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MacCracken

[11] **3,910,059**

[45] **Oct. 7, 1975**

[54] **METHOD AND SYSTEM FOR PROVIDING AN ICE SLAB WHILE PREVENTING UNDUE FREEZING PENETRATION BELOW**

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[52] **U.S. Cl.** ..... **62/99;** 61/36 A; 62/235; 165/48

[51] **Int. Cl.²** **F25D 17/02**

[58] **Field of Search** ..... 62/235, 260, 238, 99; 61/36 A; 165/45, 48

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Attorney, Agent, or Firm—Parmelee, Johnson & Bollinger

[57] **ABSTRACT**

Method and system for creating and maintaining an ice slab for use as an ice skating rink, ice chute, or the like, and for preventing heaving damage caused by freezing and expansion of moist ground and ground water under the ice slab. The system includes a first lower grid of flexible tubing overlaying an area of ground where such ice slab is to be formed, a layer of insulating material overlaying the first mat, a waterproof liner positioned above the insulating material, and a second upper mat or grid of flexible tubing overlaying the waterproof liner. Antifreeze liquid at above-freezing temperature is circulated through the lower mat to prevent freezing of the ground moisture or water, and antifreeze liquid at low temperature is circulated through the upper mat. This low temperature antifreeze liquid in the upper mat serves to freeze water placed over the waterproof liner to form the ice slab. The heat energy extracted from this low temperature antifreeze liquid may advantageously be used to warm the above-freezing temperature antifreeze liquid to be circulated in the lower mat. In installations in multi-story buildings this lower grid may be used to prevent the subflooring structure beneath the rink from becoming unduly cold and for preventing the ceiling of the basement or other rooms below the rink from becoming so cold as to cause damage or to condense atmospheric moisture and drip.

18 Claims, 7 Drawing Figures

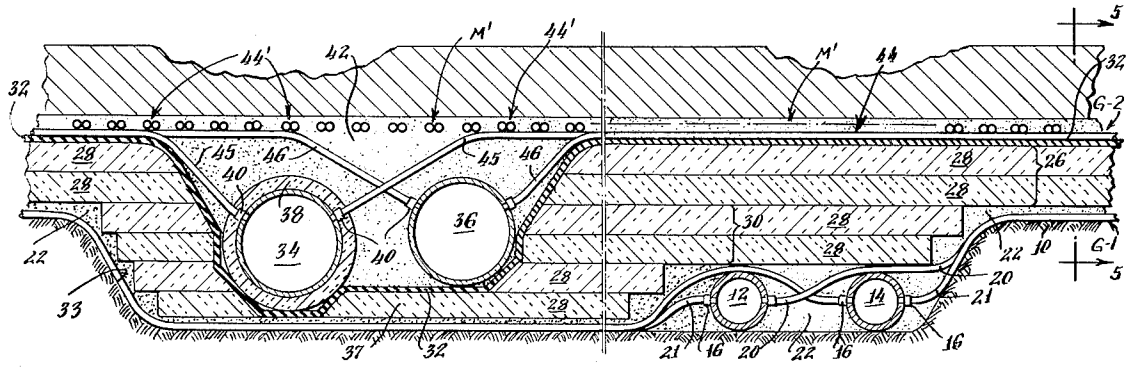


Fig. 1

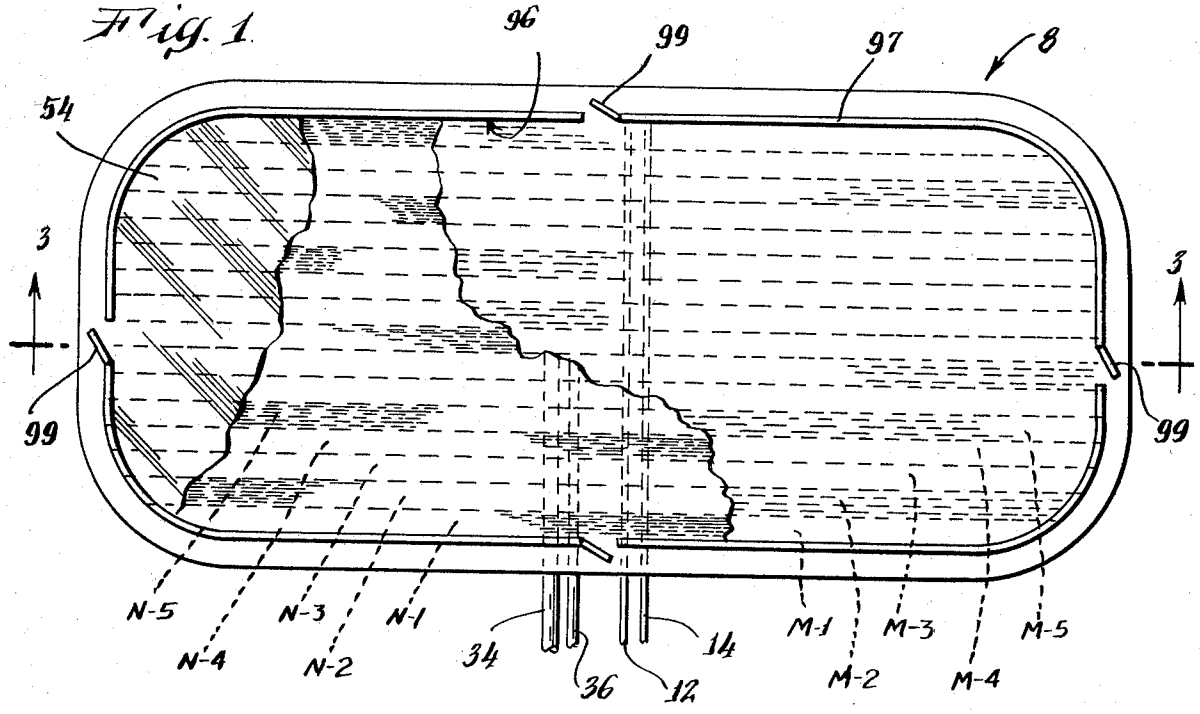
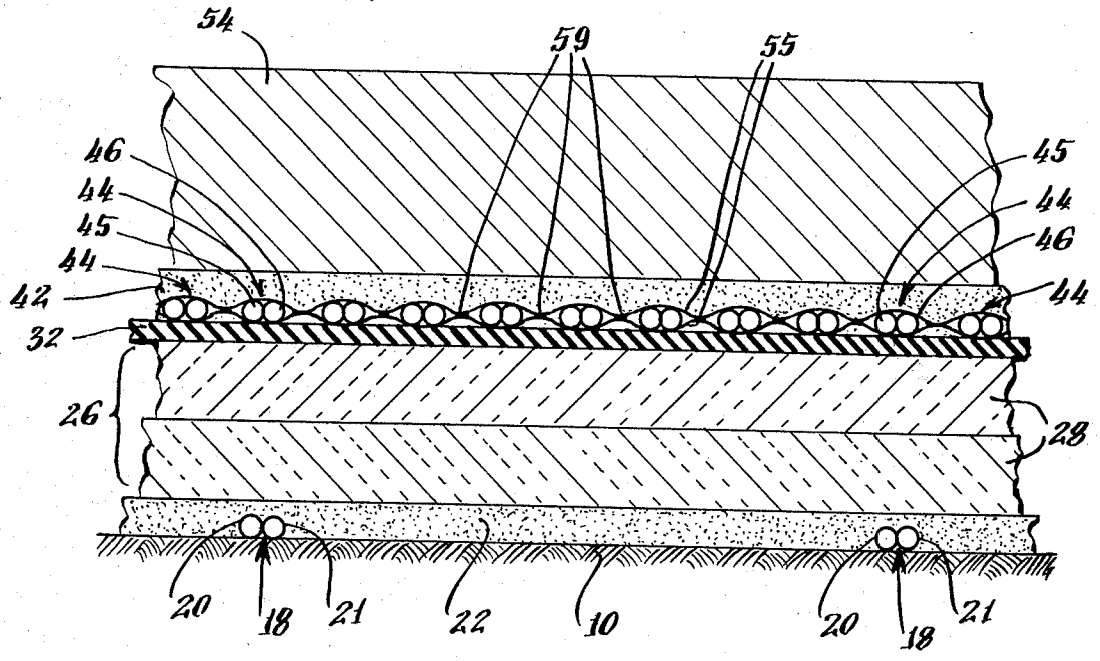

96
99
97
8
54
3
3
99
99
N-5
N-4
N-3
N-2
N-1
34
36
12
14
M-1
M-2
M-3
M-4
M-5

Fig. 5.


