

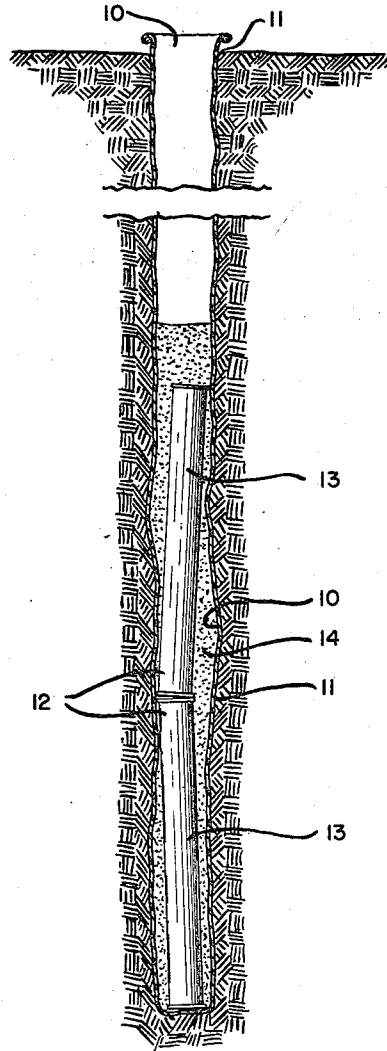
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METHOD AND APPARATUS FOR CHARGING BOREHOLES

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METHOD AND APPARATUS FOR CHARGING BOREHOLES

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This invention relates to explosives and methods of using explosives and particularly to liquid oxygen explosives and methods of loading blast holes with liquid oxygen explosives which improve the safety and the blasting efficiency of these explosives.

In the use of liquid oxygen explosives, a suitable carbonaceous absorbent is packaged in a bag or wrapper, usually of canvas, with a paper liner within the bag to provide better dimensional stability to the cartridge. Liquid oxygen is added to the cartridge by soaking in the liquid in a suitable container in which the saturated cartridge may be temporarily held prior to use. The required number of saturated cartridges, together with a detonation initiator are placed in the drill hole in the material to be blasted and initiated by any conventional means. Since liquid oxygen explosives are currently used only in large-scale open-pit blasting, the cartridges, formed as indicated, may be quite large, typically range in size from about three to eight inches in diameter by about twenty-one inches in length and used in considerable number.

In blasting with liquid oxygen explosives better explosive performance is obtained by using as large a diameter cartridge as can be loaded in the drill hole without undue difficulties. However, two factors combine to lower the practical limit of cartridge diameter with respect to drill hole diameter. The cartridge is somewhat susceptible to deformation; and, the drill hole, particularly in passing through soft or poorly consolidated strata, may have slight constrictions or projections. As a result, one of the most troublesome problems in the use of liquid oxygen explosives is the frequency of cartridges becoming stuck in the drill hole during the loading operation. This interrupts and delays completion of the loading operation until the stuck cartridge can be dislodged. In some cases the drill hole is abandoned because of the hazard of dislodgement, but this is highly unsatisfactory from the standpoint of efficiency.

A characteristic feature of these liquid oxygen explosives is that upon removal of the liquid oxygen saturated cartridge from the soaking container, it begins a continuous loss of oxygen by vaporization until the cartridge is detonated or all of the liquid is vaporized. The cartridge is designed to absorb an appreciable excess of liquid oxygen over that required for complete combustion to allow for oxygen losses during the loading operation. The time interval required for the cartridge to lose a quantity of oxygen equal to this excess is commonly known as the cartridge life and is generally considered as the maximum time interval which should be taken in loading and firing a blast. The actual value of this time interval or cartridge life varies with cartridge size, type and packing density of absorbent and environmental factors.

In modern open-pit blasting it is the usual practice to blast in multiple-hole series. In using liquid oxygen explosives, the cartridge life severely limits the number of holes which can be successively loaded and fired in a single blast. This emphasizes the importance of rapid and uninterrupted loading procedures. However, a variety of uncontrolled factors associated with the progressive loss of oxygen from the cartridge including delays in loading are closely related to relative safety and blasting effectiveness of these explosives. In utilizing the cartridge life for successively loading a series of holes for a multiple-hole blast, these factors may be accentuated to a degree

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which results in serious hazard and appreciable deterioration in blasting effectiveness. These factors may be outlined as follows:

(A) Ideally, the range of oxygen depletion of the cartridges will vary in the same consecutive order as they were loaded; and, if the blast is executed within the known time limit, even the first hole loaded will have sufficient oxygen available for essentially complete combustion. However, the explosive strength will vary inversely with the degree of oxygen depletion for the following reasons.

(1) Oxygen vaporization from the cartridge results in a thickening outer shell of highly oxygen depleted absorbent around a diminishing core of oxygen rich absorbent.

(2) The functional dependency of explosive strength upon density results in appreciably better strength for the cartridges retaining the most excess oxygen.

