

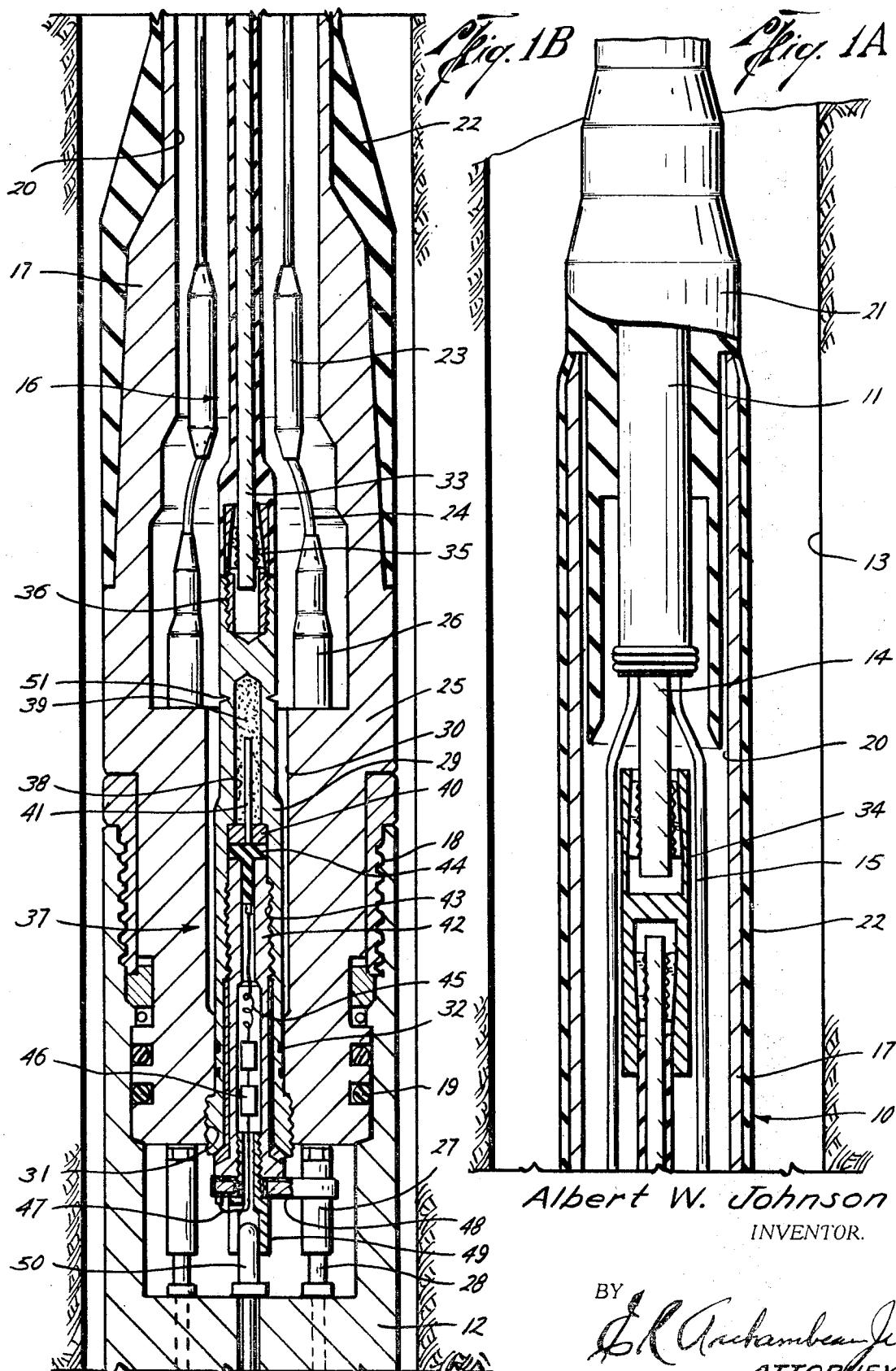
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APPARATUS FOR SELECTIVELY RELEASING CABLE-SUSPENDED WELL TOOLS

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APPARATUS FOR SELECTIVELY RELEASING CABLE-SUSPENDED WELL TOOLS

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9 Claims

ABSTRACT OF THE DISCLOSURE

The particular embodiment of selectively-operable releasing apparatus disclosed herein as illustrative of the present invention includes a load-bearing support member adapted to dependently couple a well tool to a suspension cable. Although the support member has sufficient strength to carry the weight of the tool and withstand normal loads thereon, electrically-responsive explosive means are arranged on the support member for selectively parting the support member should it be desired to release the cable from the well tool while it is in a well bore. To provide an alternative procedure for releasing the tool, the support member is also adapted to fail in response to cable tension forces in excess of those typically experienced during normal operations.

