

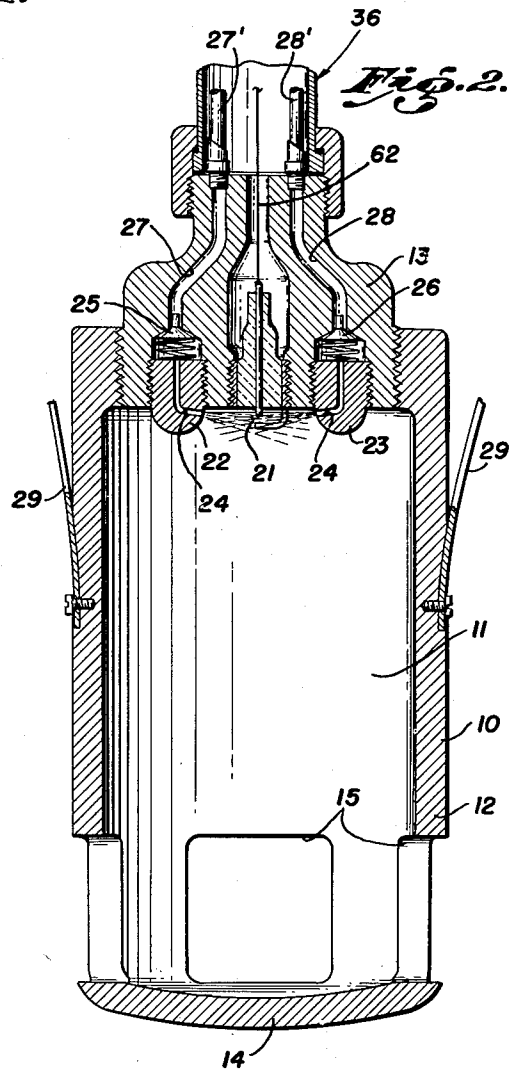
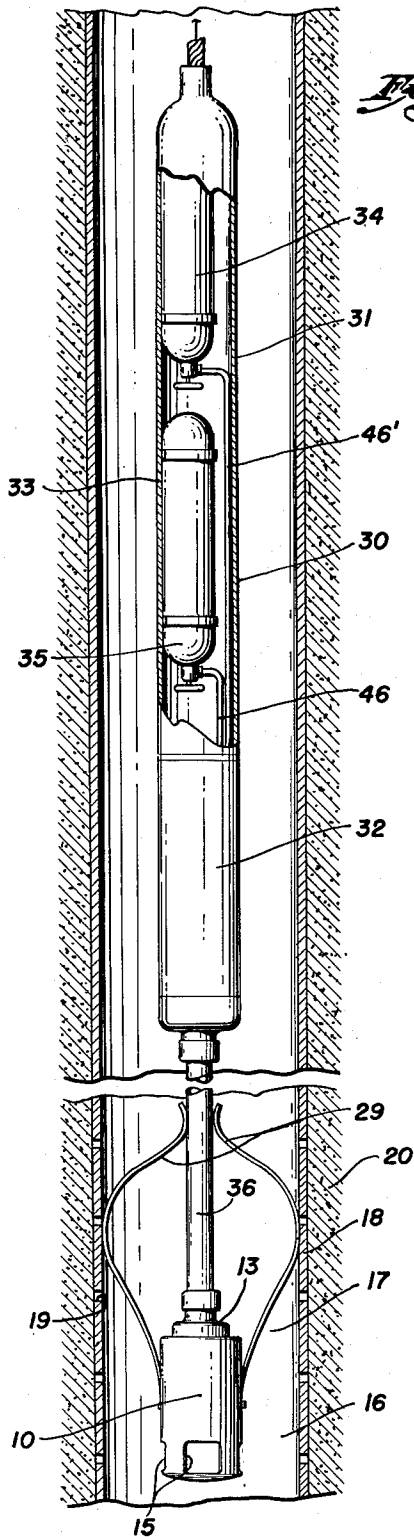
Jan. 24, 1956

N. A. MacLEOD
APPARATUS FOR PRODUCING PULSATIONS TO
CLEAR WELL CASING PERFORATIONS

2,732,016

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2 Sheets-Sheet 1



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Fig. 3.