(B) Oxygen depletion of cartridges under typical operating conditions may frequently go below the minimum needed for complete combustion. Loading cartridges in holes containing water greatly accelerates the rate of vaporization. Unanticipated delays in completing the loading operation such as those incident to dislodgement of stuck cartridges commonly result in oxygen depletion below the level needed for complete combustion of some or all cartridges of the series previously loaded.

When the blast is executed with some of the charges going below the minimum oxygen level for complete combustion, increasing volumes of carbon monoxide occur in the detonation products. While the production of significant concentrations of carbon monoxide in the detonation of the oxygen deficient explosive is well known, it has not been generally recognized that carbon monoxide in the detonation products of open-pit blasting with liquid oxygen explosives constitutes a serious blasting hazard. In fact, the literature on the subject leads one to the opposite conclusion. However, a study of accidents and recent field incidents, shows conclusively that carbon monoxide produced in previous blasting, may continue to burn in crevices and channels in the blasting area for extended periods of time, and, thereby constitute a source of accidental preignition during loading of the next round.

Under conditions of small to moderate oxygen deficiency, there will be a continuing progressive deterioration of explosive strength as previously described.

The present invention provides an explosive charge and a method of loading a blast hole which greatly minimizes the hazards which have heretofore been made common in the use of liquid oxygen explosives due to (a) carbon monoxide in the detonation products, (b) frequency of stuck cartridges in loading the bore-hole and (c) the extremely high flame susceptibility of liquid oxygen explosive in the bore-hole. At the same time, the present invention improves the blasting efficiency of liquid oxygen explosive to a high degree.

I provide an explosive charge having preferably a liquid oxygen explosive whose diameter is smaller than the smallest portion of the bore-hole and which has been saturated with liquid oxygen in the usual manner. This cartridge is surrounded in the bore-hole with free flowing ammonium nitrate or mixtures of ammonium nitrate and carbonaceous material having an excess quantity of available fixed oxygen. By my method I preferably insert a conventional liquid oxygen explosive cartridge into the bore-hole and pour free flowing ammonium nitrate or a mixture of ammonium nitrate and carbonaceous material having an excess quantity of available fixed oxygen into the hole around the liquid oxygen cartridge. This is repeated with as many cartridges as are necessary for the size of the hole and the blasting practice being followed.

It is known that ammonium nitrate is detonable at relatively low velocity in large diameter charges under

heavy confinement. I have found, however, that under the thermodynamic conditions of detonation of liquid oxygen explosive in a drill-hole that a thin-walled concentric sheath of free flowing ammonium nitrate in contact with the charge of liquid oxygen explosive will detonate at relatively high velocity, exactly opposite from its usual behavior. I have found that the excess oxygen thus released by the ammonium nitrate detonation will react in secondary reactions with the excess combustible components from the primary detonation reaction of the liquid oxygen cartridge. The net result of the secondary reactions is a greater release of explosive energy under more favorable conditions for transmitting it to the medium to be blasted.

While the foregoing disclosure is valid with common ammonium nitrate, in practice, I find it advantageous to admix, in the form of a coating on the ammonium nitrate, a quantity of a carbonaceous material such as carbon black, lampblack, finely divided graphite, coal dust or other finely divided carbonaceous fuel only sufficient to impart good free flowing qualities and a slight degree of sensitization but not sufficient to change the character of the composition in the sense that its products of combustion shall contain an excess of available oxygen. On the basis of the stoichiometry of pure carbon and pure ammonium nitrate, the admixed properties of carbonaceous material must be significantly less than seven and one-half percent by weight of the ammonium nitrate. For most conditions, I prefer to use the equivalent of not over 3.5 percent admixed carbon; however, this is subject to revision depending upon the ratio of liquid oxygen explosives to ammonium nitrate composition and the anticipated oxygen condition of liquid oxygen explosives at time of firing. In the event that the size of the cartridge is reduced to a diameter which is only a fraction of the diameter of the bore-hole and a relatively thick sheath of ammonium nitrate is added, a larger percentage of carbonaceous material may be included in the ammonium nitrate admixture. In any event, however, there should remain sufficient ammonium nitrate in excess of carbonaceous material to provide an excess of available oxygen. It is essential to the object of this invention that the ammonium nitrate composition be over-oxidized and yield sufficient available oxygen for interaction with the oxygen deficient liquid oxygen explosive.

The free flowing composition may be placed in the annular space around the cartridge by any conventional means. I prefer to accomplish this by measured or pre-packaged increments alternately poured into the hole with each cartridge loaded. The size of the increment is predetermined from the relationship of unit cartridge volume to the volume of a corresponding length of the drill hole.