It is not at all uncommon for a cable-suspended well tool, such as a perforator or logging instrument, to become stuck in a well bore as it is being used. When it has been determined that the tool cannot otherwise be dislodged, it is then necessary to disconnect the cable from the tool in one of several manners. Once the cable is disconnected from the tool, one or more of the many typical fishing tools can then be secured to the stuck tool to pull it free. It will be recognized, of course, that the cable should be disconnected as close as possible to the tool to avoid leaving a loose skein of cable piled on top of the tool which will unduly hamper these fishing operations.

Heretofore, in one manner of disconnecting a cable from a well tool, it has been customary to connect the free end of the cable to the tool by a so-called "weak point" having a reduced portion of less tensile strength than the cable. Then, should the tool become stuck, the cable can often be disconnected by pulling on the cable to break the interlinking weak-point connection.

Such weak-point connections are not always too reliable, however. It will be appreciated that a weak point must have sufficient tensile strength to support the static weight of the tool as well as any loads induced either in raising the tool or in reasonable efforts to dislodge the tool should it become stuck. On the other hand, a weak point may in some instances be too strong and the suspension cable itself may part near the surface as it is being tensioned to break the weak-point connection. For example, assume that a tool is suspended from a cable having an average tensile strength of 12,000-pounds and the particular weak point is designed to fail at 6,200-pounds. Thus, if the combined weight of the cable already in the well bore and the tool is 6,200-pounds, it is quite likely that the suspension cable will instead part near the top of the well before sufficient tension can be applied to break the weak point. This problem, of course, becomes more pronounced as the operating depth increases and a greater weight of cable is in the well bore.

There are other instances where a conventional weak point may not even be usable as, for example, where the cable itself has become stuck, as by keyseating or dif-

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ferential sticking, at one or more intermediate points in the borehole. Should this happen, sufficient cable tension usually cannot be applied from the surface to break the weak point without first parting the cable above the point where it is stuck.

Accordingly, it is an object of the present invention to provide apparatus for connecting a well tool to a suspension cable, which apparatus is selectively releasable in response either to application of tension of a predetermined magnitude through the cable or to an electrical signal from the surface through the cable.

This and other objects of the present invention are attained by interconnecting a cable-suspended well tool to a typical suspension cable by a linking support member of sufficient strength to at least carry the weight of the tool. Explosive means are appropriately arranged on the support member for selective detonation in response to an electrical signal from the surface to part the support member when the cable must be released from the tool while in a well bore. The load-bearing support member is also adapted to be selectively failed upon application of tension to the cable of a predetermined magnitude in excess of that normally expected.

The novel features of the present invention are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may be best understood by way of the following description of exemplary apparatus employing the principles of the invention as illustrated in the accompanying drawings, in which:

FIGS. 1A and 1B are successive cross-sectional views of a preferred embodiment of apparatus arranged in accordance with the present invention.

Turning now to FIGS. 1A and 1B, the releasing apparatus 10 of the present invention is shown dependently connected to a suspension cable 11 and supporting a typical well tool 12 in a well bore 13. To facilitate explanation of the invention, minor constructional details have been omitted from the drawings to better illustrate the significant features of the releasing apparatus 10.

The suspension cable 11 is spooled from a winch (not shown) at the surface of the ground in the usual manner. As is customary, means (not shown) are provided at the surface for indicating the tension on the cable 11 at any time. As is also typical, the lower end of the suspension cable 11 is comprised of a central load-carrying stranded member 14 surrounded by one or more electrical conductors, such as at 15, with all being mutually enclosed within a protective armored sheath and covered by an outer water-proof jacket.

