

Abstract

A hydraulic fracturing system on which a hydraulic fracturing plan for hydraulically fracturing a plurality of oil and gas wells is executed.

Claims

What is claimed is:

1. An apparatus according to one or more embodiments of the present disclosure.
2. A system according to one or more embodiments of the present disclosure.
3. A method according to one or more embodiments of the present disclosure.
4. A step according to one or more embodiments of the present disclosure.
5. A sub-step according to one or more embodiments of the present disclosure.
6. A fracturing system according to one or more embodiments of the present disclosure.
7. A fracturing leg according to one or more embodiments of the present disclosure.
8. A method for swapping from fracturing a first well to fracturing a second well while continuously pumping according to one or more embodiments of the present disclosure.
9. A method for swapping from fracturing first and second wells to fracturing third and fourth wells while continuously pumping according to one or more embodiments of the present disclosure.

U.S. PROVISIONAL PATENT APPLICATION

TITLED:

HYDRAULIC FRACTURING PLAN

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HYDRAULIC FRACTURING PLAN

Background

[0001] This application relates generally to oil and gas hydraulic fracturing operations and, more particularly, to a hydraulic fracturing system on which a hydraulic fracturing plan for hydraulically fracturing a plurality of oil and gas wells is executed.

Brief Description of the Drawings

[0002] Figure 1 is a diagrammatic illustration of a fracturing system, according to one or more embodiments.

[0003] Figure 2 is a flow diagram illustrating a method for fracturing wells using the fracturing system of Figure 1, according to one or more embodiments.

[0004] Figures 3A through 3K illustrate various sub-steps of a first step of the method illustrated in Figure 2, which first step is or includes equalizing a lubricator of a frac leg associated a first well, and opening the first well, according to one or more embodiments.

[0005] Figures 4A through 4C illustrate various sub-steps of a second step of the method illustrated in Figure 2, which second step is or includes perforating a stage of the first well using a wireline perforating system.

[0006] Figures 5A through 5K illustrate various sub-steps of a third step of the method illustrated in Figure 2, which third step is or includes closing the first well using a valve apparatus, and draining a lubricator, according to one or more embodiments.

[0007] Figures 6A through 6H illustrate various sub-steps of a fourth step of the method illustrated in Figure 2, which fourth step is or includes isolating a stage of a second well in preparation for a hydraulic fracturing operation, according to one or more embodiments.

[0008] Figure 7 illustrates various subs-steps of a fifth step of the method illustrated in Figure 2, which fifth step is or includes detecting or otherwise determining that a fracturing stage of a third well has ended, according to one or more embodiments.

[0009] Figure 8 illustrates various sub-steps of a sixth step of the method illustrated in Figure 2, which sixth step is or includes permitting a regular swap, a continuous pumping swap (or "CP swap"), or both, from hydraulically fracturing the third well to hydraulically

fracturing the second well by, for example, detecting or otherwise determining that an idle rate of the hydraulic fracturing system is below a threshold, according to one or more embodiments.

[0010] Figures 9A through 9B illustrate various sub-steps of a seventh step of the method illustrated in Figure 2, which seventh step is or includes the regular swap from hydraulically fracturing the third well to hydraulically fracturing the second well, according to one or more embodiments.

[0011] Figures 10A through 10B illustrate various sub-steps of an eighth step of the method illustrated in Figure 2, which eighth step is or includes the CP swap from hydraulically fracturing the third well to hydraulically fracturing the second well, according to one or more embodiments.

[0012] Figures 11A through 11F illustrate various sub-steps of a ninth step of the method illustrated in Figures 2, which ninth step is or includes latching, filling, and pressure testing a frac leg associated with a fourth well in preparation for perforating a stage of the fourth well using the wireline perforating system, according to one or more embodiments.

[0013] Figure 12 is a flow diagram illustrating another method for fracturing wells using the fracturing system of Figure 1, which another method includes swapping from simultaneously fracturing first and second wells to simultaneously fracturing third and fourth wells.

Detailed Description

[0014] Referring to Figure 1, in an embodiment, a fracturing system for fracturing wells A through C+n is illustrated, which fracturing system includes: a blender adapted to mix fluid from a fluid source with sand from a sand source to produce hydraulic fracturing fluid; a suction manifold adapted to receive the hydraulic fracturing fluid from the blender; a discharge manifold; a plurality of swap stations, each adapted to communicate the hydraulic fracturing fluid from the suction manifold to a corresponding pump truck, and, after pressurization by the corresponding pump truck, to communicate the pressurized hydraulic fracturing fluid from the corresponding pump truck to the discharge manifold; and a zipper manifold adapted to communicate the pressurized hydraulic fracturing fluid

from the discharge manifold to a plurality of hydraulic fracturing legs (or “frac legs”), each adapted to communicate the pressurized hydraulic fracturing fluid from the zipper manifold to a corresponding one of the wells A through C+n. In one or more embodiments, the swap stations each are or include one or more components shown and described in U.S. Patent Application No. 16/436,189, filed June 10, 2019, now published as U.S. Patent Application Publication No. 2020/0386359, the entire disclosure of which is hereby incorporated herein by reference.

[0015] A grease system is adapted to communicate lubricating grease to various components of the frac legs, including, for example, first and second pump down valves, first and second master valves, and first and second zipper valves of each of the frac legs. In one or more embodiments, the grease system is or includes one or more components shown and described in U.S. Patent Application No. 16/248,648, filed January 15, 2019 bearing Attorney Docket No. 57959.3US01, now issued as U.S. Patent No. 10,724,682, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the grease system is or includes one or more components shown and described in U.S. Patent Application No. 16/938,341, filed July 24, 2020 bearing Attorney Docket No. 57959.3US02, now published as U.S. Patent Application Publication No. 2020/0355322, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system is or includes one or more components shown and described in U.S. Patent Application No. 16/855,749 (the “749 Application”), filed April 22, 2020 bearing Attorney Docket No. 57959.5US01, now published as U.S. Patent Application Publication No. 2020/0248529, the entire disclosure of which is hereby incorporated herein by reference in its entirety. In addition, or instead, in one or more embodiments, the grease system is or includes one or more components shown and described in U.S. Patent Application No. 17/319,854 (the “854 Application”), filed May 13, 2021 bearing Attorney Docket No. 57959.11US01, the entire disclosure of which is hereby incorporated herein by reference in its entirety.

[0016] Referring to Figure 2, in an embodiment, a method for fracturing the wells A through C+n using the fracturing system of Figure 1 is illustrated. The method generally

includes: perforating a stage of each well using, for example, a wireline perforating system; isolating the perforated stage of each well using an object dropped, for example from a launcher; and hydraulically fracturing the isolated/perforated stage of each well.

[0017] Referring to Figures 3A through 3K, in an embodiment, the frac leg associated with the well A is illustrated, which frac leg includes: a wellhead including first and second master valves (such as, for example, gate valves) operably coupled to, and adapted to be in fluid communication with, the well A, each of the first and second master valves including first and second grease ports (or “GPs”); first and second pump-down valves (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, a pump-down truck and the well A, via the first and second master valves, each of the first and second pump-down valves including a grease port (or “GP”); and first and second zipper valves (such as, for example, gate valves) operably coupled to, and adapted communicate fluid between, the zipper manifold and the well A, via the first and second master valves, each of the first and second zipper valves including first and second grease ports (or “GPs”). In one or more embodiments, one or both of the first and second zipper valves of each of the frac legs include or are part of the zipper manifold. In one or more embodiments, as in Figures 3A through 3K, the frac leg associated with the well A also includes a flow block to which the first and second pump-down valves, the first and second zipper valves, or both the first and second pump-down valves and the first and second zipper valves are operably coupled.

[0018] The frac leg associated with the well A further includes a valve apparatus (also referred to herein as an “FSV”) via which both the wireline perforating system and the object launched from, for example, the launcher, are permitted entry to the well A. The valve apparatus includes: a first containment area (also referred to herein as “WELL”) adapted to be in fluid communication with the well A via the first and second master valves; a second containment area (also referred to herein as “LUB”) adapted to be in fluid communication with the lubricator; and a third containment area (also referred to herein as “LL”) adapted to be in fluid communication with the first containment area via a first flow control device (also referred to herein as “WELL FLAPPER”), and adapted to be

in fluid communication with the second containment are via a second flow control device (also referred to herein as "LUB Flapper").

[0019] In one or more embodiments, the valve apparatus is or includes one or more components shown and described in U.S. Patent Application No. 15/487,785, filed April 14, 2017, now issued as U.S. Patent No. 10,662,740, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the valve apparatus is or includes one or more components shown and described in U.S. Patent Application No. 16/721,203, filed December 19, 2019, now published as U.S. Patent Application Publication No. 2020/0123876, the entire disclosure of which is hereby incorporated herein by reference.

[0020] In one or more embodiments, the launcher is or includes one or more components shown and described in U.S. Patent Application No. 16/248,633, filed January 15, 2019 bearing Attorney Docket No. 57959.4US01, now issued as U.S. Patent No. 10,584,552, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher is or includes one or more components shown and described in U.S. Patent Application No. 16/801,911, filed February 26, 2020 bearing Attorney Docket No. 57959.4US02, now published as U.S. Patent Application Publication No. 2020/0190933, the entire disclosure of which is hereby incorporated herein by reference. In addition, or instead, in one or more embodiments, the launcher is or includes one or more components shown and described in U.S. Patent Application No. 16/803,156, filed February 27, 2020 bearing Attorney Docket No. 57959.8US01, now published as U.S. Patent Application Publication No. 2020/0190934, the entire disclosure of which is hereby incorporated herein by reference.

[0021] In one or more embodiments, the frac legs associated with each of the wellheads B through C+n are substantially identical to the frac leg associated with the well A; therefore, the frac legs associated with each of the wellheads B through C+n will not be described in further detail. Accordingly, each of the frac legs associated with the wellheads B through C+n includes features/components substantially identical to corresponding features/components of the frac leg associated with the well A, which substantially identical features components will also not be described in further detail.

[0022] Referring still to Figures 3A through 3K, in an embodiment, various sub-steps of a first step of the method illustrated in Figure 2 are illustrated, which first step is or includes equalizing a lubricator of the frac leg associated with the well A, and opening the well A. In one or more embodiments, the lubricator is or includes one or more components shown and described in the '749 Application. In addition, or instead, in one or more embodiments, the lubricator is or includes one or more components shown and described in the '854 Application.

[0023] Referring to Figures 4A through 4C, in an embodiment, various sub-steps of a second step of the method illustrated in Figure 2 are illustrated, which second step is or includes perforating a stage of the well A using the wireline perforating system. In one or more embodiments, the wireline perforating system is or includes one or more components shown and described in the '749 Application. In addition, or instead, in one or more embodiments, the wireline perforating system is or includes one or more components shown and described in the '854 Application.

[0024] Referring to Figures 5A through 5K, in an embodiment, various sub-steps of a third step of the method illustrated in Figure 2 are illustrated, which third step is or includes closing the well A using the valve apparatus and draining the lubricator.

[0025] Referring to Figures 6A through 6H, in an embodiment, various sub-steps of a fourth step of the method illustrated in Figure 2 are illustrated, which fourth step is or includes isolating a stage of the well B in preparation for a fracturing operation. In one or more embodiments, the fourth step that is or includes isolating the stage of the well B includes or is part of the fracturing operation.

[0026] Referring to Figure 7, in an embodiment, various sub-steps of a fifth step of the method illustrated in Figure 2 are illustrated, which fifth step is or includes detecting or otherwise determining that a fracturing stage of the well D has ended.

[0027] Referring to Figure 8, in an embodiment, various sub-steps of a sixth step of the method illustrated in Figure 2 are illustrated, which sixth step is or includes permitting a regular swap, a continuous pumping swap (or "CP swap"), or both, from hydraulically fracturing the well D to hydraulically fracturing the well B by, for example, detecting or

otherwise determining that an idle rate of the hydraulic fracturing system is below a threshold.

[0028] Referring to Figures 9A through 9B, in an embodiment, various sub-steps of a seventh step of the method illustrated in Figure 2 are illustrated, which seventh step is or includes the regular swap from hydraulically fracturing the well D to hydraulically fracturing the well B.

[0029] Referring to Figures 10A through 10B, in an embodiment, various sub-steps of an eighth step of the method illustrated in Figure 2 are illustrated, which eighth step is or includes the CP swap from hydraulically fracturing the well D to hydraulically fracturing the well B.

[0030] Referring to Figures 11A through 11F, in an embodiment, various sub-steps of a ninth step of the method illustrated in Figures 2 are illustrated, which ninth step is or includes latching, filling, and pressure testing the frac leg associated with the well E in preparation for perforating a stage of the well E using the wireline perforating system (in a manner similar to that described above in connection with well A and Figures 4A through 4C).

[0031] Referring to Figure 12, in an embodiment, another method for fracturing the wells A through C+n using the fracturing system of Figure 1 is illustrated, which another method includes swapping from simultaneously fracturing the wells D and X to simultaneously fracturing the wells B and V.

[0032] In one or more embodiments, one or more of the embodiments of the present application are provided in whole or in part as described and illustrated in Appendix A, which forms part of the present application.

[0033] In one or more embodiments, one or more of the embodiments described and illustrated in Appendix A are combined in whole or in part with one or more of the embodiments described above and/or one or more of the other embodiments described and illustrated in Appendix A.

[0034] An apparatus has been disclosed, according to one or more embodiments.

[0035] A system has been disclosed, according to one or more embodiments.

[0036] A method has been disclosed, according to one or more embodiments of the present disclosure.

[0037] A step has been disclosed, according to one or more embodiments.

[0038] A sub-step has been disclosed, according to one or more embodiments.

[0039] A fracturing system has been disclosed, according to one or more embodiments.

[0040] A fracturing leg has been disclosed, according to one or more embodiments.

[0041] A method for swapping from fracturing a first well to fracturing a second well while continuously pumping has been disclosed, according to one or more embodiments.

[0042] A method for swapping from fracturing first and second wells to fracturing third and fourth wells while continuously pumping has been disclosed, according to one or more embodiments.

[0043] It is understood that variations may be made in the foregoing without departing from the scope of the disclosure.

[0044] In several embodiments, the elements and teachings of the various illustrative embodiments may be combined in whole or in part in some or all of the illustrative embodiments. In addition, one or more of the elements and teachings of the various illustrative embodiments may be omitted, at least in part, or combined, at least in part, with one or more of the other elements and teachings of the various illustrative embodiments.

[0045] Any spatial references such as, for example, “upper,” “lower,” “above,” “below,” “between,” “bottom,” “vertical,” “horizontal,” “angular,” “upwards,” “downwards,” “side-to-side,” “left-to-right,” “left,” “right,” “right-to-left,” “top-to-bottom,” “bottom-to-top,” “top,” “bottom,” “bottom-up,” “top-down,” etc., are for the purpose of illustration only and do not limit the specific orientation or location of the structure described above.

[0046] In several embodiments, while different steps, processes, and procedures are described as appearing as distinct acts, one or more of the steps, one or more of the processes, or one or more of the procedures may also be performed in different orders, simultaneously or sequentially. In several embodiments, the steps, processes or procedures may be merged into one or more steps, processes or procedures. In several embodiments, one or more of the operational steps in each embodiment may be omitted.

Moreover, in some instances, some features of the present disclosure may be employed without a corresponding use of the other features. Moreover, one or more of the embodiments disclosed above and in Appendix A, or variations thereof, may be combined in whole or in part with any one or more of the other embodiments described above and in Appendix A, or variations thereof.

[0047] Although several embodiments have been disclosed in detail above and in Appendix A, the embodiments disclosed are exemplary only and are not limiting, and those skilled in the art will readily appreciate that many other modifications, changes, and substitutions are possible in the embodiments without materially departing from the novel teachings and advantages of the present disclosure. Accordingly, all such modifications, changes, and substitutions are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Moreover, it is the express intention of the applicant not to invoke 35 U.S.C. § 112(f) for any limitations of any of the claims herein, except for those in which the claim expressly uses the word “means” together with an associated function.

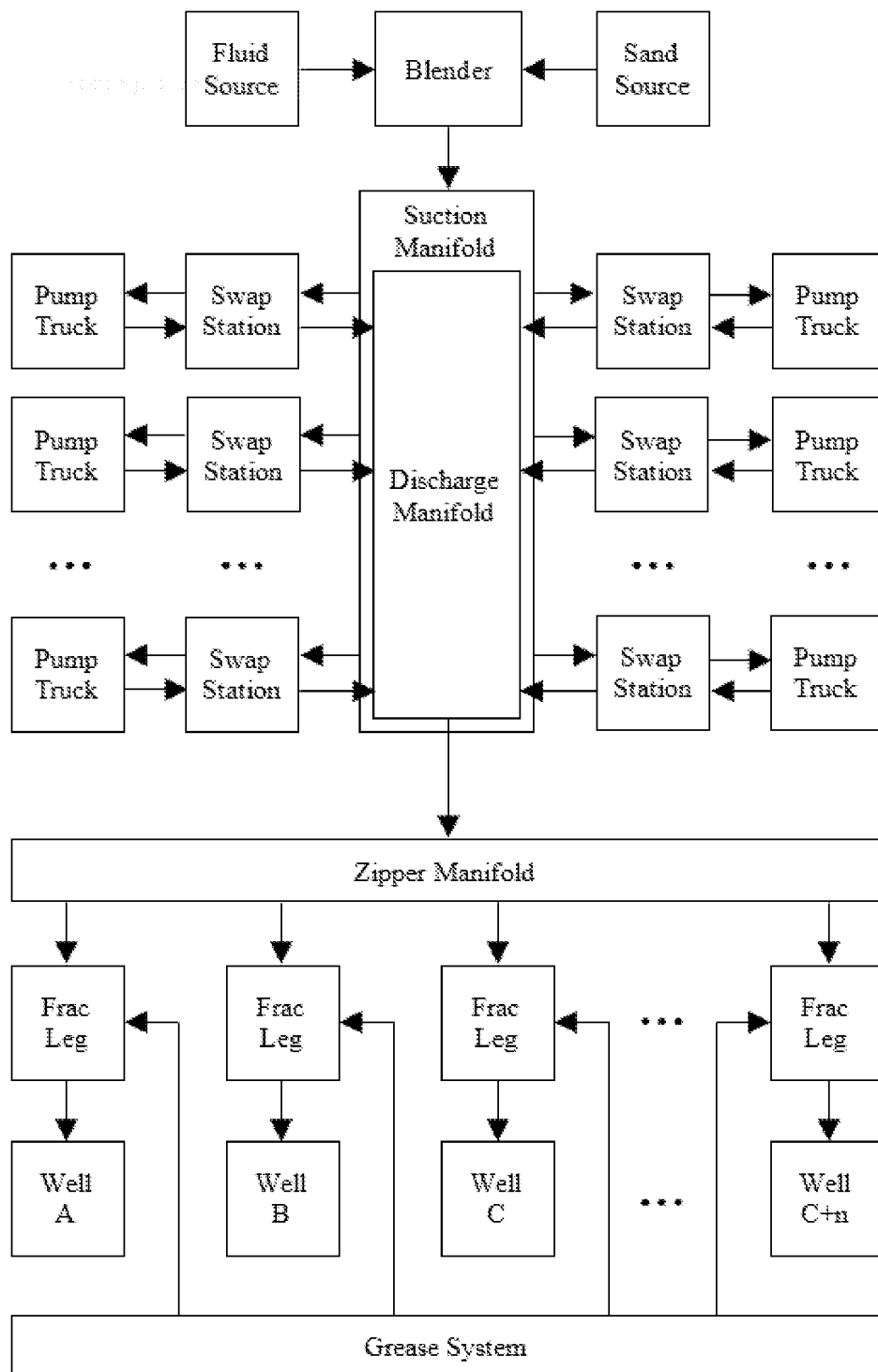


Fig. 1

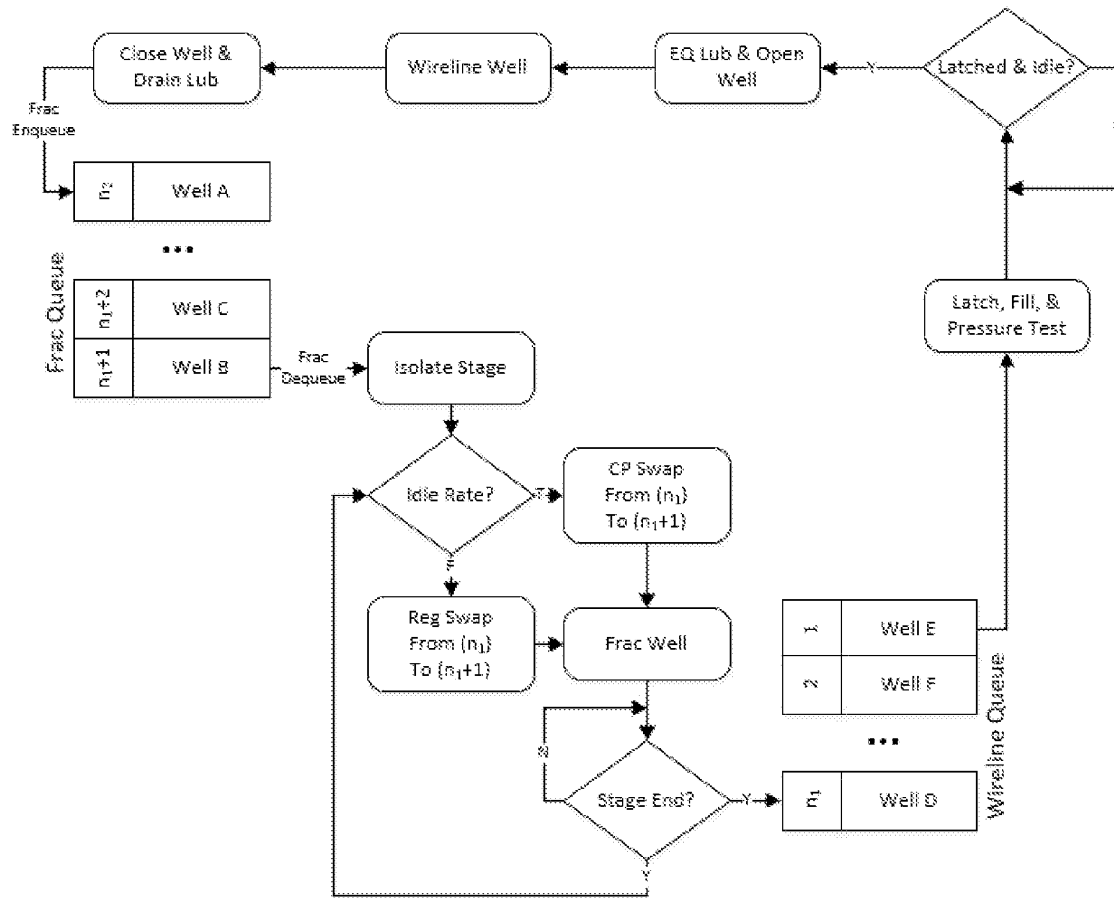
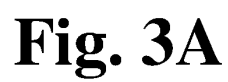