I have found that the excess oxygen of the composition I have specified, loaded as indicated, will compensate, in chemical reactions of detonation, a corresponding oxygen deficiency of the liquid oxygen explosive. Thus the formation of carbon monoxide as a product of detonation in moderately oxygen deficient liquid oxygen explosives is suppressed. I have found that such compositions, loaded as indicated, greatly increase the blasting effectiveness of liquid oxygen explosives. I have further found that the former criticality of using the largest practical cartridge diameter with respect to that of the drill hole to secure high performance does not apply to liquid oxygen explosives blasting utilizing the processes of this invention. As a result, under most field conditions, the cartridge diameter may be sufficiently reduced to eliminate the troublesome and hazardous problem of stuck cartridges while providing an increase in the blasting effectiveness of the charge as compared with conventionally loaded liquid oxygen explosives. Eliminating the problem of stuck cartridges with their attendant indeterminate delays, enables closer adherence to critical time limits in loading multiple-hole shots and results in safer loading and more uniform and effective blasting.

I have also found that the practice of my invention permits the use of carbonaceous liquid oxygen absorbents of higher density than can be conventionally used. Many of these higher density liquid oxygen absorbents are much cheaper and have greater blasting power than the materials conventionally used but their low level of oxygen absorbency has made them impractical because of their short life. My invention overcomes this undesirable short life and makes it possible to take advantage of the greater blasting power and economy of such higher density carbonaceous materials.

I have found that the nondetonatability to any conceivable causal mechanical stimulus, the very low ignition susceptibility to sparks or transient flame and the relatively slow rate of burning of the ammonium nitrate compositions specified, very markedly reduce these hazards in relation to the highly susceptible liquid oxygen explosive. These gains in safety are obvious from the fact that the cartridge of liquid oxygen explosive, loaded in the drill hole with such compositions as directed, is virtually isolated from these influences. Also, with reduction in the cartridge diameter with respect to that of the bore-hole, which this invention makes practical, if the cartridge, should become accidentally ignited, it would have a somewhat reduced tendency to detonate, thus tending to provide escape time for personnel working at the mouth of the drill hole.

I have found that where water is present in the bore-hole an expansible liner of plastic or like material may be used as illustrated in the accompanying drawing showing a section through a blast hole. In the drawing I have shown an expansible liner 10 in an irregularly shaped bore-hole 11. A charge 12 of liquid oxygen is placed in a non-expansible liner 13 axially of the bore-hole. Free flowing ammonium nitrate 14 is poured into the expansible liner 10 around the liner 13 surrounding the liquid oxygen cartridge. As will be seen in the drawing, water in the bore-hole is excluded from the ammonium nitrate and from the liquid oxygen cartridge resulting in a longer life for the cartridge and a better and more satisfactory coupling between the cartridge and the walls of the borehole than is the case in conventional liquid oxygen explosive practice.

While I have illustrated and described certain presently preferred practices of my invention, it will be understood that it may be otherwise embodied within the scope of the following claims.

I claim:

1. A method of loading a blast-hole comprising the steps of forming an axial core of liquid oxygen explosive and filling the space between said core and the blast-hole wall with an ammonium nitrate composition having an excess of available oxygen.

2. A method of loading a blast hole comprising the steps of forming an axial core of liquid oxygen explosive in the blast-hole spaced from the blast-hole wall, and filling the space between said core and the blast-hole wall with an admixture of finely divided carbonaceous material and ammonium nitrate, said admixture having an excess of ammonium nitrate sufficient to provide an excess of available oxygen for reaction with oxygen deficient liquid oxygen explosive.

3. A method of loading a blast-hole comprising the steps of forming an axial core of a liquid oxygen explosive spaced from the blast-hole wall, filling the space between the said axial core and the blast-hole wall with an admixture of ammonium nitrate and finely divided carbonaceous material selected from the group consisting of lamp black, carbon black, finely divided coal and finely divided graphite, said admixture having an excess of ammonium nitrate sufficient to provide an excess of available oxygen for reaction with oxygen deficient liquid oxygen explosive.

4. A method of loading a blast-hole comprising the steps of inserting successively liquid oxygen explosive

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cartridges into a blast-hole generally axially thereof and spaced from the blast hole wall and successively filling the space between each cartridge and the blast-hole wall with an ammonium nitrate composition having an excess of available oxygen.

5 5. A method of loading a blast-hole comprising the steps of inserting successively liquid oxygen explosive cartridges into a blast-hole generally axially thereof and spaced from the blast-hole wall and successively spacing each cartridge from one another with an ammonium ni- 10 trate composition having an excess of available oxygen and simultaneously filling the space between each cartridge and the blast-hole wall with the same ammonium nitrate composition.

6. A blasting charge comprising a core of liquid oxy- 15 gen explosive whose diameter is smaller than the internal diameter of a blast-hole into which it is inserted, said core being surrounded by a flowable ammonium nitrate composition having an excess of available oxygen filling 20 the space between the core and the blast-hole wall.

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7. A blasting charge comprising axially spaced liquid oxygen explosive cartridges having a diameter smaller than the diameter of the blast-hole into which they are inserted and surrounded by a flowable admixture of ammonium nitrate and finely divided carbonaceous material in proportions such as to provide an excess of available oxygen.

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