June 9, 1936. L. C. TILBURY ET AL 2,043,340

WELL CLEANER

Filed May 1, 1934 2 Sheets-Sheet 1

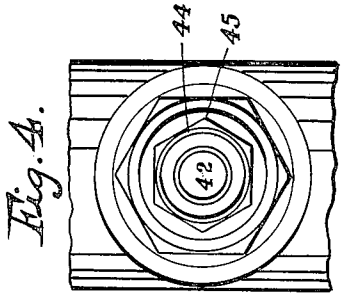


Fig. 4.

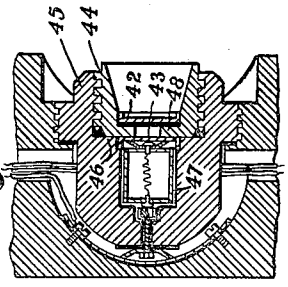


Fig. 3.

Fig. 1.

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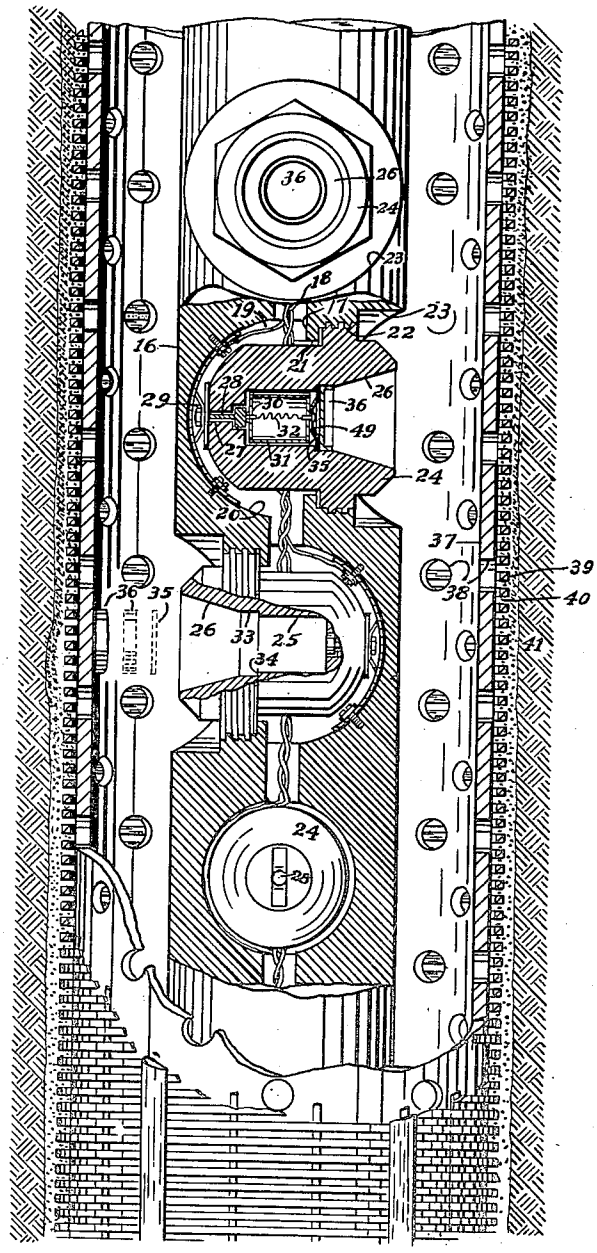


Fig. 2.

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WELL CLEANER

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Application May 1, 1934, Serial No. 723,292

21 Claims. (Cl. 166—20)

Our invention relates to a method and apparatus for increasing the production from wells such as oil wells or water wells. The invention is particularly suited for use in wells which have been cased with perforated or screen pipe. The invention may be used on old or new wells and is particularly suited for use in increasing the production from wells which have declined in production due to an accumulation of strongly cemented material on the outside of the perforated pipe. The invention is even more particularly adapted for use on that type of pipe commonly called screen pipe, one form of which consists of a pipe having relatively large perforations wrapped with a helical outer covering of small gauge wire with the convolutions of the wrap spaced slightly apart, serving as a fine screen. These fine screens become clogged quite easily and if the clogging material is of a calcareous nature, as is often the case, or if it is cemented very tightly, the ordinary methods of cleaning the perforations will either fail to open the pores or will rupture the outer wire wrapping ruining the pipe and causing the well to become sanded up.

