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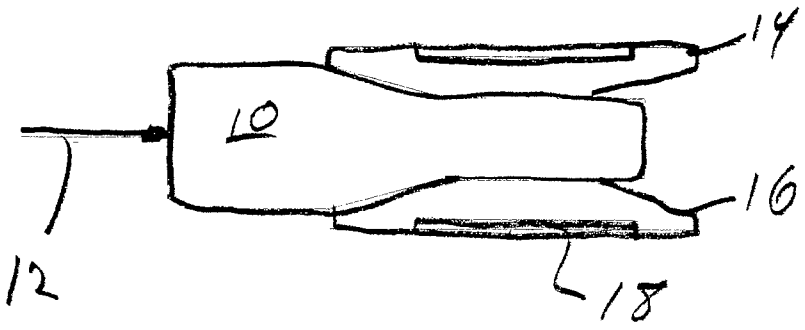
(54) Title: DOWNHOLE TRIGGER DEVICE



(57) Abstract: A trigger device keeps a downhole tool from setting until it is properly positioned. Redardless of the type of tool or the type of associated trigger, the retainer (18) of the present invention is combusted, the material is preferably one that combusts readily such as a material used in fuses for explosives . The battery requirements are to simply create the brief spark that starts the combustion, making the battery size significantly smaller than what would be needed to power a heater to melt materials that were used in the past.

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APPLICATION FOR PATENT

Title: DOWNHOLE TRIGGER DEVICE

Inventor: Yang Xu and Steve Rosenblatt

FIELD OF THE INVENTION

[0001] The field of this invention is trigger devices that are actuated downhole to operate a tool and more particularly triggers that are held immobilized until properly positioned and then released preferably with a spark, however initiated.

BACKGROUND OF THE INVENTION

[0002] Space is always a concern in downhole tool design. Some tools need to be retained in an unset position until properly placed in the well. It is only when they are properly located that it is desired to set the tool. Such tools in the past have had trigger mechanisms that are retained in an immovable position for run in until proper placement of the associated downhole tool is achieved. One technique for holding things immobile until the tool is properly placed has involved disabling the trigger with a mechanical device that is held against movement by a Kevlar® high strength fiber and an associated electrically powered heat source generally powered by stored batteries in the downhole tool. The generation of sufficient heat burns the fibers and releases the trigger so that the tool can set. Such a system is described in USP 5,558,153. The problem is that to generate enough heat downhole to burn the fibers and not damage adjacent components proves to be challenging for several reasons. One issue is the physical size of the battery pack to get a heater hot enough for long enough to compromise the fibers. Another issue is the very high temperatures needed to undermine the fibers and the effect on the overall design of the tool from having to keep heat sensitive components away from the heated area.

[0003] Another design featured a battery operated heater coil in a downhole tool to release the trigger by applying heat and melting a plug to start the setting sequence. This design is reflected in USP 6,382,234. Here again the same problems described above

are encountered. The battery size to have the required electrical capacity to create enough heat to melt the fusible plug presents a very real space concern in a downhole tool where space for a large power supply is at a premium. The cost and the reliability of a large battery pack is an issue. On many occasions, safety is another issue since some batteries need special shipping and handling requirements.

[0004] Other alternatives still involved the large battery pack to accomplish a release of the trigger. For example, USP 5,558,153 also suggests using solder wire that melts at relatively low temperatures to be the trigger material or using the stored power in the battery to advance a knife to physically cut the fiber as opposed to undermining it with a battery operated heat source.

[0005] The present invention seeks to address the issues described above with the prior designs. One way it approached the problem is to choose a material that will readily go away by being combustible. The power then required to release the trigger is greatly reduced since it takes significantly less energy to create a spark that will create a burning of the trigger retainer to result in a release of the tool. What is proposed in one embodiment is the use of fuse material that is designed to be readily ignited. While no explosives need be set off, the fuse material that serves to hold the trigger against the setting of the tool simply readily ignites with a brief spark and burns to the point where it releases its hold on the setting mechanism and the tool simply sets. In another embodiment the wire burns and removes a barrier to flow that in turn set the tool. These and other advantages of the present invention will become more apparent to those skilled in the art from a review of the preferred embodiment that is described below along with the associated drawings while recognizing that the claims further below indicate the scope of the invention.