54
59
55
46
44
45
44
42
32
26
45
44
46
44
28
20
18
21
22
10
20
18
21

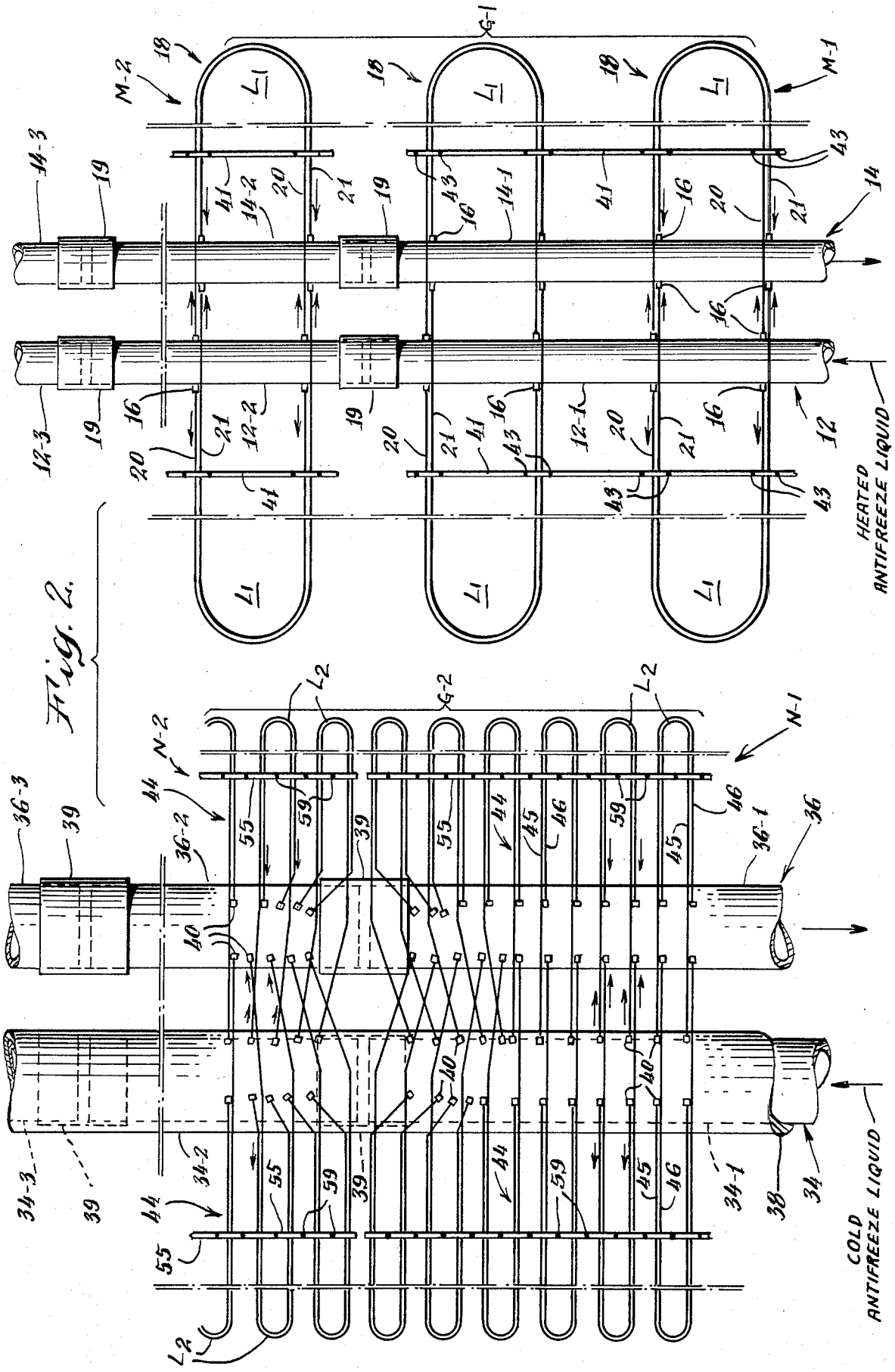

G-1
M-2
M-1
L1
18
19
14-3
14
14-2
14-1
20
21
41
43
16
12-3
12
12-2
12-1
HEATED
ANTIFREEZE LIQUID
G-2
L2
N-2
N-1
44
36-3
36
36-2
36-1
39
40
45
46
55
59
34-3
34
34-2
34-1
38
COLD
ANTIFREEZE LIQUID

Fig. 2.

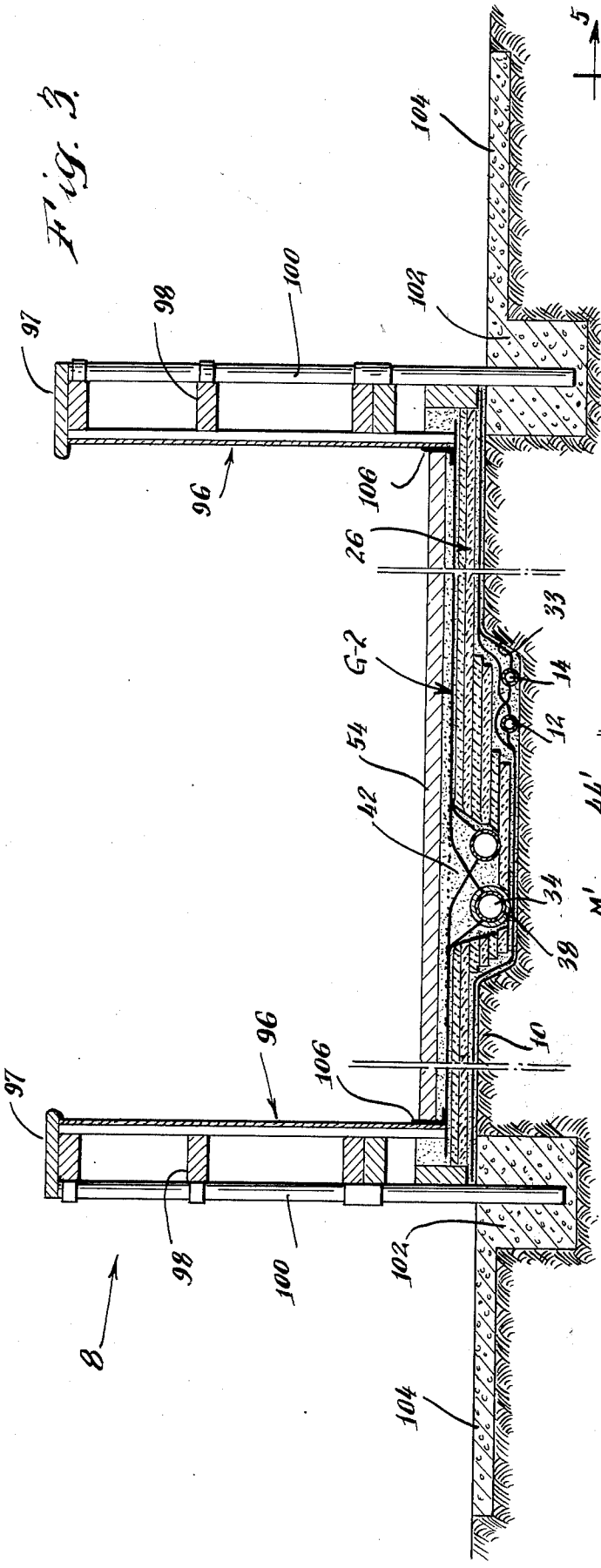

97
98
100
102
104
96
106
26
33
G-2
14
12
54
42
34
38
10
8

Fig. 3.

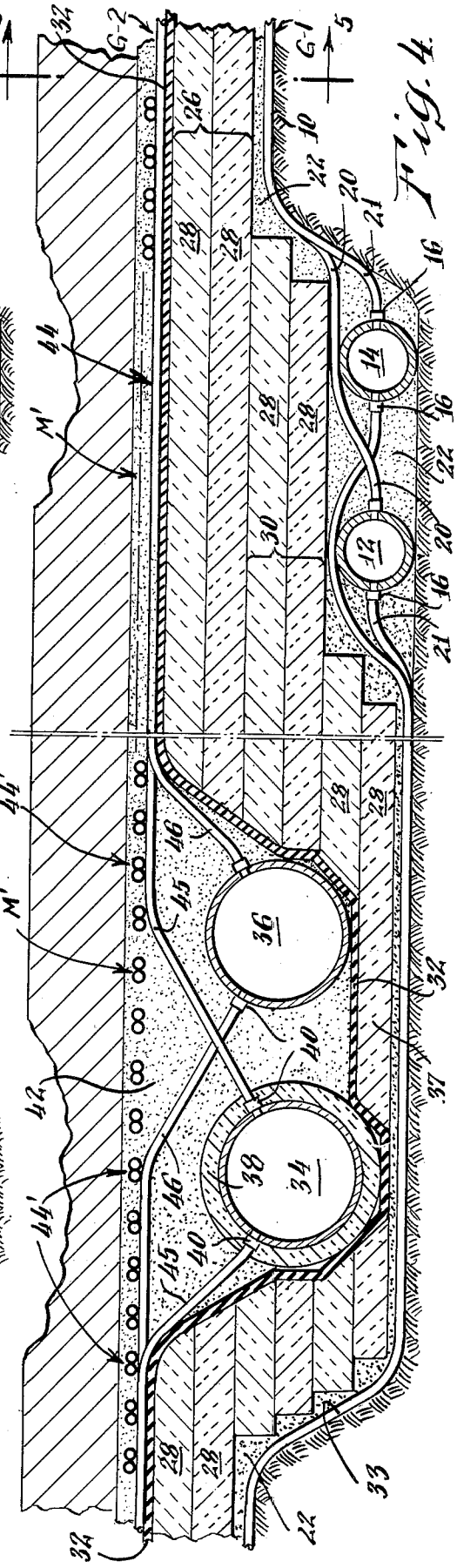

5
32
G-2
G-1
26
10
22
20
21
28
16
44
M'
14
12
30
36
46
45
40
42
44'
38
34
33

Fig. 4.

