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EXPLOSIVE ASSEMBLY

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Fig. 1.

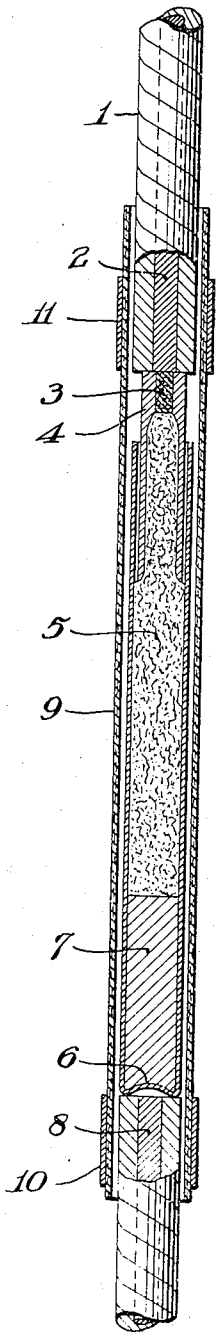
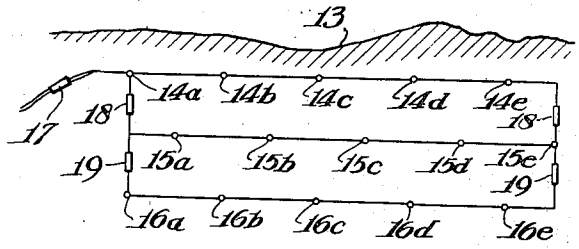


Fig. 2.



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EXPLOSIVE ASSEMBLY

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3 Claims. (Cl. 102—22)

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This invention relates to a novel method of blasting where a number of explosive charges are to be fired and more particularly to the use of a new type of detonator in the firing of explosives.

This application is a continuation of copending application No. 497,736.

A common practice in quarrying limestone and other types of rock is to drill deep vertical holes at definite distances back from the face and to load these with the desired amount of explosive. Such vertical holes may be from 30 to 100 feet deep and perhaps 20 feet apart. In many quarry blasts, it may be desired to shoot a large number of drill holes, up to 40 or 50 for example. In such a case it is customary to drill a certain number of these parallel to the face and at the desired distance therefrom and to arrange the remainder of the holes in one or more rows further removed from the face and substantially parallel to the front row.

Blast holes such as the above may be up to 9 inches in diameter and are loaded with the desired amount of explosive in cartridge diameter corresponding to the diameter of the holes. With such charges in deep holes, a safe and convenient method of detonating the explosive is by use of detonating fuse, which consists of a core of high velocity explosive enclosed in an outer casing of fabric or metal. Such fuse under the influence of a blasting cap may detonate at a velocity as high as 20,000 feet per second. With a deep bore-hole loaded with explosive, the introduction of a length of detonating fuse to the bottom of the hole alongside the cartridges insures the practically instantaneous detonation of all the explosive. When a number of holes are charged in the same manner and are connected by trunk lines of detonating fuse, the effectiveness and certainty of the blast are assured.

The same procedure may be used when several rows of holes back of the quarry face are to be blasted and where the back rows are joined to the trunk line of detonating fuse by connecting lines. With such a large number of blast holes and with the quantity of explosive involved, the simultaneous explosion of all the charges may cause an undesirable degree of earth vibration. If such explosions could be caused to take place successively, hole by hole, such excessive vibration would be avoided. It may be advantageous also, from the point of view of blasting execution, to have the front row holes shoot first, followed at a proper time interval by the second row, etc.

An object of the present invention is an improved method of blasting where explosion of more than one charge is desired, said blasts to be separated by definite time intervals. A further object is such a method applied to quarry blasting where the connections between charges are by means of detonating fuse. A still further object is an explosion-retarding device adapted to be inserted in the lines connecting the various holes for successive firing and to bring about such result. A further object is an explosive assembly comprising such arrangement of lines of detonating fuse and delay devices adapted to accomplish successive firing of charges. Additional objects will be disclosed as the invention is described with greater exactness and detail in the following.

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We accomplish the foregoing objects by connecting the explosive charges by means of detonating fuse, and introducing into the line leading to the charge or charges intended for later firing a delay element, that is to say a device that may be connected to the two lines of fuse and that comprises a container having at one end an ignition charge capable of initiation by the detonating fuse coming from the first charge, a deflagrating charge adjacent to the ignition charge and capable of being fired by said ignition charge, of burning at a predetermined rate and of igniting and bringing to detonation a charge at the second end of the delay element container. This latter charge is capable of propagating the explosion to the second line of detonating fuse and thence to the explosive charge whose later firing is desired. While we preferably use a separate ignition charge, this may be omitted if a delay composition is employed that can be ignited by the detonating fuse.

