METHOD OF REMOTELY CONSTRUCTING A ROOM

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Filed Jan. 7, 1970, Ser. No. 1,088
Int. Cl. B65g 5/00

ABSTRACT OF THE DISCLOSURE

A method of constructing a room deep within the earth by personnel at the surface. A dual wall bladdr of a watertight, pliable fabric material is lowered down a shaft into a selected position. The bladder is filled with a concrete grout while a heavy fluid having essentially the same density as the grout is maintained on both sides of the bladdr to facilitate complete deployment of the bladdr by the grout to form a room of desired configuration.

BACKGROUND OF THE INVENTION

The invention described herein was made in the course of or under Contract AT(26-1)-193 with the U.S. Atomic Energy Commission.

This invention relates to the testing of nuclear explosives, and more particularly to a method of constructing a room or chamber deep within the earth for the emplacement of a nuclear explosive device preparatory to its detonation. Even more particularly, this invention relates to a method which enables such an emplacement room to be remotely constructed by personnel located at the surface of the earth.

In recent years the underground testing of nuclear explosives has played a very important part in their development. To fully contain the radioactive materials produced by the detonation of a nuclear explosive, the nuclear device is emplaced below the surface of the earth at a distance sufficient to contain its explosive force. Since the physical size of a device and the depth of burial required to contain its explosive force increases as the explosive yield increases, the testing of nuclear devices of high explosive yield has required that cavities of relatively large size be provided at considerable distances below the surface of the earth for the pre-detonation emplacement of the device. The construction of an essentially watertight chamber or room in the cavity is generally required for the actual emplacement of the device.

Such cavities have been provided in the past by drilling a hole the diameter of the required emplacement cavity to the entire emplacement depth by rotary drilling methods. When it is realized that nuclear explosives in the yield range equivalent to a megaton or more of TNT have required emplacement rooms 16 or more feet in diameter at distances greater than 5000 feet below the surface, and that the entire length of the drilled shaft must be very carefully stemmed by a specialized stemming material prior to detonation, it can be appreciated that this method would be extremely expensive for emplacement of devices within that and larger yield ranges.

As a step toward reducing these expenses, cavities for such emplacement rooms have been excavated by miners with hand tools at the bottom of relatively smaller diameter shafts drilled by rotary drills. The rooms themselves were then constructed from structural concrete poured into forms constructed by hand down hole in the excavated cavity. It can be appreciated that the bottom of a 5000-foot hole is a very difficult and potentially dangerous working environment for miners excavating a cavity and constructing such emplacement room. It is not uncommon to encounter large quantities of subterranean water that not only increase the difficulties and hazards related to construction of the room but necessitate that the room be made waterproof by some means. It is well known that common portland cements develop shrinkage cracks which would allow seepage into a room constructed therefrom. The room itself may need to be of sufficient strength to withstand hydrostatic and ground pressure in excess of several thousand pounds per square inch.

An improvement in these procedures has been to excavate the enlarged cavity for the emplacement room at the bottom of a drilled shaft by use of expansible underreamers of the general type well known in the well drilling art. The underreamer is sent down hole attached to a drill string and its expansible arms operated from the surface of the ground to enlarge the drilled hole at the desired depth to form the emplacement room cavity. However, this still leaves the construction of the room itself in the underreamed cavity to be accomplished by workmen sent down hole.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a method for remotely constructing a room in a position some distance from the surface of the ground. It is a further object of the invention that the room so provided be sufficiently strong and waterproof to be a satisfactory enclosure for the entry of personnel and material for purposes such as the pre-detonation emplacement of a nuclear explosive.

