APPARATUS FOR COMPLETING WELLS TRAVERSING EARTH FORMATIONS

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ABSTRACT OF THE DISCLOSURE
This application discloses new and improved apparatus for completing wells having earth formations which are to be fractured, acidized, or treated for inhibiting the production of undesirable formation materials. In the preferred embodiment of the present invention disclosed herein, a new and improved string of well tools is arranged for suspension from a string of pipe and includes a well packer coupled to an elongated tubular member defining an enclosed chamber of a substantial volume and which is maintained at a reduced pressure by first and second normally-closed valves operatively arranged at the opposite ends of the member to be selectively opened at successive time intervals for quickly admitting fluids into the enclosed chamber.

It is, of course, the usual practice for a cased well bore to be perforated at one or more points to provide fluid communication with selected earth formations therebelow. Once the well is perforated, various treating operations—such as acidizing, fracturing, or sand consolidating operations—are typically conducted to prepare the well for efficient production. Those skilled in the art will appreciate, however, that it is not at all uncommon for one or more of the perforations along a given perforated interval to be at least partially blocked by loose formation materials, debris, or foreign material which may often be deposited in a perforation by a typical shaped charge. A partial or total blockage of one or more of the perforations will, of course, impede or prohibit the introduction of treating fluids into those perforations and result in the inadequate treatment of at least those portions of the earth formation immediately adjacent thereto. As a result, further and otherwise needless treating operations will ultimately be required. Accordingly, unless all of the perforations along a perforated interval are capable of readily conducting fluids, subsequent treating operations as well as the production rate of the well will be significantly affected.

In addition to the aforementioned sand consolidating operations, so-called "gravel packs" are also alternatively employed by the industry for inhibiting the production of sand from unconsolidated or incompetent formations. To form such gravel packs, a suitable slotted or screened tubular member is positioned within the perforated interval of a cased well bore and a slurry containing selectively-sized particles of either small gravel or large-diameter sand grains is pumped into the well bore and displaced into the annulus between the liner and the perforated casing. In this manner, the resulting gravel pack will serve as a permeable filter over the entrances to the perforations for blocking the entry of the fine formation particles which would otherwise flow into the well bore as the well is subsequently being produced. With a gravel pack completion, however, the partial or total blockage of one or more of the perforations by fine sand particles will at least reduce, if not significantly impair, the subsequent efficient production of the well.

Accordingly, it is an object of the present invention to provide new and improved apparatus especially arranged for completing well bores to provide improved fluid communication between the well bore and selected earth formations traversed thereby.

This and other objects of the present invention are attained by providing a tool having an elongated member defining an enclosed chamber and to which is coupled a well packer. Selectively-operable first and second valve means are spaced apart on the elongated member and cooperatively arranged for being quickly opened at successive time intervals to first communicate the chamber with the well bore below the packer and then to communicate the supporting pipe string with the well bore below the packer. In this manner, once the packer is set above a perforated well bore interval, opening of the first valve will induct connate fluids into the initially-empty chamber for purging foreign matter out of the formation and into the well bore below the packer. Then, when the second valve is quickly opened at a later time, clean fluids under pressure in the supporting pipe string are suddenly released into the chamber to develop dynamic pressure forces for forcibly displacing the fluids through the perforations and into the formation.

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

FIGS. 1A–1B schematically illustrate a preferred embodiment of a well completion tool arranged in accordance with the present invention;
FIGS. 2, 4 and 6 schematically depict the successive positions of the apparatus depicted in FIG. 1 as it is being employed for conducting a well completion operation; and
FIGS. 3, 5 and 7 respectively show a typical perforation as it may successively appear during the course of the well completion operation illustrated in FIGS. 2, 4 and 6.

