

[54] **CONCATENATED JACKET REFRIGERATION SYSTEM FOR OIL AND GAS**

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[51] Int. Cl. **E21b 43/24**

[58] Field of Search 61/36 A; 166/DIG. 1, 166/57, 302; 165/104-106, 45; 62/260

[56] **References Cited**

UNITED STATES PATENTS

3,662,832	5/1972	Keeler et al.	166/DIG. 1 X
3,685,583	8/1972	Phares	166/57 X
3,703,929	11/1972	Rardin	166/57 X

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[57] **ABSTRACT**

Heat transfer system for obtaining essentially constant temperature control over a long vertical heat transfer surface which includes a series of shallow depth, open-topped jacket segments on the inside diameter of an intermediate refrigeration casing between an inner casing and an outer casing. The jackets are filled with liquid refrigerant and are provided with overflow pipes so that refrigerant liquid can flow down through the entire series of jackets and keep each one full. Each of the jackets communicates with a common vapor space or annulus. As heat is absorbed the liquid boils and vaporizes and passes into and upwardly through the vapor annulus. By maintaining an essentially constant pressure in the vapor space an essentially constant boiling temperature is maintained in each segment and thus the heat transfer surface to which the jacket segments are fastened is also maintained at that constant temperature. The vapor is condensed at the well head and returned to the system as liquid.

