

[54] **INSTALLATION FOR CONTROLLING THE  
CONDITION OF WATER IN CONCRETE  
STRUCTURES**

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[63] Continuation-in-part of Ser. No. 647,940, June 22,  
1967, abandoned.

[30] **Foreign Application Priority Data**

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[52] U.S. Cl. .... **52/302, 52/310**

[51] Int. Cl. .... **E04b 1/16**

[58] Field of Search..... 264/354; 249/141;  
52/302, 249, 310; 176/59, 61; 110/1 A

[56] **References Cited**

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[57] **ABSTRACT**

Disclosed herein is a reinforced concrete structure for surrounding a nuclear reactor vessel containing a high-temperature, highly pressurized fluid. The concrete structure has a concentrically configured drainage network therein for evacuating water and vapor from the concrete structure, to prevent destruction thereof due to excessive vapor pressure caused by heat absorbed from the reactor. The drainage network is arranged so that the direction of vapor flow is opposite to the thermal flux within the structure, and comprises perforated pipes or prefabricated blocks assembled within the structure, adjacent the vessel, and connected to drain conduits for allowing the water and vapor to be removed from the concrete structure.

**6 Claims, 3 Drawing Figures**

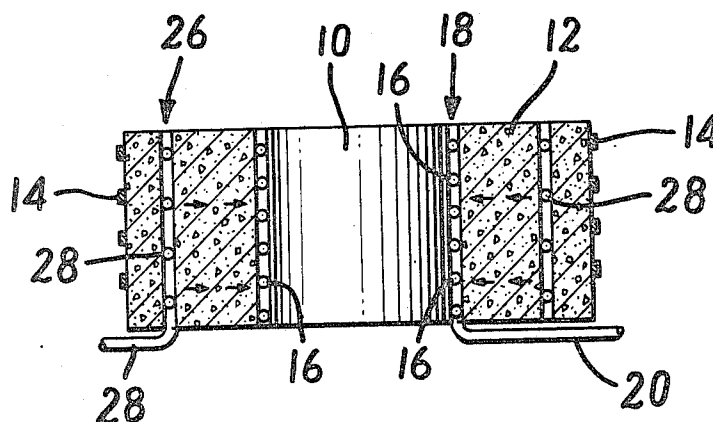


FIG. 1

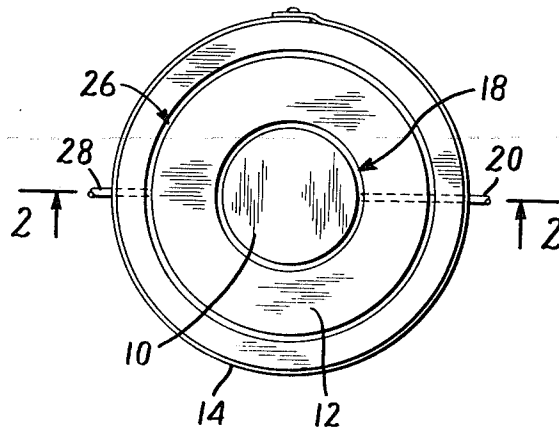


FIG. 2

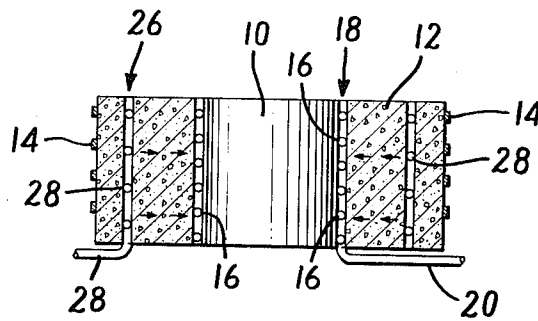
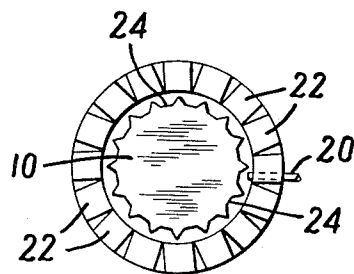


FIG. 3



# INSTALLATION FOR CONTROLLING THE CONDITION OF WATER IN CONCRETE STRUCTURES

This is a continuation-in-part application of Ser. No. 647,940, filed June 22, 1967, now abandoned, which claims priority of my earlier French application No. PV 4964, filed on June 23, 1966.