SUMMARY OF THE INVENTION

[0006] A trigger device keeps a downhole tool from setting until it is properly positioned. Regardless of the type of tool or the type of associated trigger, the retainer is combusted which results in setting the tool. This can happen by freeing a piston to move, or allowing flow through a port or by other mechanisms. The material is preferably one

that combusts readily such as a material used in fuses for explosives. The battery requirements are to simply create the brief spark that starts the combustion, making the battery size significantly smaller than what would be needed to power a heater to melt materials that were used in the past.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 shows one type of trigger using opposed sleeves held together by wire;

[0008] Figure 2 is the rotated view of Figure 1 showing the wire;

[0009] Figure 3 is an alternative embodiment of a trigger that uses a piston retained by a wire going through it;

[0010] Figure 4 shows an alternative embodiment to hold a piston with the wire until the tool is ready to be actuated when the wire is compromised and the piston moves;

[0011] Figure 5 shows another embodiment where an opening in a plug is created that sets the tool with the flow through the opening where the opening is created by compromising the wire.

[0012] Figure 6 is another embodiment showing a piston held by a shearing member with chambers on opposed sides so that when the material in the opening is compromised well hydrostatic reaches one side of the piston to break the shear device and move the piston against the opposite chamber to set the tool.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0013] Referring to Figures 1 and 2, one type of retainer for a trigger mechanism or device for a downhole tool is illustrated. It shows a piston **10** that has some applied force **12** acting on it that would otherwise make it move but for a restraint. In this case the restraint is a pair of sleeves **14** and **16** that are longitudinally split and held together by a spring or split ring **18**, for example. What completes the assembly to keep the piston **10** immovable despite the applied force **12** is a wire **20** shown in Figure 2. In this

application, the term "wire" refers to the shape as being elongate without limitation to composition or cross-sectional shape or area and without limitation to any specific function such as conducting power. The force **12** can come from a variety of sources such as hydrostatic pressure, various springs or other energy storage devices or equivalents. In general, movement of the piston **10** sets an associated tool that is not shown. While a piston is shown, any type of trigger for the downhole tool is envisioned regardless of shape or the nature of its movement or whether the movement directly or indirectly sets the underlying tool. The design of Figures 1 and 2 contemplates variations such as retaining the piston **10** with a c-ring whose open end is held fast against the piston **10** to keep it from moving by the wire **20**. When the wire or ignitable material **20** is compromised the c-ring is pushed apart by the force **12** and the piston **10** advances to set the tool.

[0014] The wire **20** is such that initial energy input to it, preferably in the form of a brief spark that can be actuated electrically, mechanically or by other equivalent methods, sets in motion an event that continues without need for further energy input. Because of this feature, the battery or other energy source **22** and the ultimate recipient of the energy or power that creates a spark **24** collectively can be significantly smaller than prior designs that required continuous power input to disable the wire **20**.Mechanical spark devices that employ relative movement to create a spark can also be used as well as other devices that will transmit the initial burst of energy necessary to disable the wire **20**. For example the wire **20** can be made from PYRO FUZE® which consists of two metallic elements in intimate contact with each other. When these two elements are brought to the initiating temperature, they alloy rapidly resulting in instant deflagration without support of oxygen. Initiation is by heat and heat alone. All that is required is the exposure of the composite to the proper minimum temperature. The trigger reaction will reach temperatures in excess of the boiling point of the constituents. Once started, the reaction will not stop until alloying is completed or the unalloyed composite is subjected to some form of massive cooling that overwhelms the composite so that it cannot reach minimum operating temperature. The reaction end products consist normally of tiny discreet particles of the alloy of the participating materials. The present PYROFUZE composition was chosen for a number of desirable characteristics; it is a composite of

alloys of Palladium and Aluminum. It is available in the following physical forms: Wire; and, Ribbon rolled from wire.

[0015] The PYROFUZE® reaction is not of an explosive or pyrotechnic nature. The only energy released is thermal (approximate minimum reaction temperature 2800° C/5000° F, 325 calories per gram, 2890 calories per cubic centimeter). The minimum initiation temperature is 650° C/1200° F.

WIRE:

	Outer Jacket	Inner Core
Chemical composition:	Balance Palladium 5% Ruthenium	#5056 Aluminum
Resistivity:	62 ohms per cmf	

[0016] Other materials are contemplated that also have explosive materials incorporated into the wire or result in a pyrotechnic response with the distinguishing characteristic being that the initial energy input that leads to the weakening of the wire **20** that ultimately lets the tool set continues after it is started without continuous energy input of the prior designs. Regardless of composition of the wire or the mechanism of the response to the energy input the defining difference is that the process continues without further energy input. Accordingly, fuses that are used to set explosives could function as wire **20**.