Fig. 2

1. Authenticator Code



FSV EQ Lub & Open Well

Cont'd

2. Close Drain

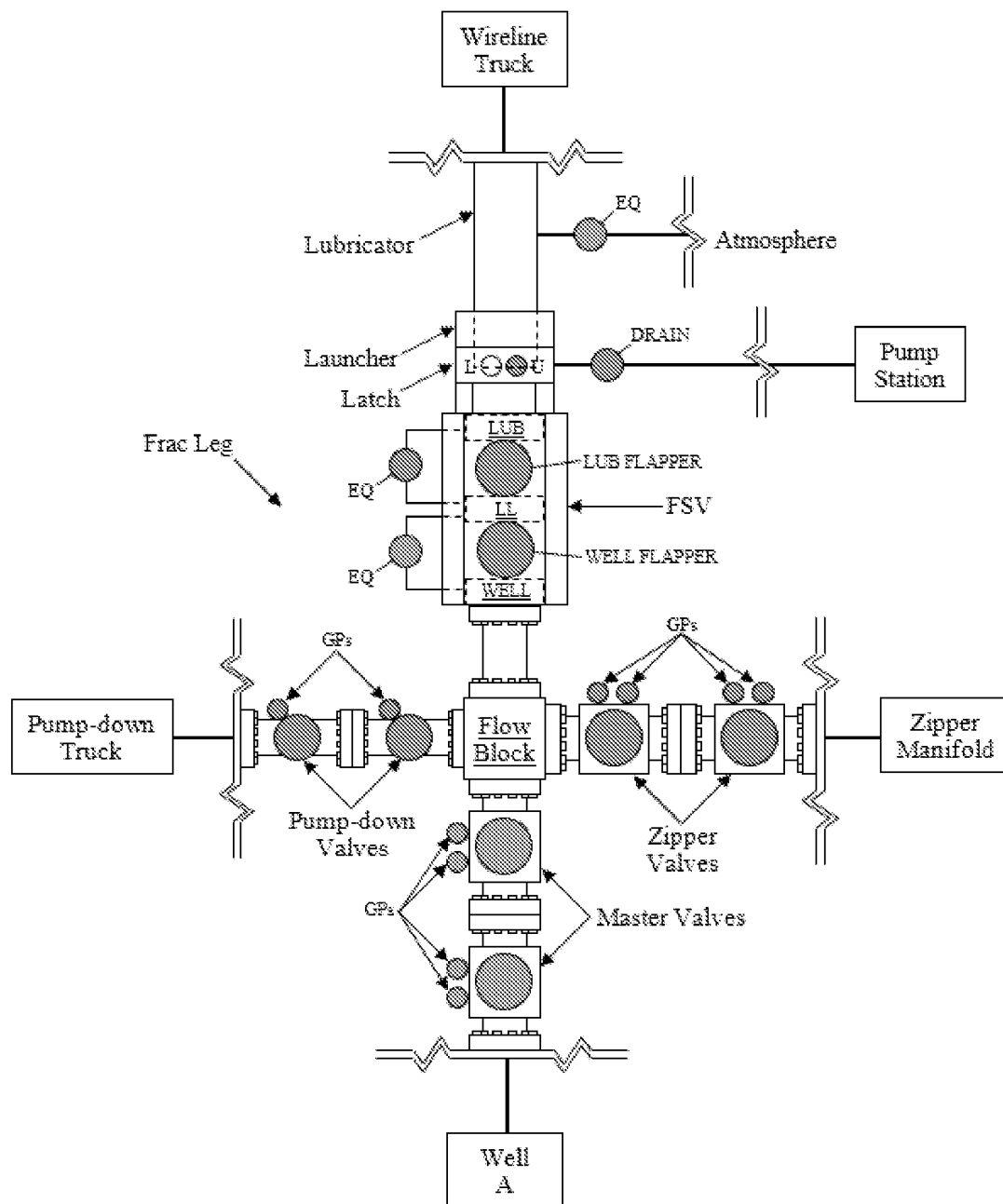


Fig. 3B

FSV EQ Lub & Open Well

Cont'd

3. Close Lub/ATMEQ

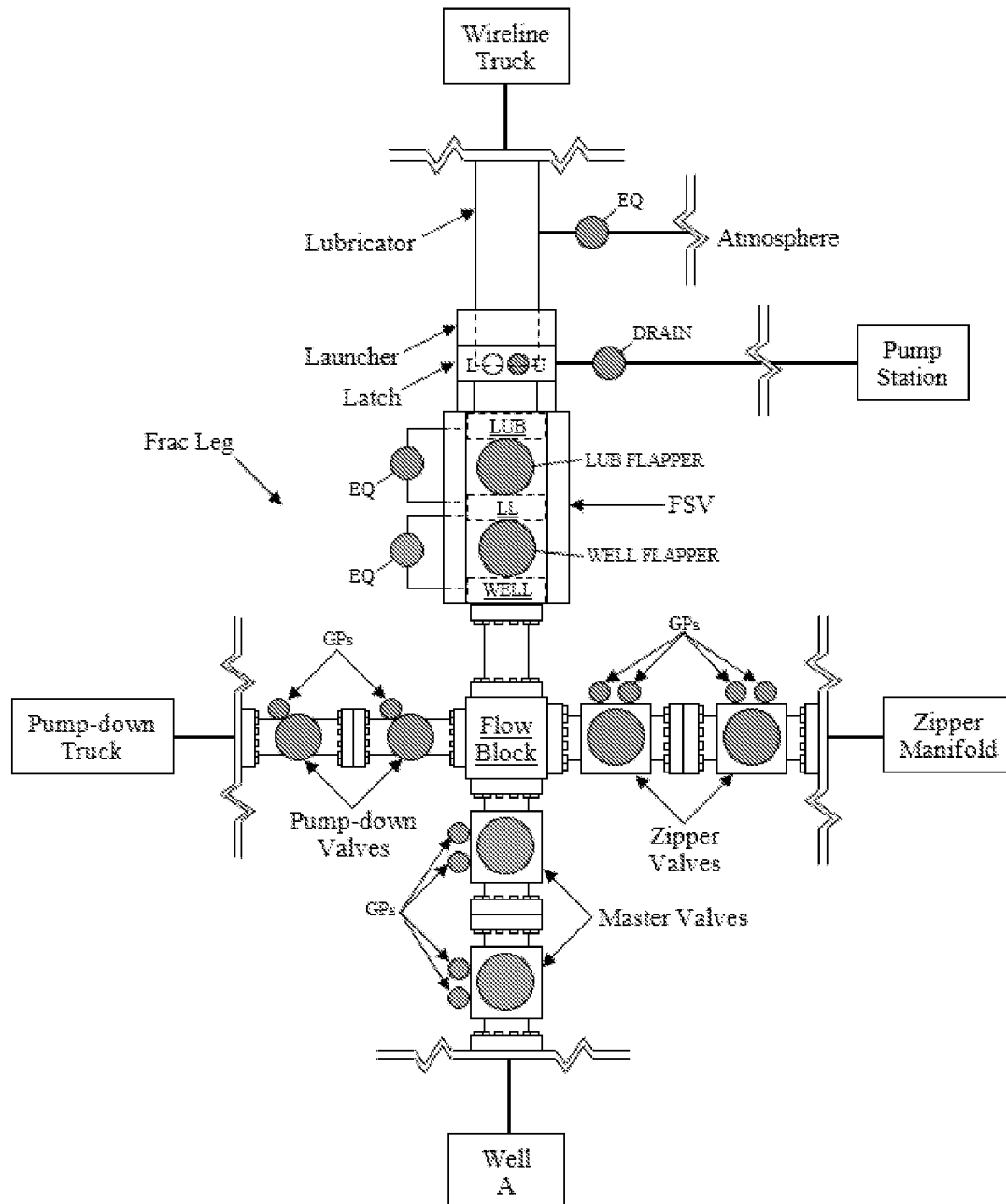


Fig. 3C

FSV EQ Lub & Open Well

Cont'd

4. Close Latch

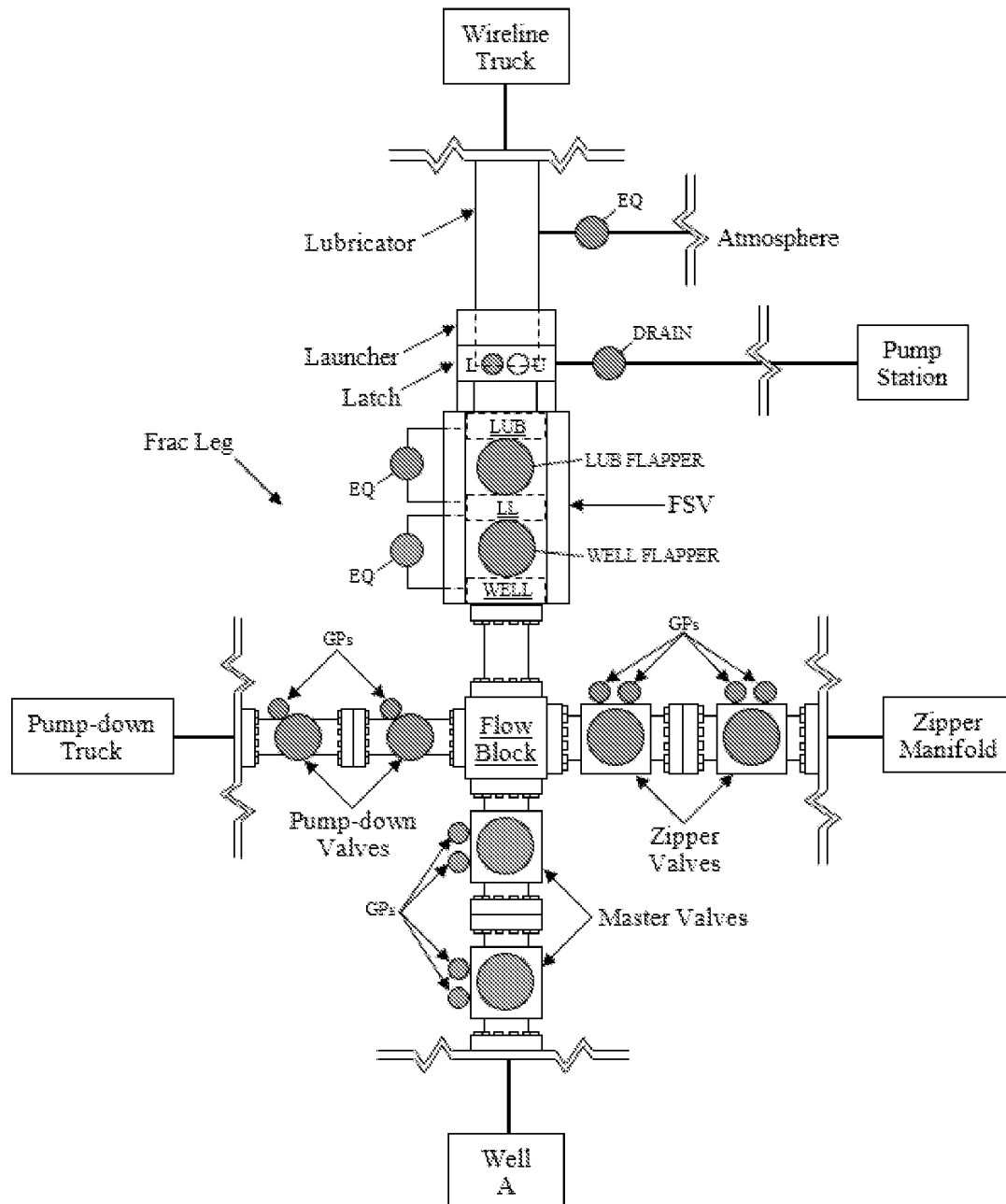


Fig. 3D

FSV EQ Lub & Open Well

Cont'd

5. Open LL/Lub EQ

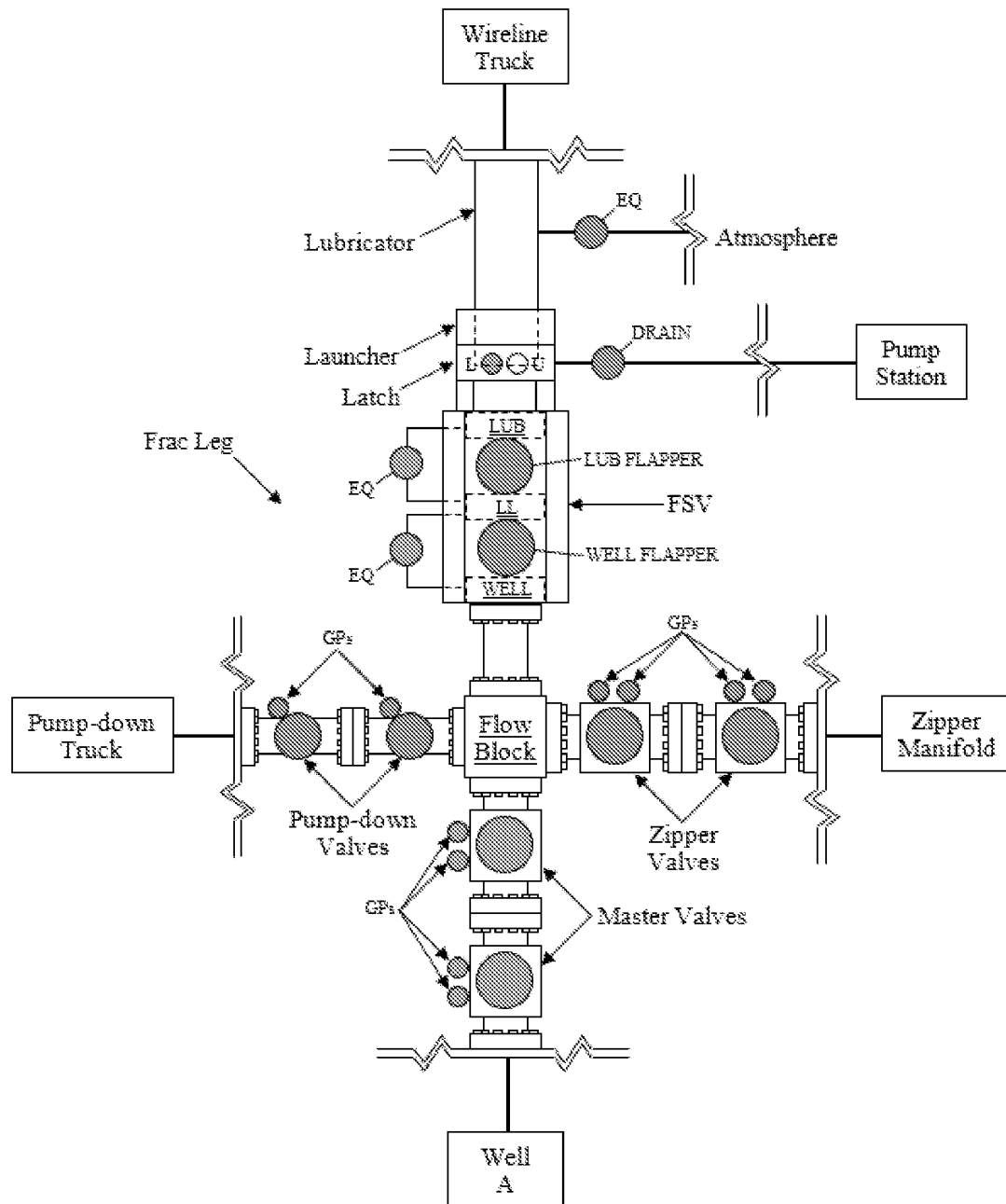


Fig. 3E

FSV EQ Lub & Open Well

Cont'd

6. Issue "Lub EQ Start" milestone

7. FSCC Boost pump on

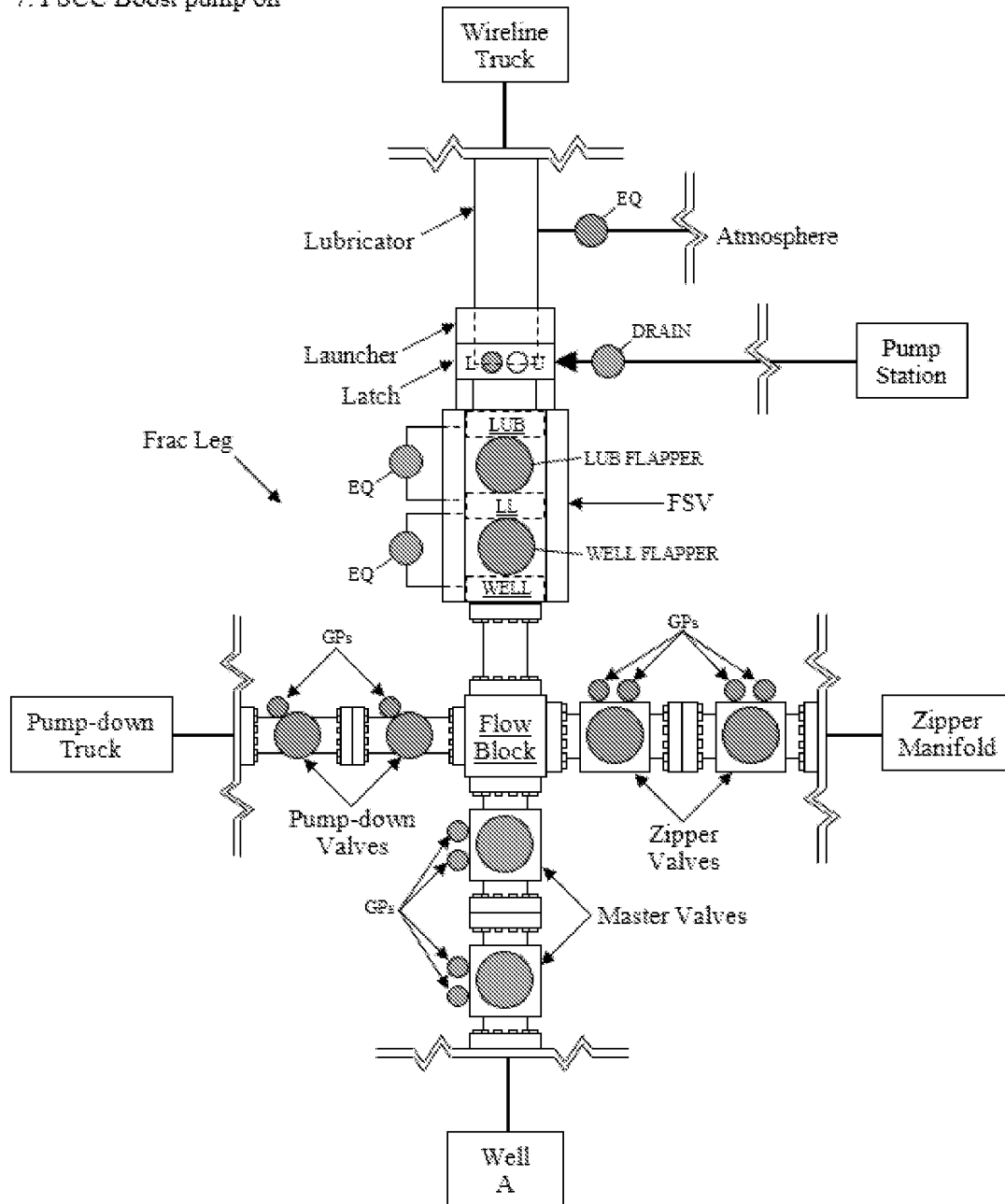


Fig. 3F

FSV EQ Lub & Open Well

Cont'd

8. Check EQ (LL/Well)

9. Open LL/Well Flapper

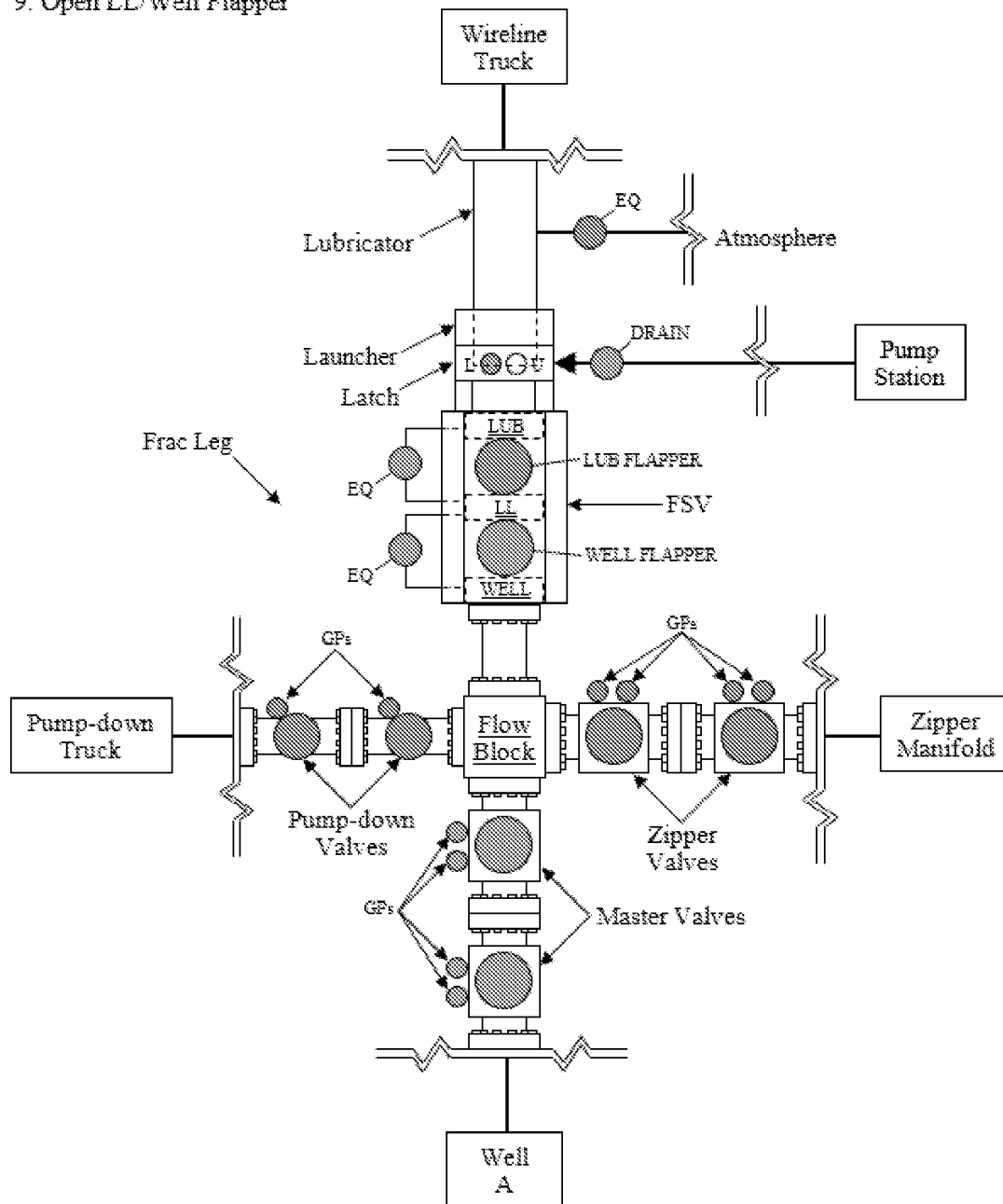


Fig. 3G

FSV EQ Lub & Open Well

Cont'd

10. Close LL/Well EQ

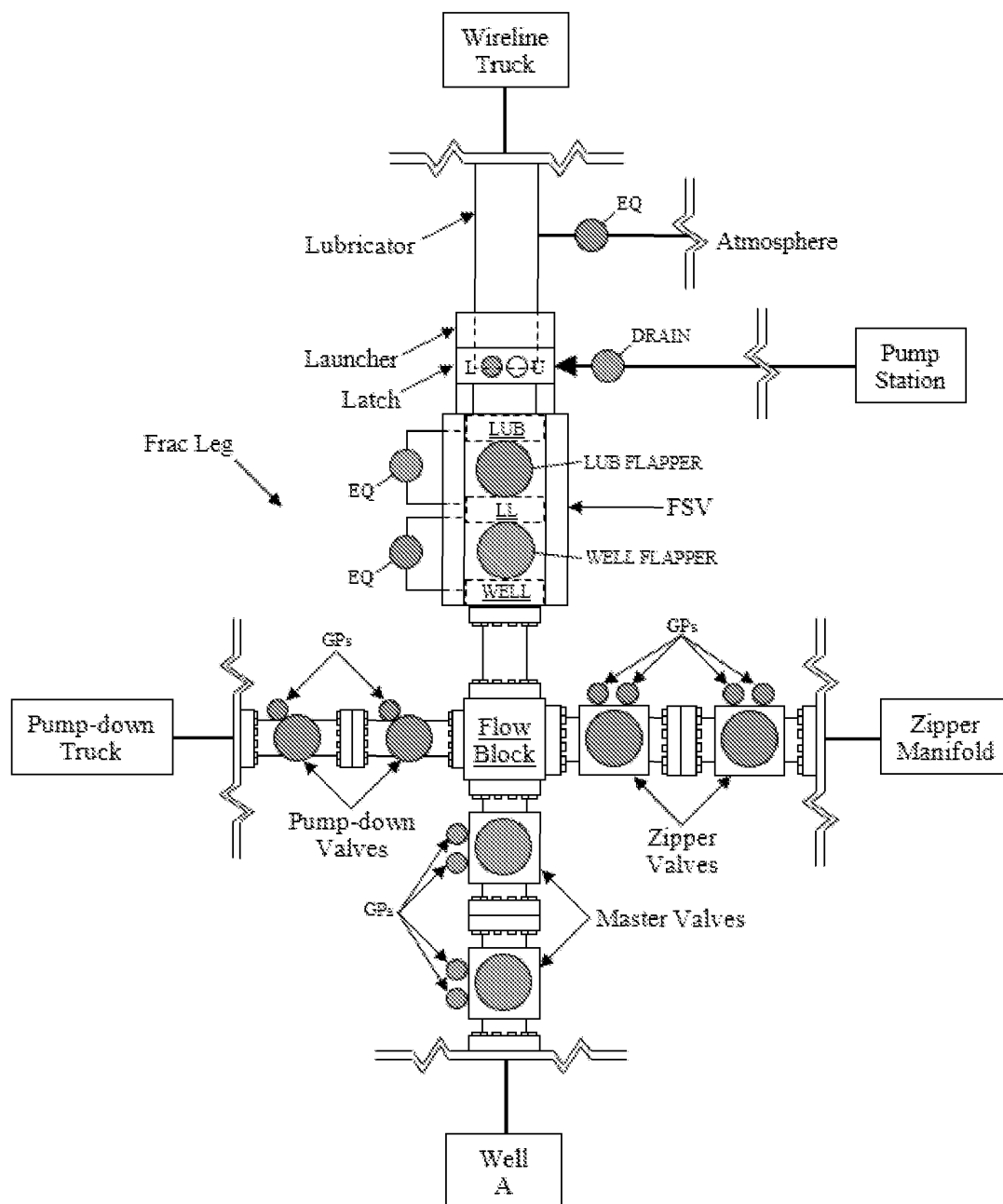


Fig. 3H

FSV EQ Lub & Open Well

Cont'd

11. Issue "Lub EQ Done" milestone
12. Wait [5s]
13. Open LL/Lub Flapper

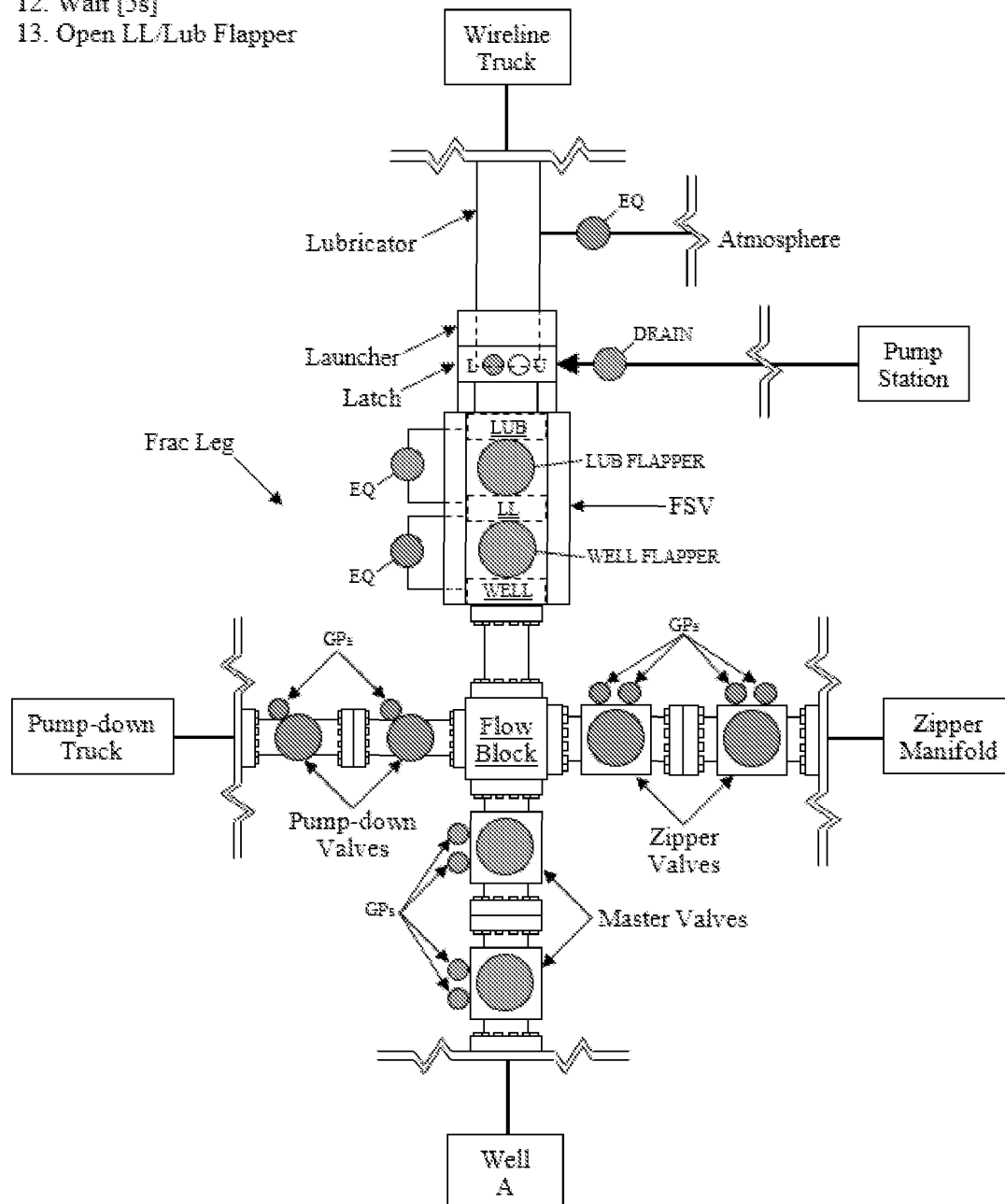


Fig. 3I

FSV EQ Lub & Open Well

Cont'd

14. FSCC Boost pump off

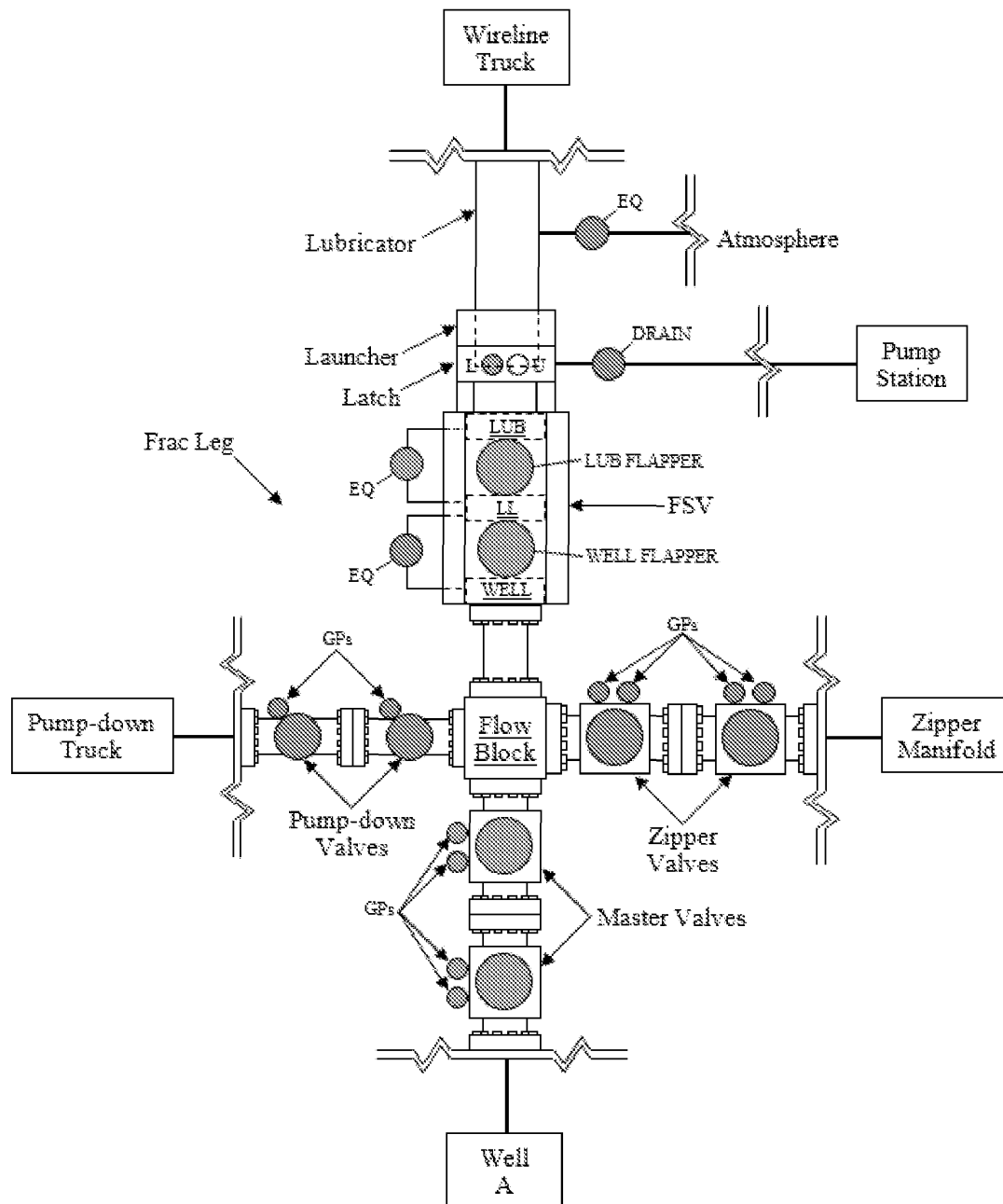


Fig. 3J

FSV EQ Lub & Open Well

Cont'd

- 15. Close LL/Lub EQ
- 16. Close Well button enabled
- 17. Increment Stage

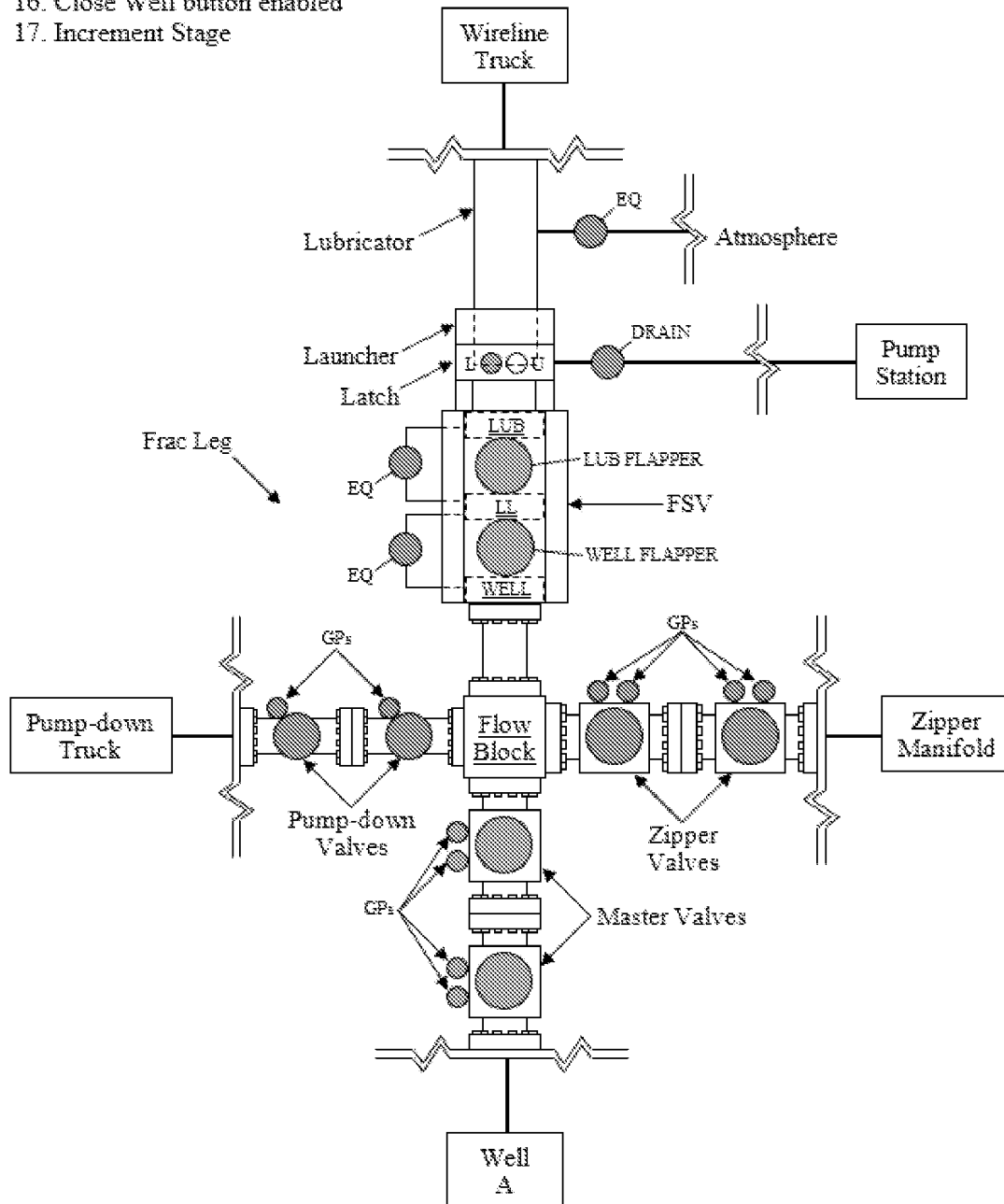


Fig. 3K

Wireline Well

1. Open Lub
