Dec. 11, 1945. F. I. ALEXANDER 2,390,676

SYSTEM FOR DETONATING EXPLOSIVES IN DEEP WELLS OR THE LIKE

Filed Aug. 25, 1942 2 Sheets-Sheet 1

Fig. 1.

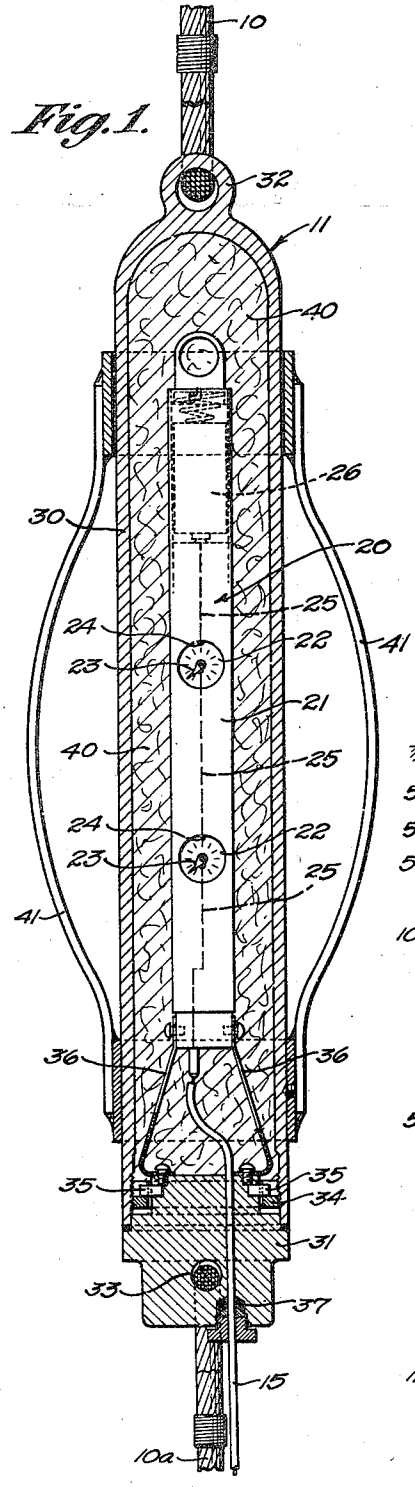


Fig. 2.

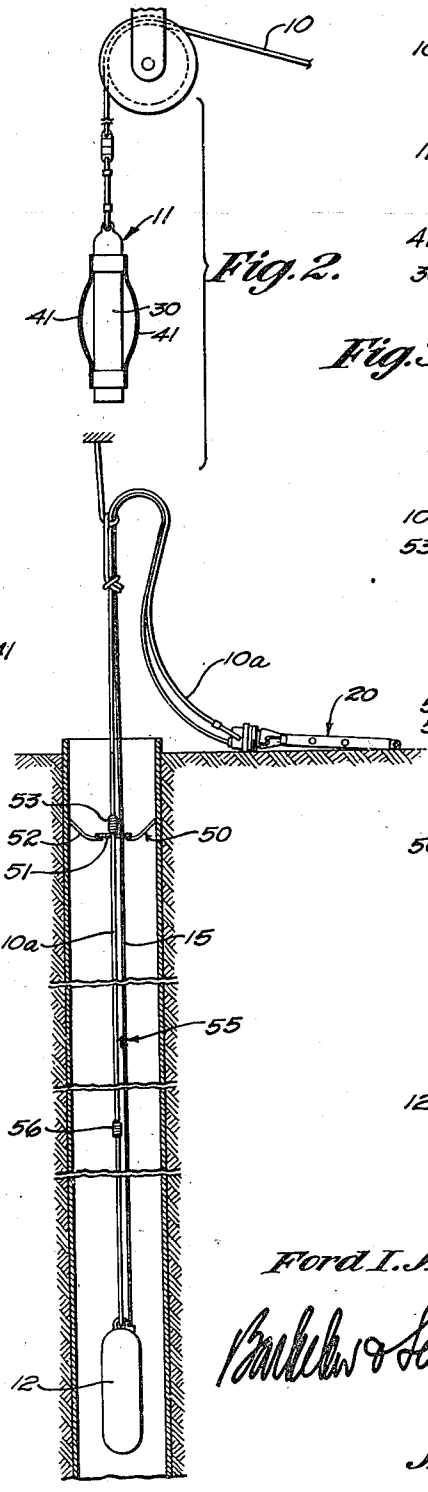
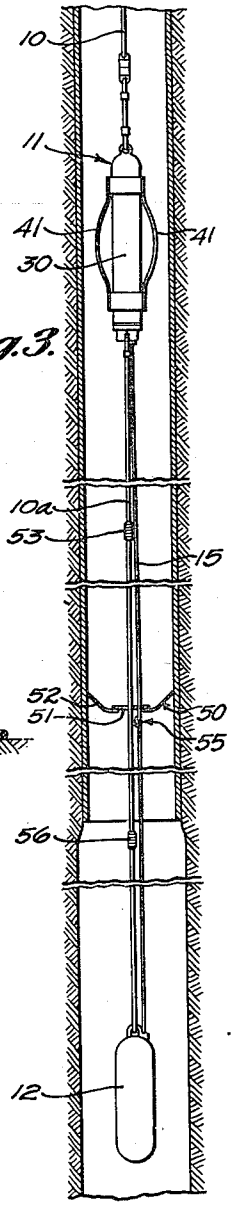


