = a \cosh \left( \frac{x}{a} \right) = \frac{a}{2} (e^x + e^{-x}) \]

where \(\cosh h\) is the hyperbolic cosine function defined by

\[ \cosh x = \frac{1}{2} (e^x + e^{-x}) \]

and ‘a’ refers to the distance between the tip of the curve to the origin of the coordinates.

The exterior shell 104 may be shaped such that the entire shell 104 approximates a catenary curve. Alternatively, the top portion 9 of the shell may approximate a catenary curve with walls 17 projecting tangentially from the top portion 9 at an angle 22 of about 75° from horizontal. In some embodiments, the top portion 9 of the shell 104 may approximate a catenary curve with an ‘a’ value of between about 2 and about 9. In some embodiments, the walls 17 may extend tangentially from the top portion at an angle 22 of about 65° to about 85° from horizontal. In other embodiments, the walls 17 may extend tangentially from the top portion at an angle 22 of about 70° to about 80°. In some embodiments, the walls 17 may account for between 50-80% of the total height 20 of the shell. In other embodiments, the walls 17 may account for between 55% and 70% of the total height 20 of the shell.

In some embodiments, the exterior shell 104 may be constructed from single lengths of material. Oftentimes, embers or other loose flammable material get stuck in cracks or crevices so commonly found on houses or other buildings. Using single lengths of material eliminates or reduces the risk posed by these cracks or crevices. Alternatively, the shell 104 may be constructed from multiple sheets of metal and may be stacked like shingles on a roof among other configurations. Because the sheets overlap one another, the probability for embers and other loose flammable material getting stuck is reduced.

The exterior shell 104 may be constructed from corrugated iron, steel, other metals, and the like. The material may come in sheets which can be curved to shape the shell 104. In some embodiments, the thickness of the material comprising the exterior shell 104 is between about 0.15" and about 0.5". In certain embodiments, the thickness is about 0.25 in.

In some embodiments, the exterior shell 104 may be constructed from or coated with a lighter color material with a higher reflectivity to reflect radiant heat and maintain the shell 104 and its interior at a low temperature as possible for as long a time as possible. For instance, the corrugated iron could be coated with a polyvinylidene Fluoride layer. Reflectivity refers to the percentage of incident infrared radiation reflected by a surface. Preferably, the reflectivity will be between about 20% and about 70%. More preferably, the reflectivity will be between about 40% and about 70%.

Referring to FIG. 2, the fire refuge shelter 100 may comprise front and rear exterior panels 110, 112 which serve to close off the ends of the exterior shell 104. Front and rear exterior panels 110, 112 may be constructed of the same material as the remainder of the shell 104, which may comprise corrugated iron, steel, other metals, and the like. However, in some embodiments, the materials used for the shell 104 and the panels 110, 112 may differ.

In some embodiments, front and rear exterior panels 110, 112 include entryways 114, 116 respectively. The entryways 114, 116 lead to fire doors 118, 120 located at opposite ends of an antechamber 206 which is part of the inner fire resistant enclosure 102 and is discussed below.

FIG. 6 shows various views of the exterior of the refuge shelter 100. FIGS. 6A-6C depict front and rear exterior panels 110, 112 including entryways 114, 116. Fire doors 118, 120 are visible through the entryways 114, 116. FIGS. 6B and 6D show a top and side view of the exterior shell 104.

The refuge shelter 100 may advantageously include the separate inner fire resistant enclosure 102, located within the exterior shell 104. As used herein, ‘fire resistant’ refers to material or structure so impervious to fire that, for specified temperature and time (for example, up to four hours), there will be no structural failure and the side away from the fire will not be hotter than a certain temperature. For example, fire resistant dry wall is a material with water bonds in it. The material will remain at 100° C. until the water in the drywall evaporates due to the fire. The fire resistant enclosure 102 may be in the configuration of a rectilinear prism, but other configurations are also contemplated, such as, for example a triangular or a pentagonal prism. The fire resistant enclosure 102 may be constructed from one or more of concrete, other masonry, autoclaved aerated concrete (AAC), sheetrock, or fire rated plasterboard, or the like. Other materials are also contemplated. In some embodiments, the thickness of the walls of the fire resistant enclosure 102 is between about 1" and about 9". In certain embodiments, the thickness of the walls of the fire resistant enclosure 102 is between about 2" and about 7".