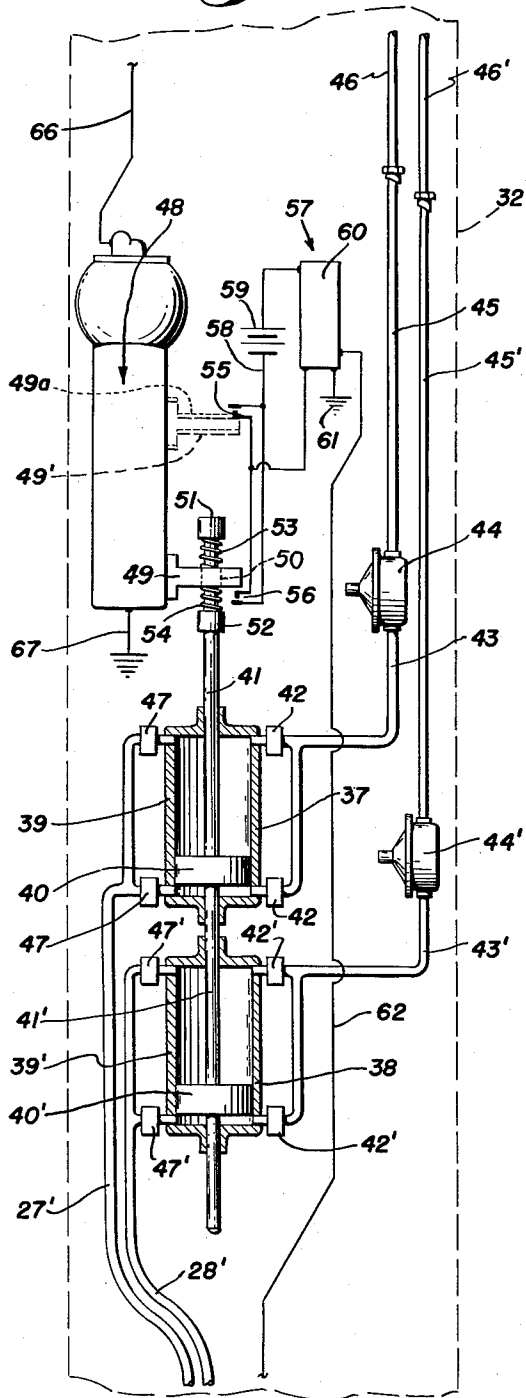
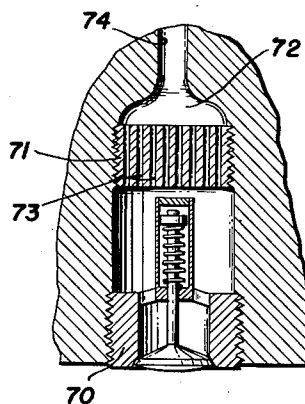


Fig. 4.



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APPARATUS FOR PRODUCING PULSATIONS TO CLEAR WELL CASING PERFORATIONS

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10 Claims. (Cl. 166—63)

My invention relates in general to the clearing of perforations in a well casing and in stimulating flow of fluid in the earth structure surrounding the well bore by application of explosively produced pulsations.

It is an object of my present invention to provide apparatus for feeding or moving an explosive substance or substances into a selected space and igniting the same in timed sequence so as to produce pulsations of such strength and character as to accomplish declogging of the openings of well casings and the opening of paths of flow of fluids in the surrounding strata, thereby increasing the flow of fluids into the well bore.

It is an object of the invention to provide apparatus whereby an oxidizer and a combustible substance may be fed into a selected space and measured quantities thereof, in substantially stoichiometrical proportions, are exploded in timed sequence so as to produce the desired pulsations. In the practice of the invention the oxidizer may consist of oxygen, air, or oxygen fortified air, and the combustible may consist of one of the hydrocarbons in gaseous form or capable of being converted to gaseous form in the selected space, for example, acetylene, methane, hydrogen, alcohol vapor, etc., may be employed. The fuel and the oxidizer are conveyed into the selected space through separate paths and upon being combined in this space are subjected to an ignition effect such as a spark from a sparkplug, for example, or the heat from an electrical heating element. The gases are preferably caused to flow into the selected space in stoichiometrical proportions, since this will result in an efficient use of the fuel. The fuel substance or substances may be caused to flow into the selected space at a constant rate, periodic operation of the igniting means causing the explosion of measured quantities of the fuel substance or substances. Also measuring means may be employed to feed quantities of the fuel substance or substances into the selected space, and upon the completion of the feeding operation actuation of the ignition means is effected.

