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METHOD OF AND MEANS FOR PROVIDING A CHARGE OF WATER
SENSITIVE EXPLOSIVE IN A BLAST HOLE

3,064,572

Filed Jan. 13, 1958

2 Sheets-Sheet 1

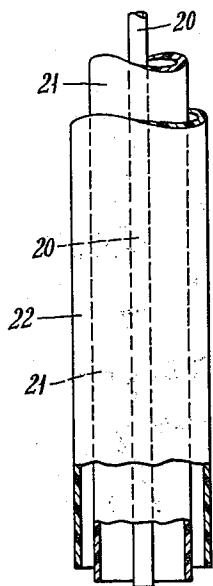


Fig. 1.

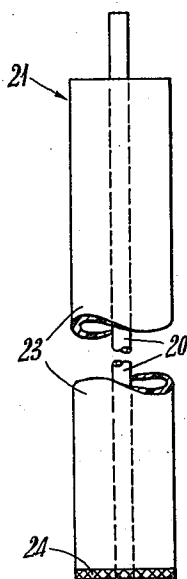


Fig. 2.

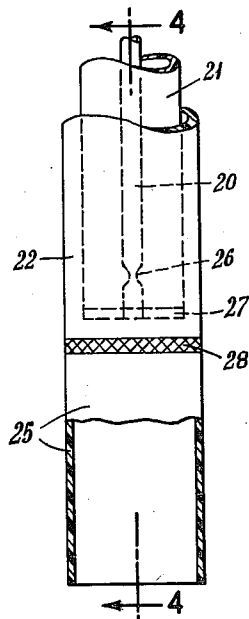


Fig. 3.

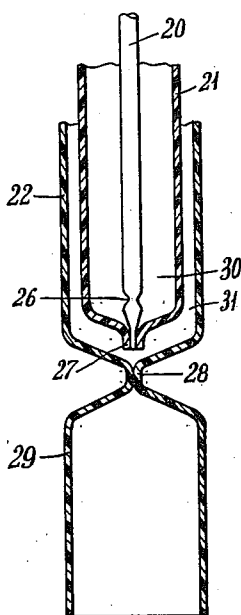


Fig. 4.

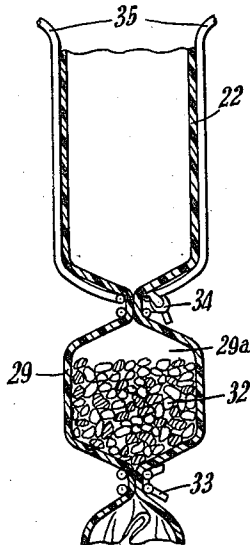


Fig. 5.

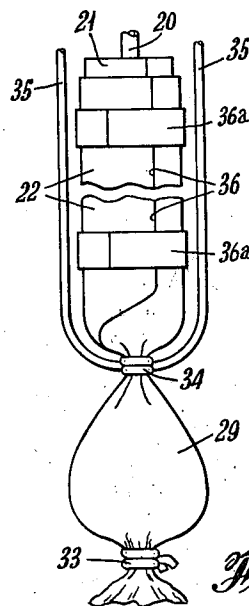


Fig. 6.

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METHOD OF AND MEANS FOR PROVIDING A CHARGE OF WATER
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2 Sheets-Sheet 2

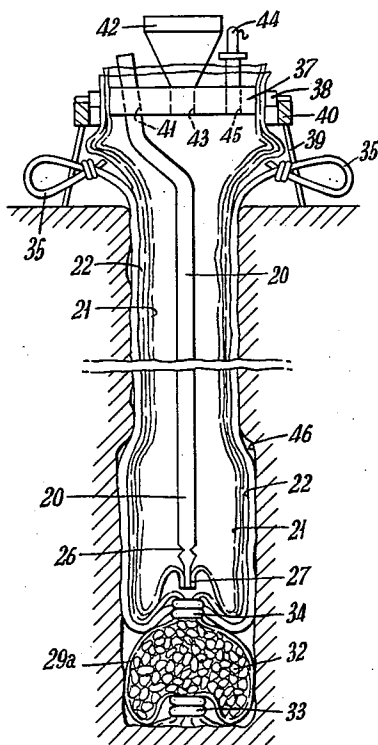


Fig. 7.

