May 19, 1953 T. C. BANNON ET AL 2,638,981

GUN PERFORATOR ACTUATOR

Filed Jan. 22, 1948

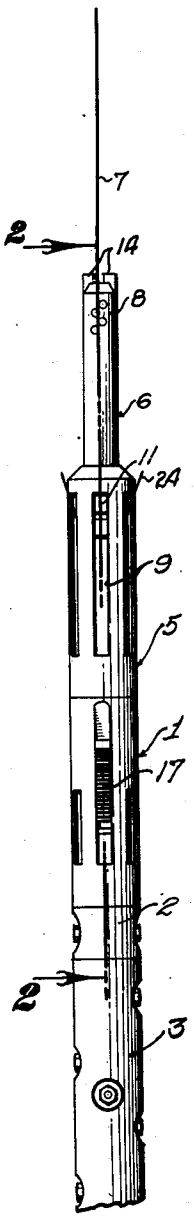


FIG. 1

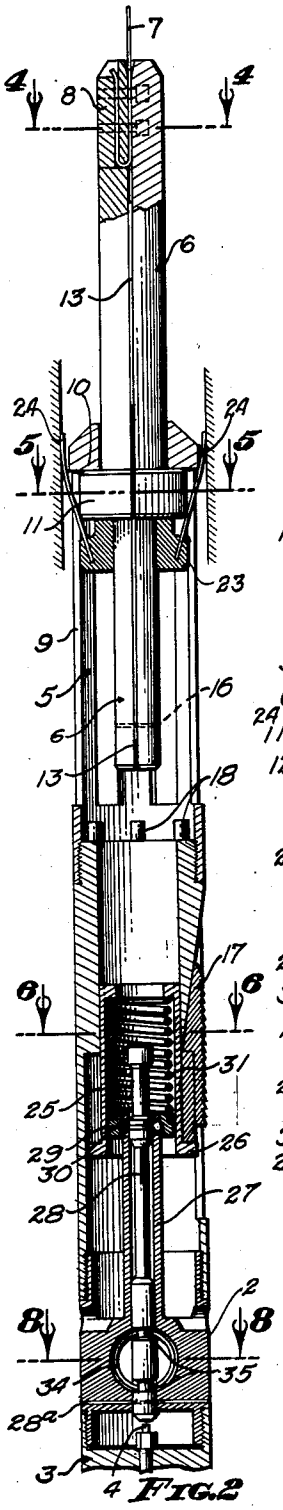


FIG. 2

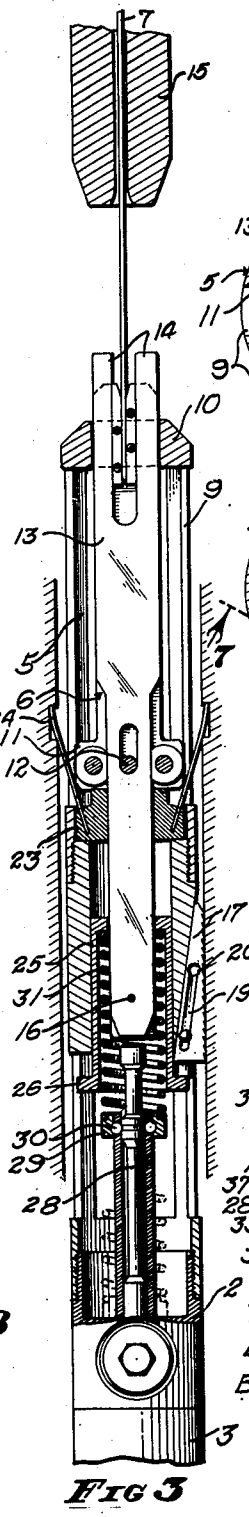


FIG 3

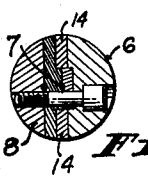


FIG. 4

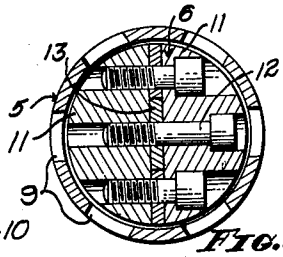


FIG. 5

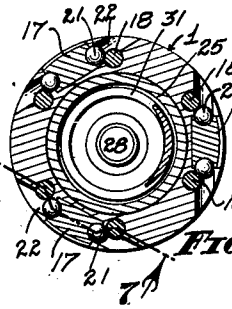


FIG 6

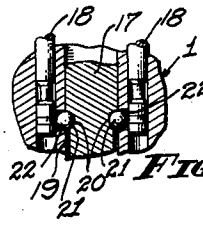


FIG. 7

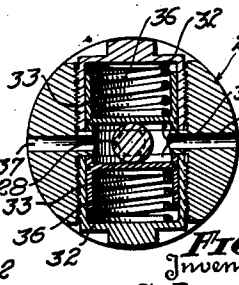


FIG. 8

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GUN PERFORATOR ACTUATOR

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13 Claims. (Cl. 164—0.5)

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Our invention relates to gun perforator actuators; that is, to devices adapted to be interposed between a gun perforator and its suspension line. Included in the objects of our invention are:

First, to provide a gun perforator actuator which is particularly adapted to percussion fired gun perforators, and which employs a firing means adapted to transmit to the gun perforator the impact of a godevil traveling down the suspension line, the actuator and its firing means being so arranged that the gun perforator is disarmed as long as the gun perforator is supported from the suspension line and it further disarms the gun perforator unless submerged in a liquid.

Second, to provide an apparatus of this character which incorporates a lost motion mechanism so associated with the firing means that the weight of the gun perforator must be removed from the suspension line and the mechanism retracted before the gun perforator may be armed.

Third, to provide an apparatus of this character which incorporates initially retracted, spring backed, wedging slips and controllable tripping mechanism arranged to release the slips for wedging engagement with a surrounding casing to support the gun perforator from the casing thereby to permit arming of the gun perforator and its operation by means of a godevil.