In general, therefore, the releasing apparatus 10 is comprised of a central supporting member 16 that is the sole load-supporting connection linking the suspension cable 11 to the well tool 12. Although provisions are made in the apparatus 10 to facilitate electrical connections between the suspension cable 11 and the well tool 12 as well as to protect these connections from well-bore fluids, the releasing apparatus is so arranged that once any portion of the load-supporting member 16 fails, the electrical connections will be easily disrupted as the cable is pulled away from the tool.

Accordingly, as seen in the drawings, the releasing apparatus 10 includes a tubular protective housing 17 adapted to be secured to the upper end of the well tool 12, as by a threaded connection 18, and fluidly sealed thereto by seals, as at 19. To provide a fluid seal around the lower end of the suspension cable 11, the upper end of the central bore 20 of the housing 17 is adapted to snugly, but releasably, receive the lower reduced-diameter portion of an elastomeric sleeve or so-called typical "boot" 21 snugly fitted over the lower end of the cable. An elastomeric

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sleeve 22 is fitted over the exterior of the housing 17 and adapted to meet the cable boot 21 and improve the fluid seal around the junction of the boot with the housing. If desired, the central housing bore 20 can be filled with a suitable grease or such to exclude well-bore fluids so long as the cable 11 is connected to the apparatus 10.

The electrical conductors 15 in the cable 11 are passed through the housing bore 20 around the central load-supporting member 16 and preferably connected through break-away connectors, as at 23, to extension conductors, as at 24, that are passed through a transverse wall 25 closing the lower end of the housing 17 by suitable conductor seals, as at 26. To facilitate making the electrical connections between the releasing apparatus 10 and well tool 12, the electrical conductors 24 are preferably connected to one member, as at 27, of an electrical coupling that is dependently mounted in the transverse wall 25 and aligned with an upright complementally-mating coupling member, as at 28, on the well tool. Accordingly, it will be appreciated that although the cable conductors 15 are reliably connected to the well tool 12 and protected from well bore fluids, once any portion of the load-supporting linking member 16 is parted, the lower end of the suspension cable 11 can be easily pulled out of the housing bore 20 upon failure of the relatively-weak break-away connectors 23.

As previously mentioned, the central member 16 is the sole load-bearing connection between the stranded cable member 14 and the well tool 12. Accordingly, as seen in FIGS. 1A and 1B, in its preferred form, this central load-bearing linking member 16 includes a generally-cylindrical body 29 that is received in an axial bore 30 through the transverse wall 25 and secured thereto as by threads 31, with O-rings 32 around the body fluidly sealing the connection. In this embodiment, the central linking member 16 further includes a stranded cable 33 of predetermined strength having typical swage fittings 34 and 35 respectively secured to its upper and lower ends. The lower swage fitting 35 is secured to the upper end of the body 29, as by a threaded connection 36, with the upper swage fitting 34 being swaged onto the lowermost end of the stranded load-supporting member 14 of the suspension cable 11. Accordingly, it will be realized that the central load-supporting member 16 is tandemly interconnected between the stranded cable member 14 and well tool 12 and provides the sole link therebetween capable of supporting the weight of the tool in the well bore 13.

As previously mentioned, the stranded cable 33 forming the upper portion of the load-supporting member 16 is selected to have a predetermined strength. By way of example, in one typical embodiment, the linking cable 33 is selected to fail in response to a tension force of about 5,400 to 6,900-pounds, with its intended average strength being about 6,200-pounds. Thus, in those situations where the tool 12 has been stuck in the well bore 13 and can be released by merely tensioning the cable 11 with a force sufficient to break the linking cable 33, this selective procedure can be followed.

For those situations earlier described, however, where the suspension cable 11 cannot be safely tensioned to break the weaker linking cable 33, the releasing apparatus 10 also includes electrically-responsive explosive means 37 for selectively parting the load-supporting member 17. In the preferred manner of accomplishing this, the cylindrical body 29 is hollowed to provide an elongated axial cavity 38 therein. A suitable explosive powder 39 is disposed in the upper closed end of the cavity 38 and confined therein by an annular member 40. An electrically-responsive igniter 41, such as that shown in Pat. No. 2,681,701 or at "133" in Pat. No. 3,329,208, is snugly fitted into the cavity 38 with its small, explosive-filled, tubular tip passing through the annular member 40 and in detonating proximity of the explosive powder 39. A tubular plug 42 is secured, as by threads 43, in the lower end of the cavity 38 and adapted to urge an elastomeric

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sealing member 44 on the igniter 41 outwardly into sealing engagement with the wall of the cavity.

