

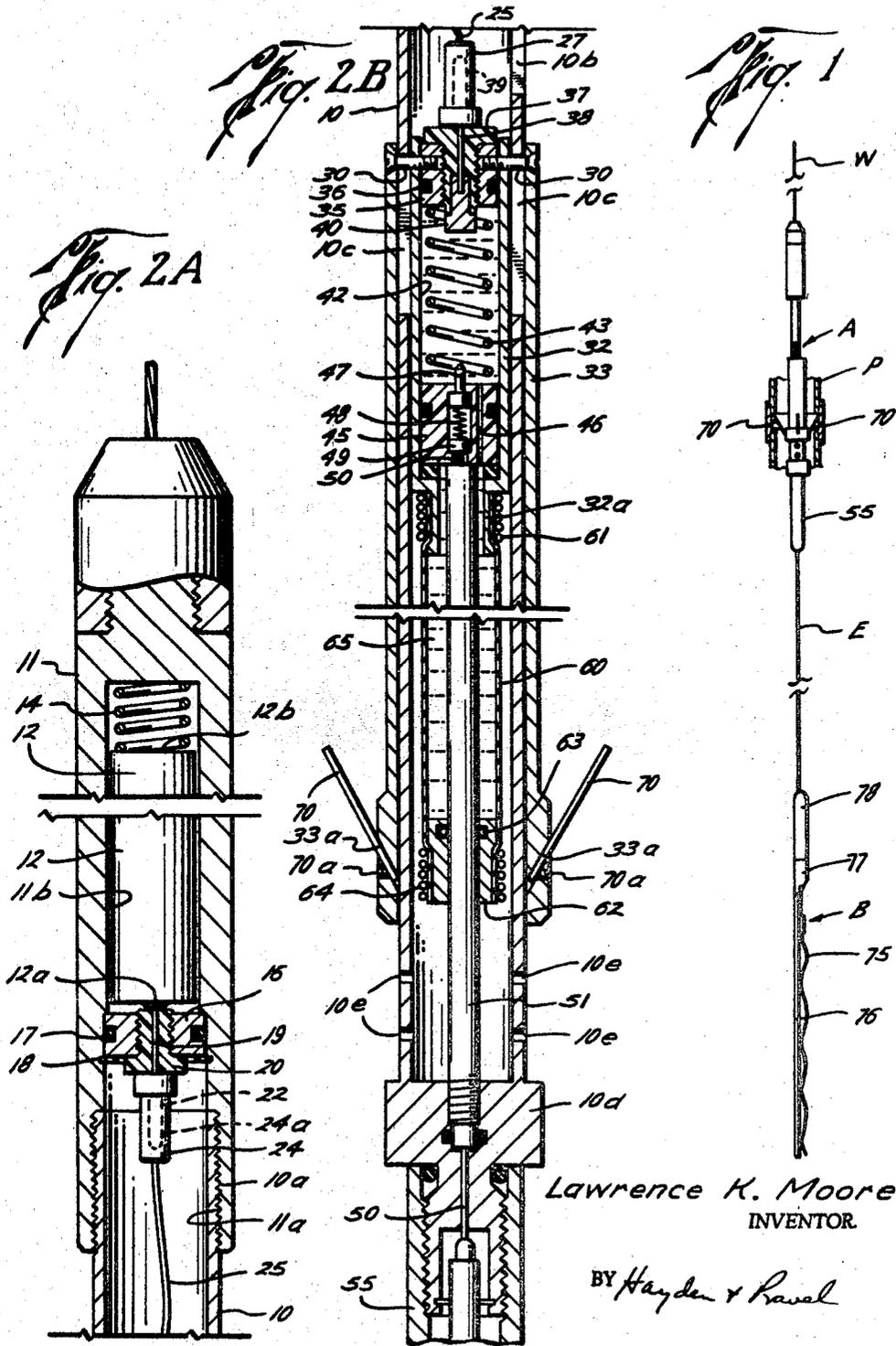
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WIRE-LINE ACTUATED DETONATOR APPARATUS

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ATTORNEYS

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WIRE-LINE ACTUATED DETONATOR APPARATUS

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This invention relates to a new and improved detonator apparatus which is particularly adapted for use in a well.