Where the invention is employed below the surface of a liquid in a well, the explosive fluid is subjected to pressure of a magnitude depending upon the factors of submersion and specific gravity of the liquid in the well. Under the conditions of pressure and confinement involved, the fuel is forcibly exploded, with an effect similar to detonation, thereby producing pulsations of great effectiveness for the cleaning of well casing and screen, and stimulating the flow of fluids in the surrounding formation. The selected space in which the explosions are produced is defined by a hollow metal body, referred to hereinafter for simplicity as a bell or bell chamber having an outlet port or ports communicating with the well space. The capacity of this bell chamber is determined in accordance with the conditions of operation and desired strength of the individual pulsations. In one practice of the invention, the bell chamber is slowly moved upwardly or downwardly in the well casing, thereby gradually changing the po-

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sition of the space in which the explosions occur in timed relation. The invention comprehends that in some practices of the invention it may be necessary to add small amounts of inert matter to the fuel substance or substances so as to maintain a gas volume at all times in the upper part of the bell chamber. For example, use of a fuel composition consisting of hydrogen and oxygen in stoichiometrical proportions would result in water as a final product which could interfere with the proper operation of the ignition means employed in the practice of the invention. The invention also comprehends the use of a mono-explosive such as nitromethane, instead of an oxidizer such as air, and a combustible, such as hydrocarbon.

A further object of the invention is to provide apparatus of the character herein described employing an oxidizer with a liquid fuel, and utilization of heat to produce gasification of the liquid fuel in the bell chamber or as it approaches the bell chamber. It is contemplated that the heat of explosion of previous explosions be utilized for this purpose, the liquid fuel being heated immediately prior to its entry into the bell chamber so that it will enter the bell chamber in gaseous condition. One of the advantages of this practice of the invention is that a larger quantity of fuel may be maintained in a given space, such as a fuel reservoir, disposed in a well in association with other equipment, thereby making it possible to maintain the pulsations over an extended period of time. Also, the invention contemplates the use of means for maintaining the apparatus and also fluid in the well at temperature within a desired range, so that there will be sufficient heat for gasification of fuel, and on the other hand, so that there will not be an excess of heat to cause boiling of the fluid in the well when this effect is not desired, or in some instances to produce boiling in the well, for example, where it is desired to effect a removal of sand from a water well.

Where an open bell is employed to define the space in which the explosions are produced, whether the explosive substance or substances are fed into the upper or lower end of the bell chamber, depends upon the specific gravity of the substance or substances as compared to the specific gravity of the fluid in the well. Where mono-fuels are employed, such as nitromethane or nitroglycerine, such fuels will be fed into the bottom of the bell chamber and there exploded. Among the objects of the invention is the inclusion of a valve means and other expedients to prevent reverse flow of the explosive effect into or through the fuel feeding system.

Further objects and advantages of the invention will be brought out in the following part of the specification wherein I have in detail described a preferred embodiment of the invention for purpose of completely disclosing one manner in which the invention and its principles may be employed without limiting the scope of the invention defined in the appended claims.

Referring to the drawings, which are for illustrative purposes only:

Fig. 1 is a partly sectioned view showing a device employed in a preferred practice of the invention;

Fig. 2 is an enlarged fragmentary sectional view of the bell chamber situated at the lower end of the device shown in Fig. 1;

Fig. 3 is a schematic view showing a feeding mechanism which may be employed in the device disclosed in Fig. 1; and

Fig. 4 is an enlarged fragmentary sectional view showing a valve means and obturator means to prevent back flash and reverse flow of fluids.

As shown in Figs. 1 and 2, a bell member 10 is employed which defines a selected space or chamber 11

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in which explosions are produced in timed relation. The bell 10 has a side wall 12, an upper end member 13, and a bottom wall 14, there being laterally directed openings 15 in the lower portion of the side wall 12, for communication of the space or chamber 11 with the interior space 16 of a well 17. The bell 10 is shown, in Fig. 1, within a perforated casing or well screen 18. The bottom wall 14 prevents downward discharge of combustion products and thereby avoids a jet action which would cause vertical movement of the bell 10 in the well. The force of the gases discharged laterally through the openings 15 is balanced.