While the invention is applicable to any group of two or more explosive charges for firing by detonating fuse where successive rather than instantaneous detonation of the various charges is desired, a particular application will be to quarry blasting where deep holes of relatively large diameter are charged with high explosive and lines of detonating fuse go to the bottom of each hole, hence are in contact with the entire charge. In such a case, the earth vibrations and the noise are greatly reduced and practically all the objectionable features overcome if the method of our invention is followed.

As a delay element for insertion in the line of detonating fuse, we employ a container for explosive charges, preferably a cylindrical metal shell into which, or against which, the detonating fuse is introduced. The various combustible and explosive charges are enclosed in said container.

The accompanying drawing will serve to illustrate a specific embodiment of our invention, in order that its utility and functioning will be thoroughly appreciated. It will be understood, however, that this is by way of illustration only and is not to be taken as limiting the invention in any way. Figure 1 is a view of a delay device interposed between two lines of detonating fuse. Figure 2 is a diagrammatic representation of a layout of a quarry shot, showing the position of the blast holes with reference to the quarry face, one scheme for connecting said holes, and showing also the place of introduction of the delay elements.

In Figure 1, which shows a suitable delay device, 1 represents a line of detonating fuse having a core 2 of PETN and butting against a small diameter cylindrical column 3 of combustible ignition mixture contained in the constricted end of the steel carrier 4. While various compositions can be used, a suitable one comprises 51% mercury fulminate, 23% potassium chlorate, 9% nitrostarch, and 17% charcoal, this being made into a paste with a suitable solvent. Adjoining the ignition mixture is a charge 5 of an 88–12 blend of barium peroxide and magnesium, e. g., 2.5 grams, which is adapted to burn relatively slowly and which gives off substantially no gas on combustion. This delay charge fills the enlarged portion of the steel carrier 5 and extends into a portion of the copper shell 6, within which the steel carrier is partly enclosed. The base of the copper shell contains a pressed charge 7 of 1 gram of an 80–20 mixture of mercury fulminate and potassium chlorate. The copper shell butts against the line of detonating fuse having the core 8 of compressed PETN. A cardboard tube 9 surrounds the copper shell and the detonating fuse at each end and holds these objects firmly together when the metal bands, 10 and 11, are crimped thereto.

In actual use, where at least two explosive charges are to be detonated with a predetermined time interval between, the detonating fuse 1 coming from the charge first fired propagates the explosion at a velocity of around 20,000 feet per second and effects the ignition of the composition 3, which in turn, ignites the deflagrating charge 5. This burns at a relatively slow predetermined rate and, after the desired retardation, effects ignition of the charge 7 which rapidly picks up to high velocity and brings about the high velocity detonation of the detonating fuse 8, leading to the second explosive charge.

In Figure 2, 13 represents a quarry face with vertical drill holes of approximately 6 inches diameter and 50 feet deep. A row of 5 holes, 14A to 14E, parallels the face, about 20 feet back from said face and spaced about 16 feet apart. A second row of 5 holes, 15A to 15E, and a third row of holes, 16A to 16E, are still farther back from the face. These are loaded with a suitable explosive, for example 60% ammonia gelatin dynamite, about 750 lb. per hole. A trunk line of detonating fuse, which comprises an explosive core of PETN contained within a waterproofed textile covering, connects the holes in the row nearest the face, 14A to 14E, and branch lines of this same fuse run to the bottom of each hole, being held in contact with the individual explosive cartridges so that the detonation of the fuse will cause the substantially instantaneous detonation of all the explosive. Connecting lines of detonating fuse lead off from the main trunk line, in advance of the first hole, 14A, and beyond the last hole, 14E. These lines connect the second row of holes, 15A to 15E. Similarly additional connecting lines of fuse go to the third row of holes, 16A to 16E. Interposed in each line leading from the front row of holes to the second row and from the second to the third row are delay elements, 18 and 19, of the type shown in Figure 1, which contain charges of relatively slow rates of combustion adapted to cause the explosive in these rows to fire at successively later times. Double connections between the row of holes for successive blasting are shown in the drawing and will ordinarily be employed as assurance against misfires, though only one connection is actually required.

In the quarry assembly shown in Figure 2, the connections are such as to cause a whole row of holes to fire at one time. By the use of delay devices between the successive rows of holes, time intervals of a few hundredths of a second are effected between the times of detonation of the successive shots. The detonating fuse commonly used, Primacord, explodes at a velocity of around 20,000 feet per second, so that when this fuse is initiated by means of an electric blasting cap 17, on application of the electric current by means of a blasting machine, the charges in the holes in the front row detonate almost instantaneously and simultaneously. This causes the blasted rock to move away from the face. After a suitable delay interval, charges in the second row of holes 15A to 15E, detonate. Delay elements 19 in the fuse lines leading from the second to the third row of holes cause a similar time interval between the firing of charges in holes in these respective rows. The moving away of a large amount of rock in front of each row of holes before the blasting in such rows adds to the effectiveness of the blast. An even greater advantage is the very considerable reduction in the noise and particularly the vibrational effects of the blast. Delay intervals of from 0.01 to 0.08 seconds may be used, the preferable delay intervals being from 0.01 to 0.05 seconds. We may carry out the invention and bring about an even greater reduction in earth vibrations by causing the holes to detonate one at a time, rather than by rows. This necessitates interposing delay elements in the line of Primacord before each hole, with the exception of the first hole.