The exterior shell 104 and inner fire resistant enclosure 102 may be separated by an insulated buffer, or in other words, a space or void that is filled with air or some other gas or material having a very low heat conductivity. Preferably, the heat conductivity of the material in this space has a range of between about 0.015 W/m K to about 0.035 W/m K at 20° C. More preferably, the material in this space has an R value of between about 0.022 W/m K and 0.027 W/m K at 20° C. Such an insulated buffer advantageously provides enhanced physi-
cal separation of the inner enclosure 102 and its occupants from the external fire sources and heat.

[0045] In some embodiments, it may be advantageous to reduce convective heat transfer within the space or void between the inner fire resistant enclosure 102 and the exterior shell 104. This can be achieved by filling the space with a material of low thermal conductivity, placing a film layer or wall spaced between and away from the inner fire resistant enclosure 102 and the exterior shell 104, or by adding a layer of insulating material directly against the interior of the shell 104 or the exterior of the inner fire resistant enclosure 102. Examples of materials that can be used are glass reinforced plastics, fibre reinforced plastics, aerogel, AmorSil™, Q-Board™ (e.g., silica aerogel), and the like. Other materials of low thermal conductivity are also contemplated.

[0046] Referring to FIG. 2, in an embodiment when the inner fire resistant enclosure 102 is a rectilinear prism, the voids between the shell 104 and enclosure 102 walls are truncated triangular prisms and the void between the enclosure 102 roof and the exterior shell 104 is a rectangular prism with a curved top surface. FIG. 7 depicts the shape of these spaces in cross-section. Therefore, the space 24, 25 between the sides of the shell 104 and sides 33, 35 of the enclosure 102, in cross section are shown as truncated right triangles. The truncated right triangles 24, 25 may include truncated triangles in which a top portion 28 of the hypotenuse is not straight. The space 26 between the top of the shell 104 and top of the enclosure 102 is a ‘curved rectangle’ which hereinafter refers to the bottom 32 and two sides 34, 36 of a rectangle with a curved line 38 connecting the two side lines 34, 36.

[0047] In some embodiments, the separation of the inner enclosure 102 and exterior shell 104 is achieved by a gap of approximately four inches at their nearest points. This distance allows the fire resistant enclosure 102 to perform its primary function of protection from heat and at the same time allows the exterior shell 104 to perform its function of flame and ember protection.

[0048] The inner fire resistant enclosure 102 may have doors 118, 120 located at opposite ends of the antechamber 206, which is described in more detail below. The doors 118, 120 are preferably constructed of a fire rated material and include heat and smoke resistant seals. The doors 118, 120 may include vision panels such as transparent portholes which would enable occupants within the shelter 100 to view the exterior conditions and assess the status of the fire. In other embodiments, the entryways 114, 116 or doors 118, 120 may be located in a different configuration.

[0049] Many existing fire shelters only contain one door or point of access. In such shelters, if trees or other debris fall and block the one door, the shelter occupants have no other means of exit. Having two doors, preferably located at opposing ends of the shelter, provides an alternate exit route in case one of the doors becomes blocked or otherwise unusable. Furthermore, having two doors provides multiple means for accessing the shelter. This can be advantageous if the fire or resulting debris makes one of the doors inaccessible or dangerous.

[0050] Having more than one external door also has the commercial advantage of allowing people to share a fire shelter with their neighbors. The shelter can be constructed in a location such that each neighbor has ready access to a door from his or her own property. This capability may encourage more people to choose this kind of shelter in order to share and reduce cost.

[0051] In some embodiments, there is a support structure 122, disposed between the exterior shell 104 and the inner fire resistant enclosure 102. A support structure in the form of a structural cage 122 is depicted in FIG. 2. The support structure 122 is designed to provide mechanical protection against impact, which may result from falling trees or other debris. In some embodiments, the exterior shell 104 rests on the support structure 122. The support structure 122 may be constructed from a variety of materials, such as, for example timber and steel, and the like. Thus, the structural cage 122 depicted in FIG. 2 may be constructed from steel or wood beams, among other materials.

