Jan. 17, 1967 P. RETZ 3,298,146

MULTILEVEL SUBSURFACE BUILDING CONSTRUCTION

Filed Oct. 26, 1964 3 Sheets-Sheet 1

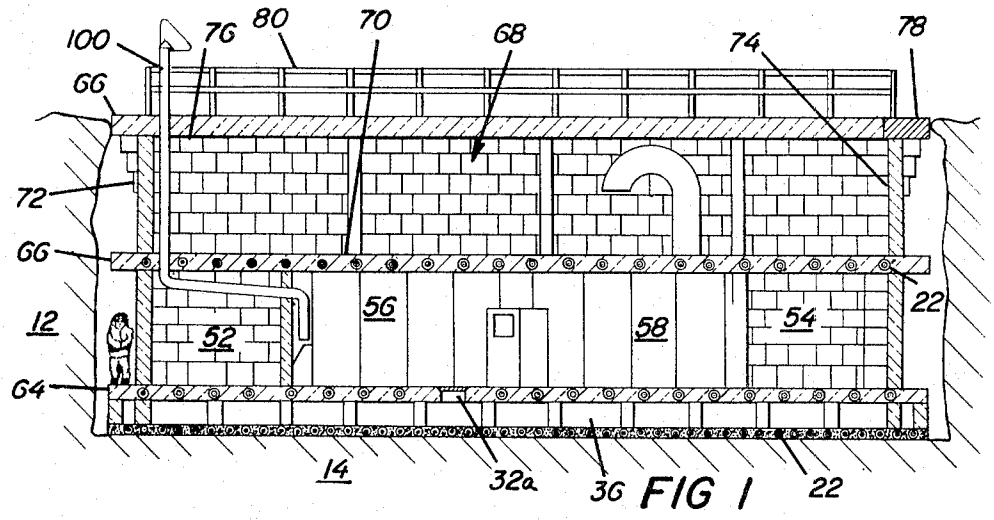


FIG 1

FIG 2

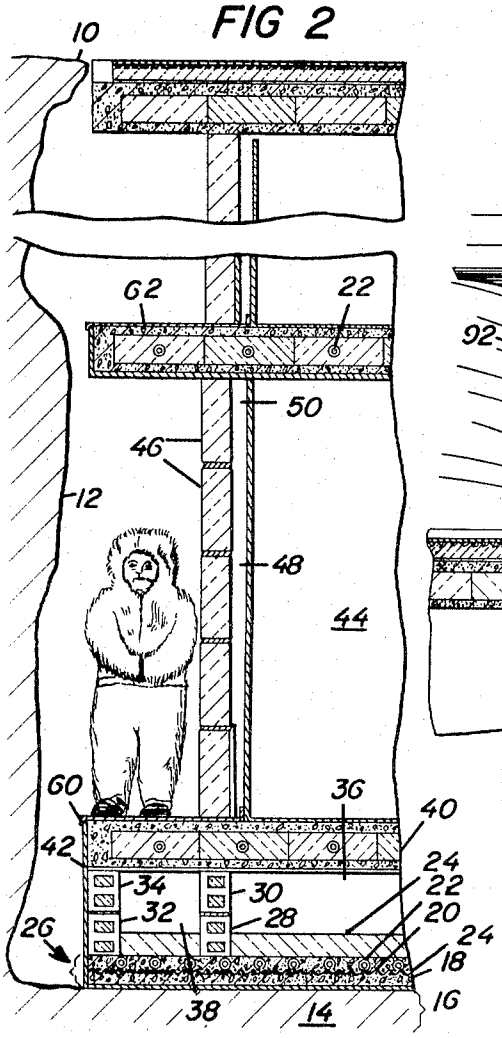
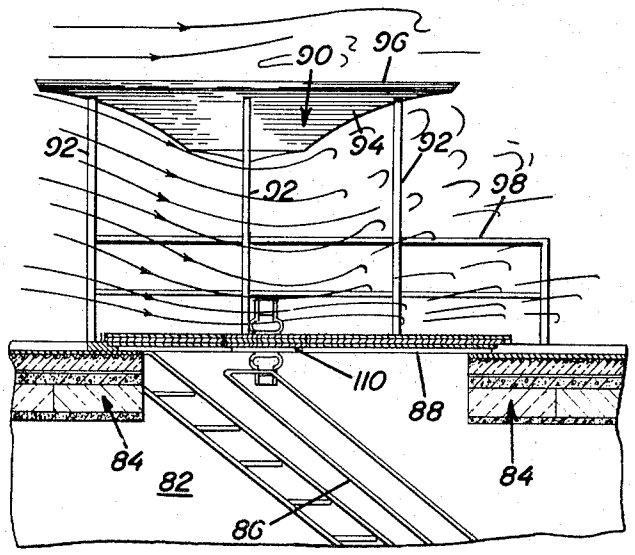