2. Deploy Plug/Gun(s) from Lub

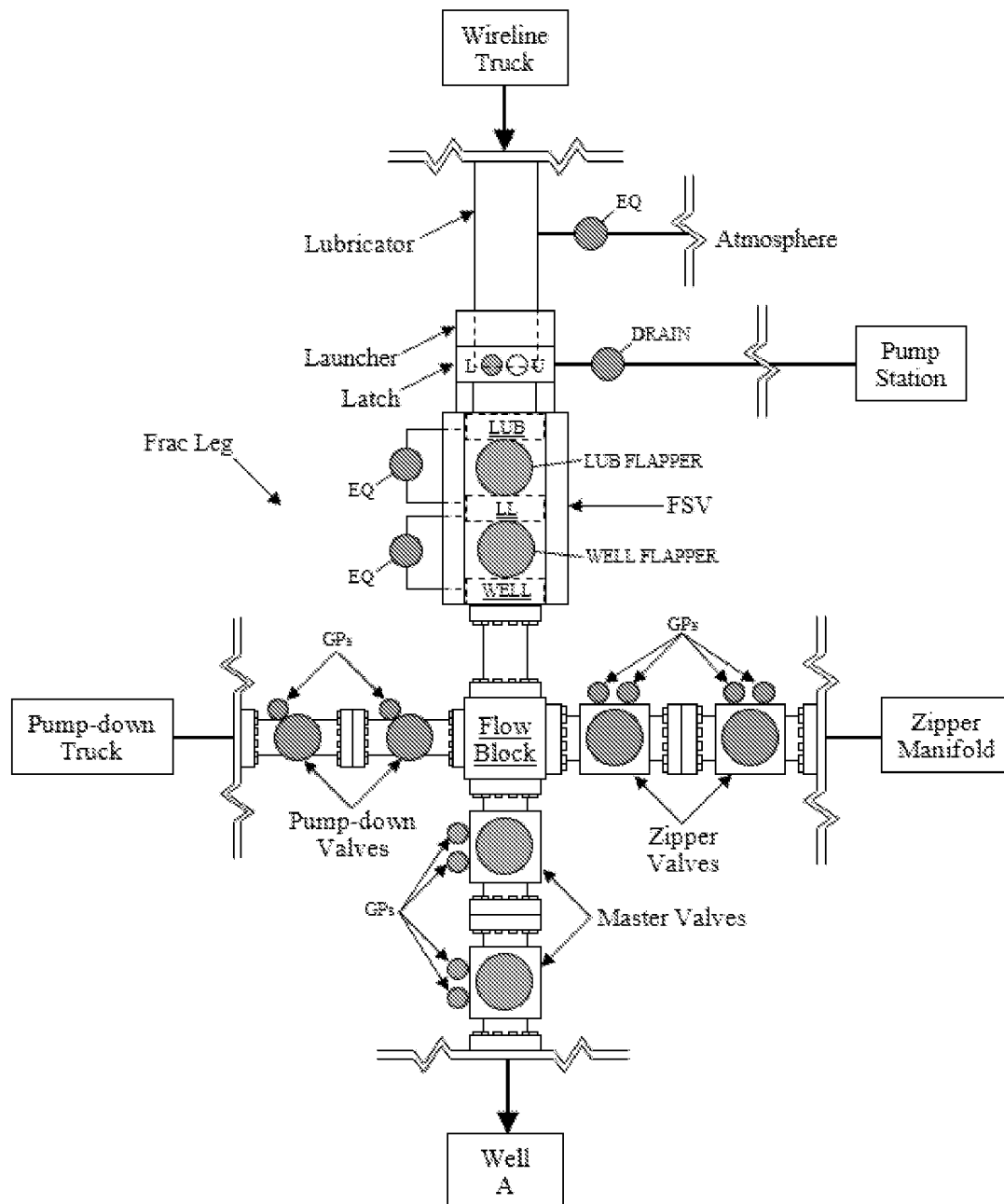


Fig. 4A

Wireline Well Cont'd

3. Open PD Valves
4. Grease PD Valves
5. Pump-down Plug/Gun(s)

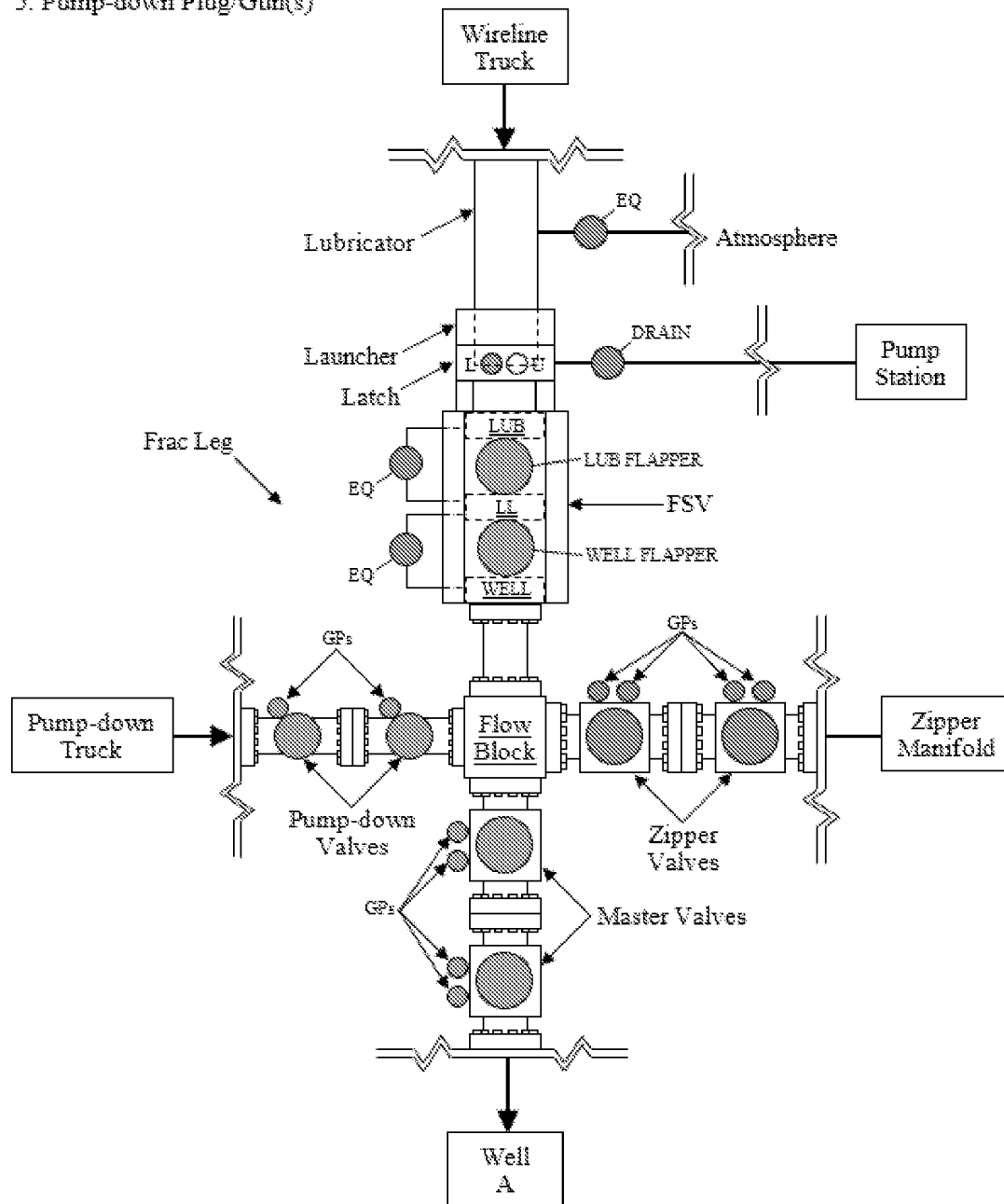


Fig. 4B

Wireline Well Cont'd

6. Close PD Valves

7. Set Plug

8. Detonate Gun(s)

9. Retrieve Spent Gun(s)

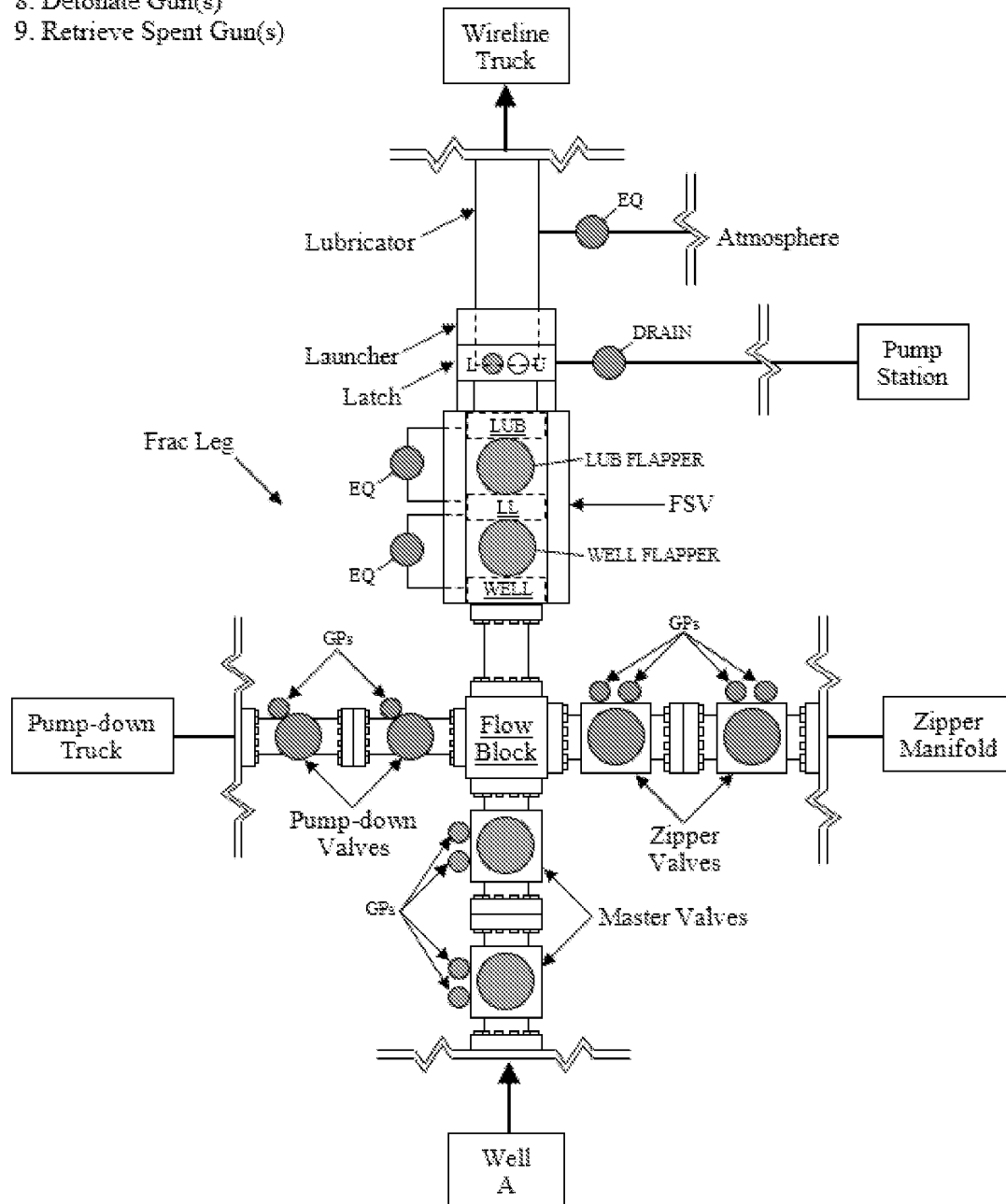


Fig. 4C

FSV Close Well & Drain Lub

1. Authenticator Code
2. Prompt for bump up (or detect with accel. And /or weight from tool on WL
3. Check WL speed
4. Close LL/Lub Flapper

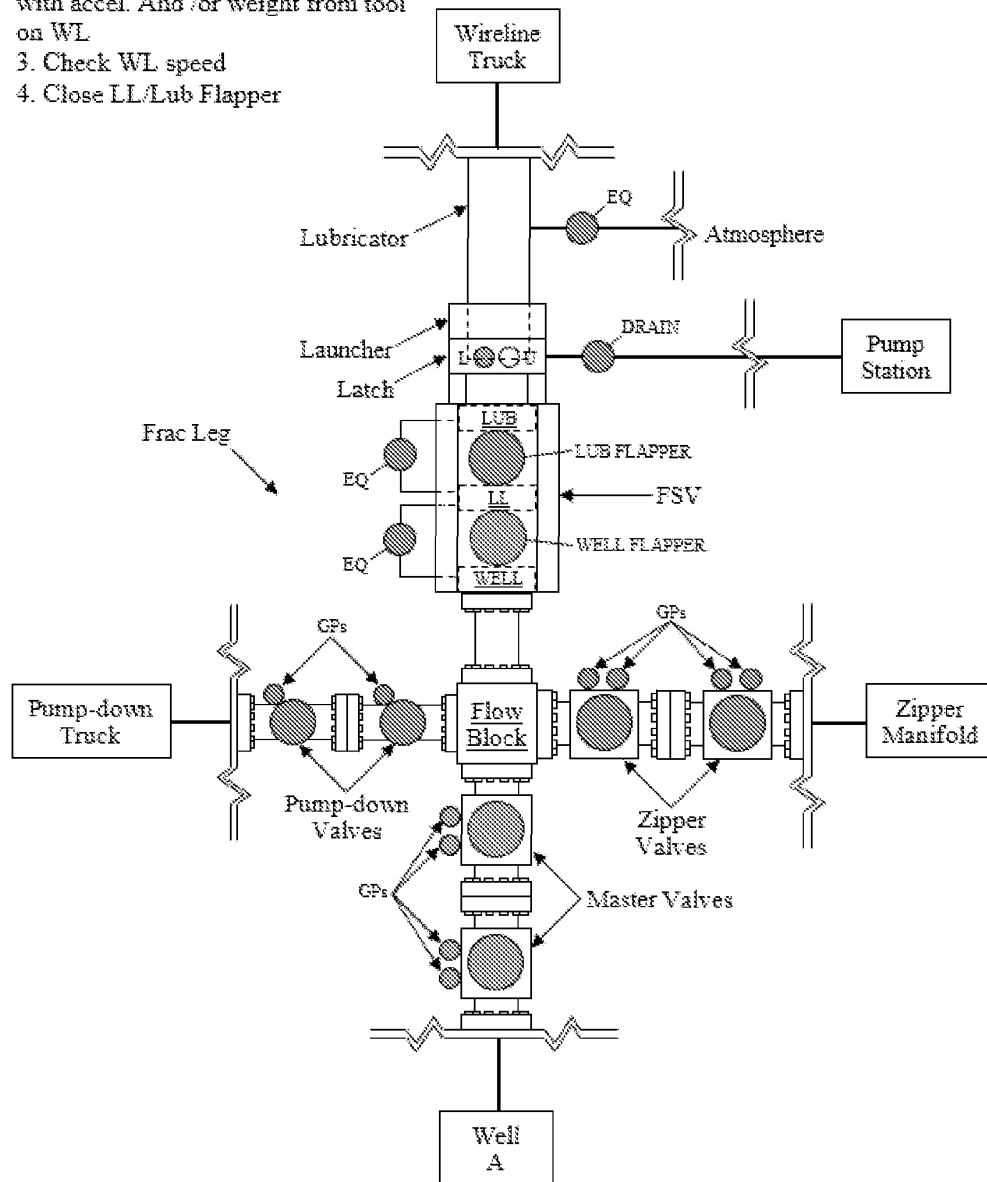


Fig. 5A

FSV Close Well & Drain Lub

Cont'd

5. Close LL/Well Flapper

6. Close LL/Well EQ

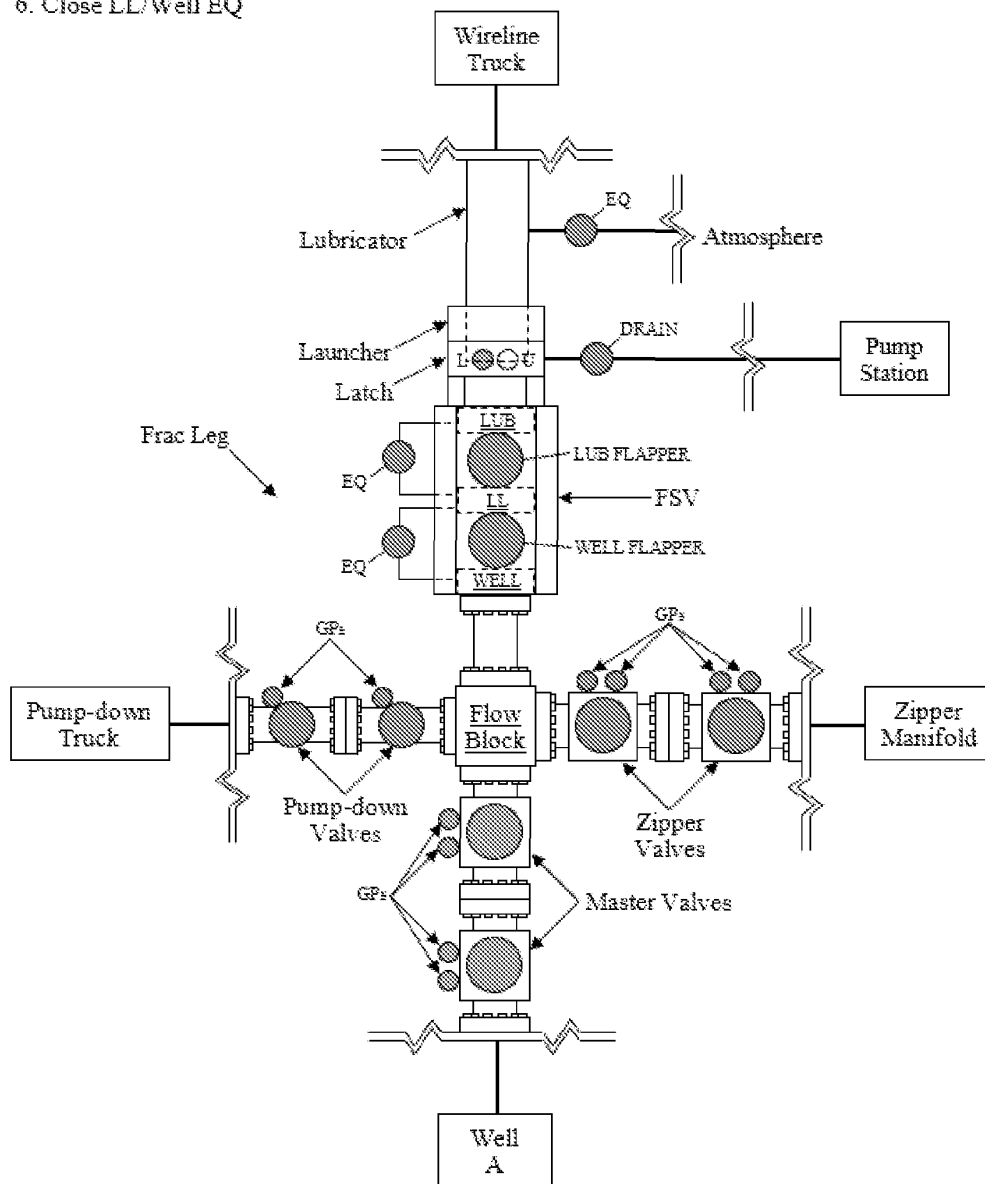


Fig. 5B

FSV Close Well & Drain Lub

Cont'd

7. Open Lub/ATMEQ

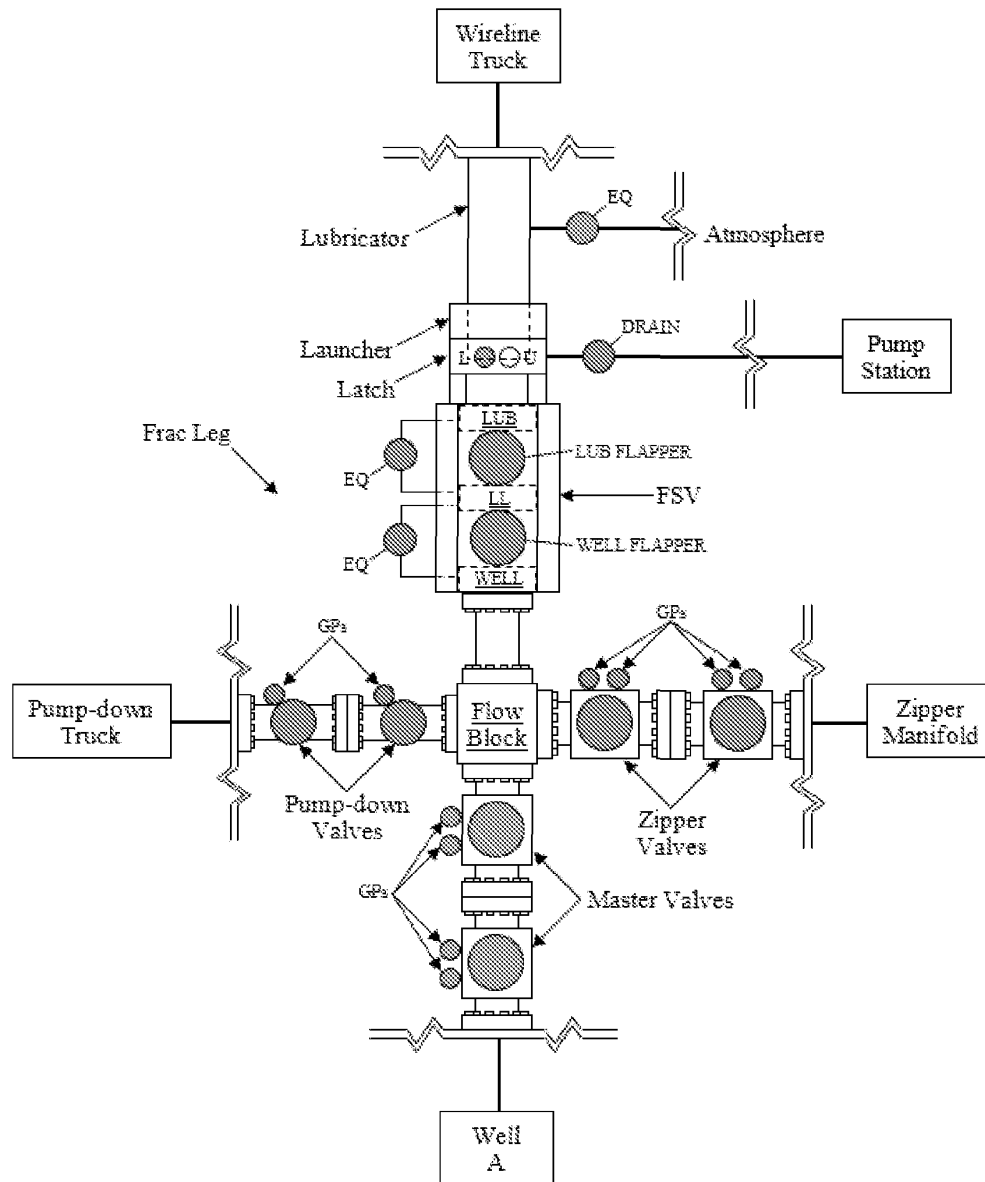


Fig. 5C

FSV Close Well & Drain Lub

Cont'd

8. Open LL/Lub EQ

9. Wait [2s]

10. Check Lub PSI below [SM
Config. Close Well Lub Bleed
PSI Limit] value

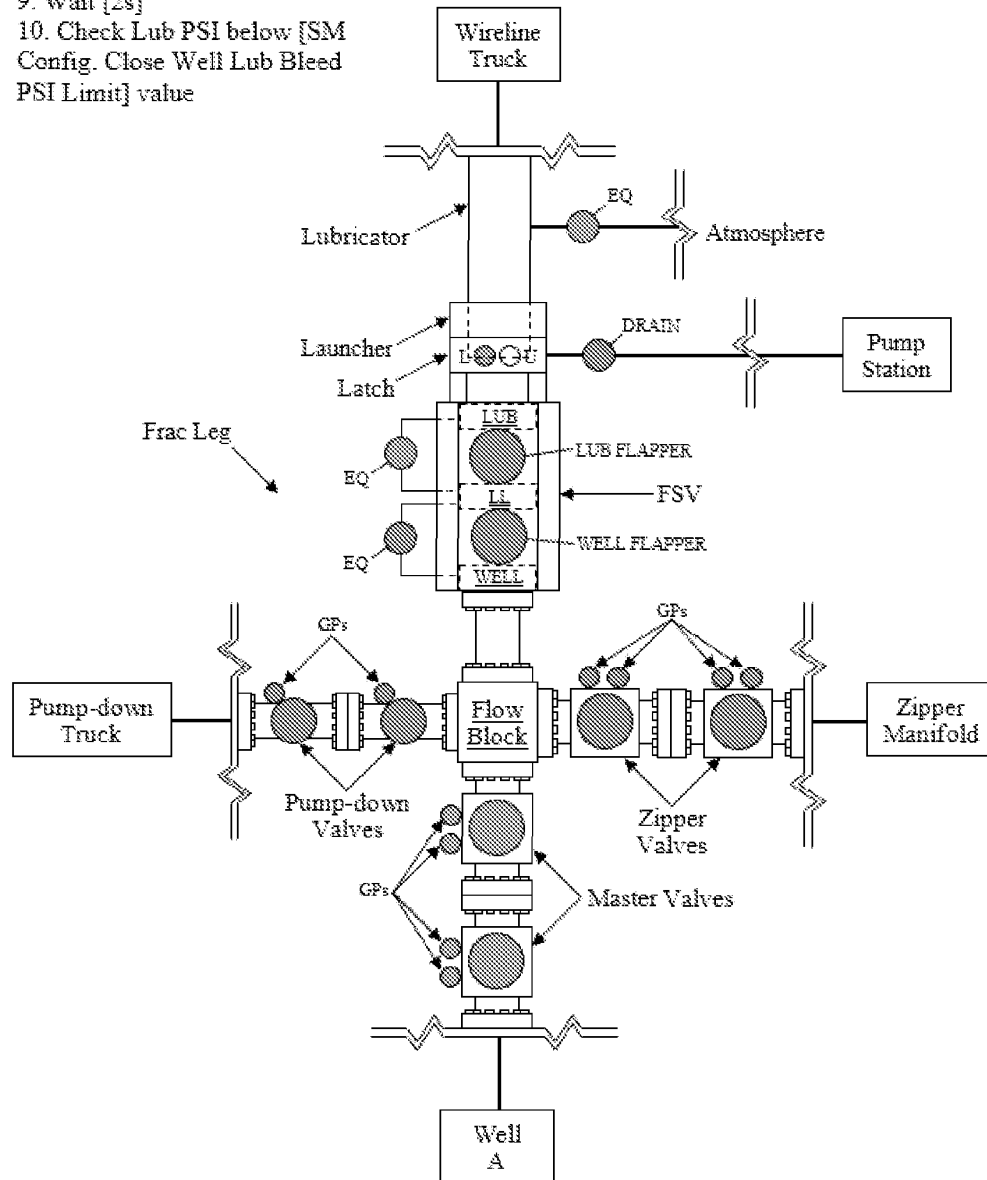


Fig. 5D

FSV Close Well & Drain Lub

Cont'd

11. Close LL/Lub EQ

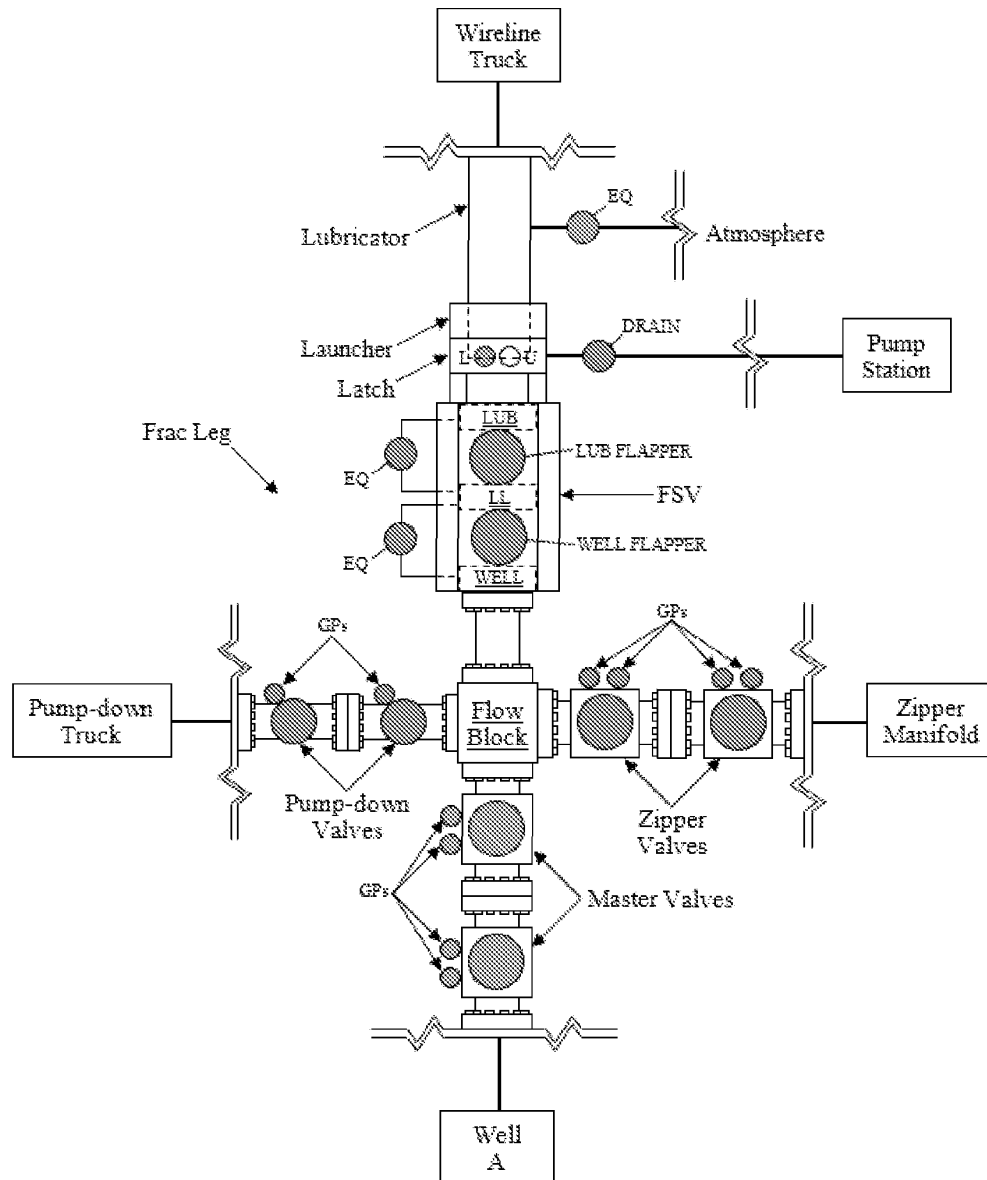


Fig. 5E

FSV Close Well & Drain Lub

Cont'd

- 12. Issue [Drain Lubricator Start] milestone
- 13. Open Drain
- 14. FSCC Auto-Drain pump on

