United States Patent

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[72] Inventors **Adelbert J. Elliott**
Livermore;
Milton O. Jones, Pleasanton, both of, Calif.

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[73] Assignee **The United States of America as represented by the United States Atomic Energy Commission**

[54] **TEMPERATURE-CONTROL SYSTEM**
9 Claims, 2 Drawing Figs.

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[51] Int. Cl. **F25d 3/02**
[50] Field of Search 165/135, 136; 62/459; 220/10, 15

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Primary Examiner—Carroll B. Dority, Jr.
Attorney—Roland A. Anderson

ABSTRACT: Explosive device temperature controlling wherein high temperature effect of an environment is minimized by isolating explosive and a low temperature medium from the environment by enclosing within apparatus comprising a container including a removable end closure, first and second open-ended double-walled housings each having an outer wall supported by the container and an inner wall spaced from the outer wall with heat-insulating barrier therebetween, the container maintaining the double-walled housings in axial alignment with the open ends thereof in substantially abutting relationship with each other.

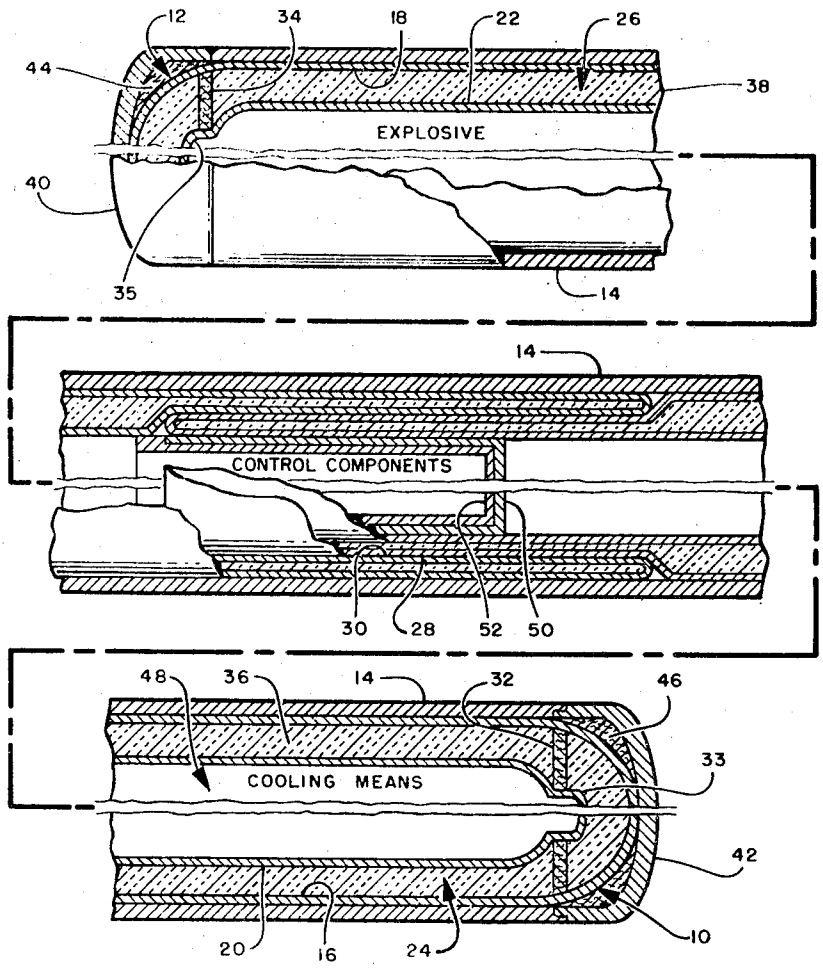


FIG. 1

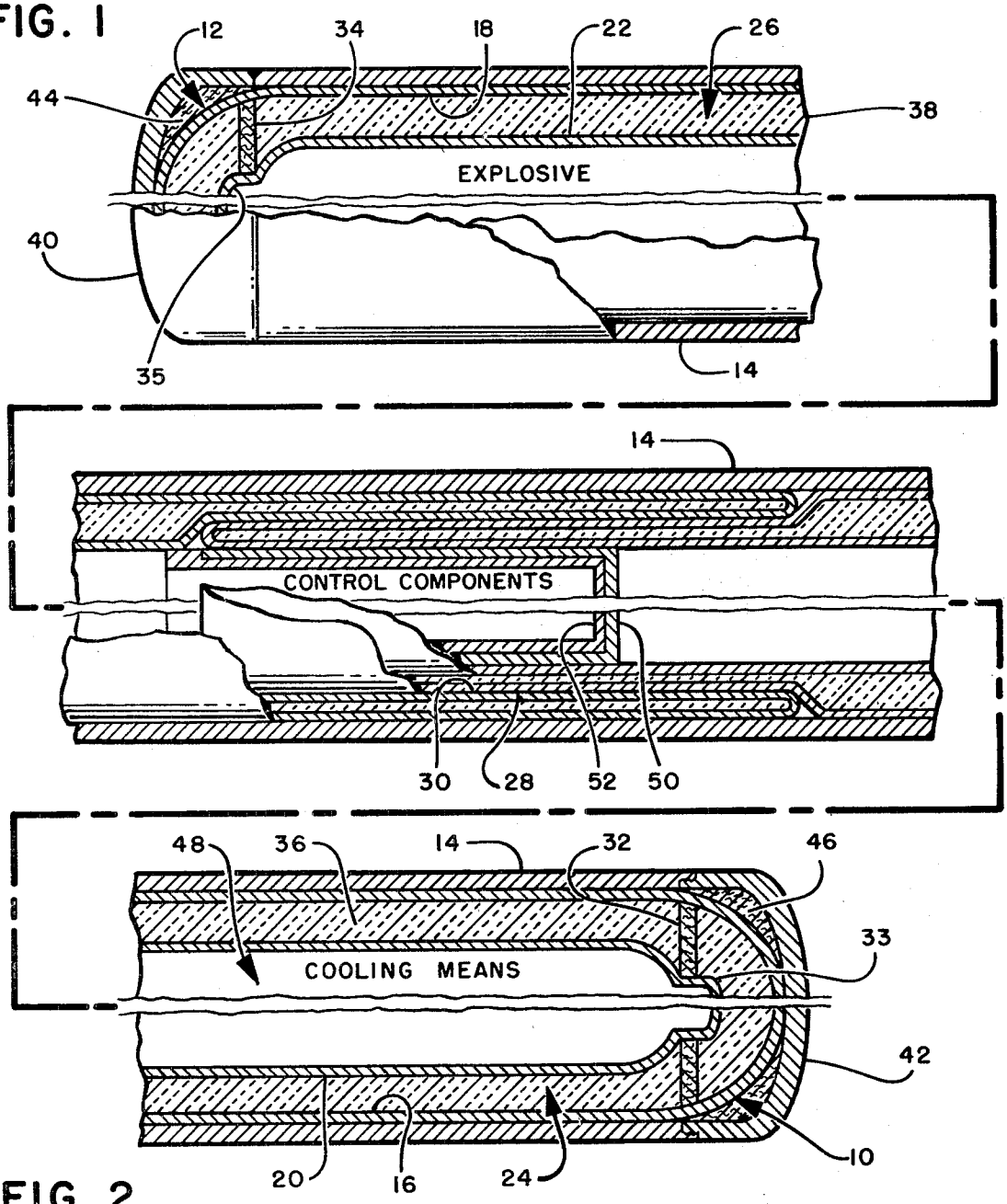
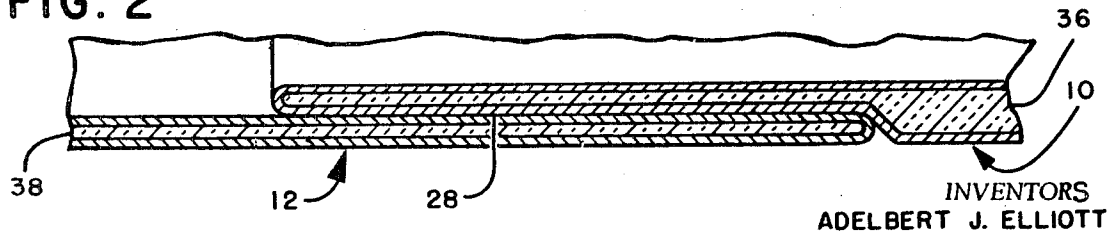