In the firing of explosives in a well, such as for performing pipe or releasing stuck pipe, the explosives must be lowered to the desired elevation in the well before detonation. Although efforts have been made in the past to handle such explosives on a non-electrical wire line, such prior efforts have lacked adequate safety against premature detonation, positive simple manipulation, accurate positioning at a desired well elevation, and release means retrieving the apparatus from the well either before or after detonation.

An object of the present invention is to provide a new and improved detonator apparatus adapted to be manipulated in a well with a non-electrical or "slick" wire line.

An important object of this invention is to provide a new and improved detonator apparatus which is adapted to be manipulated by a non-electrical wire line and which has means therewith for assuring adequate safety against premature detonation.

Another object of this invention is to provide a new and improved detonator apparatus which is adapted to be positively and simply manipulated by means of a non-electrical wire line.

A further object of this invention is to provide a new and improved detonator apparatus having means for locating a detonator apparatus at a predetermined elevation in a well pipe rotor to detonation.

A particular object of this invention is to provide a new and improved detonator apparatus having spaced electrical contacts adapted to be moved into contact with each other in opposition to fluid restraint, whereby premature engagement of said contacts is avoided.

The preferred embodiment of this invention will be described hereinafter, together with other features thereof, and additional objects will become evident from such description.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

FIG. 1 is an elevation illustrating the preferred form of the apparatus of this invention in position for locating and detonating explosive material in a well;

FIG. 2A is a view, partly in elevation and partly in section, illustrating the upper end of the detonator apparatus of this invention; and

FIG. 2B is a view, partly in elevation and partly in section, illustrating the lower portion of the detonator apparatus of this invention.

In the drawings, the letter A designates generally the detonator apparatus of this invention which is adapted to be lowered into a well on a wire line W or any other suitable non-electrical or slick wire line. As will be explained more fully hereinafter, the apparatus A provides a means for controlling the closing of an electrical circuit in a well so as to detonate explosives carried by any suitable apparatus such as indicated at B in FIG. 1. The explosive B is connected to the apparatus A by means of an electrical line E. In the normal operation of the apparatus of this invention, the apparatus A is lowered on the non-electrical wire line W into a well casing or pipe P (FIG. 1), with the explosive B suspended from the apparatus A on an electrical wire E of predetermined length. The

apparatus A is lowered to a predetermined elevation in the pipe P to thereby locate the explosive apparatus B at a predetermined elevation for perforating or performing other well operations with the explosive. Thereafter, the apparatus A is actuated by raising upwardly on the wire line W with a predetermined pull so as to close an electrical circuit to the explosive apparatus B for detonating same.

Considering the invention more in detail, the apparatus A is shown in FIGS. 2A and 2B in its preferred form. The apparatus A includes a first body portion or pipe 10 which is tubular in the preferred form of the invention and which has its upper ends threaded at 10a to a battery pack housing 11 having internal threads 11a. The housing 11 includes a bore or recess 11b for receiving one or more batteries 12. Such batteries 12 are held in place within the recess 11b by means of a spring 14 or other similar resilient means confined between upper end of the recess 11b and the uppermost battery 12. A seal-off block 16 is positioned below the battery or batteries 12 and has an annular seal-ring or O-ring 17 formed of rubber or other resilient material for preventing well fluid from entering the recess 11b in the vicinity of the batteries 12. A split snap-ring 18 formed of metal or similar material is positioned below the block 16 to removably retain same in place. The usual metal contact button 12a of the lower battery 12 is in electrical contact with the metal electrical wire 19 while the upper metal base 12b of the uppermost battery 12 is contacted by the metal spring 14 which is in engagement with the housing 11 to establish a ground connection. The wire 19 is secured in the block 16 by a threaded insert 20. The wire 19 is electrically connected to a male electrical element 22 of a Joy plug 24. The Joy plug 24 includes a removable cover 24a which is in electrical contact with the male electrical element 22. Also, an electrical conductor 25 is connected to the Joy plug 24 and extends downwardly in the first body portion 10 to another Joy plug 27 (FIG. 2B).

The body portion or pipe 10 has an opening 10b to facilitate the connection and disconnection of the Joy plug 27, as will be more fully explained.