[0017] Figure 3 shows another way to run a wire **20** through a piston **10** to hold it against a force **12**. Here the wire **20** passes through the piston **10** while being held near opposite ends by anchors **26** and **28**.

[0018] Figure 4 illustrates a piston **40** held in a body **42** by use of the restraining material **44** and optionally further retained by an adhesive such as epoxy **46**. When the

material **44** is ignited it burns to undermine itself and the surrounding adhesive **46**. At that point the tool (not shown) can be set from movement of the piston **40** or alternatively from fluid flow around it where the material **44** and adhesive **46** used to be. This can occur with or without piston movement.

[0019] Figure 5 does not use any piston. Instead a body **48** has an aperture **50** that is initially plugged by the ignitable material **52** optionally secured in a sealing manned with an adhesive **54**. Upon ignition of material **52** such as from a spark, however generated, the assembly that blocks the aperture **50**, **and** in so doing restrains an actuating member from operating, no longer resists differential pressure and flow through aperture **50** results in actuating the member that sets the tool.

[0020] Figure 6 illustrates a piston **60** held by a shear device **62**. Piston **60** separates atmospheric or low pressure chamber **64** from chamber **66**. Chamber **66** is also initially at atmospheric or low pressure that is well below the surrounding hydrostatic pressure at the anticipated depth for setting the tool. Plug **68** is in place in port **70** of chamber **66** to restrain the piston **60** stationary with the aid of shear device **62** which is optional if piston **60** is in pressure balance from chambers **64** and **66**. Plug **68** is made from a material that will be compromised with a brief spark and will continue to be compromised without additional energy input. This opens port **70** and puts a sufficient differential pressure on the piston **60** to break the shear device **62** and set the tool, not shown. In this example, well hydrostatic is used to move the piston after the spark.

[0021] In a different alternative a pressurized chamber can be isolated from one side of the piston by a plug as illustrated in Figure 5. When that plug disappears the pressurized chamber, that is higher than hydrostatic is allowed to cat on one side of the piston when the opposite side of that piston is exposed to well hydrostatic. As a result the piston moves and the tool sets.

[0022] In yet other embodiments the heat given off from the spark igniting the material that continues to combust can also be harnessed to trigger the tool to set. In such embodiments the heat given off can cut a cord or compromise the actual retaining device to allow the tool to set.

[0023] While the retaining member has been illustrated in the preferred embodiment to be a wire, other shapes are contemplated as it is the mechanism of what happens after initial energy input that sets the present invention apart and a variety of shapes for the retaining member are contemplated to be within the scope of the invention apart from a wire shape.

[0024] While the preferred embodiment has been set forth above, those skilled in art will appreciate that the scope of the invention is significantly broader and as outlined in the claims which appear below.

I claim:

1. A trigger device for a downhole tool for selectively actuating the tool, comprising:

a body;

an actuating member mounted to said body whose movement sets the tool;

a restraining member to selectively directly or indirectly restrain movement of said actuating member with respect to said body, said restraining member when subjected to an initial energy input initiates a process within said restraining member that continues without further energy input to the point of allowing said actuating member to move.

2. The device of claim **1**, wherein:

said process releases heat.

3. The device of claim **1**, wherein:

said process comprises a chemical reaction.

4. The device of claim **1**, wherein:

the response of the restraining member to energy input is pyrotechnic.

5. The device of claim **1**, wherein:

said restraining member comprises an explosive material.

6. The device of claim **1**, wherein:

said energy input comprises a spark.

7. The device of claim **6**, wherein:

said spark is supplied by a battery supported by said housing.

8. The device of claim **6**, wherein:

said spark is generated mechanically.

9. The device of claim **1**, wherein:

said actuating member comprises a piston that is subjected to an initial force.

10. The device of claim **9**, wherein:

said restraining member comprises a wire that initially retains said piston.

11. The device of claim **10**, wherein:

said wire passes through said piston.

12. The device of claim **1**, wherein:

said restraining member comprises a wire fuse.

13. A method of selectively actuating a downhole tool, comprising:

retaining directly or indirectly a triggering member with a restraining member;

applying energy to the restraining member to initiate a response in said restraining member;

removing said applied energy while said response continues; and

defeating said restraining member to let the triggering member move.

14. The method of claim **13**, comprising:

releasing heat from said response.

15. The method of claim **13**, comprising:

creating a chemical reaction as said response.

16 The method of claim **13**, comprising:

using a wire fuse for said restraining member.

