United States Patent

Willman

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[54] ARCTIC ICE PLATFORM

[72] Inventor: **Bertram T. Willman**, Marsa Bregha, Libya

[73] Assignee: **Esso Production Research Company**

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[52] **U.S. Cl.** **61/46**

[51] **Int. Cl.** **E02d 27/04**

[58] **Field of Search** ..... 61/34, 36 R, 36 A, 46, 46.5, 61/54, 50; 62/260; 165/45; 9/8 P

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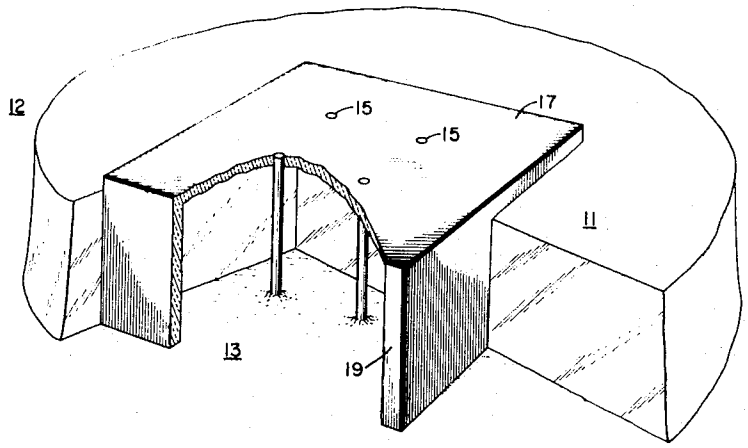
Primary Examiner—J. Karl Bell

Attorney—James A. Reilly, John B. Davidson, Lewis H. Eatherton, James E. Gilchrist, Robert L. Graham and James E. Reed

[57] **ABSTRACT**

A method of forming a permanent offshore platform in areas where a mass of ice rests on the earth's surface in winter but thaws during more moderate weather. The platform is formed by insulating the surface of the ice proximate the drilling site to prevent any substantial thawing of the ice.

