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SEISMIC SURVEYING

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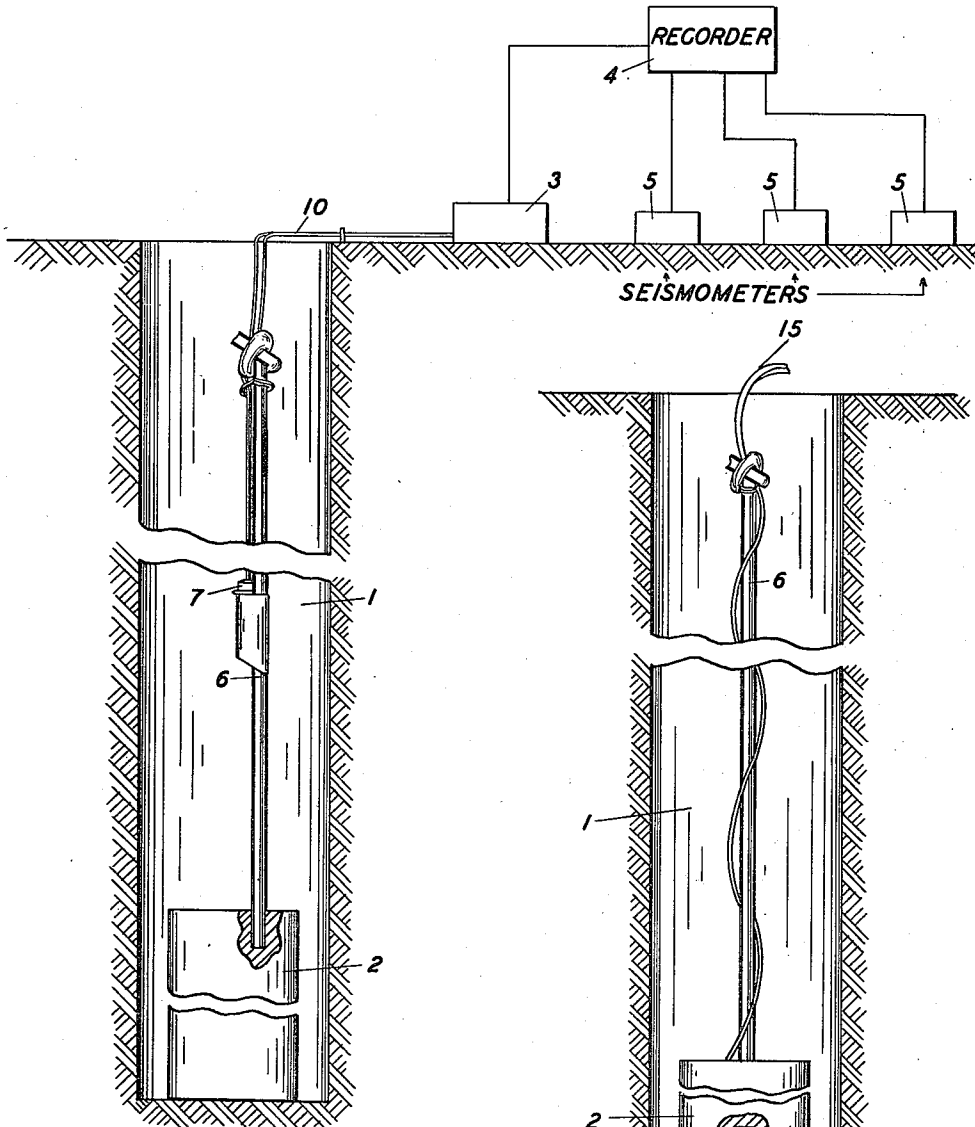


FIG. 1

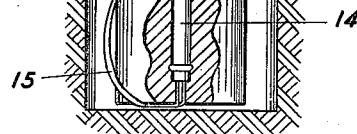


FIG. 2

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SEISMIC SURVEYING

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11 Claims. (Cl. 181—0.5)

This invention relates to seismic surveying or prospecting and, more particularly, to a means for the connection of the surface instruments used in seismic survey to the explosive charge placed in the ground to establish seismic waves.