Fourth, to provide an apparatus of this character which incorporates an arrangement whereby the spring means which urges the slips into their wedging position is rendered inoperative, upon firing the gun perforator, to facilitate withdrawal.

Fifth, to provide an apparatus of this character wherein said lost motion mechanism not only controls the arming of the gun perforator but also functions as a jar to loosen the gun perforator should it stick in the well casing.

With the above and other objects in view as may appear hereinafter, reference is directed to the accompanying drawings, in which:

Figure 1 is a reduced elevational view of our gun perforator actuator shown suspended from a wire line and indicating fragmentarily a gun perforator suspended therefrom.

Figure 2 is an enlarged longitudinal sectional view taken through 2—2 of Fig. 1, showing the parts as they appear when the gun perforator is being lowered into a well casing.

Figure 3 is a similar longitudinal sectional view showing the parts as they appear when the gun perforator is anchored in the well casing and immediately before the gun perforator is fired.

Figure 4 is a further enlarged transverse sectional view through 4—4 of Fig. 2.

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Figure 5 is a transverse sectional view through 5—5 of Fig. 2.

Figure 6 is a transverse sectional view through 6—6 of Fig. 2.

Figure 7 is a fragmentary sectional view through 7—7 of Fig. 6.

Figure 8 is a transverse sectional view through 8—8 of Fig. 2.

Our gun perforator actuator includes a body member 1 of tubular form and internally threaded at its lower end for attachment to an adapter fitting 2. The adapter fitting is, in turn, arranged for connection to the upper end of a gun perforator 3. The gun perforator is arranged so that it may be mechanically fired by a percussion operated firing pin 4, shown fragmentarily in Fig. 2, and a detonating means, not shown. Otherwise, the gun perforator may be conventional; however, as will be brought out hereinafter, it is particularly desirable that the gun have a low weight-per-shot ratio.