6 Claims, 2 Drawing Figures



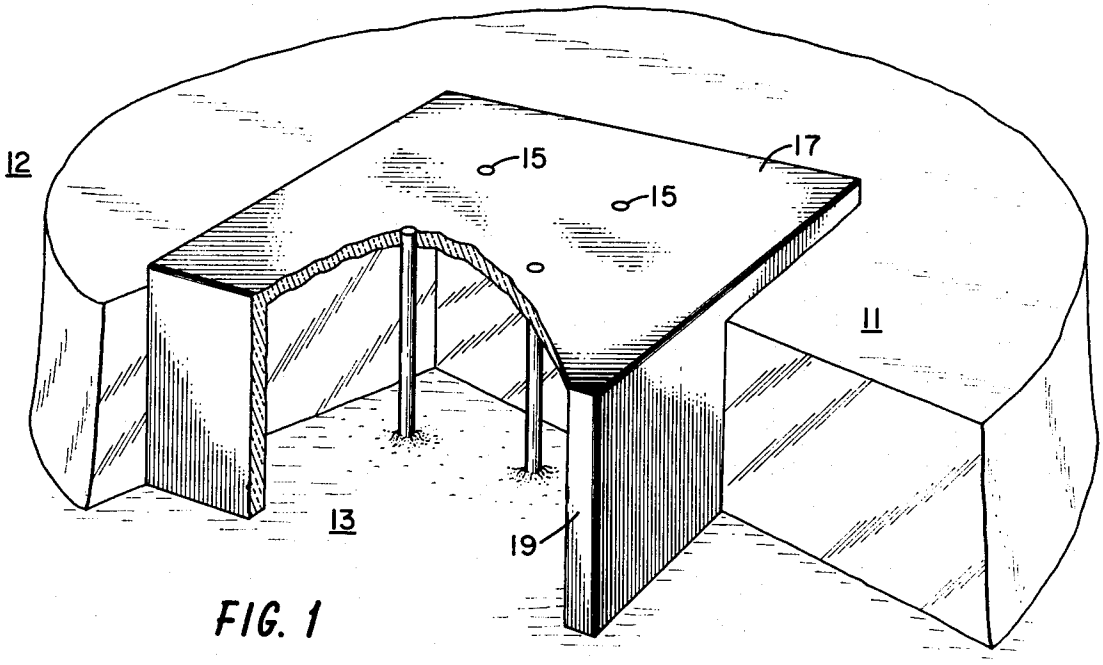


FIG. 1

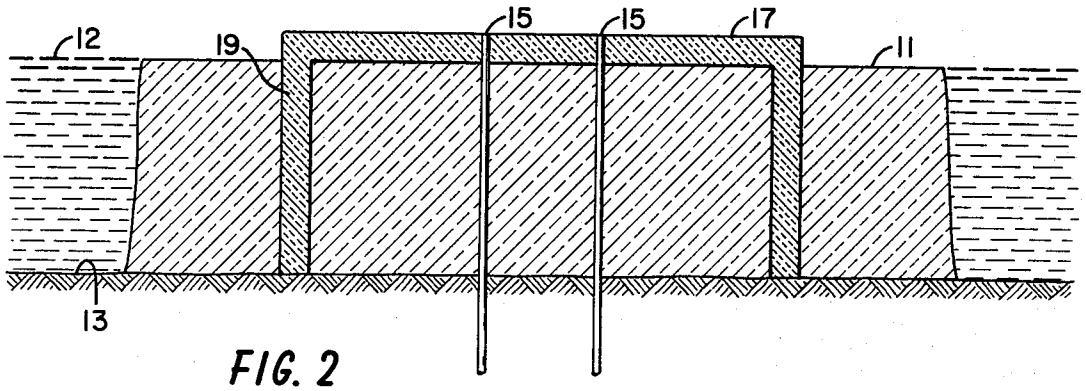


FIG. 2

INVENTOR.
BERTRAM T. WILLMAN
BY
James E. Gilchrist
ATTORNEY

ARCTIC ICE PLATFORM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to drilling platforms for use in arctic areas and is particularly concerned with a method for forming a permanent drilling platform out of a mass of ice.

2. DESCRIPTION OF THE PRIOR ART

In certain parts of the world, exploitation of deposits of crude oil and natural gas is hampered by ice that forms during severe winter weather. This is particularly true in the Arctic, where ice in shallow bodies of water may become bottom fast during the winter months and then completely thaw during the summer. Offshore drilling sites that are accessible by land-based vehicles in cold weather can often be reached only by boats in milder weather. Drilling and production operations carried out in such areas have therefore generally been conducted from pile supported platforms that extend above the water surface.

Bottom founded drilling and production platforms intended for use in arctic areas normally have to be designed to withstand the forces developed by ice freezing in the winter, ice breakup in milder weather, and floating ice masses. In addition, they must resist ice push, a phenomenon caused by the wind driving the offshore ice pack shoreward. Moreover, these offshore structures are frequently bottomed in permafrost zones which may soften and yield as the ice melts. Such platforms must therefore not only have rigid substructures that will withstand the forces imparted by moving ice but also must extend to depths sufficient to penetrate that portion of the permafrost zone that will soften during mild weather. Such platforms are thus massive, extremely expensive structures.

SUMMARY OF THE INVENTION

The method of this invention provides a relatively inexpensive platform that alleviates the problems outlined above in arctic areas where ice rests on the surface of the earth during the winter and thaws during more moderate weather. Broadly stated, the method involves insulating the surface of the ice proximate the drilling site to prevent the ice from thawing. This method is particularly useful in shallow, offshore waters adjacent arctic land masses. Platforms formed in this manner will remain fixed to the ocean bottom through summer and winter and therefore provide a relatively inexpensive, safe, stationary location for drilling and production operations. An additional advantage is that the permafrost zone is maintained in a frozen condition. Accordingly, the method of the invention offers significant advantages over the prior art.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective of an ice platform formed in accordance with the invention.