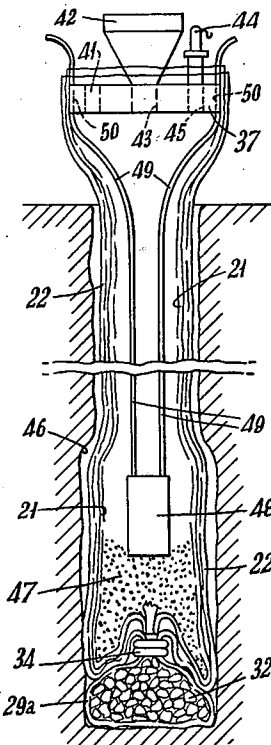


Fig. 8.

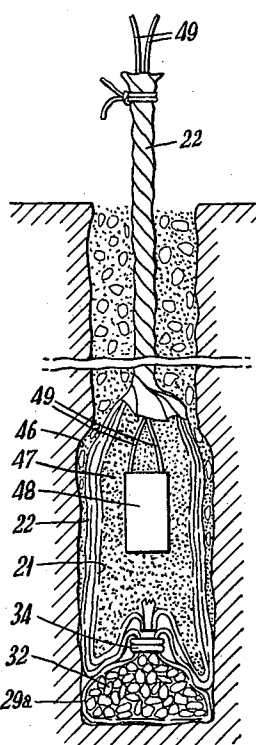


Fig. 9.

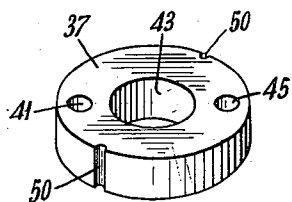


Fig. 10.

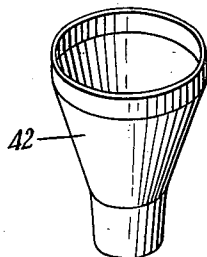


Fig. 13.

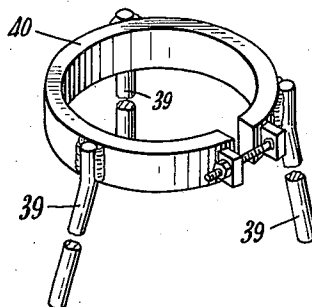


Fig. 12.

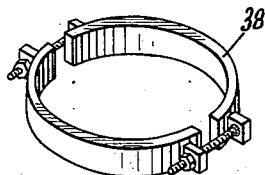


Fig. 11.

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3,064,572

METHOD OF AND MEANS FOR PROVIDING A CHARGE OF WATER SENSITIVE EXPLOSIVE IN A BLAST HOLE**Robert B. Aitchison, New York, N.Y., assignor to Union Carbide Corporation, a corporation of New York**

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2 Claims. (Cl. 102—23)

The present invention relates to a method of and means for providing a charge of water sensitive explosive in a blast hole, and more particularly to a method of and means for charging a water-containing blast hole with a water sensitive explosive.

Blast holes are commonly prepared by air drilling or wet drilling methods, and in some refractory formations of extreme hardness such as in taconite, for example, the hole is jet pierced by means of a hydrocarbon-oxygen high temperature flame. In some cases such holes have been prepared to depths greater than one hundred feet. The holes are charged with conventional cartridges of explosive which are to be detonated in the hole. Certain difficulties are often encountered when such methods are employed. Seepage water has filled such holes to substantial depths; consequently expensive high grade water-proof packed explosives have been used instead of inexpensive water sensitive compounds such as ammonium nitrate and the like. Also, blast holes may be de-watered but rain may completely ruin this work; likewise, any bags of water sensitive explosives that might be stacked near the holes ready for loading may be severely damaged from the standpoint of their use as a blasting agent.

Another disadvantage of the prior art blasting methods is that the walls of the hole are quite often not perfectly regular and could cause a temporary jamming of the explosive cartridge in the hole thereby preventing their insertion to the bottom and forming an air pocket beneath and around the cartridge. It is well known that such air pockets produce a cushioning effect which decreases the blasting efficiency.

One presently used method of charging such blast holes which partially overcomes the aforementioned problems involves the placement of a drill of an inexpensive water-sensitive explosive in a water-impervious flexible plastic bag which is then lowered into the water-containing blast hole for detonation. However, it has been found that such bags are frequently punctured either from physical handling, contact with sharp-wall surfaces within the hole, or by rock tremors from nearby blasts. As a result, water seeps into the bag and at least partially dissolves the water-sensitive explosive, thereby reducing its effectiveness as an explosive.

It is therefore an object of the present invention to provide a method of charging water-containing blast holes with a water-sensitive explosive which does not lose its brisance value by virtue of such charging.