Fig. 3.



Inventor
Ford I. Alexander.

Barkley & Leavitt & Berry

Attorneys.

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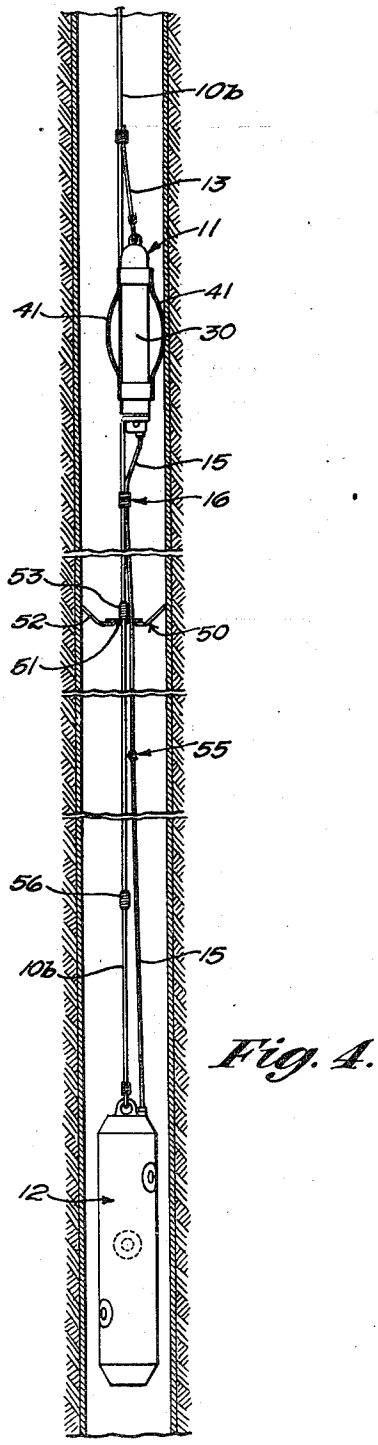


Fig. 4.

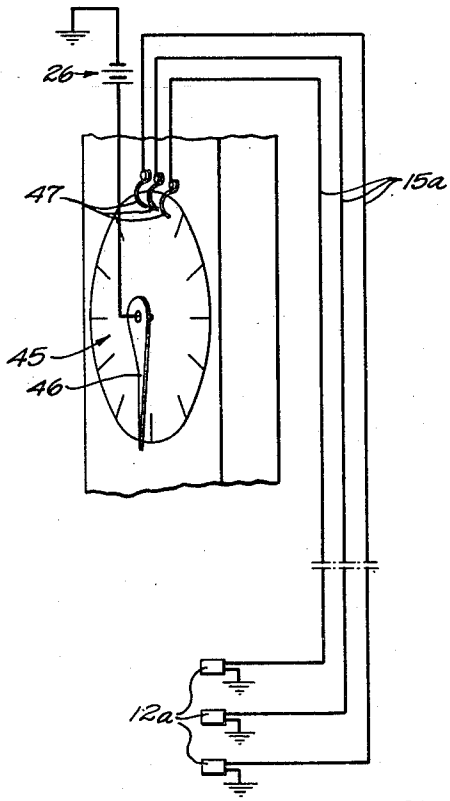


Fig. 5.

Inventor
Ford I. Alexander.

Bakewell & Sewall & Berry

Attorneys.