17. The method of claim **13**, comprising:

making said response a pyrotechnic one.

18. The method of claim **14**, comprising:

obtaining said response without the presence of oxygen.

19. The method of claim **13**, comprising:

creating a spark for said applying energy.

20. The method of claim **19**, comprising:

using a piston as said triggering member;

using a wire to retain said piston;

passing said wire around or through said piston; and

allowing said response to break said wire.

21. The device of claim **1**, wherein:

said restraining member opens a port as a result of being subjected to said energy input.

22. The device of claim **21**, wherein:

said actuating member comprises a piston flanked by chambers; said restraining material is disposed initially in a port in one of said chambers such that application of said energy input opens said port to create a net force on said piston to set the tool.

23. The device of claim **22**, wherein:

said port, when opened admits hydrostatic well pressure to one of said chambers.

24. The device of claim **22**, wherein:

said body further comprises a pressurized chamber, said port, when opened allows pressure from said pressurized chamber to reach said piston via one of said chambers to set the tool.

25. The device of claim **24**, wherein:

the other of said chambers is exposed to well hydrostatic pressure.

26. The device of claim **2**, wherein:

said restraining member comprises a final element that is in contact with the actuating member and said heat compromises said final element to allow the actuating member to move.

27. The device of claim **26**, wherein:

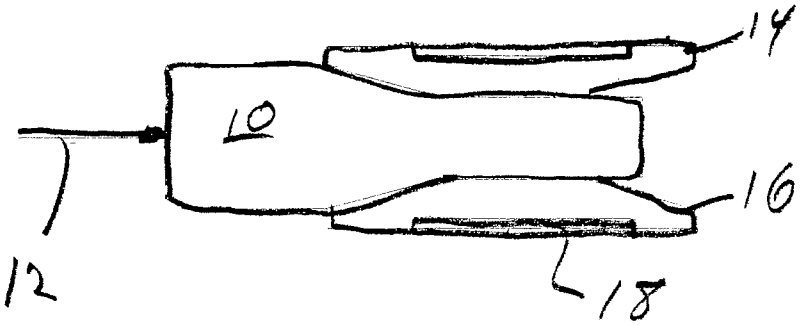
said final element comprises a cord connected to the actuating member that fails from said heat.

28. The device of claim **10**, wherein:

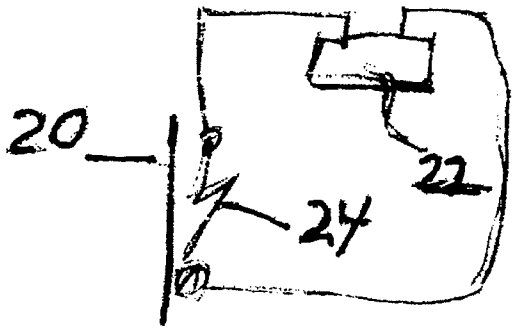
said wire holds a plurality of sleeve segments together until said initial energy input starts a process that undermines said wire.

29. The device of claim **10**, wherein:

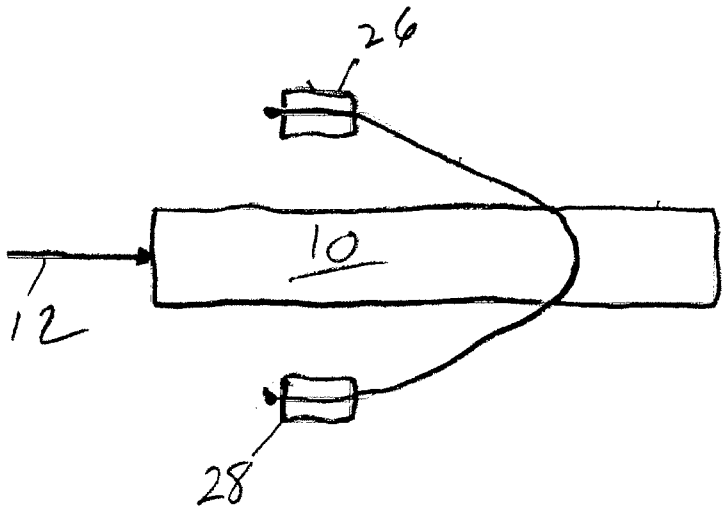
said wire holds a split ring together around said piston until said initial energy input starts a process that undermines said wire.