[0052] The fire refuge shelter 100 may comprise a water tank 124 positioned on top of the inner fire resistant enclosure 102. A sprinkler system may be connected to the water tank 124, and may be configured to provide overspray of the inner fire resistant enclosure 102 and the exterior shell 104. The sprinkler system may be operated by one or more pumps, preferably being hand pumps that do not depend on the presence of a working power source. In cases of extreme heat, a failure of the water tank 124 may result in drenching of the inner fire resistant enclosure 102. In some embodiments, the water tank 124 may be purposefully designed to fail under predetermined extreme heat conditions, as an additional fire protection for the enclosure 102, even in the absence of an operating sprinkler system. The water tank 124 may be constructed from metal, plastic, or other materials. In some embodiments, the water tank 124 is approximately 10 feet long, 1.6 feet high and 3.3 feet wide. Other sizes are also possible.

[0053] FIG. 8 depicts a floor plan 200 of a six-person fire refuge shelter having a configuration substantially similar to the shelter 100 described above with reference to FIG. 2. Common reference numerals are therefore used between the two drawings, in order to indicate common features.

[0054] As described with reference to FIG. 2, FIG. 8 shows the exterior shell 104 surrounding the fire shelter 100. Front and rear exterior panels 110, 112 close off either end of the exterior shell 104. A structural support in the form of the structural cage 122 is located within the exterior shell 104. An insulated buffer 24, 25, 26, as described above, separates the structural cage 122 and exterior shell 104 from the inner fire resistant enclosure 102.

[0055] In some embodiments, the inner fire resistant enclosure 102 depicted in FIG. 8 may have a height of between about 7 ft. and about 14 ft. The enclosure 102 may have a width of between about 7 ft and about 13 ft. The enclosure 102 may have a length of between about 12 ft and about 17 ft.

[0056] In certain embodiments, the exterior shell 104 shown in FIG. 8 may have a height of between about 18 ft. and about 28 ft. The shell 104 may have a width of between about 11 ft and about 21 ft. The shell 104 may have a length of between about 14 ft. and about 24 ft.

[0057] Entryways 114, 116 in the exterior shell 104 may provide access to the inner fire resistant enclosure 102. The fire doors 118, 120 permit entry to the antechamber 206 of the inner fire resistant enclosure 102 through openings 202, 204. In the embodiment depicted, the doors 118, 120 are located at opposite ends of the antechamber. The antechamber 206 is designed as a ‘smoke lobby’, which is separated from a main refuge chamber 208 by an openable barrier 210. The barrier 210 may comprise sliding doors made from conventional materials (e.g., timber, steel) or may alternatively comprise curtains. Smoke-retardant materials may be used. Other bar-
rier types are also possible. Advantageously, any smoke entering the antechamber 206 through openings 202, 204 may be substantially prevented from entering the main refuge chamber 208 by the barrier 210. Moreover, the doors 118, 120 may open outwards to admit entry into the antechamber 206, further limiting the amount of smoke entering the fire resistant enclosure 102.

[0058] In some embodiments, the antechamber 206 may comprise a means of ventilation such as a manually operable vent, or a manually operable fan or the like. This may advantageously allow any smoke entering the antechamber 206 to be evacuated from the antechamber 206 into a space or void 216 that exists between the inner enclosure 102 and the exterior shell 104 before the users move into main portion of the shelter.

[0059] In some embodiments, the inner fire resistant enclosure 102 may comprise internal storage facilities for supplies (e.g., food and water) and equipment (e.g., fire extinguishers, protective clothing, supplementary air supply, etc.). In some embodiments, the storage includes space for hanger equipment on a wall 212 of the antechamber 206, where it is readily accessible upon entrance or exit of the fire shelter 100. Additionally, a bench seat 214 suitable for accommodating human seating comfortably as well as one or more tables and some free standing chairs may be located within the main refuge chamber 208. The bench seat may contain storage space in its interior. This storage space could be accessed in a variety of ways including one or more hinged lids on the bench surface and one or more cabinet doors in a front panel.