FIG. 2 is a cross-sectional elevation of the platform of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A platform constructed in accordance with the invention is shown in perspective in FIG. 1 and in elevation in FIG. 2. An ice mass 11, situated in a body of water 12, extends from the water surface to the submerged bottom 13. Four wells 15 are located in a somewhat central position on the body of ice. Each well extends downwardly through the ice into an oil or gas bearing subsurface formation. An insulating material 17 covers a substantial area of the surface of the ice mass proximate the well cluster and has also been placed in trenches 19 which extend downwardly to the submerged bottom.

Formation of the permanent platform of the invention normally requires the existence of an ice mass that rests on the earth's surface. Where the platform is to be formed in a shallow water, offshore area, holes can readily be drilled through

the ice to determine its thickness. Estimation of the rigidity of the connection between the ice mass and the subsea bottom can be determined similarly, rigidity depending upon bottom topography as well as thickness and areal extent of the ice mass.

Once it is established that the ice is rigidly affixed to the bottom, the areal extent of the ice mass required to form the platform should be estimated. The areal extent needed will be governed largely by anticipated climatic conditions, by the thickness and thermal properties of the insulating material, and by the likelihood of exposure to ice push and the like.

The insulation material should be a nonaqueous waterproof material, and preferably should be of a type that may be readily applied, such as a foam. Preferred materials are foam plastics, e.g., polyurethane. Other insulating materials which will not deteriorate under arctic weather conditions would, of course, also be suitable. It will frequently be necessary to anchor the insulating material to the ice mass to prevent its movement away from the protected area. One convenient way of anchoring the insulating material is to drill a number of shallow wells on the surface of the ice and to extend the foam downwardly into these wells, thereby providing a number of anchor legs. Pilings, fences, and the like may also be utilized.

The thickness of the insulating material required at a given location will depend in part upon the thermal properties of the insulating material and by ambient weather conditions. The flow of heat across the insulating material, assuming steady state conditions, is governed by the following equation:

$$q=\frac{dQ}{dt}=kA\frac{[\partial T]}{[\partial X]_t}$$

where: $q=dQ/dt$ = rate of heat flow across area A

k = thermal conductivity of the insulation material

A = the area measured perpendicular to the area of flow

$$\frac{[\partial T]}{[\partial X]_t}=\text{the temperature gradient}$$

Thus the rate of heat flow for a unit area is directly proportional to the thermal conductivity of the insulation material and the difference in temperature between the ice and the atmosphere, and inversely proportional to the thickness of the insulating material. Techniques for determining the thermal conductivities of materials are well known to those skilled in the art. Much information on insulating materials is available in the literature. Historical data on climatic conditions has also been published for most geographical areas. From such information the seasonal variation of the difference between ambient temperature and ice temperature can be estimated. With this data and the thermal conductivity of the insulation material, the thickness of insulation necessary to prevent any substantial melting of the ice caused by heat conduction through the insulation material can be determined. In most instances, it appears that a 12-inch layer of polyurethane will suffice.

An ablation study of the Alaskan Gulkana Glacier to evaluate the importance of radiation showed solar radiation to be the most important energy exchange process to melt snow and ice on the glacier. This work is reported by Mayo and Pewe in their article entitled "Ablation and Net Total Radiation, Gulkana Glacier, Alaska," in *Ice and Snow*, Cambridge, Mass., the M.I.T. Press, 1962, p. 633–643. Accordingly, it is desirable that the insulation material employed possess a low absorptivity and a high reflectivity to minimize the effect of solar radiation. In that regard, in some instances, it may be desirable to spray the upper surface of the insulation material with a highly reflective material that will adhere to the insulation material.

It will be recognized that it will frequently not be practicable to insulate the ice platform sufficiently to completely prevent melting. In general, however, the heat flow that results in the ice melting during mild weather will be balanced by the flow of heat in the opposite direction during cold weather that causes refreezing. In those geographical locations where such

a balance is not achieved it may be desirable to refreeze the ice, as required, by partially removing the insulating material during cold weather. This could also be accomplished by installing refrigeration equipment, and periodically removing heat, as required, to refreeze the ice.