The upper end of the body member 1 is attached to a jar tube 5 in which is slidably mounted a jar bar 6. The jar bar 6 is secured to a suspension line 7 by suitable clamp means 8. The jar tube is provided with several longitudinal slots 9 and its upper end is constricted to form an anvil shoulder 10. The jar bar 6 is provided with an external flange which forms a striking head 11.

The jar bar 6 is preferably divided longitudinally into a pair of complementary members joined by bolts 12. These members define a longitudinal slot in which is mounted and guided a firing plate 13. The upper extremity of the firing plate is divided to form tongues 14 which project above the jar bar for engagement by a godevil 15 adapted to travel downwardly on the suspension line 7. A shear pin 16 may be provided to maintain the firing plate in its upper position.

The body member 1 is provided with upwardly diverging slip channels which receive slips 17 of wedge form having external serrations for engagement with a surrounding well casing. The walls of the body member are provided with longitudinal bores on opposite sides of the slip channels which receive latching pins 18. The opposite sides of the slips 17 are provided with grooves 19 terminating at their upper ends in recesses 20. Combination key and latching balls 21 ride in the grooves 19. The balls 21 are fitted in bores 22 which are intersected by the bores containing the latching pins 18. The latching pins initially hold the balls 21 in the recesses 20 to restrain the slips in their lower or retracted position, but have annular channels which permit the balls to ride in

the channels and permit limited extension of the slips.

The upper extremities of the latching pins 18 project into the jar tube 5 and may be engaged by the head 11. However, there may be interposed between the head 11 and the pins 18 a ring member 23 having upwardly diverging wire prongs 24 which project through the slots 9 of the jar tube. Thus the pins 18 may be actuated by setting the gun perforator on the bottom of the well, or by drawing upwardly on the suspension line until the wire prongs 24 catch in an internal channel formed by a collar connecting adjacent lengths of casing. The wire prongs are sufficiently weak that they may bend double without excessive force so that they do not interfere with removal of the gun perforator.

The lower portion of the body 1 is counterbored to receive a slidable liner 25 having an external flange 26. The base ends of the slip channels intersect the counterbored portion of the body member so that when the slips are in their lower positions they project therein and are engaged by the flange 26. The adapter fitting 2 is provided with a firing bar tube 27 projecting upwardly into the body 1. Within the tube 27 is a firing bar 28, the upper end of which projects upwardly for engagement by the firing plate 13. Fitted around the tube 27 is a collar 29 which is held thereon by key balls 30 extending through openings in the tube 27 and restrained by the firing bar 28 until the firing bar is forced downwardly by action of the firing plate 13. A spring 31 is interposed between the collar 29 and an internal flange at the upper end of the liner 25. The force of the spring 31 is transmitted through the liner to the slips 17. A shear pin 28a may extend through the firing bar.

The adapter fitting 2 is provided with a central bore continuing from the tube 27 and adapted to receive the lower end of the firing bar 28. A transverse bore of relatively large diameter extends through the adapter fitting. The ends of the transverse bore are threaded to receive cup shaped cylinder members 32 the open ends of which face radially inwardly and receive pistons 33 which are likewise cup shaped but with their closed ends at their radially inner side. The closed ends of the pistons are provided with axially directed rims 34 which, when the pistons are in their radially inner positions, fit in channels 35 provided in the firing bar 28 to prevent downward movement thereof. The pistons are urged inwardly by springs 36 located within the chambers formed by the pistons and cylinders. Suitable seal means such as "O" rings are employed to seal the chambers. The space between the pistons is exposed to submergence pressure of the surrounding liquid, if any, by means of ports 37. Such pressure tends to force the pistons outwardly against the action of the springs 36.

The lower end of the firing bar 28 is adapted to strike the firing pin 4 of the gun perforator.

Operation of our gun perforator actuator is as follows:

When the gun perforator is lowered into the well bore, the parts are in the position shown in Fig. 2. Before submergence in a liquid, the rims 34 of the pistons 33 prevent downward movement of the firing bar 28. After submergence in a liquid to a depth predetermined by the strength of the springs 36, the firing bar 28 is released or armed.