The first body portion or pipe 10 includes one or more longitudinal slots 10c for receiving guide screws or elements 30 which are threadedly connected to an inner mandrel 32 and an outer mandrel or sleeve 33, which form a second portion of the body of the apparatus A. The mandrel 32 and sleeve 33 are thus connected together by means of the guide screws 30 for movement longitudinally together relative to the body portion 10. The extent of such relative longitudinal movement is determined by the length of the slots 10c (FIG. 2B).

The upper end of the inner mandrel 32 is closed off by a seal block 35 having an O-ring or similar seal-ring 36 of rubber or the like. It is to be noted that the guide screws 30 preferably extend into the block 35 to hold same in its position at the upper end of the mandrel 32. A threaded insert 37 extends into the center portion of the block 35 and carries an electrical conductor or wire 38 which terminates at the upper end in an upstanding male element 39 which is electrically contacted by the Joy plug or cover 27. The conductor 38 electrically connects with a metal contact 40 which is positioned within a chamber 42 below the plug 35 and within the mandrel 32.

A piston 45 having a by-pass port 46 therethrough is mounted in the chamber 42 for longitudinal movement. Such piston 42 has an electrical contact 47 mounted therewith and urged to the upper position by a resilient member 48. Such resilient member 48 is preferably a metal spring which conducts electricity from the electrical contact 47 to a conductor plug 49 and an electrical wire 50. Such wire 50 extends through a pipe or tube 51 and is

connected with the electrical cable or conductor E (FIG. 1) through any suitable rope socket 55 of known construction.

The lower end of the tube 51 connects into a lower head 10d at the lower portion of the tubular body 10 so that the piston 45 is actually connected directly to the body portion 10 and is movable therewith. Suitable openings 10e are provided at the lower end of the body portion 10 for preventing a fluid lock within the body portion 10 during the movement of the electrical contacts 40 and 47 towards each other and away from each other, as will be more fully explained.

The mandrel 32 has a lower reduced diameter neck 32a which has a boot 60 formed of rubber or other similar material attached thereto by clamps or wrapped wires 61. Such boot 60 has its lower end closed by a seal plug 62 which surrounds the pipe 51 in sealing contact therewith, preferably including an O-ring 63 formed of rubber or similar material. A clamp or wire wrapping 64 retains the lower end of the boot 60 around the plug 62 so as to form a lower chamber 65 within the boot 60 which is in communication with the chamber 42 through the restricted opening 46 in the piston 45.

The outer mandrel 33 has one or more trip wires or other flexible holding elements 70 which are adapted to engage in a joint or collar of a pipe P, as indicated in FIG. 1, or a spacing nipple or any other element having a recess or shoulder for engagement by the elements 70. Such trip wires or elements 70 are preferably retained in place with a set screw 70a, although they do not necessarily need such retaining means since they extend into a slot 33a which is at an upwardly and outwardly extending angle as best seen in FIG. 2B. Such trip wires or elements 70 are adapted to engage the laterally extending shoulder in a joint or collar of a well casing or pipe P to prevent or hold the mandrel 33 and the inner mandrel 32 against upward movement as the body portion 10 is pulled upwardly by the wire line W. If a predetermined pull is exerted on the wire line W, the elements 70 may be flexed downwardly to permit an upward passage of the entire tool prior to the contact of the electrical contacts 40 and 47, as will be more evident hereinafter. In some instances, the elements 70 may be made of a frangible material which will crack or shear upon a predetermined pull on the wire line W. Under normal conditions, the trip wires 70 engage the lateral shoulder of the collar or joint in the pipe P and the amount of pull on the wire line W is sufficient to move the body 10 and the contact 47 upwardly while the trip wires 70 remain engaged in the collar or joint so that the mandrels 32 and 33 do not move until the contacts 40 and 47 are in engagement for completing an electrical circuit to the explosive B.

The explosive apparatus B may be any conventional apparatus such as string shot 75 or pods which are connected on a suitable weight or bar 76 from a shooting adapter 77 and a rope socket 78. The electrical cable or conductor E is connected to the rope sockets 55 and 78 and is of a predetermined length for locating the shot or explosive B at the desired elevation when the trip wires or elements 70 are set at a predetermined elevation in the pipe P.