## BACKGROUND OF THE INVENTION

Certain reinforced concrete structures are intended to support a vessel containing a high-temperature pressurized fluid. These structures generally comprise a body of reinforced concrete which surrounds an inner caisson or vessel for receiving the fluid, and binding or hooping cables which subject the concrete to a compressive stress sufficient to balance the inner pressure exerted by the vessel. The zone closest to the caisson is subjected to the highest temperature, and the outer zone is the coolest. Such zones are concentrically disposed within the concrete body, and are defined by geometric surfaces equidistant from the outer surface of the caisson.

The progressive heating of the concrete body, once placed into operation, due to the heating of the caisson by the fluids that it contains, is accompanied by an elevation in pressure and temperature of the water disposed in the concrete, and a progressive migration of this water. Since good concrete is only slightly permeable, this migration is slow and difficult, and enormous over-pressures can exist due on the one hand to the dilation of the liquid water and on the other hand to pressurized vapor. The zones near the caisson, which are the hottest zones, are those where the pressure is highest, and where the water will have the most difficulty in being discharged in liquid or gaseous form.

An object of the present invention is to overcome these difficulties.

An essential principle of the invention is to evacuate the water and vapor trapped in the concrete by making them travel in the direction opposite to the heat flux. The necessity for this evacuation can be visualized by imagining that wet sand, well stacked to a substantial thickness, is deposited in a flat bottom cauldron which is placed on a flame in order to dry the sand. It is probable that this experiment will terminate in an explosion due to the intense vaporizing of the water imprisoned in the bottom of the cauldron. However, if heat were applied above the sand by means of a radiator or a hot gas, the material will dry progressively and the vapor will rise progressively from bottom to top through the sand, and accordingly in the direction opposite to that of the applied heat flux.

In particular, the invention relates mainly to a supporting structure for a nuclear reactor having an inner steel caisson which may be, for example, 35 feet in diameter, 50 feet in height, and may have a wall thickness of about 1 inch. The supporting structure may comprise a concrete wall enveloping the caisson, and having a thickness of some 15 or 20 feet. In such cases, the caisson is brazed in situ and the concrete is poured around the caisson wherein at least the outer portion of the concrete is reinforced by pre-stressed steel. The concrete hardens quickly, but the real curing takes several years. However, due to the vapor pressures in the concrete, generated by the heat and pressure of the caisson, it would be impossible to use the structure

until a sufficient amount of water has "cured" out of the concrete, or until some other precautionary steps were taken.

In the prior art, a layer of concrete was disposed within the caisson against the inner wall as a heat barrier to avoid too rapid evaporation of the humidity of the concrete surrounding the outer wall of the caisson. However, this method often causes destruction of the inner concrete wall.

An object of this invention is to avoid the necessity of the inner concrete wall without entailing explosion of the outer concrete due to the extremely high vapor pressures in the concrete close to the caisson.

## SUMMARY OF THE INVENTION

According to the main aspect of the present invention, there is provided an installation for controlling the vapor pressure and the state of water present in a mass of concrete consisting of a reinforced concrete structure adapted to support an inner steel vessel containing a high-temperature pressurized fluid, wherein a plurality of drains are provided in the concrete, concentrically about the vessel. The drains are placed in the concrete adjacent the outer surface of the vessel, so that the flux of vapor circulating in the concrete is in the direction opposite to that of the heat flux emanating from the inside of the vessel, whereby excess water from the concrete is drained and stabilization of the water content of the concrete is achieved. Thus the vapor produced under pressure in a hot zone of the concrete will have to filter through the concrete going towards the draining network from the outside to the inside of the zone, and consequently in the direction opposite that of the heat flux which is directed from the inside to the outside.

Thus, according to the invention, perforated drain tubes such as may be fabricated of steel or ceramics, are disposed around the vessel, close to its outer wall (or directly surrounding the vessel), before the concrete is poured into a form surrounding the vessel. The diameters of the closely spaced perforations in the tubes are so small that the concrete can be molded around the vessel and around the drain tubes without penetrating into the tubes. After molding, the concrete hardens quickly and becomes solid after, for instance, a few hours, but the curing goes on for years. Thus, if, for example, the fluid containing vessel is a nuclear reactor, it is not necessary to await the end of the curing period before operating the reactor. The drain tubes remain in the concrete and have no draining function upon completion of curing of the concrete, after, say 5 years. However, upon such complete curing, it may be desirable to prevent complete dehydration of the concrete, whereupon the drainage network may be charged with moisture to maintain the concrete in a stabilized condition.