The gun perforator is lowered to the bottom of the well to permit downward movement of the jar bar 6 until its weight is applied to the latching pins 18 thereby releasing the slips 17 which are urged upwardly by the spring 31.

Alternatively, the gun perforator may be lowered to a point below its firing level, then drawn upwardly until the wire prongs 24 catch in the channel provided in the first joint encountered. The wire prongs are designed to have sufficient strength that the latching pins 18 may be depressed, but are weak enough to offer no appreciable interference with further upward movement of the gun perforator.

After tripping the slips, the gun perforator is raised to its firing level with the slips riding on the casing wall. When the firing level is reached, the suspension line is lowered causing the slips to wedge against the casing and support the gun perforator. The suspension line is lowered until the jar bar 6 is in its lower position shown in Fig. 3. It is, of course, contemplated that the hoisting equipment for the suspension line will be provided with suitable weight indicating and measuring means so that the desired movement of the jar bar 6 may be accomplished.

After the line is lowered, the godevil 15 is dropped, and on striking the firing plate 13, the blow is transmitted to the firing bar 28 and from the firing bar to the firing pin 4 which engages the gun perforator detonator. Firing movement of the firing bar 28 releases the collar 29 which, in turn, releases the spring 31. When the spring 31 is released, the slips are free to retract when the gun perforator is raised; however, retraction of the slips is not essential to withdrawal of the gun perforator.

It will be observed that the gun perforator cannot be fired by the godevil unless two conditions are satisfied; namely:

1. The gun perforator be submerged in a liquid to a depth sufficient to release the firing bar.

2. The jar bar be in its lower position, a position which cannot be obtained unless the gun perforator is resting on the bottom of the wellbore or suspended from the well casing.

Thus, the gun perforator cannot be fired while being raised or lowered in the well casing, even though the godevil should be accidentally dropped.

It should be pointed out that the weight of the suspension line has an important bearing on the feasibility of employing a godevil to fire the gun perforator. That is, the greater the weight of the suspension line, the heavier the godevil must be. Well bores are seldom straight, the casings curve in arcs of greater or lesser radius so that the godevil weight required to overcome the pressure of the suspension line against the casing may be expressed by the following formula:

$$W=\frac{F}{r}\times 2L\times f$$

where:

F=tension on suspension line
r=radius of curvature of casing
L=distance between godevil and point of tangency between the suspension and casing
f=coefficient of friction

It will be observed that with the other factors remaining constant the required godevil weight is in proportion to the tension on the suspension line. Thus, if a single strand line (No. 12 gage) weighing approximately 300 pounds per 10,000 feet is employed, the godevil

need weigh only a tenth as much as a godevil employed on a conventional cable ($\frac{7}{16}$ in. dia.) weighing 3,000 pounds per 10,000 feet. This means that a twenty pound godevil is sufficient for a single strand wire line, whereas a 200 pound godevil is required for a conventional cable, omitting in each case the effect of gun perforator weight. It will be seen that suspension of the gun perforator by the well casing while the godevil travels down the line reduces materially the required weight of the godevil as otherwise such weight is added to the factor F above.

Having thus described certain embodiments of our invention, we do not desire to be limited thereto, but intend to claim all novelty inherent in the appended claims.

We claim:

1. The combination with a suspension line, a godevil adapted to travel on said line, and a gun perforator having a firing pin, of an actuator adapted to be interposed between said suspension line and said gun perforator, and comprising: a body structure; a lost motion jar structure connecting said body structure and said suspension line, and movable between an axially extended and a retracted position; slips mounted in said body structure and movable between a radially extended and a retracted position; means initially restraining said slips; means for releasing said slips for engagement with a surrounding casing to support said body structure; and impact transmitting means incorporated in said jar and body structures, and movable with said jar structure between an extended disarmed position to prevent operation of said firing pin, when said body structure is suspended from said line, and a retracted armed position, when said body structure is supported by said slips, for transmitting the impact of a godevil traveling down said suspension line to the firing pin of said gun perforator.