While our invention is especially useful for opening up the pores or interstices of screen pipe it can also be used for opening up the interstices and breaking down bridges in producing formations in wells when the formation is relatively hard and will not slough readily. The invention may be used on either cased or uncased wells.

We have found that the two methods in use at present for cleaning wells are not very satisfactory at best and are often quite unsatisfactory. The method of cleaning by the use of mechanical pressure devices is useful only where the debris can be removed by the use of relatively low pressures which are seldom if ever over 1500 pounds per square inch because the equipment can not be made to stand much higher pressures. Such low pressures will not have the slightest effect on calcareous deposits, or other strongly cemented deposits. The other method of rejuvenating wells, the shooting with high explosives can be used only on uncased wells. The shooting method is used only in very hard formations and simply shatters the formation, forming new channels for the entrance of fluid into the well.

Our invention embodies a form of shooting but is quite different in its effect from the results obtained by the use of high explosives. We have found that by the use of progressive burning powders we can create high gas and fluid pressures within the well sufficient to remove strongly cemented and calcareous deposits without rupturing or in any way damaging either the pipe, screen or producing formation. The pressures developed by the use of progressive and fast burning powders, such as a good commercial grade of revolver powder range from 25,000 lbs. per square inch upward. Good results have been obtained with pressures around 143,000 pounds per square inch. Such a pressure is far higher than the 1500 pounds which can be obtained with mechanical pressure cleaners but is far less than the pressures developed by high explosives such as dynamite, nitro-glycerine and the like which are substantially instantaneous in action.

While various types of apparatus can be used to practice our method of well cleaning we prefer to use a device which will generate relatively small volumes of high pressure gas and will direct the gas outwardly through the perforations and into the pores of the formation.

A preferred embodiment of an apparatus suitable for use with our method is shown in the accompanying drawings wherein

Figure 1 is a fragmentary elevation showing a gun and the auxiliary operating equipment ready for operation.

Figure 2 is a fragmentary elevation, partly in section, showing our gun in place in a perforated well casing.

Figure 3 is a fragmentary cross section of a modified form of gun barrel.

Figure 4 is a plan view of the gun barrel shown in Figure 3.

Referring to Figure 1 of the drawings, a well derrick is indicated at 1 in vertical elevation partly broken away to show a hoisting cable 2 supporting a hook 3. A weight indicator 4 of any suitable design is carried by the hook 3 and is provided with a hook 5 which supports a sheave 6. Sheave 6 is guyed to one of the derrick posts by suitable means such as the rod and turn-buckle 7. Sheave 6 is provided with a counter or line measuring device, not shown. A line 8 runs over sheave 6 and is attached at one end to a gun body 9 and at its other end to a hoist 10, which in the present instance, is mounted on a truck 11. Electric cables 12 and 13 connect the weight indicator and line measuring device with the truck for the convenience of the operator. In the present instance the cable 8 is a multi-conductor insulated electric cable connected to a source of electricity thru line 14. The current may be either direct or alternating.

The gun 9, Figure 2 consists of a cylindrical steel body having a head 15 (Fig. 1) adapted to be connected to the cable 8 and screw threaded at its lower end to receive the main body member 16. The main body member 16 is provided with a longitudinal axial passage 17 to receive insulated electric wires 18 leading from the cable 8 to each of the gun chambers 20. There may be any desired number of gun chambers 20 which are cylindrical recesses provided in the body 16 at longitudinally spaced intervals and extending from the outer surface of the body 16 laterally through the body to a point adjacent the opposite wall of

the body and intersecting the passage 17. The chamber 20 is provided with a radially inwardly extending shoulder 21. Outwardly of the shoulder 21 the mouth of the chamber is threaded as shown at 22, and outwardly beyond the threaded portion it is counterbored as indicated at 23.