FIG. 2



INVENTORS
ADELBERT J. ELLIOTT
MILTON O. JONES
BY
Attorney

TEMPERATURE-CONTROL SYSTEM

BACKGROUND OF INVENTION

There are applications where it is desirable to utilize an explosive or explosive device in a high-temperature, and possibly high-pressure, environment. Many explosive devices, such as conventional chemical explosives and nuclear devices, may be permanently or temporarily damaged under such an environment and either completely fail or produce a degraded explosive output. Such damage or degradation may occur in the explosive itself or in the associated control mechanism or circuits. It would thus be desirable to provide some thermal control of the environment about the explosive device to maintain the explosive device at a safe operating level prior to ignition thereof.

One such application is in the use of explosive devices, particularly nuclear devices, in underground detonations, such as for mineral or oil recovery operations. As depth increases, the temperature, as well as the pressure, increases significantly, for example, at depths as great as 20,000 feet the temperatures may be as high as 300° F. or higher. At such depth the surrounding rock or other formations, being at the high temperature and generally exhibiting poor thermal conductivity, may provide only limited heat dissipation for conventional refrigeration systems. Refrigeration systems are generally costly and because of the use location would have to be made extremely reliable, possibly beyond the reliability capabilities of present refrigeration systems. Further, such a system would be dependent upon electrical cable extending from the earth's surface to the explosive device which would also be subjected to the high-temperature and high-pressure environments. Additionally, in such applications the hole in which the explosive device is implaced is usually back filled with some suitable filling material, such as dirt, rocks or concrete, which may potentially damage the electrical cable and prevent or degrade the operation of the refrigeration system.

Because of the inaccessibility of the explosive device in these applications and the potential temperature, pressure and back-fill damage to electrical cables, it would be desirable to provide an explosive device which would be self-contained providing thermal control for some prescribed period of time.

SUMMARY OF INVENTION

In view of the above it is an object of this invention to provide an explosive device temperature control apparatus of simple and rugged design.

It is a further object of this invention to provide an explosive device temperature control apparatus which is self-contained.

It is a still further object of this invention to provide an explosive device temperature control apparatus capable of maintaining the explosive device within some prescribed temperature range in a high-temperature and high-pressure environment.

Various other objects and advantages will appear from the following description of one embodiment of the invention, and the most novel features will be particularly pointed out hereinafter in connection with the appended claims.

It will be understood that various changes in the details, materials and arrangements of the part, which are herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art.

An explosive device temperature control apparatus comprising first and second open-ended double-walled housings supported within a container with the outer walls of said housings supported by the container and the inner walls spaced from the outer wall with heat-insulative barrier intermediate thereof with said housings in axial alignment and with the open ends thereof in abutting relationship.

DESCRIPTION OF DRAWING

The invention is illustrated in the accompanying drawing wherein:

FIG. 1 shows a temperature-control apparatus in a partially cutaway elevation side view with the explosive device shown schematically; and

FIG. 2 shows a fragmentary cutaway of a modification of the apparatus of FIG. 1.

DETAILED DESCRIPTION

The explosive device temperature control apparatus may include first and second open-ended, double-walled, cylindrical or tubular housings **10** and **12** mounted in an appropriate container **14** with the housings in axial alignment and with the open ends thereof in abutting relationship. Each of the housings **10** and **12** include an outer wall **16** and **18**, respectively, contained and supported by container **14** and an inner wall **20** and **22**, respectively, spaced from the outer wall and forming an enclosed and sealed passageway or opening **24** and **26**, respectively, therebetween. Each of said housings **10** and **12** has an open end facing each other, as shown, in abutting relationship with the opposite ends appropriately closed by the double-wall and intermediate-passageway construction. Openings **24** and **26** are evacuated and vacuum sealed to provide a vacuum-bottle-like arrangement. Openings **24** and **26**, in addition to being evacuated, may be filled with an appropriate low thermal conductivity vacuum insulating material, as described below.