2. The combination with a suspension line, a godevil adapted to travel on said line, and a gun perforator having a firing pin, of an actuator adapted to be interposed between said suspension line and said gun perforator, and comprising: a lost motion jar structure connected with said suspension line and adapted to occupy an extended position when supporting said gun perforator and to move to a retracted position when free from the weight thereof; a firing device incorporating said jar structure having a disarmed position when said jar is extended and an armed position when said jar structure is retracted to transmit an impact from a godevil traveling down said suspension line to the firing pin of said gun perforator; and means including wedging slips operable to transfer support of said gun perforator from said suspension line to a surrounding well casing, thereby to permit retraction of said jar structure.

3. The combination with a suspension line, a godevil adapted to travel on said line, and a gun perforator having a firing pin, of an actuator adapted to be interposed between said suspension line and said gun perforator, and comprising: a lost motion jar structure connected with said suspension line and adapted to occupy an extended position when supporting said gun perforator and to move to a retracted position when free from the weight thereof; a firing device incorporating said jar structure having a disarmed position when said jar is extended and an armed position when said jar structure is retracted to transmit an impact from a godevil traveling down said suspension line to the firing pin of said gun perforator; wedging slips operable to transfer support of said gun perforator from said suspension line to a surrounding well casing thereby to permit retraction of said jar structure; initially restrained yieldable means urging said slips into engagement with said well casing; means for releasing said yieldable means; and means operable by said firing device to render said yieldable means inoperative thereby to permit retraction of said slips.

4. The combination with a suspension line, a godevil adapted to travel on said line, and a gun perforator having a firing pin, of an actuator adapted to be interposed between said suspension line and said gun perforator, and comprising: a lost motion jar structure connected with said suspension line and adapted to occupy an extended position when supporting said gun perforator and to move to a retracted position when free from the weight thereof; a firing device incorporating said jar structure and movable from a disarmed to an armed position when said jar structure is retracted to transmit an impact from a godevil traveling down said suspension line to the firing pin of said gun perforator; wedging slips operable to transfer support of said gun perforator from said suspension line to a surrounding well casing thereby to permit retraction of said jar structure; initially restrained yieldable means urging said slips into engagement with said well casing; and means engageable by said jar structure when said gun perforator is resting at the bottom of a well bore to release said yieldable means, said wedging slips being when released arranged to permit upward movement of the gun perforator in the well casing.

5. The combination with a suspension line, a godevil adapted to travel on said line, and a gun perforator having a firing pin, of an actuator adapted to be interposed between said suspension line and said gun perforator, and comprising: a lost motion jar structure connected with said suspension line and adapted to occupy an extended position when supporting said gun perforator and to move to a retracted position when free from the weight thereof; a firing device incorporating said jar structure and movable from a disarmed to an armed position when said jar structure is retracted to transmit an impact from a godevil traveling down said suspension line to the firing pin of said gun perforator; wedging slips operable to transfer support of said gun perforator from said suspension line to a surrounding well casing thereby to permit retraction of said jar structure; spring means urging said slips into engagement with said well casing; latch means restraining said spring means; and a device operatively engageable with the interior of the joints between well casing sections when said gun perforator is raised to actuate said latch means and release said spring means, said wedging slips being arranged, when released, to permit upward movement of the gun perforator in the well casing.

6. A gun perforator actuator, comprising: a jar element adapted for connection to a suspension line; a coacting jar element adapted for connection with a gun perforator, said jar elements arranged for limited relative movement between an extended position when supporting said gun perforator and a retracted position when relieved of the weight of said gun perfo-

rator; a firing device associated with said jar elements and positioned for impact engagement by a godevil guided down said suspension line, said firing device having an extended disarmed position when said jar elements are extended and a retracted armed position when said jar elements are retracted to transmit the impact of said godevil to said gun perforator thereby to fire the same; and slip means engageable with a surrounding casing to support said gun perforator from a surrounding casing whereby said jar elements may be retracted, thereby to permit firing of said gun perforator by said godevil.