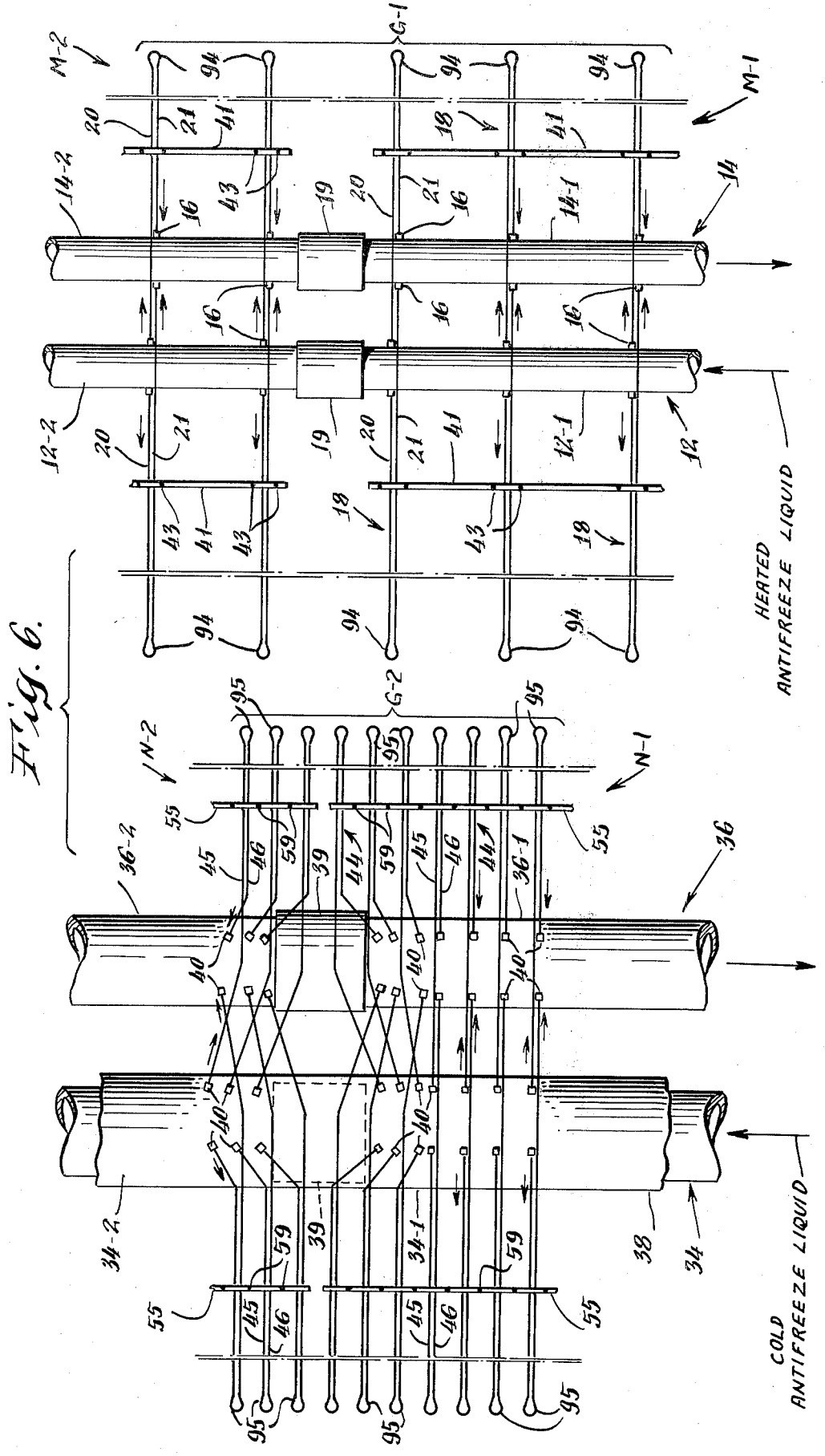
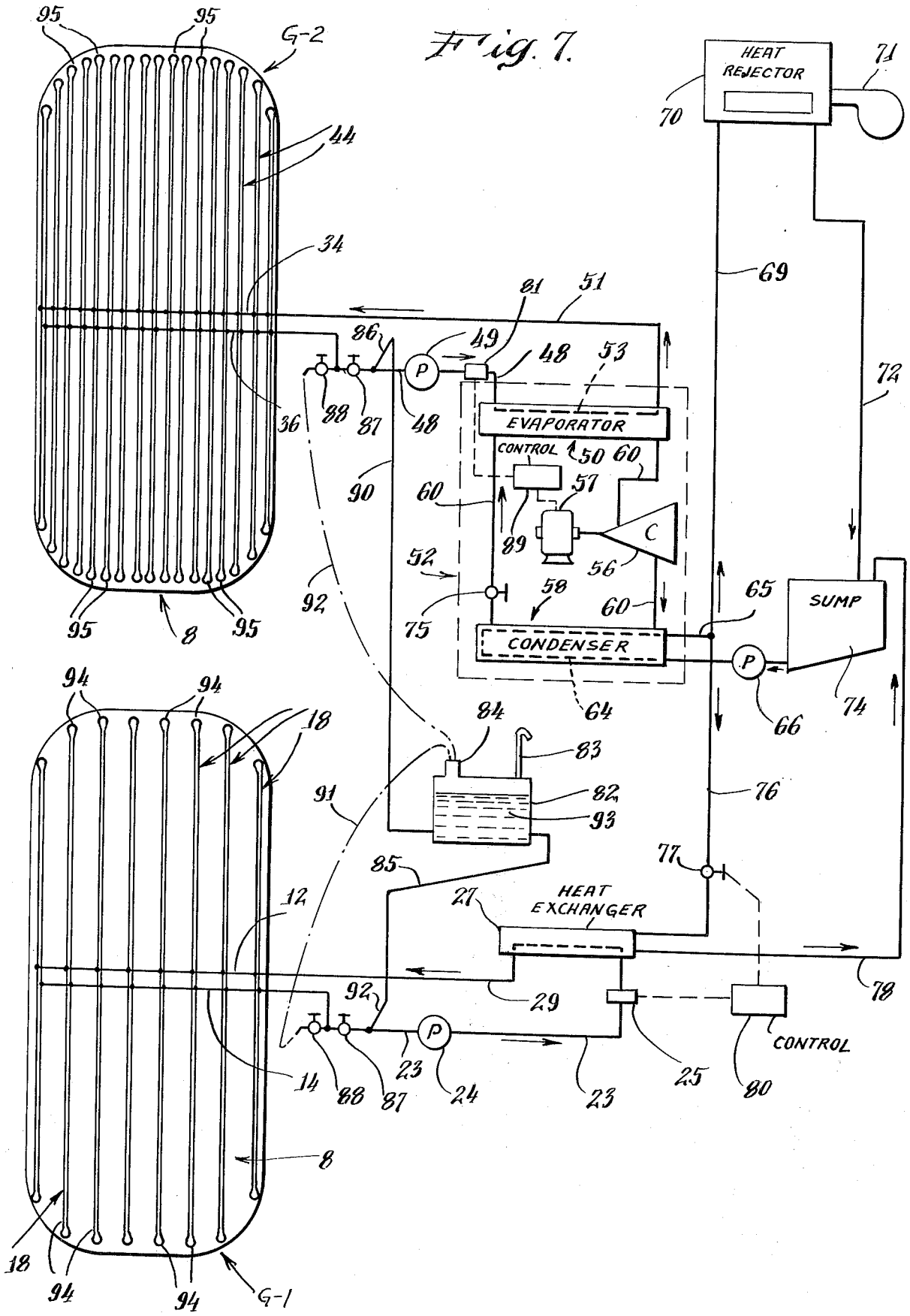

G-1
M-2
M-1
14-2
14-1
14
12-2
12-1
12
HEATED ANTIFREEZE LIQUID
G-2
N-2
N-1
36-2
36-1
36
34-2
34-1
34
38
COLD ANTIFREEZE LIQUID

Fig. 6.

Fig. 7.


HEAT REJECTOR
71
70
69
72
G-2
95
44
34
36
81
51
86
49
48
53
88
87
EVAPORATOR
CONTROL
50
60
57
90
89
C
56
52
58
92
75
65
SUMP
CONDENSER
64
66
74
8
94
18
84
83
82
93
91
76
85
77
12
27
HEAT EXCHANGER
29
78
14
23
24
25
80
CONTROL
G-1

METHOD AND SYSTEM FOR PROVIDING AN ICE SLAB WHILE PREVENTING UNDUE FREEZING PENETRATION BELOW

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a system and method for creating and maintaining an ice slab and for preventing freezing of ground moisture and water under the ice slab which may cause heaving and hence damage to the ice slab and in building installations prevents the subflooring structures from becoming unduly cold and preventing the ceiling of the basement or other rooms below the rink from condensing and dripping moisture from the air. Ice slabs created and maintained by this system and method may be used as ice skating rinks, ice chutes, or for maintaining a layer of snow for skiing.

2. Description of the Prior Art

Various systems and methods for creating and maintaining ice slabs are presently in use. In one prior art system, ice slabs are frozen by the use of an expensive network of large diameter metal pipes permanently embedded in concrete that forms a floor on which water is placed and later frozen. A large volume of brine of calcium chloride is circulated through the metal pipe network at an entering temperature of approximately 15°F to 18°F to accomplish the freezing function.