FIG 3



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FIG 4

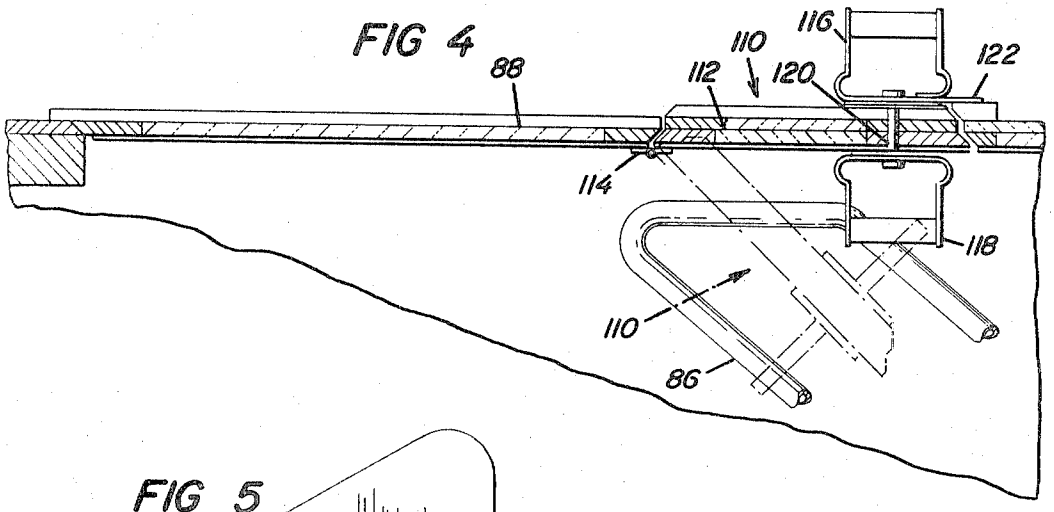


FIG 5

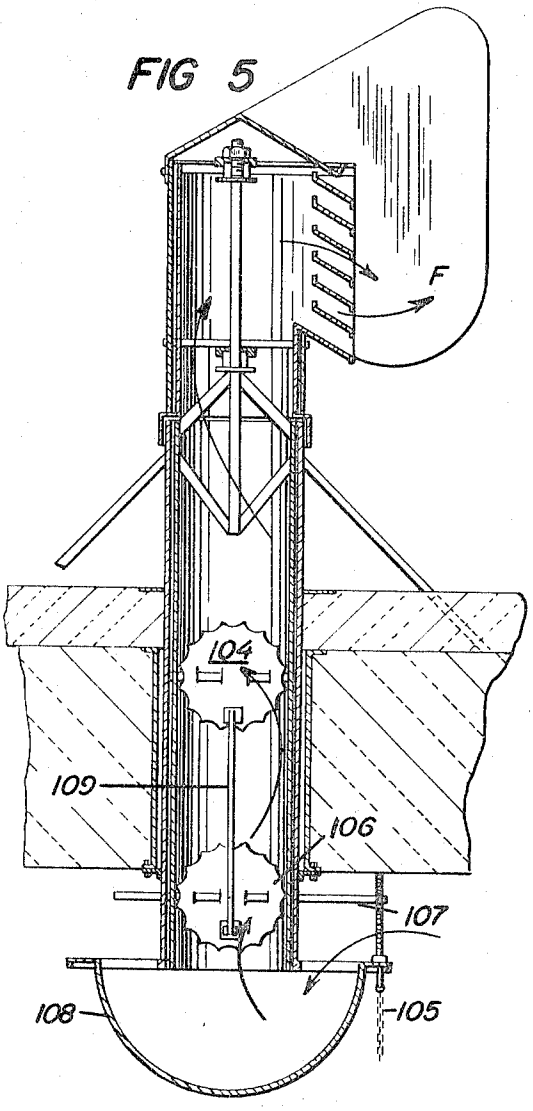
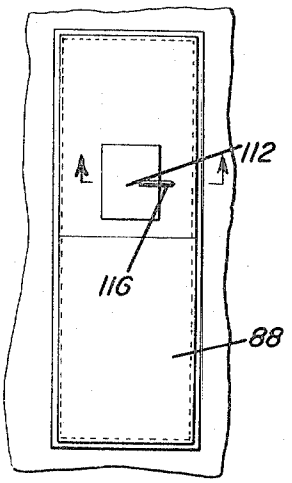


FIG 6



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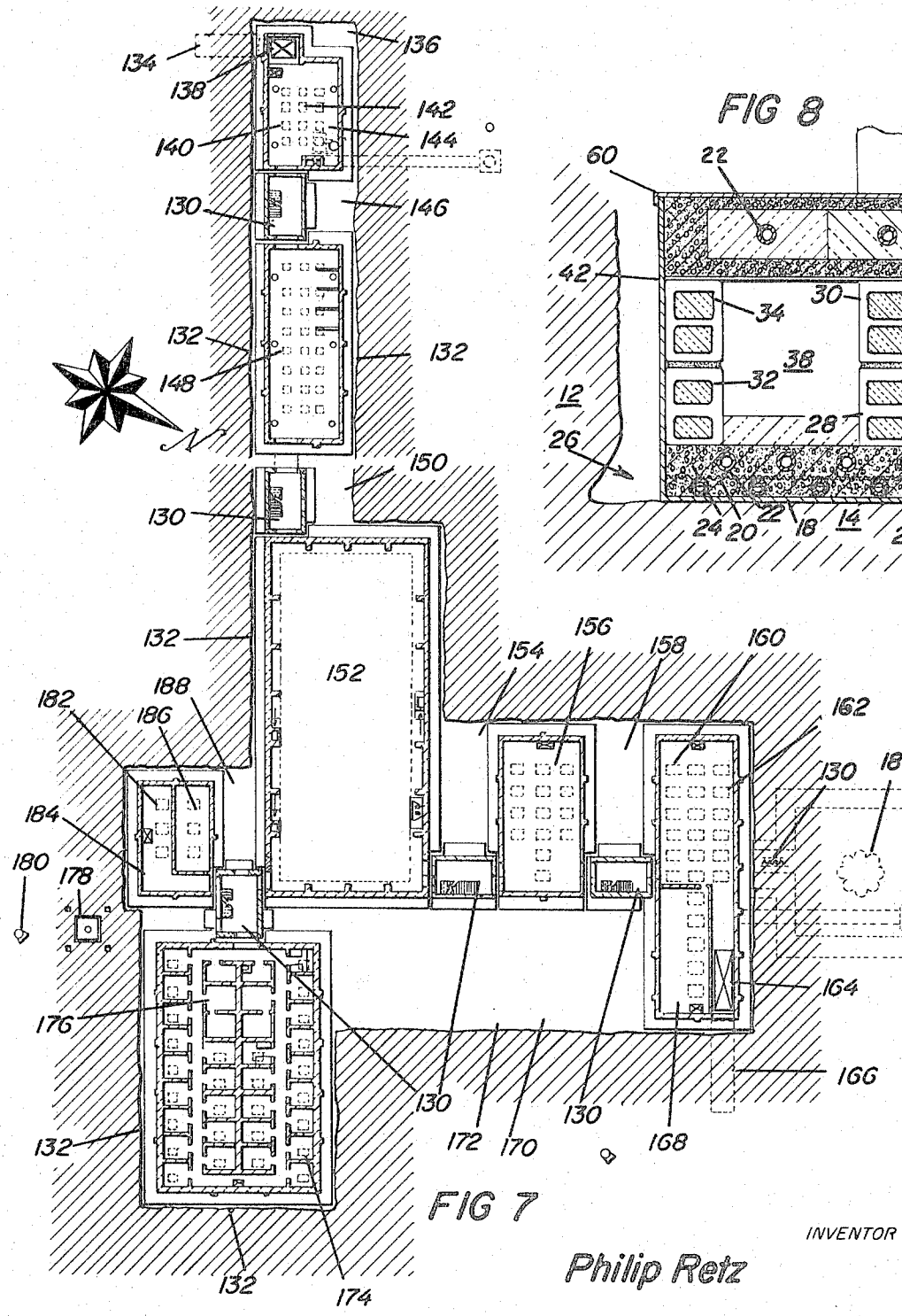


FIG 7

FIG 8

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3,298,146

MULTILEVEL SUBSURFACE BUILDING CONSTRUCTION

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Filed Oct. 26, 1964, Ser. No. 406,520
1 Claim. (Cl. 52—169)

Introduction

This invention generally pertains to the construction of storage facilities, work areas, outside work areas, play areas and living quarters in geographical areas where the temperature is below freezing during the year and is a continuation-in-part of applicant's application Serial No. 109,749, filed May 12, 1961, now Patent 3,153,912, dated October 27, 1964. More particularly this invention pertains to the construction of storage facilities, play areas, work areas and living quarters in the polar regions. In one specific embodiment this invention pertains to the construction of buildings upon a foundation of snow and ice.