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2,390,676

SYSTEM FOR DETONATING EXPLOSIVES IN DEEP WELLS OR THE LIKE

Ford I. Alexander, Whittier, Calif.

Application August 25, 1942, Serial No. 456,031

4 Claims. (Cl. 102—20)

This invention has reference to systems of the type which are used for "shooting" deep wells, or for detonating explosive charges in any location which is relatively inaccessible and where the charge is usually lowered, or supported, by a cable or similar support. Without limiting the invention to any particular use, or application to any particular circumstances, the invention will be described in its application for detonating explosive charges in deep wells.

Past common practice in deep well work has been to lower the explosive charge into the well at the end of a dual purpose cable which is especially constructed to support the charge and also to carry the electric current which causes detonation of the charge or charges. Such cables are especially made for this work and are quite expensive. The cable must have sufficient strength to support the charge or charges, which are sometimes quite heavy, and also to support as much as from five to ten thousand feet of its own length. Furthermore the current carrying wire or cable, contained within the outer sheathing of high strength cable, must be insulated thoroughly enough to prevent insulation breakdowns under rough usage and under hydrostatic pressures which are often equal to five to ten thousand feet of liquid.

With the most careful handling, these composite cables are subjected to considerable wear, and often break down either physically or electrically. The initial high cost of the cable, and its rapid deterioration and liability to break down, combine to make cable cost one of the large items of expense in all kinds of well operations where explosive charges are detonated for any purpose in deep wells.

When such a system as described above is used, the timing of detonation is controlled by switch arrangements at the surface. In another system which has been more or less commonly used, a controlling instrument, usually including a source of current, such as a small battery, and a timing instrument, is lowered into the well along with the explosive charge. For instance, a perforating gun may be equipped with its own battery and timing instrument. Or, a fairly common arrangement has been to house the battery and timing instrument in the same protective and waterproof housing which contains either the main explosive charge or an initial detonating charge. In any such case the timing instrument is very likely to be injured, and in some cases completely destroyed.

The controlling or timing instruments must be, or at least should be, well enough designed and constructed as to maintain a relatively high accuracy and reliability of timing operation. Otherwise there is always liability of disastrous premature detonation brought on by faulty operation of the timing instrument or by accidental shorting of the electric circuit through a faulty or broken down instrument. In such instances, accidental detonation may take place at the surface while the assembly is being made up, or may take place in the well before the assembly reaches the desired point.

Also, in this second described assembly, there is always some danger in pulling out a charge or charges which for any reason have failed to explode. If a charge fails, it either must be detonated by some means other than the system which is in the well at the time, or it must be pulled from the well and rendered harmless after it reaches the surface. The former operation is not convenient; the latter is dangerous.

Among the several objects of my invention which will appear from the following detailed discussion, major objects are to provide a system wherein ordinary steel cable or other suitable simple support can be used for lowering a charge into a well, to provide for saving and retrieving the controlling or timing instrument which is lowered into the well, and to provide for taking care of an undetonated charge before starting to pull it from the well. Other objects will appear in the following.

The term "explosive charge" as herein used is intended, unless expressly qualified, to include any kind of explosive charge used for any purpose in a well or the like; including for instance such explosive charges as are carried in devices known as perforating or cleaning guns. The nature of the charge, and its purpose, and the kind or type of device in which the charge or charges are carried, are immaterial to my invention in a broad sense.

In a typical arrangement embodying the invention the charge, whatever it may be, is lowered into the hole on an ordinary simple supporting line such as a cable. The supporting line can be a string of pipe or rods; a flexible cable is preferred. The controlling or timing instrument is also lowered and supported by the same cable, but is supported on or in the length of cable at a distance above the charge ample to protect the instrument against damage or destruction. In this arrangement the main charge may, upon detonation, destroy a few feet of the lower end of the cable, but the timing instrument and sub-

stantially all the length of the long supporting cable can be withdrawn unharmed from the well. If the device at the lower end of the cable is of the nature of a perforating gun or the like, it also will of course be withdrawn with the whole length of cable and with the timing instrument.

To provide against the danger of withdrawing a charge or charges which have not detonated, I provide further means for rendering the detonation control inoperative, such means being operable by upward movement of the whole assembly. With an electrical control or timer, this means preferably takes the form of a circuit breaking device. In the operation of this circuit-breaking device, the battery and timing instrument will also usually be shorted, so that it is then virtually impossible that the charge be accidentally detonated on being withdrawn from a well.