Turning now to FIGS. 1A–1B, a completion tool 10 arranged in accordance with the principles of the present invention is depicted in its so-called "running in" position, with the tool being independently coupled from the lower end of a tubing string 11 and positioned in a well bore 12 having a casing 13 secured in position by an external sheath of cement 14. As illustrated, the completion tool 10 is comprised of a typical full-bore well packer 15 that is independently coupled to a pair of similar or identical selectively-openable full bore tools 16 and 17 which are respectively coupled to the upper and lower ends of a tubular member 18 of a selected length. In those situations where a formation consolidation operation is to be performed, the completion tool 10 may also include a typical bypass valve 19 which is tandemly coupled above the upper full-bore tool 16 for providing selective communication between the well annulus and the tubing string 11 supporting the completion tool. Since it is common to employ one or more segregating pistons or plugs (not shown) for separating the several consolidation agents as they are being pumped downwardly through the tubing string 11, it is preferred that the completion tool 10 also include means for catching such segregating plugs without preventing the continued flow of the treating agents. To accomplish this, a plug catcher 20 is comprised of a tubular housing 21 suitably arranged for tandem coupling between the bypass valve 19 and the upper full-bore tool 16 and a smaller tubular member 22 coaxially mounted within the housing. One or more inwardly-directed shoulders 23 are arranged on the inner tubular member 22 for catching the first of several segregating plugs (not shown) and retaining it well below a plurality of longitud
The upper and lower full bore tools 16 and 17 are only schematically depicted in FIGS. 1A–1B since it is preferred that these tools be similar to the full bore tool disclosed in Pat. No. 3,414,061 and the particular details of construction and operation can be readily determined from that patent. In general, therefore, the lower full bore tool for this tool consists of a mandrel 25 which is telescopically arranged within an outer tubular member or housing 26 for longitudinal movement between the extended or upper position illustrated in FIG. 1B and a further-telecentric lowered position. To rotationally secure the telescoped members 25 and 26 to one another, one or more longitudinal splines, as at 27, on the mandrel are received in complemental grooves on the upper end of the housing. The tool 17 further includes a ball valve 28 and a sleeve valve 29 which are closed so long as the mandrel is in its illustrated position and are selectively opened by downward movement of the mandrel in relation to the ball valve.

As fully described in Pat. No. 3,414,061, downward movement of the mandrel 25 will successively open the sleeve valve 29 and then, as the mandrel approaches its lowestmost position in relation to the housing 26, the valve-opening mechanism shown generally at 30 will rotate the ball valve to its open position so as to provide a substantially unobstructed passage between the tubular member 18 and the well bore below the packer 15. As also described in Pat. No. 3,414,061, downward travel of the mandrel 25 in relation to the housing 26 is selectively retarded by a typical hydraulic-delay mechanism 31 cooperatively arranged between the mandrel and housing as shown in detail at 63 in FIG. 2B of the patent. In general, the hydraulic-delay mechanism 31 is cooperatively arranged to require a maintained downward force of substantial magnitude on the mandrel 25 for continuing its downward movement in relation to the housing 26. Once, however, the mandrel 25 approaches its lowestmost position, the hydraulic-delay mechanism 31 functions to discontinue further retardation of the mandrel so that the force being applied thereto will suddenly shift the mandrel to its final position. As a result, this sudden release of the downward-moving mandrel 25 in relation to the housing 26. Once, however, the mandrel 25 approaches its lowestmost position in relation to the housing 26, external threads 32 around the mandrel are arranged for cooperatively engaging a split nut 33 mounted in the housing to retain the mandrel in its downward position and maintain the ball valve 28 in its fully-open position.