Housings **10** and **12** may be held with their open ends in the abutting relationship with any appropriate mechanical coupling arrangement. An appropriate cooling means, as described below, may be enclosed within one or the other of the housings to maintain the explosive device also enclosed in the housings at temperatures within some acceptable control temperature range. However, in order to minimize thermal conductivity between the inner and outer walls at the abutting joint, it has been found particularly appropriate to use an overlapping, double-walled, flangelike extension of the bottles, as shown in the drawing. Further, it has been found that the housing enclosing the cooling means should be provided with a flange extension which is internally disposed with respect to the housing or a flange extension of the housing enclosing the explosive device. In such an arrangement, the outer wall, such as outer wall **16** of housing **10**, may have a portion **28** of reduced diameter which mates with an internal wall portion **30** of housing **12** having a greater diameter than the internal wall **22** thereof. It is preferred that these slip fitted external and internal wall portions **28** and **30** be in overlapping engagement over a relatively extended length to provide a relatively long heat-conducting path between the internal walls of housings **10** and **12** and the external walls thereof through the abutting joint. The overlapping joint may include one flangelike extension such as shown in FIG. 2 with the double-walled housing **12** having a uniform thickness throughout which may be slip fitted over the flange extension **28** of housing **10**.

The internal walls **20** and **22** of housings **10** and **12** may be mechanically supported and restrained by appropriate heat insulators **32** and **34** engaging bosses **33** and **35** to assist in positioning of the walls and to minimize or prevent lateral movement of internal walls with respect to the external walls. The inner and outer walls of the housings are preferably made of a high-strength material which can withstand the vacuum produced therein and still be made relatively thin to minimize thermal conductivity therethrough, such as from certain steels like stainless steel. Evacuated openings **24** and **26** may be filled with a very low thermal conductivity insulating material such as multilayered insulation composed of highly reflective metal foil radiation shields separated by low thermal conductivity spacers of cloth, paper, or metal-flake-opacified paper. Foils such as aluminum, copper and nickel may be used because of their low emissivity with spacers of glass or quartz fiber paper, woven quartz cloth, or copper or aluminum flake specified glass or quartz fiber paper.

Container **14** may be closed at one end or include an appropriately fastenable closure **40** which may be welded or

otherwise attached in place with the other end of the container having a removable and sealable closure **42**. Closure **42** may be implaced after assembly of housings **10** and **12** and the explosive device. Any passageways or space between closures **40** and **42** and the housings may be filled with an appropriate low thermal conductive insulating material, such as foam or the like, which may provide some lateral or longitudinal support of the explosive device and housings, such as shown by **44** and **46**.

It has been found that a particularly appropriate cooling means conductivity be a combination of water and ice which utilizes the thermal energy absorbed by the heat capacity of ice and water and the heat of fusion available from the melting of ice to maintain the temperature of the explosive device within prescribed limits or control temperature range (such as between about −65 and +**opacified** F.). Such a cooling means does not require an exhaust valving system since no significant pressure change occurs as heat energy is absorbed as there is a minimum volumetric change associated with the melting of ice and heating of water. The ice and water mixture may be initially cooled to a temperature below freezing, such as about −65° F., to increase the cooling capacity thereof, e.g., a supercooled mixture. The cooling means, that is the ice and water mixture **48** may be disposed within the housing having the internally projecting flangelike extension, such as extension **28** in housing **10**, and maintained therein by an appropriate seal and wall **50**. Other material than an ice and water mixture may be used as a cooling means which has a melting temperature in the control temperature range and which does not have an appreciable change in volume as it is heated and melts, such as certain waxes and the like.