Another object is to provide a method of charging water-containing blast holes with a water sensitive explosive in such a manner that the contour of the hole has no effect on the blasting efficiency.

A further object of the invention is to provide an explosive charge including a granular water sensitive explosive which can be placed in a water-containing blast hole without loss of brisance value.

These and other objects and advantages of this invention will be apparent from the following description and accompanying drawings in which:

FIG. 1 is a side view, partly in cross section of a triple composite plastic tubing assembly according to the present invention;

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FIG. 2 is a view of a section of the inner tubing assembly portion of FIG. 1, to be severed in preparing such assembly for insertion in the blast hole;

FIG. 3 is a view, partly in cross section, of the triple tubing assembly of FIG. 1 after the outer tubing section has been pulled down and transversely sealed;

FIG. 4 is a longitudinal sectional view of the triple tubing assembly taken on line 4—4 of FIG. 3 with each of the tubes transversely sealed according to the present invention;

FIG. 5 is a longitudinal sectional view of the triple tubing assembly of FIG. 4 after weighting material has been placed in the pocket at the lower end of the outer tube, and such pocket has been closed;

FIG. 6 is an elevational view of the triple tubing assembly of FIG. 5 after such assembly has been longitudinally folded and banded together for easy insertion into the blast hole;

FIG. 7 is a view of a longitudinal section through a blast hole into which the triple tubing assembly of FIG. 6 has been lowered and the intermediate tube inflated;

FIG. 8 is a similar view of the triple tube containing blast hole of FIG. 7 after the intermediate tube has been charged with an explosive mixture of the present invention;

FIG. 9 is a similar view of the triple tube containing blasting hole of FIG. 8 after the explosive mixture-containing tube assembly has been primed, sealed, and stemmed;

FIG. 10 is a perspective view looking downwardly on a closure plug for the upper ends of the intermediate and outer tubes;

FIG. 11 is a perspective view looking downwardly on a clamp which fits around the closure plug of FIG. 10 so as to secure the upper ends of the intermediate and outer tubes therebetween;

FIG. 12 is a perspective view looking downwardly on a stool assembly for supporting the closure plug and clamp of FIGS. 10 and 11, respectively; and

FIG. 13 is a perspective view looking downwardly on a funnel which fits into the closure plug of FIG. 10 for charging the explosive mixture into the intermediate tube.

In accordance with the method of the present invention, a water-sensitive explosive is charged in a blast hole by placing therein a hydrophobic explosive mixture encased within a water-impervious flexible plastic container, the mixture comprising the water-sensitive explosive, a liquid hydrocarbon, and a hydrophobic jelling material in an amount sufficient to impart a jelly-like consistency to the liquid hydrocarbon. The jelling material acts as a water-proofing agent which coats the explosive, thus rendering the latter unaffected by accidental leakage of water into the container.

The invention further provides a plastic tubing assembly from which the aforementioned container is formed, and a method of making such assembly and preparing same for use, the tubing assembly including a relatively small diameter inner inflation tube longitudinally within a large diameter tube that is preferably double walled. A length of the tubing assembly is prepared for insertion in the blast hole by transversely severing a section of the intermediate tube along with the corresponding inner tube section, and then transversely sealing the tubes below a gas exit notch of the inner tube. The section of the outer tube below the seal provides a pocket enclosure for a weighting material. The tubing assembly is preferably longitudinally folded for insertion in the blast hole and lowered therein, such assembly being sufficiently long for the upper ends of the tubes to extend out of the hole. Compressed gas is then passed into the intermediate tube

through the gas exit notch of the inner tube and the intermediate tube is inflated thereby to contact the blast hole walls. The aforementioned explosive mixture charge is next introduced into the inflated intermediate tube, followed by at least one primer. The upper end of the inflated intermediate tube is then closed, and the explosive charge is stemmed prior to detonation.

Referring more specifically to the drawings, FIGURE 1 illustrates a triple concentric lay-flat tubing assembly which is used in charging blast holes according to the present invention. The assembly comprises an inner inflation tube 20 which is relatively thin walled, preferably with a thickness of between about 1 mil and 2 mils. The inner tube may have an inside diameter of about $\frac{1}{2}$ to $1\frac{1}{4}$ inches, and a flattened width of about $\frac{3}{4}$ to 2 inches. About this tube is provided an intermediate flexible tube preferably having a wall thickness between about 2 mils and 3 mils, and an inside diameter of from $6\frac{1}{4}$ to 16 inches, or any diameter required by the diameter of the blast hole. The outer tube 22 preferably has a wall thickness between about 2 mils and 3 mils, and an inside diameter large enough to enclose the intermediate tube 21. The tubes 20-22 are formed of flexible water-impervious material, preferably a strong organic plastic such as polyethylene, polyethylene terephthalate, polyvinylidene chloride, and the like, and can be seamless or made of sheet material with longitudinal heat-sealed seams. This triple tubing assembly can be made up in standard lengths or in as long a length as can be conveniently wound on a reel for shipment and ease of handling.

