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T. E. FAILING

2,272,741

APPARATUS FOR SEISMIC SURVEYING

Original Filed Feb. 28, 1938

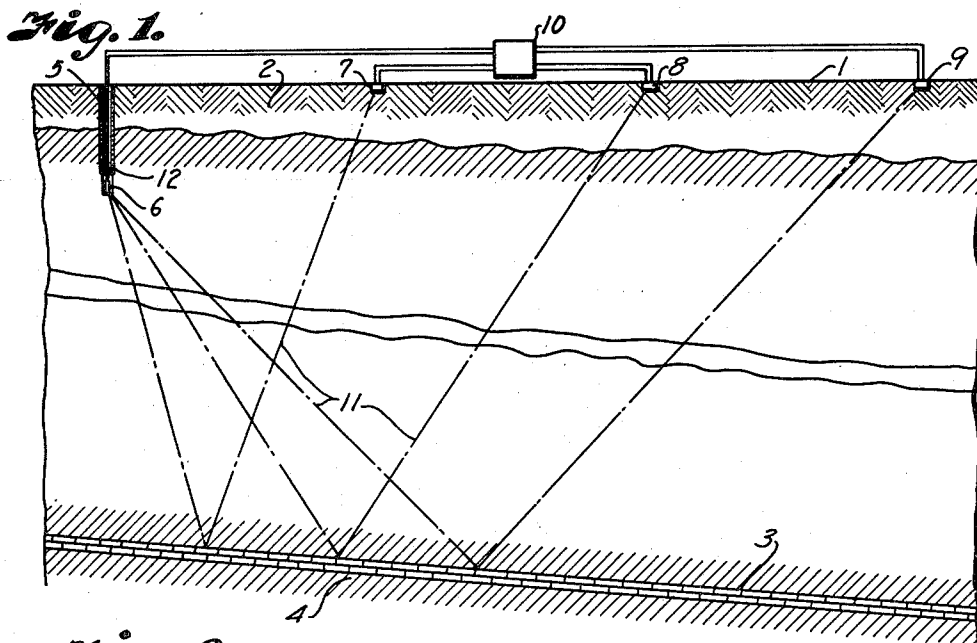


Fig. 2.

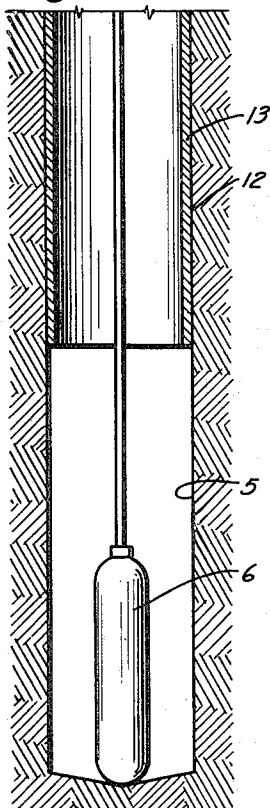
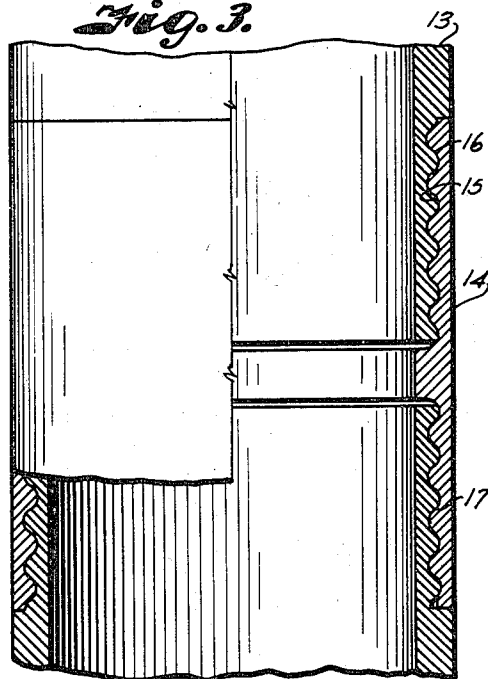


Fig. 3.



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APPARATUS FOR SEISMIC SURVEYING

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Original application February 28, 1938, Serial No. 193,114. Divided and this application May 6, 1940, Serial No. 333,551

3 Claims. (Cl. 181-0.5)

This invention relates to a method of and apparatus for seismic surveying of subterranean earth formations, and is a division of my copending application filed February 28, 1938, Serial No. 193,114, entitled "Casing for shot-holes in seismographic surveys."