Background

Since Byrd's first trip to the polar regions many years ago, this area of the world has received an increasing amount of attention and exploration by both independent explorers and government surveying and investigative groups. Most of this interest has stemmed from scientific curiosity and a desire to know more about the weather conditions which exist there. Interest in the polar regions as a living area has also been shown because of worries of the problems associated with the world population explosion. Some groups have already planned the building of hotels in the polar regions, hoping to attract tourists and even lung patients by pointing to the absence of germs in the air.

Whenever any extensive work is to be done in the polar regions, the construction of adequate storage facilities and living quarters is of primary importance. The interest in the polar regions has now increased to the extent that *permanent* storage, research and scientific facilities and living quarters are needed, rather than merely make-shift units of temporary nature. With the advent of atomic heat greater savings can be had in permanent structures, providing the facilities to house such heat are available. Some attempts have already been made in the polar regions to provide storage facilities and living quarters of a permanent nature. Unfortunately, many of these attempts have met with partial or complete failure for one reason or another. Some of these polar constructions have been torn apart by fierce arctic winds, others have been crushed by shifting ice, and others have been rendered unusable because of the inability to maintain a firm level base under the foundation and fire losses. All facilities generally are so make-shift that even dedicated persons fail to want to repeat their stay in these arctic areas.

It is therefore a primary object of this invention to provide storage facilities and living quarters in geographical areas where the temperature is considerably below freezing all of the year. A more specific object of this invention is to provide storage facilities and living quarters in the polar regions. Another object of this invention is to provide a method for constructing buildings upon a foundation of snow and ice. An additional object of this invention is to provide a means for constructing buildings in polar regions so that the foundations of the buildings will be maintained in a substantially level condition at all times. One other object of this invention is to provide a sub-surface polar construction which will not be crushed by lateral ice pressures or drifting apart ice fissures. These and other

objects and advantages will become more apparent after reading the following description taken in conjunction with the attached drawings, wherein:

FIGURE 1 is a sectional cutaway view of a sub-surface building construction in accordance with this invention;

FIGURE 2 is an enlarged fragmentary sectional drawing of a part of the structure shown in FIGURE 1;

FIGURE 3 is a partial sectional drawing of a novel device for maintaining hatch covers substantially free from snow and also as a possible escape hatch in case of pile up of snow and ice;

FIGURE 4 is a fragmentary sectional view of the hatch cover arrangement shown in FIGURE 3;

FIGURE 5 is an enlarged sectional view of the fresh air vent shown in FIGURE 1;

FIGURE 6 is a plan view of a hatch cover useful in accordance with this invention;

FIGURE 7 is a plan view of the general layout of a polar construction in accordance with this invention;

FIGURE 8 is an enlarged partial view of the foundation structure shown in FIGURE 2.

The construction of a shelter in low temperature regions in accordance with this invention involves a sequential series of steps. This sequential series of steps can be broadly outlined as follows:

(1) A covering means having an area equal to or exceeding the roof area of the building to be constructed is preferably first built and laid out in place over the area where the building is to be constructed. This covering means may be made of canvas, rubber, plastic, wood, metal or any other equivalent suitable material. The covering means may be fixed in one place by suitable anchoring means or the cover means may be arranged so that it can slide laterally from over the area which is to be worked upon, or ballooned upward as a bubble with air pressure.

(2) Once the cover has been built and put in place, and once the area to be excavated and worked upon has been suitably delineated, the digging of a suitable size hole is started. For example, if it is decided that the building structure will extend 30 feet below the upper surface of the snow, a hole is dug downwardly through the snow and ice to a depth of 35 or 40 feet. (At 20 feet glacier ice is found and temperature at this point is 0° to 20° F.) This digging can be accomplished either by manual pick and shovel methods or by mechanical tractor, cutting, scraping and digging methods, spewing snow or ice windward, or by any other suitable snow removal and ice removal means, as will be appreciated by those skilled in this art. While this hole is being dug, the cover means may be disposed over part or all of the top of the hole to protect the workers and equipment in the excavation from drifting snow or other undesirable weather conditions. In good weather the cover means may be moved aside to permit a greater amount of light and air to enter the excavation, if desired.

(3) Once a hole of the desired size and depth has been dug, the next step is to lower into the bottom of the hole a pattern of piping. The pattern of piping is adapted to carry either hot or freezing fluids. The exact pattern or arrangement of the piping is not critical except that the pattern should preferably be arranged so that whenever heating or cooling fluid is passed therethrough the said heating or cooling fluid will have an opportunity to efficiently exert its influence upon the entire area of the bottom of the hole. For example, cross arrangement of pipes somewhat resembling the strings in a harp may be satisfactory in some instances, or the pipes may be arranged in a continuous "back and forth" arrangement so that all of the pipes are substantially parallel to each other, or there may be a plurality of

separate groups of pipes. Preferably the pipes are between about three inches to five inches apart. In large excavations the pattern of pipes may comprise a plurality of groups of pipes in order to facilitate handling and placement thereof.

(4) The pattern of piping is, as noted above, connected to a heating or cooling system so that either heating liquid or cooling liquid, non-freezing, can be passed through said pattern of piping at will. The pattern of pipes is also preferably provided with a number of valves and a number of inlets and outlets so that any desired area of the pattern of pipes can be heated or cooled as desired. Selective or localized heating of certain areas is also faciliated when a plurality of groups of pipes is used. Several sources of heating fluid or several sources of cooling fluid may be provided. Also, there can be reservoirs of heating fluid at different temperatures so that different portions of the pattern of piping can be heated to different temperatures to establish a temperature gradient.