FIGURES 2-6 illustrate the preferred method of preparing the triple-tubing assembly for insertion in the blast hole. About 1 to 2 feet of the end of the outer tubing 22 are transversely folded or turned back on itself to expose a section 23 of the intermediate tube 21. This section along with the contained inner tube is transversely severed along line 24, near the inner tube fold back, and discarded. Removal of the severed section 23 leaves an outer tube skirt 25 at the end of the tubing assembly. The unsevered inner tube 20 is then notched at points 26 near the fold-back. A transverse seal 27 is then made across the inner and intermediate tubes 20 and 21, below the notching 26, at about the severance point. Sealing may be accomplished by means well-known to those skilled in the art, e.g. by heat. This seals off the bottom of the intermediate tube 21 and temporarily anchors the inner tube 20 to the intermediate tube 21. The outer tube is now unfolded and a transverse seal 28 is made across this tube just below the sealing point of the intermediate tube, so as to form a pocket 29 from the skirt 25. This method of construction preferably forms an intermediate tube bag 30 within an outer tube bag 31, which provides greater insurance against water leakage into the explosive charge-containing intermediate bag 30, as described later in more detail. The tubes may alternatively be formed into bags by gathering the ends as required, and tying such ends with string or other fasteners. However, heat sealing is preferred when a heat sealable plastic is used because it insures a quickly obtained, inexpensive leak-tight seal.

The pocket 29 is partly filled with weighting material 32 such as rock granules or a soluble material as herein after described, and the excess skirt material is tied together by suitable means such as cord 33 to form bag-like enclosure 29a. The latter is also preferably tied off at a point near or just below the seals 27 and 28. The cord 34 used for this tie off may be left with one or two ends 35 long enough to extend the full length of the tubing assembly needed for the full depth of the bore hole. Such cords can be used to lower the weighting material-containing tubing assembly into the bore hole so as to lessen the strain on the plastic tubes.

The composite tubing assembly is next preferably longitudinally folded several times as shown in FIGURE 6 to provide a narrow width of final assembly which is

readily lowered into a bore hole without excessive contact with the rough surface of the hole walls. Such folds 36 can be retained by applying bands of paper 36a around the folded assembly or by use of small pieces of pressure sensitive tape, or by the application of a small quantity of suitable adhesive between folds, any of which is released by a slight pressure.

To load or charge a blast hole containing water, it is preferable to limit the amount of water present to no more than about 3 to 5 feet depth from the bottom, and to remove any excess of water by, for example, pumping. If desired, a suitable quantity of water may be poured into an irregularly shaped dry hole to avoid an air baffle which interferes with the shock waves of the blast.

Referring now to FIGURES 7 through 13 which illustrate the method and apparatus for loading or charging a blast hole with a water-sensitive explosive, the folded tubing assembly of FIGURE 6 is lowered with the aid of cords 35 until the weighted bag-like enclosure 29a rests preferably on the bottom of the hole, or seeks its natural level below the surface of the water. The upper edges of intermediate and outer tubes are then pulled around closure plug 37 and pressed against such plug by adjustable ring clamp 38 which is preferably mounted on legs 39 as a stool 40. The inner tube 20 is connected through a small diameter hole 41 in closure plug 37 to a source of pressurized gas, such as air (not illustrated). A charging funnel 42 fits in a larger diameter hole 43 in the closure plug 37, and communicates with a hopper containing the explosive charge (not illustrated). A pressure relief valve 44 communicates with and closes another small diameter hole 45 in closure plug 37. It will be apparent from the foregoing description that the upper ends of the intermediate and outer tubes are separated from the atmosphere.

Compressed gas, e.g., air, is now blown in through inner tube 20 and this air escapes through notches 26 at the lower end thereof into the intermediate tube at a point near the lowest part of the region of tubing assembly which is pressed together by water pressure. This will cause the tubes to be inflated evenly. The paper bands or other medium employed for holding the tubing assembly in the folded condition are easily burst by the air pressure.