7. In an apparatus of operating gun perforators, the combination of: a percussion responsive instrumentality disposed between a gun perforator and a suspension line, said instrumentality having an extended disarmed position when said gun perforator is suspended from said line, and movable to a retracted armed position when the weight of said gun perforator is relieved therefrom; means operable subsequent to lowering said gun perforator into a well casing to transfer the weight of said gun perforator from said suspension line to the well casing, thereby to permit retraction of said instrumentality to its armed position; means operable through said instrumentality, when in its armed position, for firing said gun perforator and a device normally maintaining said instrumentality disarmed irrespective of whether the gun perforator is supported by said suspension line or said casing, said device being responsive to submergence pressure of a surrounding liquid to permit arming of said instrumentality.

8. A means for securing a gun perforator in a well casing, comprising: a tubular body member adapted to be connected with a gun perforator and having in its walls slip channels; slips movable in said channels and having extremities projecting into the bore of said tubular body member; spring means within said body member urging said slips into extended positions to wedge said body member and gun perforator against downward movement in a surrounding well casing; latch means restraining said slips; and a device including elements engageable with the interior of a collar connecting adjacent well casing sections for actuating said latch means to release said slips, said elements and said slips being arranged to permit upward movement of said gun perforator in said well casing.

9. A gun perforator actuator comprising: a tubular body member adapted to be connected with a gun perforator and having in its walls slip channels; slips movable in said channels and having extremities projecting into the bore of said tubular body member; spring means within said body member urging said slips into extended positions to wedge said body member and gun perforator against downward movement in a surrounding well casing; latch means restraining said slips; a means for connecting said body member and gun perforator to a suspension line; a percussion firing means for said gun perforator, said firing means having an extended disarmed position when said gun perforator is supported by said suspension line and movable to a retracted armed position when said gun perforator is supported by a surrounding casing; and means for actuating said latch means to release said slips to support said gun perforator from said casing.

10. A gun perforator actuator, comprising: a tubular body member adapted to be connected with a gun perforator and having in its walls slip channels; slips movable in said channels and having extremities projecting into the bore of said tubular body member; spring means within said body member urging said slips into extended positions to wedge said body member and gun perforator against downward movement in a surrounding well casing; latch means restraining said slips; a lost motion jar structure for suspending said gun perforator from a suspension line; a percussion firing device for said gun perforator incorporated in said jar structure, said firing device having a disarmed position when said gun perforator is suspended from said line, and movable to an armed position when said gun perforator is supported from a surrounding casing; and means for actuating said latch means thereby to support said gun perforator from said casing.

11. A gun perforator actuator as set forth in claim 10 wherein: said latch actuating means is incorporated in said jar structure and is operable when the gun perforator is set against the bottom of a well bore.

12. A gun perforator actuator as set forth in claim 10 wherein: said latch actuating means includes yieldable fingers adapted to catch in the channels formed between adjacent well casing sections, said fingers and said slips permitting upward movement of the gun perforator in said well casing.

13. A gun perforator actuator, comprising: a tubular body member adapted to be connected with a gun perforator and having in its walls slip channels; slips movable in said channels and having extremities projecting into the bore of said tubular body member; spring means within said body member urging said slips into extended positions to wedge said body member and gun perforator against downward movement in a surrounding well casing; latch means restraining said slips; a lost motion jar structure for suspending said gun perforator from a suspension line; a percussion firing device for said gun perforator incorporated in said jar structure, said firing device having a disarmed position when said gun perforator is suspended from said line, and movable to an armed position when said gun perforator is supported from a surrounding casing; means for actuating said latch means thereby to support said gun perforator from said casing; and means responsive to operation of said firing device to remove the force of said spring means from said slips thereby to facilitate withdrawal of said gun perforator.

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