Therefore, it can be seen that this invention permits the reactor to be operated immediately, whereby the already solid concrete cures progressively, heated by the vessel. However, the less cured outer layers of the concrete are not porous and do not allow the evacuation of the high pressure, high temperature vapors coming from the inner layers, but as the concrete in the inner layers cures and dries, it becomes more porous so that the water and vapors can flow in the centripetal direction rather than in the centrifugal direction where the concrete is less cured and less porous. Finally, the

water and the vapors reach the drain tubes, penetrate through the perforations, and escape to atmosphere. As the case may be, it is possible to apply a counterpressure to the drain tubes to slow down the exhausting of water, but these counterpressures must be always less than the vapor pressure inside the concrete so that the vapor flows always to the tubes and never in the opposite direction which is the direction of the thermal flux.

The drainage network must be quite extensive in order to ensure the evacuation of the vaporized water, the physical parameters of the network can be predetermined by calculus and by experimentation.

In a modification of the above-described drainage network, the perforated tubes are replaced by an assembly of concrete blocks built in place about the surface of the vessel and then enclosed by poured concrete. In this case, the vapor flow can take place through openings in the blocks, or through the spaces between the blocks if they are not joined together by mortar.

In a further modification of the invention, wherein tension cables surround the concrete structure to offset the internally exerted pressure of the vessel, non-perforated conduits are provided within the outer portions of the concrete structure, and cooling fluid is pumped through these outer conduits to maintain the concrete at a temperature below 100°C, adjacent the cables.

#### BRIEF DESCRIPTION OF THE DRAWING

The accompanying drawing illustrates a preferred embodiment of the invention. In such drawing:

FIG. 1 is a diagrammatic plan view of a reinforced concrete structure embodying the invention;

FIG. 2 is a cross-sectional view taken along the line II — II of FIG. 1; and

FIG. 3 is a partial plan view of a modification of the structure shown in FIGS. 1 and 2.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with the invention, as illustrated in the drawing, a vessel 10 of welded steel, containing a high-temperature pressurized fluid, is surrounded by a concrete supporting structure 12 for maintaining the pressurized vessel intact. In a particular example, the vessel 10 may comprise a large nuclear reactor, and may have a diameter on the order of about 30 feet, a height of about 50 feet, and a wall thickness of about 1 inch. Under these conditions, the concrete supporting structure surrounding the reactor would have a thickness of about 15 feet, and would be provided with reinforcing cables 14 connected under tension about the outer periphery of the concrete structure to provide a counterforce for balancing the internally exerted pressure of the vessel 10.

Because the mass of concrete is so large, a great deal of time is required for the complete curing of the concrete although the mass of concrete hardens into a usable structure within a short period. Thus, but for the high vapor pressure generated within the concrete due to the pressure and temperature exerted thereon by the contents of the vessel 10, the reactor could be put into immediate use.

According to the improvement of this invention, drain conduits 16 are placed about the vessel 10 prior to the pouring of the concrete 12, said conduit being

disposed in a zone 18 which is directly adjacent the vessel 10, the zone which will be subjected to the greatest vapor pressures. Such drain conduit 16 may comprise perforated tubes disposed in a network throughout the zone 18 and interconnected with a discharge conduit 20, through which the vapor and water, flowing through the drain conduit 16, may be discharged to the atmosphere. Thus, as indicated by the arrows in FIG. 2, the direction of flow of vapor and water within the concrete mass 12 is toward the center of the mass, and thus, in opposition to the direction of thermal flux which is caused by the source of heat within the vessel 10. Therefore, the water is withdrawn from the concrete directly adjacent the source of heat, so that the concrete becomes more permeable at that point, and allows the flow of vapor through such permeable portions, into the drain conduit 16, and out of the concrete mass through the discharge conduit 20.

In the operation of the reactor, the critical temperature therewithin is about 355°C, while the pressure is about 200 atmospheres. However, the concrete would have to withstand much higher temperatures and pressures than this if the drain conduit of this invention were not included in that concrete structure, since the water in the concrete would be trapped, and its migration impeded to an extent wherein the vapor pressure would cause an explosion. On the other hand, in the structure disclosed herein, the working temperature of the reactor is reached after about 1 week of use, so that the concrete has time to solidify to a sufficient extent to permit immediate use of the structure.

