CLAIMS

The invention claimed is:

1. A sleeve assembly, comprising:

a housing having an uphole end and a downhole end and defining one or more flow ports that provide fluid communication between a wellbore annulus and an interior of the housing, the housing being coupled to a top sub at the uphole end and to a bottom sub at the downhole end;

an outer sleeve arranged within the housing and movable between a closed position, where the outer sleeve occludes the one or more flow ports, and an open position, where the one or more flow ports are exposed; and

an inner sleeve concentrically arranged within the outer sleeve and defining a plurality of flow slots, the inner sleeve being movable between an open position and a closed position where, when in the open position, the plurality of flow slots are axially aligned with the one or more flow ports.

2. The sleeve assembly of claim 1, further comprising:

a piston movably arranged within a piston bore defined in the housing;

a spring arranged within the piston bore and configured to bias an uphole end of the piston; and

an upper locking device arranged within a first cavity defined in the piston and movable therewith, the upper locking device being engageable with an outer radial surface of the outer sleeve such that as the spring biases against and axially moves the piston within the piston bore, the upper locking device engages and simultaneously moves the outer sleeve into its open position.

3. The sleeve assembly of claim 2, further comprising:

a plurality of teeth defined on an inner radial surface of the upper locking device; and

a plurality of corresponding teeth defined on the outer radial surface of the outer sleeve,

wherein, when the spring biases against and axially moves the piston, the plurality of teeth of the upper locking device bind against the

plurality of corresponding teeth of the outer sleeve, thereby moving the outer sleeve into its open position.

4. The sleeve assembly of claim 2, further comprising a lower locking device arranged within a second cavity defined in the bottom sub, the lower locking device being configured to secure the outer sleeve in its open position.

5. The sleeve assembly of claim 4, further comprising

a plurality of teeth defined on an inner radial surface of the lower locking device; and

a plurality of corresponding teeth defined on the outer radial surface of the outer sleeve, wherein, when the outer sleeve is in its open position, the plurality of teeth of the lower locking device bind against the plurality of corresponding teeth of the outer sleeve, thereby securing the outer sleeve into its open position.

6. The sleeve assembly of claim 1, further comprising a locking collet provided on the inner sleeve and being configured to secure the inner sleeve in either the open or closed positions.

7. The sleeve assembly of claim 6, further comprising:

one or more locking keys extending radially from the locking collet;

a first groove defined on an inner radial surface of the bottom sub, the one or more locking keys being configured to engage the first groove in order to lock the inner sleeve in the open position; and

a second groove defined on the inner radial surface of the bottom sub, the one or more locking keys being configured to engage the second groove in order to lock the inner sleeve in the closed position.

8. The sleeve assembly of claim 7, further comprising one or more longitudinal perforations defined in the locking collet, the longitudinal perforations being configured to allow the locking collet to flex such that the one or more locking keys is able to move in and out of the first and second grooves.

9. The sleeve assembly of claim 1, further comprising a shifting tool engageable with a radial shoulder defined on the inner sleeve, the shifting tool being configured to move the inner sleeve between its open and closed positions.

10. A method of actuating a sleeve assembly installed in production tubing, comprising:

introducing a first shifting tool into the sleeve assembly, the sleeve assembly including a housing defining one or more flow ports, an outer sleeve arranged within the housing such that the one or more flow ports are exposed, and an inner sleeve concentrically arranged within the outer sleeve and defining a plurality of flow slots, wherein the plurality of flow slots are axially aligned with the one or more flow ports, thereby providing fluid communication between a wellbore annulus and an interior of the sleeve assembly;

engaging the first shifting tool on a first radial shoulder defined on the inner sleeve; and

axially moving the inner sleeve with the first shifting tool such that the plurality of flow slots are moved out of axial alignment with the one or more flow ports.

11. The method of claim 11, wherein the inner sleeve further includes a locking collet having one or more locking keys extending radially therefrom, and axially moving the inner sleeve further comprises forcing the one or more locking keys out of engagement with a first groove defined on an inner radial surface of the production tubing.

12. The method of claim 12, further comprising:

engaging the one or more locking keys in a second groove defined on the inner radial surface of the production tubing, the second groove being axially offset from the first groove; and

locking the inner sleeve in its axial position with the plurality of flow slots moved out of axial alignment with the one or more flow ports.

13. The method of claim 13, further comprising:

introducing a second shifting tool into the sleeve assembly;

engaging the second shifting tool on a second radial shoulder defined on the inner sleeve; and

axially moving the inner sleeve with the second shifting tool such that the plurality of flow slots are moved back into axial alignment with the one or more flow ports.

14. The method of claim 14, wherein axially moving the inner sleeve with the second shifting tool further comprises:

forcing the one or more locking keys out of engagement with the second groove;

engaging the one or more locking keys once more in the second groove; and

locking the inner sleeve in its axial position with the plurality of flow slots axially aligned with the one or more flow ports.