10 Claims, 3 Drawing Figures

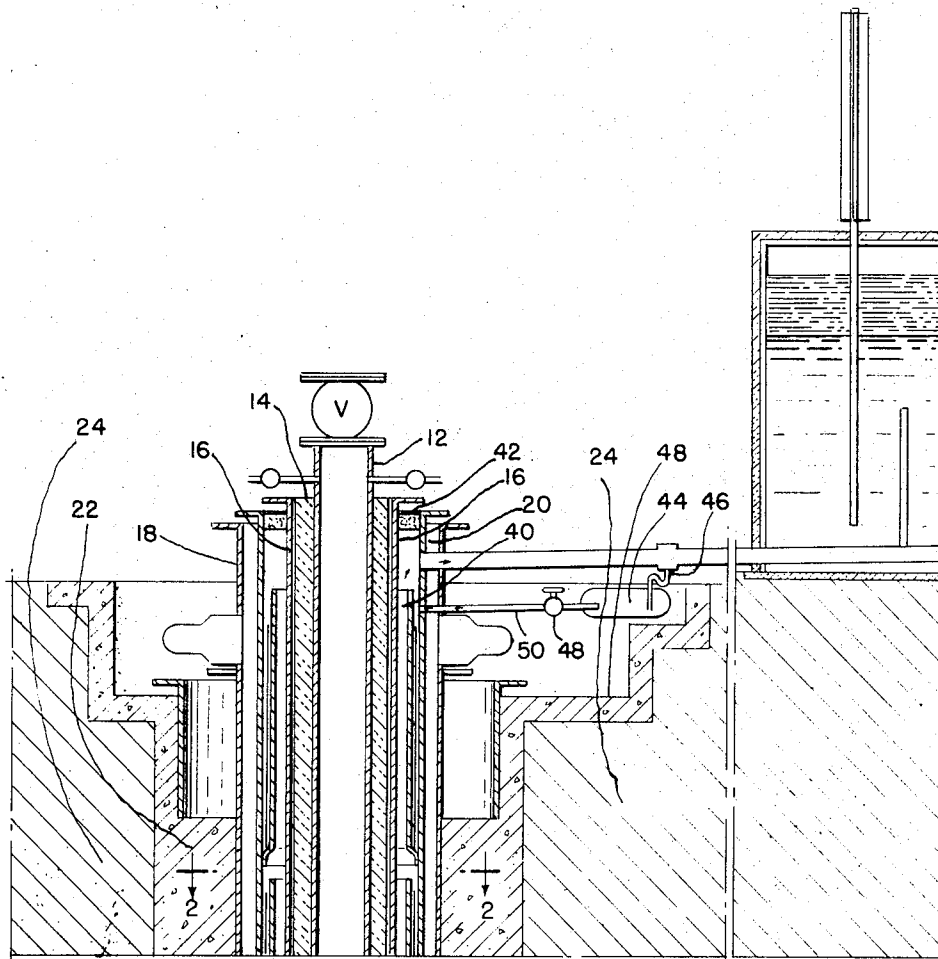


FIG. 1

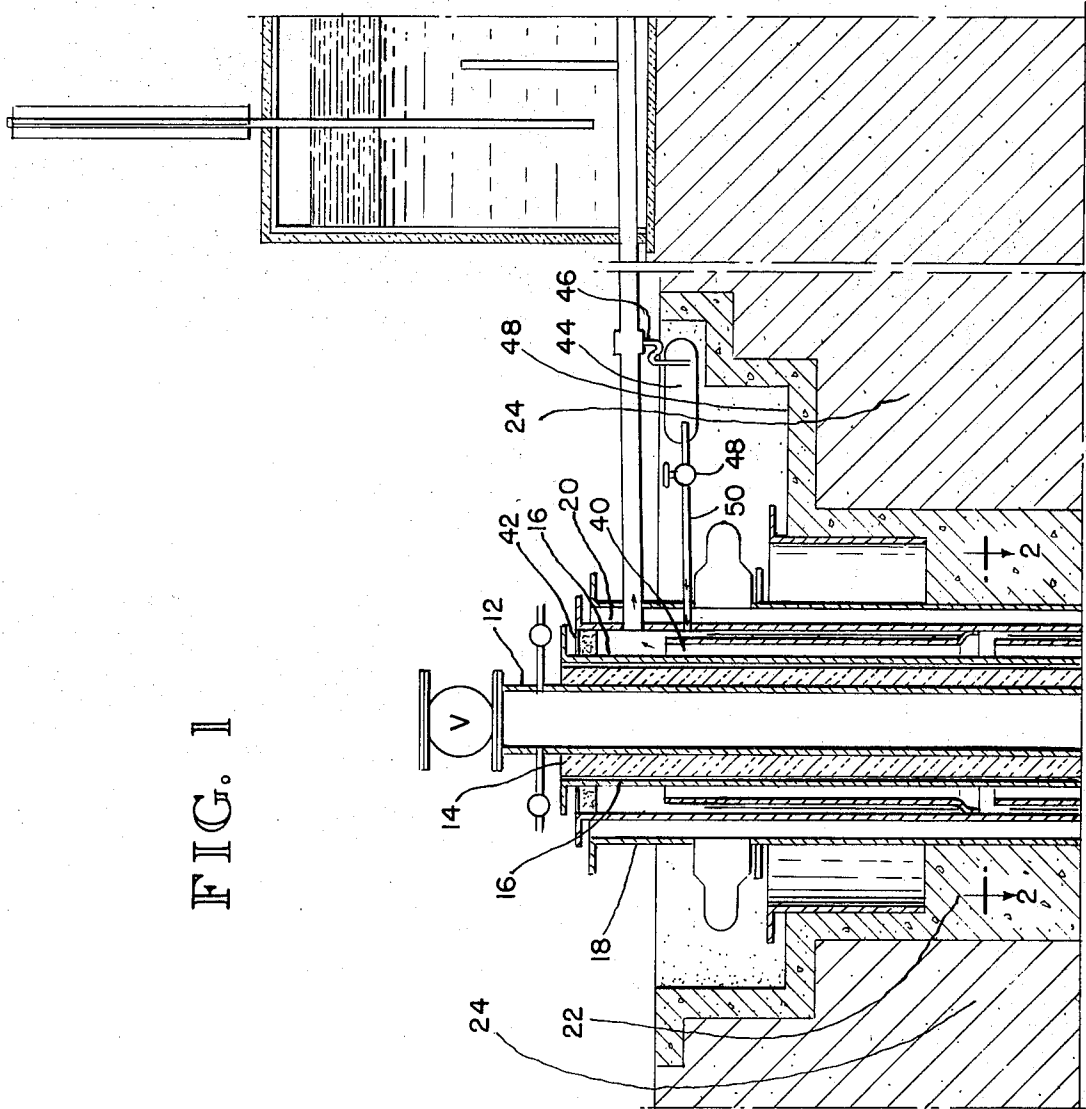