As is typical, the igniter tip encloses a suitable filament (not shown) that has one end electrically connected to the tubular tip so that one side of the electrical connection for the igniter 41 is made, as through the annular spacer 40, to the body 29. Electrical connection to the other end of the igniter filament is conveniently provided by a single wire 45 that is fluidly sealed within the sealing member 44 and extended downwardly through the tubular plug 42.

For reasons that will subsequently be more apparent, the wire 45 is connected to means such as one or more serially-arranged Zener diodes 46, that are electrically-conductive only in response to voltage in excess of a predetermined magnitude. By reversely orienting the two Zener diodes 46 in relation to one another, it will be appreciated that one of the diodes will block flow of direct current of one polarity and the other diode will block flow of direct current of the opposite polarity so long as the predetermined voltage level is not reached. The other end of these Zener diodes 46 is connected by a wire 47 to an externally-insulated jumper bar 48 that is extended laterally and suitably connected to the electrical plug member 27. A suitable electrical plug member 49 is secured in the lower end of the tubular plug 42 and adapted to matingly receive an upright electrical plug member 50 similar to the member 28 and similarly mounted on the upper end of the tool 12 to insure electrical continuity between the igniter 41 and the body of the tool.

Accordingly, as will be appreciated, only application of sufficient voltage of the correct polarity from a suitable direct-current source at the surface (not shown) to the electrical conductor 45 will be effective to detonate the explosive 39. Once the explosive 39 is detonated, the body 29 will be ruptured preferably along a weakened section thereof as conveniently provided by a circumferential notch 51 formed therearound. Once the linking body 29 is parted, the linking cable 33 will, of course, be separated from the lower portion of the load-supporting member 16 so that the suspension cable 11 can be freed from the well tool 12 in the same manner as following the tension failure of the linking cable. Thus, by employing the electrically-responsive explosive means 37, the apparatus 10 of the present invention provides an alternate arrangement for releasing the suspension cable 11 from the well tool 12.

It will be appreciated, of course, that a permanent electrical connection could simply be made to an otherwise-unused electrical conductor in the cable 11 for selective operation of the electrically-responsive explosive means 37. Such exclusive reservation of a cable conductor is not desired, however, where the usable size of the suspension cable 11 limits the number of conductors therein and a particular well tool requires many separate electrical paths. Accordingly, by coupling the explosive means 37 to the cable conductor 15 by way of the Zener diodes 46, this cable conductor can be effectively utilized for other purposes in the usual operation of the well tool 12. As will be appreciated, therefore, the reversely-oriented Zener diodes will block current flow to the igniter 41 so long as the voltage applied to the conductor 47 is no greater at least than the predetermined threshold or Zener level, if not the breakdown level, of the Zener diodes. Accordingly, by appropriately selecting the Zener diodes 46 to have a predetermined threshold level well in excess of the highest voltage normally present on the cable conductor 15 during the operation of the well tool 12, the explosive means 37 will be safely guarded from inadvertent actuation. Thus, only upon application of direct-current voltage in excess of a predetermined magnitude as well as of the correct polarity to the cable conductor 15, will the explosive means 37 of the present invention be operated to selectively part the load-supporting member 16. It will be appreciated that even if this voltage causes electrical breakdown of the Zener diodes 46, they

will still function effectively to provide a reliable current path to the igniter 41.