(5) Once the pattern of heating pipes is in place a heating fluid is preferably passed through the pattern of pipes so as to form a lake of water in the bottom of the excavation (by melting the adjacent ice) and preferably a lake of water from 6 to 12 inches deep. (However under certain conditions it may be desirable or necessary to form an ice slap 5 to 8 feet thick by progressively melting water and at times necessary to obtain a broad proper foundation for the load at hand.)

(6) While the water is still in a liquid condition within said heated lake, the pattern of pipes is raised thereabove and held thereabove by any suitable means. For example, once the pipes have been raised above the level of the heated liquid in the bottom of the excavation, blocks can be placed within said lake which are large enough to rise above the surface of the lake and the pattern of pipes supported upon such blocks.

(7) The thus-formed lake of water is then permitted to freeze solid into an "ice slab" and the upper surface thereof is automatically level by virtue of gravitational forces. (In a similar manner as outlined above, *side-walls* consisting of ice may also be formed; e.g. by spraying or by form boards to any outline required and to any thickness.) Also steam pipes driven into the snow for long lengths, say 30 feet or more, then removed would form ice piles to further stabilize a foundation.

(8) About two inches of insulation is then placed upon the level top surface of the formed ice slab. One or both surfaces of the insulation are preferably metallized so as to be partially heat reflective. This insulation is therefore disposed above the ice slab and below the pattern of pipes (which are raised above the ice slab).

(9) Next, a suitable network of concrete reinforcing means (such as wire mesh, metal rods, etc.) is placed above, on or around the aforementioned insulation, but mostly above said raised pattern of pipes (which are of necessity as close to the ice as possible, but eventually covered by one inch of concrete).

(10) Insulation is then placed around the edges of the excavation and around the lower side walls thereof, extending from the bottom of the excavation upwardly for a distance at least as high as the concrete (subsequently described) will be. The concrete rests upon the top of the aforesaid insulation and upwardly through said pipes and reinforcing covering both making an integral slab.

(11) Lightweight, high-strength concrete (or low temperature type concrete) is then poured over the aforesaid pattern of pipes, reinforcing network and insulation. The lightweight, high-strength concrete preferably weighs about 100 pounds per cubic foot and has a compressive strength of about 3,000 pounds per square inch. Such concrete compositions are known in the art. The thickness of the concrete is preferably about six to nine inches. The concrete rests upon the top of the aforesaid insulation and extends upwardly through said reinforcing network and covers said pattern of pipes.

(12) After the concrete has been poured, heated liquids can be passed through the said pattern of pipes so as to help accelerate the cure of the concrete. Such heat can also be used to prevent the concrete from freezing during the curing and setting stage.

The above procedure results in what will hereinafter be referred to as a "foundation slab."

Once a foundation slab has been constructed in the manner described above, a firm supporting base for any future construction thereabove has been established. One of the great hazards and difficulties of building structures in or upon frozen subsurfaces is that such structures will usually sooner or later tend to list or tilt to one side or corner and then drift. This listing or tilting is frequently due to the presence of more heat in one area than another or because there is more weight bearing on one portion than another, or because of the firn ice density. When such listing or tilting occurs the unfortunate result is that not only the ground floor but all floors thereabove are tilted to the same degree. Such tilting or listing of a structure sometimes becomes so bad that the entire structure becomes uninhabitable. Obviously, when structures must be abandoned for this reason great inconvenience is caused in addition to the great expense and time involved in replacing the entire structure with a new one at another location which hopefully will not list or tilt for a while. Since such listing or tilting might conceivably occur when the weather conditions were so bad that it would be impossible for the inhabitants to locate another site and build a new structure, it can be seen that any system which could be worked out which would insure that the structure would never tilt or list so much as to render the structure uninhabitable would be of great value. This is particularly true insofar as the polar areas are concerned since suitable time periods during which construction may be carried on are quite limited.

The structure of this invention can be maintained in a level condition in a rather simple manner. For example, suppose that one corner of the foundation slab structure should dip lower than the other corner because of somewhat more heat being temporarily present in that corner of the structure. That corner would therefore dip lower than the other corners since the differential increment of heat, if of sufficient magnitude, would penetrate the insulation thereunder and also melt the ice thereunder and the melted ice would give way at least slightly to the weight load above it. If this condition were not corrected then the entire building structure will tilt toward that one low corner. Tilting would itself result in greater pressure, which would in turn promote greater tilting. However, in accordance with this invention, that condition could be readily remedied by activating a portion of the pipe pattern system so as to first pass some freezing liquid to stabilize the area and since ice expands it would raise the area or hold it from further unstabilization. However if this will not work, then one must resort to passing heating fluid through the pattern of pipes in a selective manner so that the remaining three corners of the slab would also be heated. Such selective heating of the three corners would be continued until it caused a limited degree of melting of the ice therebelow, which would in turn allow these three corners to gradually drop downwardly. While heat was being applied to these three corners by proper routing of heating liquid through the pattern of pipes, a freezing fluid could be simultaneously routed through at least a portion of the remaining pattern of piping adjacent that corner which was initially lower than the others as noted heretofore so as to cool the ice therebelow and to prevent further dipping of that corner. Once it has been ascertained (e.g. by leveling equipment) that all of the

four corners were again level with each other, then the passage of heating fluid through a portion of the pattern of pipes could be discontinued and a freezing fluid could thereafter be passed through the entire pattern of pipes. The circulation of freezing fluid through the entire pattern of pipes would then freeze the ice therebeneath and again provide a firm and level foundation for the entire building structure. It is contemplated that the entire aforementioned leveling operation could be made completely automatic, for example by having one or more leveling indicators disposed around the structure, each of which would be operatively connected to valves and pumping means associated with the pattern of pipes.

Under some conditions it may be desirable to continuously pass the freezing fluid through the pattern of pipes so as to minimize the possibility that heat from above the foundation slab will penetrate the slab to the ice therebelow. However, since heat leakage through one portion of the slab is not the only reason why a structure might tilt to one side or the other (e.g., ice flows and snow compresses), the availability of the remedial leveling operation above described is always possible.

The building structure should be arranged so that at least the upper surface is level with the snow. This will permit the use of skylights or some other access to light and air and the men housed within such building structures will consider at more pleasant.