A gun barrel 24 is provided for each chamber 20. The gun barrels are short steel cylinders externally threaded near their outer ends to engage the threads 22 in the chamber. Each barrel is provided with a powder chamber 25 and an outwardly flaring discharge passage 26. At the rear of each powder chamber is a small passage 27 extending through the rear wall of the barrel and adapted to receive an insulated pin 28. The outer end of pin 28 bears against a spring contact 29 which is connected to one of the current carrying wires 19. The other (inner) end of pin 28 is provided with an enlarged head which presses against a contact button 30 on the rear end of an explosive containing cartridge 31 which fits into the chamber 25. The button 30 is connected to a fusible element 32 adapted to ignite the explosive when energized by the current from its lead wire 19. The fusible element 32 is grounded through resilient conductor 49 which contacts a metal disc 35 which fits into a cylindrical passage 33 in the gun barrel 24 as described more fully below. At the inner end of the flared discharge passage 26 the discharge aperture is provided with a short cylindrical walled passage 33 which is reduced in diameter to form powder chamber 25 and providing an inwardly extending shoulder 34. A metal disc 35 seats on the shoulder 34 and serves as a strengthening member for a cup-shaped metal disc 36 which is pressed into the cylindrical passage 33 to form a tight fit with the walls of the passage. The disc 35 may be omitted provided the disc 36 is made strong enough to stand the fluid pressure. The disc 36 is preferably inserted with the cupped portion facing outwardly.

The above described gun, except as it is modified to function as a well cleaner by shooting blank cartridges, does not constitute a part of the present application but is the invention of one Wilfred G. Lane, as embodied in his copending application entitled, "Well casing perforator", Serial No. 642,410, filed November 12, 1932.

In Figure 2 the gun is shown in place in a well casing 37 which is provided with a series of perforated openings 38. Around the exterior surface of casing 37 is a spiral wrap of small gauge wire 39 with the convolutions of the wrap spaced slightly apart to provide small openings 40. The producing formation is indicated at 41.

The operation of the device described above is as follows: When the holes 38 in casing 37 and the interstices 40 between the convolutions of the wire wrap 39 have become clogged to the extent that fluid does not readily flow from the formation into the casing 37, the gun is attached to the cable 8 and lowered into the well. The weight indicator 4 is useful for indicating whenever the gun may happen to hang up thereby enabling the operator to stop the hoist before the cable 8 can become kinked. The measuring device 13 tells the operator when he has reached the desired depth. Assuming that all of the guns have been properly loaded and assembled in their respective chambers, the operator has only to close a switch in the line 8 at the surface of the well to discharge the guns. For convenience we prefer to discharge the barrels separately and at the will of the operator. In order to accomplish this we provide a solenoid actuated progressive contacting member in the head 15 connected in the circuit between cable 8 and wires 18. The progressive contacting or firing mechanism forms no part of our invention and will not be described here. After each shot the gun is raised or lowered to a new position before firing again. The gun barrels 24 are pointed in alternate directions to discharge around the entire periphery of the casing.