A dramatically different method is disclosed in U.S. Pat. No. 3,751,935—MacCracken et al. This patented method and system employ a network of small diameter, flexible plastic tubing positioned below the area for the ice slab. A small volume of low temperature antifreeze liquid such as a mixture of ethylene glycol and water is circulated in this network at an entering temperature of preferably no more than 10°F or lower to freeze water placed above the network. In the systems and method as shown in said patent the small diameter flexible plastic tubing is connected to subheaders which in turn are connected to main supply and return header pipes positioned at the periphery of the ice slab and connected to a refrigeration system which cools the antifreeze liquid.

An ever present danger of heaving damage exists in certain prior art systems and methods for creating ice slabs. Heaving occurs when frost goes into the ground and freezes any moisture and ground water trapped under the ice slab. When the moist ground and water freeze, they expand upward to bulge or "heave" portions of the ice slab, making the slab unsuitable for skating or other activity. Furthermore, when such heaving occurs, damage to the liquid circulating system itself may occur.

In various prior art systems, electric resistance wires have commonly been positioned below the area for the ice slab, below the ice freezing apparatus, in an attempt to prevent ground heaving. However, the electric wires and their insulation are susceptible to damage during construction and operation due to heavy machines and to ground shifting and settling and to damage from water and ice which may come into contact with the electrical wires on their insulation. Additionally, the installation and operating costs of such electric resistance wire grids are high.

SUMMARY OF THE INVENTION

In the preferred embodiment of the present invention, to be described below in detail, the system for creating and maintaining an ice slab and for preventing heaving damage to the ice slab includes first supply and first return header pipes with a first lower grid of multiple lengths of flexible tubing in circuit between the supply and return header pipes arranged in the area of ground where the ice slab is to be formed. This first lower grid of flexible tubing is adapted to circulate antifreeze liquid at above-freezing temperature to prevent freezing of the ground moisture or water below the ice slab. A protective material, such as sand, is packed around and over this first lower grid of flexible tubing. A layer of insulating material such as waterproof styrofoam or fiberboard, overlays this packed protective material, and a waterproof liner, for example, a polyethylene sheet layer overlays the insulating material. This waterproof liner serves to confine the water which will later be frozen into the ice slab. Second supply and second return header pipes are provided with a second upper grid of multiple flexible tubing lengths positioned over the area of ground where the ice slab is to be formed. This upper grid overlays the waterproof liner, with the tubing lengths being in circuit between the second supply and return header pipes. The upper grid is adapted to circulate low temperature antifreeze liquid for freezing the water to form the ice slab. A second layer of protective material, which also may be sand, may be packed under, around and over the upper grid of flexible tubing.

In an alternative arrangement which may be used, the upper grid is floated on the surface of several inches of water held by the waterproof liner and subsequently frozen to ice by circulating low temperature antifreeze through the upper grid. This arrangement saves the cost of transporting and spreading sand by giving a slab of ice below this grid to provide structural strength. Then, more water is sprayed above the grid to create the ice above the grid for skating.

A first pump is provided to circulate the antifreeze liquid at above-freezing temperature through the lower grid of flexible tubing to prevent the ground moisture and water from freezing. While a second similar pump circulates the low temperature antifreeze liquid through the upper grid of flexible tubing to freeze and maintain the ice slab.

A refrigeration system is associated with the antifreeze liquid circulating in the upper grid of flexible tubing to extract heat from this antifreeze liquid for freezing and maintaining the ice slab. By extracting heat, this antifreeze liquid is cooled to a temperature well below the freezing temperature of water preferably to a temperature of no more than 10°F or below.

Advantageously, some of the heat energy extracted from the ice slab may be used to prevent the freezing and heaving of the moist or wet ground beneath the ice slab. A heat exchange unit is operated in conjunction with the refrigeration system to remove heat energy from the refrigerant fluid which in turn was used to extract heat energy from the low temperature antifreeze liquid. This heat exchange unit is also operated in conjunction with the circulation system for the lower grid of flexible tubing to deliver this heat energy into the antifreeze liquid circulated in this lower grid system for keeping this liquid above freezing temperature to prevent the ground from freezing. In this manner, the refrigeration system chills the low temperature antifreeze liquid so that it freezes water for making the ice slab.

Further, some of the heat energy extracted from this low temperature antifreeze liquid is utilized to warm the other antifreeze liquid circulating in the lower grid so that it prevents freezing of the moisture and ground water trapped underneath the ice slab, thereby preventing heaving and heaving damage. Alternatively, in installations in multistory buildings this lower grid may be used to prevent the subflooring structures beneath the rink from becoming unduly cold and for preventing the ceiling of the basement or other rooms below the rink from becoming so cold as to cause damage or to condense atmospheric moisture and drip.

The method and system of the present system provide several advantages over prior art methods and systems for creating and maintaining ice slabs. This system is an effective, uncomplicated, and reliable solution to the problem of frost heave occurring beneath ice slabs such as ice skating rinks or ice chutes. By virtue of the fact that it enables utilization of the rejected heat from the output of the ice refrigeration system, it reduces the total consumption of energy required to create and maintain the ice slab and to prevent frost heaves. It eliminates the need for the complex, easily damaged expensive electric resistance wire grid systems which have commonly been used in the past to prevent such frost heaves.

The unique structural arrangements as shown locating the supply and return header pipes for both grids of flexible tubing directly over the area where the ice slab is to be formed, greatly reduces the material costs in installing the system of the present invention. The refrigeration and pumping system utilized in the present invention may be located closely adjacent to the ice slab. The two sets of supply and return header pipes may be directly connected to this refrigeration and pumping system. Accordingly, installation and use of the method and system of the present invention result in substantial savings in initial material costs and in operating costs.

The parallel lengths of flexible tubing in both the lower and upper grids are shown as formed by coextruded tubing pairs. One tube in each of these pairs is connected to the supply and return header pipes to effect antifreeze liquid flow in one direction, while the other tube in each of these pairs is connected to the supply and return header pipes to effect antifreeze liquid flow in the opposite direction. This counterflow of the antifreeze liquid averages the temperature differences between the antifreeze liquid flowing in adjacent tubing lengths of each tube pair. This arrangement provides substantially uniform respective temperatures in the upper and lower grids. Therefore, the ice slab formed by the freezing effect of the low temperature antifreeze liquid circulating in the upper grid is substantially uniform having substantial uniform temperature throughout its area. Similarly, the lower grid, which is being warmed to prevent frost heaving under the ice slab provides substantially uniform warm temperatures under the ice slab.

In an alternative grid embodiment the coextruded tubing pairs are interconnected by "U"-bends at their ends so that the respective tubing lengths in each pair are connected to each other. Thus, flow is in one direction in one tubing length of the pair and in the opposite direction in the other tubing length of the pair.

Accordingly, it is an object of the present invention to provide a unique and novel system and method for creating and maintaining an ice slab for use as a skating rink, ice chute or the like and for preventing heaving damage caused by freezing and expansion of moisture and ground water under the ice slab.

Other objects, aspects, and advantages of the present invention will be pointed out in or will become understood from a consideration of the following detailed description, in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an overall plan view of the grid layout for a full-sized skating rink embodying the system of the present invention for creating and maintaining an ice slab and for preventing heaving damage caused by freezing and expansion of ground moisture or water. Portions of FIG. **1** are broken away in section in various layers.

FIG. **2** is an enlargement of portions of FIG. **1.**

FIG. **3** is a cross-sectional view of FIG. **1** taken along the line **3—3** in FIG. **1** showing the arrangement of the lower anti-heaving grid of flexible tubing, insulation positioned above this protective grid, then the waterproof liner overlaying the insulation, with the upper grid of flexible tubing positioned above the liner and surrounded by a protective medium.

FIG. **4** is an enlargement of portions of FIG. **3.**

FIG. **5** is a cross-sectional view of this ice skating rink taken through plane **5—5** in FIG. **4** illustrating the spacing and positioning of the flexible tubing forming the first and second grids.

FIG. **6** shows an alternative grid embodiment in which the respective tubing lengths in each coextruded tubing pair are interconnected at their ends by U-bends to provide counter flow through the respective tubing lengths.

FIG. **7** is a schematic circuit diagram illustrating the liquid circulation in both flexible tubing grid systems and showing the advantageous usage of rejected heat to prevent heaving by providing an interrelationship of the upper and lower flexible tubing grids, the refrigeration system and heat exchange means for extracting heat energy from the refrigerant fluid and for transferring this heat energy into the circulation system for the lower grid.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENT

Referring to the drawings in greater detail, the method and system for creating and maintaining an ice slab and for preventing heaving damage caused by freezing and expansion of moisture and ground water under the ice slab is illustrated embodied in an ice skating rink **8.** This system is assembled over an area of ground **10** which has been graded and which may be tamped to insure a firm, level surface. This system may be installed over a concrete slab or on the floor of a building. When installed in a building, the lower grid is used to keep the subfloor (and hence the ceiling of the space below, such as a basement) above a temperature at which moisture condensation and dripping would occur. Alternatively, this system may be installed on an area of ground prepared for use as an ice chute. In such case, the ground would not be leveled but would be contoured to provide the desired characteristics of the chute. Similarly, the system may be used for a toboggan run or a ski slope, and if so used, the run or slope would be contoured accordingly.

There are first supply and first return header pipes **12** and **14** which are laid straight and parallel side-by-side on the area of ground **10** prepared for installation of the system. These header pipes **12** and **14** are shown extending across the full width at the midrink position of the area where the ice slab is to be formed. Each header pipe **12** and **14** is fitted or formed with twin series of short tube attachment nipples **16** to which the flexible tubing lengths in the first grid G-1 are attached.