In making surveys of this character, it is the practice to drill bore or shot-holes into the earth's surface above the subterranean area under survey. A series of seismographs are then located progressive distances from the bore-hole to record reception of reflected sound waves that are generated from an explosive charge placed in the shot-hole. After reception of the reflected sound waves, the seismographs are moved different distances and/or directions and another explosive charge is placed in the same bore-hole for effecting additional sound waves. This procedure continues until the reflected waves approach a critical angle whereupon the survey is carried out in other directions from the same shot-hole to obtain lateral slopes or depths of the formation. Thus a number of explosive charges are placed in the same bore-hole. Owing to the fact that the bore-holes are drilled through relatively loose soils and cavy earth structures, it is necessary to provide casings to keep them open for the reception of the respective explosive charges, and to prevent cave-in and partially filling incidental to force of the explosions. Otherwise it would be impossible to place the subsequent explosive charges at the same depth. The casings as heretofore used have consisted of ordinary metallic pipe which was salvaged after the last shot had been effected so that it could be run into other bore-holes. The forces generated by the explosive charges often resulted in splitting and expanding of the end of the casing so that it was impossible to remove it from the bore-hole. For this reason, it has been the practice to use second-hand iron pipe; however, the present market for second-hand pipe has made this practice expensive. Even though the cost of the pipe is disregarded, there are many other features which render the use of metallic pipe objectionable, namely difficulty in handling and conveyance of the heavy pipe, particularly where seismic surveys are being made in territories which are inaccessible by the ordinary modes of transportation.

Metallic casings often lend to premature discharge of the explosive as caused by a striking of sparks, static electricity, friction, or abrasion incidental to running in of the charge, or by the conduction of earth electricity through the wall

of the casing. The metallic casings are also extremely conductive of sound waves generated by explosion of the charge so that many of the sound waves are readily transmitted to the upper strata and travel by conduction through the earth's surface, arriving ahead or in time to interfere with reception of the reflected waves, and to make it difficult to select arrival of the first of the reflected waves on the records.

It is, therefore, a principal object of the present invention to provide for retarding transmission of sound waves through the casing to the upper formations so as to avoid interference with reception or recording of the desired reflected waves from a formation under survey.

Another object of the invention is to provide means of this character which is of light weight, non-resonant material that is non-conductive of electricity and which is not subject to effects leading to the premature ignition of the explosive charge and thereby avoid uncertain timing in reception of the sound waves.

In accomplishing these and other objects of the invention, I have provided improved details of structure, the preferred forms of which are illustrated in the accompanying drawing, wherein:

Fig. 1 is a diagrammatic section through a portion of the earth showing the relative locations of a shot-hole and seismographs for recording reception of sound waves reflected from a subterranean formation under seismic survey, the shot-hole being cased in accordance with the present invention.

Fig. 2 is an enlarged section of the bottom of a shot-hole showing the explosive charge.

Fig. 3 is a fragmentary cross-section through a joint of the non-resonant casing used in the shot-hole.

Referring more in detail to the drawing:

1 designates the surface of the earth, and 2 the adjacent formation layer in which the velocity of seismic waves is abnormally low due to the presence of water, air, loose materials and other unknown causes, and which is sometimes known as the weathered layer. 3 designates the reflecting surface of a subterranean formation 4 that is to be profiled to determine the depth thereof, as in the prospecting of oil and gas in accordance with a seismic survey.

In making a seismic survey, a bore-hole 5 is drilled through the low velocity layer 2 to permit placing of an explosive charge, indicated at 6, in the underlying strata. Seismographs, indicated at 7, 8 and 9, are located at spaced points

along the surface of the ground and connected with an oscillograph 10 for receiving and recording sound waves reflected from the formation 4 incidental to explosion of the charge 6, the paths of the sound waves being indicated by the dot and dash lines 11. After reception of the reflected waves generated from the charge 6, the seismographs are moved and/or advanced different distances from the bore-hole and a new charge inserted in the bore-hole to effect recording of reflected sound waves from other points on the formation 4. The steps are thus repeated until the angle of reflection approaches a critical point, whereupon the direction of advancement of the seismographs is changed to determine lateral slope and depth of the formation 4, a new charge being exploded at the bottom of the bore-hole upon each successive location of the seismographs. To continue the survey in any direction beyond the critical angle of the reflected waves, it is necessary to place the succeeding shots in bore-holes usually located at the placement of the most remote seismograph location.