When the circuit is closed the fusible element 32 in the cartridge ignites the explosive surrounding it. The gases thus generated are confined behind the disc 36 until the pressure has built up sufficiently to force the disc out of its press fit in passage 33. By varying the closeness of the fit the confined pressure may be held within suitable bounds. When the disc has been blown out the gases rush out assuming the shape of an outwardly expanding cone because of the outward flare of the discharge passage 26. The gases are further caused to flare outwardly by the disc 36. We find that the outwardly facing cup shape of disc 36 assists in keeping the disc in its vertical position as it travels toward the pipe 37. We have found that by making the discs 36 larger in diameter than the perforations 38 we can prevent the highest pressure gas from being directed straight at the adjacent wire wrap. If the high pressure gas were to strike directly against the wire screen it would be apt to rupture it. The screen is thus triply protected (1) by the diffusion of explosive force due to the outward flare 26 in the gun barrel, (2) by the presence of the disc 36 causing the gases to flare outwardly, and (3) by having the disc 36 large enough in diameter to cover any hole 38 that may be directly in front of the gun barrel. Furthermore, the impact of the disc 36 against the wall of the pipe 37 serves to dislodge a considerable portion of the adjacent sediment. We have found that by the selection of the proper amount of explosive for a given type of screen pipe we can clean as many as 13 perforations, spaced in the usual manner, with a single shot. The gun body is provided with a number of barrels usually about twelve, so that 156 perforations can be opened each time the gun is run into the well. At a depth of 3200 feet we can make three round trips per hour, cleaning a total of 1170 perforations per hours.

Our method and apparatus will also open up the pores or interstices of the producing formation around the well without appreciable damage to the formation. The success of our method over previous "shooting" methods is due to the fact that we progressively generate a relatively small volume of high pressure gas adjacent the pores to be cleaned. Prior methods either generated pressures too low to be of any material value, or so high in such large volumes as to seriously damage the well and the surrounding formation.

While we have shown and described a preferred embodiment of the invention in which the explosive charges are fired by electrical means it is to be understood that we may fire them by any other means such as percussion caps. The gun may be run into the well on tubing instead of on a cable, and the means for actuating the detonators may be any one of several mechanical devices, such as a go-devil dropped down the tubing, or a trigger and hammer actuated by fluid pressure or electrical means such as a solenoid.

The gun body and gun barrels may take various forms. For example, in Figures 3 and 4 we show a modified form of gun barrel. The gun

may be provided with a cup shaped disc 42 similar to disc 36 but instead of relying upon a press fit of the disc into the bore of the gun barrel as heretofore described, to build up the pressure within the powder chamber, we provide a frangible disc 43 which may also serve as a sealing disc. Disc 43 is held in place by a removable, screw-threaded gun barrel 44 which is screwed into the main gun barrel 45. The barrel 45 is provided with an outwardly stepped bore forming an annular shoulder 46 adjacent the powder chamber 47 against which the disc 43 seats. The disc 43 may be cup-shaped as shown or it may be flat. The barrel 44 may be provided at its rear end with a radially inwardly extending flange 48 to assist in retaining the disc 43.

The structure shown in Figs. 3 and 4 and described in the foregoing paragraph, except for the flared or conical bore through the barrel and its coaction with the other elements, is not a part of the present invention but is the sole invention of George F. Turechek, one of the co-inventors herein, and is more fully set forth in a continuation in part of this application entitled, "Gun unit for gun perforators", Serial No. 27,024, filed June 17, 1935.

While, for convenience, no liquid is shown around the gun in Fig. 2, it should be understood that, in wells producing through screens or the formation itself, there is always a quantity of liquid at the bottom; for, obviously the well is in need of cleaning long before the interstices are entirely sealed, and regardless of this it is customary to maintain liquid inside the well casing to prevent collapsing. In other words, the well cleaner is, because of the very nature of its use, always operated while submerged in a liquid; hence, in all cases, the disks or seals 36 or 42 and/or 43 are always needed.

The presence of the liquid, however, is not detrimental to the operation of the cleaner but on the contrary accomplishes two beneficial functions; first, the liquid tends to confine or localize the force of the gas generated by the explosive; and second, some of the liquid itself is actually forced or propelled through the screen ahead of the gas generated by the explosive. The latter function results from the fact that, in most cases, gas is present in the producing formation, and said formation gas is yieldable to pressure sufficiently to permit a limited quantity of the liquid to surge through and wash the interstices, particularly when the liquid in the well is "dead", that is, substantially free of gas and therefore incompressible.