Seismic survey or prospecting is the means whereby the earth's sub-surface structure is explored, usually for oil deposits, and this art is confined to the setting up of earth vibrations which in effect are miniature earthquakes and is not directed to normal disruptive explosions. In seismic operations, a borehole is usually drilled, an explosive charge placed therein, normally close to the bottom, a connection made from this charge to a firing circuit containing firing means and the firing circuit is connected to a recorder, to which recorder is also connected a number of geophones or seismometers. Upon firing, the explosive charge explosive waves are created and there is recorded the time of the explosion. Thereafter there is recorded the time of arrival of waves (direct, reflected and/or refracted) from different parts of the earth sub-surface structure at the geophones. From these recordings and the intervals of time therebetween, the data on the sub-surface structure is calculated and plotted.

Seismograph shooting is confined to the setting up of earth vibrations and as such differs from other blasting operations. While the hazards inherent in all blasting operations are present in seismograph work, there are some hazards that are peculiar to seismograph blasting. One of these serious hazards is the need of frequently shooting close to power lines, such as high voltage electrical transmission lines. The dangers arising upon firing close to these lines are well known to the art but numerous accidents have resulted from such shooting.

In normal seismic prospecting, the crew generally drills holes along a roadway because otherwise problems pertaining to crops, livestock, speed of operation, and the like, are encountered. These shot holes usually between 3 and 4½ inches in diameter generally will be spaced between about 750 and 1500 feet apart along the line of exploration. The holes will often average about 75 feet in depth but may run from a few feet to 450 feet or more in depth. In working a line of holes along a roadway having a power line parallel thereto, it is normal to drill the holes as far from the power line as possible but often distance is not more than about 100 feet and sometimes is considerably less.

Electric blasting caps are used in seismic

shooting and each hole when shot necessarily contains metallic (copper or iron) wires leading from the shooting truck and extending down to the cap in the charge, which is usually at or close to hole bottom, but may be placed at any level desirable as the strata so dictates. As the holes must often be shot repeatedly they are almost never stemmed with anything more solid than water and mud which enables the holes to clean themselves on each shot.

While the cap or lead wires can be and usually are anchored at the collar of the hole, it is not possible to satisfactorily anchor the lengths of wires extending down the holes. When the shots are detonated, these wires are usually projected from the hole into the air for their full lengths. If the holes are as deep as or deeper than the direct distance from the hole collar to a power line, a serious hazard exists to the men at the shooting point, or sometimes even at the recorder usually located in a truck. This is especially true if a wind is blowing from the hole toward the power lines. Instances of severe electric shock—some with fatal consequences—have resulted from such conditions permitting wires often still connected to the firing point and/or recorder to be blown out of the holes into contact with power lines.

While numerous attempts have been made to catch and hold or deflect these wires as they are blown from the holes by placing grids, deflectors, and the like, over the holes before each shot, none of these have shown themselves to be entirely reliable, especially when heavy charges must be used. Some companies have minimized this hazard by ruling that no holes shall be drilled closer to power lines than 200 feet but the disadvantages of this are apparent and none of the practices resorted to have been completely satisfactory.

It may be seen, of course, that this power line hazard depends on the relationships between the lengths of the wires extending down the holes and the distances from the collars of the holes to the power or transmission lines, and that this problem would be abated if these relationships could be properly controlled.

It is the object of this invention to provide a method of more safely carrying out seismic surveying operation under special conditions.

A further object of this invention is to provide a method of more efficiently carrying out a seismic surveying operation where power or transmission lines offer a definite hazard to the operation.

A further object is to provide a means of destroying the blasting circuit used in seismic surveying.

A further object is to provide a means of destroying lead wires extending down the shot hole.