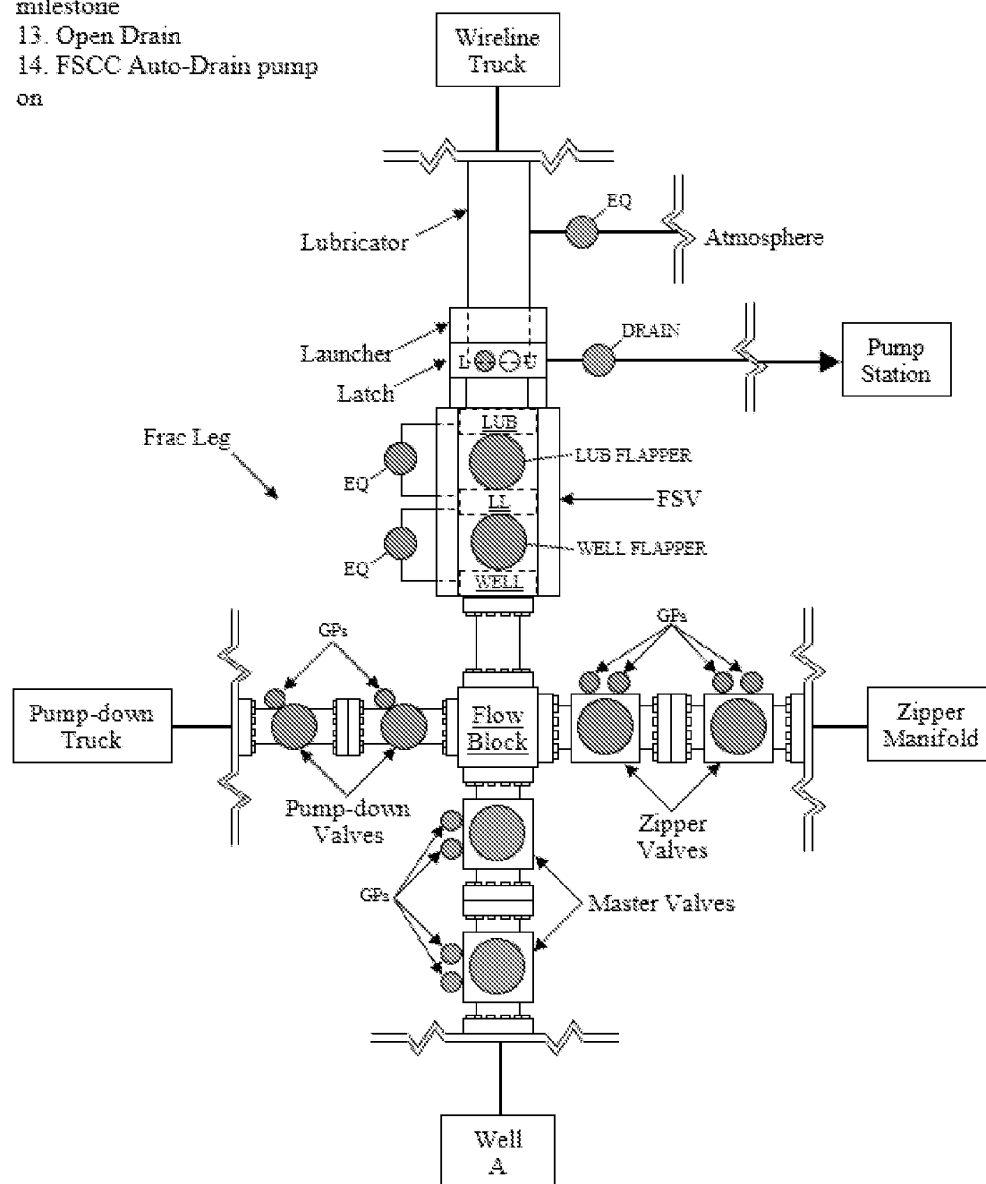


Fig. 5F

FSV Close Well & Drain Lub

Cont'd

15. Wait for FSCC Auto-Drain to finish
16. Issue [Drain Lubricator Start] milestone
17. Open Latch

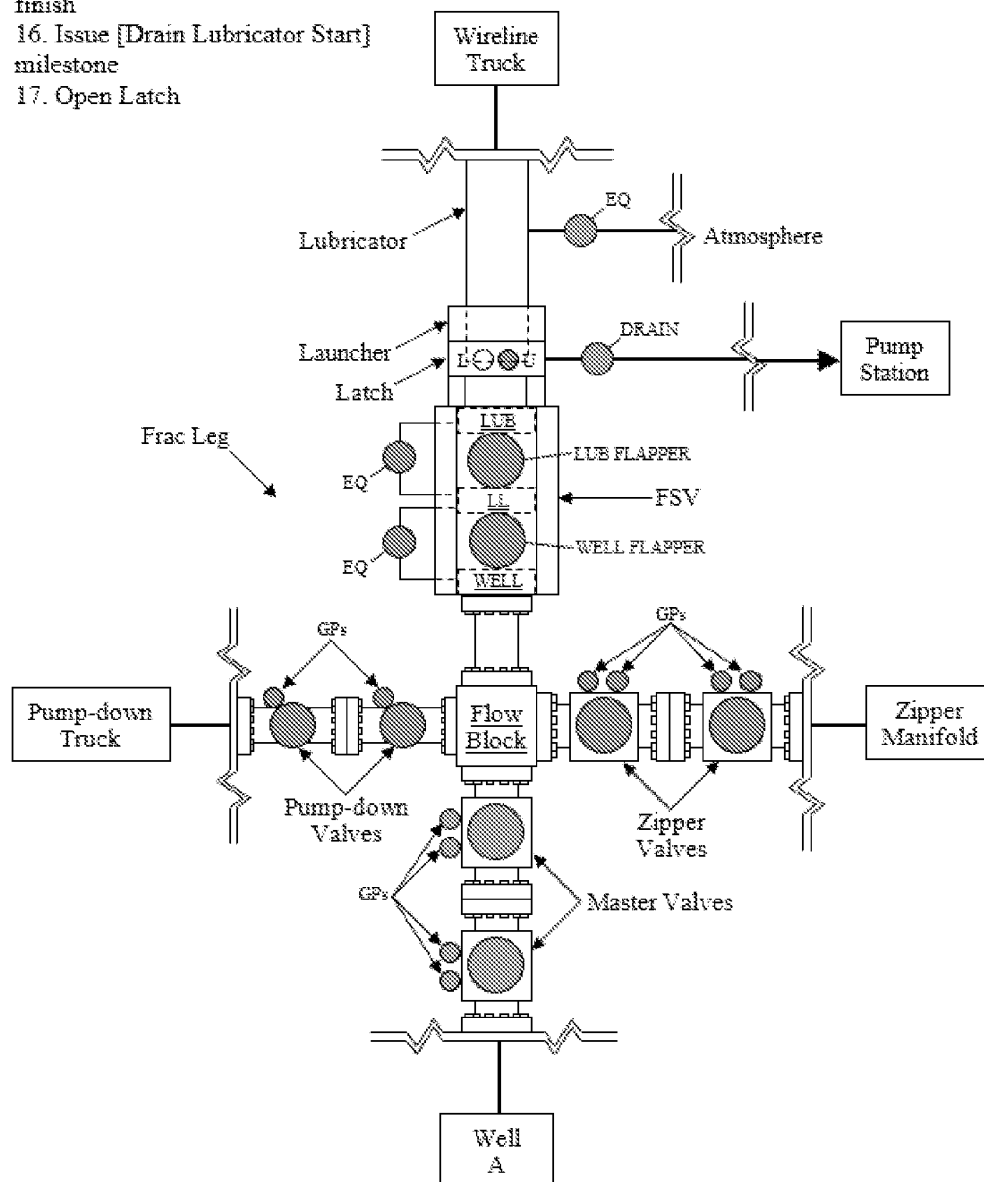


Fig. 5G

FSV Close Well & Drain Lub

Cont'd

18. Wait [SM Config. Close Well

Final Delay] value (ms)