[0060] In some embodiments, the inner fire resistant enclosure 102 advantageously may have no means of active ventilation. Lack of active ventilation may advantageously simplify the design of the overall fire shelter and will make it extremely difficult for an active ember to find its way inside. A fire shelter is not frequently used and so when it is used, failure points (where for example embers could get in) are extremely undesirable.

[0061] In some embodiments, the lack of ventilation of the inner fire resistant enclosure 102 will result in an amount of air sufficient to sustain at least six people for at least four hours. In the case that the air gets contaminated or the air supply runs low, compressed air tanks like those used by firefighting personnel may be stored within the storage facilities. In addition emergency water and food rations may also be stored in the enclosure.

[0062] FIG. 9 shows a floor plan 300 of an alternative embodiment, which is a larger, 24-person, fire refuge shelter. The embodiment depicted here contains the same features as those described with reference to FIGS. 2 and 8 above. For example, this embodiment comprises the exterior shell 104, the structural support 122 and inner fire resistant enclosure 102 discussed with reference to the previous figures.

[0063] In some embodiments, the inner fire resistant enclosure 102 depicted in FIG. 9 may have a height of between about 7 ft. and about 14 ft. The enclosure 102 may have a width of between about 15 ft and about 25 ft. The enclosure 102 may have a length of between about 25 ft and about 55 ft. In certain embodiments, the exterior shell 104 shown in FIG. 9 may have a height of between about 18 ft and about 28 ft. The shell 104 may have a width of between about 19 ft and about 32 ft. The shell 104 may have a length of between about 29 ft and about 43 ft.

[0064] FIGS. 10A-10E depict various views of the 24-person, fire refuge shelter. FIG. 9A depicts a perspective view of the fire refuge shelter including entranceway 316. FIGS. 10A and 10C depict the front and rear exterior panels including entranceways 314, 316. Fire doors 312, 304 are visible through entranceways 314, 316. FIGS. 10D and 10E show a side and top view of the exterior shell.

[0065] In an embodiment, entranceways 314, 316 are located centrally in front and rear wall panels of the shelter. These entranceways 314, 316 correspond to fire doors 302, 304 similar to the exterior doors described with reference to FIGS. 2 and 4. Unlike the doors 118, 120 described with reference to FIGS. 2 and 8 which lead to the single antechamber 206, the doors 302, 304 lead to a pair of antechambers 306, 307 through openings 318, 320. Each antechamber 306, 307 includes a barrier 310, 311 separating it from the main refuge chamber 308. As described above, the antechambers 306, 307, in some embodiments, may comprise a means of ventilation to clear any trapped smoke before the occupants enter the main refuge chamber 308. The barriers 310, 311 are like the barrier 210 described with reference to FIG. 8.

[0066] Storage facilities may be provided on walls 312, 313 of both antechambers. Furthermore, as with the previously described embodiments, storage may be provided within, or underneath, bench seats 324, 326 within the main refuge chamber 308. Compressed air tanks may be among the stored equipment as described with reference to FIG. 7.

[0067] The following is a description for a method of constructing an above-ground fire shelter as described with reference to FIGS. 1, 2, 8 and 9. For the sake of clarity, reference numerals from FIGS. 1, 2 and 8 will be used. However, the fire shelter of FIG. 8 may be constructed in a similar fashion.

[0068] An inner fire resistant enclosure 102 is provided. This enclosure 102 may be configured to provide protection from radiant heat. As described above, the enclosure 102 may have two or more external fire doors 118, 120 opening into one or more antechambers 206 which are separated by an operable barrier 210 from a main refuge chamber 208. Storage facilities may be included in both the one or more antechambers 206 and the main refuge chamber 208.

[0069] The exterior shell 104 may be disposed around the inner fire resistant enclosure 102. The exterior shell 104 is configured to provide protection against flame or ember attack. The exterior shell may be in a streamlined form as described above with reference to FIGS. 2-8. The shell 104 may have two or more entranceways 114, 116 corresponding to the two or more doors 118, 120 on the fire resistant enclosure 102.