According to the invention, an explosive substance or substances are fed into the chamber 11 and periodically exploded therein, the force of each explosion being transmitted out through openings 15, in opposite directions, into the interior 16 of the well 17. In accordance with the laws of hydrodynamics, the force of the explosion, after it leaves the openings 15, is transmitted in all directions. Certain of this pressure passes out through openings 19 in the casing 18. With each explosion there is an expansive effect applied, and following each explosion there is a contractive effect. The result of this is that a series of timed explosions produces in the space contiguous to the bell 10 a series of pulsations, or in other words, a series of cycles, each of which comprises an expansion followed by a contraction. These pulsations very rapidly and effectively produce declogging of the openings 19 of a casing or well screen 10, and likewise such pulsations, transmitted out into the surrounding formation 20 cause opening of flow channels for fluids in the surrounding formation, and so stimulate flow of fluids.

In the simple form of the invention an igniting means 21 for explosive substance in the space 11 is provided. This igniting means is shown as a spark gap such as employed in sparkplugs for internal combustion engines. The head part 13, in addition to supporting the elements of the spark gap 21, carries nozzles 22 and 23, having their jet openings 24 directed toward the spark gap 21 so that fluid jets issuing from the openings 24 will dislodge from the spark gap 21 any liquid, such as water, which may tend to close the gap and thereby interfere with proper functioning of the igniting means. The openings 24 of the nozzles 22 and 23 communicate respectively through check valves 25 and 26 with passages 27 and 28 through which an oxidizer and a combustible are conducted at such rates of flow or in such amounts that they will combine in the chamber 11 to form an explosive mixture susceptible to being ignited and exploded by the igniting means 21. The combustion of the explosive mixture produces a large volume of gas which expands and forces liquid within the well outwardly and upwardly. When the expansive force of the gas has been expended, there will be a contraction of the gas, and during this time the succeeding charge of fuel mixture is being fed into the chamber 11 from the passages 27 and 28 through the openings 24 of the nozzles 22 and 23. To hold the bell 10 substantially centralized within the well as shown in Fig. 1, bow springs 29 are secured thereto.

For cooperation with the parts just explained, with relation to Fig. 2, I provide a supply and control organization 30 which may be disposed within the well 17, relatively near the bell 10, or may be placed at or outside the upper end of the well. The organization 30 includes a supply section 31 and a control section 32. The supply section 31 is shown as having a shell or housing 33 for holding one or more containers such as schematically shown at 34 and 35. Two of these containers 34 and 35 are employed where the explosive employed in the chamber 11 consists of several fluids which are not of themselves combustible but which, upon being combined, form an explosive composition. The control section 32 is connected to the supply section 31

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and is also connected through a slender connecting means 36 with the head 13 forming a part of the bell 10.

As shown in Fig. 3, the control section 32 has therein means for controlled feeding of fluids from the containers 34 and 35 to the nozzles 22 and 23, and also has means for actuation of the igniting means 21 in timed relation to the controlled feeding of fluids into the chamber 11. As schematically shown in Fig. 3, the control section 32 has therein double acting pumps 37 and 38. The pump 37 has a cylinder 39 in which a piston 40 is reciprocated by a rod 41. Inlet check valves 42, communicating with opposite ends of the cylinder 29, are connected through a duct 43, a pressure reducing valve 44, and duct members 45 and 46 with the container 35.

The pump 38 has a cylinder 39' in which a piston 40' is reciprocated by a piston rod 41', the piston rods 41 and 41' being connected so that the pistons 40 and 40' will be reciprocated in unison. Inlet check valves 42' connect the opposite ends of the cylinder 39' through a duct member 43', a pressure reducing valve 44', and duct members 45' and 46' with the container 34, Fig. 1.