The upper full bore tool 16 is preferably identical to the lower full bore tool 17 except that the upper tool is inverted an illustrated in FIG. 1A to prevent unbalanced pressure forces from prematurely operating the upper tool as the completion tool 10 is being positioned in a well bore. Its operation is further retarded with respect to the lower tool. Accordingly, it will be appreciated that it is the housing 34 of the upper tool 16 that is moved downwardly in relation to the mandrel 35 thereof, with this downward movement being selectively retarded by a hydraulic-delay mechanism 36 until the housing is quieted and then has been moved to its final position in relation to the mandrel and secured by a split nut 37 carried on the housing and complemental threads 38 on the mandrel. As will be discussed later, the upper hydraulic-delay mechanism 36 employs a more-viscous fluid than that used in the lower delay mechanism 31. The upper tool 16 also includes a sleeve valve 38 as well as a ball valve 39 which is opened by a valve-operating mechanism 40 as the housing 34 is moved downwardly in relation to the mandrel 35. Hereagain, once the ball valve 39 has been opened, the split nut 37 will cooperate with the external threads 38 to retain the housing in its final lower position and lock the ball valve in its open position.

As will be subsequently discussed, the completion tool 10 of the present invention is uniquely applicable for performing acidizing and fracturing operations as well as typical sand consolidation or gravel packing operations. However, for purposes of illustration, FIGS. 2, 4 and 6 respectively depict the successive positions of the completion tool 10 of the present invention as it might appear during the course of what would otherwise be a typical sand consolidation or gravel pack operation if it were operated the mandrel 25. Figure 7 provides a front view of the tool. The ball valve 28 and sleeve valve 29 are shown in the fully-open position. The tool 16 is then lowered until the pin 32 engages the shoulder 33 of the ball valve 39 thereby providing a fully-opened ball valve 39 and sleeve valve 29 as well as a ball valve 28 and sleeve valve 29.

It will, of course, be appreciated that when a perforating tool which typically includes one or more shaped charges (not shown) is positioned in the well bore 12 and actuated for producing the perforations 41, the perforations will initially extend into the incompetent formation 42 as generally represented in FIG. 3. It is believed, however, by those skilled in the art that the perforation 41 will quickly fill up with loose formation materials and the incompetent formation 42 leaving open only a passage or so-called "tunnel" 43 extending through the casing 13 and the adjacent cement 14.

It is, of course, recognized that irrespective of the nature of the formation, debris, such as at 44, will usually be left in the formation 42 as a result of the disintegration of a typical shaped charge liner. Moreover, by observing test shots fired into laboratory targets, it is known that a typical shaped charge perforating jet will leave a somewhat impermeable sheath (as indicated by the dashed lines 45) around the walls of the forward portion of the perforation 41. This relatively-impermeable sheath of debris will either remain substantially in the position illustrated by the dashed lines 45; or, if the formation (as at 42) is incompetent, this impermeable sheath will most likely be collapsed inwardly as the forward portion of the perforation 41 is filled with loose formation materials. In any event, flow communication between the entrance tunnel 43 and the formation 42 will be at least retarded, if not substantially impaired, by the debris 44 and 45 deposited in the formation just outside of the tunnel. It is, therefore, this debris 44 and 45 which, irrespective of the competency of the formation 42, must be removed before the well bore 12 can be successfully completed.