When the tubing is inflated so that the outer tube 22 is in substantial contact with the hole walls, including the walls of any enlarged or chambered portions 46 which may exist, the prepared free flowing explosive charge 47 may be introduced by opening the valve at the bottom of the hopper device. Such charging may be facilitated by applying regulated air pressure to the upper part of the hopper, and over-pressurizing the plastic tubing is avoided by the presence of relief valve 44 which is set to open at the desired maximum pressure in the inflated intermediate tube 21.

When the hole has been partially charged with the hydrophobic explosive mixture 47, the closure plug 37 may be removed for the insertion of the first primer cartridge 48 at an intermediate level above the bottom of the tubing assembly. After the first primer has been lowered to its proper place, the latter may, for example, be fused with "Prima-cords" 49 which may be set in notches 50 provided in closure plug 37. Next, the inner tube 20 may be removed if desired by simply pulling it out, as it will tear off at the notches 26 which were provided just above the transverse seals 27. After the remainder of the explosive and one or more additional primers have been charged, the upper part of the intermediate and outer tubes 21 and 22 may be tied off and the remainder of the hole stemmed in a manner well-known to those skilled in the art, as illustrated in FIGURE 9.

An important aspect in this invention is the provision of a surplus of tubing assembly length i.e. at least a 50-foot length of tubing will normally be required for

a 45-foot depth hole. This is because the bag conforms to the irregularities of the hole wall to a very substantial degree, as the free flowing explosive charge falls into the bag. Where no surplus of tubing length is provided, the strain of such conforming might cause rupture of the bags.

One advantage of the present invention is that even though the outer plastic tube 22 might be torn or punctured during the charging step, the intermediate tube 21 will continue to be an effective moisture barrier. Thus, with the upper end of the tubes tied off, a charged hole can be left for an extended period before the blasting date. This allows sufficient time for successive loading of many holes so as to make up a large and economical blast, and without the danger of moisture penetrating the explosive charge to a degree that would reduce the explosiveness of such charge.

While the previously described method of charging blast holes makes it practical to employ a low cost water-sensitive explosive such as ammonium nitrate, it is advisable to avoid the moisture difficulties which would occur if the untreated explosive were used and both the intermediate and outer plastic bags should become ruptured or otherwise damaged especially near the bottom of the hole.

It has been found that the explosive efficiency of ammonium nitrate in the form of prill can substantially be increased by the addition of a liquid hydrocarbon. Its effectiveness is also increased by treatment with other relatively non-compressible materials. Treatment with hydrocarbon liquid such as kerosene or fuel oils will reduce the ammonium nitrate's sensitivity to water to a certain degree but not sufficiently for present purposes.

The water resistance of low cost, water sensitive explosives can be greatly increased by incorporating a hydrophobic jelling agent in the hydrocarbon liquid to be mixed with the granular explosive. Metallic soaps have been found suitable as jelling agents. For example, in one test kerosene was employed as the hydrocarbon liquid and to this was added an aluminum soap of 2-ethylhexoic acid compound in the proportion of 7½ parts, by weight, of the soap to 100 parts of kerosene. The soap was completely dissolved in the kerosene by stirring and heating to about 125 to 150° F., and after cooling the liquid acquired a jelly-like consistency. Ammonium nitrate prill was then added to form a freely flowable slurry. The proportions were about 1 gallon of the solution to about 80 lbs. of commercial-grade ammonium nitrate. The increased water resistance attainable by the present invention was shown experimentally by stirring ammonium nitrate with the jelly-like hydrocarbon mixture, draining off the excess liquid, and placing the otherwise unprotected aluminum nitrate in a cold water bath. It was readily apparent that the hydrophobically jelled hydrocarbon coated the ammonium nitrate granules with a protective film, and only after 35 minutes was there any appreciable dissolving action of the water on the ammonium nitrate. This compares favorably with a similar test in which uncoated ammonium nitrate was placed in cold water and found to dissolve immediately, and a third test in which ammonium nitrate was coated with untreated kerosene, placed in cold water, and found to dissolve in less than 2 minutes.

Thus, the hydrophobically jelled kerosene protective film was found to be stable when immersed in water for relatively long periods, and was broken during the interim only by stirring. When the jelled kerosene ammonium nitrate mixture is charged into the plastic bag in a bore hole, only a very small area of the mixture adjacent a possible puncture of the intermediate tube bag can be subject to the action of water in the bore hole. The dissolving action of the water is so greatly retarded that only a very small portion of the explosive can be inactivated in periods substantially longer than ½ hour.