It should be noted that when the electrical contacts 40 and 47 engage each other, an electrical circuit is completed from the batteries 12 through the battery housing 11, the body portion 10 and the electrical cable E to the explosive B so as to detonate such explosive.

In the operation or use of the apparatus of this invention, the entire apparatus A with its explosive B suspended therefrom on the conductor E is lowered into the pipe P. Since the length of the entire apparatus down to the explosive B is known, the position at which the apparatus is to be stopped in its downward movement may be readily determined by observing or measuring the amount of the wire line W lowered into the well. When the desired elevation is reached, an upward pull is exerted on

the wire line W so as to engage the flexible fingers or wires 70 in a collar or joint of the pipe P as shown in FIG. 1. Upon engagement of the wires 70 in such joint or collar, the mandrels 33 and 32 are prevented from further upward movement so that the electrical contact 40 is held against upward movement. However, the upper body portion 10 is moved upwardly as the wire line W is pulled upwardly for thereby moving the piston 45 and the electrical contact 47 upwardly. The upward movement of the piston 45 is restrained by the fluid such as silicone oil in the chamber 42 which must pass through the restricted passage 46. In some instances, other by-pass arrangements may be employed. For example, the by-pass may be in the body 32 or the outer diameter of the piston 45 may be smaller than the internal diameter of the mandrel 32 so as to provide a restricted annular passage or space which functions in the same manner as the restricted opening 46. In any event, it requires a steady but not an excessive pull on the wire line W to overcome the restraint provided by the fluid in the chamber 42 as it flows through the restricted passage 46 into the boot 60 therebelow. So long as the amount of pulling force W is not sufficient to break the wires 70 or put such a reverse bend in them as to permit release from the collar or joint, the body portion 10 continues to move upwardly and the electrical contact 47 continues to move upwardly towards the electrical contact 40 until the contacts 40 and 47 engage with each other, at which time the electrical circuit to the explosive B is completed and is thereby detonated. The spring 43 returns the piston 45 to its lower position shown in FIG. 2B after the predetermined pulling force on the wire line W is released.

After the detonation of the explosive B, the entire apparatus A may be removed from the pipe P since the explosion is sufficiently therebelow to normally avoid damage from the explosion. The apparatus A is removed by pulling upwardly on the wire line W with a sufficient force to either flex the element 70 downwardly or to fracture such elements 70.

With the present invention, a premature firing of the explosive apparatus B is avoided. This is accomplished in several ways, one of which is the use of the removable plug 27 which is not placed into contact with the male electrical element 39 until all of the explosive has been lowered into the well casing or pipe. A further safety feature of this invention resides in the hydraulic restraint provided by the piston 45 and the restricted passage 46. Thus, with the present invention, it requires a period of time and a force on the wire line W in an upward direction in order to bring the contacts 40 and 47 into engagement with each other. Such contact cannot be accomplished except by a deliberate pulling upwardly on the wire line W over a period of time which is sufficiently long to prevent any inadvertent firing of the explosive B. Also, in some instances it may be desirable to pull the tool completely out of the well without firing the explosive B, and this can be accomplished by exerting a rapid jerking pull on the wire line W so that the flexible fingers 70 are either fractured or are bent downwardly to release them so that there is either no substantial movement or insufficient relative movement of the contact 47 towards the contact 40 to contact same. It should also be noted that the firing of the explosive B with the detonator apparatus A of this invention is accomplished with a positive simple pulling force on the wire line W, which facilitates operation by an operator at the well head.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape, and materials as well as in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. A detonator apparatus adapted to be used in a well, comprising:

(a) a tubular body forming a chamber for fluid,

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- (b) a piston mounted in said chamber for longitudinal movement,
- (c) a first electrical contact in said chamber,
- (d) a second electrical contact mounted on said piston for movement therewith,
- (e) said piston having a restricted passage means for permitting restricted flow of fluid from one side of the piston to the other as the piston moves in said chamber,
- (f) electrical means connected to said contacts for completing an electrical circuit upon engagement of said contacts, and
- (g) a flexible boot connected to said chamber and in communication therewith for receiving fluid and expanding as the piston moves in said chamber to engage said contacts with each other.