FIG#1



FIG#2



FIG#3

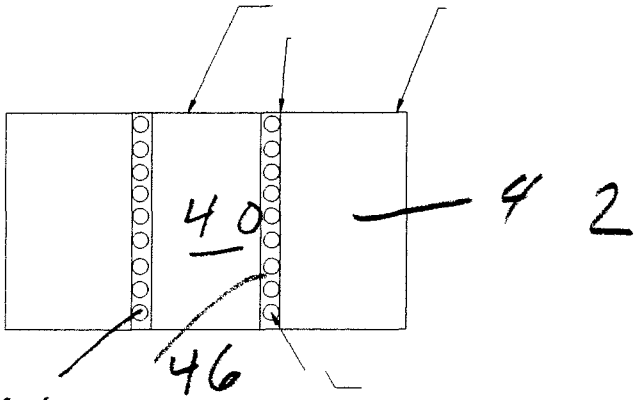


FIG # 4

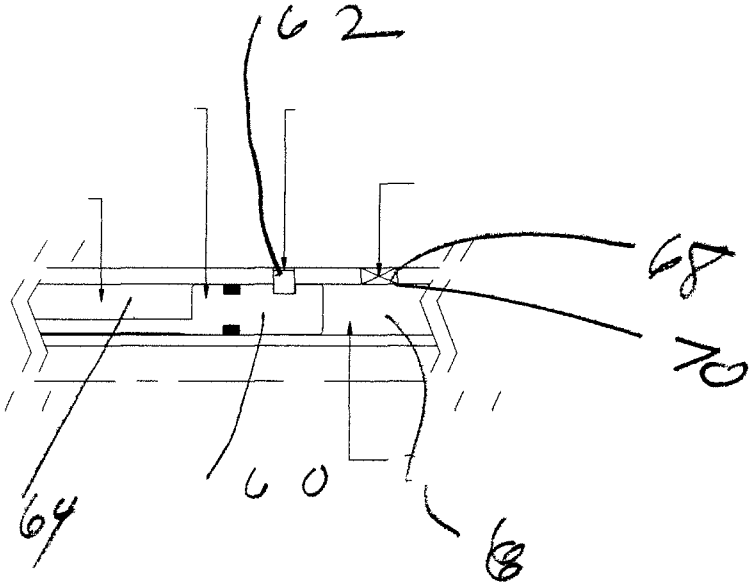


FIG # 6

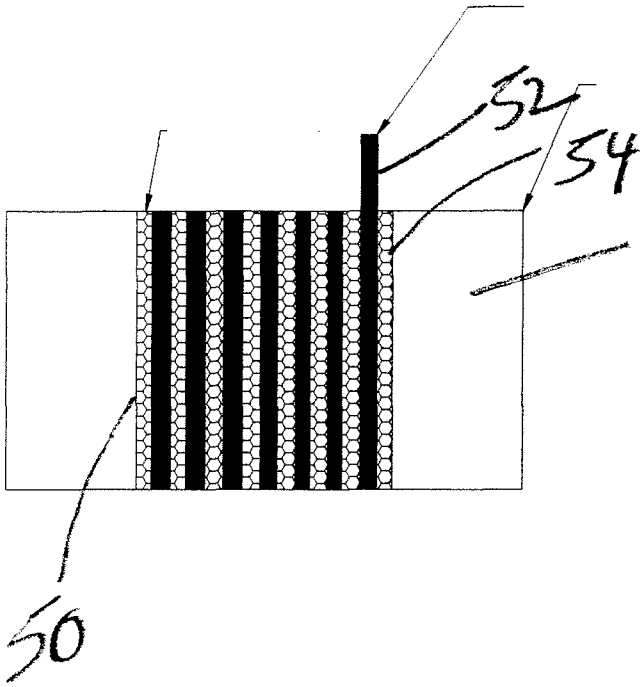


FIG #5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/062949

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B41/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 382 234 B1 (BIRCKHEAD JOHN [US] ET AL) 7 May 2002 (2002-05-07) cited in the application the whole document	1,13
A	US 5 199 497 A (ROSS RICHARD J [US]) 6 April 1993 (1993-04-06) column 4, line 1 - column 5, line 60	1,13
A	US 2 965 078 A (CHESNUT JOHN D ET AL) 20 December 1960 (1960-12-20) the whole document	1,13
P,A	US 2006/048949 A1 (MURRAY DOUGLAS J [US]) 9 March 2006 (2006-03-09) the whole document	1,13

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 June 2007	09/07/2007

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2007/062949

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6382234 B1	07-05-2002	NONE	
US 5199497 A	06-04-1993	NONE	
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