A further object is to provide an improved method of detonating charges in the bore hole.

A further object is to provide an improved blasting means for seismic surveying.

Other objects will appear hereinafter.

Now, in accordance with this invention, the problem of more safely and efficaciously firing seismograph shots close to power lines has been accomplished by the use of a detonating fuse in the borehole containing the explosive charge.

In general, the invention comprises the placing of a length of detonating fuse in the borehole for a distance sufficient to allow the blasting connection between a point close to the surface of the earth and the explosive charge to be destroyed upon the firing of the shot and thereby preventing any wires of sufficient length from being expelled from the hole and contacting power lines.

Having described the broad scope of the invention, preferred embodiments thereof are described with reference to the accompanying drawing in which

Fig. 1 shows a borehole containing an explosive charge connected via a detonating fuse and electric blasting cap to recorder.

Fig. 2 shows a borehole containing an explosive charge containing an electric blasting cap with wires extending to the recording instrument and a detonating fuse positioned to destroy the wires.

Referring now to the figures, a method of seismic prospecting and apparatus is shown comprising a borehole 1 of desirable depth and diameter and containing an explosive charge 2. The charge 2 is connected to instruments comprising a firing means 3, a recorder 4 and seismometers 5 via a detonating fuse 6, a blasting cap 7 connected to said fuse at tape joint 8 and by wires 10 from the electric blasting cap 7. Wires 10 are anchored at the hole collar to stake or "tie down" 11. In firing a shot with the setup of Fig. 1, the blasting cap 7 is fired from a firing means 3; the time is recorded and the action then comprises a detonation of the fuse 6 and charge 2. The charge sends waves into the ground which are picked up by the seismometer 5 and recorded. From the differences in time of firing and receipt of waves, the data on the sub-surface structure is calculated and plotted.

In Fig. 2, the setup is similar to Fig. 1 but the explosive charge 2 is fired by cap 14 through leg wires 15 which leg wires are adjacent a length of fuse 6 extending up the hole 1. The leg wires 15 will be attached to a "tie down" at the hole collar. In operating by this means, the explosive charge cap 14 when fired detonates the charge 2 which detonates the fuse 6 and this fuse destroys the wires 15 adjacent thereto. The fuse 6 is positioned in the hole by any suitable means. Thus, the wires may maintain it in position or supporting means from the collar of the hole (not shown) may be used.

If desired, the fuse 6 in Fig. 2 may be fired by means of an electric blasting cap attached to its upper end. In this instance, it would be necessary to fire the cap in series with cap 14.

In order to more fully describe the present

invention in detail, the following examples of operation are given:

Example 1

A seismograph hole 75 feet deep was to be fired and the explosive charge therefor was made up in the usual manner except that one end of a 60 foot length of Primacord (pentaerythritol tetranitrate detonating fuse) was inserted into the explosive charge instead of a cap. The explosive charge was let down the hole by the fuse in lieu of cap wires. When the charge had been lowered down the hole almost the full length of the fuse, a simple knot was tied at the end of the Primacord, and the cap wires at a point about 8 inches from the cap were tied around the fuse just below this knot. The cap, pointing downward, was then placed alongside the fuse and lashed firmly to it by friction tape. The charge was next lowered the remaining distance to hole-bottom, the cap wires strongly anchored at the collar of the hole, connections made to the shooting truck in the usual way and the shot fired.

This shot had every normal appearance, with no more than the usual surface noise and disturbance. The shot hole was undamaged. The length of wires in the hole were simply projected out for their length of 15 feet and fell back on the ground undamaged except for the 8 inches where juncture with the fuse was made. It was apparent no contact with the nearby power line was possible.

Because of the 60 foot length of Primacord from the cap to the charge, a lag in the arrival times at the recorder of .003 second, compared to those of previous normally made shots, was expected. This was based on Primacord's speed of approximately 20,350 ft./sec. and within the limits of the accuracy of the instruments this lag was exactly as anticipated.