Once the floor slab has been constructed and has solidified, the operation of building successive floors or stories thereabove can be started. There is no limit to the number of floors or stories which can be built and the greater the number of floors or stories then the deeper the excavation should be, particularly if the roof level of the upper story is to coincide or be closely adjacent to the upper surface of the frozen subsurface or the snow level. The deeper the structure the firmer the foundation and at levels below 75 feet it will always be 0° F.

Once the floor slab is in place, vertical supporting columns can be placed at appropriate spaced intervals around the floor slab, such columns with spread footings being used to support floors.

A layer of insulation **18**A, such as Rubatex (a firm foam rubber) approximately 4 inches to 6 inches in thickness, is preferably cemented to the top of the foundation slab either shortly before or after the foundation walls and columns are started. This is to maintain heating or freezing temperatures in the foundation slab when fluids are introduced through the pipes. Also this insulation will keep frost from penetrating upwardly into the usuable crawl space.

The various floors above the foundation slab can be constructed in accordance with known building techniques, which would include the use of wooden floors, concrete floors, metal floors or combinations thereof. The many floors above the foundation slab may be provided with *heating means, such as radiant heating* means and should extend some distance, say one foot, to the outside and beyond the outside face of the building for the ice inspection balcony to be able to work. The side walls of the building structure can likewise be of conventional construction such as wood, concrete, aluminum, plastic, steel or combinations thereof. The floor levels and the walls may be provided with ample insulation in addition to heating or freezing means.

A construction of the nature just described is illustrated in FIGURE 2. In this figure the upper surface of the snow or ice is indicated by **10**, the sides of the excavation by **12** and the bottom of the excavation by **14**. The previously described procedure is followed, namely: the digging of the excavation to the desired depth; a pattern of piping lowered into the bottom of the excavation; heated fluid passed therethrough in order to form a shallow lake; the pattern of pipes raised thereabove, and the lake allowed to freeze solid into an ice slab **16** whose upper surface is automatically level by virtue of gravitational forces. The thickness of the ice slab may vary considerably, constructed, that is from a few inches up to 6 feet or more. About two inches of insulation **18** is then placed upon the level top surface of the formed ice slab **16**. As previously noted, one or both surfaces of the insulation are preferably metallized so as to be heat reflective. A network of concrete reinforcing means **20** (such as wire mesh, iron rods, etc.) is then positioned *on or above* the layer of insulation **18** yet above the pipes generally. Preferably, the concrete reinforcing means **20** is positioned above or around the surface of the pipes **22** and above insulation **18**, as for instance by a pattern of blocks, etc.

(If some kind of insulation were not placed between the pipes and ice slab it would not be possible to properly cure the slab when it was poured. If there is an inch or so of concrete around the pipes the weight of the foundation slab and pipes with concrete will cause some crushing of the insulation but not enough to interfere with the setting of the concrete. Also note that when the superstructure is superimposed upon the slab and the weight is carried on the insulation it will now become finally approximately ⅛ to ¼ inch thick.)

Next, the reinforcing, which has until now been raised high enough so that the aforesaid insulation and concrete and pattern of piping could be put in place, is lowered again until it is positioned a relatively short distance above the insulation **18**. In FIGURE 8, the pattern of pipes is indicated by **24**. Lightweight, high-strength concrete is then poured over the aforesaid pattern of pipes **24**, the reinforcing network **20** and the insulation **18**. The lightweight, high-strength concrete preferably weighs about 100 pounds per cubic foot and has a compressive strength of about 3,000 pounds per square inch. Such concrete compositions are well known in the art. The thickness of the concrete is preferably about six or eight inches but can be any thickness desired. It will be noted that the concrete preferably extends from the top surface of the insulation **18** to above the pipes **24** to the upper surface of the reinforcing **20**. Pipes **22** may also be provided above the reinforcing **20** if desired.

Once the aforesaid concrete has been poured and leveled, heated liquids can be passed through the pattern of pipes **24** to help accelerate the cure of the concrete. Such heat can also be used to prevent the concrete from freezing during the curing and setting stage.

The above procedure results in what will be hereinafter referred to as a "foundation slab" **26**.

Once this "foundation slab" has been provided in the bottom of an excavation the remainder of the building structure can be placed thereabove. For instance, as is shown in FIGURE 2, insulated building blocks **28**, **30**, **32** and **34** made of plastic, timber, metal or masonry can be put in place on top of the foundation slab so as to form insulating air spaces (or crawl spaces) **36** and **38** between the foundation slab and the first floor layer **40** (also trap door **32***a*). The sides of the structure may be covered with an insulation material **42** (preferably metallized) so as to minimize heat transfer between the side walls **12** of the excavation and interior air spaces **36** and **38**.

The exact nature and manner of construction of the floor **40** is not critical, but it will of course be realized that as a general rule the thicker the floor and deeper the crawl space the smaller will be the heat transfer through the floor. Likewise, the precise construction of the side walls of the rooms located above the foundation slab is not a critical matter, but again the more suitable insulation that is provided the less heat transfer there will be between the interior of the rooms and the exterior of the rooms which are adjacent to the sides of the frozen excavation. In FIGURE 2, the side wall of room

44 is shown as consisting of a plurality of insulation-type blocks 46, an interior but thinner layer of metallized insulation 48 and a space 50 therebetween either consisting of air or filled with further insulation material. This is needed where living quarters must be maintained.

The ceiling or roof of one room can obviously become the floor of another room as is shown in FIGURE 2. The only limit imposed by the number of floors or stories is the bearing load which the ice or frozen subsurface below the foundation slab 26 can take. In the majority of the polar regions a load of about 900 pounds per square foot exists for firn snow and somewhat greater for ice. The ice will bear 137 tons per square foot before there is a change in the freezing point, all depending upon the ice that is below.

Now referring to FIGURE 1, it will be seen that in order to conserve heat within a structure built in the previously described fashion and in order to minimize heat loss to the sides or bottom of the frozen subsurface, it is most desirable to place any storage rooms around the sides of the structure and to provide for the living quarters in the central interior of the construction. In FIGURE 1, the numerals 52 and 54 represent storage areas whereas the numerals 56 and 58 represent living quarters. Since the living quarters must generally be warmer than the storage areas, any heat transfer from the living quarters 56 and 58 in an outward direction will ordinarily be largely dissipated in storage rooms 52 and 54, thus making storage rooms tolerable to work in. Storage area will require less radiant heat underfoot (wider spacing of pipes).