Outlet check valves 47 connect the opposite ends of the cylinder 39 through duct means 27' with the duct 27 leading to the opening 24 of the nozzle 22. Discharge or outlet check valves 47' connect the opposite ends of the cylinder 39' through duct means 28' with the duct 28, Fig. 2, leading to the opening 24 of the nozzle 23. In further schematic illustration, I have shown the motor means 48 for reciprocating the pistons 40 and 40' of the feed pumps 37 and 38. This motor means 48 may be driven electrically or hydraulically, and is provided with a member 49 having rectilinear reciprocation in a direction parallel to the axis of the piston rod 41, when the motor means 48 is in operation. The reciprocating member 49 has an opening 50 through which an end portion of the piston rod 41 extends, and abutments 51 and 52 are fixed on the rod 41 on opposite sides of the member 49 and in spaced relation thereto. Springs 53 and 54 are disposed around the rod 41 between the reciprocating member 49 and the abutments 51 and 52. When the pistons 40 and 40' reach the ends of the respective cylinders 39 and 39', and movement of the piston rod 41 is thereby stopped, there is a continued small movement of the reciprocating member 49, permitted by the springs 53 and 54. When this additional movement of the reciprocating member 49 occurs, it engages and closes switches 55 and 56 of an electrical means 57 for energizing the igniting means 21, Fig. 2, of the type having a vibrator 60 in association therewith so that there will be a continued delivery of high voltage oscillating spark-producing current as long as either switch 55 or 56 is closed. The high voltage or secondary circuit of the electrical means 57 includes a ground connection 61, Fig. 3, and conductor means 62 which connects with the central electrode of the spark gap means 21, Fig. 2. In the form of the invention disclosed in Fig. 1, the interconnecting means 36 is shown as a steel tube. The duct members 27' and 28' and the conductor means 62 are carried from the lower end of the organization 30 to the bell 10 through this connecting means 36, the length of which connecting means 36 is determined by selected vertical spacing of the parts 10 and 30. The parts 10 and 30 are shown supported in the well, Fig. 1, by a cable 65 having a conductor 66 extending therethrough for energization of the motor 48, Fig. 3. The circuit for the motor means 48 is completed by the sheath of the cable 65 which is grounded to the metal housing 33 to which the motor means 48 also makes a connection through a ground 67. It will be understood that the duct members 27' and 28' and the conductor 62 may be extended so that the organization 30 may be placed at the top of the well, if desired.

In explaining the operation of the preferred form of the invention disclosed, it may be assumed that the re-

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ciprocating member 49 is moving upwardly and that the pistons 40 and 40' are being thereby moved upwardly so as to discharge through the upper discharge check valves 47 and 47' the fluid contents of the cylinders 39 and 39' previously drawn into these cylinders 39 and 39' from the respective containers 35 and 34, Fig. 1, through the upper intake check valves 42 and 42'. When the pistons 40 and 40' reach the upper ends of the cylinders 39 and 39', completely discharging fluid therefrom, the reciprocating member 49 will be in a position such as indicated by dotted lines 49', Fig. 3. Continued upward movement of the reciprocating member 49 from the position 49' will cause it to move into the switch actuating position indicated by dotted lines 49a, closing switch 55 and actuating the electrical means 57 so that a spark will be produced across the gap of the igniting means 21 immediately following the discharge of the contents of the pumps 37 and 38 into the upper portion of the bell chamber 11. During the upward movement of the pistons 40 and 40', just described, volumes of fluid will be drawn into the lower portions of the cylinders 39 and 39' through the lower intake valves 42 and 42', so that when the reciprocating member 49 moves downward from the raised position 49', there will be a subsequent feeding of explosive components into the chamber 11 followed by an ignition effect therein as the result of the closing of switch 56 by the member 49. The foregoing operations will be repeated as long as the motor means 48 is operated and as long as the supply of explosive components in the containers 34 and 35 lasts. Proportioning of the fluids delivered through the respective nozzles 22 and 23 may be controlled in part by differences in volume of the cylinders 39 and 39', and in part by the differences in pressure maintained in the duct members 43 and 43' by the pressure regulating valves 44 and 44', Fig. 3. The proportions of fuel and oxidizer are thus obtained for any selected mediums. For example, where propane and oxygen are employed, detonation will occur where the mixture fed into the bell chamber 11 contains between three and thirty-seven percent of propane.

Where a mono-fuel, such as nitromethane, or other liquid explosive is employed, my invention employs means such as shown in Fig. 4, for preventing flash-back of ignition effect through ducts to the main supply tank. As indicated in Fig. 4, one or more check valves 70 and a flash-back barrier (or obturator) 71 are employed in the path of flow 72 of a liquid explosive. The barrier 71 comprises a body having a plurality of parallel capillary channels 73 whose total cross-sectional area may be greater than, but is of the same order as the cross-sectional area of the feed duct 74. In the use of an arrangement such as shown in Fig. 4, the charge of liquid explosive is forced through the duct 74, the passages 73 of the barrier 71, and through the check valve 70, by a following body of non-explosive liquid, so that after the entire quantity of liquid explosive passes through the check valve 70 it will be followed by a small amount of non-explosive liquid, which non-explosive liquid will occupy the space behind the check valve 70, the passages 73 of the barrier 71, and the duct 74. Should any explosive effect be transmitted back through the check valve 70 when the charge of liquid explosive is fired in the space with which the valve 70 communicates, such explosive effect will be damped and extinguished by the capillary passages 73 and also by the non-explosive fluid contained in the path of flow 72 back of the check valve 70.