On the other hand, after about 5 years use, it may be desirable to control the dehydration of the concrete, whereupon the drainage conduits can be charged with water through the discharge conduit 20, so that the now porous concrete will absorb this water, and the pressures can be stabilized at a desirable level.

In a modification of the previously described embodiment, an assembly of concrete blocks 22 can be disposed about the periphery of the vessel 10 prior to the pouring of the concrete mass 12, and the faces within or between the concrete blocks 22 can provide the necessary drainage conduits for allowing the removal of moisture from the concrete. In combination with such concrete block assembly, the outer periphery of vessel 10 can be provided with an irregular shape as indicated by reference numeral 24, so that channels are provided directly adjacent the surface of the vessel for draining the concrete mass into the discharge conduit 20. Also, the perforated tubes 16 or concrete blocks 22 can be covered with screening or other suitable means for preventing the entry of concrete into the drainage conduits during the pouring of the concrete mass 12.

In a further modification of the above-described structure, the outer portions of the concrete mass, at a zone 26, are provided with non-perforated tubes 28 for carrying a cooling fluid to maintain those outer portions of the concrete at a temperature below 100°C, thereby preventing harmful effects upon the usefulness of the reinforcing cable 14.

What I claim:

1. In a concrete support structure surrounding an imperforate vessel containing a high-temperature pressurized fluid, the improvement comprising drainage network means comprising a network of perforated tubing disposed within an inner portion of said concrete structure and adjacent said vessel, and discharge conduit

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means connected to said drainage network means for carrying excess water out of said support structure, whereby the flow of vapor, generated within said concrete by the heat of said vessel, is in the direction opposite to the direction of heat flow within said concrete support structure.

2. An improved apparatus for removing water from concrete comprising a vessel for containing a high temperature pressurized fluid; a mass of poured concrete surrounding said vessel, drainage network means comprising a network of perforated tubing disposed at the junction of said vessel and said concrete, and discharge conduit means connected to said drainage network means for carrying excess water out of said concrete mass, whereby the flow of vapor, generated within said concrete by the heat of said vessel, is in the direction opposite to the direction of heat flow within said concrete.

3. A process for controlling vapor pressure and the presence of water in a solid mass of concrete which contains an inner imperforate steel vessel adapted to contain a fluid at high temperature and pressure, comprising the steps of laying drain conduit around said vessel prior to pouring said concrete, said drain conduit being placed adjacent said vessel, pouring the concrete around the vessel and establishing a temperature gradient therein decreasing in a direction from a point adjacent said vessel to a point on the external periphery of said concrete to effect flow of excess vapor and water from said concrete and through said drain conduits in the direction opposite to the direction of heat flux emanating from inside said vessel.

4. A process for controlling vapor pressure and the presence of water in a solid mass of concrete which contains an inner imperforate steel vessel adapted to contain a fluid at high temperature and pressure, com-

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prising steps of laying a concrete block assembly having drainage openings therein around said vessel to provide drain conduits in said assembly, pouring concrete around the concrete blocks, and establishing a temperature gradient therein decreasing in a direction from a point adjacent said vessel to a point on the external periphery of said concrete to effect flow of excess vapor and water from said concrete and through said drain conduits in the direction opposite to the direction of heat flux emanating from inside said vessel.

5. In a concrete support structure surrounding an imperforate vessel containing high-temperature pressurized fluid, the improvement comprising drainage network means comprising an assembly of concrete blocks abutting said vessel and surrounded by solid concrete, said assembly of concrete blocks having means defining drainage openings therein, and discharge conduit means connected to said drainage network means for carrying excess water out of said support structure, whereby the flow of vapor, generated within said concrete by the heat of said vessel, is in the direction opposite to the direction of heat flow within said concrete support structure.

6. An improved apparatus for removing water from concrete comprising: a vessel for containing a high temperature pressurized fluid; drainage network means comprising an assembly of concrete blocks having means defining drainage openings therein and abutting said vessel; a mass of poured concrete surrounding said discharge network means; and discharge conduit means connected to said drainage network means for carrying excess water out of said concrete mass, whereby the flow of vapor, generated within said concrete by the heat of said vessel, is in the direction opposite to the direction of heat flow within said concrete.

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