15. The method of claim 11, preceded by the following steps:

increasing a pressure within the sleeve assembly;

generating a pressure differential across a piston movably arranged within a piston bore defined in the housing;

forcing the piston to move axially within the piston bore from a first position to a second position, thereby axially compressing a spring arranged within the piston bore;

reducing the pressure within the sleeve assembly;

forcing the piston with the spring back to the first position; and

engaging and moving the outer sleeve with an upper locking device arranged within a first cavity defined in the piston and movable therewith, the upper locking device moving the outer sleeve so as to expose the one or more flow ports and provide the fluid communication between the wellbore annulus and the interior of the sleeve assembly.

16. The method of claim 16, wherein generating the pressure differential across the piston further comprises collapsing a piston chamber defined between the piston and the outer sleeve.

17. The method of claim 16, wherein forcing the piston to move axially within the piston bore from the first position further comprises shearing one or more shear pins used to couple the piston to the outer sleeve.

18. A sleeve assembly, comprising:

a housing defining one or more flow ports that provide fluid communication between a wellbore annulus and an interior of the housing, the housing being configured to be coupled at each end to production tubing;

an outer sleeve arranged within the housing and movable between a closed position, where the outer sleeve occludes the one or more flow ports, and an open position, where the one or more flow ports are exposed;

an inner sleeve concentrically arranged within the outer sleeve and defining a plurality of flow slots, the inner sleeve being movable between an open position and a closed position where, when in the open position, the plurality of flow slots are axially aligned with the one or more flow ports;

a piston movably arranged within a piston bore defined in the housing;

a spring arranged within the piston bore and configured to bias an uphole end of the piston; and

an upper locking device arranged within a first cavity defined in the piston and movable therewith, the upper locking device being engageable with an outer radial surface of the outer sleeve such that as the spring biases against and axially moves the piston within the piston bore, the upper locking device engages and simultaneously moves the outer sleeve into its open position.

19. The sleeve assembly of claim 18, further comprising a locking collet provided on the inner sleeve and being configured to secure the inner sleeve in either the open or closed positions.

20. The sleeve assembly of claim 19, further comprising:

one or more locking keys extending radially from the locking collet;

a first groove defined on an inner radial surface of the production tubing, the one or more locking keys being configured to engage the first groove in order to lock the inner sleeve in the open position; and

a second groove defined on the inner radial surface of the production tubing and axially offset from the first groove, the one or more locking keys being configured to engage the second groove in order to lock the inner sleeve in the closed position.

CLAIMS

The invention claimed is:

1. A sleeve assembly, comprising:

a housing having an uphole end and a downhole end and defining one or more flow ports that provide fluid communication between a wellbore annulus and an interior of the housing, the housing being coupled to a top sub at the uphole end and to a bottom sub at the downhole end;

an outer sleeve arranged within the housing and movable between a closed position, where the outer sleeve occludes the one or more flow ports, and an open position, where the one or more flow ports are exposed;

an inner sleeve concentrically arranged within the outer sleeve and defining a plurality of flow slots, the inner sleeve being movable between an open position and a closed position where, when in the open position, the plurality of flow slots are axially aligned with the one or more flow ports;

a piston movably arranged within a piston bore defined in the housing;

a spring arranged within the piston bore and configured to bias an uphole end of the piston; and

an upper locking device arranged within a first cavity defined in the piston and movable therewith, the upper locking device being engageable with an outer radial surface of the outer sleeve such that as the spring biases against and axially moves the piston within the piston bore, the upper locking device engages and simultaneously moves the outer sleeve into its open position.

2. The sleeve assembly of claim 1, further comprising:

a plurality of teeth defined on an inner radial surface of the upper locking device; and

a plurality of corresponding teeth defined on the outer radial surface of the outer sleeve,

wherein, when the spring biases against and axially moves the piston, the plurality of teeth of the upper locking device bind against the plurality of corresponding teeth of the outer sleeve, thereby moving the outer sleeve into its open position.

3. The sleeve assembly of claim 1, further comprising a lower locking device arranged within a second cavity defined in the bottom sub, the lower locking device being configured to secure the outer sleeve in its open position.

4. The sleeve assembly of claim 3, further comprising

a plurality of teeth defined on an inner radial surface of the lower locking device; and

a plurality of corresponding teeth defined on the outer radial surface of the outer sleeve, wherein, when the outer sleeve is in its open position, the plurality of teeth of the lower locking device bind against the plurality of corresponding teeth of the outer sleeve, thereby securing the outer sleeve into its open position.

5. The sleeve assembly of claim 1, further comprising a locking collet provided on the inner sleeve and being configured to secure the inner sleeve in either the open or closed positions.

6. The sleeve assembly of claim 5, further comprising:

one or more locking keys extending radially from the locking collet;

a first groove defined on an inner radial surface of the bottom sub, the one or more locking keys being configured to engage the first groove in order to lock the inner sleeve in the open position; and

a second groove defined on the inner radial surface of the bottom sub, the one or more locking keys being configured to engage the second groove in order to lock the inner sleeve in the closed position.