For the purpose of describing my invention I have illustrated certain typical and preferred arrangements in the accompanying drawings in which

Fig. 1 is a vertical sectional view of a typical timer unit such as used in my system;

Fig. 2 is a fragmentary elevation and vertical section illustrating operations of lowering the charge into the well;

Fig. 3 illustrates the condition of the system either while being lowered into the well or upon reaching the desired depth;

Fig. 4 is a view similar to Fig. 3 but showing a modified arrangement; and

Fig. 5 is a diagrammatic showing of suitable electric timing circuits for controlling multiple charges.

Referring first to the arrangements shown in Figs. 1, 2 and 3, numeral **10** designates the lowering and supporting cable which is connected into the upper end of the control assembly **11** which I will call the timing unit. From the lower end of that timing unit, in the arrangement shown in these figures, there is an extension **10***a* of the supporting cable which carries at its lower end the element **12** which I here refer to broadly as the explosive charge or charge container. Its form and make-up may be anything desired. In the arrangement shown in the figures at present under particular discussion, it will be seen that timing unit **11** is carried and supported in the length of the supporting cable, as the main cable **10** is attached to the upper end of that unit, and the extension cable **10***a* is connected to and supported by the lower end of that unit. In the arrangement shown in Fig. 4, the main supporting cable **10***b* extends on downwardly past timing unit **11** and has its lower end directly connected to the explosive charge **12**, or the carrier therefor which in this instance is shown in the form of a perforating gun or the like having a body which carries several charges. And in the form shown in Fig. 4 the timing unit **11** is supported on cable **10***b* by having its upper end lashed to cable **10***b* through the medium of a small supporting cable **13**.

In both the described arrangements, an insulated electrical conductor **15** runs from the lower end of timing unit **11** down to the explosive charge; usually directly to a detonating cap which detonates the main charge or charges. The details are not illustrated as they are well known in the art. As shown in Fig. 4 conductor **15** may be lashed to the main supporting cable as at **16**.

The connective conductor **15** may be constituted as a part of the short piece of cable **10***a*; that piece of cable may be of the dual-purpose type. But, for economy and simplicity, I prefer to make conductor **15** independent of the cable.

I may use in my system any suitable form of controlling or timing instrument, preferring one which is rugged and reliable in operation, for the reasons which I have given. Generally speaking, the detonation controlling instrument may be an instrument of any suitable type and operated and connected to the charge in any suitable manner. I prefer a timing control, and one which operates to control an electrical detonating circuit. The one here illustrated, and generally designated by the numeral **20** in Fig. 1, is an electrical timer, known on the market as the "Zero Hour Electric Bomb." The general nature of that timing instrument is shown in the patent to Morrison, et al., 1,764,222. I do not here need to illustrate or describe the details of such an instrument, beyond a reference to those features which are necessary to the operation of my system. As constructed and obtainable upon the market, the instrument has an outer cylindric case **21**, and is provided with two clockworks each with a dial **22** and hand **23**. The clockworks are settable for predetermined time intervals. The switches controlled by the clockworks are here simply illustrated as including contacts **24** engaged by hands **23**. The hands may bring up against the contacts and stop; and the two switches may be connected in series in a line **25** which runs from one side of battery **26** through the two switches and thence to conductor **15**, previously spoken of. With the two switches in series, any shorting break-down of or at one switch will not cause premature detonation of the charge.

The other side of battery **26** is grounded in casing **20** in the usual manner. Casing **20** is grounded to the outer structural or protective shell **30** of timing unit **11**, as will be described; and that shell is ground connected by either cable **10***a* or cable **10***b* to the casing or shell which carries the explosive charge, and to which casing or shell the detonating cap or caps are grounded. Thus, whenever the timing switch is closed, the circuit is closed to detonate the caps and charges.

The timing unit illustrated in Fig. 1 is designed primarily for the purpose of carrying and protecting the timing instrument. Outer shell **30** is sufficiently strong to withstand any fluid pressures encountered and is closed fluid-tightly at its lower end by a gasketed cap **31**. An upper eye **32**, and a lower eye **33** on the cap, facilitate the connection of cables **10** and **10***a*. To be certain that cap **31** seats tightly all round, its screwthreads are carried on a loose ring **34** which is swivelly connected with the body of cap **31** through a pair of pivot pins **35**. This arrangement allows the cap to adjust itself, with reference to the screwthreads, so that the cap will seat tightly all round.