Another novel feature in accordance with this invention is the provision of exterior ice balconies or walkways around the entire building structure, preferably from the ground slab upwardly, each ice balcony being at least wide enough to permit a man to walk thereon. Suitable access (e.g. doors) to these balconies can be provided through some portion of the side walls. These balconies are shown as 60 and 62 in FIGURE 2 and as 64 and 66 in FIGURE 1.

The purpose of these balconies is to permit men to periodically walk around them and to chip or shave the surrounding ice so that the surrounding ice walls will not press destructively against the sides of the building structure. This is very important in polar regions since it frequently happens that a shifting subsurface ice mass can gradually crush in the sides of the building structure unless a very careful watch is kept on the movement of the ice. Provided that a man periodically walks around the balconies to check on the closeness of the ice walls to the sides of the building structure and providing that the man chips off or shaves off some of the surrounding ice wall when it comes too close, there will be little danger that the structure will be suddenly crushed by any slowly shifting mass of ice. The ice which is thus chipped off from the walls of the ice mass may be collected and then taken up to the central part of the building structure and deposited above the upper surface of the snow at some other location or it may be disposed of in some other manner. Large vacuum cleaners can be used for this purpose if desired. It will be noted that there will be some heat transfer by way of the balconies to the exterior because they are a part of the floor slab, but the heating pipes will not extend too far into these balconies (e.g. 1 to 12 inches). This transferred heat will also melt ice that could crush against the ice balcony or edge before it is necessary to chip or cut it away.

The ice balconies are also lead offs to the various caches of supplies stored in the ice beyond the buildings, such as oil, food, etc. These ice balconies also serve to provide an insulating air space between the exterior of the building and the surrounding ice structure.

Present techniques of heat preservation would also suggest that insulation could be put on the exterior wall

by some blow-on type of expanding foam that would help insulate the structure. The existence of the balcony would facilitate the application of such insulation. There are doors from the interior of the building to the balconies and the balconies are secondary means of escape from either side of the building structure if there is danger of fire or cave-ins.

The ice balcony space will also be used in certain areas where cold air must circulate about the exterior wall so that melting of the exterior firn ice will not break down the vertical face and cause cave-ins of the surface snow onto the ice balcony space. The ice balconies can also be used for air ducts, wires and pipes.

When structures are to be added adjacent to an existing structure the balconies only need to touch by means of an expansion joint so that the transportation of supplies and people between buildings can be quickly accomplished.

In living quarters 174 and certain types of storage areas the roof may extend thereover as a balcony and have heavy insulation at its edge to help seal the ice balcony below. A flexible flap of plastic or canvas will do to keep snow from blasting into the area and keep the air temperature at the desired level in this area to prevent melting.

FIGURE 1 illustrates a further novel feature of this invention, namely the provision of a "griddle" structure or "griddle" enclosure generally indicated by the numeral 68 and specifically comprising a floor portion 70, side wall portions 72 and 74 and peripheral roof portion 76 and 78 which permit open access to the sky thereabove. It will be seen that "griddle" structure in accordance with this invention essentially comprises an upper surface exposed to the sun during good weather and which can be used for a great variety of purposes, including sports. The griddle itself may consist of colored (black) concrete with a hardener, wood, metal, plastic or asphalt material and a pattern of pipes closely together may be embedded in the griddle surface, such pipes carrying heated fluid so that when an undesirable amount of snow or ice forms or gains entrance on the griddle it can be melted and withdrawn therefrom. The speed of the heated fluid will bring up or lower the heated surface. Large vacuum cleaners can also be used to keep snow off the griddle. During times of inclement weather the surface of the griddle can be protected by a sliding rigid cover or by a canvas covering or by an air filled balloon-type structure of plastic or rubberized material (not shown). The balloon or envelope of plastic or rubberized material should be of sufficient strength to carry a load of snow of moderate weight and height. It can be stretched or pulled over the griddle area (e.g. as sails are) and then inflated by means of relatively low air pressure. Even if there is leakage of the inflating air, the leakage will usually not be sufficient to cause collapse of the balloon-type cover so long as air is being continuously pumped into it.

Water that is a product of the melted snow from the griddle can be collected and used for washing, cleaning, etc. and spewed downwind as snow. Or it can be conveyed by heated pipes to an ice crevasse (of which there seem to be unlimited numbers).

Another means of keeping snow off of the surface of the griddle is to provide a curtain of air around the griddle surface which will deflect snow up and away from the griddle surface. Such a curtain of air wound preferably be selectively directed to the same direction the wind was blowing so that the air jets would serve to blast the oncoming snow up and over the griddle surface. By proper arrangement of the air jets, snow could be blasted for 60 feet or more.

A very simple pipe fence or equivalent protective barrier means 80 is also preferably disposed around the top of the "griddle" 68 so as not to pile up snow in drifts. It will be apparent that the griddle structure is largely protected from any fierce surface winds which would be prevalent and thus it would permit the occupants of the structure to

occasionally sun themselves and to enjoy generally a limited degree of outdoor activity which is so important to those who are confined within such housings for long periods of time. It could also serve as a launching area, or for weather rockets, for copter landings, or repairs or for large radar hauled in by tractor.

When the sun is high in the heavens it will beat down directly upon the floor **70** and provide considerable heat during certain portions of the year even in polar regions.

The griddle section **68** and **152** plan will have an ice balcony outside, but the balcony will also extend into the griddle area and be held in place by columns of concrete or cables with structural corbels. Shown in FIGURE 1 No. **72** and plan **152**. The extension or spandrel beam inside of the griddle can carry a plastic or rubberized balloon (or possibly a folded umbrella-type structure) that will give cover in the manner of a low dome to the griddle in inclement weather. Geodisic domes may also be used.) This balloon or cover can be zippered or have magnetized flap covers—sealing it from the elements.

The griddle ice balconies will also carry a thin-piped wire fence T50 steel at its top. The fence and its uprights will permit as little snow drifting as possible. The inner ice balcony of the griddle will also have duct openings to bring in fresh air for lower work quarters. The balconies can be high enough to accommodate transport planes and be provided with balloon coverings for major repairs.

In super-imposing an air balloon over the griddle a layer of insulated air will be provided so that the temperature at the griddle face will be confortable for ordinary work clothes. Also two balloons may be superimposed over one another and different pressures used, yet the outer layer of air would be a lower temperature so that the heat would be held on the inside.