Advantageously, the header pipes **12** and **14** are initially formed in short sections **12-1, 12-2, 12-3, 12-4,** etc., and **14-1, 14-2, 14-3, 14-4,** etc., each section being of equal length, and these sections are adapted to be joined together by coupling sleeves **19** to form the header pipes. The pair of short header sections **12-1** and **14-1** together with their associated lengths of small diameter flexible tubing **20** and **21** as will be described, form a flexible mat M-1 adapted to be prefabricated at a manufacturing site and rolled up to be conveniently delivered to the rink site for installation. Similarly, the next pair of short header sections **12-2** and **14-2** together with their associated lengths of small diameter flexible tubing **20** and **21** form another flexible mat M-2 which can be prefabricated, rolled up and delivered to the rink site for installation, and so forth with the other mats M-3, M-4, etc. During installation these mats M-1, M-2, M-3, M-4 are unrolled and laid side-by-side with their tubing lengths **18** in parallel relationship and with the header sections **12-1, 14-1** aligned with the next successive header sections **12-2, 14-2,** which in turn are aligned with the next header sections **12-3,** 14-3 and so forth; so that the sections can be joined together by the couplings **19** to form the completed header pipes **12** and **14.**

The small diameter flexible tubing **20** and **21** is formed of plastic material, for example such as ethylene vinyl acetate and has an inside diameter between one-eighth and three-eights of an inch. These tubing lengths **20** and **21** are laid out on the area of ground **10** in elongated parallel loops L to form the lower grid G-1 which overlays the entire area where the rink is to be installed. As illustrated in FIGS. **2** and **4,** the parallel lengths of tubing **20** and **21** are shown advantageously grouped in pairs **18.** A convenient way to manufacture the pairs **18** of tubing lengths **20** and **21** is to coextrude the tubing **20** and **21** side-by-side to form a figure eight pattern as seen in cross section. One single tubing length **20** in each pair **18** has one end connected to a nipple **16** on the supply header pipe **12** and its other end connected to a nipple **16** on the return header pipe **14.** The other tubing length **21** in each pair **18** is reverse flow connected to the supply and return header pipes so that flow through the pairs **18** of tubes **20** and **21** occurs in opposite directions, i.e. counterflow is provided.

A protective layer of material such as sand **22** (FIG. **4**) approximately one-half inch thick is packed around the pairs of tubing **20** and **21,** and where this protective material surrounds the supply and return header pipes **12** and **14,** it is packed to a height greater than the diameter of these pipes. This protective material **22** serves to distribute the weight of the remaining components of the system to be later installed and to thus protect the tubes **20** and **21** and pipes **12** and **14** from being crushed, pinched or otherwise damaged during installation and use. This sand **22** is leveled and may be tamped after it is packed around the first grid G-1 to form firm level surfaces on which the remaining components of the system can conveniently be installed. A trench **33** (FIG. **4**) is provided across the midrink region to receive the supply and return headers **12** and **14.**

The first return header **14** is connected through a line **23** (FIG. **7**) to a pump **24** which feeds the circulating antifreeze liquid through a temperature sensing unit **25** into a heat exchanger **27** and back through a line **29** into the return header **12** in the lower grid G-1. This pump **24** circulates through the flexible tubing lengths **20** and **21** of the lower grid G-1 an antifreeze liquid such as a mixture of ethylene glycol and water or methanol and water. In a manner to be described in detail below, this antifreeze liquid is heated to a temperature above the freezing temperature of water. Thus, when circulated through the tubing in the first grid G-1, it functions to prevent freezing of the moist ground **10** and any water trapped in this ground under the rink area **8.**

The reason for using antifreeze liquid in the lower grid G-1 is to prevent inadvertent freeze-up of the liquid in the tubing, for example if the circulating pump **24** should malfunction. It will be appreciated that if the liquid in the lower grid G-1 should happen to freeze, then it becomes necessary to stop freezing the ice slab and to allow the whole rink area to thaw out, a process usually taking several days, during which the whole rink is out of operation. Thus, freeze-up of the lower grid should be avoided in case of any eventuality. This freeze-up is avoided by using an antifreeze liquid in grid G-1 which is capable of withstanding the same cold temperature as the antifreeze liquid being circulated in an upper grid G-2 to freeze the ice. Thus, since the latter does not freeze, the former will not do so either.

A layer **26** of insulating material overlays the protective layer **22** of sand packed around the first flexible tubing grid G-1. A product manufactured by the Dow Chemical Company under the name "SM" waterproof styrofoam has been found satisfactory. This insulation layer may be constructed of panels **28** measuring 2 feet by 8 feet by 1 inch thick styrofoam laid side-by-side. It has been found that two thicknesses of such material forming an insulation layer at least 2 inches thick is satisfactory, but a thicker layer may be used if desired. The layer of insulating material **26** serves to retard the rate at which heat from the warm antifreeze liquid circulating through the flexible tubing grid G-1 is conducted upward to the very cold upper grid G-2.

As shown in FIG. **4,** the first supply and first return header pipes **12** and **14** are accommodated by a channel or trench **33** in the ground or sub-floor **10.** A cover layer of insulation material **30** spans across the headers **12** and **14** and extends the length of this channel **33** in the area where the ice slab is to be formed. Additionally, this channel may accommodate the second supply and return header pipes **34** and **36** to be described in greater detail below.

A waterproof liner **32** for the ice slab, which may be a plastic sheet, for example a polyethylene sheet or a film having a thickness of at least 0.004 of an inch, overlays the layer **26** of insulation material. This liner acts as a barrier for water and water vapor and as a sand barrier and serves to confine the overlying fresh water which will be frozen into the ice slab.

Second supply and second return header pipes **34** and **36** are laid in spaced parallel side-by-side relation

in the accommodating channel **33.** These second supply and return header pipes also extend across the area where the ice slab is to be formed. As shown in FIG. **4,** the insulation may have a step-like configuration near the headers **34** and **36.** An inwardly projecting portion **37** of the lowest thickness of insulation material **28** provides a shelf for supporting the return header pipe **36** with its axis at about the same level as the axis of the supply header **34.** The second return header pipe **36** rests on the waterproof liner **32** which covers this insulation panel shelf **37.** The second supply header **34** is provided with an insulating sheath **38** for example provided by pipe insulation one-half an inch thick, since it conveys very cold antifreeze liquid and is underlain by no layers of insulation panel. Alternatively, this second supply header pipe may be positioned in the same fashion, over a single layer of insulation material, as is the second return header pipe. The second supply and return headers have a series of short tubing attachment nipples **40** similar to the nipples **16** provided on the first supply and return header pipes. However, these attachment nipples **40** are spaced much more closely together than those on the first headers **12** and **14.**

A second protective layer **42,** for example, of sand, or wood pulp, extending approximately 2 to 3 inches above the headers **34** and **36** is spread on the waterproof liner **32** and is packed under, around and above these headers **34** and **36.** The protective layer **42** if formed of wood pulp may be quite thin on the regions of the waterproof liner **32** located away from the headers **34** and **36.** For example, the wood pulp, which contains numerous fibers, may be approximately one-eighth of an inch thick above the grid G-**2.** This wood pulp effectively expands 3 or 4 times when wet, and upon freezing the interlocked multiple frozen fibers provide a rigid structurally strong layer beneath the ice to support ice stresses such as caused by heavy ice surfacing machines, thereby to prevent the ice from cracking due to localized compression or deflection of the insulation layers **28** beneath the ice when such heavy machines are present on the ice. This structurally strong layer also protects the tubing grid G-**2** against damage or puncture.

The headers **34** and **36** are initially formed in short sections **34-1, 34-2, 34-3,** etc., and **36-1, 36-2, 36-3,** etc., each section being of equal length. These header sections are adapted to be joined together by coupling sleeves **39** to form the header pipes. The pair of short header sections **34-1** and **36-1** together with their associated lengths of small diameter flexible tubing **45** and **46** as will be described, form a flexible mat N-**1** adapted to be prefabricated at a manufacturing site and rolled up to be conveniently delivered to the rink site for installation. Similarly, the next pair of short header sections **34-2** and **36-2** together with their associated lengths of small diameter flexible tubing **45** and **46** form another flexible mat N-**2** which can be prefabricated, rolled up and delivered to the rink site for installation, and so forth with the other mats N-**3,** N-**4,** etc.

During installation these mats N-**1,** N-**2,** N-**3,** N-**4** are unrolled and placed side-by-side with their tubing lengths in parallel relationship and with the respective header sections **34-1, 36-1** aligned with the next successive header sections **34-2, 36-2,** which in turn are aligned with the next header sections **34-3, 36-3** and so forth. Thus, the header sections can be joined together by the couplings **39** to form the completed header pipes **34** and **36.**

The small diameter flexible tubing **45** and **46** is formed of plastic material, for example such as ethylene vinyl acetate, and has an inside diameter between one-eighth and three-eighths of an inch. These tubing lengths **45** and **46** are laid out on the protective layer **42** in elongated parallel loops L**2** to form the upper grid G-**2** which overlays the entire area where the rink is to be installed. As illustrated in FIG. **2,** the parallel lengths of tubing **45** and **46** are shown advantageously grouped in pairs **44.** A convenient way to manufacture these pairs **44** is to coextrude the tubing **45** and **46** side-by-side to form a figure eight pattern as seen in cross section.

One single tubing length **45** in each pair **44** has one end connected to a nipple **40** on the supply header **34,** and its other end is connected to a nipple **40** on the return header **36.** The other tubing length **46** in each pair **44** is reverse flow connected to the supply and return header pipes so that flow through the tubing pairs **45** and **46** occurs in opposite directions, i.e. counterflow is provided.