Shell **21** of timing instrument **20** is mounted on cap **31**, as for instance through the medium of a pair of metal straps **36**, which serve to space the timing instrument from the walls and the ends of shell **30** and also to ground instrument shell **21** on the main shell **30**. Conductor wire **15** extends through cap **31**, and a fluid tight joint is effected by packing gland **37**.

After the timing instrument has been set it is inserted in shell **30**, surrounded by a packing **40** of some suitable shock absorbing material, such as cotton, sponge rubber, or the like. Then when

cap 31 is set up tightly, the whole unit is ready to be inserted in the well casing for lowering. Shell 30 carries externally a set of spring shoes 41 adapted to absorb shocks which otherwise might be caused by contact of the unit with the casing or walls of the hole.

So far I have described the system as if the timed electrical circuit were intended only to set off a single detonation. Fig. 5 indicates diagrammatically an arrangement whereby multiple charges in a perforating gun or the like may be successively detonated. In this figure a clockworks is indicated diagrammatically at 45, with a contact hand 46 adapted successively to engage several contacts 47. One side of battery 26 is connected to the contact hand, and the several contacts 47 are connected by several conductors 15a to the several detonators 12a.

In using my system the charge or charges, typified at 12 in the drawings, are first attached to the end of cable 10a or 10b. The explosive charge is then lowered in the well casing to a distance which depends upon the desired spacing between the explosive charge and the timing unit 11. That spacing distance may be, say, 20 feet; and determines the length of cable 10a in Fig. 2 or determines the point at which the timing unit is lashed to cable 10b in Fig. 4. After the explosive charge has been lowered a safe distance down the hole, the timing instrument 20, which is then out of its protective shell 30, may be laid out in a position to one side of the top of the hole while the battery is inserted and the clock mechanism wound and set. In such relative positions, accidental detonation of the explosive charge while the timing instrument is being set up is relatively harmless to the operators. After the timing instrument has been set up, protective shell 30 may be taken to the same location away from the top of the hole, and the whole timing unit there assembled in comparative safety. The protective shell 30 may have been previously connected to the main supporting cable 10 as in Fig. 2 or to the supporting cable 10b as in Fig. 4. If not, that operation may be performed after assembly of the timing unit and away from the hole. The electrical conductor 15, or conductors 15a, will have been connected between the explosive charge or charges and the timing instrument before the above described operations take place.

After the timing unit has been completely set up and assembled, then the whole system is ready for lowering to the predetermined zone of action in the well. The timing system will have been set to give ample time for reaching that zone of action; and then, after detonation of the charge, the timing unit and the whole length of cable, except possibly the lowermost foot or so may be withdrawn from the hole.

Connected to, or in association with, the previously described parts of the system, I provide a conductor breaking device which, as here shown, is in the form of a simple drag 50. In the form as here shown, this drag surrounds the cable and conductor 15 at a point below the timing unit, and is inserted in the casing after charge 12. Fig. 2 shows the parts of the system with the explosive charge hanging in the upper part of the casing with drag 50 inserted in the casing, and with timing instrument 20 in a safe position at one side, ready to be set up and to be inserted in the protective shell 30.

The general function of the device shown at 50 is to enable the operator to effectively break the detonating circuit by suitable manipulation if anything goes wrong in the operation of the system. For this purpose, any device which will operate by virtue of relative upward movement of the parts, to break the circuit, will suffice for my purpose. I prefer to use such a simple device as is shown in the drawings and which acts to break the circuit by the simple expedient of pulling conductor 15 in two. Thus, in its simple and preferred form the device comprises a metal disk 51 with a central hole which is loosely threaded upon cable 10a, or upon cable 10b below the timing unit. Mounted upon disk 51 is a surrounding annulus 52 of some flexible or resilient substance, such as spring metal or rubber. This annulus may either be a solid annulus or a ring-like formation of fingers. Relative upward movement of disk 51 on the cable is preferably limited by a stop 53 which may be in the nature of a winding placed upon the cable. Such a stop prevents disk 51 from dragging upward against the lower end of timing unit 11 and from possibly injuring conductor 15 while the system is being lowered into the well. During lowering into the well the flexible resilient annulus 52 is bent upwardly as indicated in Fig. 2 and disk 51 rides upwardly against stop 53.