When the present invention is used in conjunction with a cable-suspended tool, as at 12, it will be realized that the apparatus 10 will normally be inactive to allow the well-completion operations to be conducted in their usual manner. On the other hand, should it ever be necessary to release the suspension cable 11 from the tool 12, the apparatus 10 of the invention is selectively operable to reliably release the tool 12 in either one of two alternate manners. If, for example, the well tool 12 becomes stuck in the well bore 13 and the suspension cable 11 can be safely tensioned, application of tension thereto sufficient to part the linking cable 33 comprising the upper portion of the load-carrying member 16 will quickly release the suspension cable and allow it to be removed from the well bore. Conversely, if the tool 12 becomes stuck and the suspension cable 11 either cannot be safely tensioned or if it is not possible for some reason to apply a breaking force to the linking cable 33, application of sufficient voltage of a selected polarity to the cable conductor 15 will still reliably part the lower portion of the load-bearing linking member 16.

Accordingly, it will be appreciated that the present invention has provided new and improved cable-releasing apparatus that is suitably arranged to permit a suspension cable to be selectively disconnected from a well tool suspended therefrom in two alternate manners. In one mode of operation, by transmitting a signal, such as electrical voltage, through the suspension cable to the releasing apparatus, the selectively-operable explosive means thereof are effective to safely and reliably release the suspension cable from the tool. On the other hand, without having to transmit an electrical signal, application of a tension force to the suspension cable will suffice to release the cable from the releasing apparatus and well tool.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects; and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. In a sub-surface tool adapted for suspension from a cable extending to the surface, means operable from the surface for selectively releasing said tool from such a cable and comprising: load-supporting means secured to said tool and adapted for dependent connection to a suspension cable; means permanently arranged on said load-supporting means and adapted for sealingly enclosing explosive; selectively-operable electrically-detonatable explosive means fluidly sealed within said enclosing means and adapted, upon detonation, for parting said load-supporting means; and means operatively connected to said electrically-detonatable explosive means normally interrupting the flow of electrical current thereto and electrically conductive only in response to voltage in excess of a predetermined potential for passing electrical detonating current to said explosive means.

2. The sub-surface tool of claim 1 wherein said current-interrupting means are electrically conductive only in response to direct-current voltage of a selected polarity and in excess of said predetermined potential.

3. The sub-surface tool of claim 1 wherein at least one portion of said load-supporting means has a breaking strength of a predetermined magnitude greater than the weight of said tool.

4. The sub-surface tool of claim 1 wherein said load-

supporting means includes a body and said enclosing means include a cavity adapted to receive said explosive means formed in said body, and sealing means adapted for closing said cavity against entrance of external fluids after said explosive means are disposed in said cavity.

5. The sub-surface tool of claim 4 wherein at least one portion of said load-supporting means has a breaking strength of a predetermined magnitude greater than the weight of said tool.

6. Well bore apparatus comprising: a well tool; a suspension cable including at least one electrical conductor; means connecting said cable to said well tool and including first and second interconnected linking members substantially providing the sole support between said tool and said cable; first means adapted for selective operation from the surface for parting said first linking member and including a cavity formed in said first linking member, electrically-responsive explosive means in said cavity, means fluidly sealing said explosive means in said cavity, and conductor means operatively interconnecting said explosive means to said cable conductor; and second means adapted for selective operation from the surface for parting said second linking member in response to predetermined tension forces on said cable greater than the weight of said tool.

7. The apparatus of claim 6 wherein said interconnecting conductor means include diode means normally blocking the flow of electrical current between said cable conductor and said explosive means and electrically conductive only in response to a direct-current voltage on said cable conductor of a selected polarity and in excess of a predetermined voltage potential.

8. The apparatus of claim 7 wherein said diode means include at least one Zener diode.

9. As a sub-combination, selectively-operable releasing means adapted for dependently connecting subsurface tools to suspension cables including at least one electrical conductor, and comprising: linking means adapted for being tandemly coupled between a suspension cable and a sub-surface tool to substantially provide the sole support therebetween, at least a selected portion of said linking means being adapted for intentional failure upon application of a tensile load thereon greater than the weight of sub-surface tools coupled thereto but less than the tensile strength of a suspension cable coupled thereto, said linking means including a member having a cavity therein; and means adapted for selective operation from the surface for parting said linking means and including an explosive material in said cavity having sufficient explosive force, upon detonation, to at least materially weaken said member, electrically-responsive detonating means in detonating proximity of said explosive material, means fluidly sealing at least said explosive material within said cavity, and electrical conductor means operatively connected to said detonating means.

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