7. The sleeve assembly of claim 6, further comprising one or more longitudinal perforations defined in the locking collet, the longitudinal perforations being configured to allow the locking collet to flex such that the one or more locking keys is able to move in and out of the first and second grooves.

8. The sleeve assembly of claim 1, further comprising a shifting tool engageable with a radial shoulder defined on the inner sleeve, the shifting tool being configured to move the inner sleeve between its open and closed positions.

9. A method of actuating a sleeve assembly installed in production tubing, comprising:

introducing a first shifting tool into the sleeve assembly, the sleeve assembly including a housing defining one or more flow ports, an outer sleeve arranged within the housing such that the one or more flow ports are exposed, and an inner sleeve concentrically arranged within the outer sleeve and defining a plurality of flow slots, wherein the plurality of flow slots are axially aligned with the one or more flow ports, thereby

providing fluid communication between a wellbore annulus and an interior of the sleeve assembly;

engaging the first shifting tool on a first radial shoulder defined on the inner sleeve; and

axially moving the inner sleeve with the first shifting tool such that the plurality of flow slots are moved out of axial alignment with the one or more flow ports, wherein the inner sleeve further includes a locking collet having one or more locking keys extending radially therefrom, and axially moving the inner sleeve further comprises forcing the one or more locking keys out of engagement with a first groove defined on an inner radial surface of the production tubing.

10. The method of claim 9, further comprising:

engaging the one or more locking keys in a second groove defined on the inner radial surface of the production tubing, the second groove being axially offset from the first groove; and

locking the inner sleeve in its axial position with the plurality of flow slots moved out of axial alignment with the one or more flow ports.

11. The method of claim 10, further comprising:

introducing a second shifting tool into the sleeve assembly;

engaging the second shifting tool on a second radial shoulder defined on the inner sleeve; and

axially moving the inner sleeve with the second shifting tool such that the plurality of flow slots are moved back into axial alignment with the one or more flow ports.

12. The method of claim 11, wherein axially moving the inner sleeve with the second shifting tool further comprises:

forcing the one or more locking keys out of engagement with the second groove;

engaging the one or more locking keys once more in the second groove; and

locking the inner sleeve in its axial position with the plurality of flow slots axially aligned with the one or more flow ports.

13. The method of claim 9, preceded by the following steps:

increasing a pressure within the sleeve assembly;

generating a pressure differential across a piston movably arranged within a piston bore defined in the housing;

forcing the piston to move axially within the piston bore from a first position to a second position, thereby axially compressing a spring arranged within the piston bore;

reducing the pressure within the sleeve assembly;

forcing the piston with the spring back to the first position; and

engaging and moving the outer sleeve with an upper locking device arranged within a first cavity defined in the piston and movable therewith, the upper locking device moving the outer sleeve so as to expose the one or more flow ports and provide the fluid communication between the wellbore annulus and the interior of the sleeve assembly.

14. The method of claim 13, wherein generating the pressure differential across the piston further comprises collapsing a piston chamber defined between the piston and the outer sleeve.

15. The method of claim 14, wherein forcing the piston to move axially within the piston bore from the first position further comprises shearing one or more shear pins used to couple the piston to the outer sleeve.

16. A sleeve assembly, comprising:

a housing defining one or more flow ports that provide fluid communication between a wellbore annulus and an interior of the housing, the housing being configured to be coupled at each end to production tubing;

an outer sleeve arranged within the housing and movable between a closed position, where the outer sleeve occludes the one or more flow ports, and an open position, where the one or more flow ports are exposed;

an inner sleeve concentrically arranged within the outer sleeve and defining a plurality of flow slots, the inner sleeve being movable between an open position and a closed position where, when in the open position, the plurality of flow slots are axially aligned with the one or more flow ports;

a piston movably arranged within a piston bore defined in the housing;

a spring arranged within the piston bore and configured to bias an uphole end of the piston; and

an upper locking device arranged within a first cavity defined in the piston and movable therewith, the upper locking device being engageable with an outer radial surface of the outer sleeve such that as the spring biases against and axially moves the piston within the piston bore, the upper locking device engages and simultaneously moves the outer sleeve into its open position.

17. The sleeve assembly of claim 16, further comprising a locking collet provided on the inner sleeve and being configured to secure the inner sleeve in either the open or closed positions.

18. The sleeve assembly of claim 17, further comprising:

one or more locking keys extending radially from the locking collet;

a first groove defined on an inner radial surface of the production tubing, the one or more locking keys being configured to engage the first groove in order to lock the inner sleeve in the open position; and

a second groove defined on the inner radial surface of the production tubing and axially offset from the first groove, the one or more locking keys being configured to engage the second groove in order to lock the inner sleeve in the closed position.