ABSTRACT OF THE DISCLOSURE

Drilling a borehole, locating a casing in the borehole, filling the space between the casing and the borehole with grout, underreaming a large borehole beneath the grout, underreaming the large borehole, filling the large underreamed borehole with additional grout that binds with the previously underreamed grout, drilling a small borehole from the casing into the added grouting and underreaming the small borehole but leaving a wall of grout to form a lined cavity.

The invention disclosed herein was made under, or in the course of a Contract W-7405ENG-48 with the United States Atomic Energy Commission.

DESCRIPTION OF THE INVENTION

The invention relates to a method for constructing a lined underground cavity, and more particularly it relates to a method adaptable for simple remote construction of an underreamed and integrally grouted cavity. It is necessary in preparing for an underground explosion of an atomic device that an underground waterproof room be constructed for location of the device and its associated equipment. In prior methods of construction of such rooms, a casing is sunk, and then workmen are lowered into the casing for cutting through it to hollow out a cavity. The cavity is then lined with a material for strengthening the cavity and for making it waterproof. Because of the extensive manual labor required and the inherent dangers of working underground, such methods are found to be expensive and hazardous. It is preferable therefore that the construction of underground cavities be done remotely, with the workers above ground at all times.

SUMMARY OF THE INVENTION

The invention is a simple, safe and economical method for constructing a lined underground cavity. The process in brief includes the steps of securing a casing in a borehole by grouting, underreaming the casing, filling the underreamed region with additional grouting, and then drilling in through and underreaming the added grouting, thereby forming a room having a lining formed of the grouting. By using a structurally strong grouting that is impervious to water, the resulting room is waterproof and is suitable for on-site storage of an atomic device and its associated equipment prior to an underground atomic event.

Such cavities also have other uses; for example, the cavities may be made very deep and used for storage of various fluids such as natural gas storage.

It is an object of the invention to remotely construct a lined underground cavity.

Another object is to reduce the cost and hazard of constructing a lined underground cavity.

Another object is to simply, safely, and economically construct a large structurally reliable waterproof underground cavity.

Other objects and advantageous features of the invention will be apparent in a description of a specific embodiment thereof, given by way of example only, to enable one skilled in the art to readily practice the invention, and described hereinafter with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cross-sectional diagram of an initial borehole that is made during construction of a lined underground cavity according to the method of invention.

FIG. 2 is a cross-sectional diagram of a casing grouted in the hole of FIG. 1.

FIG. 3 is a cross-sectional diagram of a borehole drilled through the grouting of FIG. 2.

FIG. 4 is a cross-sectional diagram of a borehole underreamed below the grouting casing of FIG. 3.

FIG. 5 is a cross-sectional diagram of a cavity formed by underreaming the borehole of FIG. 4.

FIG. 6 is a cross-sectional diagram of the cavity of FIG. 5 after being filled with added grouting material.

FIG. 7 is a cross-sectional diagram of a small borehole through the grouting shown filled with the cavity of FIG. 6.

FIG. 8 is a cross-sectional diagram of a lined underground cavity formed by further removal of the grouting of FIG. 7 by underreaming.

DESCRIPTION OF AN EMBODIMENT

First, it is preferable that a conductor pipe 11 (FIG. 1) be grouted in a large shallow hole 12 for support of heavy equipment for drilling the deeper holes required in the method of the invention. Next a borehole 10 is drilled and a casing 14 (FIG. 2) is centered in the hole 10 with the upper end extending above the earth's surface. The space between the casing 14 and the hole 10 is filled with a grouting material 16 which may, for example, be a thin mixture of neat cement comprised of high-strength synthetic fibers added to a dry bulk cementing mixture before the addition of water. Suitable fibers for such a mixture may be nylon fiber filaments chopped short (about 3/4 to 5/8) in a ratio of 1/10 to 10/1 of fibers in the dry cement mixture. Conveniently, the mixture may be made sufficiently thin to be forced downward through the center of the casing 14 and into the hole 10 until the hole is completely filled to the surface of the earth.

The next step of the method is to drill a borehole 17 (FIG. 3) through the grouting material 16 at the lower end of the hole 10 and then to underream the grouting material and the earth beneath the hole 10 thereby extending the hole 10 to a lower region 18 (FIG. 4). At the level at which it is desired to construct the lined underground cavity, the lower region 18 is underreamed to form an enlarged unlined cavity 20 (FIG. 5).

In the next step of the method, additional grouting material 22, which may be the same as the material 16 previously described, is forced down the center of the casing 14 to completely fill the region 18 (FIG. 6) and the space of the enlarged cavity 20. The filling of the cavity 20 with the added grouting material 22 brings the material 22 into contact with the grouting material 16 previously poured into the hole 10. Such contact permits the two groutings upon setting to bind together as an integral unit. At the end of this step, the holes 10, 18 and 20 are completely filled with grouting material as shown in FIG. 6.

In the next step of the method, a borehole 24 having the diameter of the casing 14 is drilled from the lower end of the casing into the lower region 18 as shown in FIG. 7.

In the final step of the method, the grouting material 22 in the region of the enlarged cavity 20 is further removed by underreaming to an extent less than the cavity 20, thereby forming a room 26 (FIG. 8) having a lining 28 comprised of a wall of the grouting material 22.
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By using a structurally strong grouting material, as described, that also is impervious to water, the room 26 is formed by walls that are integral and continuous to the lower part of the casing 14 where the grouting 22 is bound to the grouting 16 thereby forming a sealed underground room such as may be used for storage of an atomic device and its associated equipment.

For other uses, such as storage of natural gas, it may be desirable to extend the cavity 20 into the lower region 18 thereby providing for a larger storage space 26; or alternatively, the step of forming the cavity 20 may be omitted and the hole 24 with a wall 30 may be extended to very deep levels, for example 4500 feet, to provide for storage of the gas entirely within the hole 24.

While an embodiment of the invention has been shown and described, further embodiments or combinations of those described herein will be apparent to those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. A method for constructing a lined underground cavity, comprising the steps of:
   (a) drilling a first borehole;
   (b) securing a casing in said borehole with grouting material;
   (c) drilling and underreaming a second borehole beyond the lower end of said casing;
   (d) filling said second borehole with a liquid lining material and allowing it to set; and
   (e) removing a portion of said set lining material from said second borehole by drilling and underreaming to form said cavity to have a diameter greater than the diameter of said casing and to have an integral wall of said lining material.

2. The method of claim 1, wherein the step of drilling and underreaming said second borehole includes underreaming to the extent that the grouting material for said casing is exposed at its lower end, and
the step of filling the second borehole with lining material includes filling the second borehole to a level that the lining material is brought into contact with the exposed grouting material for binding thereto.

3. The method of claim 1, wherein
the step of drilling said second borehole includes underreaming a region below said casing and expanding a portion of the underreamed region by further underreaming, and
the step of removing said lining material from said second borehole includes the step of underreaming the lining material in the expanded portion of said underreamed region.

4. The method of claim 1, wherein
the step of drilling a second borehole beyond the lower end of said casing includes drilling a pilot hole equal to the inner diameter of said casing, underreaming said pilot hole, and expanding at least a portion of said underreamed pilot hole by further underreaming, and
the step of removing a portion of said lining material includes drilling a pilot hole through said lining material equal to the inner diameter of said casing, and underreaming the pilot hole in the lining material adjacent the expanded portion to a diameter less than the expanded portion to form said cavity to have an integral wall of said lining material.

5. The method of claim 1, wherein a large diameter conductor pipe is grouted in a large shallow hole concentric with and larger than said first borehole, prior to drilling said first borehole, for support of heavy drilling equipment.

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