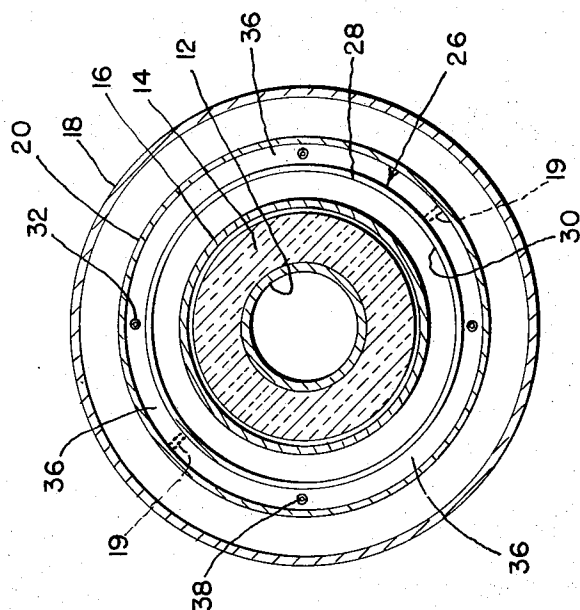
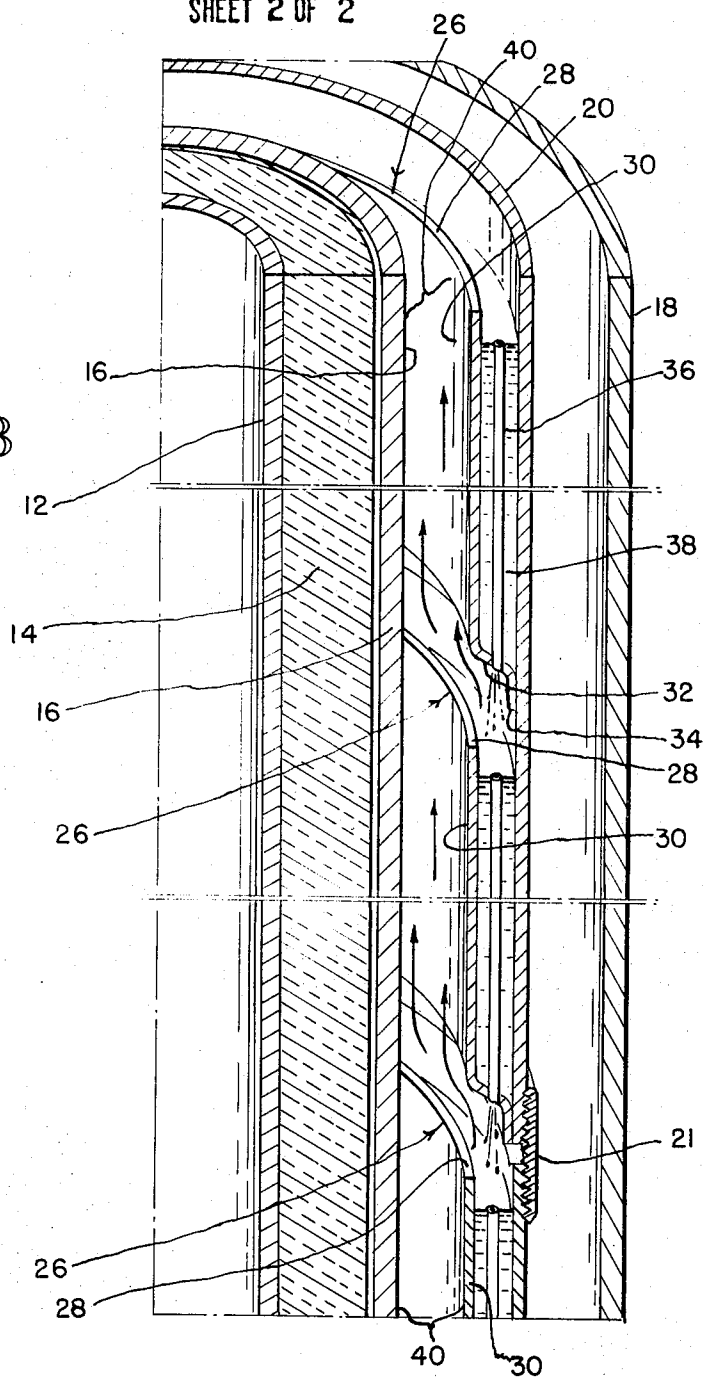