In carrying out the present invention, any type of detonating fuse is applicable. The specific example has shown the use of Primacord, which is a detonating fuse having a core of PETN enclosed in a fabric covering and having a velocity of around 20,000 feet per second. Cordeau is likewise applicable, a lead-wrapped fuse of somewhat lower velocity, around 17,500 feet per second, having a core of TNT.

Various compositions may be used for the delay charge in the connecting element or detonator, for example blends of barium peroxide and magnesium, barium peroxide and selenium, potassium permanganate and antimony, and the like. The foregoing are advantageous in that they produce substantially no gases on combustion. Various gas-producing compositions are applicable also, however, such as black powder and nitrocellulose compositions.

It is recognized that delay electric blasting caps are known in the art which bring about the explosion of charges after definite time intervals. The delay devices of the present invention are novel, however, in that they are adapted to be

nitiated by an extremely high velocity detonation vave. The explosion is transmitted to the igni-ion composition of the delay device, thence to the lelay composition, where it travels at a low velocity, possibly around 0.5 meter and well under ive meters per second. The delay composition auses the subsequent ignition of the detonating omposition at the base of the shell which picks p rapidly to detonating velocity, such that it ffectively detonates the juxtaposed line of deto-ating fuse. Any ignition composition that is apable of receiving a detonation wave and trans-nitting it as simple combustion under the condi-ions outlined is suitable. We have found an ffective composition to comprise 51% mercury ulminate, 23% potassium chlorate, 9% nitro-tarch and 17% charcoal, thoroughly blended nd made into a paste by use of a suitable solvent. 'arious compositions are likewise adapted to ollow the delay composition, for example an 0–20 fulminate-chlorate mixture, lead azide ompositions, nitromannite, diazodinitrophenol nd the like.

In carrying out the invention, it will be under-ood that it is not limited in any way by the ype of explosive in the holes to be blasted, or sewhere, except that they must be detonating xplosives adapted for explosion by means of etonating fuse. In the case of quarrying opera-ons, such high explosives are commonly used as mmonia dynamites, Straight dynamites, gelatin ynamites, blasting agents containing high per-ntages of ammonium nitrate and free from quid explosive, and many others.

Many variations in exact procedures and details assembly may be employed, therefore, without parture from the scope of the invention. While s use in such operations as quarry blasting and e like has been emphasized, it will be under-ood that it is applicable to all uses of explosive, nether commercial or military, where more than e explosive charge is to be fired by means of tonating fuse, and in fact to all firing of suc-ssive lengths of detonating fuse, which are sepa-ted by delay elements of the type described. e intend to be limited only by the following tent claims:

We claim:

1. An explosive assembly for use where two nnected lengths of detonating fuse are pres-t and where the second length is to be fired at lelayed time interval after the first length, said sembly comprising an explosion-retarding ele-nt interposed between said lengths of detonat-g fuse and butted up against them in detonating relationship therewith, said element containing at the end adjacent to the first length of fuse an initiating deflagrating charge, at the end adjacent to the second length of fuse a detonating charge, and intermediate the initiating and detonating charges a delay composition, said charges being such as to propagate the explosion from the first to the second length of detonating fuse.

2. An explosive assembly for blasting operations where more than one explosive charge is to be fired and where a delayed time interval is desired between successive times of firing, said assembly comprising lengths of detonating fuse interposed between and connecting said charges for successive firing and an explosion-retarding element between said lengths of detonating fuse and butted up against said lengths of fuse in detonating relationship therewith, each of said retarding elements containing at the end adjacent to the first length of fuse an initiating deflagrating charge, at the end adjacent to the second length of fuse a detonating charge, and intermediate the deflagrating and the detonating charges a delay composition, said charges in said retarding elements being such as to propagate the explosion at renewed high velocity beyond the retarding elements from the first length to the second length of detonating fuse.

3. An explosive assembly according to claim 2, in which more than one series of explosive charges are to be fired, where practically instantaneous firing of the charges within each series is desired and where a delayed time interval is desired between the successive series of charges for instantaneous firing, said assembly comprising the connection of each of the series of charges for instantaneous firing by the explosion-retarding element.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
663,724	Bryant	Dec. 11, 1900
1,999,820	Nash	Apr. 30, 1935
2,139,581	Hanley	Dec. 6, 1938

FOREIGN PATENTS

Number	Country	Date
15,647	Great Britain	1898
113,411	Australia	July 2, 1941