A final protective layer forming an upward extension of the layer **42,** for example of sand, from one-quarter to 1 inch thick is packed around and over the upper grid G-**2** of flexible tubing. This final protective layer serves to protect the second grid G-**2** during installation and during use by ice skaters, or skiers, etc. For example, should the ice slab inadvertently be penetrated by the blade of an ice skate or a bobsled runner, it will not likely puncture, tear, cut, or otherwise damage the tubing since the sand retards the thrust of the intruding blade.

Fresh water is pumped over the protective layer **42** and is confined above the waterproof liner **32.** This water should be added in sufficient quantity to saturate the sand or other protective material **42** confined above the waterproof liner **32** and to form a layer of water approximately one and one-half to two inches thick, to form ice slab **54.**

As shown in FIG. **7,** the second return header **36** is connected by a line **48** to a pump **49** which feeds the antifreeze liquid through an evaporator unit **50** which in turn is connected by a line **51** to the second supply header **34,** thus forming a closed, antifreeze liquid conducting system for circulating the cold liquid through the upper grid G-**2.** Low temperature antifreeze liquid, which may also be a mixture of ethylene glycol and water or methanol and water is circulated through the second supply and return headers and through the second flexible grid G-**2** by this pump **49.** As will be described in greater detail below, this low temperature antifreeze liquid is chilled by the refrigeration system **52** to a temperature well below the freezing temperature of water and functions to freeze the water confined by the waterproof liner **32** into an ice slab **54.**

As shown in FIG. **2,** the flexible tubing loops L**2,** which form the second grid G-**2** are spaced closely together. It has been found that a spacing of 1½ inches between each pair **44** works to advantage. This close spacing provides substantially uniform freezing effect for the ice slab. Additionally, the arrangement of the flexible tubing lengths **45** and **46** in pairs **44** which conduct low temperature antifreeze liquid in opposite directions contributes to the uniformity of this freezing effect since temperature variations in the antifreeze liq-

uid are averaged as it passes through the tubing pairs.

As shown in FIG. 2, the flexible tubing loops L1, which form the lower flexible tubing grid G-1, are spaced a substantially greater distance apart. When this anti-heaving grid G-1 is installed on an area of ground, it has been found that twelve-inch spacings for the lengths of tube pairs is satisfactory. This spacing provides an adequate warming effect to prevent freezing of the moist ground and water trapped beneath the installation. However, in some installations including those where the system for creating and maintaining an ice slab is positioned over a basement or other room in a building, the subfloor temperature sometimes must be maintained at 60°F or above. In such a case, more heat is needed to meet the 60°F specification and closer spacings of the parallel tubing pairs 18, for example a spacing of 6 inches has been found satisfactory. Also, more insulation may be used in the layer 26. This arrangement whereby warm antifreeze liquid flows in opposite directions in adjacent tubes in each tube pair provides substantially uniform warming of the installation sub-floor.

The layer of insulation material 26, which functions to retard conduction of heat up to the ice slab, may be considered as also functioning to insulate the subrink ground 10 from the low temperatures of the upper freezing grid G-2.

To assure uniform freezing of the ice slab over the trench 33, a tubing mat M' (FIG. 4) 4 feet wide, containing tubing pairs 44', may be laid with its length extending parallel with the length of the headers 34 and 36. The tubing mat M' may have its header (not shown) located at one end of the mat M', i.e., at the side of the rink near the supply and return lines 51 and 48 (FIG. 7) for convenient connection thereto.

In order to hold the tubing pairs 18 positioned in the described parallel spaced relationship in the respective heating mats M-1, M-2, M-3, M-4, etc., there are spacer strips 41 of heat sealable plastic material extending transversely to the tubing pairs 18 in each mat. These spacer strips are positioned in pairs above and below the tubing pairs 18 and are heat sealed together at spots 43 on opposite sides of each tubing pair 18 for holding the tubing pairs. Thus, the tubing pairs 18 are free to slide longitudinally for self-adjustment with respect to the spacer strips 41 as may be desirable when the tubing mats M-1, M-2, etc. are being laid around curves as may occur for a ski trail or bobsled or tobaggon run. These spacer strips 41 may be located approximately every eight feet along the heating mats M-1, M-2, etc. Only one spacer strip 41 is shown on each side of the headers 12 and 14 for convenience of illustration.

Similarly, the tubing pairs 44 are held positioned in the desired parallel spaced relationship in the respective freezing mats N-1, N-2, N-3, N-4, etc. by spacer strips 55 formed by pairs of strips of heat sealable plastic material located above and below the tubing pairs 44. The strips 55 are heat sealed together at spots 59 (See also FIG. 5). Thus, again the tubing pairs 44 are free to slide longitudinally for self adjustment for reasons similar to those discussed above. The spacer strips 55 may be located approximately every 2 feet along the freezing mats N-1, N-2, N-3, N-4, etc. Only one spacer strip is shown on each side of the headers 34 and 36 for convenience of illustration.

Referring again to FIG. 7, the system of the preferred embodiment of the present invention for creating and maintaining an ice slab and for preventing ground heaving damage or subfloor damage includes a refrigeration system 52 which includes the evaporator or chiller 50, a compressor 56 driven by a motor 57, and a condenser 58. The evaporator 50, compressor 56, and condenser 58 are serially connected in a closed system by conduits 60 in which a refrigerant such as freon is circulated. This refrigerant evaporates, changing from a liquid to a gaseous state, in the evaporator 50. During this evaporation process, heat is extracted from the antifreeze liquid being circulated by the pump 49 through the lines 48 and 51 so as to cool this liquid to a temperature preferably of no more than 10°F or below. There is a conduit 53 which passes through the evaporator unit. This conduit 53 may be in the form of a heat exchange coil within the evaporator, and it interconnects with lines 48 and 51.

From the evaporator, the refrigerant passes into the compressor 56 where it is compressed and forced into the condenser 58. There the refrigerant is condensed, changing from a compressed gaseous state into a liquid state, yielding its heat energy to another fluid heat conveyor in the condenser as will be described.

There are means for removing heat energy from the refrigeration system 52 which in turn was extracted from the low temperature antifreeze liquid in the evaporator 50. This means includes a suitable passage 64 formed by a conduit or coil mounted in the condenser for carrying a fluid heat conveyor such as water through the condenser. Heat energy is transferred in the condenser 58 to the water, passing through the passage 64, so that this water becomes heated. A pump 66 is provided to drive this heated water out through the outlet connection 65 from the passage 64 and through a line 69 to means 70 for rejecting the heat which may be associated with a blower 71. This heat rejector 70 may be a cooling tower. Advantageously, this means 70 for rejecting the heat may comprise a series of room air heaters for heating the air and room above the ice rink so as to keep the skaters comfortable. In this room heating arrangement the blower 71 passes room air over coils in the heater 700 to warm the room. Thus, heat energy which is being extracted from the ice slab is being transferred into the room above the ice slab, which transfer process acts to conserve energy utilization in the over-all method and system as compared with using an oil burner furnace to heat the room air above the ice. The heated water transfers its heat energy into the atmosphere in the heat rejector 70 or alternatively usefully transfers heat energy into room air. Then the water is returned through a line 72 to be collected in a sump 74 for eventual recirculation by the pump 66 into the condenser 58. A shut-off valve 75 may be provided in the line 60 between the condenser 58 and the evaporator 50 for use when the refrigeration system is shut down.

An advantageous method of providing heat energy for the anti-heaving grid G-1 is provided. Additionally, this method is efficient and conserves energy. A heated water line 76 (FIG. 7) is connected to the outlet connection 65 from the water heating passage 64 in the condenser. This line 76 is extended to a control valve 77 and thence into the heat exchanger unit 27. A return water line 78 is connected from the heat exchanger 27 into the sump 74. Thus, when the control valve 77 is

fully open, much of the water which was heated in its passage **64** through the condenser **58** is circulated by pump **66** via lines **76** and **78** through the heat exchanger **27** and back into the sump **74.** Some of the water which was heated in the condenser **58** is still circulated by pump **66** via lines **69** and **72** up through the heat rejector **70** and then back into the sump **74.**

The purpose of the control valve **77** is to regulate the relative amount of the heated water being circulated through the heat exchanger **27.** In order to provide this control function, the temperature of the antifreeze liquid returning through the line **23** from the anti-heaving grid G-**1** is sensed by the sensor unit **25,** for example a bimetallic thermostat, which operates a control switch associated with a valve operator **80.** The pump **24** is operated continuously in this control method. Thus, when the temperature of the antifreeze liquid returning through the line **23** drops below a predetermined temperature, depending upon the installation, for example in the range from 36°F to 56°F, the valve **77** is opened. Conversely, when the temperature of this returning liquid rises above a predetermined limit, for example in the range from 40°F to 60°F, then the valve **77** is closed by the control **80.**

The system of the present invention may be provided with other automatic controls. Such a control may include a thermostat located under the insulation layer **26** near the first flexible tubing grid G-**1.** Such a thermostat may operate the automatic control **80** and valve **77** in a manner similar to the sensor **25,** to open the valve **77** when the temperature in the ground **10** or subfloor drops below a predetermined temperature, for example in the range from 35°F to 55°F, and turns this valve off when the temperature in the ground or subfloor rises above a predetermined temperature, for example in the range from 38°F to 58°F, depending upon the installation.