An explosive, such as a nuclear explosive or conventional explosive, and the necessary control means and detonation means may be mounted in the other housing with an appropriate environmental seal **52**, if needed, separating the explosive and control mechanism or circuits from the cooling means. The explosives and control components may be assembled using the housing, such as housing **12**, as the case structure for the explosive and control components. This package may be preassembled and stored and then shipped to the use site, as needed. In order to minimize possible damage to the double-walled housing and insulation intermediate thereof it may be desirable to maintain the assembled package in a vertical position. Before implacement of the explosive device in its use location, the other housing, such as housing **10**, may be filled with an appropriate amount of the water ice cooling mixture and sealed therein by wall **50**. The smaller diameter flange extension of this housing may then be assembled into the open neck or end of housing **12** containing the explosive device. The explosive device may be completely enclosed within housing **12** or it may extend partially into housing **10**, as shown, depending upon the cooling requirements of the use site and explosive device. The assembled housings may then be placed within container **14** and end cap **40** attached thereto. Before placing in use site, a system leak check may be performed, if desired or needed. With end closure **42** attached, the explosive device and temperature control apparatus may then be placed in the use site. If such a use site is a deep underground hole, the apparatus and device may be lowered therein with appropriate mechanical support and the hole back filled in a suitable manner. Such a system is particularly attractive for those applications where the explosive device is initiated by remote control without any physical connection to the explosive device, such as in underground detonations with the use of seismic control signals. With such an arrangement, the only connection to the surface would be the lowering cable. Multiple in-line implacement of explosive devices, each interattached by only a mechanical support cable, may thus be feasible.

With an underground use site % about 20,000 feet depth at a temperature of about 300° F. and with an internal heat load within the explosive device of about 30 b.t.u./hr. and a multifoiled insulation thermal conductivity of about 2.75×10^{16} b.t.u./hr.-in.-°F., a down-hole time of about 40 days may be accomplished with a water-ice cooling means approximately 6 cubic feet in volume which has an initial supercooled temperature of about −65° F. With an insulation thermal conductivity of about 15×10^{16}, a down-hole time of 40 days may be accomplished with a water-ice cooling means approximately 15 cubic feet in volume.

In a typical application using the nuclear explosive, container **14** may be made from half-inch thick carbon steel with an outside diameter of about 13 inches and an overall length of about 20 feet. The housing walls may be about 0.07-inch thick stainless steel with an insulating barrier or intermediate passageway about 0.2- to 0.4-inch thick. The overlapping flange extensions of the housings may be about 20 inches long. Wall **50** may be made of copper about 0.33 inches thick.

What is claimed is:

1. Temperature-controlling apparatus for enclosing an explosive device comprising an elongated container including a removable end closure; a first open-ended double-walled housing within said container adjacent one end thereof having outer wall supported by the container and inner wall spaced from said outer wall and with heat-insulating barrier intermediate said inner and outer walls, a boss projecting from said inner wall and a heat-insulating member intermediate said inner and outer walls and positioning them in spaced-apart relationship; a second open-ended double-walled housing within said container having outer wall supported by the container and inner wall spaced from said outer wall and with heat-insulating barrier intermediate said inner and outer walls, a boss projecting from said inner wall and a heat-insulating member intermediate said inner and outer walls and positioning them in spaced-apart relationship; said container maintaining the double-walled housings in said axial alignment and the open ends thereof in substantially abutting relationship with each other.

2. The apparatus of claim **1** wherein one of said housings has a double-walled portion of reduced diameter projecting into and enclosed by an overlapping double-walled portion of the other housing.

3. The apparatus of claim **2** having cooling means disposed in said housing having the reduced diameter portion for maintaining the explosive device at a temperature within a preselected temperature range.

4. The apparatus of claim **3**, wherein said cooling means includes a mixture of ice and water.

5. The apparatus of claim **4** wherein said cooling means is cooled at an initial temperature substantially below freezing.

6. The apparatus of claim **1** wherein said heat-insulating barrier includes an evacuated passageway between the double walls of said first and second housings.

7. The apparatus of claim **6** wherein said heat-insulating barrier includes a multilayered insulation.

8. The apparatus of claim **7** wherein said insulation comprises reflective metal radiation shields separated by low-thermal-conductivity spacers.

9. The apparatus of claim **1** wherein said housing walls are made of stainless steel.