Accordingly, after the packer 15 has been positioned as depicted in FIG. 2 above the formation 42, the packer is set in the usual manner for isolating the interval of the well bore 12 immediately adjacent to the perforations 41 from the remainder of the well bore thereof. Then, as depicted in FIG. 4, the lower tool 17 is actuated for opening the lower ball valve 28. To accomplish these operations, the pipe string 11 is "slacked-off" so as to impose a substantial downwardly-directed force on the completion tool 10 for setting the packer 15 as illustrated in FIG. 3. It will be appreciated, therefore, that at this point, this downwardly-acting force will be tending to simultaneously move the full-bore tools 16 and 17 toward their respective telescoped positions for opening the ball valves 28 and 29. The rates of relative telescoping movements of the mandrels 25 and 35 and their respective housings 26 and 34 will, however, be adaptively regulated at different rates by the hydraulic-delay mechanisms 31 and 36 provided in the two full bore tools 16 and 17. Accordingly, as previously mentioned, by employing a more-viscous fluid in the upper hydraulic-delay mechanism 36 than that used in the lower delay mechanism 31, the lower full bore tool 17 will be selectively operated before the upper full bore tool 16 to assure that the lower sleeve valve 29 and the lower ball valve 28 remain closed.
will open well before their counterparts in the upper tool. It will be appreciated, of course, that once the lower valve 28 and 29 are opened the same as in FIG. 4, a sudden high-pressure differential is developed between the connate fluids in the formation 42 and the voided chamber 50 defined in the tubular member 18 and the mandrels 25 and 35 between the ball valves 28 and 39. This chamber 50 is, preferably, initially at atmospheric pressure until the lower valve 28 is opened. Thus, the sudden pressure differential which is developed across the perforated well bore interval will, of course, induce a rapid, high-velocity flow of connate fluids 51 from the formation 42 through the several entrance tunnels 43 and into the empty chamber 50. These rushing fluids, therefore, will effectively wash out the debris, as at 44 and 45 (FIG. 3), along with a limited quantity of loose formation materials through the several tunnels 43. As a result, as shown in FIG. 5, once this sudden flow ceases upon the filling of the chamber 50, the perforations 41 will be effectively cleaned leaving only clean formation particles, as at 52, partially or totally filling the tunnels 43 through the casing 13 and cement 14. Although the upper valves 38 and 39 could be opened after the lower valves 28 and 29 are opened by continuing to maintain the downwardly-acting forces on the upper tool 16 for overcoming the upper delay mechanism 36 as soon as possible, as a matter of operating technique it is preferred to further postpone the opening of the upper valves for at least one or two hours to allow loose formation materials and debris which have been exhausted into the tubular member 18 to settle out into the well below the packer 15. Accordingly, as shown in FIG. 4, once the lower valves 28 and 29 are open, an upward strain is applied on the tubing string 11 to prevent further downward movement of the upper housing 34 in relation to the upper mandrel 35. During this waiting period, treating fluids, as at 53, can be pumped into the pipe string 11 whereby they will be in position above the upper full-bore tool 16. It will be recognized, of course, that with even clean formation particles, as shown at 52 in FIG. 5, deposited in the entrance passages 43, the subsequent injection of consolidating agents as well as the production of connate fluids 51 are materially limited. It is, therefore, of paramount importance that these loosened particles 52 be removed from the tunnels 43 before consolidating or gravel pack completion operations are conducted. Accordingly, to accomplish this, the clean fluid, as at 53 in FIG. 4, is confined in the tubing string 11 and, by applying weight to the pipe string 11 to activate the upper delay mechanism 36, the upper ball valve 39 will be rapidly opened to suddenly introduce the pressured fluid into the previously-closed chamber 50. It will, of course, be appreciated that although the chamber 50 is then filled with the connate fluids 51, these fluids as well as those in the isolated portion of the well bore below the packer 15 will be at a pressure no greater than the natural formation pressure of the earth formation 42. Accordingly, by rapidly opening the upper ball valve 39 as shown in FIG. 6, the injection fluid 53 will be suddenly moved downwardly into the chamber 50 and develop significant dynamic or shock pressures which are substantially greater than the formation pressure within the isolated portion of the well bore 12 below the packer 15. Thus, as illustrated in FIG. 7, the sudden release of the injection fluid 53 into the chamber 50 will cause the formation particles 52 out of the several tunnels 43 and back into the surrounding formation 42. It will, of course, be appreciated that once these transitory shock pressures have subsided, the injection fluid 53 is maintained at a pressure sufficient for preventing the production of further connate fluids from the several perforations 41 so that additional sand particles will not re-enter the several tunnels 43. Where the earth formation 42 is to be consolidated by typical sand-consolidating techniques, it is generally preferred that the injection fluid 53 be a so-called "pre-flush fluid" such as kerosene, diesel oil, or an acetic acid solution. Once the pressured pre-flush fluid is pumped into the formation 42, one or more consolidating agents (not shown) are successively pumped into the formation to accomplish the desired consolidation. As is typical, the consolidating fluid may then be followed by a suitable after-flush agent, such as kerosene. In some instances, temporary plugging agents such as "Black Magic," an oil-base mud as supplied by Oil Base, Inc., of Compton, Calif. It will be recognized that the hydrostatic pressure and the pumping pressure of these successively-injected treating fluids will be greater than the formation pressure of the formation 42 so that the tunnels 43 will remain open throughout the consolidation operation. The particular nature or type of sand consolidation agents are, of course, of no significance to the present invention and the consolidating agents may be either porous-setting or solid-setting plastics. On the other hand, where the well bore 12 is to be subsequently gravel-packed, the injection fluid 53 needs only to be a suitable fluid such as a clean saline solution. By properly selecting a saline solution of sufficient density, the resulting hydrostatic pressure of the injection fluid 53 will be effective for forming the formation 42 in position as the tool 10 and the tubing string 11 are removed and the appropriate tools are installed for performing a typical gravel packing operation. Hereagain, since the particular techniques employed for setting a typical gravel pack and screen in the casing 11 around the perforations 41 are of no significance to understanding the present invention, these details have not been illustrated. It is believed that a proper gravel packing operation will result in filling the still-open tunnels 43 with the larger gravel particles so as to define adequate fluid channels through the packed tunnels and prevent the re-entry of fine formation materials.