Both layers of balloons may be of the quilted type, the air pressure in the inside of the quilting would be held at a higher pressure so that shape would be maintained.

The griddle will also be an important area for bringing fresh air into the working areas or the rooms below. (See bent vent pipe under the ice balcony for air to be brought to the floor below ready to be heated to the proper temperature. Also air can be taken from the ice balconies, but would require heating.)

Note that all liquids will be the non-freeze type for use in heating floors. The higher the temperature they carry the more useful will they be.

FIGURE 3 shows another important feature in accordance with the teachings of this invention. This figure shows the manner in which a hatchway or similar passageway to an underground construction could be protected from the excessive deposition of snow. Numeral **82** represents the interior of a stair link located near the upper portion of one of the previously described subsurface constructions. The ceiling or roof structure of this roof **82** is generally represented by **84**, and **86** represents a stairway hand-rail extending from the bottom of the stair **82** to a point adjacent the ceiling **84**. Numeral **88** is a hatchway or hatch cover which is designed to be either raised or lowered so as to permit one to walk up the stairs **86** to the ground level thereabove.

In some cases it may happen that an accumulation of snow several feet thick may be present upon the hatch cover **88**. When this occurs, one who walks up the stairway **86** and attempts to lift the hatch cover **88** upwardly against this accumulated weight of snow may have considerable difficulty. Accordingly, the hatch cover **88** can be provided with what essentially amounts to an emergency exit **110**. As is perhaps best seen in FIGURE 4, this emergency exit **110** consists of a manhole type of arrangement, for instance having a rectangular removable outlet means **112** (large enough to accommodate a man) which is hingedly connected to the underside of the hatch cover **88**, as for instance by a spring hinge means **114**. The exit means **112** can be maintained in essentially the same plane as the hatch cover **88** by providing a rotary handle-type of locking device comprising an upper handle **116**, a lower handle **118** (so that it may be operated from above or below), a bolt **120** operatively connecting the two handle means and a locking extension **122**.

The hatch cover is preferably made of wood. However, the emergency exit hatch cover **110** would be more helpful if it were made of heavy transparent insulating plastic strong enough to walk on. Thus at night, it could be spotted from the outside better because of the lights below and from the stairs or ladder it would permit persons leaving the escape hatch from the inside to have light and also judge the amount of snow above it.

When a person coming up the stairs or ladder **86** desires to open the emergency exit **110** he merely needs to grasp the lower handle **118** and turn it so that the locking extension **122** will move out of locking relationship with the non-movable portion of hatch cover **88** and the emergency exit **110** will then swing downwardly by virtue of its hinged connection to the underside of the hatch cover **88**. When the emergency exit has thus dropped downwardly, the person on the stairs can rise through the exit **110** and with the aid of a shovel or other similar tools remove the accumulation of snow which is present on the hatch cover **88**. When the snow on the hatch cover has thus been removed the hatch cover in its entirety can be raised without difficulty. Obviously, the emergency exit **110** should have an area about as large as a man so that a man can easily work his way therethrough in order to free the snow from the top of the hatch cover. Such an emergency exit is also useful when extremely high wind conditions are prevalent and the raising of the entire hatch cover **88** would be somewhat dangerous. The above is also true in reverse if a person is outside and wishes to enter, in which event it can be considered as a "kick-open" trap door.

FIGURE 6 is a plan view of the hatch cover and emergency exit shown in more detail in FIGURE 4.

In prior art constructions utilizing a hatchway type of entrance in polar regions, it has been observed that one of the difficulties is that blowing winds will cause a foot or several feet of snow to overlay the hatch cover **86**, making access thereto difficult and also often causing considerable amounts of snow to fall downwardly within the building when the hatch cover is removed. In accordance with my invention these difficulties are considerably lessened by providing what can generally be described as an inverted dome-like structure over the hatchway area. This thin, streamlined dome-like structure is represented in FIGURE 3 by the numeral **90**. It will be seen that the structure **90** is supported by a plurality of thin supports **92** spaced at intervals around the periphery of the dome-like structure **90**. The thin supports can be made of type T50 (high tensile strength) steel which will make the supports very thin in profile. The canopy can also be made of this type steel (airplane wing stainless) or the whole of clear, heavy molded plastic. The inclined under surfaces **94** of the structure **90** are substantially symmetrical and any horizontal plane through said structure **90** preferably has an essentially circular or elliptical cross-section. The upper surface **96** of structure **90** can be flat as shown, preferably streamlined. The structure **90** may extend over all or only a portion of the hatchway area. A non-snow gathering or drifting fence **98** may be disposed around the hatchway area also so as to guard against falling into said open hatch. The fence must be as thin as possible so as to not cause the excess accumulation of snow. Any lights on the underside should preferably be built into the surface so as to thoroughly streamline the underface of the canopy. Any plastic skylights must be made flush with the skin on both sides.

By using a structure such as shown in FIGURE 3, winds which pass beneath dome-like structure **90** will be accelerated by virtue of the venturi-like effect caused by the inverted dome structure. Thus, any winds which would otherwise tend to deposit snow upon the hatchway

cover will now be so accelerated and turbulent with respect to the adjacent wind currents that the snow in the hatchway area will be preferentially blown away. By installing television, radar or laser scopes in the thin shell **90** and only enough showing on top for directional use, the structure underneath would be quite clear of snow. Also servicing would be much easier. All wires would run in the thin steel structure to the rooms below. A structure such as shown in FIGURE 3 is of great utility in any snowy region.

A further novel feature of the polar construction techniques in accordance with this invention is shown in FIGURE 5. In FIGURE 1 there is shown in very general outline an air vent stack or smokestack **100** which connects the interior room **56** with the atmosphere above the building or above the griddle structure. The use of a conventional smokestack or air vent, however, presents a number of problems in polar regions. For example, the air within a building structure is warmed and carries a considerable amount of moisture. When this air is drawn from a warm room to be expelled into subfreezing areas, the moisture in the warm air will rapidly be converted to ice or ice crystals. Accordingly, if a conventional vent damper is used having one or more dampers therein to control the air flow, there is the danger that the damper will be rendered partially inoperative because of ice build-up on the interior surface of the vent pipe. This is of course undesirable since there will then be no control on the vent. (The smokestack **100** can terminate immediately above the griddle surface if desired.)