2. An apparatus for detonating an explosive in a well, comprising:

- (a) a tubular body having a longitudinal slot through the wall thereof,
- (b) a wire line connected to the upper end of said tubular body for exerting an upward pulling force thereon,
- (c) an outer sleeve surrounding said tubular body,
- (d) resilient latch fingers mounted on said outer sleeve for passing downwardly in a well pipe past pipe joints but being adapted to releasably latch in a pipe joint or collar upon an upward pull on said wire line,
- (e) an inner chamber disposed within said tubular body,
- (f) a pin extending from said outer sleeve to the wall of said inner chamber through said longitudinal slot for connecting said chamber wall to said outer sleeve to thereby prevent said chamber from moving upwardly when said outer sleeve is latched against upward movement in a well pipe by said latch fingers,
- (g) a piston disposed in said chamber and movable longitudinally therein,
- (h) a pipe extending downwardly from said piston in said body and connecting said piston to said body for upward movement together when said body is pulled upwardly by said wire line,
- (i) seal means in said chamber engaging said pipe to retain fluid within said chamber,
- (j) said piston having a fluid restriction therewith to retard the upward movement of the piston in said chamber,
- (k) a first electrical contact in the upper end of said chamber,
- (l) a second electrical contact on the piston for engagement with said first electrical contact when said piston moves upwardly in said chamber relative to the wall of said chamber,
- (m) resilient means disposed in said chamber in engagement with said piston for resiliently holding said piston and said second electrical contact therewith below said first electrical contact,
- (n) an electrical circuit which is closed upon engagement of said first and second electrical contacts, and
- (o) an explosive means detonated upon a closing of said electrical circuit.

3. An apparatus for detonating an explosive in a well, comprising:

- (a) a tubular body having a longitudinal slot through the wall thereof,
- (b) a wire line connected to the upper end of said tubular body for exerting an upward pulling force thereon,
- (c) an outer sleeve surrounding said tubular body,
- (d) resilient latch fingers mounted on said outer sleeve for passing downwardly in a well pipe past pipe joints but being adapted to releasably latch in a pipe joint or collar upon an upward pull on said wire line,
- (e) an inner chamber disposed within said tubular body,

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- (f) a pin extending from said outer sleeve to the wall of said inner chamber through said longitudinal slot for connecting said chamber wall to said outer sleeve to thereby prevent said chamber from moving upwardly when said outer sleeve is latched against upward movement in a well pipe by said latch fingers,
- (g) a piston disposed in said chamber and movable longitudinally therein,
- (h) a pipe extending downwardly from said piston in said body and connecting said piston to said body for upward movement together when said body is pulled upwardly by said wire line,
- (i) seal means in said chamber engaging said pipe to retain fluid within said chamber,
- (j) said piston having a fluid restriction therewith to retard the upward movement of the piston in said chamber,
- (k) a first electrical contact in the upper end of said chamber,
- (l) a second electrical contact on the piston for engagement with said first electrical contact when said piston moves upwardly in said chamber relative to the wall of said chamber,
- (m) an electrical circuit which is closed upon engagement of said first and second electrical contacts, and
- (n) an explosive means detonated upon a closing of said electrical circuit.

4. An apparatus for detonating an explosive in a well, comprising:

- (a) a tubular body having a longitudinal slot through the wall thereof,
- (b) a wire line connected to the upper end of said tubular body for exerting an upward pulling force thereon,
- (c) an outer sleeve surrounding said tubular body,
- (d) resilient latch fingers mounted on said outer sleeve for passing downwardly in a well pipe past pipe joints but being adapted to releasably latch in a pipe joint or collar upon an upward pull on said wire line,
- (e) an inner chamber disposed within said tubular body,
- (f) a pin extending from said outer sleeve to the wall of said inner chamber through said longitudinal slot for connecting said chamber wall to said outer sleeve to thereby prevent said chamber from moving upwardly when said outer sleeve is latched against upward movement in a well pipe by said latch fingers,
- (g) a piston disposed in said chamber and movable longitudinally therein,
- (h) a pipe extending downwardly from said piston in said body and connecting said piston to said body for upward movement together when said body is pulled upwardly by said wire line,
- (i) a flexible boot depending from said chamber for receiving fluid and expanding upon an upward movement of said piston,
- (j) seal means with said flexible boot in engagement with said pipe to retain fluid within said chamber and said boot,
- (k) said piston having a fluid restriction therewith to retard the upward movement of the piston in said chamber,
- (l) a first electrical contact in the upper end of said chamber,
- (m) a second electrical contact on the piston for engagement with said first electrical contact when said piston moves upwardly in said chamber relative to the wall of said chamber,
- (n) resilient means disposed in said chamber in engagement with said piston for resiliently holding said piston and said second electrical contact therewith below said first electrical contact,
- (o) an electrical circuit which is closed upon engagement of said first and second electrical contacts, and