We claim:

1. In a well cleaning apparatus adapted to clean by fluid pressure a localized section of a well bore: a gun body adapted to be lowered into a well, means for supporting said gun body, an explosive chamber in said gun body, sealing means to prevent the entrance of fluid into the explosive chamber, and means in the explosive chamber for igniting the explosive and means utilizing the force of said explosive to direct fluid under pressure against a localized section of said well bore.

2. In a well cleaning device adapted to clean by fluid pressure a localized section of a well bore: a gun body adapted to be lowered into a well on an insulated hoisting and electric current conducting cable, a chamber in said gun body having a threaded opening, a tubular gun barrel adapted to be threaded into the opening in said gun body, said gun barrel being provided at one end with means contacting the electric circuit, an explosive chamber adjacent the contact means, a discharge passage communicating the explosive chamber with the exterior of the gun and adapted to utilize the force of said explosive to direct fluid under pressure against a localized section of said well bore, and sealing means for the explosive chamber releasable at a predetermined pressure.

3. A device as described in claim 2 in which the discharge passage is provided with a radially inwardly extending shoulder and the powder chamber sealing means is inserted in the discharge passage with a press fit seating against said shoulder.

4. A well cleaning apparatus comprising a gun adapted to be lowered into a well, an explosive containing chamber in the gun, a gun barrel leading from said explosive chamber said barrel being flared outwardly, and means for sealing the explosive chamber against the entrance of fluid.

5. A method of opening interstices at the producing zone of a well, characterized by: igniting a progressively burning explosive and directing the resulting gases in an expanding conical stream against a localized region of the producing zone to be opened.

6. A method of opening interstices at the producing zone of a well, characterized by: igniting a progressively burning explosive and directing the resulting gases in an expanding conical stream against a localized region of the producing zone to be opened while shielding the center of said region from the direct force of said explosive.

7. A method of cleaning the producing zone of a well, characterized by: generating contiguous to a localized region of said producing zone a confined relatively small volume of gas; then directionally discharging the gas laterally in a stream toward said region; the generation of the gas being so predetermined that the ultimate pressure developed is within a pressure range between that required to break up deposits in said region and that required to disrupt or damage the normal walls of the producing zone.

8. A method of cleaning a liquid filled producing zone of a well, characterized by: introducing into said liquid a plurality of explosive charges each calculated to generate a gas, the ultimate pressures of which will be below the pressure required to rupture the normal walls of the producing zone; and igniting said explosive charges sequentially while so immersed in said liquid; directly discharging and impinging the gas resulting from each charge against a quantity of the surrounding liquid to drive the same through a predetermined localized region of said producing zone.

9. A method of cleaning the producing zone of a well, characterized by: igniting an explosive charge positioned contiguous to a localized segmental section of said producing zone; and directionally discharging the resulting gas toward said segmental section; the charge being so predetermined that the ultimate pressure developed upon its ignition is within a pressure range above that required to break up deposits clogging the region of the producing zone being treated and below that required to disrupt or damage the normal walls of said producing zone.

10. A method of cleaning the producing zone

of a well, characterized by: igniting an explosive charge positioned contiguous to a localized segmental section of said producing zone; and directionally discharging the resulting gas toward said segmental section; the charge being so predetermined that the ultimate pressure developed upon its ignition is within a pressure range above that required to break up deposits clogging the region of the producing zone being treated and below that required to disrupt or damage the normal walls of said producing zone, and then igniting sequentially other similar explosive charges opposite adjacent localized segmental sections of said producing zone; and directionally discharging the resulting gas charges thereagainst.

11. In a well screen and formation cleaning device: a submergible blank cartridge unit comprising: an explosive receiving chamber, a projectile free barrel, and non-penetrating means for initially sealing against a surrounding liquid an explosive in said chamber, and harmlessly engageable with a surrounding well bore upon discharge of said explosive.