When aluminum soaps are employed with hydro-

carbons of the kerosene type, it is found that about 3% by weight of the soap is sufficient to impart a jelly-like consistency to the liquid with 7% the preferred upper limit, although up to about 10% by weight aluminum soap can be used. Other suitable liquid hydrocarbons suitable for practice of the present invention include gasoline, kerosene, and fuel oil. Also, other well-known jelling agents that are hydrophobic may be used, such as colloidal carbon blacks, colloidal silicas, and mineral waxes. The hydrocarbon-jelling agent mixture should form at least about 10% by weight of the explosive.

It is important that the charge fill the blast portion of the hole as completely as possible, so as to avoid air pockets which tend to cushion the explosion and decrease the explosive efficiency. To this end, it is preferable to employ a weighting material having a high bulk density and which is comminuted fine enough to spread out against the bottom of the blast hole so as to avoid air spaces. Since water in the blast hole contributes to fill any spaces as a non-compressible shock transmitting medium, it will be advantageous to puncture the weight material bag so that water can mix with the comminuted weighting material and fill spaces between the individual particles. Alternatively, it is also contemplated that the comminuted weighting material may consist of water soluble substance such as a metal salt which, when water leaks through suitably sized small punctures, will dissolve slowly to allow the explosive charge above it to sink and fill the bottom of the blast hole more snugly and completely with active explosive. In this way practically no loss in blast hole depth is sustained.

Although preferred embodiments of the invention have been described in detail, it is contemplated that modifications of the method, apparatus, and explosive mixture may be made and that some features may be employed without others, all within the spirit and scope of the invention. For example, when a jelled hydrocarbon ammonium nitrate mixture is employed, it has been found that the water resistance of the water-sensitive explosive is so improved that instead of a triple tubing assembly, a double tubing assembly can be employed. Also, in a dry blast hole or even when only a small amount of water is present, the jelled hydrocarbon treated explosive can be charged directly into the hole without the use of plastic bags.

What is claimed is:

1. A method of preparing for insertion in a blast hole, a length of flexible thin-walled plastic triple tubing assembly comprising an inner tube, an intermediate tube concentric to and surrounding said inner tube with an annular space therebetween, and an outer tube concentric to and surrounding said intermediate tube, which method comprises transversely folding back on itself a desired length of said outer tube thereby exposing a section of said intermediate tube, transversely severing the exposed intermediate tube section along with the corresponding enclosed inner tube section at a point near the outer tube fold-back, notching the unsevered inner tube near the fold-back, transversely sealing the intermediate and inner tubes below the notching at about the severance point, unfolding the outer tube and transversely sealing such tube below the first seal so as to form a pocket, placing in said pocket below the outer tube seal a desired amount of granular weighting material, closing off the lower end of said outer tube to form a bag-like enclosure from said pocket to retain the weighting material, and longitudinally folding the triple tube assembly for insertion in the blast hole.

2. A method of blasting by means of a water-sensitive explosive in a water containing blast hole which comprises providing a length of flexible thin-walled plastic triple tubing assembly comprising an inner tube, an intermediate tube concentric to and surrounding said inner tube with an annular space therebetween, and an outer tube concentric to and surrounding said intermediate tube; preparing said length for insertion in the blast hole by transversely fold-

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ing back on itself a desired length of said outer tube thereby exposing a section of said intermediate tube, laterally severing the exposed intermediate tube section along with the corresponding enclosed inner tube section at a point near the outer tube fold-back, partially notching the unsevered inner tube near the fold-back, transversely sealing the intermediate and inner tubes below the notching at about the severance point, unfolding the outer tube and transversely sealing such tube below the first seal so as to form a pocket, placing in said pocket below the outer tube seal a desired amount of granular weighting material, closing off the lower end of said outer tube to form a bag-like enclosure from said pocket to retain the weighting material, and longitudinally folding the triple tube assembly for insertion in the blast hole; lowering the longitudinally folded triple tube assembly into the blast hole; separating the upper end of said intermediate tube from the atmosphere and passing compressed gas into said inner tube and through said notching into said intermediate tube so as to inflate said intermediate and outer tubes sufficiently to contact the blast hole walls; providing a freely flowing hydrophobic explosive charge comprising said water-sensitive explosive coated with a hydrophobically jelled hydrocarbon liquid; introducing the explosive charge

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into the inflated intermediate tube; introducing at least one primer into such inflated tube; closing the upper portion of the inflated intermediate tube; stemming the explosive charge and detonating such charge.

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