As previously mentioned, the completion tool 10 of the present invention is also equally applicable for otherwise typical acidizing or hydraulic fracturing operations. Accordingly, the formation 42 is to be either acidized or fractured, the treating fluid fluid 53 will, of course, be the fluid which is to be injected into the several perforations 41 for such operations. The sequence of events will, of course, be substantially as depicted in FIGS. 2-7 with the possible exception that the formation 42 may be sufficiently competent that there will be little or no loose formation materials, as at 52, deposited in the tunnels 43. In either situation, however, those skilled in the art will appreciate that the new and improved completion tool 10 of the present invention will be of significant benefit for conducting either an acidizing operation or a hydraulic fracturing operation. Of particular significance, it should be recognized that by employing the completion tool 10 of the present invention to commence either an acidizing operation or a fracturing operation, the dynamic shock or surge pressures that are developed when the treating fluid 53 is suddenly released upon opening of the upper ball valve 39 will be of material benefit in conducting the operation. This sudden surge or pressure shock will, therefore, be particularly useful in "breaking down" the formation 42 to assure that the treating fluid 53 is entering all of the perforations. As a further benefit, it has been found that the pumping rate required to continue movement of the treating fluid 53 into the formation 42 will be significantly reduced in comparison to the pumping pressures normally required for conducting acidizing or fracturing operations with only conventional completion tools.

It should be noted that where the completion tool 10 is used for sand consolidating operations or gravel packing operations, a sufficient surge or shock will usually
be developed even where the chamber 50 is completely filled before the upper ball valve 39 is opened. On the other hand, where such perforating or fracturing operation is being conducted with the completion tool 10, it has been found that a greatly-enhanced surge or pressure shock will be obtained by arranging the interconnecting tubular member 16 to have a volumetric capacity (i.e., the chamber 50) that is greater than the anticipated volume of the connate fluids 53 that will enter the chamber during the predetermined time interval before opening the upper ball valve 39. In this manner, the upper portion of the chamber 50 will be empty when the upper ball valve 39 is opened and the sudden entrance of the movement of the pipe string; and said first means are further operable for opening said lower valve means quickly only after said packer means have isolated the perforated interval to promote a surge of such connate fluids into the isolated perforated interval and said chamber.