[0070] In some embodiments, the support structure 122 such as the structural cage may be disposed between the exterior shell 104 and the fire resistant enclosure 102. The support structure 122 is configured to provide protection against impact.

[0071] A water tank may also be provided above the fire resistant enclosure with a sprinkler system configured to provide overspray to the enclosure as well as the exterior shell.

[0072] Conditional language used herein, such as, among others, “can,” “might,” “may,” “e.g.,” and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or states. Thus, such conditional language is not generally intended to imply that features, elements and/or states are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without
author input or prompting, whether these features, elements and/or states are included or are to be performed in any particular embodiment. The terms “comprising,” “including,” “having,” and the like are synonymous and are used inclusively, in an open-ended fashion, and do not exclude additional elements, features, acts, operations, and so forth. Also, the term “or” is used in its inclusive sense (and not in its exclusive sense) so that when used, for example, to connect a list of elements, the term “or” means one, some, or all of the elements in the list.

While the above detailed description has shown, described, and pointed out novel features as applied to various embodiments, it will be understood that various omissions, substitutions, and changes in the form and details of the devices or algorithms illustrated can be made without departing from the spirit of the disclosure. As will be recognized, certain embodiments of the inventions described herein can be embodied within a form that does not provide all of the features and benefits set forth herein, as some features can be used or practiced separately from others. The scope of certain inventions disclosed herein is indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed is:

1. An above-ground fire refuge shelter comprising: an inner fire resistant enclosure; and an exterior shell configured to provide protection from flame or ember attack, the exterior shell comprising a top portion that approximates a curve with a rounder middle portion of the curve compared to flatter ends of the curve and walls extending from the ends of the curve, the walls either extending the flatter curve or extending in a substantially straight orientation; wherein the exterior shell and the inner fire resistant enclosure are separated by a space of a low thermal conductivity; wherein sides of the exterior shell and sides of the inner fire resistant enclosure define, in cross section, a truncated triangle and wherein a roof of the inner fire resistant enclosure and the top portion of the exterior shell define in cross section a curved rectangle; and wherein the fire refuge shelter is located above ground.

2. The fire refuge shelter of claim 1, wherein the walls of the exterior shell comprise about 50% to about 80% of a total height of the fire refuge shelter.

3. The fire refuge shelter of claim 1, wherein the walls of the exterior shell comprise about 55% to about 70% of a total height of the fire refuge shelter.

4. The fire refuge shelter of claim 1, wherein a ratio of a height of the rounder middle portion of the curve to a length between endpoints of the rounder portion of the curve is between about 10% and about 50%.

5. The fire refuge shelter of claim 1, wherein a ratio of a height of the rounder middle portion of the curve to a length between endpoints of the rounder portion of the curve is between about 10% and about 25%.

6. The fire refuge shelter of claim 1, wherein a ratio of a height of the rounder middle portion of the curve to a total height of the curve is between about 10% and about 45%.

7. The fire refuge shelter of claim 1, wherein a ratio of a height of the rounder middle portion of the curve to a total height of the curve is between about 12% and about 25%.

8. The fire refuge shelter of claim 1, wherein an angle formed between the walls and a horizontal line is between about 65° and about 85°.

9. The fire refuge shelter of claim 1, wherein an angle formed between the walls and a horizontal line is between about 70° and about 80°.

10. The fire refuge shelter of claim 1, further comprising a support structure disposed between the inner fire resistant enclosure and the exterior shell and configured to provide protection from impact.

11. The fire refuge shelter of claim 10, wherein the support structure comprises a structural cage.

12. The fire refuge shelter of claim 1, wherein the inner fire resistant enclosure comprises a main chamber and one or more ante-chambers, wherein the main chamber and the one or more ante-chambers are separated by an openable barrier.

13. The fire refuge shelter of claim 12 wherein one or both of the main chamber and the one or more ante-chambers comprises means for storage of supplies and equipment.

14. The fire refuge shelter of claim 13, wherein the equipment comprises compressed air tanks.

15. The fire refuge shelter of claim 12, wherein the one or main ante-chambers comprises a means of ventilation.

16. The fire refuge shelter of claim 1, further comprising a water tank located above the inner fire resistant enclosure and configured to provide overspray of one or both of the fire resistant enclosure and the exterior shell.