FIG. 2



SHEET 2 OF 2

FIG. 3



CONCATENATED JACKET REFRIGERATION SYSTEM FOR OIL AND GAS

CROSS REFERENCE TO RELATED APPLICATION

This application relates to applicant's co-pending U.S. Pat. Application, Ser. No. 137,340 for "System and Method for Cold Storage Protection of Permafrost" filed Apr. 26, 1971.

BACKGROUND ON INVENTION

As those familiar with Arctic and Subarctic areas of the world are aware, permafrost is delicate and easily disturbed. It is a problem of great concern, for instance, that hot oil must be brought to the surface through a substantial depth of permafrost and then transported by pipeline over or through large areas of permafrost to get the hot oil to shipping points. Because of the temperatures at which oil and gas are recovered and transported, it is necessary to protect the permafrost areas and layers from melting. An outstanding example of the problem of protecting or stabilizing permafrost is that situation in which a well has been drilled through a permafrost layer into a producing formation. The well must be capable of recovering the oil or gas without damaging, that is thawing, the permafrost. With no protection the heat from the oil, roughly between 100° to 200° F., will warm the multiple casings and then thaw the soil beyond. Such thawing has produced cave-ins around casings resulting in severe strains and subsidence around the well head. Even more seriously is the failure of the bond between the casing and the soil which could and has resulted in a "blow-out" or an uncontrolled release of oil or gas externally of the casing. However, if the integrity of the permafrost is maintained adjacent the outer casing the "blow-out" condition will be prevented.

Heretofore known efforts to solve the problem of temperature control on hot vertical surfaces usually employ variations of two methods. One is the circulation of a fluid and the other is the use of a boiling refrigerant. Circulation of a fluid removes heat by allowing the fluid temperature to rise. However, since the fluid temperature must rise in such a system, it is essentially incapable of constant temperature control. An approach to the temperature control problem can be obtained with high fluid circulation rates, but this usually incurs high cost pumping power. Changes in heat loads produce changes in the fluid temperature rise or else require matched changes in the circulation rates. A conventional fluid circulation system therefore is not wholly satisfactory because of its poor temperature control and/or high pumping costs. The boiling refrigerant method of temperature control has not been effective because the boiling temperature is determined by pressure. The pressure in an assembly filled with liquid increases with the jacket's depth and hence the boiling temperature also increases with depth.

SUMMARY OF INVENTION

Concatenated Down Hole Jacket Refrigeration system for oil and gas wells. The invention contemplates use of standard casing sizes wherein an intermediate refrigeration casing is disposed between the soil or concrete contacting outer casing and the outer production casing. The intermediate casing is provided with a vertical series of closely spaced, relatively shallow or short jackets which are open at the top and sealed around the

bottom to the inner surface of the intermediate casing to define a liquid cavity. The top of one jacket is closely spaced to the bottom of the jacket segment next above. Overflow pipes extend from near the top of each jacket segment downwardly through the jacket cavity to an opening at the bottom of the jacket. The jackets are filled with low boiling point refrigerant liquid which flows through the overflow pipe downwardly to drop into the jacket segment next below. The jackets are spaced from the production casing sufficiently so that between the jacket and the outer surface of the outer production casing there is defined a vapor space or annulus through which the boiling or vaporized refrigerant fluid rises. Vapor carrying off the heat absorbed from the hot oil or gas is taken to the well head and directed to a condenser system within which it gives up its heat and returns through a return line to the jacket cavities in liquid form.

Accordingly it is among the many features, objects and advantages of this invention to provide a system which preserves the integrity of the permafrost by carrying off the heat load from the oil or gas to the surface thereby preventing the heat load from damaging the permafrost. The system is economical and reliable in stabilizing permafrost around oil or gas wells or other deep, heat producing structures. The system provides constant temperature control for long or short vertical applications involving substantial and varying heat loads. Additionally the system will not be sensitive to small quantities of foreign matter which may be carried into the jacket segments while the system is operating. With an essentially constant boiling temperature in the jackets the heat transfer surface to which the jacket segments are fastened is maintained at an essentially constant temperature. Since there will be more than one overflow tube per segment the possibility of plugging from foreign matter of one overflow tube will not hamper operation of the system. The vaporized refrigerant may be condensed by conventional or other condensing systems and returned as a liquid to the upper most jacket segment.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 illustrates the environment in which the method and system operate, namely an oil or gas well together with means for condensing the vaporized refrigerant as it comes off at the well head and returning the condensed liquid to the topmost jacket segment;

FIG. 2 is a cross sectional plan view taken along the line 2—2 of FIG. 1 and further illustrates details of the invention; and

FIG. 3 is a partial view in both perspective and cross section to further illustrate details of the system.