5. Well completion apparatus adapted to be connected to a pipe string and suspended in a well bore having a perforated interval traversing earth formations containing connate fluids, said apparatus comprising: upper and lower valve means respectively including inner and outer tubular members cooperatively telescopically together and adapted for movement relative to one another between spaced positions, and means operatively arranged between said telescopically members for blocking flow communication therethrough until said telescopically members are moved from a first position to a second position; an elongated tubular member tandemly interconnecting one of said telescopically members of said upper valve means to one of said telescopically members of said lower valve means and defining an enclosed chamber in said inter-connected tubulars of foreign matter and then, after a delay, quickly opening the upper valve for imposing a sudden pressure shock or dynamic force to the perforations, the apparatus of the present invention assures that a complete treating operation can be realized.

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

What is claimed is:

1. A well completion tool adapted to be connected to a pipe string and suspended in a well bore having a perforated interval traversing earth formations containing connate fluids, said well completion tool comprising: tubular body means adapted for connection to a pipe string and including a longitudinal flow passage there through; upper and lower normally-closed valve means spatially disposed along said body means and operatively arranged for defining therebetween an enclosed chamber in said flow passage so long as said upper and lower valve means are closed; said upper portion of the chamber will produce a corresponding substantial implosing force which in turn develops the greatly-enhanced shock forces referred to above.

Accordingly, it will be appreciated that by employing the new and improved apparatus of the present invention, it can be reliably assured that perforations in a well bore traversing earth formations will be well conditioned for readily accepting subsequently-injected treating agents such as acids, formation-consolidating agents, protective fluids, or other fluids which are to be introduced into earth formations. By first quickly opening the lower valve for entering the formations and operations of foreign matter and then, after a delay, quickly opening the upper valve for imposing a sudden pressure shock or dynamic force to the perforations, the apparatus of the present invention assures that a complete treating operation can be realized.

2. The well completion tool of claim 1 wherein said packer means are selectively operable in response to movement of the pipe string; and said first means are further operable for opening said lower valve means only after said packer means have isolated the perforated interval.

4. The well completion tool of claim 1 wherein said packer means are selectively operable in response to movement of the pipe string; and said first means are further operable for opening said lower valve means quickly only after said packer means have isolated the perforated interval to promote a surge of such connate fluids into the isolated perforated interval and said chamber.

5. Well completion apparatus adapted to be connected to a pipe string and suspended in a well bore having a perforated interval traversing earth formations containing connate fluids, said apparatus comprising: upper and lower valve means respectively including inner and outer tubular members cooperatively telescopically together and adapted for movement relative to one another between spaced positions, and means operatively arranged between said telescopically members for blocking flow communication therethrough until said telescopically members are moved from a first position to a second position; an elongated tubular member tandemly interconnecting one of said telescopically members of said upper valve means to one of said telescopically members of said lower valve means and defining an enclosed chamber in said inter-connected tubulars of foreign matter and then, after a delay, quickly opening the upper valve for imposing a sudden pressure shock or dynamic force to the perforations, the apparatus of the present invention assures that a complete treating operation can be realized.

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

What is claimed is:

1. A well completion tool adapted to be connected to a pipe string and suspended in a well bore having a perforated interval traversing earth formations containing connate fluids, said well completion tool comprising: tubular body means adapted for connection to a pipe string and including a longitudinal flow passage there through; upper and lower normally-closed valve means spatially disposed along said body means and operatively arranged for defining therebetween an enclosed chamber in said flow passage so long as said upper and lower valve means are closed; said upper portion of the chamber will produce a corresponding substantial implosing force which in turn develops the greatly-enhanced shock forces referred to above.

Accordingly, it will be appreciated that by employing the new and improved apparatus of the present invention, it can be reliably assured that perforations in a well bore traversing earth formations will be well conditioned for readily accepting subsequently-injected treating agents such as acids, formation-consolidating agents, protective fluids, or other fluids which are to be introduced into earth formations. By first quickly opening the lower valve for entering the formations and operations of foreign matter and then, after a delay, quickly opening the upper valve for imposing a sudden pressure shock or dynamic force to the perforations, the apparatus of the present invention assures that a complete treating operation can be realized.