Briefly summarized, the above and other objects of the invention are obtained by a method wherein a dual wall bladdr is utilized as a form for receiving a grout of structural concrete which upon curing will provide the desired enclosure for use as an emplacement room. The bladdr is attached to the exterior of a support, such as a section of drill string casing, which is lowered into the shaft while the bladdr is in an essentially collapsed posture around the casing. When in the desired position, the bladdr is filled with grout while a weighted fluid having essentially the same density as the grout is maintained on both sides of the expanding bladdr. The weighted fluid minimizes any tendency of the bladdr to sag (or float) during the filling step and thereby facilitates complete deployment of the bladdr by the grout into its expanded configuration to form a room of proper configuration. It also minimizes the stresses placed upon the fabric walls of the bladdr. After sufficient curing of the concrete within the walls of the bladdr, the weighted fluid is removed from the interior of the bladdr. The compartment formed within the inner bladdr wall is then opened up to provide the emplacement room. Prior to opening up the room, the heavy fluid surrounding the exterior of the bladdr may be replaced with concrete in order to structurally relate the emplacement room to the walls of the shaft.

The above and additional objects and advantages will appear and the summarized explanation of the invention understood from the following description of a preferred embodiment of the invention, the most novel features of which will be particularly pointed out hereinafter in the appended claims.

BRIEF DESCRIPTION OF DRAWING

The single figure of drawing is a sectional representation of a partially completed emplacement room constructed in accordance with the invention with associated down hole apparatus shown, partially in schematic.
DESCRIPTION OF PREFERRED EMBODIMENT

Referring now more specifically to the drawing, a section of drill string casing 10 which has been adapted to serve as a support structure for dual wall bladder 12 is shown in position down drill shaft 14 for expansion of bladder 12 into enlarged cavity 16. Bladder 12 is shown in a partially filled condition obtained in a manner to be explained hereinafter. Bladder support casing section 10 is fastened onto the terminal end of conventional drill string 11 which extends to the surface of the earth, not shown. Outer and inner walls 18 and 20 of bladder 12 are fastened onto flanges 22, 23, 24 and 25 of casing 10. Centering guides 26 and 28 are of sufficiently larger diameter than the flanges to permit the bladder to be contained within the outer extremities of the centering guides when in a collapsed or undeveloped posture.

The walls of bladder 12 are made from an essentially watertight pliable material such as a neoprene coated fabric made from polyester fibers. Longitudinally extending fabric webbing, not shown, between the walls increases the structural strength of the bladder.

Within and near the bottom of casing 10 is a cementing tool 30 which consists of an assemblage of valves and distribution conduits which provide the means by which the fluids at the surface of the earth are distributed into various compartments defined by the apparatus and the shaft walls in a manner well known in the well cementing art. The particular functions and sequence thereof which are schematically illustrated on the drawing by valves 36, 38, 40, 42, 44 and 46 will be further described hereinafter. The upper end of cementing tool 30 terminates in fitting 32 having an enlarged, tapered opening for receiving cementing string 34. Cementing string 34 extends to the surface of the earth where various fluids are introduced and pumped down to the cementing tool 30 and distributed in the manner to be described.

Looking now to the sequence of operations by which the emplacement room is constructed, after excavation of shaft 14 and enlarged cavity 16 by any suitable means, such as by rotary drilling and underreaming, a drill string 11 having bladder support casing 10 attached to the lower end thereof is lowered into the desired position. Dual wall bladder 12 is in an essentially collapsed posture during the lowering of casing 10, preferably folded or otherwise packaged about casing 10 within the outer extremities of centering guides 26 and 28. Straps or other suitable means, not shown, either releasable from the ground surface or in response to pressure buildup within the bladder upon entry of grout therein may assist in holding the bladder in the folded condition. Under some combinations of hole and bladder parameters, it may be desirable, or necessary, to reduce tensile or flexural loading which would be induced into the bladder fabric by the action of hydrostatic pressure on air pockets in the packaged bladder. This may be accomplished in connection with packaging the bladder either by removing air from the bladder by subjecting it to a vacuum or by using a small amount of an essentially incompressible fluid such as water within the various internal fabric compartments. In the event formation water or drilling fluid is present in the hole, water may be loaded into casing 10 from the ground surface, or fluid in the hole permitted entry into casing 10 through conduits 48 and 50 and valve 36.