The effect of ice thickness and climatic conditions on the areal extent of insulating material required will be governed by a number of factors. For example, when the insulating material covers only the upper surface of the ice mass, the periphery of the platform may be subject to thawing during warm weather. It will therefore be desirable to extend the insulating material a substantial distance away from the well to insure that if any portion of the ice melts, that portion will not affect the wells drilled through the insulated block of ice. While the amount required will vary from location to location, extending the insulating material to a radius of at least 300 meters from the well site will probably be adequate in most instances. Alternatively, a trench may be excavated around the insulated area and filled with insulating material to protect the peripheral surfaces of the ice mass.

In areas where ice floes, ice push, or glaciers are a major problem, concern for the rigidity of the ice mass when impacted by natural forces may affect the areal extent of the insulation material. As pointed out above, the mobility of an ice mass resting on the earth's surface will be governed in large part by the thickness and areal extent of the ice mass and the topography of the earth's surface on which it rests. Where the ice is relatively thin and the surface is quite smooth, a relatively great areal extent is desirable. On the other hand, if the bottom topography is rough and the ice is thick, a smaller areal extent will suffice. Where problems with ice floes and rafting are anticipated, it may be desirable to elevate the surface of the platform a substantial distance above sea level to prevent the moving ice from sweeping the equipment off the platform. This may be accomplished in a fashion well known to those skilled in the art by pumping water to the top of the platform and allowing it to freeze. Once a sufficient height is attained, the insulating material may be applied in the fashion discussed above.

Once the immobility of the ice mass has been established and the insulating material requirements have been determined, the insulating material is applied and the wells are drilled from atop the ice downwardly into the earth below. Such drilling operations may be carried out in the same general manner conventionally used to drill wells for crude oil and natural gas onshore in arctic areas. Completion practices would also parallel those presently used in arctic environments. Alternatively, the insulating material may be applied after the wells are drilled and completed and the rig has been moved out.

What is claimed is:

1. A method of forming a permanent ice platform in a shallow body of water which freezes to form a bottom-fast mass of ice in the winter and thaws during moderate weather comprising:
   a. applying a layer of a nonaqueous insulating material to the surface of said mass of ice at a time when said mass of ice is fixed to the bottom, said layer being sufficiently thick to prevent any substantial melting of said mass of ice during moderate weather;
   b. excavating a trench around the periphery of the insulated ice surface; and thereafter,
   c. applying a layer of insulating material to the peripheral surface of the ice mass.

2. The method defined by claim 1 further comprising the steps of:
   a. removing said insulating material, as required, during cold weather to refreeze any ice that has melted; and thereafter,
   b. replacing said insulating material to prevent ice from melting during mild weather.

3. The method defined by claim 1 further comprising the step of refrigerating the ice beneath said insulating material, as required, to refreeze any ice that has melted.

4. A method of forming a permanent ice platform in a shallow body of water which freezes to form a bottom-fast mass of ice in the winter and thaws during moderate weather comprising:
   a. applying a layer of nonaqueous insulating material to the surface of said mass of ice at a time when said mass of ice is fixed to the bottom, said layer being sufficiently thick to prevent any substantial melting of ice during moderate weather;
   b. coating the surface of said layer of insulating material with a substance which adheres to said material and reflects radiant energy;
   c. excavating a trench around the periphery of the insulated ice surface; and thereafter,
   d. applying a layer of insulating material to the peripheral surface of the ice mass.

5. The method defined by claim 4 further comprising the steps of:
   a. removing said insulating material, as required, during cold weather to refreeze any ice that has melted; and thereafter,
   b. replacing said insulating material to prevent the ice from melting during warm weather.

6. The method as defined by claim 4 further comprising the step of refrigerating the ice beneath said insulating material, as required, to refreeze any ice that has melted.

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