12. In a well screen and formation cleaning device; a gun body adapted to be lowered into a well bore; a plurality of submergible blank cartridge units each comprising an explosive receiving chamber, a projectile free barrel, and non-penetrating means for initially sealing against a surrounding liquid an explosive in said chamber and harmlessly engageable with a surrounding well bore upon discharge of said explosive; and means for firing said cartridge units sequentially.

13. In a well screen and formation cleaning device: a submergible blank cartridge unit comprising; an explosive receiving chamber, a barrel, and means for initially sealing against a surrounding liquid an explosive in said chamber, said means likewise constituting a shield and force spreading means operable upon ignition of said explosive to protect that portion of the screen or formation in immediate alignment with the barrel from the direct force of the explosive.

14. A method of cleaning a liquid filled producing zone of a well, characterized by: generating a relatively small volume of gas opposite a localized region of said producing zone below the surface of said liquid; sealing the gas therefrom until a predetermined pressure is developed; and suddenly releasing the gas whereby the gas drives a limited quantity of the surrounding liquid through interstices occurring in said localized region.

15. A method of cleaning a liquid filled producing zone of a well, characterized by: generating at sequentially timed intervals relatively small charges of gas opposite adjacent localized regions of said producing zone below the surface of said liquid; sealing each gas charge therefrom until a predetermined pressure is developed; and suddenly releasing each gas charge against the surrounding liquid to drive a quantity of the liquid commensurate with the charge through the interstices occurring in the corresponding localized region.

16. A method of cleaning a liquid filled producing zone of a well, characterized by: introducing into said liquid an explosive charge calculated to generate a gas, the ultimate pressure of which will be below the rupturing pressure of the producing zone; igniting the explosive charge while so immersed in said liquid; sealing the gas generated by the explosive charge therefrom until a predetermined pressure is developed; and then impinging the gas in a laterally directed stream against the surrounding liquid to expel a quantity thereof.

17. In a screen and formation cleaning device for well bores, a submergible blank cartridge unit comprising: an explosive receiving chamber; means for initially sealing an explosive in said chamber; an open barrel continuing from said sealing means and adapted, when submerged, to receive a quantity of liquid, whereby upon discharge of said explosive, said liquid is forced under pressure from said barrel and against a localized region of the surrounding well bore.

18. In a screen and formation cleaning device for well bores, a submergible blank cartridge unit comprising: an explosive receiving chamber; means for initially sealing an explosive in said chamber; an outwardly flaring open barrel continuing from said sealing means and adapted, when submerged, to receive a quantity of liquid, whereby upon discharge of said explosive, said liquid is forced under pressure from said barrel and against a localized region of the surrounding well bore.

19. In a screen and formation cleaning device for well bores, a submergible blank cartridge unit comprising: an explosive receiving chamber; a non-penetrating means initially sealing an explosive in said chamber; an open barrel continuing from said sealing means and adapted, when submerged, to receive a quantity of liquid, whereby upon discharge of said explosive, said liquid is forced under pressure from said barrel and against a localized region of the surrounding well bore, said sealing means being harmlessly engageable with the surrounding well bore, and tending to shield the well bore from the direct force of said explosive.

20. In a screen and formation cleaning device for well bores, a submergible blank cartridge unit comprising: an explosive receiving chamber; a non-penetrating means initially sealing an explosive in said chamber; an outwardly flaring open barrel continuing from said sealing means and adapted, when submerged, to receive a quantity of liquid, whereby upon discharge of said explosive, said liquid is forced under pressure from said barrel and against a localized region of the surrounding well bore, said sealing means being harmlessly engageable with the surrounding well bore, and tending to shield the well bore from the direct force of said explosive.

21. In a screen and formation cleaning device for well bores, a submergible blank cartridge unit comprising: an explosive receiving chamber; means for directing the force of the explosive against a localized region of the surrounding well bore; and means for shielding the central portion of said region from the destructive force of said explosive.

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