An alternate control method is to use the thermostat sensor to turn the pump **24** on and off. For example, the pump **24** may be turned on at 35 °F to 55°F and turned off at 38°F to 58°F, depending upon the installation.

To control the freezing temperature of the grid G-**2** for the ice slab, a sensor unit **81,** for example a bimetal thermostat unit, senses the temperature of the returning antifreeze liquid in the line **48** and actuates a control circuit **89** including a relay which controls the operation of the compressor motor **57.**

In order to supply and fill the grid systems G-**1** and G-**2** with antifreeze liquid a central supply tank **82** (FIG. 7) is provided having a vent pipe **83** and a fill port **84.** A supply line **90** extends from the tank **82** to a riser **86** leading into the line **48.** There is a valve **87** and a hose bib **88** associated with the line **48,** these being located on opposite sides of the point where the return header **36** is connected to the line **48.** Similarly, a supply line **85** extends from the tank **82** to a riser **92'** leading into the line **23.** Another valve **87** and a hose bib **88** are associated with the line **23.** The valve **87** is on one side of the point where the return header **14** joins the line **23,** and the hose bib is on the other side.

When filling the grid systems G-**1** and G-**2** it is desirable to remove all air bubbles. In order to fill these grid systems and remove bubbles, a pair of hoses **91** and **92** are temporarily connected from both hose bibs **88** back to the tank fill port **84.** Both of the valves **87** are closed off while the hose bib valves **88** are opened. The pumps **24** and **49** are placed in continuous operation.

The pumps **24** and **49** plus gravitational flow cause antifreeze liquid **93** to be drawn from the tank **82** through the supply lines **85** and **90** and through the lines **23** and **48** respectively into the tubing in grids G-**1** and G-**2.** The antifreeze liquid circulates back through the hoses **91** and **92** into the tank, because the shut valves **87** prevent the antifreeze liquid from returning directly from the grids G-**1** and G-**2** into the lines **23** and **48.**

As the liquid continues to circulate, any air bubbles are driven through the hoses **91** and **92** into the tank **82** whence they escape. By using transparent plastic hoses **91** and **92** the operator can observe the returning bubbles and can determine when substantially all of the air bubbles have been purged from the grids G-**1** and G-**2.** Then the hose bibs **88** are shut off, the hoses **91** and **92** are removed, and the valves **87** are opened to place the system in normal operation.

The tank **82** need not be so large as to contain the full quantity of antifreeze liquid required to fill the two grids. During the initial fill cycle, additional quantities of antifreeze liquid can be dumped from time-to-time into the tank **82** as the pumps **24** and **49** are withdrawing liquid through the supply pipes **85** and **90.** The tank **82** also serves to mix the ethylene glycol or methyl alcohol with water. For example, a mixture which can be used to advantage is **8** parts of ethylene glycol by volume to **12** parts of water.

It is noted that the tank **82** remains connected through the respective lines **85** and **90** to the grids G-**1** and G-**2.** Accordingly, this tank serves as an expansion tank and as venting means to assure that the grids remain full, while accommodating expansion and contraction of the total volume of liquid due to temperature changes.

The risers **86** and **92'** extend vertically from the lines **23** and **48** in front of the pumps **24** and **49.** These risers **92'** and **86** serve to catch and remove any straggler air bubbles which may approach the pumps **24** and **49** during normal operation. The air bubbles float up through these risers **92'** and **86** and find their way up through lines **85** and **90** into the tank **82** and escape through the vent.

FIG. **6** shows another embodiment of the warming mats M-**1,** M-**2,** M-**3,** etc. and the freezing mats N-**1,** N-**2,** N-**3,** etc. The tubing lengths **20** and **21** of the respective tubing pairs **18** have their free ends interconnected by small U-shaped bends **94** producing very narrow circuit loops with counter-current flow in the adjacent tubing lengths **20** and **21** of each pair **18.** The spacer strips **41** are heat sealed at spots **43** to hold the tubing pairs **18** in substantially uniformly spaced relationship similar to the action of the spacer strips **41** in FIG. **2.**

Similarly, in the freezing mats N-**1,** N-**2,** etc., the free ends of the tubing lengths **45, 46** in each tubing pair are interconnected by small U-shaped bends **95** providing narrow circuit loops with countercurrent flow in the adjacent tubing lengths **45, 46** of each pair **44.** The spacer strips **55** are heat sealed at the spots **59** to hold the tubing pairs **44** with substantially uniform spacing.

The countercurrent flow in the adjacent tubing lengths **20, 21** of each pair **18** or **45, 46** of each pair **44** averages out the warming effect or the freezing effect, respectively, throughout the grids G-**1** and G-**2** in FIG.

6, and thus throughout the area where these grids are located.

The grid layout shown in FIG. 6 in which the narrow circuit loops are provided with small U-shaped bends 94 and 95 at the ends of the tubing pairs 18 and 44 is my presently preferred arrangement because it is somewhat easier to handle during installation. Thus, this preferred grid layout is shown in FIG. 7. If desired, the header pipes 12, 14, 34 and 36 may be located at the ends of the respective mats in each grid, in which case these headers are located in a trench extending across one end or along one side of the rink area. Also, subheaders may be used in conjunction with each individual mat. Such subheaders may be constructed as shown in my prior Pat. No. 3,751,935.

As shown in FIG. 3, in a permanent rink system the ice slab 54 may be surrounded by dasher boards 96 mounted on a railing 97 with a framework 98 held by multiple steel posts 100 embedded in concrete footings 102. Access doors 99 are provided at convenient locations in the railing 97. A concrete sidewalk 104 bordering the rink area 8 may be cast in conjunction with the footings 102. A skirt 106 (FIG. 3) of the waterproof liner is shown brought up against the lower edge of the dasherboards 96 to prevent leakage of the water.

The header pipes 12 and 14 for the lower grid G-1 may have a diameter in the range from 1.25 to 4 inches, and a diameter of approximately 2 inches is advantageous for conventional size ice skating rinks with a grid layout as shown. The header pipes 34 and 36 for the upper grid may have a diameter in the range from 2 to 6 inches, and a diameter of approximately 4 inches is advantageous for skating rinks of conventional size with a grid layout as shown. These header pipes 12, 14, 34, and 36 may be made of plastic material such as polyvinyl chloride or may be made of metal. The warming mats M-1, M-2, M-3, M-4, etc. and the freezing mats N-1, N-2, N-3, N-4, etc. and the additional freezing mat N′ over the trench all may have a width of four feet which is suitable for handling and laying out during installation. The tubing pairs 18 for the warming grid may have a spacing in the range from 4 inches to 16 inches. In a multi-story building installation a spacing of 6 inches is usually advantageous for maintaining the desired subfloor temperature of approximately 60°F. If a higher subfloor temperature is desired, then the tubing pairs 18 may be placed closer together and also a higher temperature of the warming antifreeze liquid in grid G-1 may be used. The tubing pairs 44 for the freezing grid may have a spacing in the range from 1 to 3 inches. The tubing lengths 20, 21 and 45, 46 have an internal diameter in the range from one-eighth to three-eighths of an inch and have a wall thickness of about one-thirty-second of an inch.

The system of the present invention is an integrated arrangement for creating and maintaining an ice slab, and for preventing heaving damage caused by freezing and subsequent expansion of moist ground and water under the ice slab. It provides several advantages. Heat extracted from low temperature antifreeze liquid used to freeze the ice slab, is subsequently used to warm the antifreeze liquid which prevents freezing and expansion of the moist ground and water under the ice slab. The heat extracted from the low temperature antifreeze liquid is not merely dissipated and wasted but is put to use. Further, the construction of the illustrative embodiment of the present invention, placing the first and second supply and return header pipes in side-by-side relation over the area where the ice slab is formed saves considerable material costs. Such an arrangement eliminates the need for peripheral header pipes stretching the entire length or the entire width of the ice slab. However, it is to be understood that if desired the header pipes 12, 14, 34 and 36 can be positioned in a peripheral location with respect to the rink area 8, in which event the headers are located along the ends of the respective mats M-1, M-2, M-3, M-4, etc. and N-1, N-2, N-3, N-4, etc. Regardless of the specific layout employed, the method and system of the present invention provide an inexpensive, efficient way for creating and maintaining an ice slab and for preventing heaving damage to the ice slab.

Although specific embodiments of the present invention have been disclosed in detail above, it is to be understood that these are only for purposes of illustration. This disclosure of a method and system for creating and maintaining an ice slab and for preventing heaving damage to that ice slab should not be construed as limiting the scope of the invention, since modifications may be made to the described method and structure by those skilled in the art in order to adapt this invention to particular applications, without departing from the scope of the invention as defined by the following claims.

I claim:

1. The method for preventing the penetration of undue cold into the region beneath an ice slab which is to be maintained by refrigerating and pumping cold antifreeze liquid through tubing located for freezing the ice slab comprising the steps of:

positioning a multiplicity of small diameter coextruded flexible tubing pairs in spaced parallel relationship forming a grid in which each flexible tubing pair includes two lengths of tubing in the region beneath the freezing tubing and ice slab into which the penetration of undue cold is to be prevented,

placing a layer of insulation above said flexible tubing pairs and beneath said freezing tubing and ice slab,

warming antifreeze liquid to a temperature above the freezing temperature of water, and

circulating said warm antifreeze liquid through said multiple flexible tubing pairs beneath the insulation layer, said warm antifreeze liquid flowing in opposite directions through the respective lengths of tubing in each tubing pair for providing a uniform warm temperature in said region beneath the insulation layer in which said grid is located, thereby to prevent the penetration of undue cold into said region.