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

What is claimed is:

1. A well completion tool adapted to be connected to a pipe string and suspended in a well bore having a perforated interval traversing earth formations containing connate fluids, said well completion tool comprising: tubular body means adapted for connection to a pipe string and including a longitudinal flow passage there through; upper and lower normally-closed valve means spatially disposed along said body means and operatively arranged for defining therebetween an enclosed chamber in said flow passage so long as said upper and lower valve means are closed; said upper portion of the chamber will produce a corresponding substantial implosing force which in turn develops the greatly-enhanced shock forces referred to above.

Accordingly, it will be appreciated that by employing the new and improved apparatus of the present invention, it can be reliably assured that perforations in a well bore traversing earth formations will be well conditioned for readily accepting subsequently-injected treating agents such as acids, formation-consolidating agents, protective fluids, or other fluids which are to be introduced into earth formations. By first quickly opening the lower valve for entering the formations and operations of foreign matter and then, after a delay, quickly opening the upper valve for imposing a sudden pressure shock or dynamic force to the perforations, the apparatus of the present invention assures that a complete treating operation can be realized.

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

What is claimed is:
other telescoped member of said upper valve means; and further including second delay means operatively ar-
anged on said lower valve means for retarding the move-ment of said lower telescoped members to their said second position until after said packer means are operated and before said upper telescoped members have been moved to their said second position.

11. The well completion apparatus of claim 10 wherein said second delay means are operative for retarding the relative movement of said lower telescoped members for only the initial portion of their relative span of movement so that the movement of said lower telescoped members over the remaining portion of their relative span of movement will be accelerated for quickly moving said lower telescoped members to their said second position and suddenly opening flow communication through said lower valve means.

12. Well completion apparatus adapted to be connected to a pipe string and suspended in a well bore having a perforated interval traversing earth formations containing connate fluids, said apparatus comprising: upper and lower well tools respectively including inner and outer tubular members cooperatively telescoped to-
gether and adapted for longitudinal movement relative to one another between spaced positions, and valve means operatively arranged between said telescoped members for blocking flow communication therethrough until said telescoped members are moved for an ex-
tended position to a telescoped position; and elongated tubular member tandemly interconnecting the lower one of said upper telescoped members to the upper one of said lower telescoped members and defining an enclosed chamber in said interconnected tubular members so long as said upper and lower valve means are blocking fluid communicating through said upper and lower well tools; packer means including a tubular actuating member coupled to the lower one of said lower telescoped mem-
bers, and pack-off means operatively arranged around said actuating member and adapted for isolating the perforated interval of a well bore from fluids in the well bore thereabove upon longitudinal movement of said actuating member in relation to said pack-off means; first delay means operatively arranged on said lower well tool for retarding the movement of said lower telescoped members to their said telescoped position until after movement of said actuating member for operating said pack-off means; and second delay means operatively ar-
 ranged on said upper well tool for retarding the move-
ment of said upper telescoped members to their said telescoped position until after said lower telescoped mem-
bers have been moved to their said telescoped position in response to movement of a pipe string connected to the upper one of said telescoped members of said upper well tool.

13. The well completion apparatus of claim 12 wherein said first and second delay means respectively include a piston chamber defined in said outer tubular member of each of said upper and lower well tools, a piston member mounted on said inner tubular member of each of said upper and lower well tools and operatively received within its respectively associated piston chamber for movement therein by its respectively associated inner tubular member, a restricted bypass passage across each of said piston members, and a viscous fluid disposed in each of said piston chambers, said viscous fluid disposed within said upper piston chamber having a greater viscos-
ity than said viscous fluid disposed within said lower piston chamber.

14. The well completion apparatus of claim 13 where-
in said second delay means further includes a less-re-
stricted second bypass passage in a portion of said upper piston chamber and operatively arranged to allow ac-
celerated movement of said upper inner tubular member toward its said telescoped position once said upper piston means reaches said second bypass passage for quickly opening said upper valve means once said upper telescoped members reach their said telescoped position.

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