DESCRIPTION OF PREFERRED EMBODIMENT

FIG. 1 illustrates the general environment in which the inventive concept will be used, namely the down hole arrangement of casings in an oil or gas well. In the north slope area of Alaska the permafrost layer through which hot oil and gas must be removed may extend as much as two thousand feet below the ground surface. For the purpose of showing application of the invention to a down hole heat source, this figure includes production or oil carrying casing 12, a urethane insulation layer 14 around the outside thereof, an outer production or standard 7 inch casing 16, and a standard 13 inch surface casing 18. In the event the well becomes

a producer there is introduced between the 7 inch casing and the 13 5/8 inch casing an annular 10 3/4 inch intermediate casing 20. The well head shows typical valving as well as concrete 22 around the largest casing in which concrete extends downwardly around the well at least through the permafrost layer 24.

Referring now to FIGS. 2 and 3 it will be seen that secured on the inside surface of intermediate casing 20 are a series of annular shallow jackets generally designated by the number 26. The jackets are short or relatively shallow segments having an open top defined by wall 30 and upper edge 28. Wall 30 at the bottom end of the jacket segment has an inwardly extending or offset or bottom surface 32 and a downwardly extending short mounting wall 34 which is secured in liquid tight relationship to the inside diameter of intermediate casing 20. Joining of mounting surface 34 to the casing is done by means such as a continuous resistance well. Wall 30 of the jacket segment is spaced from the inner surface of intermediate casing 20 to define refrigerant liquid cavity 36. The segments may be incorporated on the inside of intermediate casing 20 in lengths or depths of from about 2 to 20 feet although the preferred range is from about 10 to 13 feet. Thus in a standard casing length of 40 feet there may be approximately three of such segments.

Within each jacket cavity 36 will be disposed at least one and preferably several overflow tubes 38 extending from a point an inch or two below the top edge 28 down through the cavity and into bottom wall 32. Overflow tubes 38 open directly above the jacket segment next below so that refrigerant liquid overflowing runs down through the tube and drops into the next jacket segment below. The distance between the bottom of one jacket and the top of the next will be approximately 1 foot though this distance may be slightly less or greater. Between the jackets and casing 16 is defined a continuous, uninterrupted annulus 40 through which vaporized refrigerant rises and carries off heat absorbed from the hot oil being carried to the surface in production casing 12. Couplings 21 join added lengths of casing 20, each of which is also provided with jacket segments 26 and seriation down the length of the casing through the permafrost zone or at least to that depth to which soil stabilization is required. The vapor annulus 40 and the refrigerant cavity formed by the jackets are of about the same cross-sectional area.

It will be noted again, referring to FIG. 1 that the annular space between casings 16 and 20 is sealed at the top by plug or seals 42. Vaporized coolant is directed at the well head into condenser header 44 where it is directed into a heat transfer means to reject the heat and to condense the cool vapor back to liquid. The heat transfer means may be that which is covered by applicant's co-pending application, Ser. No. 137,340 mentioned above or other condensing means. The liquid returns to the system by running back through header 44 or other appropriate piping via trap 46, surge tank 48 for keeping air or gas locks out of the liquid side of the system, and thence through pressure regulator valve 48 and line 50 back to the top jacket segment.

Those skilled in the art will appreciate that a low boiling point refrigerant, such as propane, freon 12, liquid petroleum gas, or equivalents thereof is used since it is necessary to maintain the temperature of the outer well casing below about 30° F. Because the temperature at which the refrigerant liquid will boil is proportional to