17. The fire refuge shelter of claim 16, further comprising a sprinkler system arranged in association with the water tank.

18. The fire refuge shelter of claim 17, wherein the sprinkler system is operated by one or more pumps.

19. The fire refuge shelter of claim 18, wherein the one or more pumps are hand pumps.

20. The fire refuge shelter of claim 1, wherein the fire refuge shelter is located on a non-flammable surface.

21. The fire refuge shelter of claim 20, wherein the non-flammable surface comprises a concrete slab.

22. The fire refuge shelter of claim 1, further comprising at least two exterior doors.

23. The fire refuge shelter of claim 22, wherein the at least two exterior doors are located in opposition to one another.

24. The fire refuge shelter of claim 21, wherein the exterior shell comprises a material or coating with a reflectivity of between about 20% and about 70%.

25. The fire refuge shelter of claim 24, wherein the exterior shell comprises a material or coating with a reflectivity of between about 40% and about 70%.

26. The fire refuge shelter of claim 1, wherein the inner fire resistant enclosure contains no means of ventilation and is configured to be occupied by humans.

27. The fire refuge shelter of claim 1, wherein the space of low thermal conductivity comprises a thermal conductivity of between about 0.015 to about 0.035 W/m K at 20°C.

28. The fire refuge shelter of claim 1, wherein the space of low thermal conductivity comprises a thermal conductivity of between about 0.022 to about 0.027 W/m K at 20°C.

29. The fire refuge shelter of claim 1, wherein the inner fire resistant enclosure has a height of between about 7 and about 14 ft, a length of between about 12 and about 17 ft, and a width of between about 7 and about 13 ft.
30. The fire refuge shelter of claim 1, wherein the exterior shell has a height of between about 18 and about 28 ft, a length of between about 14 and about 24 ft, and a width of between about 11 and about 21 ft.

31. The fire refuge shelter of claim 1, wherein the inner fire resistant enclosure has a height of between about 7 and about 14 ft, a length of between about 25 and about 35 ft, and a width of between about 15 and about 25 ft.

32. The fire refuge shelter of claim 1, wherein the exterior shell has a height of between about 18 and about 28 ft, a length of between about 29 and about 43 ft, and a width of between about 19 and about 32 ft.

33. The fire refuge shelter of claim 1, wherein the thickness of the walls of the exterior shell is between about 0.15 and about 0.5 inches.

34. The fire refuge shelter of claim 1, wherein the thickness of the walls of the exterior shell is about 0.25 inches.

35. The fire refuge shelter of claim 1, wherein the thickness of walls of the inner fire resistant enclosure is between about 1 and about 9 inches.

36. The fire refuge shelter of claim 1, further comprising a material of low thermal conductivity disposed between the inner fire resistant enclosure and the exterior shell, the material configured to reduce convective heat transfer.

37. An above-ground fire refuge shelter comprising: an inner fire resistant enclosure, the inner fire resistant enclosure comprising a main chamber and at least one antechamber, the main chamber and the at least one antechamber separated by an openable barrier; an exterior shell configured to provide protection from flame or ember attack, the exterior shell not being in contact with the inner fire resistant enclosure, the exterior shell comprising a top portion that approximates a curve with a rounder middle portion of the curve compared to flatter ends of the curve and walls extending from the ends of the curve, the walls either extending the flatter curve or extending in a substantially straight orientation; and a support structure configured to provide protection against impact disposed between the inner fire resistant enclosure and the exterior shell; wherein the fire refuge shelter is located above ground.

38. The fire refuge shelter of claim 37, wherein sides of the exterior shell and sides of the inner fire resistant enclosure define, in cross section, a truncated triangle and a top portion of the inner fire resistant enclosure and the top portion of the exterior shell define, in cross section, a curved rectangle.

39. The fire refuge shelter of claim 37, wherein the walls of the exterior shell comprise about 50% to about 80% of a total height of the fire refuge shelter.