19. Close Drain

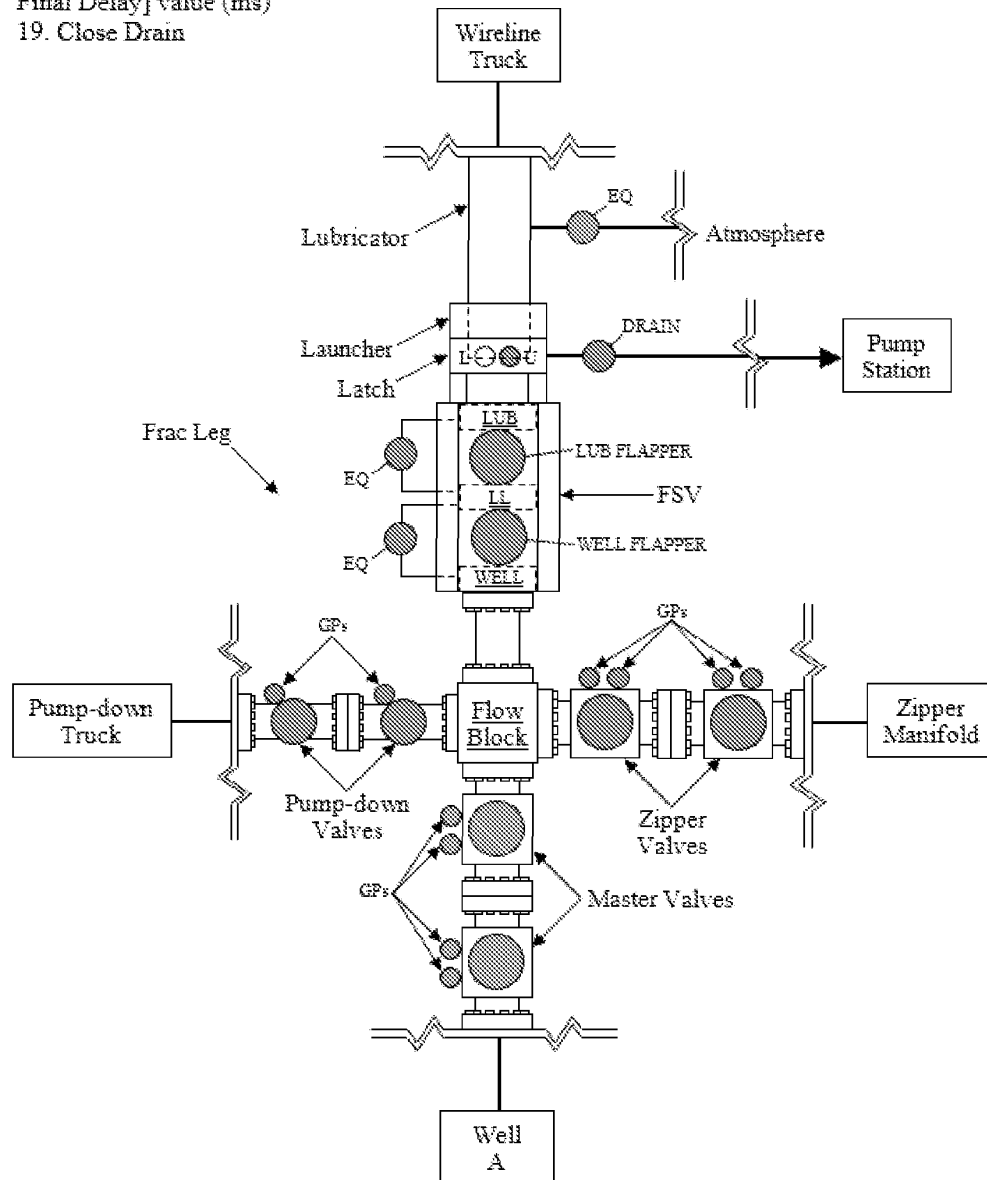


Fig. 5H

FSV Close Well & Drain Lub

Cont'd

20. Close Lub/ATMEQ

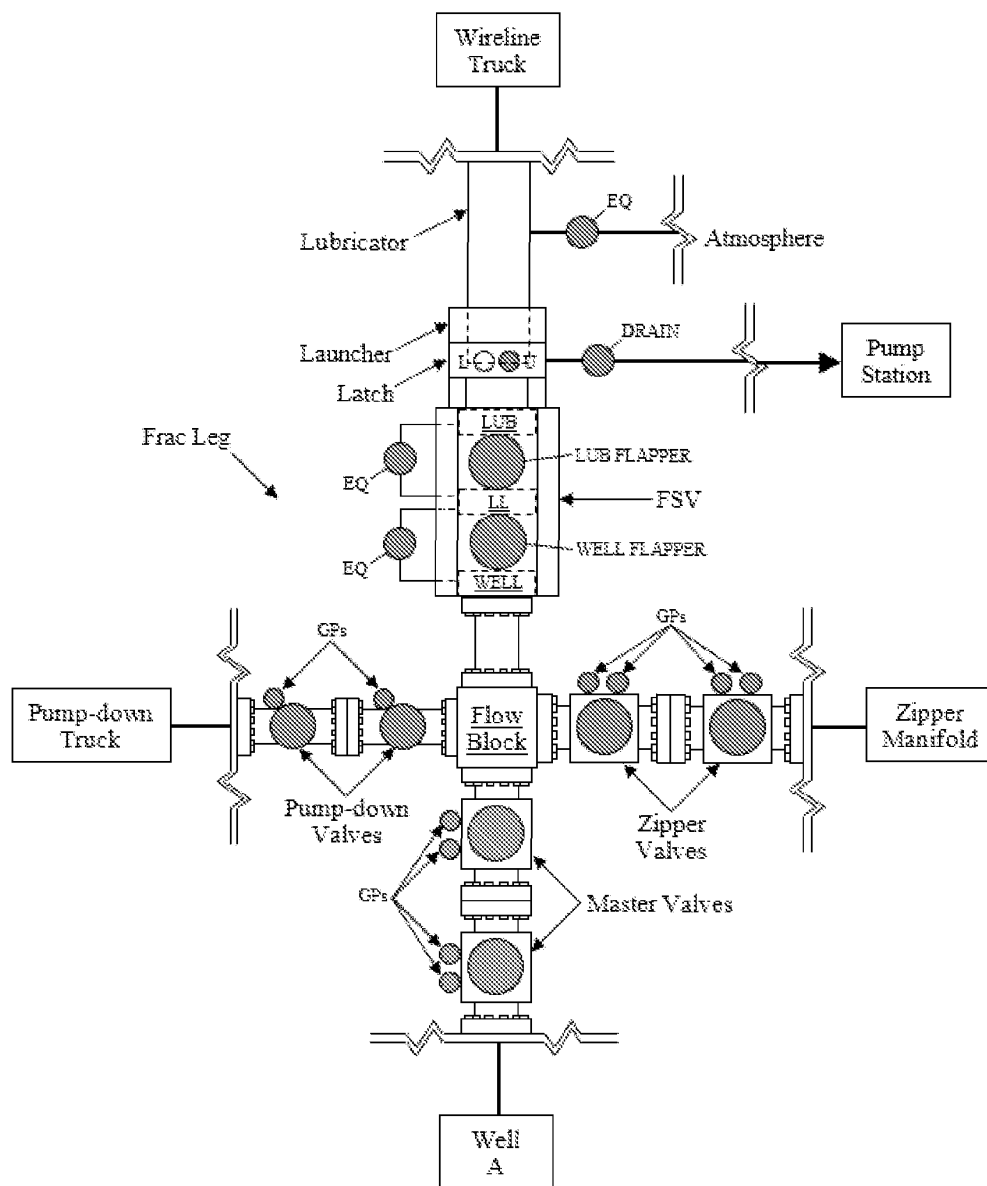


Fig. 5I

FSV Close Well & Drain Lub

Cont'd

21. Close LL/Lub EQ

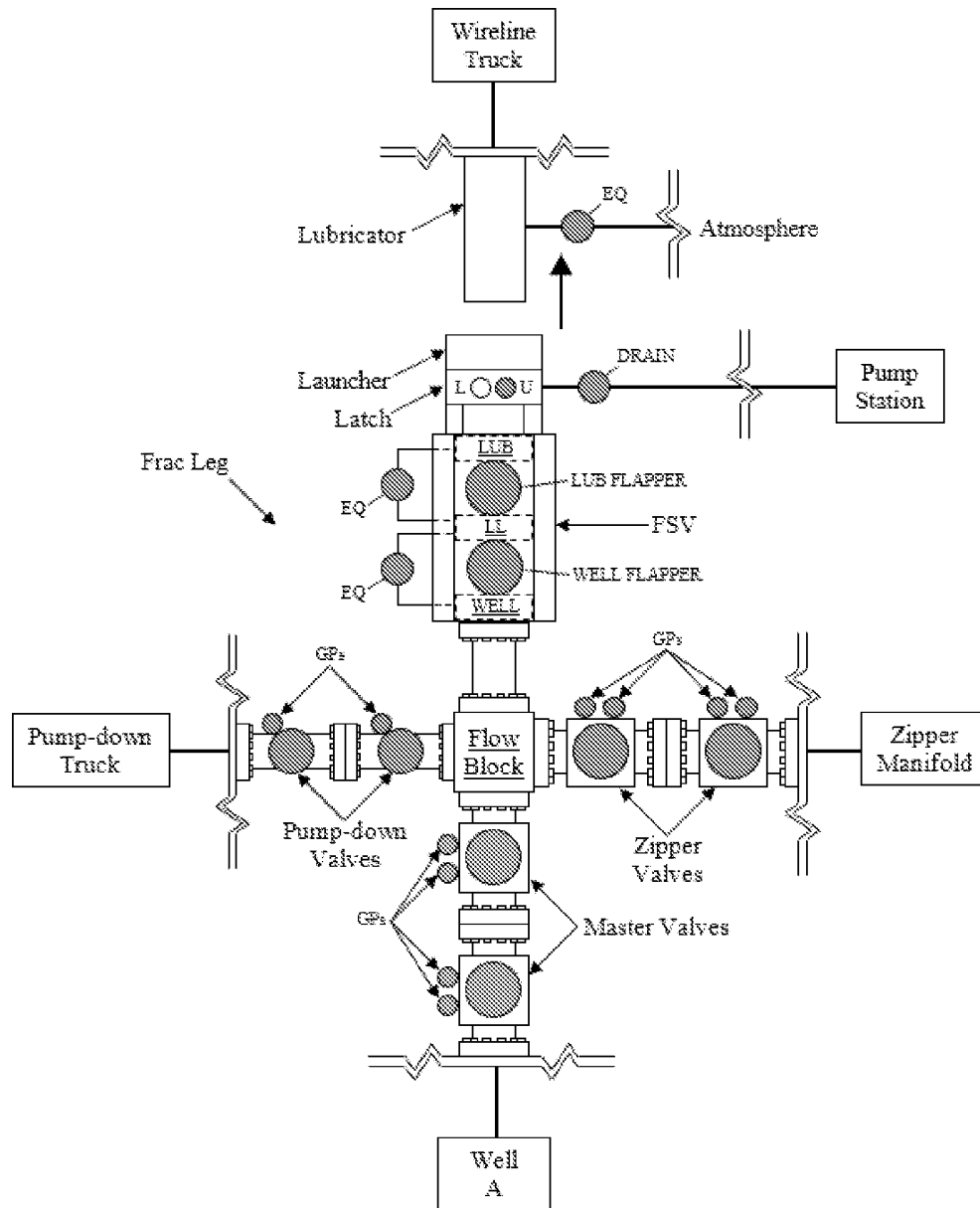


Fig. 5J

FSV Close Well & Drain Lub

Cont'd

22. Remove Lub

23. Ball Drop and Test Press buttons
enabled

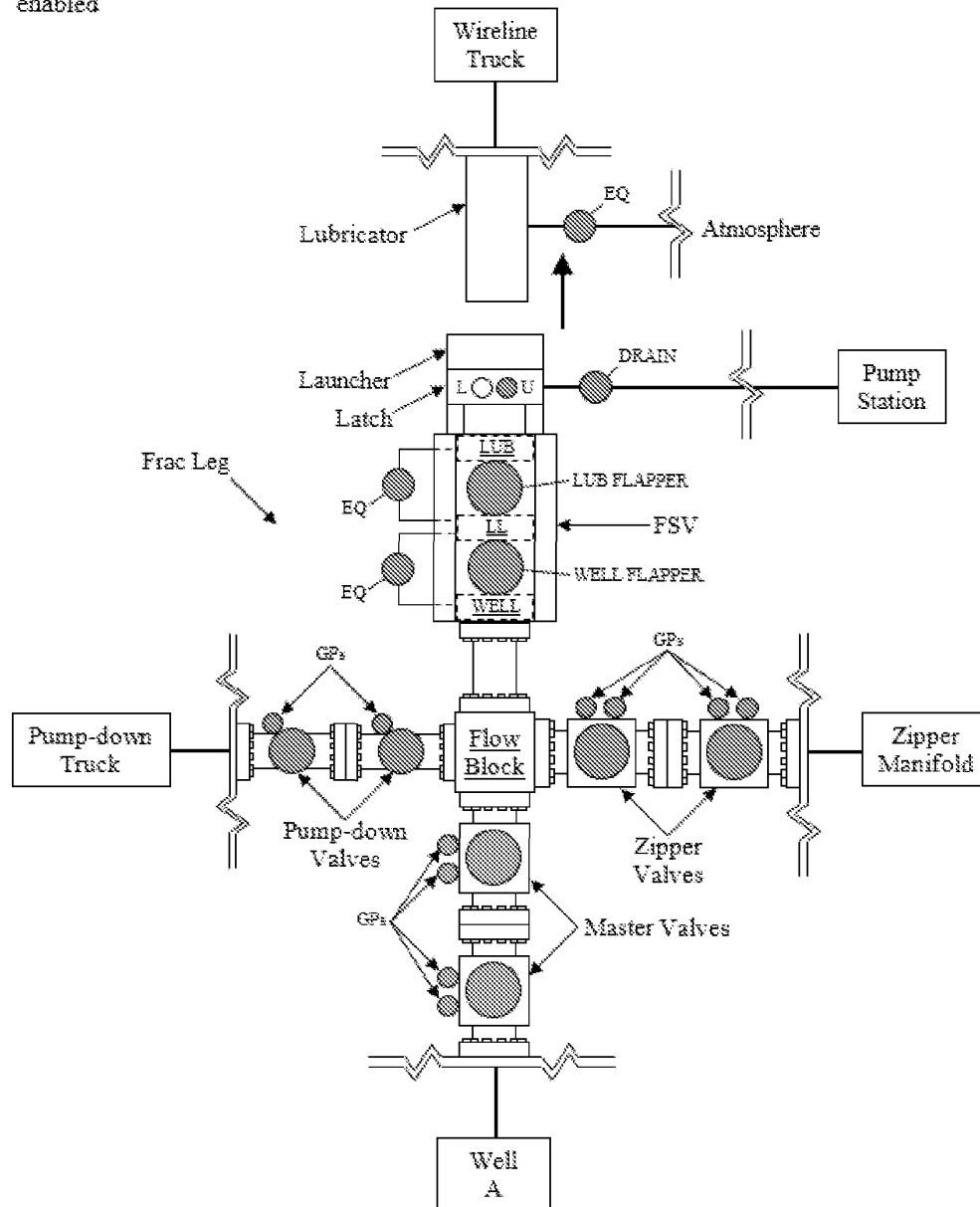


Fig. 5K

- FSV Isolate Stage**
1. Open LL/Lub EQ
 2. Drop Ball

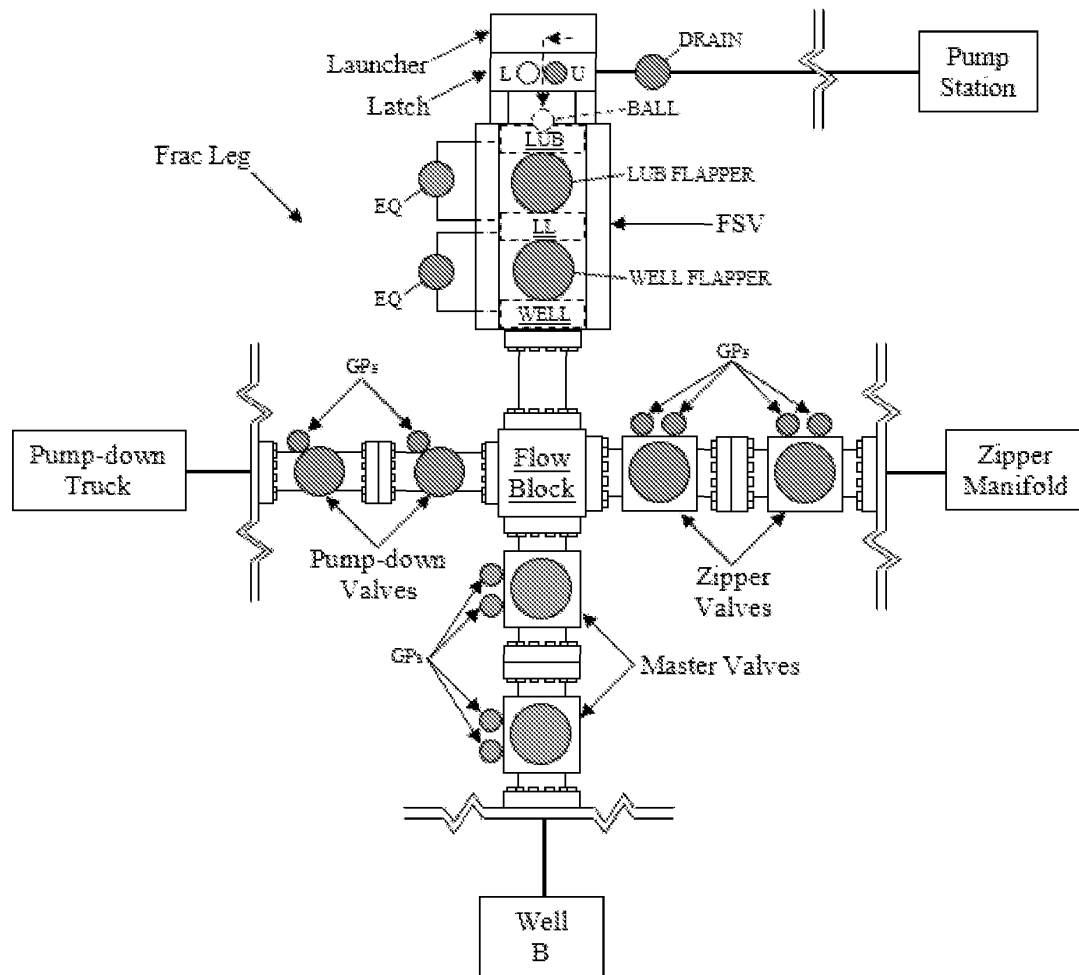


Fig. 6A

FSV Isolate Stage Cont'd

3. Check EQ (LL/Lub)
4. Open LL/Lub Flapper

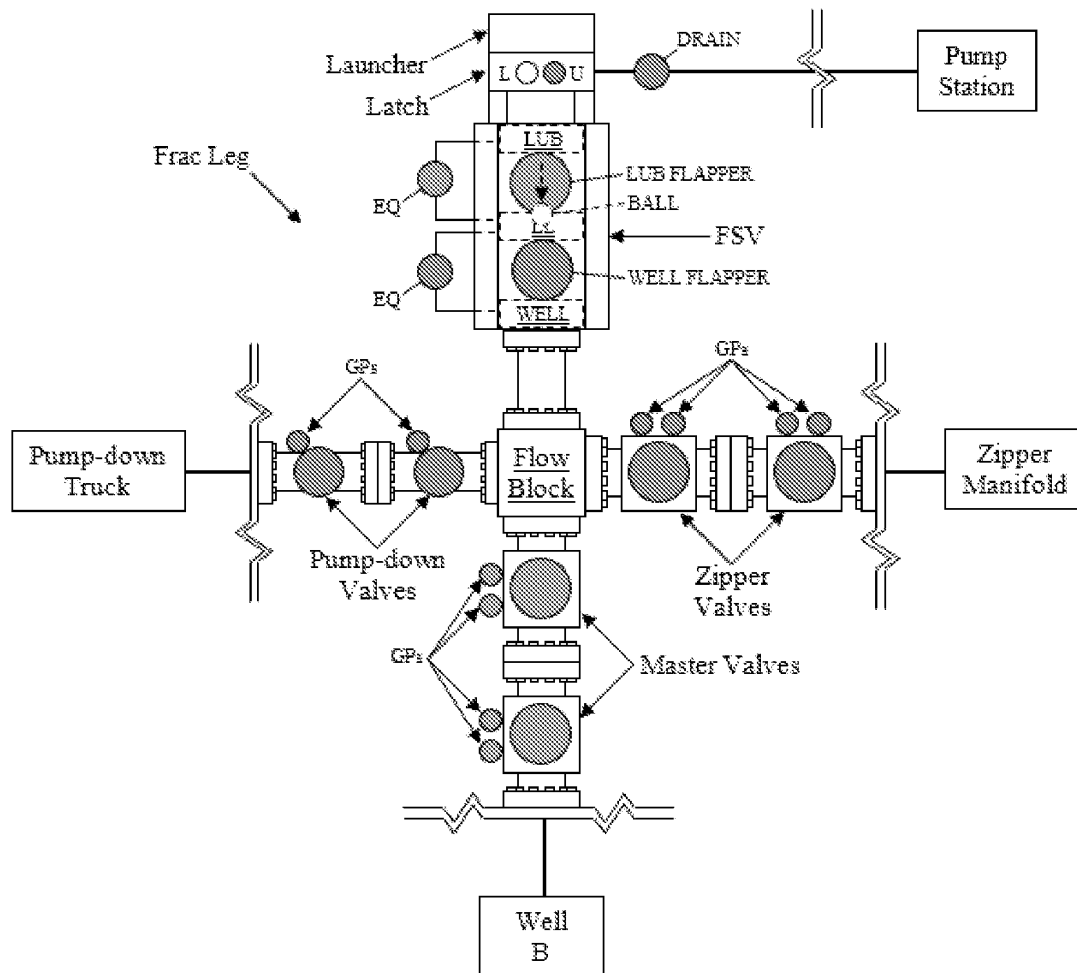


Fig. 6B

FSV Isolate Stage Cont'd

5. Ball to LL

6. Close LL/Lub Flapper

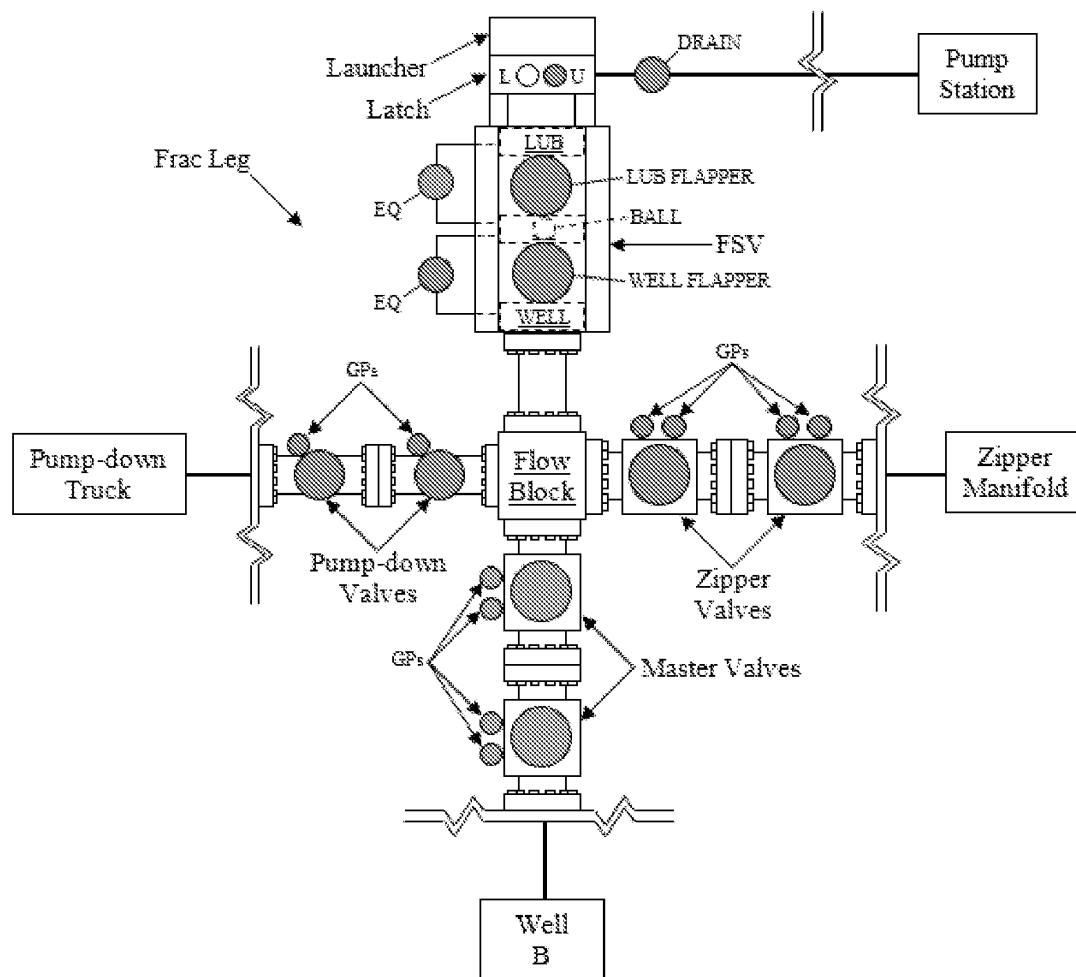


Fig. 6C

7. Close LL/Lub EQ



FSV Isolate Stage Cont'd

8. Open LL/Well EQ

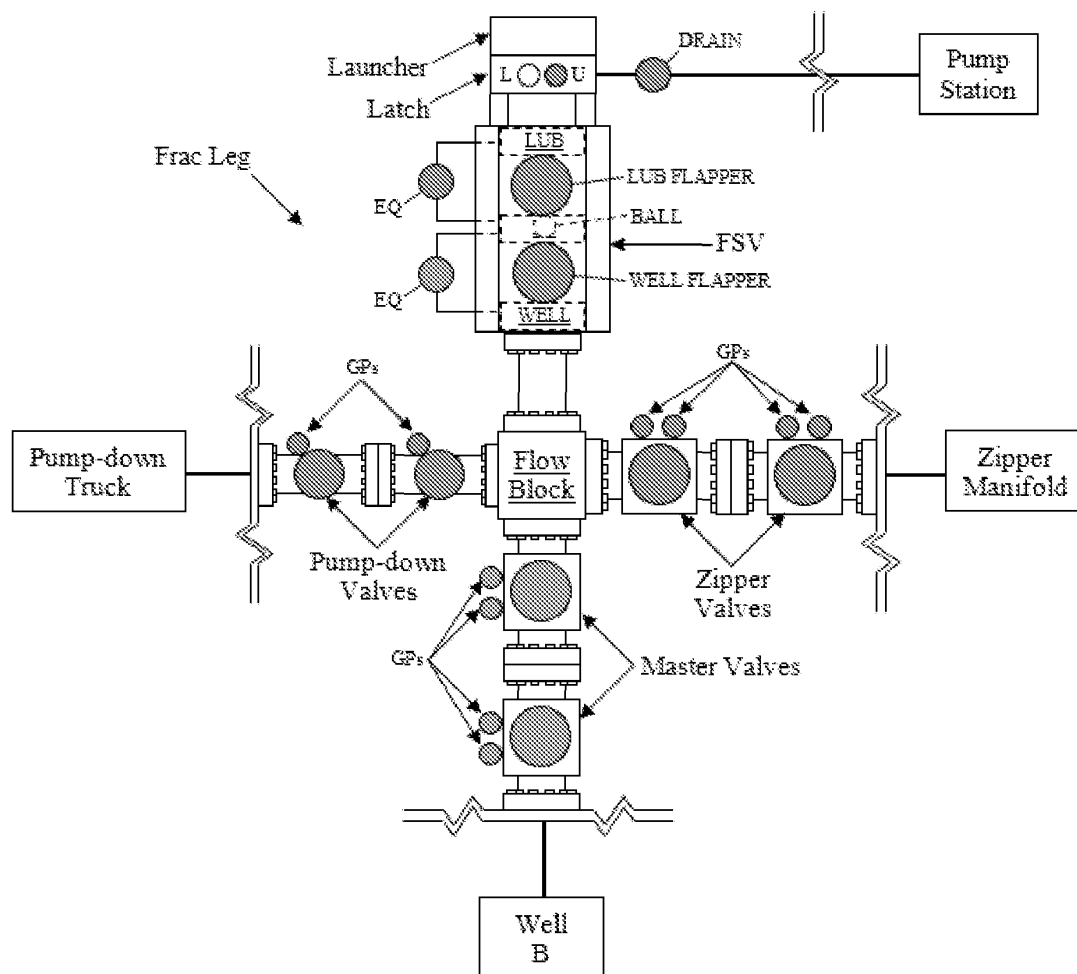


Fig. 6E

FSV Isolate Stage Cont'd

9. Check EQ (LL/Well)
10. Open LL/Well Flapper
11. Ball to well

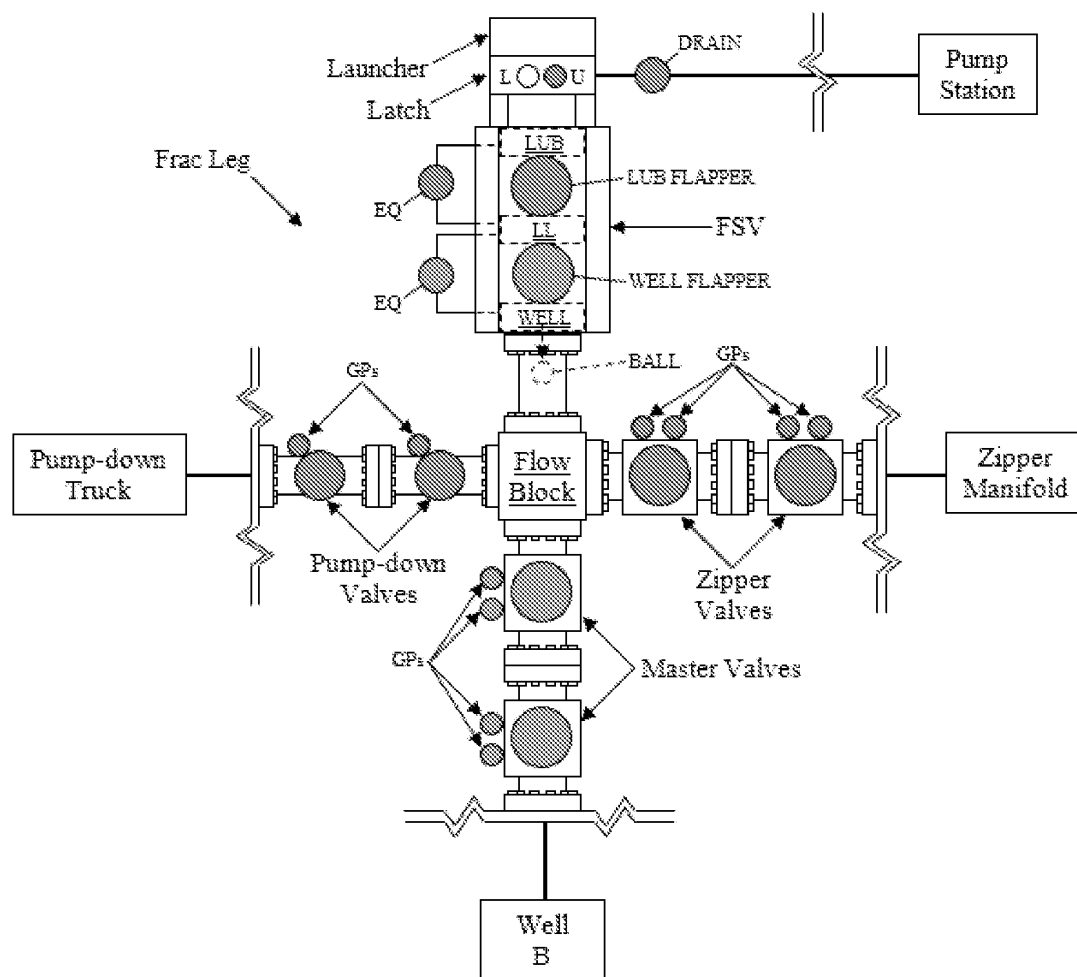


Fig. 6F

FSV Isolate Stage Cont'd

12. Close LL/Well Flapper

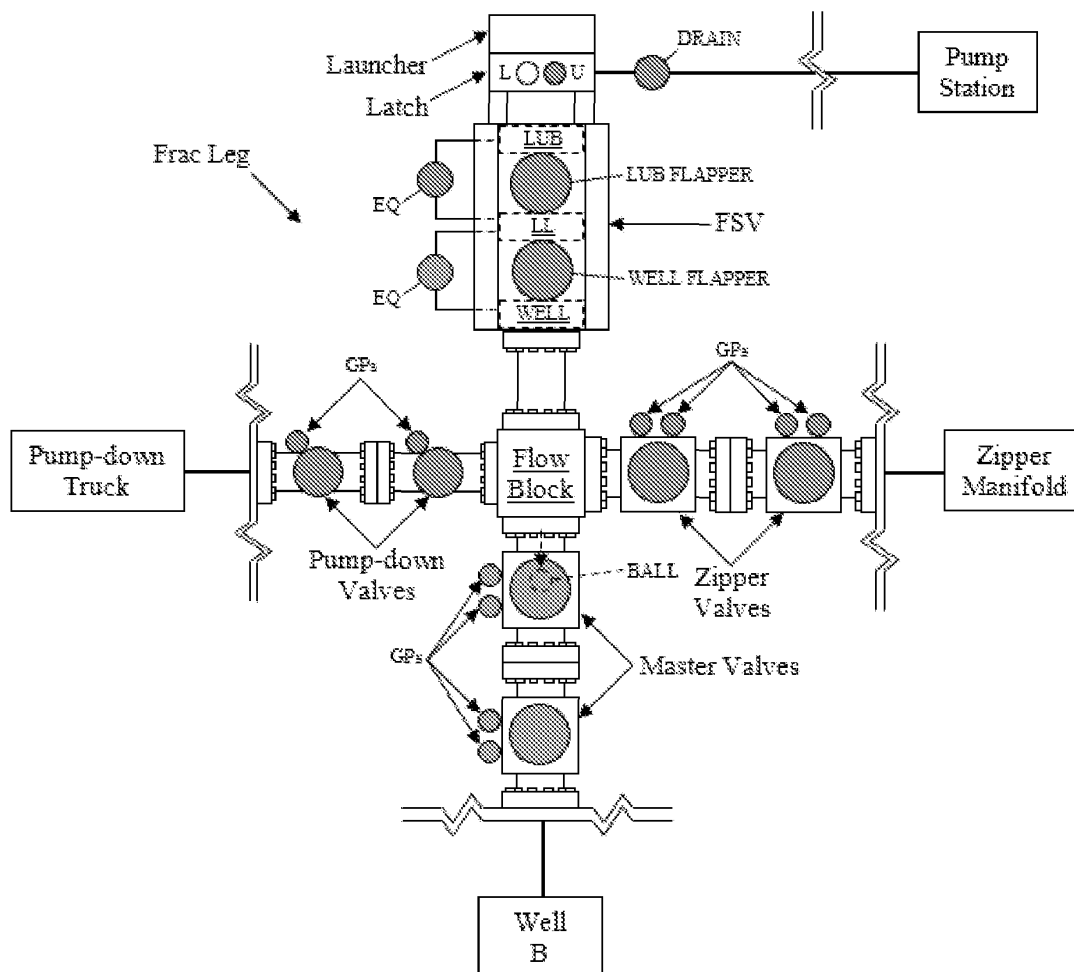


Fig. 6G

FSV Isolate Stage Cont'd
13. Close LL/Well EQ

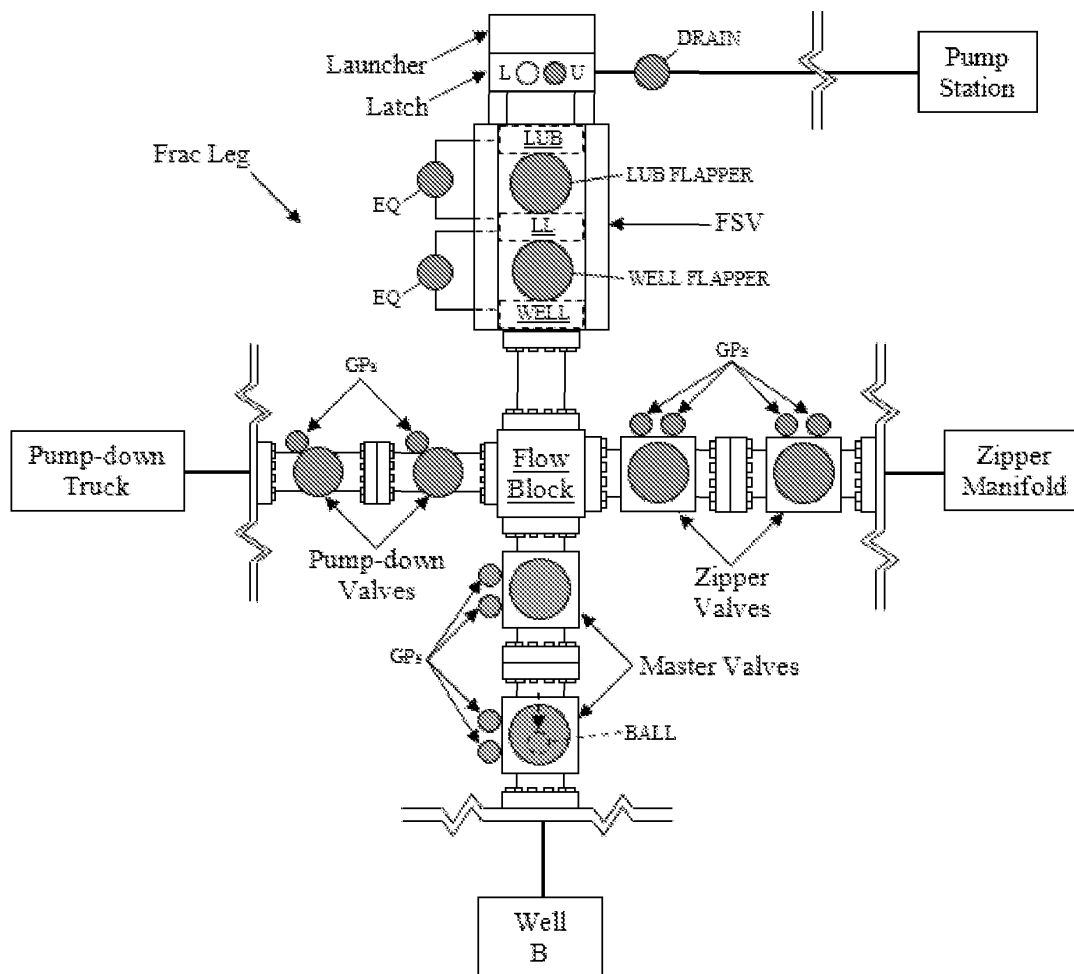


Fig. 6H

FSiC Frac Stage End

1. Monitor for external signal (CBT, user input) for n_1 well
2. Monitor Frac data for n_1 well
3. Dequeue next zipper valve set, compare against Frac's order if available

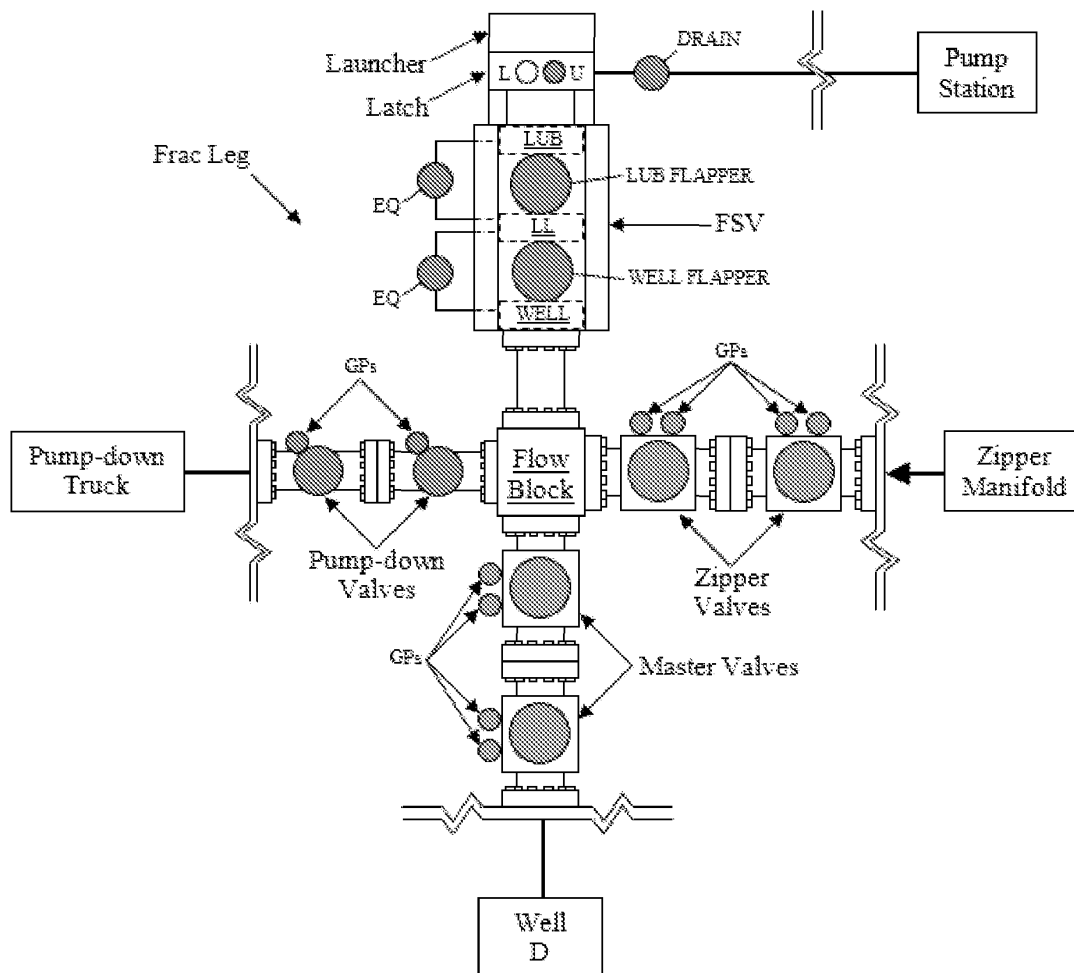


Fig. 7

FSiC Idle Rate

1. Check Frac rate of n_1 well
2. If $< [\text{threshold (e.g., 10 bbl)}]$ for
[threshold (e.g., 10s)]
 - a. True = CP Swap
 - b. False = Reg swap

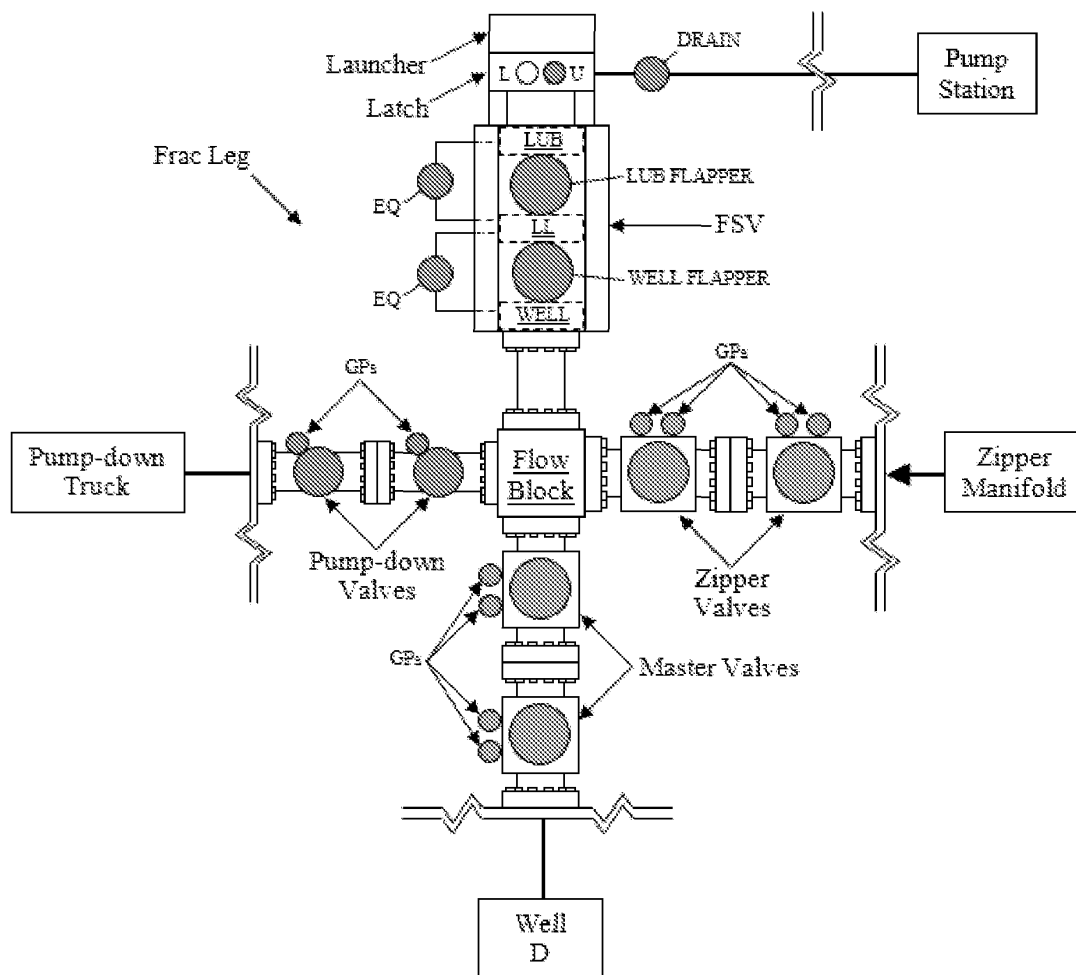


Fig. 8

FSiC Regular Swap

1. Close n₁ well's zipper valves
2. Wait until signal to advance
 - a. External signal (CBT, user input)
 - b. Frac EQ for > [10 seconds] & PTs
 - c. Automate Frac bleeds?