When casing 10 is in position, the space between casing 10 and the walls of shaft 14 may be regarded as being divided into three compartments by dual wall bladder 12. Accordingly, for ease of reference hereinafter, first compartment 52 is defined as being delimited between the outside surface of outer bladder wall 18 and the walls of shaft 14 up a height sufficient for fluid filling the compartment to completely surround bladder 12. Second compartment 54 is delimited by the inner surface of inner bladder wall 20 and the outer surface of casing 10, and third compartment 56 is defined between walls 18 and 20 of bladder 12.

With casing 10 in position, cementing string 34 is stabbed into fitting 32 of cementing tool 30 to provide fluid communication with the surface of the ground. A heavy fluid having a density approximately the same as the grout of the concrete which will be used to fill bladder 12, as will be explained, is introduced into cementing string 34 and enters first compartment 52 through conduit 48. Since the heavy fluid is selected to be of a greater density than the formation water or any drilling fluid that may be present in compartment 52, such water or drilling fluid will be displaced upwardly out of the first compartment.

The manipulation of valves 36 and 38 to close conduit 50 and place conduit 48 in fluid communication with cementing string 34, and more generally, the manipulation of valves 36, 38, 40, 42, 44 and 46 may be by any conventional means. However, those familiar with the well cementing art, and cementing tools generally, will appreciate that the manipulation of slidable valve operators to block or unblock ports in valve bodies by the action of the pressure of the fluid passing through the cementing string on hydraulic piston surfaces on either the operators themselves or on plugs pumped down the cementing string with the fluid and wedged into the operators, is a well developed art. Accordingly, the use of valves similar to those commonly used in the cementing tool art is considered to be preferred.

Heavy fluid is next introduced into second compartment 54 through conduit 58 by manipulation of valve 40. After the total volume of heavy fluid in the first and second compartments is sufficient to fill them after total deployment of the bladder—a volume that can be readily established, for instance by well logging prior to casing 10 being lowered into shaft 14—the flow of heavy fluid is discontinued. The grout is then pumped into third compartment 56, i.e., bladder 12, through conduit 60 and valve 42. The drawing illustrates this step in a stage of partial completion.

During the filling of bladder 12 with grout, first and second compartments 52 and 54 are in fluid communication through conduits 62 and 64. Accordingly, the pressure on either side of the bladder is equalized while the bladder is being filled. This minimizes the tendency of the bladder to sag (or float) during filling thereby assuring that it will be fully expanded into proper configuration by the grout and that the fabric will not be overstressed by the weight of the grout. As the drawing suggests, the relative volumes of first compartment 52 and second compartment 54 will change as the bladder is expanded, and heavy fluid will flow from the first compartment to the second as the bladder assumes the fully deployed posture illustrated in the drawing by the lower portion of the bladder.

It will be appreciated here that it is not necessary that the steps regarding filling of the three compartments be followed in the precise sequence just outlined. The important consideration is that as the grout proceeds to fill bladder 12 the weight of the grout is transmitted to and supported by the heavy fluid in compartments 52 and 54. This could be accomplished by simultaneously filling two or more of the three compartments, although somewhat different arrangements of apparatus than that illustrated on the drawing would be required.

Water or other liquid that may have been used in the bladder to facilitate its packaging preparatory to its being lowered down hole will be displaced upwardly and exhausted from the bladder through conduit 66. A check valve, not shown, in conduit 66 will prevent undesired backflow of heavy fluid into the bladder. The pumping of grout into the bladder is continued until bladder 12 is filled with grout and a small differential pressure established between the bladder and the two compartments filled with heavy fluid.
While the structure of the emplacement room itself will be complete upon curing of the grout in bladder 12, in most instances it will be desirable, if not necessary, to replace the heavy fluid in first compartment 52 with a material such as concrete that will structurally relate the emplacement room to the geologic formation. It will be appreciated that if this is not done a buoyant force will be placed upon drill string 11 upon removal of the heavy fluid from compartment 54 preparatory to opening up the emplacement room. By formulating the grout for such structural concrete such that its density is greater than that of the heavy fluid in the first compartment, pumping it directly into chamber 52 will displace the heavy fluid upwardly along shaft 14 beyond the defined limits of compartment 52. This second, heavier grout can be introduced into cementing string 34 immediately after the first grout and made to flow into outer compartment 52 through conduit 68 by manipulation of valve 44.