Example 2

A seismograph shot was made that was approximately comparable to the shot described in Example 1 except that the blasting cap wires extended the full length of the hole and the blasting cap was inserted into the explosive charge. A 60 foot length of Primacord (pentaerythritol tetranitrate detonating fuse) was attached to the charge and extended up the hole with the cap wires spirally wound thereabout. The blasting cap in the explosive charge when fired detonated the charge which detonated the Primacord. The detonation of the Primacord destroyed the wires of the blasting cap before they could be blown out of the hole. The hole was undamaged and the record of the shot was acceptable.

Many modifications of the above examples of use may be made to fit various individual situations. The basic consideration is either to shorten the length of the wires in the hole by substituting detonating fuse to a point where the wires cannot make contact with nearby power lines when the hole is shot or to place the detonating fuse in a manner whereby it will destroy the connections before they are blown from the hole. The necessary amount of detonating fuse substitution depends on the relationship between the hole depth and distance to the power lines existing in each situation. Beyond this amount necessary a reasonable margin of safety to fit the individual circumstances is allowed in each case. Cost considerations suggest that the lengths of fuse used do not much exceed this point although,

except for this, extra lengths are not disadvantageous when proper allowance is made in figuring lag of arrival times at the recorder. It is contemplated in accordance with this invention that lengths of detonating fuse in multiples of 10 feet be used in the various shots as these lengths are easy to handle and in addition supply a means of simplifying computation of arrival time lag since each 10 foot section has a detonating speed of .0005 second.

The Primacord which has been described is the preferable detonating fuse to use; however, the detonating fuse known as Cordeau, which is a lead sheathed core of TNT having a detonating speed of 17500 ft./sec. may be substituted therefor. When Cordeau is used, the normal connectors must be employed to insure the firing thereof and alterations made in the time lag. Primacord is about .22 inch in diameter and Cordeau is about .25 inch in diameter.

In firing holes in accordance with this invention, it is preferable to bring the detonating fuse to within only 10 or 15 feet of the top of the borehole. This margin is desirable since the fuse is a powerful explosive and may cause surface disturbances or may produce an excess amount of flying dirt, mud, and the like. Normally, the force of the detonating fuse pushes the 10 or 15 feet of wire from the hole before the force of the explosive charge can act thereon. This early projection from the hole allows the wires to fall easily about the hole collar and there is no chance of breaking the connection between the wires and the "tie down" or anchor at the collar.

The boreholes which are used in seismic surveying have been described as from a few feet to 450 feet in depth and 3 to 4½ inches in diameter but any desired depth or diameter hole may be used. Further, the hole may be plain or may be cased by any of the various type casings. In most instances, it is preferable to use uncased holes as the detonating fuse may damage the casing.

In accordance with the invention, the detonating fuse may be used either as a means to destroy the circuit wires extending down the hole when the explosive charge is directly initiated by an electric blasting cap and hence prevent the wires from being projected into the air or the fuse itself may be used as the connection between the electric cap near the surface of the ground and the explosive charge as well as the initiator of the same. Thus, the fuse may be substituted for the circuit wires or arranged to destroy the wires and as it also destroys itself, it obviates the possibility of making accidental contacts with power sources on top of the ground.

Many variations in the method of using the fuse in the borehole are possible but the advantage gained is the destruction of the blasting circuit and the prevention of material flying through the air with possible serious results in the accidental establishment of electric circuits is gained with each variation. An advantage of the invention is the prevention of delays due to the need of locating holes with special reference to power lines and wind direction. The overall cost of drilling holes is also lowered as the instances of shooting holes equipped with deflectors, grids, etc. are reduced or entirely eliminated.

What I claim and desire to protect by Letters Patent is:

1. In the process of seismic surveying which comprises positioning an explosive charge in the

lower portion of a borehole, firing said charge and recording seismic waves therefrom, the step of positioning a column of detonating explosive having a diameter less than one-half inch throughout a substantial length of the said borehole and detonating this column of detonating explosive approximately simultaneously with the detonation of the said explosive charge whereby connections between the explosive charge and the surface of the ground are destroyed.