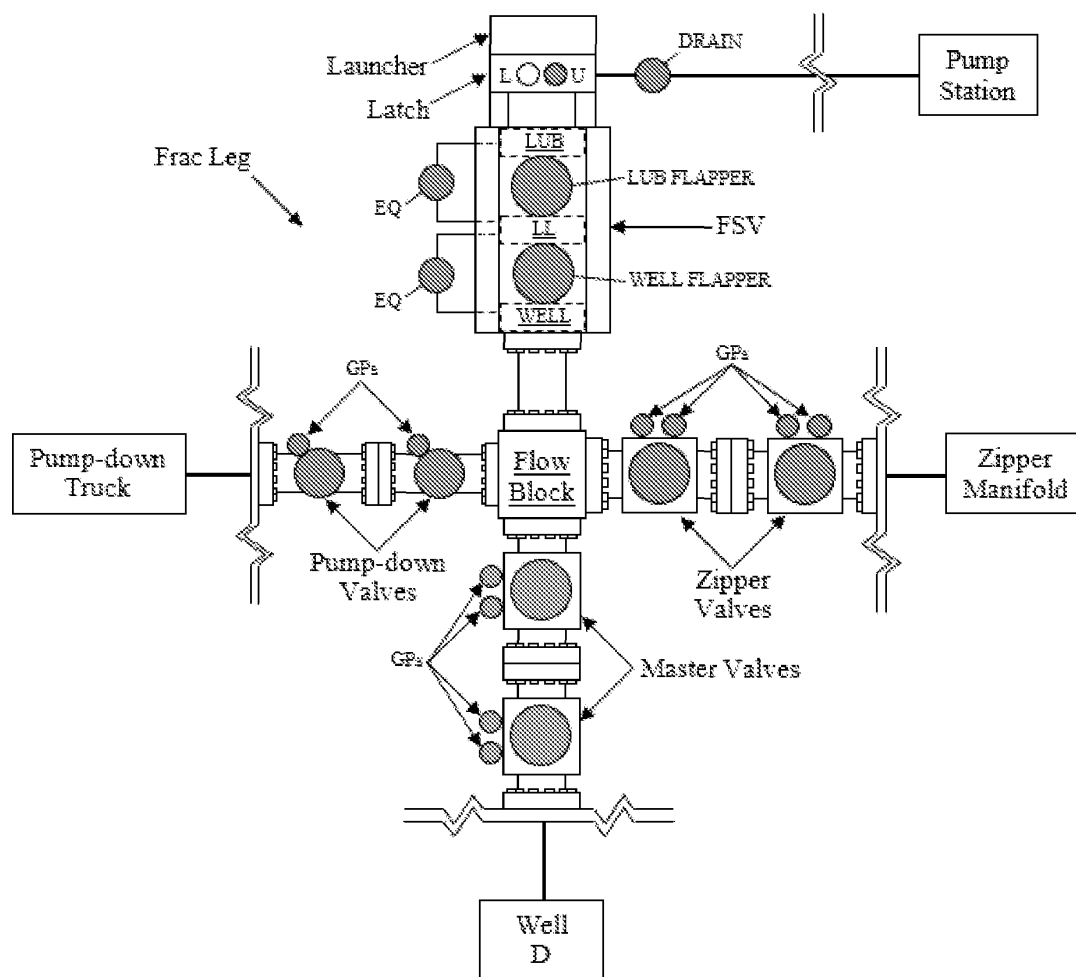


Fig. 9A

FSiC Regular Swap Cont'd

3. Open n_1+1 well's zipper valves

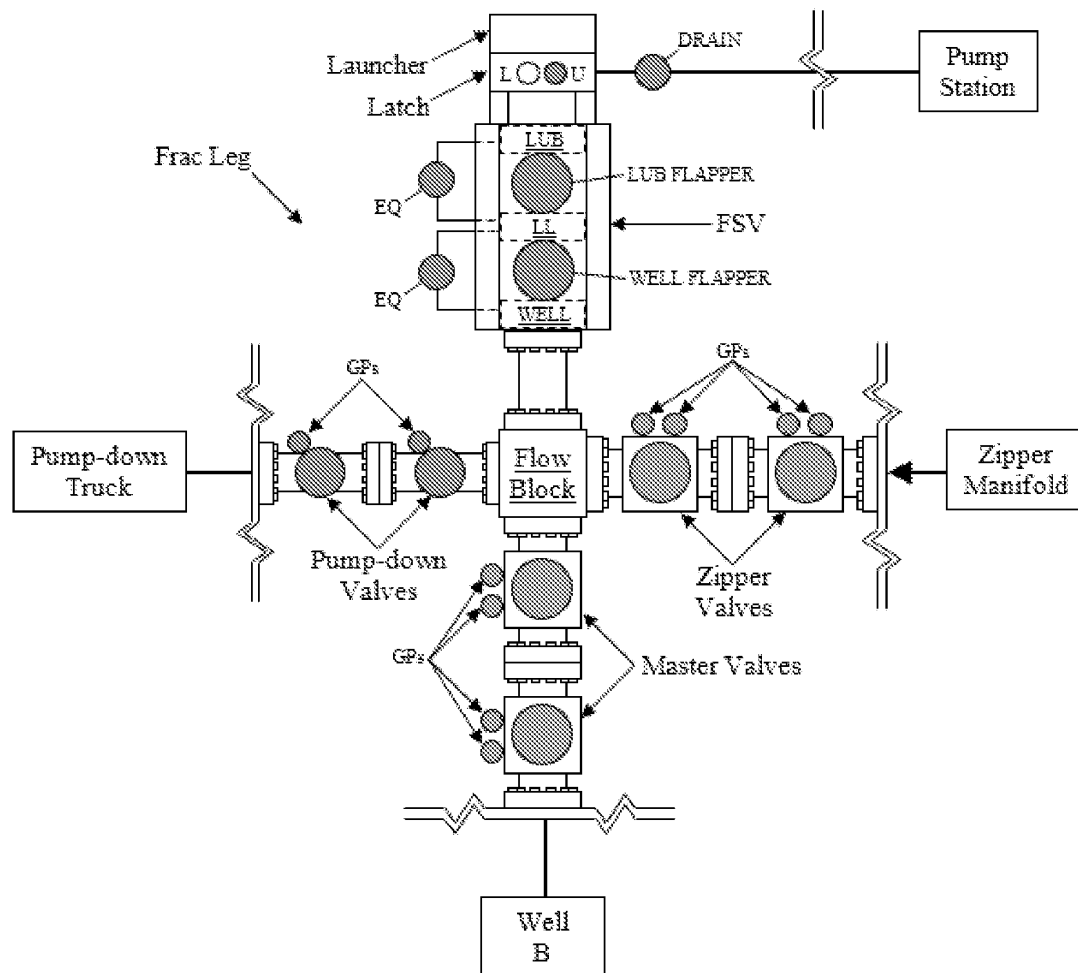


Fig. 9B

FSiC CP Swap

1. Open zipper valves of n_i+1 well

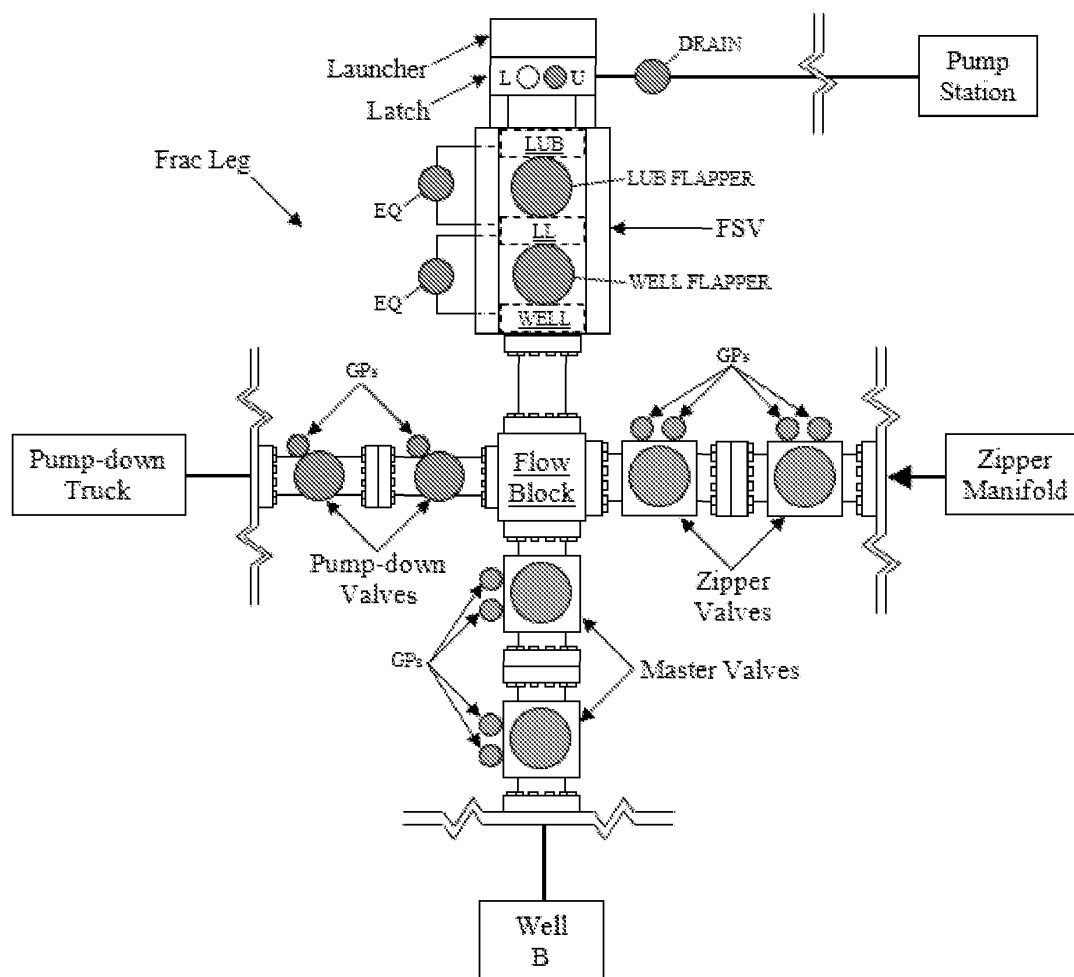


Fig. 10A

FSiC CP Swap

2. Wait until zipper valves of n_1+1 well and n_1 well are fully open
3. Close zipper valves of n_1 well

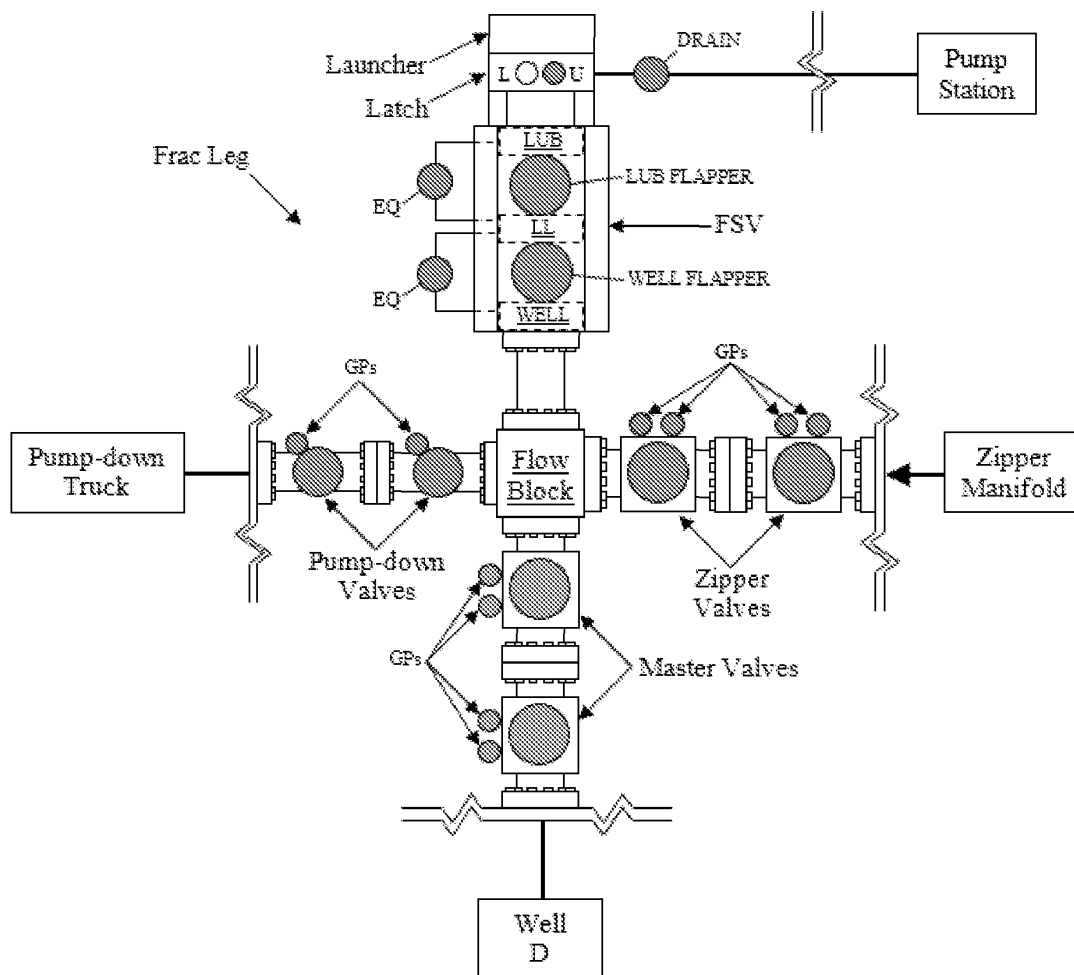


Fig. 10B

FSV Latch/Fill/Press Test

1. Stab Lub

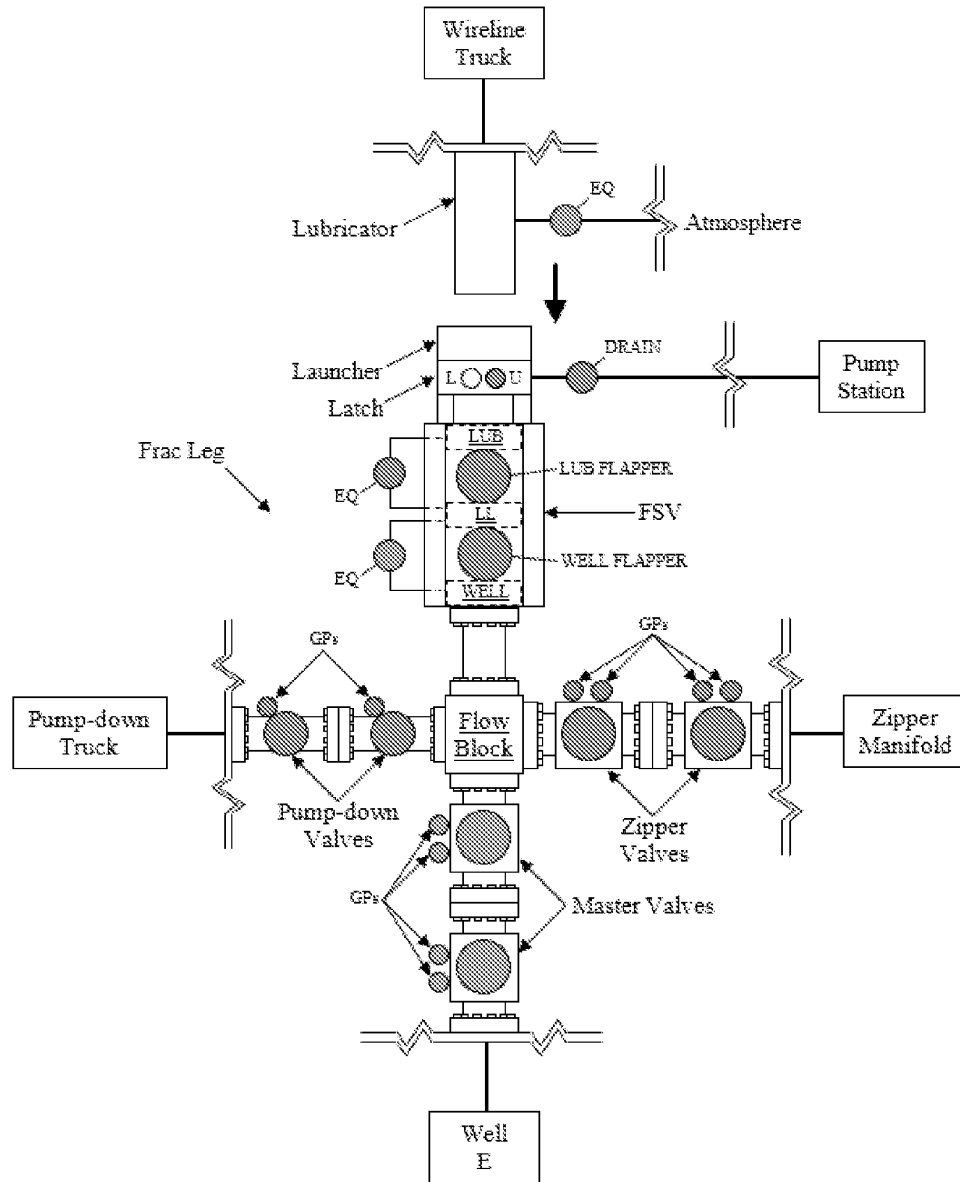


Fig. 11A

FSV Latch/Fill/Press Test Cont'd

2. Close Lub/ATM EQ

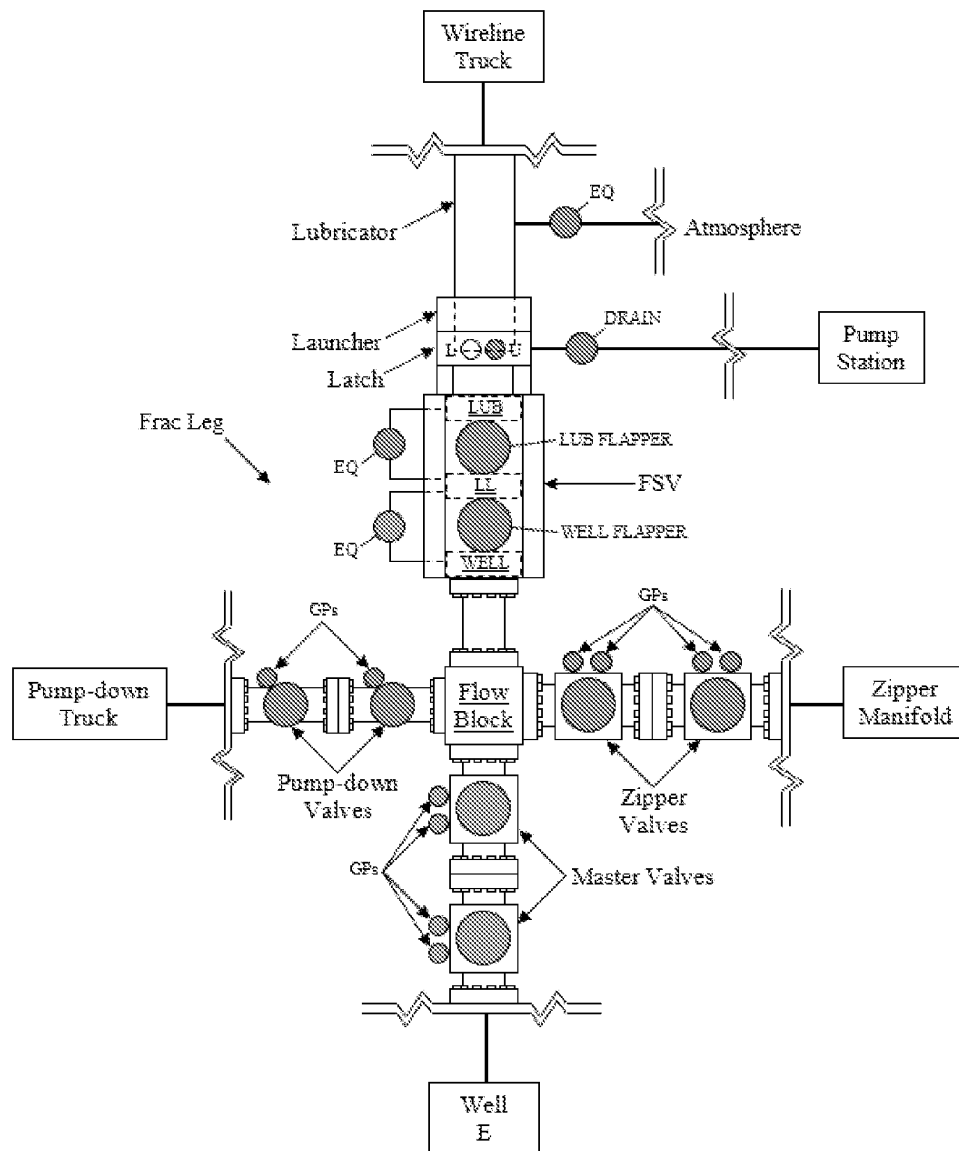


Fig. 11B

FSV Latch/Fill/Press Test Cont'd

3. Energize Latch Close relay
4. Check Latch Close prox switch
5. Wait [2s]
6. De-energize Latch Close relay
7. Energize Test Press relay
8. Wait [2s]
9. De-energize Test Press relay
10. Wait [5s]
11. Open Drain
12. Open Lub/ATM EQ
13. Check Test Press
Values for held pressure
14. If pass, proceed