2. The method for preventing the penetration of undue cold into the region beneath an ice slab as claimed in claim 1, in which:

said small diameter co-extruded flexible tubing pairs each include two lengths of tubing having an inside diameter in the range from one-eighth to three-eighths of an inch.

3. The method for preventing the penetration of undue cold into the region beneath an ice slab as claimed in claim 2, in which:

said tubing pairs are in spaced parallel relationship and are spaced apart in the range from 4 to 16 inches.

4. The method for preventing the penetration of undue cold into the region beneath an ice slab which

is to be maintained by refrigerating and pumping cold antifreeze liquid through tubing located for freezing the ice slab comprising the steps of:

placing a grid of small diameter flexible tubing beneath the tubing and ice slab in the region into which the penetration of undue cold is to be prevented,

placing a layer of insulation material above said flexible tubing and beneath said ice slab and freezing tubing,

removing heat energy from the cold antifreeze liquid,

using some of the heat energy removed from the cold antifreeze liquid for warming some antifreeze liquid to a temperature above the freezing temperature of water, and

circulating said warm antifreeze liquid through said grid of flexible tubing beneath the insulation material for preventing the penetration of undue cold into said region.

5. The method for preventing the penetration of undue cold into the region beneath an ice slab as claimed in claim 4, including the steps of:

using some of the heat energy removed from the cold antifreeze liquid for heating some water to a room heating temperature,

circulating said heated water through room heaters for heating the space above the ice slab to a comfortable temperature for skaters.

6. The method of creating and maintaining an ice slab such as for a skating rink, ice chute or the like and for preventing heaving damage caused by freezing and expansion of ground moisture under the ice slab, said method comprising the steps of:

providing an area of ground,

overlaying said area of ground with a first grid of parallel lengths of flexible tubing and providing first supply and return header pipes for said first grid,

overlaying said first grid with a layer of insulation material,

overlaying said insulation material with a waterproof liner,

overlaying said waterproof liner with a second grid of parallel lengths of flexible tubing and providing second supply and return header pipes for said second grid,

putting water over said waterproof liner to be frozen into an ice slab,

circulating antifreeze liquid through said second header pipes and said second grid,

refrigerating said antifreeze liquid to a temperature below the freezing temperature of water by extracting heat energy from this antifreeze liquid for freezing the water in said ice slab,

circulating antifreeze liquid through said first header pipes and said first grid,

warming said latter antifreeze liquid to a temperature above the freezing temperature of water to prevent freezing and expansion of ground moisture under said ice slab thereby to prevent heaving damage.

7. The method of creating and maintaining an ice slab such as for a skating rink, an ice chute or the like and for preventing heaving damage caused by freezing and expansion of ground moisture under the ice slab, as claimed in claim 6, including the step of:

using some of the heat energy extracted from the freezing antifreeze liquid for warming the latter antifreeze liquid to a temperature above the freezing temperature of water.

8. The method of creating and maintaining an ice slab such as for a skating rink, ice chute, or the like and for preventing heaving damage caused by freezing and expansion of ground moisture under the ice slab as claimed in claim 6, including the steps of:

providing a trench extending across said area of ground,

positioning said first and second supply and return header pipes in said trench, and

placing insulation material in said trench between said first supply and return header pipes and said second supply and return header pipes.

9. A system for creating and maintaining an ice slab for use as a skating rink, ice chute, or the like and for preventing damage caused by penetration of undue cold into the region under the ice slab, said system comprising:

a first grid of flexible tubing positioned in the region beneath the area where said ice slab is to be formed, for conducting antifreeze liquid therethrough,

insulation material overlaying said first grid of flexible tubing,

a waterproof liner overlaying said insulating material for holding water,

a second grid of flexible tubing, overlaying said liner for conducting antifreeze liquid therethrough,

first pump means for circulating antifreeze liquid through said first grid,

second pump for circulating second antifreeze liquid through said second grid,

a refrigeration system for extracting heat from the antifreeze liquid circulated through said second grid to cool it below the freezing temperature of water,

said refrigeration system including a refrigerant condenser for rejecting the heat extracted by said system, and

heat exchange means for using the heat energy extracted from the second antifreeze liquid by said refrigeration system to heat the first antifreeze liquid circulated through said first grid to a temperature above the freezing temperature of water,

whereby the antifreeze liquid circulated in said first grid at a temperature above the freezing temperature of water prevents undue penetration of cold into the region under the ice slab.

10. The system for creating and maintaining an ice slab for use as a skating rink, ice chute, or the like and for preventing damage caused by penetration of undue cold into the region under the ice slab, as claimed in claim 9, in which:

said heat exchange means includes a refrigerant condenser in said refrigeration system wherein heat energy is rejected that was extracted from said second antifreeze liquid,

a heat exchanger through which is circulated the antifreeze liquid to be heated, and

means for transferring heat energy from said refrigerant condenser to said heat exchanger.

11. The system for creating and maintaining an ice slab for use as a skating rink, ice chute, or the like and for preventing damage caused by penetration of undue cold into the region under the ice slab, as claimed in claim 10, in which:

said means for transferring heat energy from said refrigerant condenser to said heat exchanger includes a sump for holding water, a circuit for conducting water from said sump through said refrigerant condenser and through said heat exchanger back to said sump, and pump means for circulating the water through said circuit.

12. The system for creating and maintaining an ice slab for use as a skating rink, ice chute, or the like and for preventing damage caused by penetration of undue cold into the region under the ice slab, as claimed in claim **11**, in which:

said circuit for conducting water includes room heating means for heating an indoor region above the ice slab for keeping the users comfortable, and means for selectively controlling the flow of water through said heat exchanger.

13. The system for creating and maintaining an ice slab for use as a skating rink, ice chute, or the like and for preventing damage caused by penetration of undue cold into the region under the ice slab as claimed in claim **9** wherein said system further comprises:

a first layer of protective material packed about said first grid of flexible tubing below said insulating material.

14. The system for creating and maintaining an ice slab for use as a skating rink, ice chute or the like and for preventing damage caused by penetration of undue cold into the region under the ice slab as claimed in claim **9**, in which:

said first grid of flexible tubing comprises a multiplicity of small diameter co-extruded pairs of tubing lengths, and

said pairs of tubing lengths are positioned in spaced parallel relationship and are interconnected to produce flow of the warm antifreeze liquid in opposite directions through the respective tubing lengths in each pair for producing a uniform warming effect in the region in which said first grid is located.

15. The system for creating and maintaining an ice slab for use as a skating rink, ice chute or the like and for preventing damage caused by penetration of undue cold into the region under the ice slab as claimed in claim **14**, in which:

said tubing lengths each have an internal diameter of one-eighth to three-eighths of an inch and said tubing pairs are spaced apart by an amount in the range from 4 inches to 16 inches.

16. The system for creating and maintaining an ice slab for use as a skating rink, ice chute, or the like and for preventing damage caused by penetration of undue cold into the region under the ice slab as claimed in claim **9**, in which:

a trench is provided extending across the region beneath the area where the ice slab is to be formed,

first supply and return header pipes are positioned in said trench and are connected to said first grid for circulating warm antifreeze liquid through the first grid,

second supply and return header pipes are positioned in said trench and are connected to said second grid for circulating cooled antifreeze liquid through said second grid; and

insulation material is provided in the trench between said first supply and return header pipes and said second supply and return header pipes.

17. A system for creating and maintaining an ice slab for use as a skating rink, ice chute, or the like and for preventing damage caused by penetration of undue cold into the region under the ice slab, said system comprising:

first supply and first return header means,

a first grid of parallel lengths of flexible tubing overlaying the area of ground where said ice slab is to be formed, one end of each length of said tubing being connected to said first supply header means, the other end of each length of said tubing being connected to first return header means, said first supply and return header means and said first grid being adapted to circulate antifreeze liquid therethrough,

insulating means overlaying said first grid,

waterproof liner means overlaying said insulating means for holding water,

second supply and second return header means,

a second grid of parallel lengths of flexible tubing overlaying said waterproof liner means, one end of each length of said tubing being connected to said second supply header means, the other end of each length of said tubing being connected to said second return header means, said second supply and return header means and said second grid being adapted to circulate antifreeze liquid therethrough,

first pump means for circulating antifreeze liquid through said first supply header means, said first grid, and said return header means,

second pump means for circulating antifreeze liquid through said second supply header means, said second grid, and said return header means,

refrigeration means for extracting heat from the antifreeze liquid circulated by said second pump means to cool it below the freezing temperature of water, and

heat exchange means associated with said refrigeration means for heating the antifreeze liquid being circulated by said first pump means to a temperature above the freezing temperature of water with heat extracted from the antifreeze liquid being circulated by second pump means,

whereby the antifreeze liquid circulated by said first pump means above the freezing temperature of water, prevents penetration of undue cold into the region under the ice slab, and the antifreeze liquid circulated by said second pump means below the freezing temperature of water freezes water above said liner means into said ice slab.

18. The system for creating and maintaining an ice slab for use as a skating rink, ice chute, or the like and for preventing penetration of undue cold into the region under the ice slab as claimed in claim **17** wherein said first and second supply and return header means are laid in spaced side-by-side relation in a trench extending across substantially on the centerline beneath said ice slab and insulation means are positioned between the first supply and return header means and the second supply and return header means.

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