While selection of the concrete mixtures will be determined by strength requirements for the particular application, a concrete mixture comprising 3 parts by weight cement to approximately 1 part each of sand and water and less than 1/6 of 1% of a commercially available fluidizer has been found to be quite satisfactory for constructing the emplacement room per se. This mixture had a density of 18.2 lbs./gal. The second, heavier grout used in compartment 52 was weighted with sand to raise its density to about 19 lbs./gal. The heavy liquid of 18.2 lbs./gal. density was composed of the following mixture of components:

Water—.6 bbl.
Wyoming bentonite clay—13 lbs.
Barite—300 lbs.
Ligino-sulfonate clay disperser—.3 lb.

After the concretes in the compartment 52 and within bladder 12 have cured to develop sufficient strength, the fluids in inner compartment 54 and casing 10 may be pumped out through conduits 72 and 74 and cementing string 34 after appropriate manipulation of valve 46. Cementing string 34 is then disconnected and withdrawn from shaft 14. A portion of casing 10 can then be cut away from the remainder by a milling tool attached to a small diameter drill string lowered down hole and operated from the surface and lifted out of the hole. A reduced diameter portion 76 of casing 10 facilitates this removal.

Thus, the concrete walled emplacement chamber is ready for receipt of men and materials from the surface of the earth for the emplacement of a nuclear explosive device. In addition to having provided the form for the concrete grout during construction, the waterproof walls of the bladder now also assure that the emplacement chamber remains dry by preventing the entry of formation water therein. It will be understood that various changes in the details herein described and illustrated in order to explain the nature of the invention may be made by those skilled in the art within the scope of the invention as expressed in the appended claims.

What is claimed is:

1. A method of constructing a room of structural concrete at a selected position along a shaft some distance below the earth's surface, said method comprising lowering a support structure into the shaft to a position where an expansible dual wall bladder attached to the exterior thereof in an essentially collapsed posture can be expanded at said selected position, filling a first compartment defined by the outside of the bladder and the shaft wall with a fluid of a predetermined density heavier than water, filling a second compartment the outer limits of which are defined by the inner wall of said dual wall bladder with said fluid, and filling said dual wall bladder with a grout of structural concrete having said predetermined density.

2. The method of claim 1 further comprising thereafter essentially completely displacing said fluid from said first compartment with a grout of a structural cement having a density greater than said predetermined density.

3. The method of claim 2 further comprising thereafter removing said fluid from said second compartment and removing a portion of said support structure from within said second compartment.

4. The method of claim 1 further comprising the step of establishing fluid communication between said first and said second compartments while filling said bladder with grout.

5. The method of claim 1 wherein said selected position is within an enlarged cavity located at essentially the bottom of a shaft of smaller cross section.

6. The method of claim 5 further comprising the steps of drilling said shaft and underreaming said enlarged cavity from the surface of the earth prior to lowering said support structure thereinto.

7. The method of claim 1 wherein said support structure is a section of drill string casing at least a portion of which is of smaller diameter than the remainder of said drill string casing.

8. The method of claim 4 further comprising thereafter essentially completely displacing said fluid from said first compartment with a grout of structural cement having a density greater than said predetermined density.

9. The method of claim 8 further comprising thereafter removing said fluid from said second compartment and removing a portion of said support structure from within said second compartment.

10. The method of claim 9 wherein said selected position is within an enlarged cavity located at essentially the bottom of a shaft of smaller cross section and further comprising the steps of drilling said shaft and underreaming said enlarged cavity from the surface of the earth prior to lowering said support structure thereinto.

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U.S. Cl. X.R.
52—2, 169; 61—41 R, 53.6; 64—35, 314