40. The fire refuge shelter of claim 37, wherein the walls of the exterior shell comprise about 55% to about 70% of a total height of the fire refuge shelter.

41. The fire refuge shelter of claim 37, wherein a ratio of a height of the rounder middle portion of the curve to a length between endpoints of the rounder portion of the curve is between about 10% and about 50%.

42. The fire refuge shelter of claim 37, wherein a ratio of a height of the rounder middle portion of the curve to a length between endpoints of the rounder portion of the curve is between about 10% and about 25%.

43. The fire refuge shelter of claim 37, wherein a ratio of a height of the rounder middle portion of the curve to a total height of the curve is between about 10% and about 45%.

44. The fire refuge shelter of claim 37, wherein a ratio of a height of the rounder middle portion of the curve to a total height of the curve is between about 12% and about 25%.

45. The fire refuge shelter of claim 37, wherein an angle formed between the walls and a horizontal line is between about 65° and about 85°.

46. The fire refuge shelter of claim 37, wherein an angle formed between the walls and a horizontal line is between about 70° and about 80°.

47. The fire refuge shelter of claim 37, further comprising at least two exterior doors, wherein the at least two exterior doors are located on opposing sides of the inner fire resistant enclosure.

48. The fire refuge shelter of claim 37, further comprising a water tank, the water tank located above the inner fire resistant enclosure and configured to provide overspray of the inner fire resistant enclosure.

49. The fire refuge shelter of claim 37, wherein the fire refuge shelter is located on a non flammable surface.

50. The fire refuge shelter of claim 37, wherein the exterior shell comprises steel.

51. The fire refuge shelter of claim 37, wherein the exterior shell comprises corrugated iron sheeting.

52. The fire refuge shelter of claim 37, wherein the support structure comprises wood.

53. The fire refuge shelter of claim 37, wherein the support structure comprises steel beams.

54. The fire refuge shelter of claim 37, wherein the exterior shell comprises a material or coating with a reflectivity of between about 20% and about 70%.

55. The fire refuge shelter of claim 37, wherein the exterior shell comprises a material or coating with a reflectivity of between about 40% and about 70%.

56. The fire refuge shelter of claim 37, wherein the inner fire resistant enclosure contains no means of ventilation and is configured to be occupied by humans.

57. The fire refuge shelter of claim 37, wherein a space of low thermal conductivity exists between the inner fire resistant enclosure and the exterior shell and comprises a thermal conductivity of between about 0.015 to about 0.035 W/m K at 20° C.

58. The fire refuge shelter of claim 37, wherein a space of low thermal conductivity exists between the inner fire resistant enclosure and the exterior shell and comprises a thermal conductivity of between about 0.022 to about 0.027 W/m K at 20° C.

59. A method of constructing a fire refuge shelter comprising: providing an inner fire resistant enclosure, the inner fire resistant enclosure comprising a main chamber and at least one antechamber, the main chamber and the at least one antechamber separated by an openable barrier; providing an exterior shell over the inner fire resistant enclosure, the exterior shell comprising a top portion that approximates a curve with a rounder middle portion of the curve compared to flatter ends of the curve and walls extending from the ends of the curve, the walls either extending the flatter curve or extending in a substantially straight orientation, the exterior shell configured to provide protection from flame or ember attack, wherein the inner fire resistant enclosure and the exterior shell are in contact with one another; and providing a support structure configured to provide protection against impact disposed between the inner fire resistant enclosure and the exterior shell; wherein the fire refuge shelter is constructed above ground.
60. The method of claim 59, wherein sides of the exterior shell and sides of the inner fire resistant enclosure define in cross section a truncated triangular space and wherein a top portion of the inner fire resistant enclosure and the top portion of the exterior shell define in cross section a curved rectangle.

61. The method of claim 59, wherein the walls of the exterior shell comprise between about 50% and about 80% of a total height of the fire refuge shelter.

62. The method of claim 59, wherein the walls of the exterior shell comprise between about 55% and about 70% of a total height of the fire refuge shelter.

63. The method of claim 59 further comprising providing a water tank located above the fire resistant enclosure and configured to provide overspray of one or both of the fire resistant enclosure and the exterior shell.

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