I claim:

1. In a device for producing pulsations in a well: means for defining in the well a chamber having communication with the interior of the well; separate container means for explosive components; means operative to consecutively feed separate quantities of said components into said chamber so as to form separate quantities of explosive mixture in said chamber; and means operative to consecutively explode said separate quantities of said

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explosive mixture in said chamber so as to transmit pulsations from said chamber into the well.

2. In a device for producing pulsations in a well: means for defining in the well a chamber having communication with the interior of the well; container means for explosive; walls forming at least one path of movement from said container means to said chamber; means operative to move consecutive portions of explosive from said container means through said path into said chamber; a source of electrical energy; electrical igniting means in said chamber; and means for intermittently supplying electrical energy from said source to said igniting means to fire consecutive portions of said explosives in said chamber so that pulsations will be transmitted from said chamber to the interior of the well.

3. In a device for producing pulsations in a well: means for defining in the well a chamber having communication with the interior of the well; separate container means for volatile explosive components; pump means operative to consecutively feed separate quantities of said components into said chamber so as to form separate quantities of explosive mixture in said chamber; and means operative to consecutively ignite said separate quantities of said explosive mixture in said chamber so as to transmit pulsations from said chamber into the well.

4. In a device for producing pulsations in a well: means for defining in the well a chamber having communication with the interior of the well; separate container means for volatile components; pump means operative to consecutively feed separate quantities of said components into said chamber, so as to form separate quantities of explosive mixture in said chamber; and electrical means operative in timed relation to said pump means to consecutively ignite said separate quantities of said explosive mixture in said chamber so as to transmit pulsations from said chamber into the well.

5. In a device for producing pulsations in a well: means for defining in the well a chamber having communication with the interior of the well; separate container means for fluid explosive components; pump means operative to feed said components under high pressure into said chamber so as to form an explosive composition in said chamber; means operative to ignite consecutive portions of said explosive composition in said chamber so as to transmit pulsations from said chamber into the well; and pressure reducers for said fluid explosive components disposed between said container means and the inlet of said pump means.

6. In a device for producing pulsations in a well: means for defining in the well a chamber having only lateral communication with the interior of the well so that the issue of gases from said means will be lateral and cause minimum vertical movement of said means; separate container means for volatile explosive components; means operative to consecutively feed portions of said components into said chamber so as to form an explosive composition in said chamber; and means operative to ignite consecutive portions of said explosive composition in said chamber so as to transmit pulsations from said chamber into the well.

7. In a device for producing pulsations in a well: means for defining in the well a chamber having only equally distributed lateral communication with the interior of the well so that the forces of the issuing gases will be laterally directed and distributed so as to produce minimum lateral and vertical movement of said means; container means for explosive; means operative to consecutively feed portions of said explosive into said chamber; and means operative to ignite the consecutive portions of said explosive in said chamber so as to transmit pulsations from said chamber into the well.

8. In a device for producing pulsations in a well: means for defining in the well a chamber having communication with the interior of the well; container means for explosive; walls forming at least one path of movement

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from said container means to said chamber; means operative to consecutively feed separate portions of said explosive from said container means through said path into said chamber; and means operating to fire said separate consecutively fed portions of said explosive in said chamber so that pulsations will be transmitted from said chamber to the interior of the well.

9. In a device for producing pulsations in a well; means for defining in the well a chamber having communication with the interior of the well; separate container means for explosive components; means operative to feed separate portions of said components consecutively into said chamber so as to consecutively form separate explosive compositions in said chamber; and means operative to consecutively explode said separate explosive compositions in said chamber so as to transmit pulsations from said chamber into the well.

10. In a device for producing pulsations in a well: means for defining in the well a chamber having communication with the interior of the well; separate container means for volatile explosive components; means operative to feed separate measured quantities of said

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components separately and consecutively into said chamber so as to consecutively form explosive separate compositions in said chamber; and means operative to ignite said consecutively formed separate explosive compositions in said chamber so as to transmit pulsations from said chamber into the well.

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