liquid pressure it is necessary that there be no substantial increase in the hydrostatic head in the refrigerant liquid. Thus the use of relatively short or shallow jacket cavities breaks up the potential overall hydrostatic head so that the increase in the liquid pressure of each segment at the bottom produces a predictable increase in the boiling temperature of the refrigerant. Thus this increase in the liquid pressure plus the pressure in the vapor space will be such that the maximum boiling temperature will not exceed the melting point of the permafrost. In this way the intermediate casings on which the jackets are mounted will also be maintained within the temperature range established. The jackets are closely spaced so that no warm or cold spots occur on the heat transfer surfaces between jackets. Thus, the distance between the bottom of one jacket and the top of the one next below will be in the order of 2 feet. The overflow tubes insure that each segment stays full of liquid and yet allows free flow downward to other segments. The flow may be great or small without any influence on the level of liquid in the segments or on the pressure in the vapor space. Therefore, stability of the constant temperature maintained by the concatenated jacket system is not influenced by changing refrigeration loads. In the system described the temperatures will be maintained between about 23° to about 28° F. The jackets have been shown to be full annulus. Nevertheless it will be appreciated that they could be compartmented along a vertical line such as a wall 19 shown in dotted lines in FIG. 2 so that the jackets would be composed of arcuate sectors of a full circle. In this event each compartment would have to be provided with at least one overflow tube 32.

What is claimed is:

1. A concatenated jacket refrigeration system for the stabilization of soils contiguous to oil and gas wells, comprising:

- a. an inner first series of casings and an outer second series of casings generally concentric with and radially spaced from said first casings,
- b. an intermediate series of casings disposed between and spaced from each of said first and second series of casings,
- c. a series of jacket segments having a jacket wall spaced from the inner surface of said intermediate casing and a bottom wall secured to the inner surface of said intermediate casing to define a refrigerant liquid cavity having an open top, said jacket segments having a relatively shallow depth and being located seriatim one below the other so that the open top of one is generally closely spaced below the bottom wall of the segment next above, said series of segments extending downwardly into said well at least through that depth of the well which is to have the contiguous soils stabilized,
- d. at least one overflow tube in each jacket segment extending from near the open top down through the liquid cavity and through the bottom wall to permit flow of refrigerant liquid from one segment to the segment next below,
- e. The jacket walls of the jacket segments also being spaced from said inner series of casings to define a continuous refrigerant vapor annulus extending from the bottommost to the topmost jacket segment to permit vaporized refrigerant to carry off heat from said well, and

5

f. means at the head of said well for condensing said vapor and returning it as liquid to the jacket segments.

2. The refrigeration system according to claim 1 and in which said jacket segments extend substantially completely around the inner surface of said intermediate casing to form a substantially complete annular refrigerant liquid cavity. 5

3. The refrigeration system according to claim 1 and in which said jacket segments form a substantially complete annulus which is subdivided into arcuate sectors, each of which includes at least one overflow tube therein. 10

4. The refrigeration system according to claim 1 and in which said jacket segments have a depth of from about 2 to about 20 feet. 15

5. The refrigeration system according to claim 1 and in which said jacket segments have a depth of from about 9 to 13 feet.

6. A concatenated jacket refrigeration system for the stabilization of soils contiguous to oil and gas wells, comprising: 20

a. a first series of inner casings from which heat is radiated,

b. a series of refrigeration casings disposed around and generally concentrically with and radially spaced from said first series of casings, 25

c. a series of open topped, relatively shallow jacket segments secured at their lower ends to the inner surface of said refrigeration casings and shaped to define a liquid refrigerant cavity between said jacket and said refrigeration casing, said jacket segments being located so that the top of one segment is generally closely spaced below the bottom of the 30

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segment next above, each of said segments also including at least one overflow tube extending from near the top of said segment and extending downwardly to and opening through the bottom thereof so that refrigerant liquid runs through said tube and flows into the segment next below,

d. the jacket segments being spaced from said inner series of casings to define a substantially continuous refrigerant vapor annulus extending from the bottommost to above the topmost jacket segment to permit refrigerant vaporized by said heat from said inner casings to be carried upwardly through said vapor annulus, and

e. means at the head of said well for condensing said vapor and returning it as liquid to the jacket segments.

7. The refrigeration system according to claim 6 and in which said jacket segments extend substantially completely around the inner surface of said intermediate casing to form a substantially complete annular refrigerant liquid cavity.

8. The refrigeration system according to claim 6 and in which said jacket segments form a substantially complete annulus which is subdivided into arcuate sectors, each of which includes at least one overflow tube therein.

9. The refrigeration system according to claim 6 and in which said jacket segments have a depth of from about 2 to about 20 feet.

10. The refrigeration system according to claim 6 and in which said jacket segments have a depth of from about 9 to 13 feet.

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