- (p) an explosive means detonated upon a closing of said electrical circuit.
5. An apparatus for detonating an explosive in a well, comprising:
- (a) an explosive means adapted to be lowered in a well,
 - (b) an electrical cable electrically connected to said explosive means and extending thereabove for a predetermined distance,
 - (c) detonator means having a pipe with a first electrical contact mounted thereon and a sleeve externally of the pipe and with a second electrical contact connected to said sleeve and disposed internally of the sleeve,
 - (d) means connecting the detonator means to and above said electrical cable for positioning same at a predetermined elevation in a well pipe above said explosive means,
 - (e) said pipe and said sleeve being movable longitudinally relative to each other,
 - (f) a wire line connected to the pipe for lowering the detonator means in the well to a predetermined elevation,
 - (g) anchor elements on the sleeve and projecting outwardly therefrom for engagement in a recess in the bore of the well pipe,
 - (h) restraining means for holding the pipe and sleeve in a predetermined position with respect to each other during the lowering thereof,
 - (i) means for transmitting an upward pull on said wire line from the pipe to the sleeve to position the anchor elements in a recess,
 - (j) said restraining means permitting movement of the pipe upwardly relative to the sleeve after the anchor elements are positioned in the recess for moving the electrical contacts together, and
 - (k) an electrical circuit which is closed upon the engagement of the electrical contacts for detonating the explosive means.
6. An apparatus for detonating an explosive in a well, comprising:
- (a) an explosive means adapted to be lowered in a well,
 - (b) an electrical cable electrically connected to said explosive means and extending thereabove for a predetermined distance,
 - (c) detonator means having a pipe with a first electrical contact mounted thereon and a sleeve externally of the pipe and with a second electrical contact connected to said sleeve and disposed internally of the sleeve,
 - (d) means connecting the detonator means to and above said electrical cable for positioning same at a predetermined elevation in a well pipe above said explosive means,
 - (e) said pipe and said sleeve being movable longitudinally relative to each other,
 - (f) a wire line connected to the pipe for lowering the detonator means in the well to a predetermined elevation,
 - (g) anchor elements on the sleeve and projecting outwardly therefrom for engagement in a recess in the bore of the well pipe,
 - (h) resilient means for resiliently holding the pipe and sleeve in a predetermined position with respect to each other during the lowering thereof,
 - (i) means for transmitting an upward pull on said wire line from the pipe to the sleeve to position the anchor elements in a recess,
 - (j) said resilient means permitting movement of the pipe upwardly relative to the sleeve after the anchor elements are positioned in the recess for moving the electrical contacts together, and
 - (k) an electrical circuit which is closed upon the engagement of the electrical contacts for detonating the explosive means.