2. In an apparatus for seismic surveying including an explosive charge, a blasting circuit, and means to record seismic waves set up by the detonation of said explosive charge, an improved initiation structure comprising a column of detonating explosive having a diameter less than 0.5 inch positioned between the said explosive charge and the firing means, said column of explosive adapted to be detonated approximately simultaneously with the said explosive charge whereby the blasting circuit is destroyed upon the detonation of the said explosive charge.

3. In the process of seismic surveying which comprises positioning an explosive charge primed with an electric blasting cap in the lower portion of a borehole, firing said charge through the lead wires of said electric blasting cap and recording seismic waves from said charge, the step of positioning a column of detonating explosive having a diameter less than one-half inch throughout a substantial length of the said borehole and adjacent the lead wires of said blasting cap and detonating this column of detonating explosive approximately simultaneously with the detonation of the said explosive charge whereby said lead wires extending between the explosive charge and the surface of the ground are destroyed.

4. In an apparatus for seismic surveying including an explosive charge, an electric blasting cap for firing said charge, a blasting circuit, and means to record seismic waves set up by the detonation of said explosive charge, an improved initiation structure comprising a column of detonating explosive having a diameter less than 0.5 inch positioned between and in detonating contact with the said electric blasting cap and the explosive charge.

5. In the process for seismic surveying which comprises positioning an explosive charge in the lower portion of a borehole, firing said charge and recording seismic waves therefrom, the step of initiating said explosive charge by means of a detonating fuse comprising pentaerythritol tetranitrate surrounded by a textile covering said detonating fuse extending from substantially below the collar of the borehole to the explosive charge.

6. In the process for seismic surveying which comprises positioning an explosive charge in the lower portion of a borehole, firing said charge and recording seismic waves therefrom, the step of initiating said explosive charge by means of a detonating fuse comprising trinitrotoluene surrounded by a lead sheath, said detonating fuse extending from substantially below the collar of the borehole to the explosive charge.

7. In the process of seismic surveying which comprises positioning an explosive charge in the lower portion of a borehole, firing said charge and recording seismic waves therefrom, the step of positioning adjacent the firing circuit used for firing said charge a length of detonating fuse, said length extending downward from a point substantially below the collar of the borehole and of sufficient length to substantially com-

pletely destroy the firing circuit when detonated, whereby said firing circuit is prevented from being projected into the air as a unit.

8. In the process of seismic surveying which comprises positioning an explosive charge in the lower portion of a borehole, firing said charge by means of an electric blasting cap having metallic wires extending to the surface of the ground and recording seismic waves from said explosion, the step of positioning adjacent the blasting cap wires used for firing said charge a length of detonating fuse, said length extending from a point substantially below the collar downward and being detonated substantially simultaneously with said explosive charge whereby said cap wires are destroyed.

9. In an apparatus for seismic surveying which includes recording means firing means and a blasting circuit extending therefrom and an explosive charge at the end of the blasting circuit, an improved circuit structure comprising a detonating fuse firmly attached to the blasting cir-

cuit and connected to the explosive charge in a manner such that it may be fired approximately simultaneously with the firing of the explosive charge.

10. In an apparatus for seismic surveying which includes recording means firing means and a blasting circuit extending therefrom and an explosive charge at the end of the blasting circuit, an improved circuit structure comprising a detonating fuse connected to the blasting circuit and connected to the explosive charge whereby said blasting circuit is destroyed upon detonation of the explosive charge and fuse.

11. In an apparatus for seismic surveying including a recording means, an initiating circuit and an explosive charge, an improved circuit comprising a detonating fuse in priming contact with the said explosive charge and connected to firing means extending from the recording means, said detonating fuse extending substantially throughout the length of the borehole.

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