The arrangement shown in FIGURE 5 is designed to eliminate or at least minimize such difficulties. In FIGURE 5 it will be noted that the interior cylindrical wall surface of the vent thereshown is provided with two dampers **104** and **106**. The edges of the dampers **104** and **106** are serrated rather than perfectly round. The purpose of this is that when the dampers **104** and **106** are moved from one position to another, the sharp serrated edges thereof will cut into any ice or frost which has formed near the damper closure area and the ice which is thus cut or broken off by the serrated edges can drop downwardly into snow and drip collector **108**, where it can be periodically removed as desired by means of a trap door (not shown). The beginning-to-end path of the vented gases is shown by the arrows E and F. This construction insures that the ice adjacent to the damper areas will not build up to a sufficient extent to render the dampers inoperable, even in part. As shown, the dampers or baffles **104** and **106** may be arranged in tandem by means of connection **109** so that (in conjunction with damper arm **107** and chain **105**) two or more baffles may be moved at the same time by a person located within the building structure. Also, since the flue is made of metal, it can have heat blasted through it to remove all loose frost or ice.

The flue in general should be made of high-strength stainless steel T50 while the dampers can be of somewhat heavier thickness for preventing bending the serrated edges. Most of the stair escape hatches should be equipped with at least one vent stack to keep the temperature cool in this area or balanced with the outside temperature so that condensation will be kept low and the steam would be at a minimum. Certainly all the work shops would use a number of air exhausts because these would be pressure fed with pre-warmed air along with the radiant heated floors. The air pumped in primarily for a member of air changes per hour.

Another important and novel feature of this invention resides in the concept of having a multiplicity of building structures, each of such building structures being joined by "links" which are of a comparatively weak nature and which will permit the multiplicity of building structures to break at planned breaking points should the ice suddenly shift to a considerable extent. The "links" preferably contain only stairways or passageways or escape hatches. It is preferred that no stairways or escape hatches pass through or join any of the floor slabs or roof slabs for the reason that if considerable stress should be suddenly applied to these slabs they would not be inclined to break in the areas weakened by stairways or passageways. For instance, suppose that on a glacier which moves three feet per year a crack suddenly opened between buildings or under a building; one part could slide from under the building pulling only a stair link with it and this would allow time to patch or repair the space between.

The above-described concept of utilizing "links" on a comparatively weak nature between building structures is generally illustrated in FIGURE 7. In this figure "links" **130** connect the various building units together. As shown, such "links" **130** contain stairways and the exterior doors of each building unit preferably open into such "links." Also these links allow for flexible conduits and heat pipes to pass from one building to another and any connections so desired. In the links the humidity and temperature drop close to those prevailing on the outside—thus a minimum cloud of steam or humidified air will be encountered each time a door is opened. They are thus like air vestibules and these air vestibules or links provide passage to the open air griddle. Further, these stair links provide ready access to the outside snow surfaces.

FIGURE 7 further shows the over-all layout of a construction arrangement which would be most suitable in polar regions. More particularly this figure shows the general plan of such a construction for the first floor below the upper surface of the snow. It will be first of all observed that the edge of the snow or glacier ice **132** is spaced away from the side walls of the various building units for the purposes previously set forth. The other portions of the construction arrangement can be listed as follows: movable tractor ramp **134**; oil cache **136**; tractor lift **138**; abbattoir **140**; oil rendering area **142**; cooking or heating range **144**; animal skin cache **146**; plant culture area **148**; animal food cache **150**; the "griddle" **152** (corresponding generally to the "griddle" structure **68** shown in FIGURE 1); chemical cache **154**; general laboratory **156**; wood and spare parts cache **158**; machine shop **160**; tractor repair area **162**; tractor lift **164**; tractor ramp **166**; generator room **168**; oil tank cache **170**; general cache **172**; living quarters **174**; clothes washing and bathing area **176**; radio tower **178**; gas vent **180**; meteorological workshop **182**; print shop **184**; radio shack **186**; meteorological equipment cache **188** and atomic power plant **189**. Much heat will be needed for a plant of this nature.

This invention is also particularly applicable to building structures which must be located in tundra areas where the subsurface becomes much less firm during the summer months and which would consequently result in an unsteady base. With the building foundation slab construction of this invention, this condition can be remedied by passing through the pattern of pipes a refrigerated fluid which would in effect freeze the soil structure beneath the slab and thereby provide a firm non-shifting base for the slab which would not shift with the higher temperature conditions or thawing conditions encountered during the summer months.

This invention is also particularly applicable and particularly suitable for constructions in polar areas wherein an atomic reactor is to be used. Since atomic reactors can generate a great deal of heat, and since great amounts of heat are useful in connection with this invention, the advantages of using such an energy source are quite apparent. The economies of operating an atomic reactor become much more attractive in polar regions because of the relative unavailability and high cost of conventional fuels.

In addition it should be mentioned that the prevoiusly described techniques for forming an ice slab or founda-

tion slab (e.g. with heating pipes) can also be employed for forming a level surface at the ground level, thereby providing a landing field, radar tower foundation, a balloon support station, work area, etc., of any thickness desired. Also as mentioned previously, huge ice piles made into the firn ice can help stabilize a base. Such piles can be installed at all angles giving a broad and firm base to any structure.

In conclusion, while there has been illustrated and described a preferred embodiment of my invention, it is to be understood that since the various details of construction may obviously be varied considerably without really departing from the basic principles and teachings of this invention, I do not limit myself to the precise constructions herein disclosed and the right is specifically reserved to encompass all changes and modifications coming within the scope of the invention as defined in the appended claim.

Having thus described my invention, what I claim as new and desire to secure as United States Letters Patent is:

An improved multilevel subsurface building construction for polar regions containing ice and snow which comprises:

(a) a foundation slab disposed in a subsurface cavity in an ice formation,

(b) a first level consisting of a floor surface positioned at a fixed distance above said foundation slab and disposed parallel to said foundation slab,

(c) a seond level disposed above said first level and parallel thereto so as to provide a useful living and storage space therebetween,

(d) vertical walls extending between said first and second levels which form the side walls of the aforesaid living and storage space,

(e) vertical walls extending upwardly from said second level and terminating adjacent the surrounding surface level of ice and snow,

(f) the outer portions of said first and second levels extending outwardly of said vertical walls so as to form subsurface balconies that extend around substantially the entire exterior periphery of the building structure,

(g) the vertical space between said balconies being free of the adjacent subsurface material,

(h) whereby occupants of the building structure are enabled to walk around the exterior of the building at periodic intervals and remove any increment of ice which is pressing precariously close to the subsurface structure.

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