7. An apparatus for detonating an explosive in a well, comprising:
- (a) an explosive means adapted to be lowered in a well,
 - (b) an electrical cable electrically connected to said explosive means and extending thereabove for a predetermined distance,
 - (c) detonator means having a pipe with a first electrical contact mounted thereon and a sleeve externally of the pipe and with a second electrical contact connected to said sleeve and disposed internally of the sleeve,
 - (d) means connecting the detonator means to and above said electrical cable for positioning same at a predetermined elevation in a well pipe above said explosive means,
 - (e) said pipe and said sleeve being movable longitudinally relative to each other,
 - (f) a wire line connected to the pipe for lowering the detonator means in the well to a predetermined elevation,
 - (g) anchor elements on the sleeve and projecting outwardly therefrom for engagement in a recess in the bore of the well pipe,
 - (h) releasable holding means for releasably holding the pipe and sleeve in a predetermined position with respect to each other during the lowering thereof,
 - (i) means for transmitting an upward pull on said wire line from the pipe to the sleeve to position the anchor elements in a recess,
 - (j) said releasable holding means permitting movement of the pipe upwardly relative to the sleeve after the anchor elements are positioned in the recess for moving the electrical contacts together,
 - (k) fluid restraint means for restraining the longitudinal upward movement of the second portion relative to the first portion to provide a time delay before the electrical contacts engage, and
 - (l) an electrical circuit which is closed upon the engagement of the electrical contacts for detonating the explosive means.
8. A detonator apparatus adapted to be used in a well, comprising:
- (a) a body having a pipe and a sleeve longitudinally movable relative to each other,
 - (b) a first electrical contact on said pipe,
 - (c) a second electrical contact on said sleeve,
 - (d) an electrical circuit having electrical means connected to said contacts for completing an electrical circuit upon engagement of said contacts,
 - (e) a wire line secured to said pipe and unreleasable therefrom in the well for applying an upward pull thereon to move said contacts into engagement,
 - (f) means for anchoring said sleeve in the bore of a well pipe to prevent upward movement thereof while said pipe is moving upwardly relative thereto,
 - (g) fluid restraint means for restraining the longitudinal movement of said sleeve and pipe and their contacts towards each other to provide a time delay before the contacts engage each other, and
 - (h) an explosive means connected in the electrical circuit with said electrical means for detonation upon the engagement of the electrical contacts with each other.
9. A detonator apparatus adapted to be used in a well, comprising:
- (a) a body having a pipe and a sleeve longitudinally movable relative to each other,
 - (b) a chamber formed internally of the pipe and having fluid therein,
 - (c) a piston disposed in said chamber for longitudinal movement therein, said piston having restricted passage means for permitting restricted flow from one side of the piston to the other in said chamber,
 - (d) a first electrical contact on said piston,

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- (e) means connecting said piston to said pipe,
- (f) a second electrical contact in said chamber and connected to said sleeve,
- (g) an electrical circuit having electrical means connected to said contacts for completing an electrical circuit upon engagement of said contacts, 5
- (h) a wire line secured to said pipe and unreleasable therefrom in the well for applying an upward pull thereon to move said contacts into engagement,
- (i) means for anchoring said sleeve in the bore of a well pipe to prevent upward movement thereof while said first body portion is moving upwardly relative thereto, 10
- (j) the fluid in said chamber restraining the longitudinal movement of said piston and the first electrical contact towards the second electrical contact to provide a time delay before the contacts engage each other, and 15
- (k) an explosive means connected in the electrical circuit with said electrical means for detonation upon the engagement of the electrical contacts with each other. 20

10. The structure set forth in claim 9, wherein said restricted passage means with said piston is provided by having the annulus of the piston slightly smaller than the inner bore of the chamber. 25

11. A detonator apparatus adapted to be used in a well, comprising:

- (a) a body having a pipe and a sleeve longitudinally movable relative to each other, 30
- (b) a first electrical contact on said pipe,
- (c) a second electrical contact on said sleeve,
- (d) an electrical circuit having electrical means connected to said contacts for completing an electrical circuit upon engagement of said contacts,

- (e) a wire line secured to said pipe and unreleasable therefrom in the well for applying an upward pull thereon to move said contacts into engagement,
- (f) flexible anchoring fingers mounted on said sleeve and externally thereof for anchoring in the bore of a well pipe to prevent upward movement thereof while said pipe is moving upwardly relative thereto with a steady sustained pull on the wire line and being capable of bending downwardly or fracturing to release the fingers when the wire line is jerked with a predetermined force,
- (g) fluid restraint means for restraining the longitudinal movement of said sleeve and pipe and their contacts towards each other to provide a time delay before the contacts engage each other so as to prevent the engagement of the contacts when the wire line is jerked to release the fingers from their anchored position to thereby enable the apparatus to be removed from the well pipe without being detonated, and
- (h) an explosive means connected in the electrical circuit with said electrical means for detonation upon the engagement of the electrical contacts with each other.

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