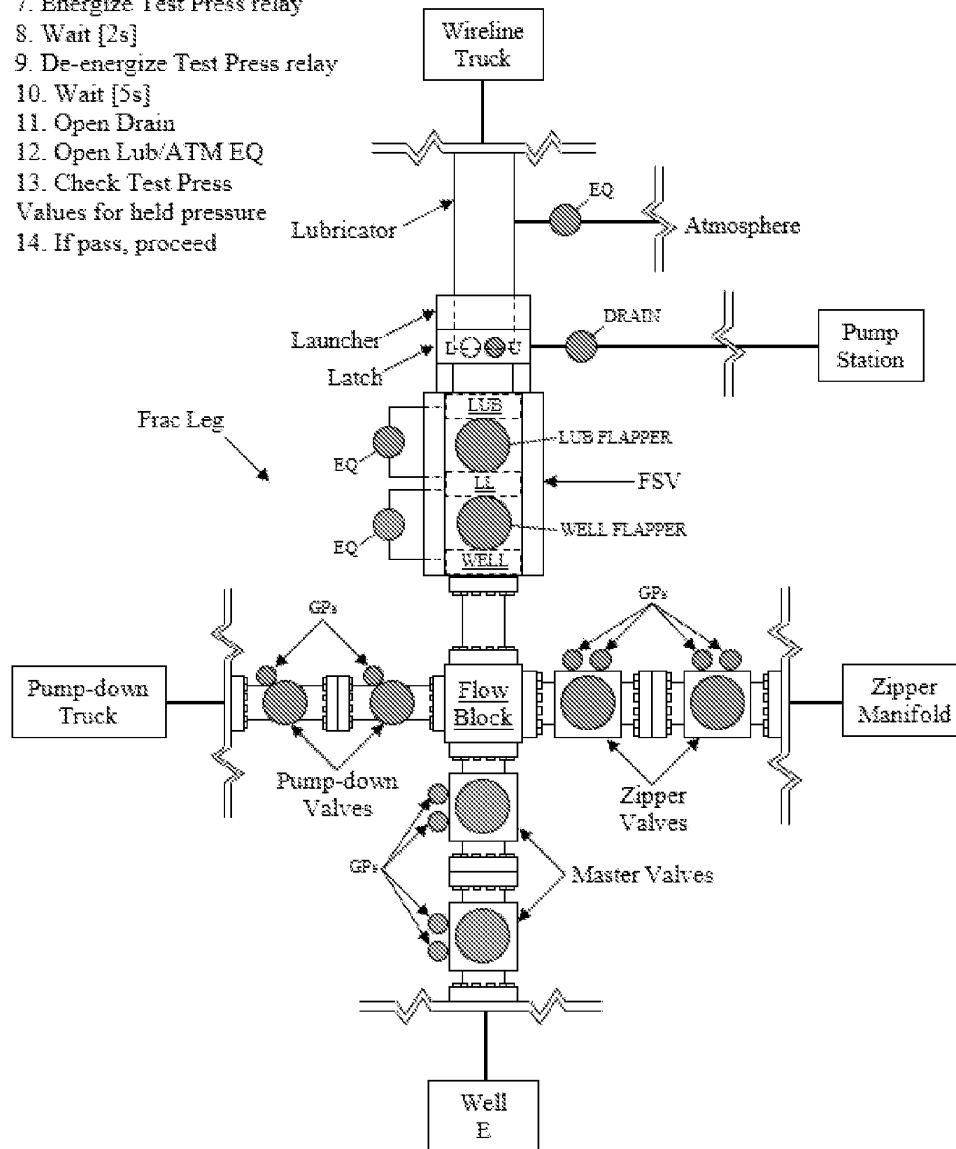


Fig. 11C

FSV Latch/Fill/Press Test Cont'd
15. FSCC Auto-Fill pump

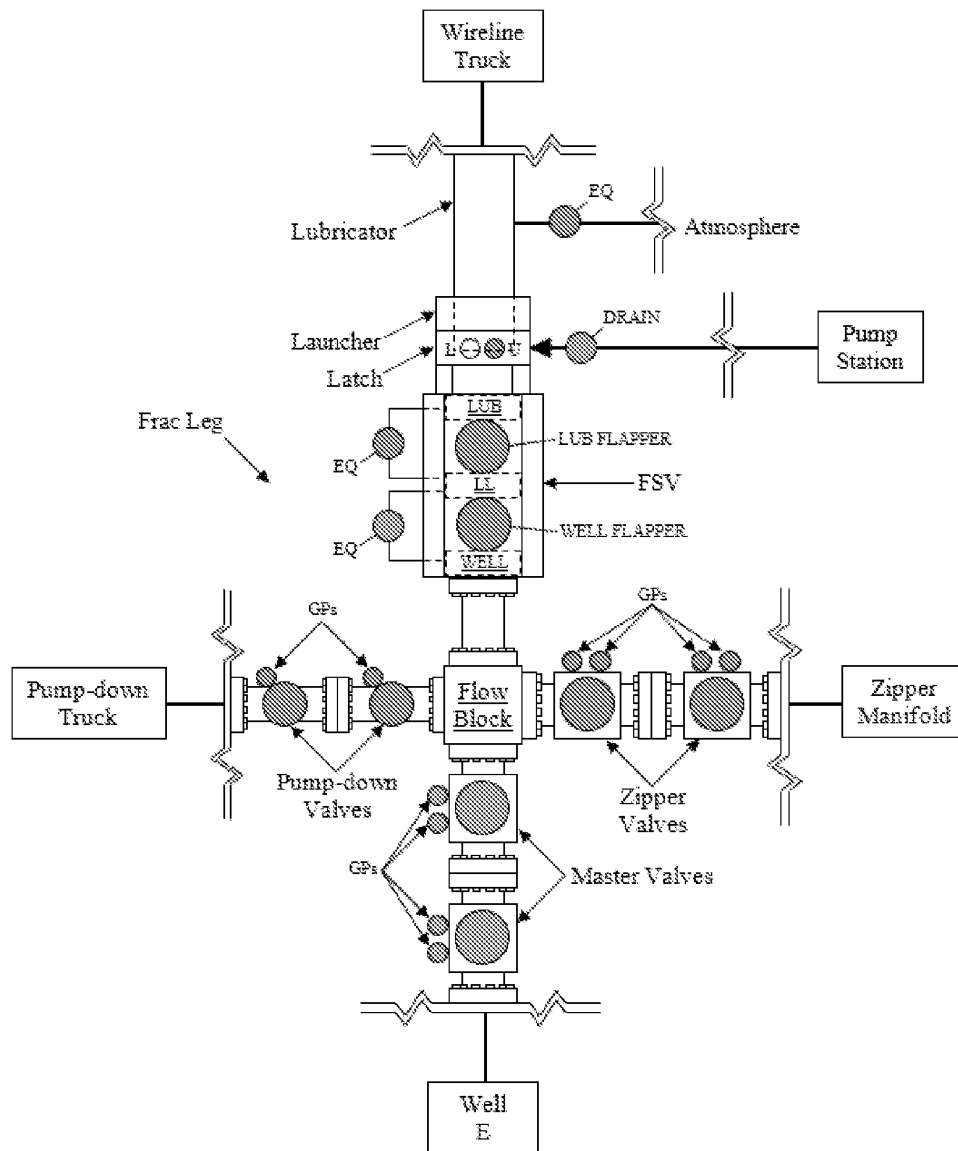


Fig. 11D

FSV Latch/Fill/Press Test Cont'd

16. Wait for Auto-Fill done from FSCC

17. Open LL/Lub EQ

18. FSCC Boost pump on

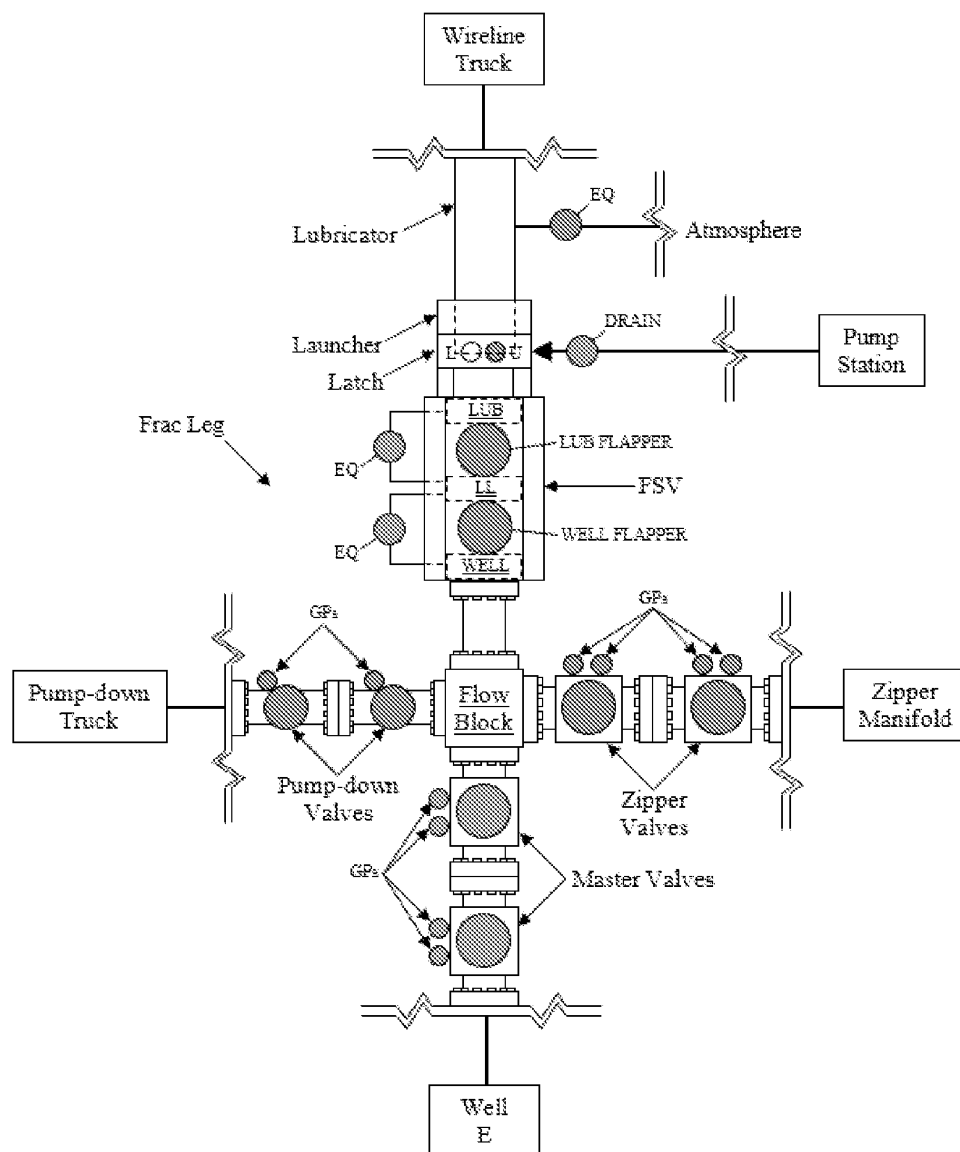


Fig. 11E

FSV Latch/Fill/Press Test Cont'd

19. Check Lub PSI > Well PSI – [500PSI]
20. When True, FSCC Boost Pump off
21. FSV Idle – Waiting for Swap

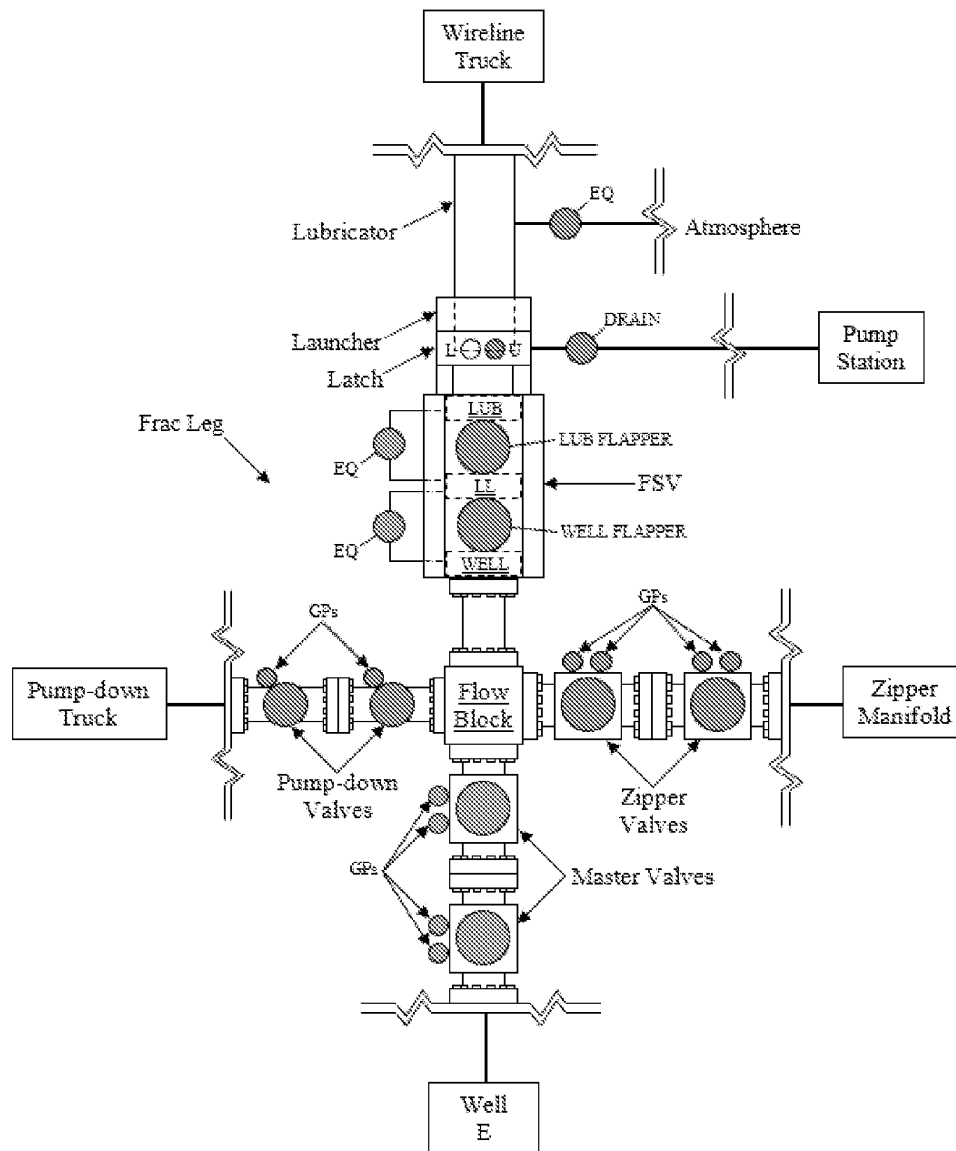


Fig. 11F

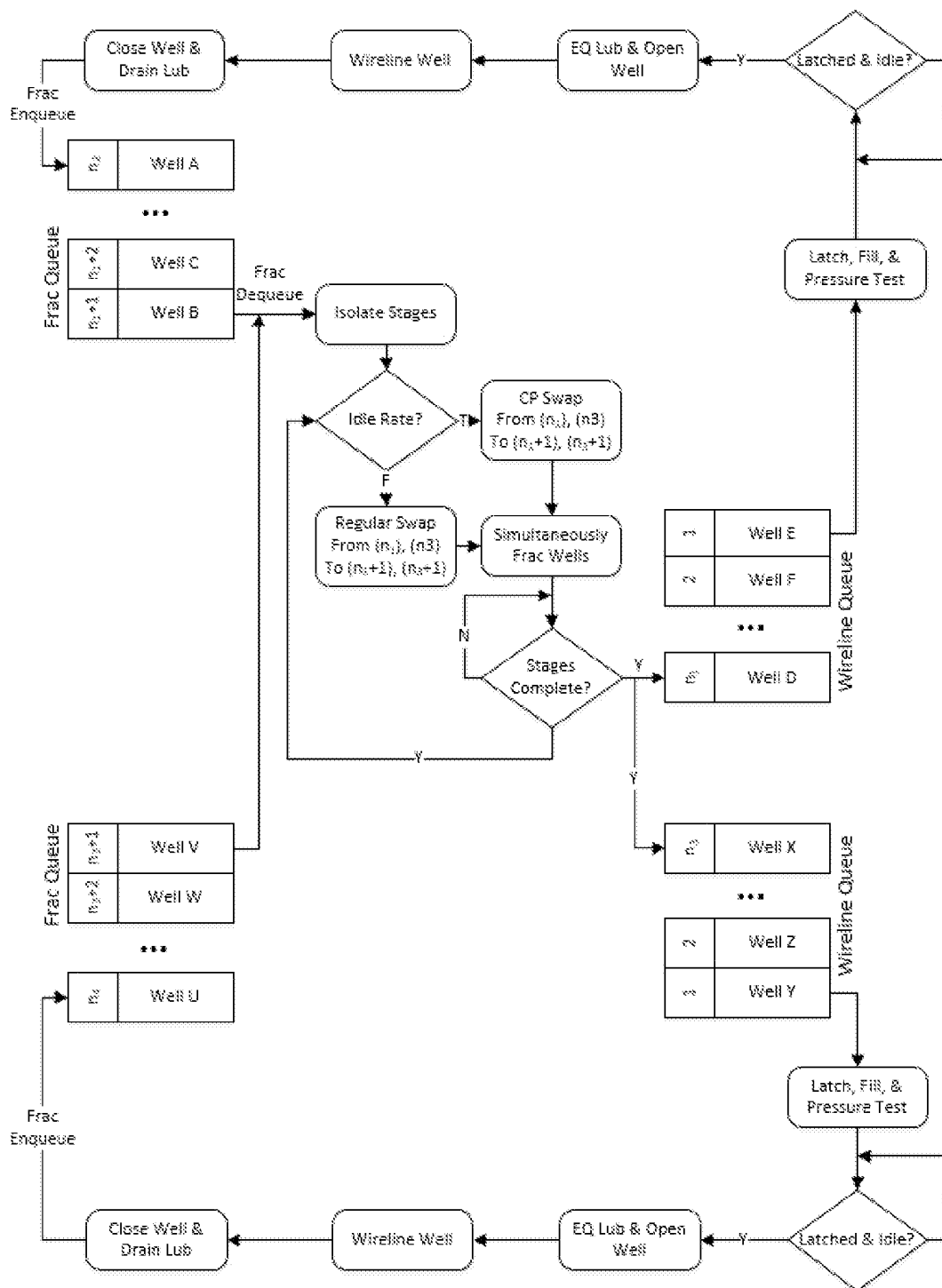
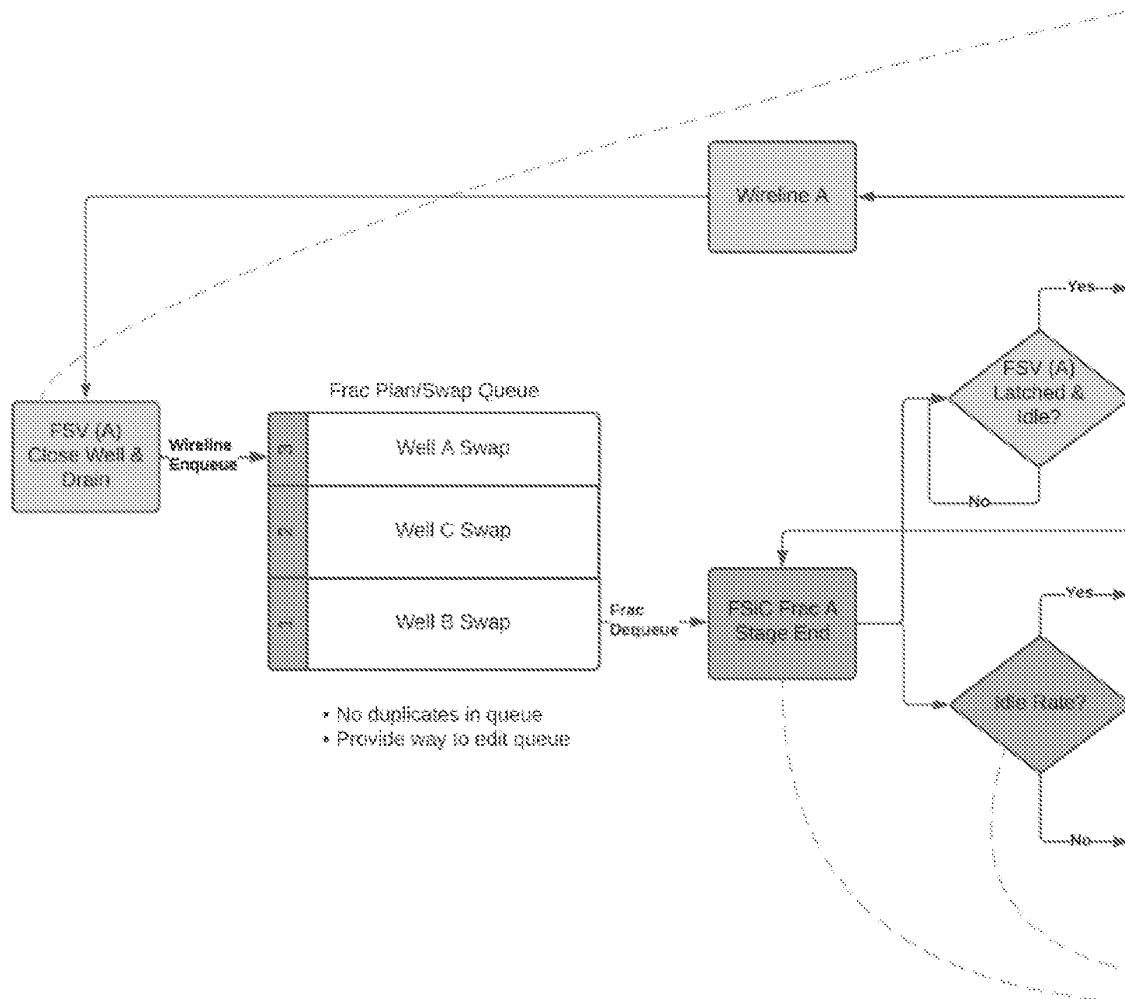
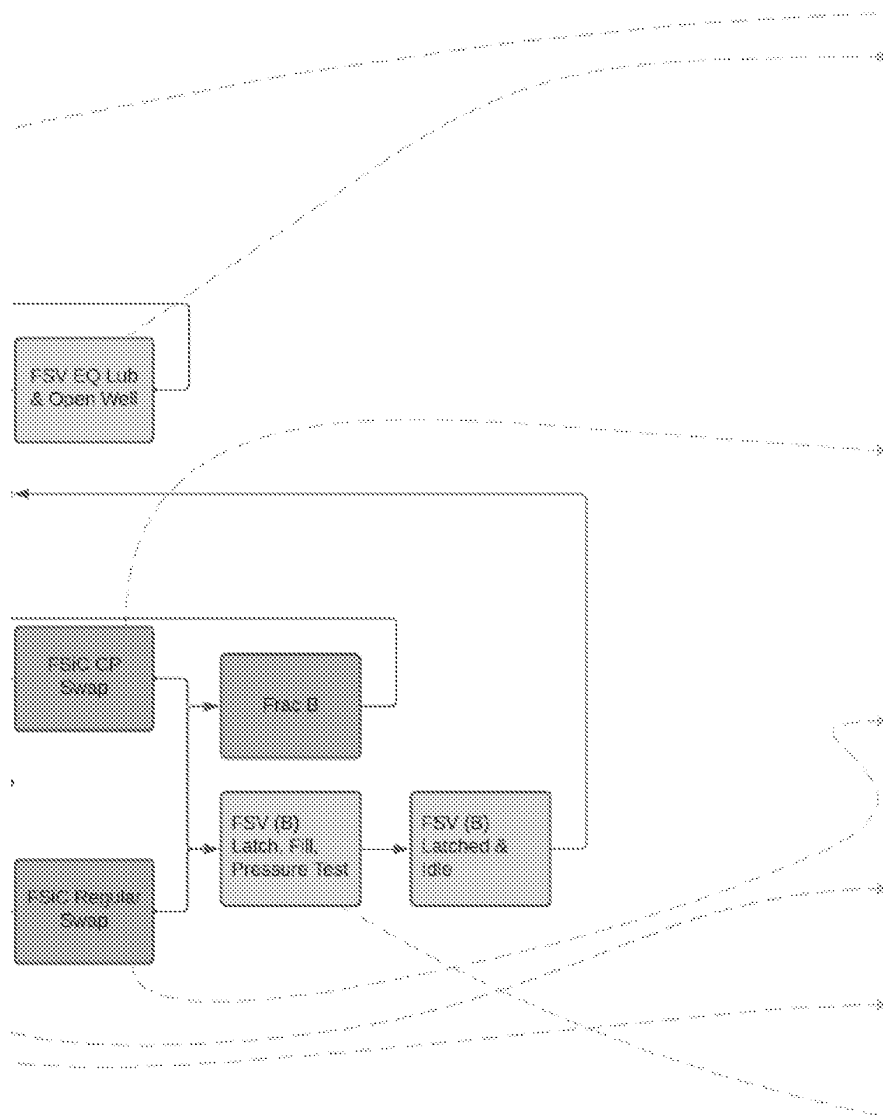


Fig. 12

Appendix A

FS Swap Queue Automation





FSV EQ Lub & Open Well

1. Authenticator Code
2. Close Drain
3. Close Lub/ATM EQ
4. Close Latch
5. Open LL/Lub EQ
6. Issue "Lub EQ Start" milestone
7. FSCC Boost on
8. Check EQ (LL/Well)
9. Open LL/Well Flapper
10. Close LL/Well EQ
11. Issue "Lub EQ Done" milestone
12. Wait [5s]
13. Open LL/Lub Flapper
14. FSCC Boost pump off
15. Close LL/Lub EQ
16. Close Well button enabled
17. Increment Stage

FSIC CP Swap

1. Open new well's zippers
2. Wait until both fully open
3. Close current well's zippers

FSIC Regular Swap

1. Close current well's zippers
2. Wait until signal to advance
 - a. External signal (CBT, user input)
 - b. Frac EQ for > [10 seconds] & PTs
 - c. Automate Frac bleeds?
3. Open new well's zippers

FSIC Idle Rate

1. Check Frac rate
2. If < [10bbl] for [10 seconds]
 - a. true = CP Swap
 - b. false = Regular Swap

FSIC Frac Stage End

1. Monitor for external signal (CBT, user input)
2. Monitor Frac data
3. Dequeue next zipper set, compare against Frac's Order if available

FSV Close Well & Drain

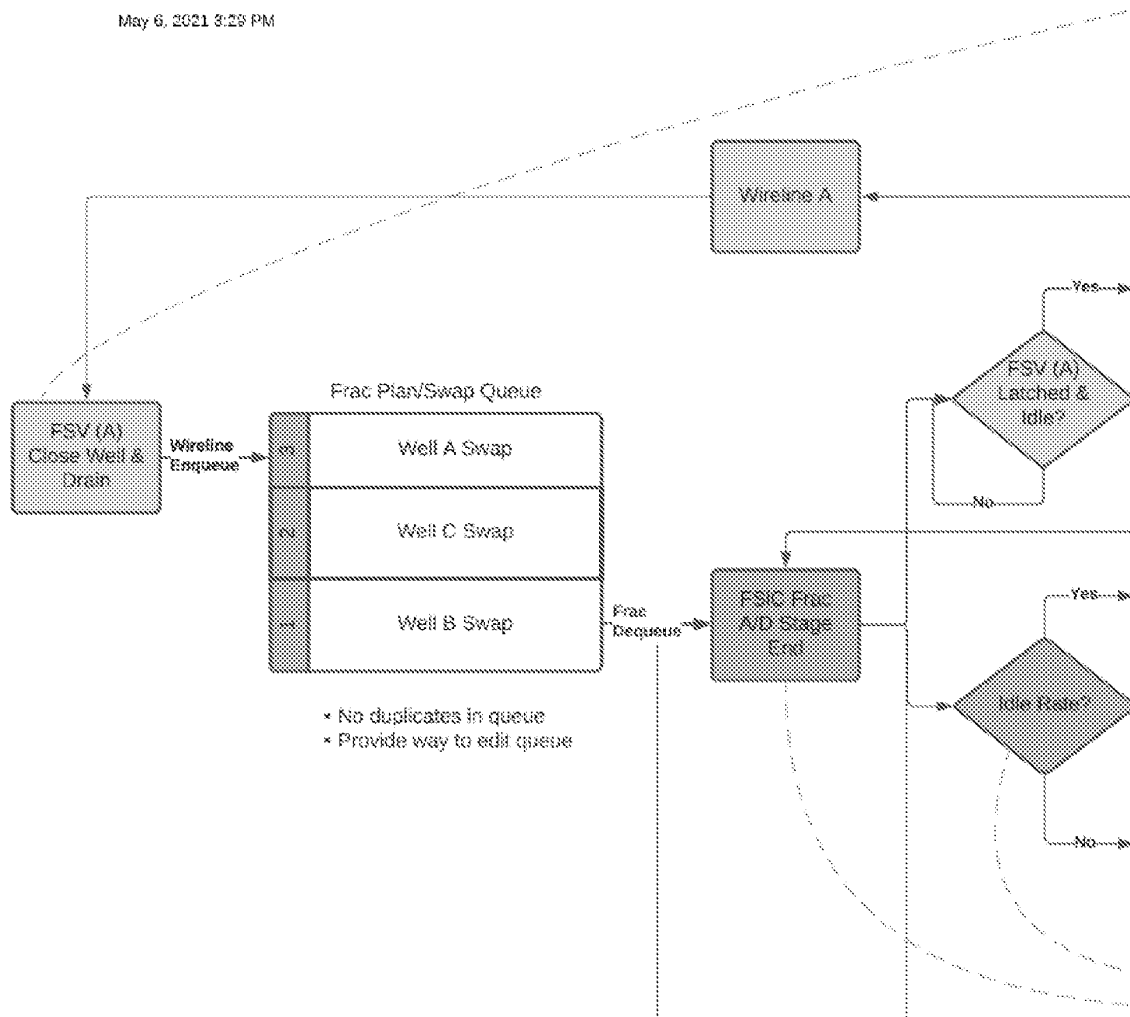
1. Authenticator Code
2. Prompt for bump up (or detect with accel. and/or weight from tool on WL)
3. Check WL speed
4. Close LL/Lub Flapper
5. Close LL/Well Flapper
6. Close LL/Well EQ
7. Open Lub/ATM EQ
8. Open LL/Lub EQ
9. Wait 2s
10. Check Lub PSI below [SM Config.Close Well Lub Bleed PSI Limit] value
11. Close LL/Lub EQ
12. Issue [Drain Lubricator Start] milestone
13. Open Drain
14. FSCC Auto-Drain
15. Wait for Auto-Drain done from FSCC
16. Issue [Drain Lubricator Done] milestone
17. Open Latch
18. Wait [SM Config.Close Well Final Delay] value (ms)
19. Close Drain
20. Close Lub/ATM EQ
21. Close LL/Lub EQ
22. Ball Drop and Test Press buttons enabled

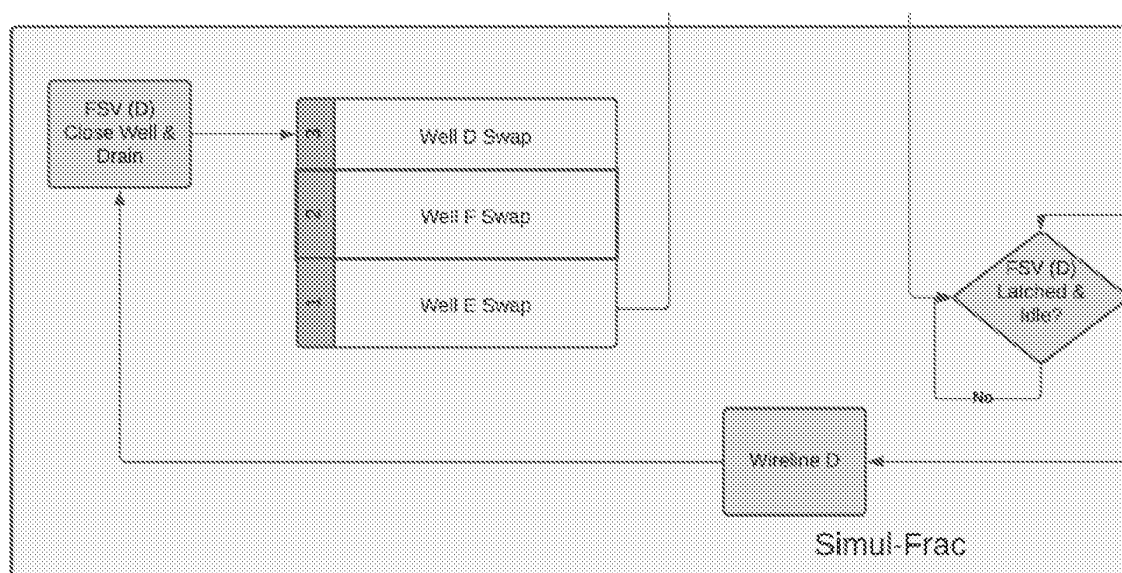
FSV Latch/Fill/Pressure Test

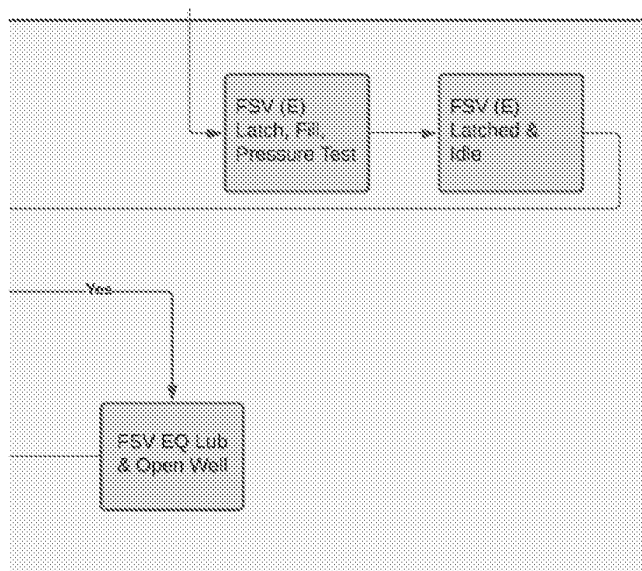
1. Close Lub/ATM EQ
2. Energize Latch Close relay
3. Check Latch Close prox switch
4. Wait [2s]
5. De-energize Latch Close relay
6. Energize Test Press relay
7. Wait [2s]
8. De-energize Test Press relay
9. Wait [5s]
10. Open Drain
11. Open Lub/ATM EQ
12. Check Test Press Values for held pressure
13. If pass, proceed
14. FSCC Auto-Fill
15. Wait for Auto-Fill done from FSCC
16. Open LL/Lub EQ
17. FSCC Boost On
18. Check Lub PSI > Well PSI - [500PSI]
19. When True, FSCC Boost pump off
20. FSV Idle - Waiting for Swap

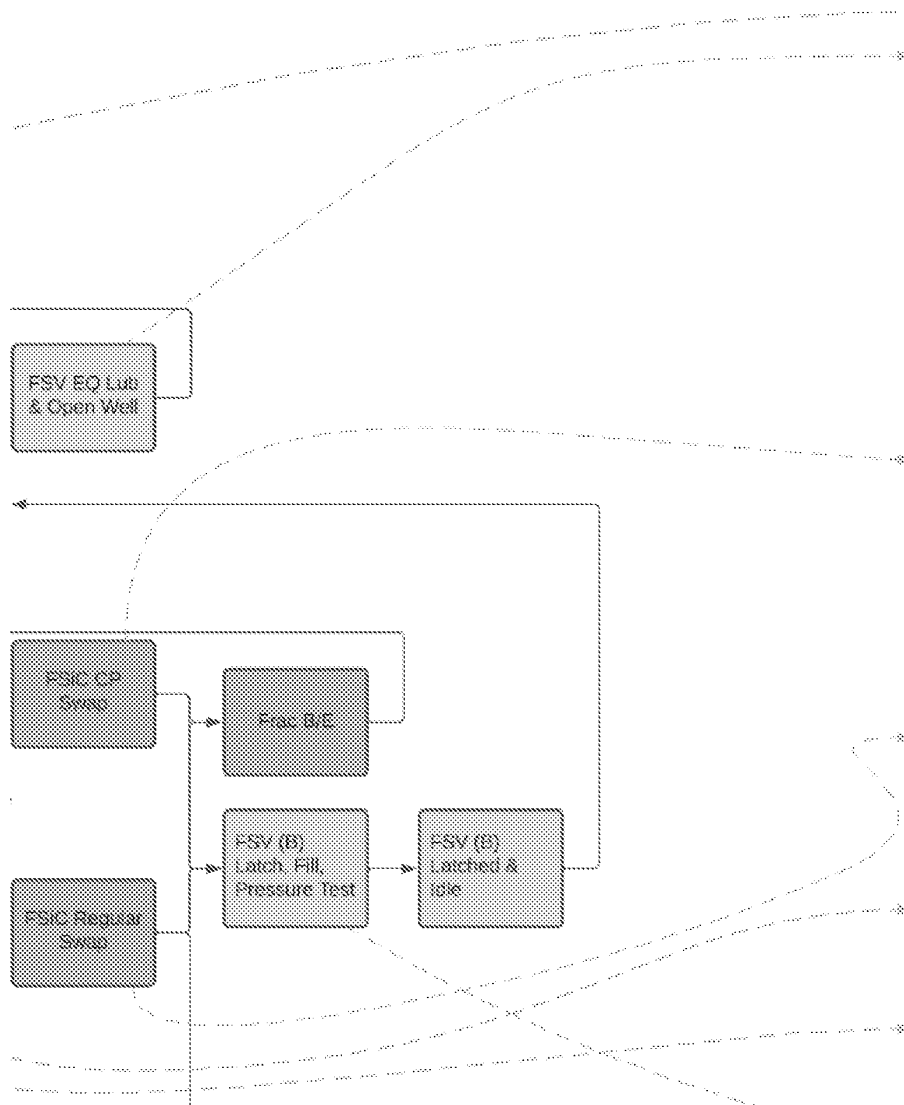
FS Swap Queue Automation

May 6, 2021 3:29 PM









FSV EQ Lub & Open Well

1. Authenticator Code
2. Close Drain
3. Close Lub/ATM EQ
4. Close Latch
5. Open LL/Lub EQ
6. Issue "Lub EQ Start" milestone
7. FSCC Boost on
8. Check EQ (LL/Well)
9. Open LL/Well Flapper
10. Close LL/Well EQ
11. Issue "Lub EQ Done" milestone
12. Wait [5s]
13. Open LL/Lub Flapper
14. FSCC Boost pump off
15. Close LL/Lub EQ
16. Close Well button enabled
17. Increment Stage

FSiC CP Swap

1. Open new well's zippers
2. Wait until both fully open
3. Close current well's zippers

FSiC Regular Swap

1. Close current well's zippers
2. Wait until signal to advance
 - a. External signal (CBT, user input)
 - b. Frac EQ for > [10 seconds] & PTs
 - c. Automate Frac bleeds?
3. Open new well's zippers

FSiC Idle Rate

1. Check Frac rate
2. If < [10bbl] for [10 seconds]
 - a. true = CP Swap
 - b. false = Regular Swap

FSiC Frac Stage End

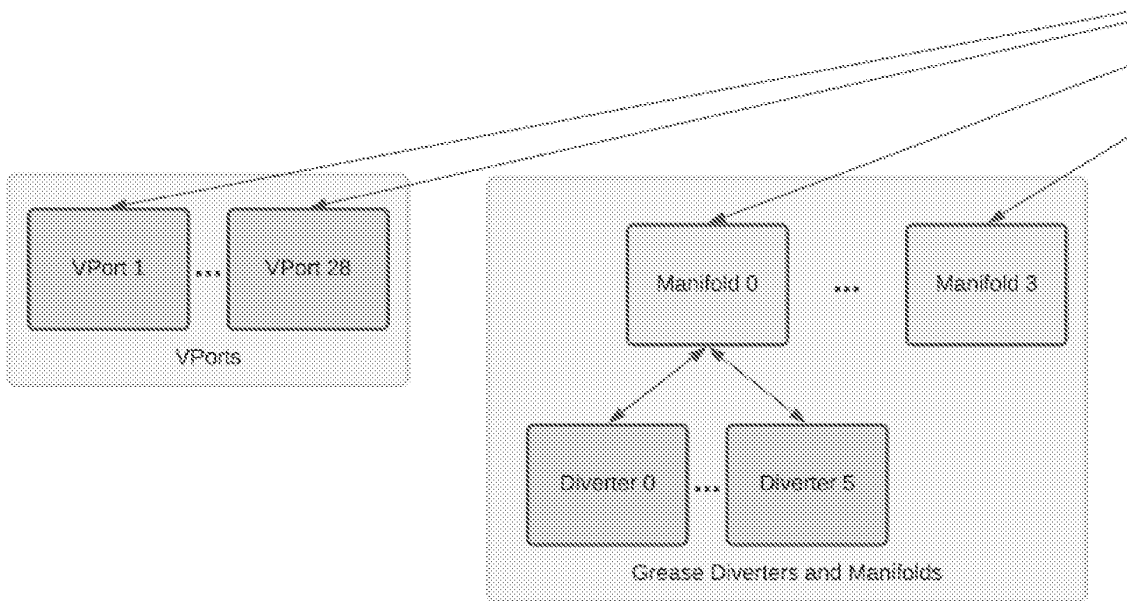
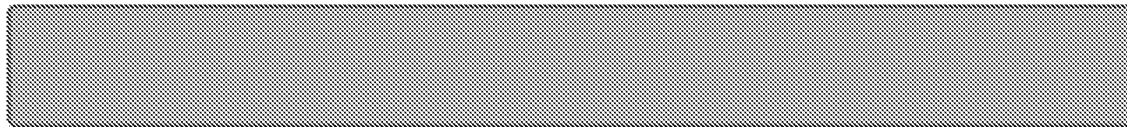
1. Monitor for external signal (CBT, user input)
2. Monitor Frac data
3. Dequeue next zipper set, compare against Frac's Order if available

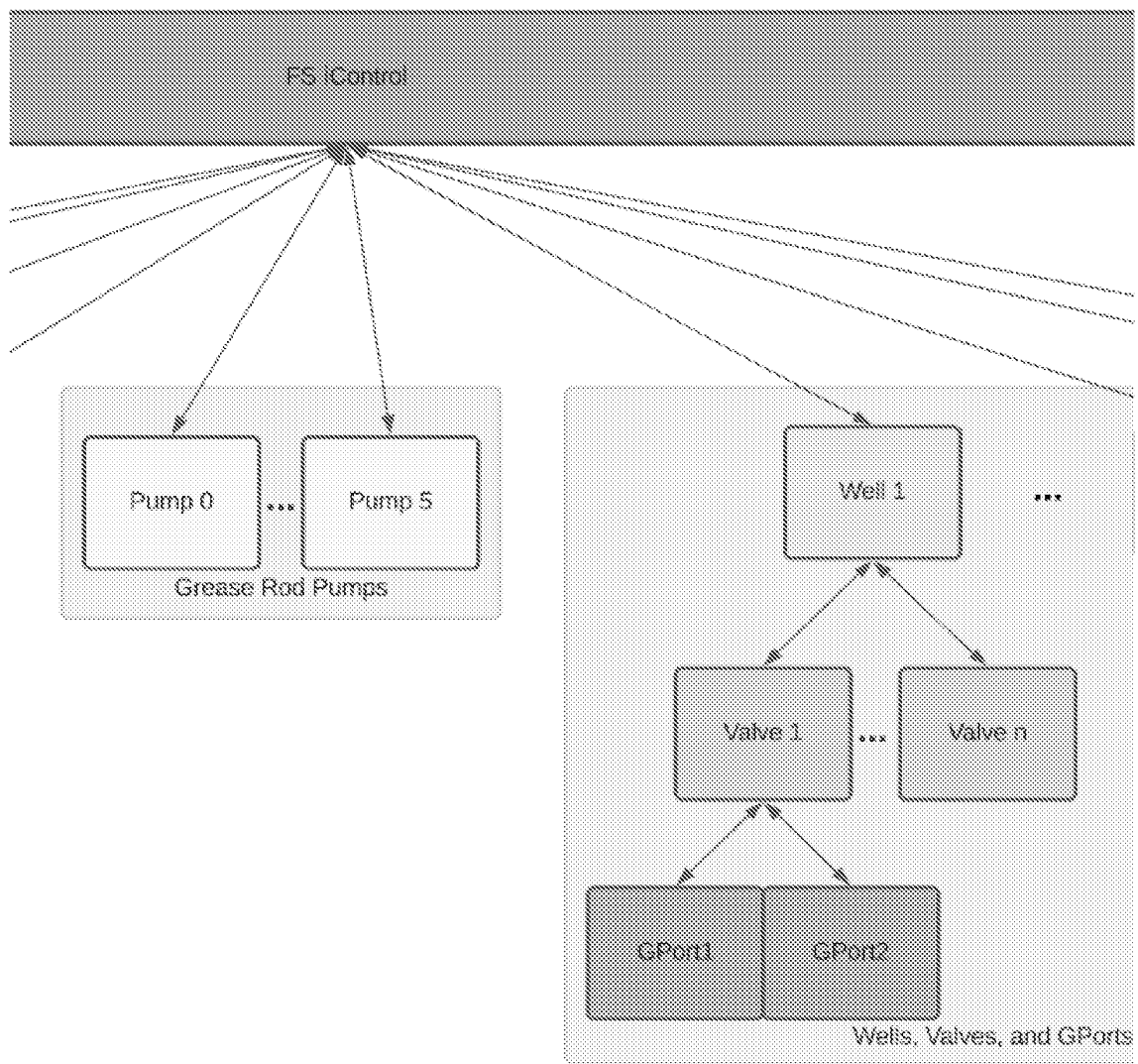
FSV Close Well & Drain

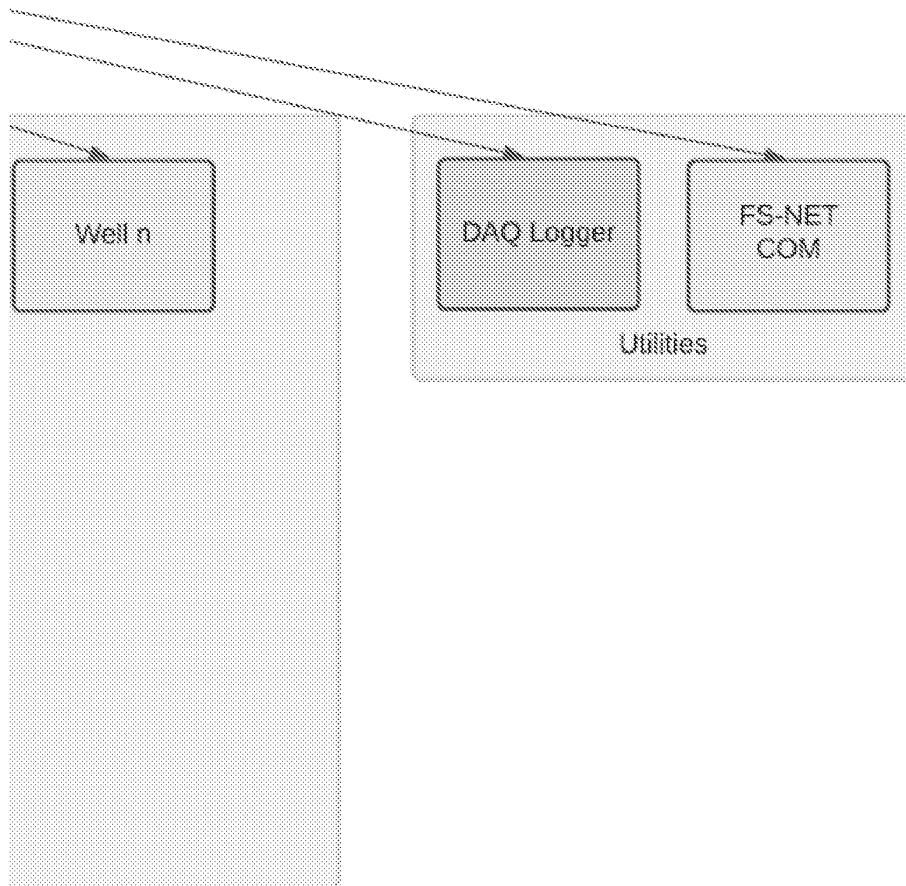
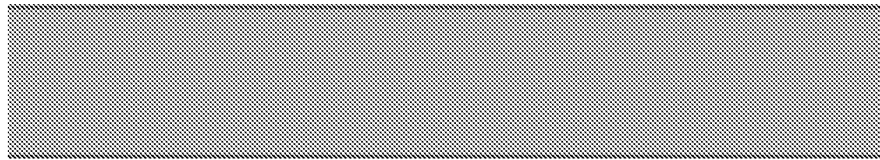
1. Authenticator Code
2. Prompt for bump up (or detect with accel. and/or weight from tool on WL)
3. Check WL speed
4. Close LL/Lub Flapper
5. Close LL/Well Flapper
6. Close LL/Well EQ
7. Open Lub/ATM EQ
8. Open LL/Lub EQ
9. Wait 2s
10. Check Lub PSI below [SM Config.Close Well Lub Bleed PSI Limit] value
11. Close LL/Lub EQ
12. Issue [Drain Lubricator Start] milestone
13. Open Drain
14. FSCC Auto-Drain
15. Wait for Auto-Drain done from FSCC
16. Issue [Drain Lubricator Done] milestone
17. Open Latch
18. Wait [SM Config.Close Well Final Delay] value (ms)
19. Close Drain
20. Close Lub/ATM EQ
21. Close LL/Lub EQ
22. Ball Drop and Test Press buttons enabled