Disk 51 also has an opening which loosely passes conductor 15. That conductor has a knot or other suitable stop 55 formed in or upon it, at a suitable distance below stop 53, say at a distance of a few feet. At any suitable distance below knot 55 cable 10a or 10b has another stop 56. The vertical distance between stop 53 and knot 55 is made enough to allow a few feet of upward movement of the lower part of the cable and the charge before conductor knot 55 will engage disk 51, so as to allow a reasonable amount of adjustment movement of the cable and the charge in case the charge has initially been run into the hole a little further than desired.

Whenever anything goes wrong in the operation of the system, it is only necessary to pull the whole system upwardly in the hole, when the electrical conductor will be pulled in two, the detonating circuit thus broken, the lower broken off part of the conductor pulled downwardly away from the upper conductor portion, and the broken end of the upper conductor portion more or less grounded in the liquid which most usually fills the hole. Thus, if the explosive charge fails to detonate, or if for any reason the charge cannot be lowered to the desired point in the hole, it is only necessary to immediately hoist the whole system, when it will be immediately rendered inoperative to detonate the charge. The operation takes place in the following manner. As has been stated before, the drag device 50 remains in the relative position and condition shown in Fig. 1 while the system is being lowered in the well and as long as the system is not pulled upwardly. After a few feet of upward movement knot 55 moves up into contact with disk 51. The drag of device 50, particularly with annulus 52 bent upward, is then sufficient to pull conductor 15 in two. On further upward movement of the cable, drag 50 remaining stationary, the lower broken off part of conductor 15 is shoved down away from the upper portion of the conductor, and cable stop 56 then comes up against disk 51. The upward pull on the cable is then sufficient to move device 50 upwardly, reversing the angular inclination of the flexible annulus 52, so that device 50 is then easily withdrawn from the well along with the other parts of the system.

I claim:

1. Detonation apparatus for deep wells and the like, comprising in combination an explosive charge, a detonation controlling instrument which controls an electrical detonating circuit, means for lowering and raising the instrument and charge in the well, said means including a depending supporting line and means for attaching the instrument and the charge to the supporting line with the instrument spaced at a distance above the charge sufficient to prevent damage to the instrument by charge detonation, an electrical conductor forming a part of the detonating circuit and extending between the controlling instrument and the charge alongside the supporting line, and means for physically breaking the conductor embodying a drag loosely mounted on the supporting line, draggingly engaging the wall of the well, and engageable with the conductor.

2. Detonation apparatus for deep wells and the like, comprising in combination an explosive charge, a detonation controlling instrument which controls an electrical detonating circuit, means for lowering and raising the instrument and charge in the well, said means including a depending supporting line and means for attaching the instrument and the charge to the supporting line with the instrument spaced at a distance above the charge sufficient to prevent damage to the instrument by charge detonation, an electrical conductor forming a part of the detonating circuit and extending between the controlling instrument and the charge alongside the supporting line, and means for physically breaking the conductor embodying a drag loosely mounted on the supporting line and draggingly engaging the wall of the well, said drag having an aperture through which the conductor loosely passes, a stop on the supporting line limiting upward relative movement of the drag with respect to the supporting line, and a stop on the conductor spaced by a predetermined distance below the line stop so that on upward movement greater than said predetermined distance the conductor stop will engage the drag, the frictional drag of the latter being great enough to break the conductor.

3. Detonation apparatus for deep wells and the like, comprising in combination an explosive charge, a detonation controlling instrument which controls an electrical detonating circuit, means for lowering and raising the instrument and charge in the well, said means including a depending supporting line and means for attaching the instrument and the charge to the supporting line with the instrument spaced at a distance above the charge sufficient to prevent damage to the instrument by charge detonation, an electrical conductor forming a part of the detonating circuit and extending between the controlling instrument and the charge, and means for opening the detonating circuit on upward movement of the supporting line in the well, said means including a drag supported on the supporting line for limited vertical movement with reference thereto and draggingly engaging the wall of the well, and means whereby downward movement of the drag with reference to the line causes opening of the detonating circuit.

4. Detonation apparatus for deep wells and the like, comprising in combination an explosive charge, a detonation controlling instrument, a detonation circuit connecting the controlling instrument with the charge, means for lowering and raising the instrument and charge in the well, said means including a supporting line to which the instrument and charge are attached, and means for opening the detonating circuit on upward movement of the supporting line in the well, said means including a drag supported on the supporting line for limited vertical movement with reference thereto and draggingly engaging the wall of the well, and means whereby downward movement of the drag with reference to the line causes opening of the detonating circuit.

FORD I. ALEXANDER.