Thus a number of explosive charges are fired within the same shot-hole so that it is necessary to case the hole, as indicated at 12, to prevent caving of the relatively loose formation 2. This casing usually consists of second-hand metallic pipe which has many disadvantages, as above pointed out. I therefore contemplate casing of the shot-hole with interconnected, tubular sections that are formed of light weight, non-metallic, non-resonant material, such as fibre, impregnated paper, wood pulp, synthetic resins, and the like, which are substantially non-conductive of electricity and which are relatively poor transmitters of sound.

In carrying out the present invention I particularly contemplate tubular sections 13 that are formed from masonite, a material consisting of wood fibres, water-proofed with an emulsion having a paraffin base and pressed into tubular form of the desired wall thickness. Such material is of extremely light weight when compared with iron pipe, and is sufficiently strong to withstand caving pressures when inserted in a bore-hole, but is sufficiently fragile to permit fracture thereof under direct force of an explosion so as to permit salvaging thereof.

The sections 13 are formed of convenient lengths so that they may be readily transported and handled when run into the bore-hole, and the sections are connected together by light weight couplings as indicated at 14 in Fig. 3. The couplings 14 may be formed of the same material as the pipe and have internal threads 15 to receive threads 16 and 17 on the pipe sections.

A casing formed of sections as described is of light weight and is readily transported to remote locations where seismic surveys are usually made and which are many times inaccessible by the ordinary modes of conveyance, so that the pipe sections must be carried by coolies or porters. The pipe sections are also sufficiently inexpensive that they may be left in the bore-hole. The material, being a relatively poor conductor of sound, dampens the vibrations incidental to explosion of a charge so that the sound waves are not distributed by way of the casing to the weathered layer 2, so that non-reflected sound waves do not interfere with reception of or obscure arrival of the first reflected waves.

While I have referred to a specific material in describing the construction of the casing sections, it is obvious that the sections may be formed of other suitable non-resonant materials, such as fibre, impregnated paper pulp, or one of the various synthetic resins such as phenol formaldehyde or similar condensation products.

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

1. In a seismic surveying apparatus for surveying subterranean formations, an explosive charge located in the lower end of a bore-hole extending in the direction of the formation to be surveyed, a seismograph stationed in spaced relation with the bore-hole for detecting sound waves reflected from the subterranean formation being surveyed, an oscillograph connected with the seismograph, and means casing the bore-hole from the top thereof and through which the explosive charge is lowered to said lower end of the bore-hole, said casing means being formed of a material having the characteristic of being substantially non-resonant for shielding the formations through which the bore-hole extends from direct transmission by way of said casing means of sound waves emanating from the explosive charge to said seismograph whereby the reflected sound waves received by the seismograph are better distinguished from any direct waves received by the seismograph and recorded by said oscillograph.

2. In a seismic surveying apparatus for surveying subterranean formations, the combination of an explosive charge located in the lower end of a bore-hole extending in the direction of the formation to be surveyed, a seismograph stationed in spaced relation with the bore-hole for detecting sound waves reflected from the subterranean formation being surveyed, an oscillograph connected with the seismograph, and a non-resonating tube casing the bore-hole and through which the explosive charge is adapted to be lowered and for shielding the formations through which the bore-hole extends from direct transmission of sound waves emanating from the explosive charge to said seismograph whereby the reflected sound waves received by the seismograph are better distinguished from any direct waves received by the seismograph and recorded by said oscillograph, said tube having sufficient strength to maintain the major part of the bore-hole open for the insertion of a second explosive charge.

3. In a seismic surveying apparatus for surveying subterranean formations, the combination of an explosive charge located in the bottom of a bore-hole extending in the direction of the formation to be surveyed, a seismograph stationed in spaced relation with the bore-hole for detecting sound waves reflected from the subterranean formation being surveyed, an oscillograph connected with the seismograph, and a non-metallic tube casing the bore-hole and terminating short of the explosive charge and through which successive explosive charges are lowered into the bore-hole, said tube being of non-resonant material for shielding the upper formation from direct transmission of sound waves emanating from the explosive charge to said seismograph.

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