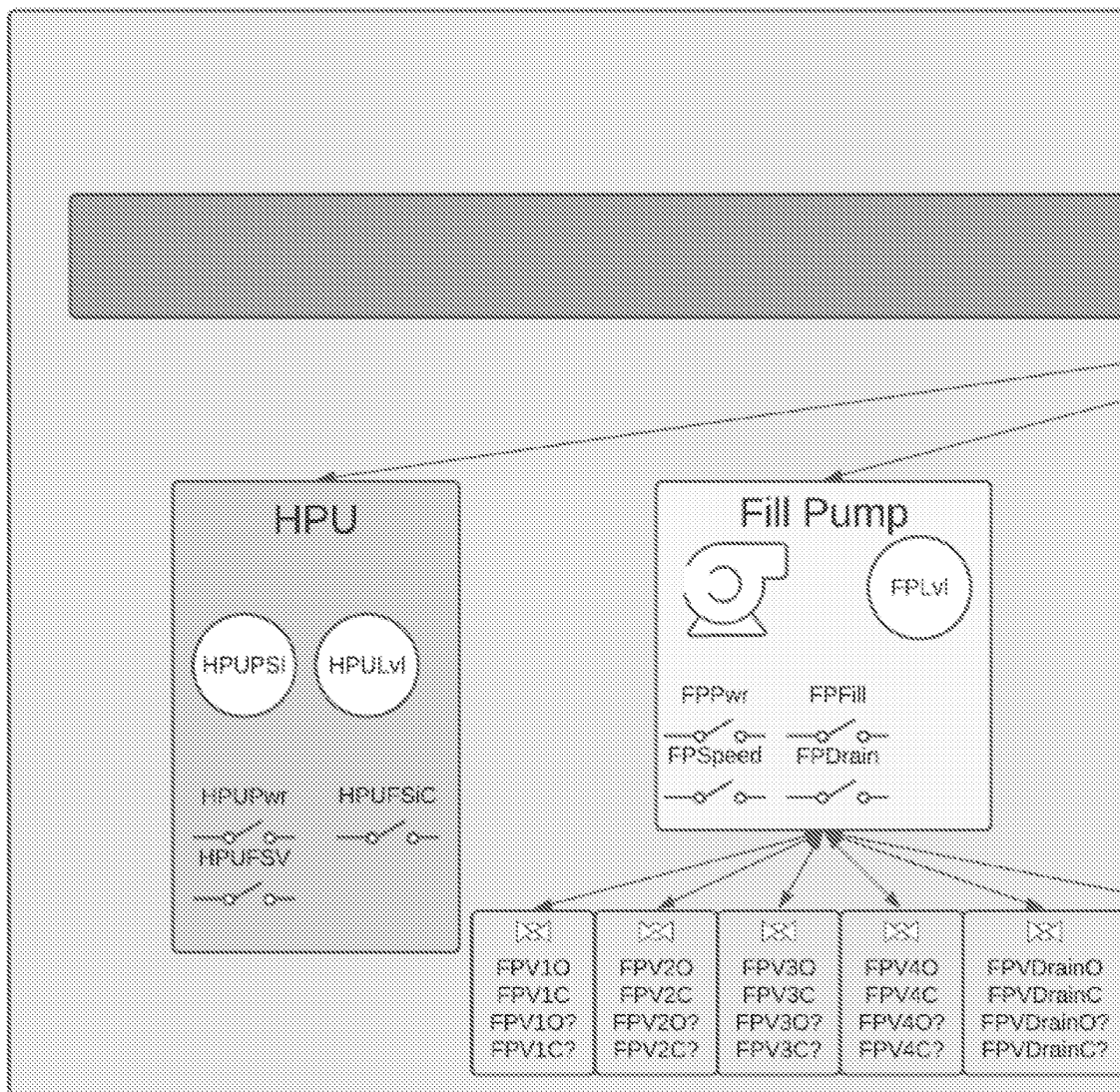
FSV Latch/Fill/Pressure Test

1. Close Lub/ATM EQ
2. Energize Latch Close relay
3. Check Latch Close prox switch
4. Wait [2s]
5. De-energize Latch Close relay
6. Energize Test Press relay
7. Wait [2s]
8. De-energize Test Press relay
9. Wait [5s]
10. ~~Open Drain~~
11. ~~Open Lub/ATM EQ~~
12. Check Test Press Values for held pressure
13. If pass, proceed
14. FSCC Auto-Fill
15. Wait for Auto-Fill done from FSCC
16. Open LL/Lub EQ
17. FSCC Boost On
18. Check Lub PSI > Well PSI - [500PSI]
19. When True, FSCC boost pump off
20. FSV Idle - Waiting for Swap

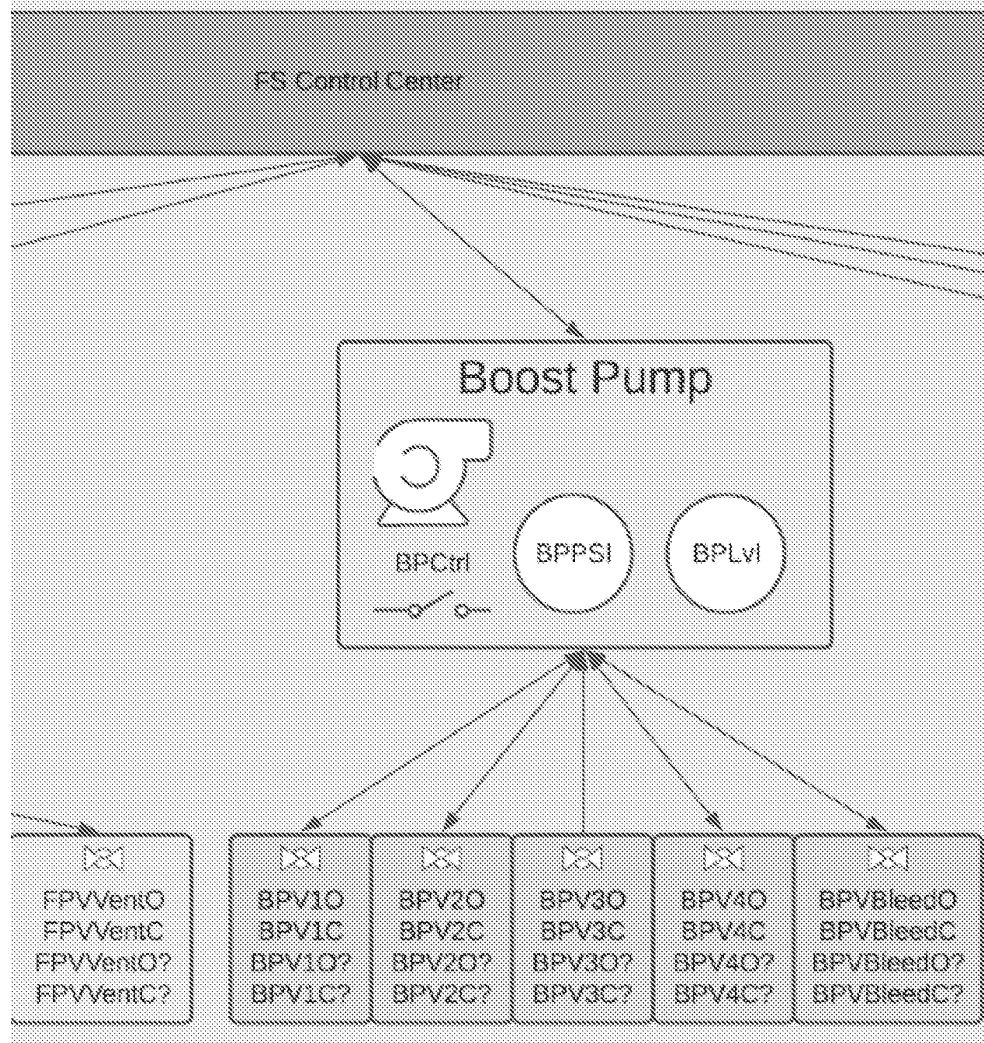


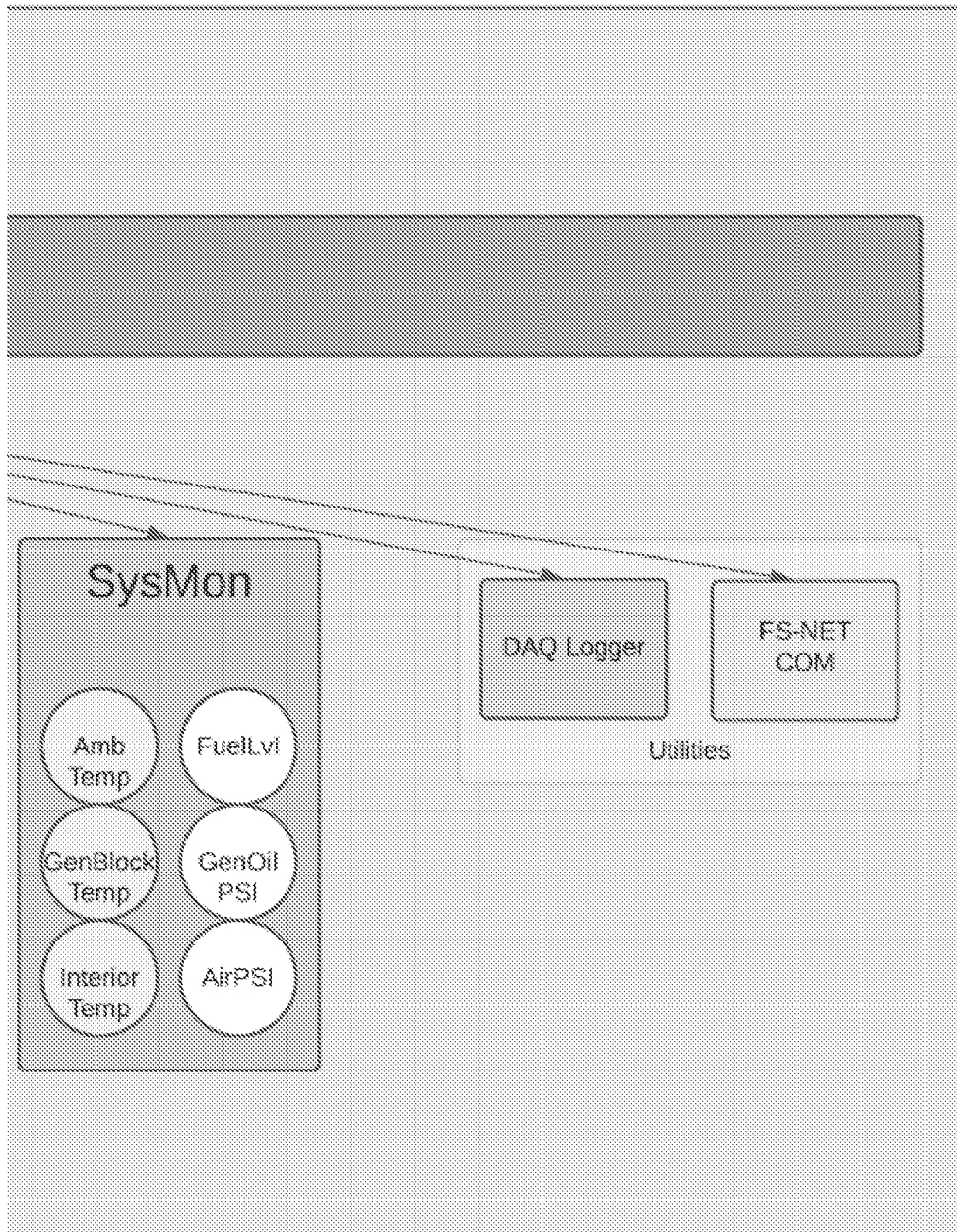


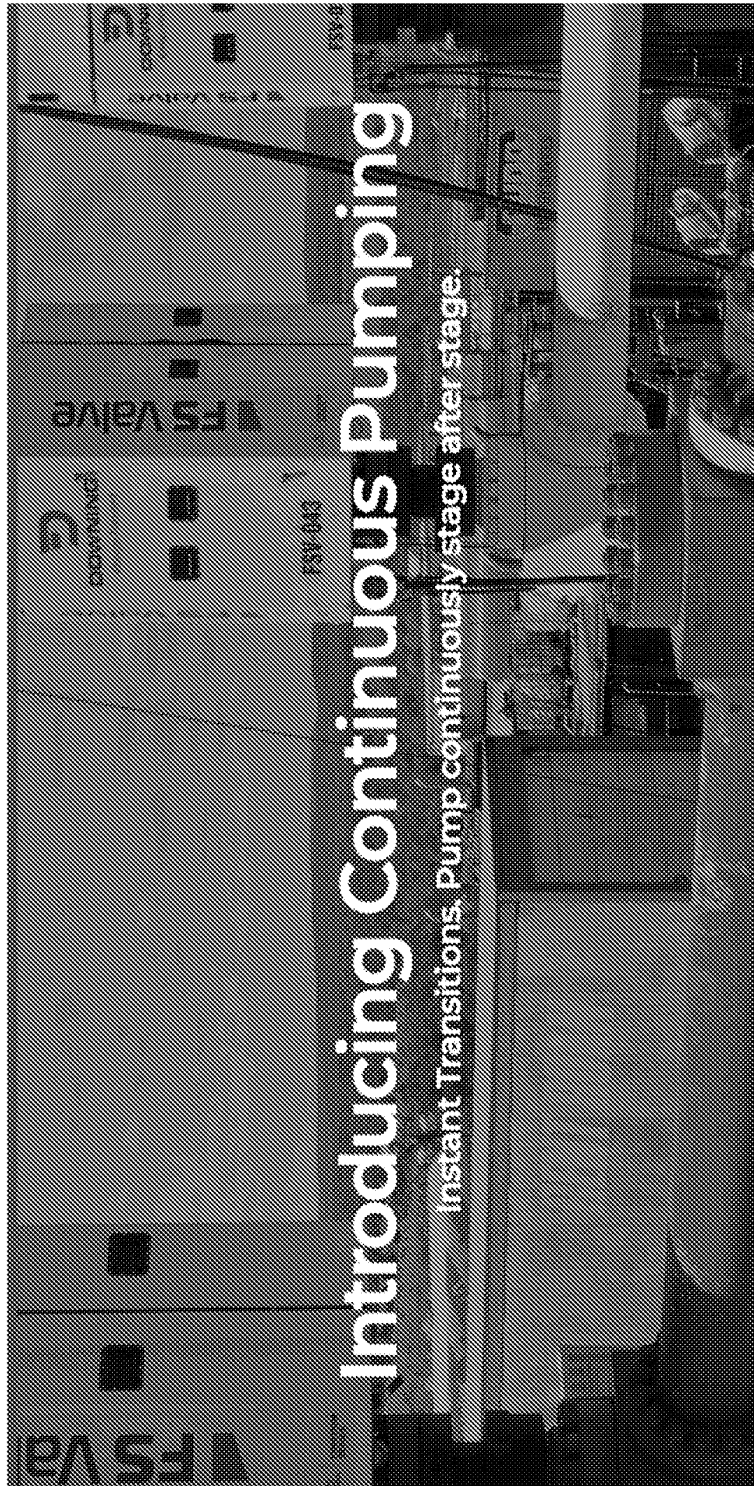




FSCC System Diagram





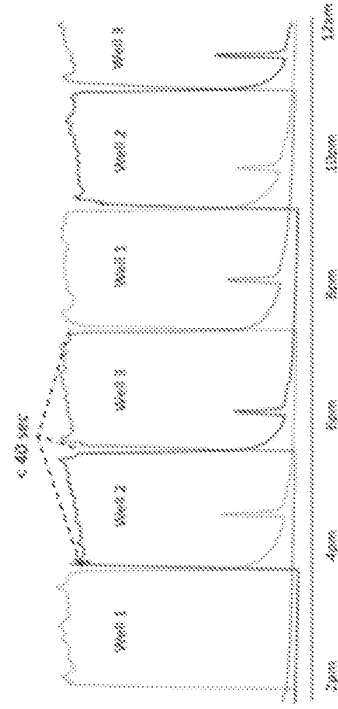


Freedom Series iControl

The Freedom Series Completion System with FS iControl enables instant transitions between stages, allowing your pumps to run continuously, dramatically increasing completion rates and reducing cost per well. By automating the hydraulic gate valves and integrating automatic greasing, along with Downing's proprietary algorithms, FS iControl delivers unrivaled efficiency to your completion operation.

Goodbye Transition Time

FS iControl's proprietary algorithms integrated with the Freedom Series Completion System transition the zipper valves from one well to the other, opening the second well and subsequently shutting-in the first well, all while pumping. The transition is instantaneous and the total time between stages measured at treatment pressure is as fast as 40 seconds.





Instantaneous Transition Time

- Reduces transition time to zero
- Stage-to-stage time (measured at treatment pressure) in 40 seconds or less
- Wireline downhole immediately at end of stage



Automatic Greasing Every Time Valves are Actuated

- Reduces greasing costs by up to 90% with data to prove it
- Grease to valve manufacturer specifications
- Fills the grease cavity with exact amount of grease. No more, no less.
- Real-time data output: amount of grease, time-stamp, and valve greased
- Reduces NPT incidents by ensuring valves greased properly



Reduce Employee Exposure

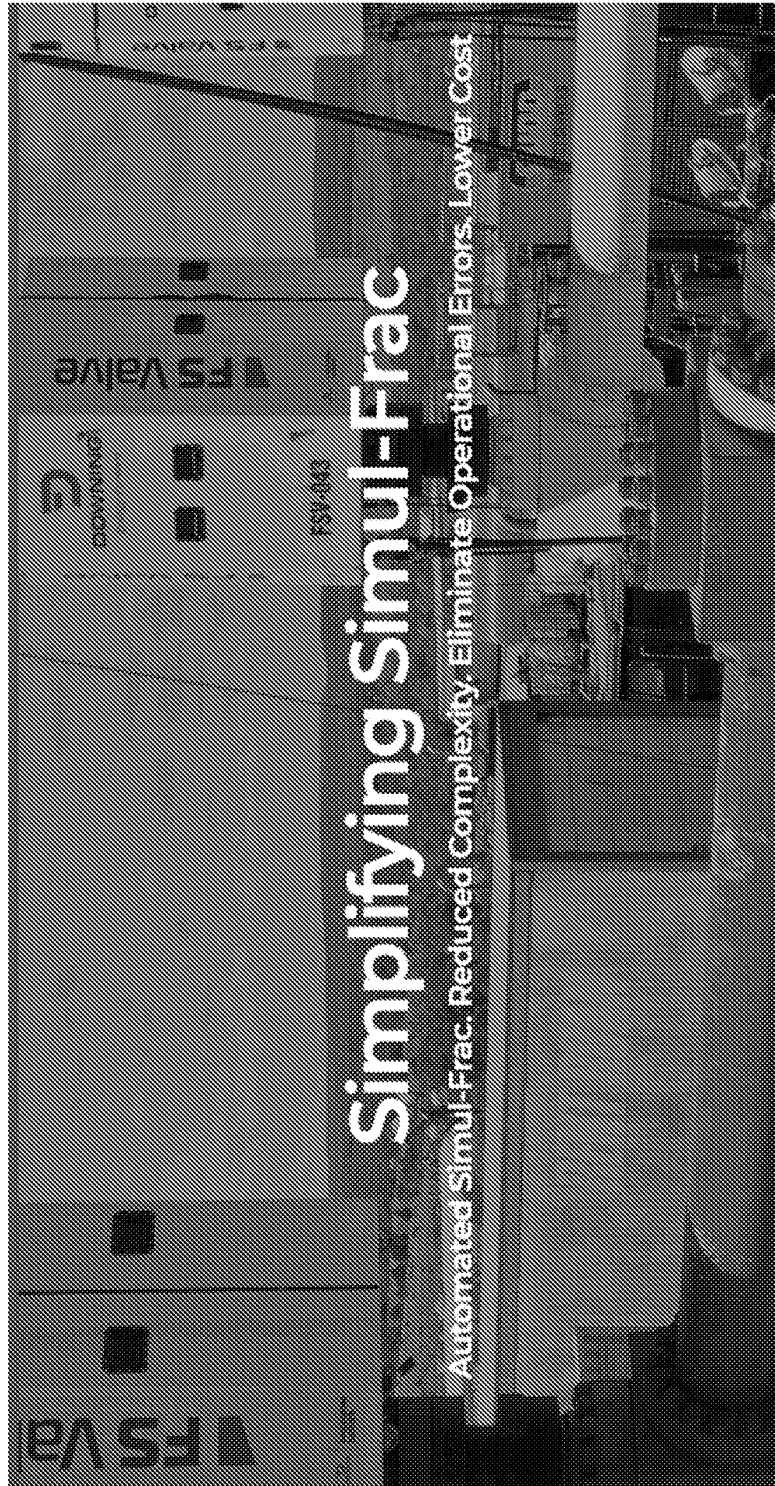
- Eliminates manual operation of valves
- Requires fewer personnel onsite

APPLICATION

- Multi-well zipper fracs using the FS Completion System

KEY FEATURES & BENEFITS

- Reduces overall cost per well
- Continuously pump stage to stage
- Automatically greases valves to manufacturer specifications
- Reduces personnel on the frac site



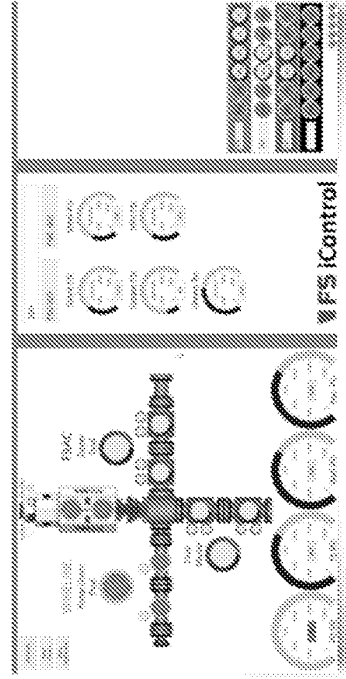
Let Freedom Series Simplify Your Simul-Frac

Frac'ing multiple wells is already a complex process. From logistics challenges, to valve actuation, to operational issues, to driving efficient operations, personnel are under immense pressure and pulled in multiple directions, requiring a special focus to ensure operational integrity. Add in Simul-frac operations and the complexity substantially increases....double the number of valves, actuations, greasing operations, wireline operations, etc. The traditional way to handle this added complexity is with additional personnel (and added cost).

Downing took a different road....we automated the entire surface system process, giving the operator complete control over their simul-frac operation while significantly reducing complexity. The Freedom Series Completion System integrates the surface systems into a single control system and automates the completion process. This provides an unparalleled view of all sub-systems, workflow-driven process steps, and mechanical and software interlocks to ensure a safe, efficient operation....all without the attendant costs associated with added complexity.

Simul-Frac Made Easy

Downing's Freedom Series Completion System integrates your surface systems into a single operational dashboard. The control system algorithms know the state of your surface equipment and the process sequence ... so you can focus on what really matters, fracturing rock.





Simplified Operations

- Freedom Series simplifies and automates the simul-frac process, eliminating the potential for operational missteps and the attendant costs associated with added complexity.
- Simul-frac complexity can lead to longer transitions. Freedom Series eliminates complexity and enables instant transitions.
- Easily shut one well of a simul-frac and continue fracturing another



Automated Control Reduces Additional Cost

- Move to simul-frac operations without adding additional personnel cost
- When a wireline mis-run occurs, the Freedom Series Completion System can recover lost time quickly and resynchronize with the planned operational sequence.



Reduce Employee Exposure

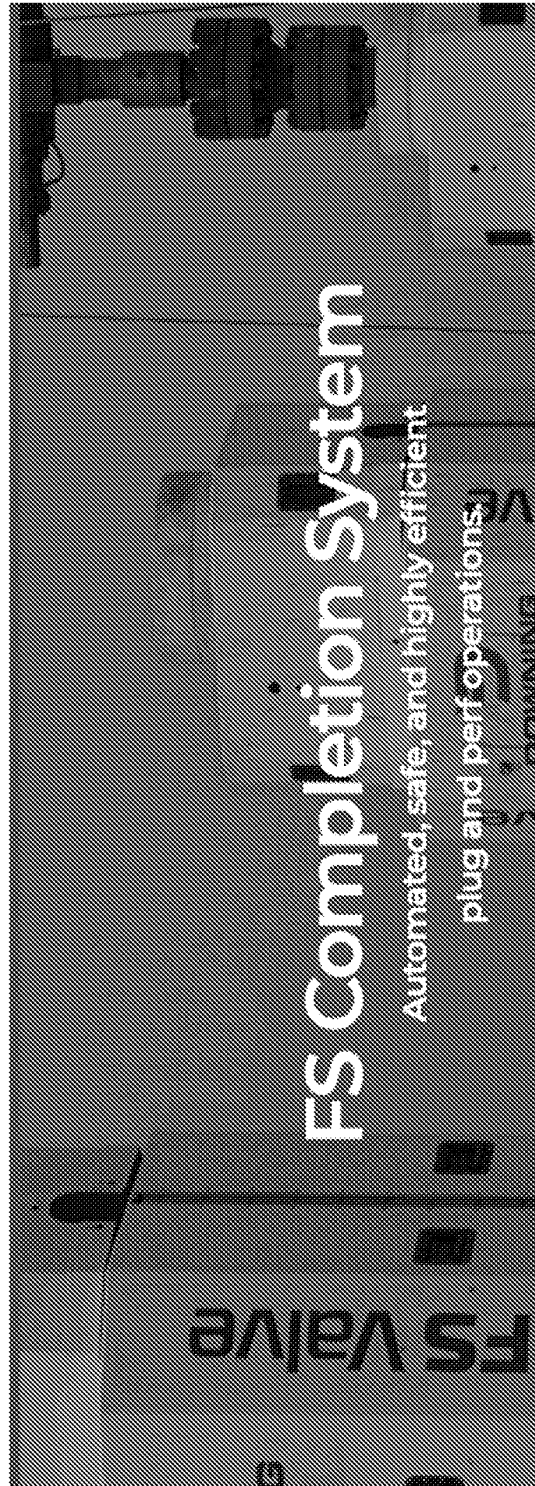
- Eliminates manual operation of valves
- Requires fewer personnel onsite

APPLICATION

- Simul-frac operations using the Freedom Series Completion System

KEY FEATURES & BENEFITS

- Reduces simul-frac complexity and errors
- Reduces personnel on the frac site
- Lower cost simul-frac operations



The Fastest Completions on the Market

The fully-automated FS Completion System (FSCS) is an integrated multi-chamber hydraulic valve with quick-connect latch system and optional ball dropper. Operated by an on-site control center or remotely, the system enables continuous frac operations by significantly reducing the time required to transition wireline-to-frac and frac-to-wireline. No other system on the market today, whether traditional latches or wellhead connection units, is as fast as the FS Completion System.

Maximize Pump Efficiency	Improved Safety and Environmental (ESC)	Lower Cost Per Well
- Automated pressure equalization enables any tool to enter a pressurized wellbore without pressurizing down and re-pressurizing the flow iron - Near instantaneous transition times between wireline-to-frac and frac-to-wireline	- Eliminates sending personnel into the red zone - Remove personnel from frac site - Reduced carbon emissions - Automated workflows eliminate human error	- Eliminates unplanned costs like cut wireline and gate valve failures - Significantly reduces valve repairs & greasing costs